U.S. Department of Transportation

Federal Aviation Administration

Port of Seattle

FINAL ENVIRONMENTAL IMPACT STATEMENT

for

PROPOSED MASTER PLAN UPDATE DEVELOPMENT ACTIONS

at

SEATTLE-TACOMA INTERNATIONAL AIRPORT

VOLUME 1 OF 7

CHAPTERS I THROUGH VI, APPENDICIES A - B

This statement is submitted for review pursuant to the requirements of Section 102(2)(C) of the National Environmental Policy Act of 1969 (42 U.S.C. 4321 et seq); E.O. 11990, Protection of Wetlands; E.O. 11998, Floodplain Management; the 49 USC Subtitle VII; 42 U.S.C. 7401 et seq; 49 U.S.C. 47101 et seq; Washington State Environmental Policy Act (RCW 43.21C); and other applicable laws. The proposed action will impact the 100-year floodplain as indicated on the Federal Emergency Management Agency's Flood Insurance Rate Map. This Environmental Impact Statement (EIS) is a combined National Environmental Policy Act and Washington State Environmental Policy Act (SEPA) document. With regard to SEPA requirements, this EIS represents the second step of a phased environmental review which began with publication of the 1992 Flight Plan Final EIS, which assessed alternatives for addressing regional aviation needs. This Final EIS also contains the draft conformity statement, as required by the Clean Air Act amendments.

The Port of Seattle, operator of Seattle-Tacoma International Airport, has prepared a Master Plan Update for the Airport. The Plan shows the need to address the poor weather operating capability of the Airport through the development of a third parallel runway (Runway 16X/34X) with a length of up to 8,500 feet, separated by 2,500 feet from existing Runway 16L/34R, with associated taxiways and navigational aids. Other development needs include: extension of Runway 34R by 600 feet; establishment of standard Runway Safety Areas for Runways 16R/34L and 16L/34R; development of a new air traffic control tower; development of a new north unit terminal, Main Terminal improvements and terminal expansion; parking and access improvements and expansion; development of the South Aviation Support Area for cargo and/or maintenance facilities, and relocation, redevelopment, and expansion of support facilities. This Environmental Impact Statement assesses the impact of alternative airport improvements, including installation of navigational aids, airspace use, and approach and departure procedures. The proposed improvements would be completed during the 1996-2020 period, with initial 5-year development focused on the proposed new parallel runway, and existing passenger terminal, parking and access improvements. The proposed improvements and its alternatives would result in wetland impacts, floodplain encroachment, stream relocation, social, noise, water, and air quality impacts.

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Date: February, 1996

Federal Aviation Administration
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February 1, 1996

Dear Reader:

Officials of the Central Puget Sound Region have been faced with developing a plan to meet the future transportation demands in the Region, that exist now and will continue to grow in the future. The Master Plan Update for Seattle-Tacoma International Airport has confirmed earlier studies which indicated that poor weather conditions currently produce significant delays and that the present airside, terminal, and landside facilities will no longer be able to efficiently accommodate air travel needs. As was noted in the 1992 Flight Plan Study, without undertaking expansion of the transportation facilities in the Region, delays and inefficient facilities "could ultimately affect the Region's economy". This Final Environmental Impact Statement examines the range of alternatives for addressing these needs and the resulting environmental consequences.

In late 1993, the Port of Seattle initiated a Master Plan Update for Sea-Tac to examine the types of facilities that would be needed through the year 2020. The Master Plan Update began with the development of aviation demand forecasts, the review of airside facilities (runways, taxiways, etc.) and the review of landside facilities (roadways, terminals, cargo facilities, etc.). Based on the review of various landside options and airside options, a series of development alternatives were formulated. This Environmental Impact Statement is a project specific assessment and examines the full range of alternatives to satisfying these needs, ranging from alternative modes of transportation, use of a new or existing airport, activity management/system management, development alternatives at Sea-Tac, and the Do-Nothing/No Build. Based on the public and agency comments, the Master Plan Update analysis, and the Draft EIS, the Port of Seattle staff selected Alternative 3 as the Preferred Alternative. Primary features of the Preferred Alternative are a proposed North Unit Terminal and a new parallel runway with a length of 8,500 feet located about 2,500 feet west of existing runway 16L/34R. To present information for review by regional decision-makers, the Final EIS addresses three runway lengths (7,000 feet, 7,500 feet and 8,500 feet), and thus, consideration of the runway is noted as "up to 8,500 feet".

This Environmental Impact Statement has been a joint effort between the Federal Aviation Administration (FAA) and the Port of Seattle, with the FAA taking the lead in preparation of the technical analysis and report production. To solicit public comments on the Draft EIS, the FAA provided a 90-day comment period and conducted two public hearings. This Final EIS reflects comments received at the Hearings and during the comment period.

Key issues addressed in this Environmental Impact Statement are:

1. **Why is development needed at Sea-Tac Airport? If it proceeds, when will it occur?**

Chapter I describes the background leading to preparation of this Draft EIS and the issues and needs that were identified. Chapter II, "Alternatives " describes the specific alternatives that could meet the need.

2. **Why are improvements planned at Sea-Tac versus development of a new airport?**

Following the 1992 Flight Plan Study, two planning efforts were undertaken, the Major Supplemental Airport Study (called the MSA) and the Sea-Tac Master Plan Update. Chapters I and II and Appendix B provide detailed descriptions of these efforts that led the Executive Board of the Puget Sound Regional Council (PSRC) to determine that there were no feasible alternative airport sites. After extensive study

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by the officials of the Region, as led by the PSRC, Sea-Tac Airport was identified as the only feasible site for addressing a portion of the future air transportation needs of the Region through 2020. The Port of Seattle and the FAA have reviewed the regional planning studies and have independently concluded that a new airport can not meet the needs addressed by this Environmental Impact Statement.

3. **What are the impacts of noise, air pollution, and water pollution, as well as the human heath impacts?**

This Environmental Impact Statement identifies the environmental consequences of the alternatives across twenty-four environmental categories, including noise, air, water, and human health. Chapter IV, and Appendices C through Q contain this analysis.

4. **What mitigation will be recommended to implement any of the alternatives?**

Each section in Chapter IV contains a summary of recommended mitigation. In addition, Chapter V contains an overall summary of the environmental impacts and mitigation measures.

5. **What comments were submitted on the Draft EIS and how did you change the document in response to these comments?**

Appendix T of the Final EIS contains all of the comments received on the Draft EIS. Responses to applicable comments are provided in Appendix R. To aid in public review of the Final EIS, the entire document has been reproduced, with changes made in the Draft EIS text in response to the comments.

6. **Federal Approval Declaration**

After careful and thorough consideration of the facts contained herein, and following consideration of the views of those Federal agencies having jurisdiction by law or special expertise with respect to the environmental impacts described, the undersigned finds that the proposed Federal actions are consistent with existing national environmental policies and objectives as set forth in Section 101(a) of the National Environmental Policy Act of 1969.

Lowell H. Johnson
Manager
Northwest Mountain Region Airports Division

1 Feb. 1996
Date

DRAFT ENVIRONMENTAL IMPACT STATEMENT

PROPOSED MASTER PLAN UPDATE

Seattle-Tacoma International Airport

LIST OF EXHIBITS

DRAFT ENVIRONMENTAL IMPACT STATEMENT

PROPOSED MASTER PLAN UPDATE

Seattle-Tacoma International Airport

LIST OF EXHIBITS (Continued)

FACT SHEET

roject Title: Master Plan Update improvements for Seattle-Tacoma International Airport.

Description of Project: The proposed Master Plan Update improvements at Sea-Tac Airport would reduce existing poor weather aircraft operating delay and accommodate forecast growth in passengers, cargo and aircraft operations. Port of Seattle staff have recommended Alternative 3 - North Unit Terminal with a new 8,500 foot long parallel runway. To present information for consideration by regional decision-makers, this EIS addresses a proposed runway with a length up to 8,500 feet. Proposed airport improvements would include:

- Third parallel runway with a length of up to 8,500 feet located about 2,500 feet west of existing Runway 16L/34R, and associated taxiways, safety areas, relocated utilities, and navigational aids
- 600 foot extension southward of Runway 34R
- Standard Runway Safety Areas for existing Runways 16R/34L and 16L/34R
- Terminal improvements and expansion, including the development of a North Unit Terminal
- Parking and access improvements and expansion
- Development of the South Aviation Support Area
- Relocation, redevelopment and expansion of support facilities

Project Sponsor: Port of Seattle

Lead Agencies: The Federal Aviation Administration (FAA) and the Port of Seattle are joint lead agencies for the purpose of the National Environmental Policy Act (NEPA) and State Environmental Policy Act (SEPA) Environmental Impact Statement (EIS).

The Port of Seattle contact is: Ms. Barbara Hinkle, Health, Safety and Environmental Management Division, Port of Seattle, P.O. Box 68727, Seattle, Washington, 98168.

The FAA responsible official is: Mr. Dennis Ossenkop, Northwest Mountain Region, Airports Division, Federal Aviation Administration, 1601 Lind Avenue, S.W., Renton, Washington 98055-4056.

Cooperating Agency: The U.S. Army Corps of Engineers is a cooperating agency under NEPA.

Licenses, Permits and Other Approvals Potentially Required:

Federal: FAA Record of Decision, Air Quality Conformity Determination; and approval of the Airport Layout Plan; U.S. Army Corps of Engineers Section 404 permit;

State: Department of Ecology Water Quality Certification and National Pollutant Discharge Elimination System Permit for Stormwater; Department of Fisheries and Wildlife Hydraulic Project Approval; Temporary Modification of Water Quality, Department of Natural Resources Forest Practices Permit, Governors Clean Air and Water Certification;

Local: Puget Sound Regional Council Review; Port of Seattle Commission project decisions; City of SeaTac comprehensive plan and zoning process, clearing and grading permits, floodplain filling permits, demolition permits, and others.

Principal Authors and Contributors to the Draft and/or Final EIS: This NEPA/SEPA EIS was prepared under the direction of the Federal Aviation Administration and Port of Seattle. Technical analysis was provided by:

Landrum & Brown, Incorporated
Shapiro and Associates, Inc.
INCA Engineers, Inc.
Metro Communications, Inc.
Gambrell Urban, Inc.
Parametrix, Inc.
Synergy Consultants, Inc.

FACT SHEET (Continued)

Date of Issue of Final EIS: February 9, 1996

Public Meetings: Two *scoping meetings* were held. The Public Scoping meeting was held on February 9, 1994. A meeting with Federal, State and local agencies was held at Sea-Tac Airport on February 10, 1994.

Two *public hearings* were conducted: June 1, 1995 at the SeaTac Red Lion and on June 14, 1995 at the Calvary Lutheran Church in Federal Way. Copies of comments received are provided in Appendix T (Volumes 5 through 7); responses to applicable comments are provided in Appendix R (Volume 4).

Approximate Date of Final Action by Lead Agencies: In accordance with the National Environmental Policy Act, the issuance of the Final EIS is followed by a 30-day cool down period, which will end on March 18, 1996. After compliance with applicable requirements, the FAA will issue the Record of Decision and then sign the Airport Layout Plan. Similarly, the Port of Seattle action approving the Master Plan Update is expected in early 1996.

Approximate Date of Implementation: Limited terminal development, cargo area expansion, development of an On-Airport hotel and existing terminal entrance roadway improvements could be initiated as early as 1996. The new runway, and associated navigational aids and taxiway development, could be completed by 2001.

Availability of Copies: Copies of the Draft and Final EIS are available for inspection at:

Federal Aviation Administration, Airports Regional Office, Room 540, 1601 Lind Avenue, SW, Renton, WA

Port of Seattle, *Aviation Planning*, 3rd floor, Terminal Building, Sea-Tac Airport, and *Pier 69* Bid Office, 2711 Alaskan Way, Seattle

Puget Sound Regional Council, Information Center, 216-1st Avenue, Seattle

Beacon Hill Library, 2519 - 1st Avenue, South, Seattle

Boulevard Park Library, 12015 Roseberg South, Seattle

Seattle Public Library, 1000 - 4th Avenue, Seattle

Magnolia Library, 2801 - 34th Ave W, Seattle

Rainier Beach Library, 9125 Rainier Avenue S., Seattle

Bothell Regional Library, 9654 NE 182nd, Bothell

Burien Library, 14700-6th SW, Burien

Des Moines Library, 21620-11th South, Des Moines

Federal Way Regional Library, 34200-1st South, Federal Way

Foster Library, 4205 South 142nd, Tukwila

Kent Regional Library, 212 - 2nd Ave N, Kent

Vashon Ober Park, 17210 Vashon Highway, Vashon

Tacoma Public Library, 1102 Tacoma Ave S., Tacoma

University of Washington, Suzallo Library, Government Publications, Seattle

Valley View Library, 17850 Military Road South, SeaTac

West Seattle Library, 2306 - 42nd Ave SW, Seattle

Bellevue Regional Library, 1111 - 110th Ave NE, Bellevue

To Purchase A Copy: This document is available for public reproduction at Kinko's located at Kent-Des Moines Way and International Blvd./SR 99. All 7 volumes of this report cost over $350, including color exhibits.

Locations of Other Documents: The Flight Plan EIS issued in 1992, technical reports, background data, adopted documents, and material incorporated by reference in this EIS are, unless otherwise stated in this EIS, located at:

Federal Aviation Administration, Airports Regional Office, Room 540, 1601 Lind Avenue, SW, Renton, WA

Port of Seattle, Aviation Planning, 3rd Floor, Terminal Building, Sea-Tac Airport

Puget Sound Regional Council, Information Center, 216-1st Avenue, Seattle

FINAL ENVIRONMENTAL IMPACT STATEMENT

PROPOSED MASTER PLAN UPDATE

Seattle-Tacoma International Airport

TABLE OF CONTENTS

FINAL ENVIRONMENTAL IMPACT STATEMENT

PROPOSED MASTER PLAN UPDATE

Seattle-Tacoma International Airport

TABLE OF CONTENTS (Continued)

APPENDICIES

FINAL ENVIRONMENTAL IMPACT STATEMENT

PROPOSED MASTER PLAN UPDATE

Seattle-Tacoma International Airport

TABLE OF CONTENTS (Continued)

DRAFT ENVIRONMENTAL IMPACT STATEMENT

PROPOSED MASTER PLAN UPDATE

Seattle-Tacoma International Airport

LIST OF TABLES

DRAFT ENVIRONMENTAL IMPACT STATEMENT

PROPOSED MASTER PLAN UPDATE

Seattle-Tacoma International Airport

LIST OF TABLES (Continued)

DRAFT ENVIRONMENTAL IMPACT STATEMENT

PROPOSED MASTER PLAN UPDATE

Seattle-Tacoma International Airport

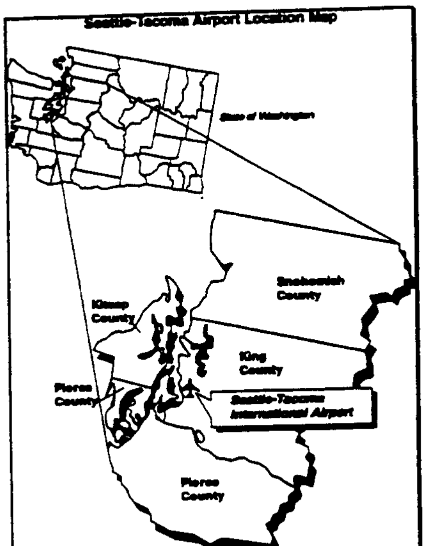
LIST OF TABLES (Continued)

EXECUTIVE SUMMARY

FINAL ENVIRONMENTAL IMPACT STATEMENT

For the Seattle-Tacoma International Airport Master Plan Update

Seattle-Tacoma International Airport (Sea-Tac Airport) is the primary air transportation hub of Washington State and the Northwestern United States. As the primary commercial service airport for the Pacific Northwest, Sea-Tac Airport is the only airport which provides scheduled commercial air carrier service in the four-county Central Puget Sound area serving 2.8 million residents. The Region consists of: King, Pierce, Snohomish, and Kitsap counties. Sea-Tac Airport is operated by the Port of Seattle (also referred to as "The Port"), a municipal corporation of the State of Washington. Located within King County and the City of SeaTac, the Airport is 12 miles south of downtown Seattle and about 20 miles north of Tacoma.



As of August 1995, service is provided by 54 airlines. Non-stop air service is provided to 44 cities nationwide and to the international cities of Copenhagen, London, Tokyo, Hong Kong, Taipei, Seoul, Shanghai, Osaka, Vancouver and Victoria. Sea-Tac Airport is the 21st busiest airport in the country, as measured by total passengers. It is also the 8th largest international air gateway to Europe and Asia, and the 18th busiest cargo airport.

CHAPTER I

BACKGROUND AND PURPOSE AND NEED

A number of studies conducted in the late 1980s concluded that the existing two runways at Sea-Tac would not be adequate to meet regional air travel needs beyond the year 2000. As a result, the Port of Seattle and the regional planning council (now called the Puget Sound Regional Council - PSRC) co-sponsored a process, called the Flight Plan Study, to identify a long-term solution to the Puget Sound Region's air transportation needs. Based on the two and a half year effort which examined ways to accommodate demand, the 1992 Flight Plan Study recommended a multiple airport system that included a new runway at Sea-Tac Airport.

In response to the Flight Plan Study and additional study by the PSRC, the PSRC General Assembly adopted a Resolution (No. A-93-03) in April 1993 to amend the Regional Aviation System Plan. The PSRC resolution states:

> "... That the region should pursue vigorously, as the preferred alternative, a major supplemental airport and a third runway at Sea-Tac.
>
> 1. The major supplemental airport should be located in the four-county area within a reasonable travel time from significant markets in the region.
> 2. The third runway shall be authorized by April 1, 1996:
>   a. Unless shown through an environmental assessment, which will include financial and market feasibility studies, that a supplemental site is feasible and can eliminate the need for the third runway; and
>   b. After demand management and system management programs are pursued and achieved or determined not to be feasible, based on independent evaluation; and
>   c. When noise reduction performance objectives are scheduled, pursued and achieved based on independent evaluation and based on measurement of real noise impacts.
> 3. The Regional Council requests consideration by the Federal Aviation Administration of modifying the Four-Post Plan to reduce noise impacts, and the related impacts on regional military air traffic.
> 4. Evaluation of the major supplemental airport shall be accomplished in cooperation with the state of Washington.

5. **Proceed immediately to conduct site-specific studies, including an environmental impact statement on a Sea-Tac third runway.**
6. **Eliminate small supplemental airports, including Paine Field, as a preferred alternative."**

The PSRC undertook a study of the feasibility of a major supplemental airport -- which became known as the Major Supplemental Airport (MSA) study -- in response to the recommendations of the Flight Plan Study and subsequent Resolution A-93-03. MSA Phase I consisted of an exhaustive examination of new airport sites which subsequently narrowed the site evaluation to 3 sites (Arlington, Marysville and Tanwax Lake). However, MSA Phase II was not initiated following the Executive Board Resolution EB-94-01 (dated October 27, 1994) which states:

"WHEREAS, regional studies completed by the Puget Sound Air Transportation Committee, the Washington State Air Transportation Committee, and the Puget Sound Regional Council (PSRC) have clearly identified a near term air transportation capacity problem at Sea-Tac International Airport, and concluded that the addition of a third all-weather runway at Sea-Tac would provide adequate capacity for the region through the year 2030; ....WHEREAS, **the Executive Board concludes that there are no feasible sites for a major supplemental airport within the four-county region** and that continued examination of any local site will prolong community anxiety while eroding the credibility of regional governance; and....NOW, THEREFORE BE IT RESOLVED, that the Executive Board further clarifies that the 'Resolution A-93-03: Implementation Steps' adopted by the Executive Board allow the Executive Board to determine whether the Regional Council should go forward with additional supplemental airport studies and pursuant to that authority, **the Executive Board determines that further studies should not be undertaken.** ..." (Emphasis added)

This Environmental Impact Statement for the Master Plan Update is the second step of a phased State Environmental Policy Act (SEPA) environmental review process that began with the publication of the EIS accompanying the 1992 Flight Plan EIS. The Flight Plan EIS examined alternative sites and configurations for new or expanded airports, along with demand management techniques, rail and other ground transportation, and technological alternatives to limit the number of flight operations and encourage alternatives to air travel. The Flight Plan EIS and related materials are listed and described, and their locations are identified, in **Appendix B**.

The Master Plan Update forecast the following aviation demand:

MASTER PLAN UPDATE FORECASTS

	Actual	Master Plan Update Forecast		
	1993	2000	2010	2020
Enplaned Passengers:				
Domestic	8,700,000	10,800,000	13,800,000	17,200,000
International	700,000	1,100,000	1,500,000	1,900,000
Total Enplanements	9,400,000	11,900,000	15,300,000	19,100,000
Aircraft Operations:				
Air Carrier	188,000	223,000	255,000	287,000
Air Taxi/Commuter	127,000	127,000	118,000	117,000
All-Cargo	16,000	20,000	23,000	27,000
General Aviation	8,100	8,900	9,500	10,300
Military	400	300	300	300
Total Operations	339,500	379,200	405,800	441,600
Average Day Operations	930	1,040	1,112	1,210
Peak Month/Average Day	1,056	1,163	1,253	1,369

Source: *1994 Master Plan Update Technical Report No. 5 Preliminary Forecast Report*, Port of Seattle.

Note: Enplanements - Passengers boarding aircraft. Operations - total arrivals and departures.

In 1994, aircraft operations were 353,052 with 10.5 million enplaned passengers

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With or without improvements at Sea-Tac Airport, aviation demand will increase as a consequence of growth in the population and income of the region.

As a result of existing high levels of poor weather delay and forecast increased demand, the following four needs (**shown in bold**) were identified:

(A) Improve The Poor Weather Airfield Operating Capability in a Manner That Accommodates Aircraft Activity with an Acceptable Level of Delay

Weather conditions and their patterns of occurrence are important considerations when evaluating the operational capability of an airfield. The safe spacing between aircraft specified by the FAA's air traffic control standards differ depending upon weather conditions (i.e., the cloud ceiling and visibility). Because of the narrow distance between the existing parallel runways at Sea-Tac, simultaneous arrivals to both runways are permitted only in good weather conditions.

When poor weather occurs at Sea-Tac, the total number of arrivals that can be accommodated is reduced from the good weather level of 60 to 24 arrivals per hour, as shown below.

Present Runway System Arrival Operating Capability at Sea-Tac Airport

Condition	Hourly Airfield Capability Maximum Arrivals
Good Weather:	
VFR1	60
Poor Weather:	
VFR2	48
IFR1	36
IFR2 & 3	24

Source: *1994 Master Plan Update Inventory*, P&D Aviation, Pg. 3-8
VFR - Visual Flight Rules,
IFR - Instrument Flight Rules

Current FAA air traffic control rules require at least a 2,500-foot separation between parallel runway centerlines for two staggered arrival streams during poor weather. Because the runways at Sea-Tac are only 800 feet apart, the existing airfield only allows a single arrival stream during poor weather (VFR2 and IFR). Based on the 10-year weather analysis performed by the Master Plan Update, poor weather (with the associated single arrival stream at Sea-Tac), occurs about 44 percent of the time.

The 1995 FAA Capacity Enhancement Update found that about 4.5 minutes of average delay is currently experienced per aircraft operation at Sea-Tac. Virtually all of the available air traffic procedural and technological improvements that are currently available, have been implemented at Sea-Tac. As a result of these improvements, delay has been reduced in recent years over earlier levels. However, arrival delay during poor weather continues to exceed the good weather delay by about 850 percent.

While Sea-Tac currently has sufficient operating capability during good weather conditions, during poor weather today, the existing runway system produces extensive arrival delays as is noted in the tables on the next page. Average delay is expected to more than triple as aircraft operations grow 23 percent (from 345,000 to 425,000). When aircraft operations exceed 525,000 annually (after year 2020), aircraft delay will have increased more than 700% over current levels. The single arrival stream during poor weather produces the greatest quantity of delay at Sea-Tac Airport. Arrival delay represents over 85% of total current delay experienced by an average flight.

Using average aircraft operating costs, delay at Sea-Tac currently costs the airlines about $42 million annually. When aircraft operations reach 425,000 annually, delay costs are expected to exceed $176 million annually.

The FAA's National Plan of Integrated Airports System (NPIAS) indicates that when average delay exceeds 9 minutes per operation, impacts occur to the national aviation system. The maximum "acceptable" delay for any single component of the National Airspace System is extremely subjective and dependent upon a number of factors unique to an individual facility. Factors which typically influence "acceptable" delay levels at an airport include the relative occurrence of poor weather conditions, individual airline cost of delay, and the effect of this airport's delay at other airports throughout the system. Since operating conditions are unique at each airport, a single measure of acceptable delay which applies to all airports has not been established. As a result, the weighted average delay level is often used as an indicator of airports which may be experiencing significant levels of delay during certain conditions, and thus, should consider delay reduction actions.

The average all-weather delay per operation is a convenient way to describe airport efficiency because it is a single number. However, describing the airport efficiency with a single number can lead to poor decision-making because the all-weather average delay does not reveal the large difference in delay that occurs between good and poor weather.

As the number of operations increase, the average delay in VFR2 and IFR weather conditions will increase exponentially, creating further discrepancy between good and poor weather delays, unless action is taken to address the poor weather airfield operating capability.

A new parallel runway would have saved the airlines $24 million annually if it had been available for use in 1994. The delays saving is expected to grow to around $59 million per year in 2000, $70 million per year in 2002 and $146 million annually when activity reaches 425,000 operations (near the year 2013). As a result, if the runway were available for use in year 2002, the delay savings would compensate for the cost of construction in a 5 year period. If completed later, the pay-back period would be sooner than 5 years.

AVERAGE ALL-WEATHER DELAY

	Average Delay (minutes) Existing Airfield			
Operations	Arrival	Departure	Estim. Taxi	Average Operation
345,000	7.7	1.3	0.1	4.5
425,000 *	22.2	2.6	0.2	12.4
525,000 *	63.7	11.6	0.4	37.7

ARRIVAL DELAY

	Average Arrival Delay (minutes) Existing Airfield					
Operations	VFR1	VFR2	IFR1	IFR2/3	IFR4	All-Weather
345,000	1.0	11.4	21.7	21.7	333.2	7.7
425,000 *	1.6	41.8	71.2	101.0	524.5	22.2
525,000 *	3.1	163.6	181.3	219.4	711.9	63.7

DELAY REDUCTION BENEFITS OF A NEW PARALLEL RUNWAY

	Do-Nothing		New Runways with the following Separation: 2,500 ft Separation		3,000 ft Separation	
Operations	Arrival	Average	Arrival	Average	Arrival	Average
345,000	7.7	4.5	NA	NA	NA	NA
425,000 *	22.2	12.4	4.7	3.8	4.2	3.3
525,000 *	63.7	37.7	13.3	8.3	12.3	7.7

Source: FAA Capacity Enhancement Update, Data Package 12, June, 1995.

* Assumes full use of the 2.5 nm separation.

Chapter II of the Final EIS presents a detailed discussion of the alternatives to addressing existing and future poor weather delay. The following briefly summarizes the findings of the review:

Alternatives	Summary of Evaluation
1. Use of Other Modes of Transportation: - Automobile, Bus - Rail - Teleconferencing	Not considered further, as this alternative will not address the poor weather operating issues at Sea-Tac. Less than 5% of passengers using Sea-Tac are traveling to distances where surface transportation is efficient and cost effective and likely to be used.

2. Use of Other Existing Airports or Construction of a New Airport: - Use of an existing airport - Development of a new airport -- Replacement -- Supplemental	Not considered further. Regional consensus has been established through PSRC EB-94-01 that: 1) There is no sponsor or funding for a new airport; 2) Extensive studies of these alternatives indicate that there are no feasible sites; 3) If a site could be identified, market forces and planning and development requirements would prevent the airport from successfully serving regional demand until 2010 or later. The FAA and Port have independently confirmed that a new airport would not satisfy the needs addressed by this EIS.
3. Activity Alternatives: - Demand Management - System Management	Not considered further, as these actions will not eliminate the poor weather operating need as all feasible actions have been implemented.
4. Runway Development at Sea-Tac	To be considered further: Runway lengths from 7,000 feet to 8,500 feet (each length is included in Alternatives 2, 3 and 4).
5. Use of Air Traffic and Flight Technology (i.e., FMS/GPS, LDA, etc.)	Not considered further. No technologies currently exist, or are planned, to address the poor weather operating constraint at Sea-Tac.
6. Delayed or Blended Alternative (Combination of other modes, use of existing airports, and activity/ demand management)	The net result of this alternative would be a delay in the implementation of the Master Plan Update alternatives. Because there is no commitment to any individual or combination of other alternatives and because aviation activity levels are currently growing at a rate slightly higher than forecast, this alternative was not considered further.
7. Do-Nothing/No-Build	To be considered further (Alternative 1).

(B) Provide Sufficient Runway Length to Accommodate Warm Weather Operations Without Restricting Passenger Load Factors or Payloads For Aircraft Types Operating to the Pacific Rim.

The length of runway required by departing aircraft is significantly affected by temperature, especially at higher temperatures and humidity. The Master Plan Update examined runway lengths relative to cities currently served from Sea-Tac, as well as cities likely to be served in the future. This analysis showed that flight distances to the Pacific Rim are the greatest. A B747-200B with a full load requires approximately 12,500 feet of runway length, when operating with a full passenger/cargo load to fly non-stop from Sea-Tac to Hong Kong or Shanghai at 76°F.

Currently, Sea-Tac's runway lengths are: 9,425 feet, and 11,900 feet. These runway lengths require airlines to off-load payload (passengers or cargo) to takeoff during warm weather conditions when serving the most distant cities. With increased emphasis on direct service to Asian-Pacific cities, this constraint is expected to grow and potentially inhibit the Region's long-term economic growth. By the year 2020, approximately 681 departures annually (0.3% of all departures or 1.3% of passenger aircraft and 15.3% of all-cargo aircraft) will be subject to takeoff weight penalties when using Runway 16L/34R.

Non-Stop Pacific Rim Service Alternatives	Summary of Evaluation
1. Extension of Runway 16L/34R to 12,500 feet	To be considered further, as this is presently the longest runway (included in Alternatives 2, 3 and 4).
2. Extension of Runway 16R/34L to 12,500 feet	Not considered further due to the cost of addressing impacts to S. 188th.

3. Development of a new runway with a 12,500 ft length	Not considered further due to substantial cost and community disruption that would result.
4. Delayed or Blended Alternative	Not considered further , as it would not address the needs at Sea-Tac.
5. Do-Nothing/No-Build	To be considered further (Alternative 1).

This loss of weight operating capability would result in passengers and cargo not getting to their destination as desired or an increase in operations to serve the demand. In year 2000, this continued practice would result in an annual economic loss to the airlines of $1.2 million, growing to $2 million annually by 2010 and $3 million by 2020 to the airlines.

Over 90 percent of the weight restricted departures would be by all-cargo operators. Currently 10% of the cargo transported through Sea-Tac is destined for the Pacific Rim. Economists predict that the Pacific Rim will continue to experience above average economic growth in the foreseeable future. Thus, for the Puget Sound and Washington State to retain their pre-eminence in exporting area products, the ability to serve the fastest economic growing market in the world is essential.

The alternatives that would satisfy this need are shown above.

(C) Provide Runway Safety Areas (RSAs) that meet current FAA Standards

An RSA is "A defined surface surrounding the runway prepared or suitable for reducing the risk of damage to airplanes in the event of an undershoot, overshoot, or excursion from the runway". When the runways at Sea-Tac were originally built, they met then-current FAA design standards. However, as a result of aircraft overruns and incidents at airports in the U.S., the FAA modified Federal Aviation Regulation 139.309(a)(2) which now requires:

> "To the extent practicable, each certificate holder shall provide and maintain for each runway and taxiway which is available for air carrier use - ... (2) If construction, reconstruction, or significant expansion of the runway or taxiway began on or after January .1, 1988 a safety area which conforms to the dimensions acceptable to the Administrator at the time construction, reconstruction, or expansion began.".

The FAA previously issued a funding grant to the Port which includes the following condition "13. By acceptance of this grant, the sponsor agrees that the safety areas for Runway 16L/34R will be improved to dimensions acceptable to the FAA on the following schedule.... September 1996 safety areas to be complete". Subsequently, the Port requested that the alternatives for addressing the RSA be included in the Master Plan Update.

The RSA dimension for Sea-Tac is defined as a rectangular area that is centered about the runway that is 500 feet wide and extends 1,000 feet beyond each runway end. This area should be cleared, drained and graded, and is usually turfed. Under dry conditions, this area should be capable of supporting occasional aircraft that could overrun the runway, as well as fire fighting and snow removal equipment.

Thus, the Master Plan Update recommends that the RSAs be upgraded to current FAA design standards in accordance with grant assurances and Federal Aviation Regulation Part 139. The following alternatives could address this need:

RSA Alternatives	Summary of Evaluation
1. Displaced Thresholds/ Declared Distance Procedures	Considered as the Do-Nothing/No-Build.
2. Clearing, grading and development of areas for 1,000 feet beyond the existing pavement	Considered further.

3. Clearing, grading for 1,000 feet including the 600 ft extension to 34R	Considered further (included in Alternatives 2, 3 and 4).
4. Delayed or Blended Alternative	Not addressed further, as it would not address the RSA requirements
5. Do-Nothing/No-Build	To be considered further for declared distances (Alternative 1).

(D) Provide Efficient and Flexible Landside Facilities to Accommodate Future Aviation Demand.

Regional population and employment growth are expected to fuel growth in aviation demand regardless of the availability of facilities at Sea-Tac Airport. While enplaned passenger volumes are forecast to grow by 103 percent by 2020, air cargo tonnage is expected to grow 150 percent. This anticipated growth will place extreme demands on the existing airport facilities. Congestion currently exists on the Main Terminal roadway during peak hours. By year 2020, significant congestion could result throughout the day. Therefore, to avoid congestion and passenger inconveniences, improvements to the landside facilities will be necessary. Flexibility will be required to enable airport facilities to be accommodated by varying types of airlines (shuttle operations as well as long-haul), cargo operators as well as aircraft maintenance needs.

Currently, airport facilities at Sea-Tac provide 90 narrow-body equivalent aircraft gates (NBEG) within 12,100 linear feet of gate frontage. Based on the forecast of aviation demand, Sea-Tac Airport will require 101 NBEG gates by 2000, 111 NBEG gates by 2010 and 120 NBEG gates by the year 2020. In total, Sea-Tac will require an additional 30 passenger gates by year 2020.

Over the last decade, several airlines have examined the possibility of developing aircraft maintenance bases at various airports throughout the country. Based on these requests, and anticipated future requests, the Port initiated the necessary planning and design to assure that a base maintenance facility can be accommodated at Sea-Tac Airport. These plans have become known as the South Aviation Support Area (SASA) development plan and were assessed in a 1994 Final Environmental Impact Statement. The benefits of such a facility are the resulting high-skill jobs and economic activity which meet the Port of Seattle's mission of fostering regional economic development that will benefit the port district.

To ensure that the Region's primary aviation facility is capable of efficiently accommodating forecast air travel demand generated by area economic activity and population, the Port of Seattle proposes to incrementally expand the terminal, support facilities and other landside facilities.

The following summarizes the alternatives identified for this need.

Alternative	Summary of Evaluation
1. Use of Other Modes of Transportation - Auto and Bus - Rail - Video Conferencing	Not considered further, as less than 5% of the future passengers using Sea-Tac are traveling to distances where surface transportation is efficient and cost effective.
2. Use of Other Airports or Construction of a New Airport	Not considered further. Regional consensus has been established through PSRC EB-94-01 that: 1) there is no sponsor or funding for a new airport; 2) Extensive studies of these alternatives indicate that there are no feasible sites; 3) If a site could be identified, market forces and planning/development requirements would prevent the airport from successfully serving regional demand until 2010 or later. The FAA and Port have independently concluded that a new airport would not satisfy the needs addressed by this EIS.

3. Activity/Demand Management Alternatives	Not considered further, as these actions will not reduce demand as all feasible alternatives have been implemented.
4. Landside Development at Sea-Tac	To be considered further: Three primary alternatives to be considered further: Central Terminal Development, North Unit Terminal Development and South Unit Terminal Development (Alternatives 2, 3 and 4, respectively).
5. Use of Technology	Not considered further. No technologies currently exist to address regional aviation demand growth. No new technologies are anticipated.
6. Delayed or Blended Alternative (Combination of other modes, use of existing airports, and activity/ demand management)	The net result of this alternative would be a delay in the implementation of the Master Plan Update alternatives. Because there is no commitment to any individual or combination of other alternatives and because aviation activity levels are currently growing at a rate slightly higher than forecast, this alternative was not considered further.
7. Do-Nothing/No Build	To be considered further (Alternative 1)

(E) Alternatives Considered

The following alternatives and key improvements, as described in detail in Chapter II, were carried forward for detailed:

- **Alternative 1 - Do-Nothing/No Build** - The previously described needs would not be addressed in the Do-Nothing alternative. However, a number of other developments would occur: preparation of the South Aviation Support Area (as approved in the 1994 Final EIS and Record of Decision), completion of the Runway 34L and 34R RSA grading, development and implementation of declared distances for Runway 16R and 16L; implementation of terminal area ground access and seismic improvements, installation of a Category IIIb Instrument Landing system on Runway 16L; development of an On-Airport hotel; and implementation of the Des Moines Creek Technology Campus.
- **Alternative 2 (Central Terminal)** this alternative would include a new dependent (2,500 ft separation) parallel runway with a length of up to 8,500 feet; a 600 ft extension to Runway 34R; fill, clearing and grading of the 1,000 ft Runway Safety Areas for all runway ends; and completion of the landside and terminal development for centralized terminal facilities; and completion of the South Aviation Support Area.
- **Alternative 3 (North Unit Terminal)** this alternative would include a new dependent (2,500 ft separation) parallel runway with a length of up to 8,500 feet; a 600 ft extension to Runway 34R; fill, clearing and grading of the 1,000 ft Runway Safety Areas for all runway ends; and completion of the landside and terminal development in a north unit terminal configuration; and completion of the South Aviation Support Area.
- **Alternative 4 (South Unit Terminal)** this alternative would include a new dependent (2,500 ft separation) parallel runway with a length of up to 8,500 feet; a 600 ft extension to Runway 34R; fill, clearing and grading of the 1,000 ft Runway Safety Areas for all runway ends; and completion of the landside and terminal development in a south unit terminal configuration; and completion of the South Aviation Support Area.

Exhibits II-5 through Exhibit II-8 show these alternatives.

After review of the Draft Environmental Impact Statement, the Port of Seattle staff recommended the implementation of **Alternative** 3 (the North Unit Terminal) with a proposed 8,500 foot long new parallel runway located about 2,500 feet west of Runway 16L/34R. However, to aid in public review, the document refers to a runway with a length "up to 8,500 feet" so that the impacts of a 7,000 ft., 7,500 ft., and 8,500 ft.

runway are identified. The elements of the improvements included in the Preferred Alternative are listed beginning on page II-41 of this Final EIS.

This alternative was recommended for the following reasons:

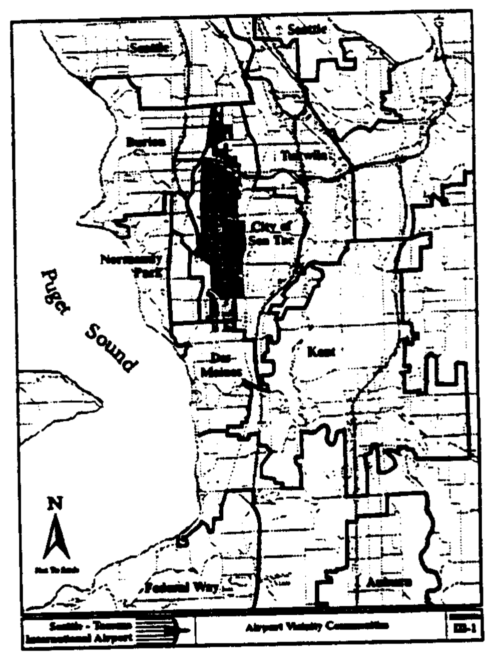
- Reduces the existing and future disparity between the poor weather and good weather operating capability, enabling dependent parallel arrival streams during poor weather conditions;
- Provides the greatest delay reduction of all alternatives considered. The reduced operating times associated with the implementation of a third parallel runway would result in a substantial cost savings to the airlines. A new parallel runway would have saved the airlines $24 million annually if it had been available for use in 1994. The delays saving is expected to grow to around $59 million per year in 2000, $70 million per year in 2002 and $146 million annually when activity reaches 425,000 operations (near the year 2013). As a result, if the runway were available for use in year 2002, the delay savings would compensate for the cost of construction in a 5 year period. If completed later, the pay-back period would be sooner than 5 years;
- The proposed new runway would accommodate 99% of the possible aircraft types for landing which currently use or are anticipated to be operating at Sea-Tac;
- Enables unrestricted departure weights for aircraft departing to the Pacific Rim countries during warm summer weather;
- Provides efficient and flexible landside facilities to accommodate future aviation demand providing the greatest levels of service to air passengers by improving curb-to-terminal and curb-to-gate access, decreased walking distances, and the lowest cost per new aircraft gate;
- Relieves the surface vehicle congestion on the existing terminal drive system;
- Minimizes disruption of commercial development along International Boulevard;
- Enables future expansion of terminal and support facilities in an incremental fashion to accommodate air travel demand as growth occurs;
- Minimizes the disruption to existing airport facilities during the implementation of the proposed improvements; and
- Minimizes aircraft push-back and taxiing conflicts as flights enter and exit the terminal area.

CHAPTER III

AFFECTED ENVIRONMENT

Communities which abut the City of SeaTac, in which the Airport is situated, are Des Moines, Tukwila, and Burien. Unincorporated portions of King County also abut the City of SeaTac. These communities, and others, may be directly or indirectly affected by operations at Sea-Tac Airport, especially by aircraft noise exposure.

The majority of Port owned Airport land is bound by International Blvd. to the east, SR 509 and 12th Avenue to the west, SR 518 to the north, and South 200th Street to the south. Sea-Tac Airport abuts the City of SeaTac on all sides and occupies more than 2,500 acres of land.



This EIS addresses impacts of the Airport and the proposed Master Plan Update improvements that would be experienced within the Puget Sound Region. Within this general geographic area, this EIS references two primary study areas:

General study area - encompassing the existing noise exposure area as defined by the existing (1994) DNL 60 and greater noise contour; and

Detailed focus area - the area which would be affected to construct alternative airport improvements. This area includes any land which might be acquired.

Where applicable, other study areas were used to disclose the existing or anticipated impacts.

Built Environment

The current pattern of land use within the general study area consists of the following uses:

- Residential: 49.5% of the study area
- Open space/agriculture: 16.7% of the study area
- Commercial/industrial: 12.6% of the study area
- Airports (Sea-Tac and Boeing Field): 11.4% of the study area
- Community and public facilities 2.7% of the study area
- Other: 7.0% of the study area

Based on the 1990 Census, the general study area contains 43,347 single-family homes, 25,702 multi-family dwelling units, and 3,006 mobile homes. Located within the boundary of the general study area are several classes of land uses that are normally considered to be sensitive to high levels of aircraft noise exposure.

Natural Resources

Because the prevailing winds are from the Pacific Ocean, the general meteorological conditions of the Puget Sound Region are typical of a marine climate. The relatively cool summers, mild climate are enhanced by the presence of Puget Sound. The Cascade Range to the east serves as a partial barrier to the temperature extremes of the continental climate of eastern Washington State.

There are two independent stream systems that drain the major portions of the airport area, Des Moines Creek and Miller Creek. The Airport covers an estimated 30 percent of the Des Moines Creek basin and five percent of the Miller Creek basin. Both Des Moines and Miller creeks are classified by the State as Class AA (extraordinary) waters, although stormwater runoff from urban development within the two drainage basins have contributed to water quality degradation and violations of some water quality standards. Degradation of water quality from stormwater runoff has had harmful effects on aquatic biota and the biological integrity of both creeks. Diversity of aquatic life has tended to shift from pollutant-intolerant forms to pollutant-tolerant forms. Additionally, major spills of aviation fuel into Des Moines Creek in the mid-1980s resulted in the mortality of most fish and aquatic life in that creek.

In the Puget Sound Region, sand and gravel units within the glacial drift form the principal aquifers. These aquifers are recharged from precipitation. Water levels within wells are generally within 100 feet of the ground surface. Perched water is also commonly encountered in the glacial deposits where silt and clay within the glacial soils act as acquitards, allowing water to accumulate in sand and gravel lenses.

A total of 55 wetlands were identified in the detailed focus area. These wetlands range in size from approximately 0.01 acres to 30.3 acres, with a combined area of nearly 150 acres. A total of 20 emergent, nine scrub-shrub, four open-water, and 22 forested wetlands were identified.

Biological Resources

Habitat in the airport vicinity consists of isolated parcels of forest, shrub, and grass with scattered wetlands. Approximately 714 acres of upland forest, 191 acres of upland shrub, 1,012 acres of upland herbaceous habitat, and 144 acres of wetlands are present within a one-mile radius from the airfield area. Fragmented stands of second growth deciduous and coniferous forest characterize much of the area. These areas provide habitat for a typical assemblage of wildlife species found in lowland Puget Sound forests.

Two federally listed or proposed threatened or endangered species, which may occasionally use the airport area, are the peregrine falcon and bald eagle. The closest bald eagle nests to the Airport are located at Angle Lake (.75 mile southeast) and Seahurst Park (two miles northwest).

Future Planned Development

Specific planned development projects are envisioned by local and county governments in the general study area in addition to those generally described in the comprehensive land use plans. These projects are: 28th/24th Avenue South Arterial Project; State Route 509 Extension and South Access Road; Regional Transit Authority High-Capacity, Light-Rail System; On-Airport Hotel by the Port of Seattle; Des Moines Creek Technology Campus; South Aviation Support Area (SASA); Regional Justice Center; and Airport Business Center in SeaTac.

CHAPTER IV

ENVIRONMENTAL CONSEQUENCES OF THE ALTERNATIVES

The following summarizes the environmental impacts of the four Master Plan Update alternatives.

1. NOISE

The percentage of people, housing units, and area affected by sound levels of DNL 65 and greater is expected to decline in the future in comparison to current and past noise exposure, regardless of future development at Sea-Tac Airport. This decline in impacts is expected due to the Port's noise reduction program and the Federal mandate to phase-out Stage 2 aircraft no later than the year 2000.

Aircraft Noise
(DNL 65 and Greater)

	Population	Housing	Sq. Mi.
1994	31,800	13,620	9.31
2000			
Altern. 1	8,970	3,870	3.40
Altern. 2	9,890	4,020	2.87
Altern. 3	9,890	4,020	2.86
Altern. 4	9,890	4,020	2.86
2010			
Altern. 1	9,450	4,060	3.54
Altern. 2	9,870	4,190	2.97
Altern. 3	9,860	4,190	2.98
Altern. 4	9,860	4,190	2.98
2020			
Altern. 1	10,800	4,610	3.97
Altern. 2	11,270	4,760	3.31
Altern. 3	11,240	4,740	3.34
Altern. 4	11,270	4,760	3.34

Note: Alternative 1 = Do-Nothing,
Alternative 2, 3 & 4 are "With Project".
All "With Project" alternatives include a new dependent (2,500 ft separation) parallel runway with a length up to 8,500 feet. Area is non-airport land.

The differences between the noise impacts of the three "With Project" alternatives are very small, as is shown in the Aircraft Noise table above. Because the new dependent parallel runway is proposed to reduce poor weather delay, which is predominantly arrival related, the runway is expected to be used primarily for arrivals. About 12.1 percent of arrivals in a south flow would occur on the new runway, with about 2.6 percent of departures.

The development of a new parallel runway would be expected to increase dwelling unit impacts 6.1 percent over the Do-Nothing/No-Build alternative. However, in all instances, these future impacts would be less than the current noise exposure. A 7,000-ft long new runway would result in slightly less noise impacts in comparison to the longer 8,500-foot. However, a 7,500-foot long runway, with a north threshold staggered south, could result in fewer impacts than the shorter 7,000-foot long runway. **Exhibit IV.1-1** shows the existing (1994) noise exposure while **Exhibit IV.1-13** shows the year 2020 impacts of the Preferred Alternative (Alternative 3). The future "With Project" departure flight tracks are shown in **Exhibit C-16**.

While this analysis has focused on the areas exposed to DNL 65 and greater sound levels, for residents that are disturbed by noise less than DNL 65, these impacts could continue and change slightly. As is shown by the assessment of noise impacts caused by aircraft flying at altitudes between 3,000 feet and 18,000 feet (provided in **Appendix C**), these impacts are not expected to be significant.

The proposed Master Plan Update alternatives would affect the volume of traffic using area roadways. As is shown, the proposed new parallel runway would not affect area roadway noise. The terminal and landside development within the Master Plan Update alternatives would alter the use of roads, and result in increased noise at some residential/incompatible locations and decreased noise at other locations. The roadway noise analysis indicates that the greatest change in peak hour roadway noise would occur with the development of the SR-509 Extension and South Access Road (a Do-Nothing and "With Project" action that is expected to be undertaken by the Region).

2. LAND USE

Compared to existing conditions, under the Do-Nothing alternative (Alternative 1) there would be a reduction of approximately 66 percent in population affected by noise levels of 65 DNL or greater in the year 2020. This decrease is primarily due to the replacement of the noisier Stage 2 aircraft with quieter Stage 3 aircraft.

Noise impacts for all Master Plan Update Alternatives will be less in all forecasts years relative to existing and historical impacts. Compared to the Do-Nothing alternative for the same years, each of the "With Project" alternatives (with a dependent separated new 8,500-foot runway) would affect about 5 percent more people in the year 2020 with noise levels of 65 DNL or greater. Fewer schools (1) and churches (3) would be affected under the year 2020 "With Project" alternatives compared to the Do-Nothing alternative.

This section of Chapter IV summarizes the municipal comprehensive plans and the compatibility of the Master Plan Update with these plans. Existing land use is shown in **Exhibit IV.2-1** and **Exhibit IV.2-2** shows the locations of the noise sensitive facilities in the area.

3. CULTURAL, ARCHAEOLOGICAL AND HISTORICAL RESOURCES

Impacts to archaeological, cultural, and historical resources, both on and off-airport, can be caused by airport development and airport activity. Subject to continued coordination under the Section 106 process, it was concluded that there are a number of historic and archaeological sites in the Airport area, but none would be adversely affected by the proposed Master Plan Update alternatives.

4. DEPARTMENT OF TRANSPORTATION SECTION 4(F) LANDS

The U.S. Department of Transportation Act of 1966, Section 4(f), provides for the protection of certain publicly owned resources: public parks; recreational areas; wildlife and waterfowl refuges of federal, state, or local significance; and land that holds historic site of federal, state, or local significance. The parks and recreational facilities in the airport area, but no DOT Section 4(f) or LAWCON Section 6(f) resources would be directly or indirectly impacted by any of the Master Plan Update alternatives.

5. PRIME AND UNIQUE FARMLAND

Throughout the 20th century, the nation's prime and unique farmland has decreased dramatically because of urban development throughout the country. The Farmland Protection Policy Act of 1981 was enacted to minimize the extent to which federal programs contribute to unnecessary and irreversible conversion of farmland to non-agricultural uses. No prime or unique farmlands were identified within the acquisition or construction areas of any "With Project" alternative. Thus, no such farmlands would be adversely affected.

6. SOCIAL IMPACTS

The Master Plan Update alternatives were evaluated for their impact on adjacent residential communities, and businesses. Social impacts considered in this section include the following: residential and business displacement, and disruption of existing communities and planned development.

Assuming a development of a new runway length up to 8,500 feet, the following number of properties could be acquired under the "With Project" alternatives to complete construction, to clear the runway protection zones (RPZs), and to mitigate adverse environmental impacts:

8,500-ft Dependent	Number to be Acquired: Single Family	Condos/ Apartments	Business
Runway related:			
Alternative 1	0	0	0
Alt. 2, 3, & 4	388	260	105
Non-Runway related:			
Alternative 1	3	0	0
Alternative 2 & 3	3	0	0
Alternative 4	3	0	12

If a 7,000-foot new parallel runway were constructed, 348 single-family residences, 26 apartment or condominium units, and 96 businesses would be acquired. A 7,500-foot runway would require the acquisition of 361 single-family residences, 26 apartments or condominiums units, and 104 businesses. All acquisition would comply with the Uniform Relocation Act.

7. HUMAN HEALTH IMPACTS

The EIS assesses the human health related issues associated with:

- noise,
- air quality,
- water quality,
- radio transmissions and light emissions, and
- aircraft incidents/accidents.

The Airport present environment has the potential to affect human health, although the potential is difficult to assess and characterize because many research studies indicate conflicting reports of human health impacts.

In general, adverse environmental impacts are expected to decrease in the future as improved technology results in lower air, noise, and water pollutant emissions. The proposed Master Plan Update alternatives are expected to increase noise and stormwater flows slightly over the Do-Nothing alternative. However, the impacts of the future "With Project" alternatives are expected to be less than the current conditions.

8. INDUCED SOCIO-ECONOMIC IMPACT

As major passenger and cargo transportation facility, Sea-Tac Airport directly and indirectly contributes to the economic structure of the Puget Sound Region. Induced socio-economic benefits are generated in the Region by changes in employment opportunities, payroll generation, business expenditures for goods and services, and tax revenue. The existing and forecast Do-Nothing induced socio-economic impacts are shown on the next page.

All of the Master Plan Update alternatives would create jobs in construction. Further elaboration of these impacts is provided in Section 23 "Construction Impacts." Construction-related jobs would be approximately 8,200 for the Do-Nothing (Alternative 1 and about 45,500 for the "With Project" alternatives.

	Airport Activity Related Impacts Alternative 1, 2, 3, and 4		
	1993	2010	2020
Total Jobs	205,690	335,344	418,632
Personal Income (Millions)	2,585.6	4,215.4	5,262.4
Earnings/Dir Jobs (Millions)	15,910	25,938.7	32,380.9
Business Revenue (Millions)	6,355.7	10,361.9	12,935.5
State & Local Taxes (Millions)	406.6	662.9	827.9

The activity-related, induced socio-economic impacts would be the same for all Master Plan Update alternatives. However, the acquisition effects would differ. The following summarize the impacts of the "With Project" alternatives compared to the Do-Nothing (Alternative 1):

	Impacts Due to:		
	Alt 2	Alt 3	Alt 4
Annual Loss in Property Tax (Thousands)	$227.5	$227.5	$291.9
Annual Lost Taxable Sales Transactions (Millions)	$2.2	$2.2	$15.6
Jobs Displaced	627	627	822

Impacts are less if displaced businesses relocated within the area. Assumes the 8,500 ft new dependent parallel runway. and that commercial property in the RPZ is acquired.

A new 8,500 foot parallel runway would displace businesses and numerous residences through property acquisitions, reducing the existing property and sales tax revenue and employment. The property tax and sales impacts to an individual community are less than five percent. This would occur primarily in the City of SeaTac and, to a lesser extent, in the City of Burien. The only acquisition of property landside development the is the South Unit Terminal (Alternative 4), which would acquire 12 properties on the northwest corner of International Blvd. and South 188th Street.

Reductions in tax revenues would be offset long term by positive net gains in future tax receipts as property is more intensely developed in the Airport vicinity. Local sales tax revenues will be generated by people directly employed at Sea-Tac Airport and induced revenues by airport activity (e.g., taxable spending on goods and services by people employed at the Airport, air cargo businesses, hotel and commercial uses).

9. AIR QUALITY

The majority of the pollutant emissions in the Puget Sound Region--75 percent--is generated by motor vehicles (i.e., cars, trucks, buses, taxis, motorcycles). Aircraft operating at Sea-Tac contribute less than one percent of the carbon monoxide emissions, nitrogen oxides, and volatile organic compounds for all mobile sources within the Puget Sound Region. Whether a new runway is built or not, air pollutant emissions from roadway vehicles and aircraft would be expected to increase in the Region as population increases.

Key findings of this analysis are:

- *Air Pollutant Inventory:* Airport-related pollutant emissions from Sea-Tac are less than the levels established by the State Implementation Plan for reducing air pollutants. They would continue to be less than forecast, with or without airport improvements.

- *Area Dispersion Analysis*: The dispersion analysis performed for the airport area indicates that exceedances of the Ambient Air Quality Standards would occur with or without Airport improvements.

  Development of the proposed third parallel runway would not worsen air pollution in the Airport area. In fact, use of a third runway would result in a reduction in pollutant concentrations at most locations.

- *Roadway Intersection Analysis*: Pollutant concentrations at several highly congested intersections on International Boulevard (SR 99) currently exceed the 8-hour carbon monoxide standard. The addition of the proposed North Unit Terminal would result in changes in traffic volumes and patterns which would increase pollutant levels above already high levels. However, proposed mitigation would alleviate the increased pollutant concentrations.

The proposed Master Plan Update improvements at Sea-Tac conforms to the requirements for the Puget Sound Region and to the State of Washington's plan for "eliminating or reducing the severity and number of violations of the national ambient air quality standards and achieving expeditious attainment of such standards."

10. WATER QUALITY AND HYDROLOGY

Changing the Airport's landscape, as would happen with the proposed Master Plan Update alternatives, could affect the hydrology of the airport area as well as the downstream systems. Alternatives 2, 3, and 4 ("With Project") would include earthwork and the addition of impervious land surface area. This decreases the amount of rainfall infiltrating the soil and increases stormwater runoff flow rates and volumes. **Exhibit IV.10-4** shows the locations of proposed airport improvements relative to the watersheds.

Preliminary estimates indicated that 61 acre-feet of new on-site detention storage volume would be required for the proposed developed areas that drain to Miller Creek, and 31 acre-feet of storage for areas draining to Des Moines Creek. These detention volumes would attenuate peak runoff rates from the Airport to provide protection from downstream flooding for storms having up to a 100-year return period. New impervious areas would increase annual runoff volumes to Miller Creek by 6 to 8 percent and volumes to Des Moines Creek by 1 to 2 percent. Most of the additional volume would flow through the downstream systems at rates that have low erosion potential. Higher runoff volumes could be partially offset by stormwater infiltration where on-site soils are suitable.

Although pollutant loading will increase somewhat because of greater amounts of stormwater runoff associated with the "With Project" alternatives, compliance with mitigation requirements is expected to prevent significant pollution or degradation of surface and groundwater resources.

11. WETLANDS

Wetland investigations of the airport area identified almost 150 acres of wetland. The Master Plan Update alternatives at Sea-Tac Airport would affect areas of these wetlands through placement of fill material, grading, removal of existing vegetation, and changes in hydrologic regimes as a result of increased impervious surface area and stormwater management system restructuring. **Exhibit IV.11-2** shows the locations of the wetlands.

The elements of the wetlands affected by each of the "With Project" alternatives are palustrine emergent, scrub-shrub, open water, and forested systems. The wetlands disrupted from the "With Project" alternatives will be determined by how much earth is excavated from the on-site borrow locations. Utilization of Borrow Area 8 (North Borrow Area) would result in direct impacts occurring to 16-acres of wetland in six different systems. Due to the large quantity of wetlands at this site. excavation in this area will be avoided.

Alternative	Wetland Impacts
Alt 1 (Do-Nothing)	1.7 acres
Alt 2 (Central Terminal with):	
8,500 ft runway	10.37 acres
7,500 ft runway	9.43 acres
7,000 ft runway	9.62 acres
Alt 3 (North Terminal with):	
8,500 ft	10.37 acres
7,500 ft	9.43 acres
7,000 ft	9.62 acres
Alt 4 (South Terminal with):	
8,500 ft	10.37 acres
7,500 ft	9.43 acres
7,000 ft	9.62 acres

Source: Shapiro & Associates. 1995

Development that poses a significant threat to wetlands would require permits or approvals from the following agencies: U.S. Army Corps of Engineers, Washington State Department of Ecology, and Washington Department of Fisheries and Wildlife. In addition to these permits or approvals, compensatory mitigation would be required.

12. FLOODPLAINS

Construction and operation of the proposed Master Plan Update alternatives could significantly reduce the 100-year floodplain area and flood storage capacity, increase volumes of stormwater runoff and peak flows, and increase flooding potential in downstream areas on both Miller and Des Moines Creeks. **Exhibit IV.12-2** shows the locations of the floodplains. Because mitigation is required to prevent reductions of 100-year floodplain area and flood storage capacity, the proposed Master Plan Update alternatives are unlikely to result in significant encroachment on the 100-year floodplain or loss of flood storage capacity. In addition, flow modeling results using detention requirements for the new development show that the proposed alternatives will not increase peak flows or potential flooding in downstream areas of Miller or Des Moines Creek.

13. COASTAL ZONE MANAGEMENT AND COASTAL BARRIERS

The Airport Master Plan alternatives will conform to all applicable Coastal Zone Management Program policies. The Port will certify that the Master Plan Update improvements conform to all applicable Coastal Zone Management and Shoreline Management policies.

14. WILD AND SCENIC RIVERS

The proposed Master Plan Update alternative will not affect wild or scenic rivers.

15. SURFACE TRANSPORTATION

Continued regional population growth will impact the surface transportation system in the vicinity of Sea-Tac Airport regardless of the improvements undertaken at the Airport. Two surface transportation analyses were performed, as are described in detail in Appendix O:

- an equivalent level of analysis of all Master Plan Update alternatives based on preliminary regional surface travel levels, and;
- a refined analysis of the Preferred Alternative (Alternative 3), reflecting the Region's adopted metropolitan transportation plan regional surface travel levels.

The refined analysis of the Preferred Alternative showed the following:

- Total Airport surface traffic is expected to increase from approximately 75,030 vehicles per average day in 1994, to approximately 139,035 vehicles per average day in 2020 for the Do-Nothing Alternative, or to approximately 129,055 vehicles per average day in 2020 for the Preferred Alternative. The differences between the Do-Nothing Alternative traffic volumes and the Preferred Alternative traffic volumes are associated with the off-site parking mode choice assumptions.
- The transportation improvement project that would have the greatest impact on conditions in the Airport area is the construction of the State Route 509 Extension and South Access.
    - ♦ The Preferred Alternative (With State Route 509) impacts the surface transportation system at five intersections and one freeway ramp in comparison with the Do-Nothing Alternative.
    - ♦ The Preferred Alternative (Without State Route 509) impacts the surface transportation system at ten intersections and one freeway ramp in comparison with the Do-Nothing Alternative.

16. PLANTS AND ANIMALS (BIOTIC COMMUNITIES)

Approximately 40 percent of the detailed study area is occupied by Sea-Tac Airport and is characterized by frequently mowed grassland bisected by service roads and taxiways. This area provides little wildlife habitat value. Wildlife habitat surrounding the airfield consists of fragmented habitat, which is composed of forest, shrub, and grassland with scattered wetlands. These areas are subject to a variety of airport-related disturbances as well as increasing residential, commercial, and industrial development. Each of the "With Project" alternatives would remove approximately the same amounts of vegetation (about 712 acres total). Of the total, the majority is managed grassland (about 303 acres) About 269 acres of forest, 78 acres of shrub, 52 acres of unmanaged grassland, and 10 acres of wetlands would be removed under each "With Project" alternative.

Various physical, biological, and chemical factors affect fisheries and aquatic biota. Urbanization in the Miller and Des Moines Creek basins has altered some of these factors with resulting changes in the aquatic ecosystem. Hydrologic regime and channel morphology have been altered, habitat complexity and quality have been reduced, and water quality has been degraded. These alterations have reduced the diversity and abundance of fish and aquatic biota in Miller and Des Moines Creeks.

Construction and operation of the dependent parallel runway would have some adverse affects on fishery and aquatic resources of Miller and Des Moines Creeks and Puget Sound. About 3,700 feet of Miller Creek and its tributaries would require realignment and relocation to complete the runway. About 200 feet of Des Moines Creek would require relocation due to the 600 ft extension of Runway 34R. About 2,200 feet of open channel on Des Moines Creek would require relocation due to the South Aviation Support Area (SASA). The 200-foot section of Des Moines Creek that would be affected by the extension of Runway 34R is within the area that would be realigned as mitigation for SASA. Proposed mitigation would reduce potential impacts on the hydrology, water quality, and aquatic habitat and biota the two creeks and Puget Sound.

17. ENDANGERED SPECIES OF FLORA AND FAUNA

Section 7 of the Endangered Species Act of 1973 (as amended) requires an analysis of the effects of major construction projects on federally listed or proposed threatened or endangered species that may use a project area. Records suggest the potential for use of the area of the proposed Master Plan Update alternatives by bald eagles, peregrine falcons, marbled murrelets, pileated woodpeckers, and great blue herons, as well as several other candidate species. A Biological Assessment was conducted for all Federally listed and candidate species in consultation with the US Fish and Wildlife Service. No significant impacts on threatened and endangered species are expected as a result of the proposed Master Plan Update Alternatives.

18. PUBLIC SERVICES AND UTILITIES

Public services and utilities would require minor changes based on the residences, businesses, and facilities displaced by development. Major utilities that would be relocated or protected in-place are the Southwest Suburban Sewer District, Miller Creek Interceptor, Seattle Water Department trunk line, Puget Power third electrical service metering point, and US West trunk lines entering at S. 176th Street. A variety of existing utility services, both on the Airport and off the Airport, would be abandoned. The extent of the off-airport abandonments depends on the area ultimately acquired to complete the Master Plan Update development.

19. EARTH

Project construction and operation (including clearing, grading, excavation, and fill placement) are evaluated and potential mitigation measures identified. Source of fill materials, depth of fill placement, and methods of placement and compaction also are addressed. Actions that would occur in sensitive hazard areas are identified and described.

The Master Plan Update alternatives would require the movement of the following quantities of earth:

Alternative	Million Cubic Yards of Fill
Alternative 1 (Do-Nothing)	2.4
Alternative 2	23
Alternative 3	23
Alternative 4	23

Note: Alternatives 2, 3 and 4 assume a new parallel runway with a length up to 8,500 feet, located 2,500 ft west of Runway 16L/34R. - The Do-Nothing includes the development of the South Aviation Support (SASA) and Des Moines Creek Technology Campus.

Of the 23 million cubic yards of fill needed, about 17.25 million cubic yards would be needed for an 8,500-foot new parallel runway. The 7,500-foot and 7,000-foot new parallel runway options are estimated to require 13.52 and 16.77 million cubic yards of fill, respectively. Preliminary investigations indicate that all of the required fill could be obtained from a combination of Port of Seattle-owned property and off-site borrow sources.

Two seismic hazard areas have been identified by the City of SeaTac on the site of the proposed new parallel runway. They are small areas of shallow, loose sediment that likely would liquefy during a seismic event. During construction this sediment would be removed and replaced with compacted fill.

Erosion of exposed soils in areas of excavation, fill, and stockpile would occur during construction. The amount of erosion would depend on the design and implementation of an Erosion and Sedimentation Control Plan.

20. SOLID WASTE

Solid waste is composed of solid and semi-solid waste, including such things as garbage, rubbish, metal, paper, plastic, and wood. Based on the analysis of solid waste conditions, and the impacts of the Master Plan Update alternatives, no significant impacts on solid waste generation and disposal are expected.

21. HAZARDOUS WASTE

Operations at the Airport by the Port and airport tenants involve the storage and use of hazardous materials and the generation of hazardous wastes. Fifty-one potential or known hazardous substance sites exist on the Airport property and in the vicinity of the Sea-Tac Airport. Eleven of those sites are located in the area where a new parallel runway would be completed, and one is located in the proposed SASA Area. Sites located west of the Airport, and those located on Port of Seattle (POS) property, have the potential to be most affected by the Master Plan Update alternatives.

Potential hazards during construction phases (of all alternatives) could include the exposure of contaminated soils during excavation, release of hazardous substances during UST removal and building demolition, and spills of construction-related hazardous materials (e.g., fuels, lubricants, paints, and asphalt).

Mitigation for potential construction-related hazards include developing a Spill Prevention, Control, and Countermeasures Plan (SPCCP) outlining procedures for transport, storage, and handling of hazardous materials, and a Hazardous Substances Management and Contingency Plan outlining procedures for removal, storage, transportation, and disposal of hazardous wastes. All federal, state, and applicable local rules and guidelines for handling and disposal of hazardous substances would be followed.

22. ENERGY SUPPLY AND NATURAL RESOURCES

Energy and natural resources in the form of electricity, natural gas, aviation fuel, diesel fuel, and gasoline are consumed through the operation of the airport facilities, aircraft, and attendant equipment. Demand for Airport services, would increase demand on the sources of energy at the Airport. The proposed "With Project" alternatives (Alternative 2, 3 and 4) are expected to increase in annual energy usage seven to nine percent over the Do-Nothing (Alternative 1). All suppliers of these natural resources have indicated the capability of serving the increased demand.

23. CONSTRUCTION

Construction impacts are short-term and temporary. Construction impacts considered in this section include:

- noise,
- air,
- surface transportation,
- social impacts,
- socio-economic, and
- water quality.

At this time detailed design and construction plans have not been prepared. Therefore, it is not possible to identify the specific types of construction equipment and frequency of usage that could occur with any of the Master Plan Update alternatives. Depending upon the amount of fill excavated from on-site borrow areas, the impacts to wetlands could vary substantially as would construction related surface traffic, noise and air pollution. Provisions of FAA Advisory Circular 150/5370-10, "Standards for Specifying Construction of Airports," will be incorporated into construction specifications.

24. AESTHETICS AND URBAN DESIGN

The proposed "With Project" will change the visual character of the area. Adherence to applicable design and landscaping standards can ensure that this impact would not be adverse, rather enhance the views and aesthetic characteristics around the Airport perimeter.

CHAPTER V

MITIGATION MEASURES FOR PROBABLE, UNAVOIDABLE, ADVERSE ENVIRONMENTAL

The following measures could be implemented to lessen the impact of the "With Project" alternatives:

1. NOISE, LAND USE AND SOCIAL IMPACTS

Through the implementation of the Noise Remedy Program, the Port of Seattle has conducted an extensive noise and land use compatibility effort. As a result of this noise and land use compatibility program, a notable portion of the existing and future noise exposed area has been subject to sound insulation and, for the more severely noise affected areas, acquired and relocated. Therefore, the noise exposure that would result from any of the "With Project" alternatives would effect a small number of residents compared to the Do-Nothing. **Exhibit IV.2-3** shows the year 2020 noise exposure relative to the Noise Remedy Program boundaries.

To facilitate continued noise reduction, the noise and land use mitigation now in effect should be continued:

- Noise Budget - limiting the total noise energy carriers may generate at the Airport.
- Nighttime Limitations Program - limiting the hours of operation for Stage 2 aircraft.
- Ground Noise Control - reducing the noise of ground events such as powerback operations, run-ups, and reverse thrust on landing.
- Flight Corridorization - maintenance of runway heading flight tracks by departing jets until reaching altitudes above 4,000 feet.
- Flight Track and Noise Monitoring - maintenance of noise levels records flight track location information for identification of deviations and communication with public and users.

Several land use mitigation strategies will be undertaken:

Mitigating Significant Noise Impacts: The following five noise sensitive facilities would experience significant increased noise impacts (i.e. an increase of 1.5 DNL or more) in the year 2020 in comparison to the Do-Nothing:

- Sea-Tac Occupational Skills Center;
- Woodside Elementary:
- Sunny Terrace Elementary;
- Brunelle Residence;
- Bryan House.

The Port will coordinate with the owners of these properties and sound insulate the noise sensitive uses subject to FAA sound insulation guidelines.

Provide Directional Soundproofing: Residences that were insulated prior to 1992 may need additional directional soundproofing to mitigate noise generated from new flight paths from the operation of the new runway. Many residences evaluated for noise impacts prior to 1992 were not evaluated to consider the additional noise impacts that the proposed runway would generate. The Port of Seattle estimates that some 60 and 70 houses that were evaluated and/or insulated prior to 1992. The Port will audit these facilities, and subject to FAA sound insulation criteria, sound insulate the remaining portions of the home that do not achieve the applicable noise level reduction guidelines.

Acquisition in the Approach Transitional Area - In recognition of the fact that the standard Runway Protection Zone (RPZ) dimensions do not always provide sufficient noise and safety buffer to the satisfaction of nearby residents, the FAA will cost-participate with airport operators to acquire "up to 1,250 feet laterally from the runway centerline, and extending 5,000 feet beyond each end of the primary surface.[1] The FAA Memorandum provides funding eligibility for a box up to 5,000-foot long and 2,500-foot wide, centered on the runway and beginning 200 feet from the physical end of the runway. Based on the configuration of current airport land, local streets, and residential development patterns, the approach and transitional area selected for use as a mitigation area includes the standard Runway Protection Zone and a rectangular extension of the RPZ outward another 2,500 feet. The limit of coverage of the proposed approach and transitional areas are shown in **Exhibit IV.6-3.**

In the northern approach and transitional area, 82 single-family residential parcels, 2 apartment buildings (with 28 units), and 2 mobile home parks, with 96 units, would be acquired. To the south, 71 single-family residential parcels and 6 apartment buildings (with 32 units) would be acquired. Only residential properties in the approach and transitional area would be acquired – commercial land uses, which make up most of the area to the south, would not be acquired and would remain in place on both runway ends. Based on the current assessed value of these 309 residential homes and multi-family buildings located in the approach and transitional area, it is estimated that the cost of acquisition and relocation would be approximately $35 million.

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[1] FAA Memorandum, Action: Land Acquisition - eligible Runway Protection, Object Free Area and Approach and Transitional Zones, dated April 30, 1991.

As the probable impact of low flying aircraft would not be experienced until the opening of the proposed new parallel runway, this option will receive further consideration during the forthcoming Sea-Tac Airport FAR Part 150 Update, which the Port anticipates undertaking during 1996. It is anticipated that during the Part 150 Update, the Port would further explore this action with the specific residents within the Approach Transition Area, and, if the residents so desire, establish a program including relocation objectives, timing and funding priorities.

(2) <u>Water Quality</u>

The following stormwater management mitigation will be undertaken unless basin planning determines that other actions would mitigate the impacts of the proposed improvements:

- Provide stormwater detention for construction and operation of new on-site development.
- Stormwater quality treatment would be provided with a combination of wet vaults and biofiltration swales.
- Design stormwater facility outlets to reduce channel scouring, sedimentation and erosion, and improve water quality. Where possible, flow dispersion and outlets compatible with stream mitigation should be incorporated into engineering designs.
- To mitigate potential reductions in shallow groundwater recharge and incremental reductions in base flows in the creeks, infiltration facilities would be constructed where feasible.
- Maintain existing and proposed new stormwater facilities.
- The potential for using constructed aquifers within the runway fill, as described in **Appendix Q-C**, should be further investigated.
- Tyee pond would be relocated and enlarged as part of the SASA.

Various mitigation requirements, as stipulated by federal, state, and applicable local laws, policies, and design standards, would be applicable to construction and operation of the proposed new parallel runway and landside development at the Airport. These requirements would be components of the proposed design and are expected to reduce potential impacts on surface water and groundwater quality.

Effective erosion and sedimentation control could be achieved by using a system of erosion controls (e.g., mulching, silt fencing, sediment basins, and check dams) that are properly applied, installed, and maintained.

Use of BMPs at construction sites, such as spill containment areas, phasing of construction activities (to minimize the amount of disturbed and exposed areas), and conducting activities during the dry season (April through September), also should prevent or reduce potential impacts on surface water and groundwater quality.

Temporary and permanent terraces are recommended for fillslopes and cutslopes wherever possible because they reduce sheet and rill erosion. Terraces reduce slope length, reducing potential rill development and surface erosion. Terraces also increase deposition, reducing transport of eroded materials from construction sites.

The Port of Seattle's National Pollutant Discharge Elimination System (NPDES) permit requires the Port to prepare several plans and to carry out several studies to identify pollutants coming from the Airport, and to prevent and control potential operational impacts on surface and groundwater resources from industrial wastewater system (IWS) and storm drainage system (SDS) discharges.

- Specific plans required as part of compliance with the NPDES permit include:
  - a stormwater pollution prevention plan (SWPPP);
  - a spill prevention, control and countermeasures plan (SPCCP);
  - a construction erosion and sediment control plan for each project exposing more than 5 acres of ground;
  - a sludge characterization and treatment disposal plan; and
  - a solid waste disposal plan.

- Specific studies required as part of compliance with the NPDES permit include:
  - an engineering and treatability study of the IWS
  - a vehicle washwater study
  - annual stormwater monitoring reports
  - whole effluent (both IWS and stormwater) toxicity studies
  - a marine sediment monitoring study.
- Major elements of the SWPPP include:
  - monitoring of base flow and stormwater runoff from the Airport outfalls;
  - identification and implementation of operational BMPs and applicable source control BMPs that do not require capital improvements (by December 31, 1995);
  - identification and implementation of BMPs requiring capital improvements (by June 30, 1997);
  - development of a list of pollutants that would be present in stormwater and estimation of annual quantities of these pollutants in stormwater discharges;
  - inspection of SDS periodically to ensure they are functioning properly and that there are no illegal discharges (i.e., to the SDS); and
  - modification of the existing plan whenever there is an alteration of airfield facilities or their design, construction, operation or maintenance, which causes the SWPPP to be less effective in controlling pollutants.

The Stipulated Settlement Agreement and Agreed Order of Dismissal, which dismissed Ms. Brasher's, Normandy Park Community Club's, and the City of Des Moines' appeal of the Port's NPDES permit contained the following provisions. Components of the stipulated NPDES permit appeal settlement agreement expected to mitigate potential operational impacts on water quality include:[2]

- Creating a Monitoring Team, including representatives appointed by the appellants;
- Conducting at least two additional sampling events of permitted stormwater outfalls in 1995;
- Contributing funds to the Des Moines Creek Basin planning and visioning process;
- Developing a short-term monitoring plan in cooperation with the Monitoring Team to sample Miller Creek basin outfalls and the outfall from Lake Reba examining glycol, BOD TSS, flow, ammonia, and turbidity and develop appropriate responses, as necessary, for any identified water-quality problems.

Additional mitigation for potential operational impacts to surface water quality would be considered depending on the results of the stream monitoring study[3] and the effects of Airport stormwater runoff on Miller and Des Moines Creeks. Monitoring of selected stations upstream and downstream of Airport outfalls to Miller and Des Moines Creeks is planned for this winter (95/96). Potential additional mitigation that would be considered includes use of alternative, FAA-approved runway anti-icing chemicals (e.g., calcium magnesium acetate and sodium formate) or diversion of runway runoff to the IWS during anti-icing events. The latter option is being evaluated as part of ongoing IWS engineering study, which includes capital improvements to increase the treatment efficiency and capacity of the IWS treatment plant.

Basin planning is another method for investigating mitigation of water quality impacts on Miller and Des Moines Creeks and Puget Sound from Airport and urban runoff. Although the Airport affects relatively small proportions of both the Miller and Des Moines Creek drainage basins (approximately 5 and 30 percent, respectively), activities on these areas could significantly affect these drainages. The Port of Seattle is actively participating in basin planning activities in the Miller and Des

[2] *Stipulated Settlement Agreement No. 94-157*, Washington Pollution Control Hearings Board, 1995.

[3] *Stormwater Receiving Environment Monitoring Plan*, Port of Seattle, August, 1995.

Moines Creek basins with local jurisdictions, including King County and the cities of Des Moines, Normandy Park, SeaTac, and Burien.

(3) **Wetlands and Floodplains**

The Port of Seattle has initiated the wetland permitting process with the Seattle District of the Corps. The Corps is a cooperating agency in the preparation of this EIS. Additional coordination is anticipated with the Washington State Department of Ecology. It is anticipated that permits would be issued after approval of the Final Environmental Impact Statement/Record of Decision for the Master Plan Update actions and that no adverse impacts would occur on wetlands as a result of the Master Plan Update prior to issuance of the appropriate permits.

Significant unavoidable adverse impacts will occur to wetlands as a result of implementation of the proposed improvements. These impacts include filling, grading, changes of hydrology, and removal of vegetation. The Port of Seattle will avoid adverse impacts where possible (e.g., use of off-site fill to avoid wetland impact in Borrow Area 8), will minimize impact by using Best Management Practices (BMP) during construction and operation of the proposed improvements. However, as is noted in Chapter IV, Section 23 "Construction Impacts', the filling of on-site borrow sources could further minimize wetland impacts. However, if the minimum use of on-site material occurs, maximum off-site truck trips will result as well as possible increased cost of construction.

After extensive study, the Port of Seattle has selected a preferred wetland mitigation site in the lower Green River Valley. Mitigation for impacts on wetlands at the Airport, within the watershed where the impacts may occur, is not feasible for three reasons: (1) the majority of the area surrounding the Airport is developed, and not enough land area exists in the watershed to create compensatory mitigation wetlands, (2) much of the undeveloped land in the watersheds is existing wetland, or land unsuitable for wetland mitigation due to topographic (moderate to steeply sloping) or hydrologic (lack of sufficient water) conditions, and (3) the FAA guidelines strongly recommend[4] that airports do not have "wildlife attractions" within 10,000 feet of the edge of any active jet runway. For these reasons, the Port proposes to conduct wetland mitigation outside of the watershed where these constraints do not exist.

After investigating over 100 individual parcels, the Port has selected a site located within the City of Auburn for the development of the compensatory wetland mitigation. This site, located in Section 31, Township 22N, Range 5E, Willamette Meridian in the Green River watershed, is a 69 acre parcel of land slightly south of S. 277th Street and east of Auburn Way. The undeveloped parcel has been farmed in the recent past, and currently supports a mix of upland pasture grasses and forbs that are common to abandoned agricultural land in the Puget Sound Region. Approximately 4.3 acres of reed canarygrass-dominated wetland was delineated at the site. The site is bound by a variety of land uses including agriculture to the north and south; undeveloped land, multi-family housing and a drive-in theater to the west; and the Green River, patches of riparian forest, and undeveloped slopes to the east. A narrow strip of land along the western banks of the Green River is held by King County. In December 1995, the Port of Seattle gained ownership of the property following a bankruptcy proceeding by the previous owners.

The Port of Seattle has coordinated with the Corps of Engineers concerning the proposed mitigation site and the plan included in this Final EIS. **Appendix P** contains a detailed mitigation plan for the wetland mitigation.

Floodplain encroachment and flooding impacts in the Miller and Des Moines Creek basins resulting from the proposed improvements would be unlikely because of required mitigation. Mitigation will include adherence to floodplain development standards and floodway management requirements of the FAA and Washington State Department of Ecology. Compensatory mitigation is required by state law for any proposed filling of 100-year floodplain so as to achieve no net loss in flood storage capacity and to prevent an increased risk of loss of human life or property damage.[5]

[4] "Wildlife Attractions On or Near Airports," *FAA Draft Advisory Circular 150/5200-*, no date.

[5] *Environmentally Sensitive Areas - Flood Hazard Areas, Chapter 15.30210-250, City of SeaTac Municipal Code.*

Compensatory mitigation for floodplain impacts near the northwest corner of the proposed new parallel runway has been incorporated into the stream relocation design (**Appendix P**). The stream mitigation design, which was developed in cooperation with several resources agencies, including the U.S. Army Corps of Engineers, would create an equivalent amount of floodplain storage - so no net loss of flood storage capacity or increased risk of loss of human life or property damage would result.

As this Environmental Impact Statement demonstrates, no other practicable alternative exists other than completion of one of the proposed Master Plan Update alternatives. Significant floodplain encroachment would be unlikely as a result of the "With Project" alternatives due to strict mitigation requirements which would be adhered to under any of the alternatives.

Storm flow modeling based on conceptual stormwater detention facilities and using these design storms indicates no increase in peak flow rates and little risk of flooding from the proposed Master Plan Update alternatives. Preliminary compensatory floodplain replacement designs for floodplain encroachment in the Miller Creek basin for the 8,500-ft runway length, demonstrating no net loss of flood storage capacity, are presented in **Appendix P.**

(4) Air Quality

The proposed landside improvements included in the "With Project" alternatives--improved terminal facilities and public and employee parking--would result in changing vehicular traffic movement and patterns in the immediate airport area. For the Preferred Alternative, (Alternative 3), the majority of employee parking within the terminal area shifts to a new lot located north of SR 518, reducing congestion and pollutant concentrations.

The analysis contained in this document represents a worst case evaluation. Thus, the Port of Seattle will conduct an air monitoring program at two roadway intersections to determine if such exceedances would occur. If such exceedances are found, the Port of Seattle will undertake appropriate action such as those identified below. . .

(A) Mitigation for International Blvd. and South 170th Street

The Preferred Alternative increases pollutant concentrations over the Do-Nothing alternative at this intersection. This is due primarily to changes in how airport-related traffic would access the Airport in the future. The mitigation measures include the addition of an additional northbound left-turn lane (2 total); the construction of high capacity right-turn lanes in the southbound and eastbound directions; and the construction of a westbound right-turn lane. These improvements would occur by 2010 when relief would be needed to substantially decrease the time vehicles idle at this intersection. By 2020, an additional lane along International Boulevard (SR 99) would also be added

(B) Mitigation for International Blvd. and South 160th Street

The Preferred Alternative increases pollutant concentrations over the Do-Nothing alternative at this intersection. Pollutant concentrations at this intersection are only marginally higher by the year 2020. Mitigation measures proposed would include adding an additional southbound left-turn lane (2 total); and improvements to the westbound right-turn lane. These improvements would occur by 2010. An additional lane along International Boulevard (SR 99) would be needed by 2020 to provide additional relief at this intersection.

(C) Additional Initiatives For Reducing Air Pollutants within the Airport Area

The Port of Seattle continues to support the air quality initiatives which have been enacted in the Puget Sound Region to improve air quality. The Port of Seattle is also committed to reducing emissions from various sources at the Airport. On-going considerations have focused on reducing the number of vehicles accessing the airport by providing alternatives to single-occupancy vehicle access to and from the Airport. Other actions have addressed motor vehicle idling along the terminal curbfront. Airport staff rigorously monitor access and idling by taxi's, limousines, and buses within the terminal area.

The Port of Seattle has supported a trip reduction strategy which has several components: employee shuttle bus service to remote public and employee parking to reduce vehicle trips in the terminal area; regional light-rail transit system; limiting passenger drop-off and pickup, and providing short-term parking alternatives.

Additional actions that could further reduce air pollutant concentrations at Sea-Tac:

- Financial disincentives for single occupancy driving to the Airport
  - Raise short-term parking rates
  - Implement toll system on the airport roadway with lower fees for High Occupancy Vehicles (HOV).
- Convenience disincentives/incentives:
  - Development of remote Park'n'Fly operations
  - Require private autos to use third floor plaza instead of terminal curbfront
  - Require use of alternative fuels by courtesy vehicles
- Improved airport access roads that attract users off the area arterials (i.e., South Access Road).

(5) <u>Surface Transportation</u>

Mitigation is proposed for each adverse impact that would occur with each "With Project" alternative (Alternatives 2, 3, and 4). An adverse impact is defined as a significant degradation in level of service (reducing the level of service) compared to the Do-Nothing alternative. In all cases the proposed mitigation measures will be sufficient to alleviate the significant adverse impact caused by proposed Airport improvements.

Because of the uncertainty of the proposed extension of SR 509 and South Access, as well as the public acceptance and use of high and higher occupancy vehicles and the impact of regional traffic on airport area roadways, the Port will continue to participate in cooperative planning with State and local officials to address its respective share of surface transportation impacts. Mitigation actions that are expected to be addressed in continued mitigation planning include the following associated with the Preferred Alternative:

<u>North Unit Terminal Alternative (With State Route 509)</u>

The following mitigation possibilities have been identified:

- International Boulevard (State Route 99) and South 160th Street - For the year 2010 only minor improvements to the intersection are necessary (dual southbound left-turn lanes, improvements to the westbound right-turn lane). These improvements are not sufficient for the year 2020 traffic levels due to the significant amount of regional traffic on International Boulevard (State Route 99). For the year 2020, the International Boulevard (State Route 99) corridor would need to be improved to provide additional capacity (i.e. seven lanes plus HOV treatments). The Port of Seattle would be responsible for a pro-rata contribution towards the proposed improvements at this intersection.
- International Boulevard (State Route 99) and South 170th Street - For the year 2010 only minor improvements to the intersection are necessary (dual northbound left-turn lanes, high-capacity right-turn lanes in the southbound and eastbound directions, westbound right-turn lane. These improvements would not be sufficient for the year 2020 due to the significant amount of regional traffic on International Boulevard (State Route 99). For the year 2020, the International Boulevard (State Route 99) corridor would need to be improved to provide additional capacity (i.e. seven lanes plus HOV treatments). The Port of Seattle would be responsible for a pro-rata contribution towards the proposed improvements at this intersection.
- Air Cargo Road and Southbound Airport Expressway Ramps; Air Cargo Road and South 170th Street; Northbound Airport Expressway Ramps and South 170th Street - These three intersections would require signalization by the year 2010. However, the construction of the North Unit Terminal would eliminate these three intersections by the year 2010. Therefore, temporary signals should be installed when the signal warrants are satisfied in order to provide adequate intersection control until the North Unit Terminal is constructed. The Port of Seattle would only be responsible for a pro-rata contribution towards the installation of the temporary signals due to the significant amount of

regional pass-through traffic utilizing the Airport Expressway at this interchange area.

- Northbound Interstate 405 On-Ramp from Southbound Interstate 5 - Eastbound State Route 518/ Northbound Interstate 405 should be widened to two lanes through the interchange. This additional lane could then be dropped at the State Route 181 Off-Ramp located down-stream. The Port of Seattle would only be responsible for a pro-rata contribution towards the proposed improvements at this interchange.

<u>North Unit Terminal Alternative (Without State Route 509)</u>

- International Boulevard (State Route 99) and South 160th Street - The impacts and possible mitigation measures are the same for this scenario as with SR 509. The Port of Seattle would be responsible for a pro-rata contribution towards the proposed improvements at this intersection.
- International Boulevard (State Route 99) and South 170th Street - The impacts and possible mitigation measures are the same for this scenario as with SR 509. The Port of Seattle would be responsible for a pro-rata contribution towards the proposed improvements at this intersection.
- International Boulevard (State Route 99) and South 188th Street - This intersection would require the construction of an urban interchange to meet the City of SeaTac's adopted level of service standard. With this type of improvement it would also be possible to incorporate a fly-over ramp design for the Airport South Access. The Port of Seattle would be responsible for a pro-rata contribution towards the proposed improvements at this intersection.
- International Boulevard (State Route 99) and South 200th Street - These include the following: providing additional capacity along the International Boulevard (State Route 99) corridor (i.e. seven lanes plus HOV treatments); providing additional capacity along the South 200th Street corridor (i.e. seven lanes); dual left-turn lanes in the southbound, eastbound, and westbound directions; and a westbound right-turn lane. The Port of Seattle would be responsible for a pro-rata contribution towards the proposed improvements at this intersection.
- 28th/24th Avenue South and South 200th Street - Only minor improvements to this intersection would be required (dual westbound left-turn lanes, eastbound right-turn lane, re-striping the northbound approach to provide one left-turn, one through, and two right-turn lanes). The Port of Seattle would be responsible for a pro-rata contribution towards the proposed improvements at this intersection.
- Military Road South and South 200th Street/Southbound Interstate 5 Ramps - Only minor improvements to this intersection would be required (dual northbound left-turn lanes, two eastbound through lanes). The Port of Seattle would be responsible for a pro-rata contribution towards the proposed improvements at this intersection.
- Military Road South and Northbound Interstate 5 Ramps - Only minor improvements to this intersection would be required (widening the eastbound approach to provide one left-turn and one right-turn lane, and providing a southbound right-turn phase overlap). The Port of Seattle would be responsible for a pro-rata contribution towards the proposed improvements at this intersection.
- Air Cargo Road and Southbound Airport Expressway Ramps; Air Cargo Road and South 170th Street; Northbound Airport Expressway Ramps and South 170th Street - These three intersections would require signalization by the year 2010 without SR 509. However, the construction of the North Unit Terminal would eliminate these three intersections by the year 2010. Therefore, temporary signals should be installed when the signal warrants are satisfied in order to provide adequate intersection control until the North Unit Terminal is constructed. The Port of Seattle would only be responsible for a pro-rata contribution towards the installation of the temporary signals due to the significant amount of regional pass-

through traffic utilizing the Airport Expressway at this interchange area.

- Northbound Interstate 405 On-Ramp from Southbound Interstate 5 - The impacts and proposed mitigation measures are the same for this scenario as with SR 509. The Port of Seattle would be responsible for a pro-rata contribution towards the proposed improvements at this interchange.

(6) Earth

An Erosion and Sedimentation Control Plan, including measures specific to site conditions, will be designed and implemented to minimize erosion and sedimentation levels. The plan would include elements for site stabilization, slope and drainageway protection, sediment retention, and dust control on haul routes and borrow sites.

As stated in Chapter IV, Section 2 "Land Use, the application and implementation of City of SeaTac regulatory provisions to the Master Plan Update improvements is currently the subject of negotiation through interlocal processes between the Port and City. If applicable, as determined from the result of the interlocal negotiation process between the Port of Seattle and the City of SeaTac (not expected prior to issuance of the Final EIS), the City of SeaTac Environmentally Sensitive Areas Ordinances allow alterations to seismic hazard areas only if (1) site-specific subsurface investigations show the site is not a seismic hazard or (2) mitigation is implemented that renders the proposed development as safe as if it were not located in a seismic hazard area.[6] Two seismic hazards occur on the site of the new parallel runway in relatively small areas of loose, shallow sediment. During runway construction, this sediment would be removed and replaced with compacted fill. If future subsurface investigations verify the occurrence of seismic hazards on Borrow Source Areas 1, 5, and 8, special measures to maintain cut slope stability during excavation in these areas may be required.

A landscaping plan will be developed for areas of excavation and construction. For the borrow source areas, the landscaping plan could include recontouring, seeding, and planting of trees and shrubs. Potential mitigation measures for aesthetic impacts of the proposed new runway are included in Chapter IV, Section 24 "Aesthetics and Urban Design" of this Final EIS.

(7) Construction Impacts

Although no surface transportation congestion mitigation is required, the following measures are identified to minimize construction related surface transportation impacts:

1. Develop a Construction and Earthwork Management Plan. The Plan would designate preferred haul routes and specific conditions such as hours of operations, traffic control changes, and route mitigation. Depending upon the selected contractor(s) haul routes, such controls could include:
   - Provisions that restrict truck traffic during AM and PM peak periods.
   - Contract provisions which would require the contractor to cover all loads to reduce debris and dust loss from the transport activities and to provide for street cleaning and pavement repairs during the construction process.

2. Consider acquiring material rights to the Maury Island sites. Use of Site #14 and the Maury Island King County Park (consistent with the development of the park and if permits can be obtained) would limit the affected routes to SR 509, which could handle additional truck traffic throughout the day without significant impacts on levels of service.

Because of the social disruption that would occur in the general vicinity of the proposed new runway construction, a construction mitigation acquisition will be implemented. This acquisition includes about 70 residential and commercial properties located east of Des Moines Memorial Drive between SR 509 and SR 518.

To minimize the fugitive dust transport, unpaved roads and inactive portions of the construction site will be watered (achieving a 50 percent reduction in dust) or chemically stabilized (achieving an 80 percent reduction) during dry periods.

[6] *Environmentally Sensitive Areas Ordinance*, City of SeaTac, 1994.

CHAPTER I

PROJECT BACKGROUND AND PURPOSE AND NEED

1. BACKGROUND

Seattle-Tacoma International Airport (Sea-Tac Airport) is the primary air transportation hub of Washington State and the Northwestern United States. The Airport is located within King County and the City of SeaTac, about 12 miles south of downtown Seattle and about 20 miles north of Tacoma. Airport property consists of about 2,500 acres of land.

As of August 1995, service was provided by approximately 54 airlines. Scheduled passenger service is provided at Sea-Tac by 10 major airlines.[1/] In addition, 14 all-cargo carriers have scheduled service at the Airport. Non-stop air service is provided to 44 cities nationwide and to the international cities of Copenhagen, London, Seoul, Tokyo, Hong Kong, Taipei, Shanghai, Osaka, Vancouver, and Victoria. Sea-Tac Airport is the 21st busiest airport in the country, as measured by total passengers. It is also the 8th largest international air gateway to Europe and Asia, and the 18th busiest cargo airport.

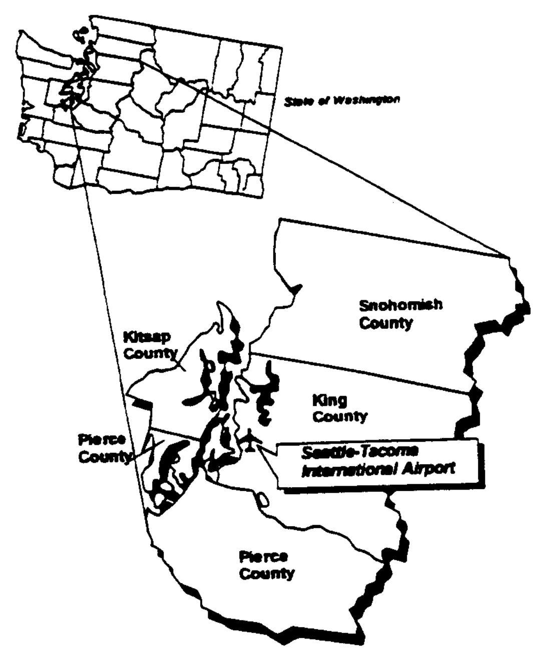
Sea-Tac Airport is the primary commercial service airport for the Pacific Northwest and is the only airport which provides primary scheduled commercial air carrier service in the four-county Central Puget Sound area, which consists of King, Pierce, Snohomish, and Kitsap counties. **Exhibit I-1** shows the location of Sea-Tac Airport relative to the Puget Sound Region (referred to as "Region").

On a per-capita basis, Washington State conducts more international trade than any other state. Washington State is the fourth largest exporter in the nation, behind California, Texas and New York. Top air exports include automatic data processing equipment, measuring instruments, aircraft parts, and engines.

1/ As of year end 1993, Major Air Carriers, as defined by the US. Department of Transportation, include: America West, American, Continental, Delta, Federal Express, Northwest, Southwest, TransWorld, United, and US Air. A major airline is one with an annual revenue in excess of $1 billion.

EXHIBIT I-1

Seattle-Tacoma Airport Location Map



(1) Airport Management

Seattle-Tacoma International Airport is operated by the Port of Seattle (also referred to as "The Port"), a municipal corporation of the State of Washington. The policies of the Port are established by a five member Commission, elected at large by the voters of King County for four-year terms. The policies enacted by the Commission are implemented by the Port's Executive Officer, administrative, and operations staff. The operations and taxation boundaries of the Port coincide with the geographic boundaries of King County. The Port finances its operations and capital improvements at Sea-Tac Airport through the collection of revenue from leases, rentals and other charges to airlines, and other users of Port facilities and services. The Port has the authority to levy

AR 038782

real property taxes, but, no such property tax revenue has been used for Sea-Tac Airport in over 20 years.

(2) <u>Airport History</u>

The Puget Sound Region has been a focal point for aviation since the first Boeing aircraft was built in 1916. In 1928, King County built the area's first commercial airport (Boeing Field - now known as King County International Airport). In January of 1941, with Boeing Field overcrowded and the area in need of additional commercial and military aviation facilities, the Aviation Committee of the Seattle Chamber identified the need for another major airport and immediately started considering possible sites. By mid-February 1942, two suitable sites had been found (Bow Lake and Lake Sammamish). With the City of Seattle and King County unable to serve as sponsors, the Port of Seattle was requested to serve as airport sponsor.

When the Chamber approached the Port of Seattle concerning sponsorship of the airport, the Port initially rejected the opportunity. However, based on the desires of more than 100 trade, labor and service organizations in the Region, the Seattle Chamber passed a resolution requesting the Port operate and manage the new airport.[2] The Port acquired 906 acres of land, and in 1943 officially broke ground on the new airport. The land originally contained a horse riding academy, two rabbitries, a frog farm, a mushroom farm, a dog kennel and 50 homes.

At its opening, the Airport consisted of 4 runways - a main runway (6,100 feet long) was oriented north/south, with crosswind runways in the east/west, southeast/northwest and southwest/ northeast directions. As early as June of 1956, the Port of Seattle began preparing for the jet age by extending the main runway. During the 1960s and 70s, extensive additions and improvements were made to the passenger terminal. From 1967 to 1973, Sea-Tac underwent notable change with the completion of the second parallel runway, north and south satellite terminals, the passenger subway, the north airport access freeway, and an eight story parking garage. During this time, the Airport roadways were separated into upper and lower levels for departing and arriving passengers.

In 1976, the Port of Seattle and King County adopted the Sea-Tac/Communities Plan to guide development of the Airport and surrounding unincorporated King County neighborhoods. Included was the first major off-airport land acquisition program in the country designed to reduce the impact of jet aircraft noise on the community. The plan was updated in 1985 when the Port adopted the Noise Remedy Program, a $140 million program to expand land acquisition and noise insulation of homes, and to give home-selling assistance to those most affected by aircraft noise.

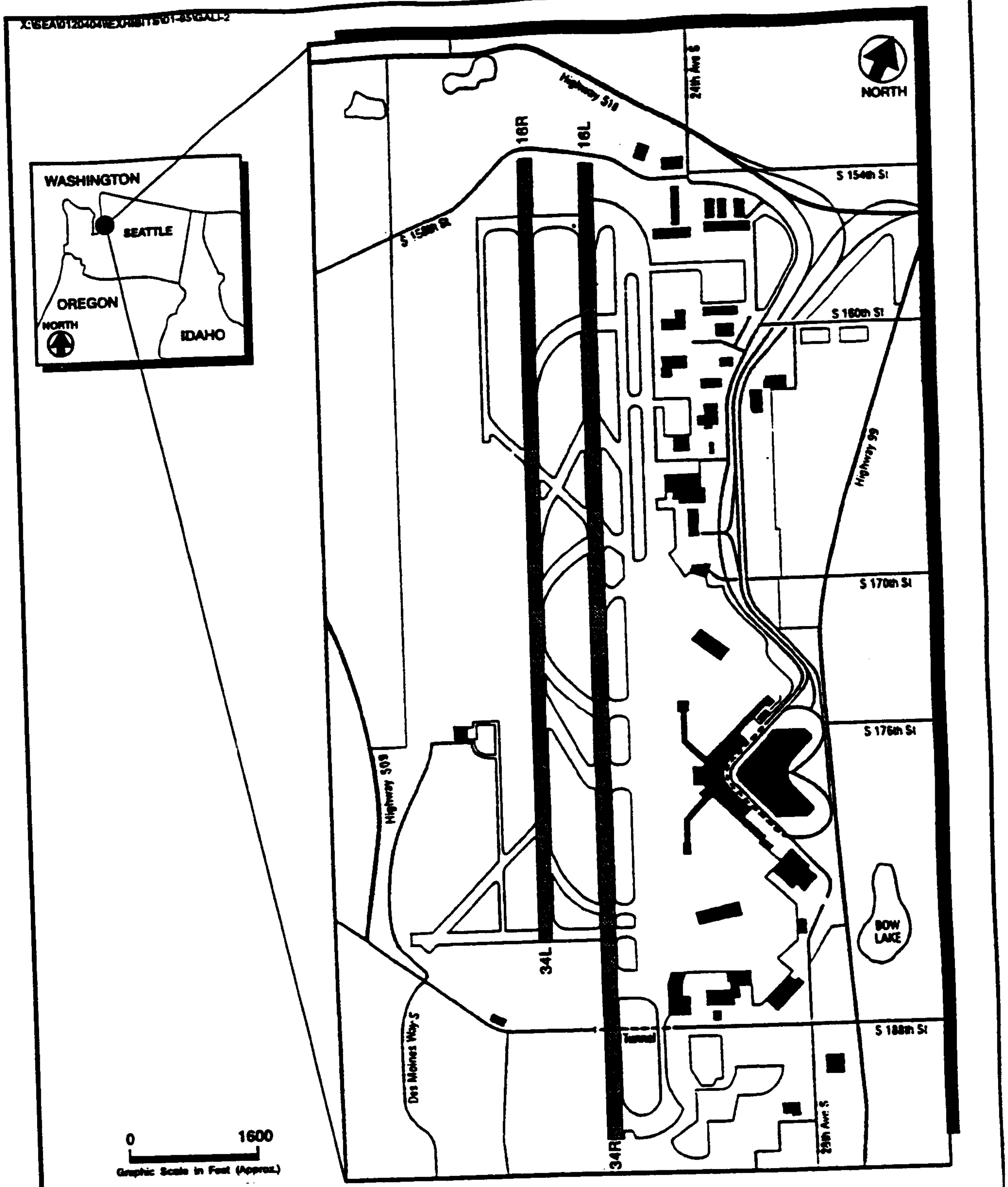
By 1984, 26 carriers served Sea-Tac, an increase from 12 carriers prior to airline deregulation in 1979. In 1985, the Port completed an update of the Sea-Tac Airport Master Plan. Many of this plan's recommendations were implemented through the 1980s and early 1990s.

The inability of existing airfield facilities to accommodate traffic into the 21st century was first recognized in the mid-1980s when the Port completed the Comprehensive Planning Review & Airspace Update Study. The purpose of the Study was to assess the validity of previous plans developed for Sea-Tac in light of air travel growth and other changing conditions at the Airport. While previous plans had not indicated a need for new runway capacity, this new study showed that the existing runway system would not be capable of serving the increased demand past the year 2000.

In 1989, the Federal Aviation Administration (FAA) initiated an Airport Capacity Enhancement Study for Seattle-Tacoma International Airport. This study found that 48,000 hours of aircraft delay were incurred, costing aircraft operators $69 million annually in 1989 with 335,259 operations. The primary cause of delay was found to be poor weather which reduces operational capacity from 98 to 55 operations[3] per hour. This reduction in capacity is a result of the close spacing between the two parallel runways. **Exhibit I-2** shows the general layout of the Airport.

[2] "Port Backing of Field Requested", Seattle Times, March 3, 1942.

[3] Total aircraft operations are the sum of the landings and takeoffs.



Not to scale

Seattle - Tacoma International Airport	General Airport Layout	EXHIBIT: I-2

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(3) Regional Airport Planning

Both the 1988 Sea-Tac Airport Comprehensive Planning Review and the 1988 Puget Sound Council of Governments (since renamed Puget Sound Regional Council - PSRC) Regional Airport System Plan (RASP) concluded that the existing two runways at Sea-Tac would not be adequate to meet regional air travel needs beyond the year 2000. As a result, the Port of Seattle and the PSCOG entered into an interlocal agreement to co-sponsor a process to identify a long-term solution to the Puget Sound Region's air transportation needs. The blue-ribbon panel, known as the Puget Sound Air Transportation Committee (PSATC) conducted the effort known as the Flight Plan Study. Based on the two and a half year effort which examined ways to accommodate demand, the Flight Plan Study recommended a multiple airport system that included a new runway at Sea-Tac Airport. Two supplemental airports were recommended: Paine Field in Snohomish County (located north of the Airport), and another airport to be located somewhere in Pierce County (south of King County).

In November 1992, based on the Flight Plan Study, the Port of Seattle passed Port Resolution (No. 3125) mandating:

"SECTION 1: (a) .... the Port of Seattle adopts the portions of the PSATC (Puget Sound Air Transportation Committee) recommendations, dated June 17, 1992, that directly pertain to adding a dependent runway at Sea-Tac International Airport to improve the all-weather capacity and safety of the airfield. In addition, the Port of Seattle Commission calls for the remainder of the regional solution to include a reconsideration of a fast rail system linking Portland, OR and Vancouver, B.C. airports and central business districts together with the diversion of all cargo only carriers to an alternative airport site as well as the multiple airport system recommended by the PSATC."

Chapter II of this Environmental Impact Statement addresses the alternatives identified by the Port resolution. Also in response to the Flight Plan Study and additional study, the PSRC General Assembly adopted Resolution No. A-93-03 in April 1993 to amend the RASP. This resolution establishes three conditions for proceeding with a third runway at Sea-Tac: (1) the feasibility of a major supplemental airport, and whether it could be put into service in time to eliminate the need for a third runway; (2) implementation of noise reduction objectives; and (3) feasible demand and system management actions. The PSRC resolution states:

" ... That the region should pursue vigorously, as the preferred alternative, a major supplemental airport and a third runway at Sea-Tac.

1. The major supplemental airport should be located in the four-county area within a reasonable travel time from significant markets in the region.
2. The third runway shall be authorized by April 1, 1996:
   a. Unless shown through an environmental assessment, which will include financial and market feasibility studies, that a supplemental site is feasible and can eliminate the need for the third runway; and
   b. After demand management and system management programs are pursued and achieved or determined not to be feasible, based on independent evaluation; and
   c. When noise reduction performance objectives are scheduled, pursued and achieved based on independent evaluation and based on measurement of real noise impacts.
3. The Regional Council requests consideration by the Federal Aviation Administration of modifying the Four-Post Plan to reduce noise impacts, and the related impacts on regional military air traffic.
4. Evaluation of the major supplemental airport shall be accomplished in cooperation with the state of Washington.
5. Proceed immediately to conduct site-specific studies, including an environmental impact statement on a Sea-Tac third runway.
6. Eliminate small supplemental airports, including Paine Field, as a preferred alternative."

In response to the requirement in A-93-03 for independent evaluation of demand/system management and noise reduction action for Sea-Tac, the Executive Board established an Expert Arbitration Panel to make decisions in these areas binding upon the Regional Council. Copies of these resolutions are located in **Appendix A**.

In response to the recommendations of the Flight Plan and subsequent PSRC Resolution A-93-03, the PSRC undertook a study of the feasibility of a major supplemental airport – which became known as the Major Supplemental Airport (MSA) study. The MSA was envisioned to be conducted in two phases: MSA Phase I to identify feasible sites, and MSA Phase II to prepare a site plan for the feasible sites. MSA Phase I consisted of an exhaustive examination of new airport sites and narrowed the site evaluation to three general locations (Arlington, Marysville and Tanwax Lake). However, MSA Phase II was not initiated as a result of the PSRC Executive Board Resolution EB-94-01(adopted in October 1994):

"WHEREAS, regional studies completed by the Puget Sound Air Transportation Committee, the Washington State Air Transportation Committee, and the Puget Sound Regional Council (PSRC) have clearly identified a near term air transportation capacity problem at Sea-Tac International Airport, and concluded that the addition of a third all-weather runway at Sea-Tac would provide adequate capacity for the region through the year 2030; and ....WHEREAS, ***the Executive Board concludes that there are no feasible sites for a major supplemental airport within the four-county region and that continued examination of any local site will prolong community anxiety while eroding the credibility of regional governance***; and.....NOW, THEREFORE BE IT RESOLVED, that the Executive Board further clarifies that the "Resolution A-93-03: Implementation Steps" adopted by the Executive Board allow the Executive Board to determine whether the Regional Council should go forward with additional supplemental airport studies and pursuant to that authority, the Executive Board determines that further studies should not be undertaken. BE IT FURTHER RESOLVED, that ***the decision of the Executive Board of the Puget Sound Regional Council is to affirm the General Assembly's approval of a third runway for Sea-Tac***, provided the project meets the independent evaluation of the noise and demand management conditions set out in Resolution A-93-03, and satisfies the environmental impact review process. FURTHER, the Executive Board recommends that the Region work with the State to enact legislation allowing for substantial and equitable incentives and compensation for communities impacted by the proximity of essential public facilities. (Emphasis added)

With regards to the Washington State Environmental Policy Act (SEPA) requirements, this Environmental Impact Statement for the Master Plan Update is the second step of a phased environmental review process that began with the publication of the EIS accompanying the 1992 report of the PSATC (referred to as the Flight Plan EIS). The Flight Plan EIS, along with extensive studies conducted by the PSATC, analyzed potential environmental impacts of a wide range of alternatives for meeting future air transportation demand. The Flight Plan EIS, as a programmatic/non-project EIS, examined alternative sites and configurations for new or expanded airports (including Sea-Tac), along with demand management techniques, rail and other ground transportation, and technological alternatives to limit the number of flight operations and encourage alternatives to air travel. The Flight Plan EIS and related materials are listed and described, and their locations are identified, in **Appendix B**.

Following publication of the Flight Plan EIS and related materials, and based on information in that EIS and elsewhere, the PSRC and Port directed the focus of additional studies and environmental review to development of a new runway and associated facilities at Sea-Tac. With regard to its SEPA responsibilities, therefore, the Port has prepared this EIS as a Phase II project-level EIS, focusing on alternative configurations for new and expanded facilities at Sea-Tac.

Similar to SEPA's requirements, NEPA and other federal statutes and regulations require the FAA to consider alternative courses of action to accomplish its objectives. In response to this requirement, as well as the requirements of SEPA, the Flight Plan EIS and related materials listed in Appendix B are hereby incorporated by reference into this EIS. Copies of these documents are available for public review as indicated in Appendix B. In addition, information regarding the alternatives considered by the FAA and the Port is presented in Chapter II.

2. AVIATION DEMAND FORECASTS

The rate of air transportation passenger growth at Sea-Tac has outpaced the national rate over the last four decades. Much of this has been a function of tremendous population growth in the Puget Sound Region during the same period. The annual rate of population and economic growth in the Region during the 1980s, 70s, 60s and 50s was nearly double that of the nation.

(1) Population and Employment

In developing VISION 2020, the Metropolitan Planning Organization (Puget Sound Regional Council - PSRC) has published its regional travel characteristics and socio-economic assumptions for years through 2020. Sea-Tac Airport is generally considered to serve the four-county Central Puget Sound Region (consisting of King, Kitsap, Pierce, and Snohomish counties). To ensure compatibility with the regional planning process, this Environmental Impact Statement has used the PSRC's most recent estimates of current and future population, employment, travel, and congestion.

In 1993, the Region had a population of 2.95 million and employed 1.58 million persons. The past and future population and employment levels developed by the PSRC are listed in **Table I-1.**

TABLE I-1

Population and Employment of the Puget Sound Region

Year	Population	Employment
1960	1.51 million	605,900
1970	1.94 million	803,800
1980	2.24 million	1,112,500
1990	2.75 million	1,562,500
2000	3.28 million	1,876,000
2010	3.65 million	2,131,800
2020	4.14 million	2,265,700

Source: PSRC STEP 94 and Metropolitan Transportation Plan Technical Report: MTP-12, September, 1994.

The population of the Region has nearly doubled between 1960 and 1990. While the growth rate is anticipated to slow, the 1.4 million new residents that are forecast by year 2020 is greater than the growth that occurred between 1960 and 1990 (1.2 million). Between 1960 and 1990, net in-migration (people moving from outside the Region to the four counties), averaged 57 percent of the annual population change over the period. Because the Region is a major employment center, migration into this area has been primarily for economic reasons (such as better jobs or business opportunities).

Population and employment growth of the Puget Sound Region has and will likely continue to outpace the national average. Between 1960 and 1990, the population of the United States grew at an average annual growth rate of 1.08 percent. In contrast, the population of the Puget Sound Region grew at a rate of 2.0 percent. The population of the United States is expected to grow at an average annual rate of 0.86 percent between 1990 and 2020, while the Puget Sound Region is forecast to grow at a rate of 1.4 percent, nearly double the national average. During the 30 year period, the U.S. civilian labor force grew at an average annual growth rate of 1.1 percent - while the Puget Sound Region experienced a 3.2 percent growth.

Three Fortune 500 manufacturing companies are headquartered in the Puget Sound Region: Boeing (aircraft), PACCAR (diesel trucks), and Weyerhaeuser (forest products). A number of Fortune 500 service companies are headquartered in the Region: Airborne Freight, Alaska Airlines, Costco Wholesale, Microsoft, Nordstrom, Safeco Financial, Univar, and Washington Mutual Savings and Loan Association. Although the Region's economic base is strong, it is highly concentrated in the aerospace industry. In the past, employment in the Puget Sound Region fluctuated by a much wider magnitude than that of the nation, due in large part to the cyclical swings of the aerospace industry. In 1992, aerospace accounted for 7 percent of total jobs or 44 percent of the total manufacturing sector jobs of the Region. Since the early 1970s, the Region has experienced a fast growth in service and trade sectors, paralleling the trends observed throughout the country.

The Region's economy is made up of two categories of industries: the basic sector, which exports goods and services outside the Region, and the non-basic sector, which produces goods and services consumed within the local economy. Growth in basic sector employers is critical for generating new employment, income, and sales by injecting new funds into the local economy. Exports of consumer and business services, and of goods sold through wholesalers located within the Region, are traded to outside communities through distribution channels in the Central Puget Sound Region. Forest products, pulp, paper, aircraft, ships, and seafood products are recognized as the traditional components of the Region's economic base. Services such as transportation, engineering, and finance are also exported and thus considered base industries. In addition, an increasing share of software and durable goods are exported, making these industries significant contributors to the economic base.

The PSRC's forecast recognizes that the future regional economic performance will probably depend considerably upon the prospects of certain trade and service industries. Manufacturing is expected to remain rather constant through 2020. Trade and service industries are expected to be the main growth sectors in the future, with annual growth rates of 1.6 and 2.2 percent respectively through the year 2020. By 2020, 56 percent of the forecast total employment in the Region will be in the trade and service sectors.

(2) <u>Aviation Demand</u>

In assessing aviation traffic and demand, the following terms are used:

- <u>Passengers</u> - the sum of enplanements and deplanements;
- <u>Enplaned Passengers</u> - passengers boarding aircraft that will be departing an airport. Enplanements are approximately half of total passengers; and
- <u>Operation</u> - An aircraft arrival or departure from an airport.

Exhibit I-3 lists annual enplaned passengers and total aircraft operations between 1964 and 1993 at Sea-Tac. As is shown, the number of enplaned passengers nearly tripled between 1960 and 1970, and doubled in the 10 years between 1970 and 1980. Enplaned passenger levels doubled again between 1980 and 1993. Enplaned passengers grew from nearly 2.4 million in 1970 to approximately 9.4 million in 1993.

While passenger demand grew 299 percent between 1970 and 1993, aircraft operations grew at a much slower rate - 125 percent over the same period. Commuter operations during this period grew at the fastest rate, significantly increasing the percentage of smaller aircraft operating at Sea-Tac. Commuter operations peaked in 1990 and have declined slightly. In 1970, commuter operations represented 4 percent of total airport operations. By 1990, commuters represented 42 percent of total operations, declining to 38 percent in 1993. Because of the smaller aircraft used by these carriers, commuter passengers only represent about 7 percent of total passengers in 1993.

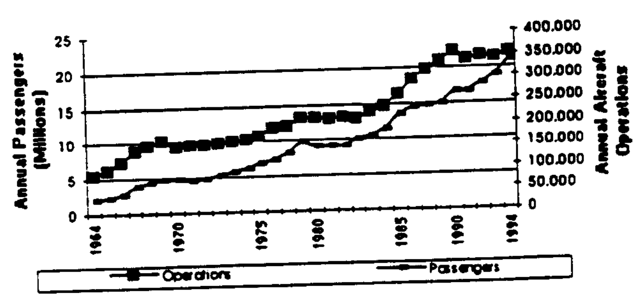
While the passenger growth rate at Sea-Tac over the last 5 years has slowed compared to previous years, its average 4.6 percent increase per year far surpasses the total growth experienced within the U.S. of 1.7 percent per year over the same period.

During the 1990s, national air travel growth slowed radically. Aircraft operations have declined or stayed relatively constant from year to year as a result of airline consolidation in response to declining financial conditions and reduced nation-wide passenger traffic. During the first four years of the 1990s, the lethargy of both the U.S. and world economies have presented the U.S. aviation industry with a series of challenges. Economic growth averaged less than 0.5 percent annually. As a result of a slowing world economy and increased airline competition, the airlines lost more than $10 billion (more than the total profit earned by the industry since the initiation of commercial passenger service).

This combination of slow traffic growth and record financial losses that occurred in the late 1980s and early 1990s resulted in the liquidation of four major airlines: Eastern, Pan American, Midway (which did not operate at Sea-Tac), and Braniff. Three carriers (America West, Continental, and Transworld Airlines) entered into Chapter 11 bankruptcy; while all three have emerged from bankruptcy, their operating characteristics have been substantially altered.

The slowing of national passenger growth that has occurred since 1987 has not been experienced at Sea-Tac, (shown in **Exhibit I-3**. In 1970, Sea-Tac enplaned about 1.3 percent of the total U.S. enplanements. By 1987, this had grown to 1.5 percent. However, by 1993, Sea-Tac had grown to accommodate 1.8 percent of U.S. enplanements. While aircraft operations fluctuated in recent years, enplaned passengers have continued to increase each year.

EXHIBIT I-3
Historical Airport Activity



AR 038788

The following summarizes the number of passengers and aircraft operations by the 10 busiest carriers serving Sea-Tac Airport in 1993:

	1993 Activity	
Airline	Passengers	Landings
Horizon	1,715,242	40,697
United	3,864,779	34,346
Alaska	3,575,849	24,437
Delta	1,470,668	8,089
Northwest	1,911,565	7,239
American	1,328,787	6,753
Harbor	NA	5,081
Morris Air	959,259	4,565
MarkAir	557,604	3,757
Continental	676,960	3,495

As was noted earlier, Sea-Tac is the 18th busiest cargo airport in the United States. Air cargo consists of freight and mail and is handled by a variety of airline types: cargo carried in the cargo section of commercial passenger aircraft, integrated express carriers, dedicated cargo airlines, overseas passenger airlines, regional and charter airlines.

In 1991, 58 percent of the Sea-Tac air cargo was carried by major, U.S., foreign flag or regional passenger airlines. In 1993, 46 percent of the cargo shipped through Sea-Tac was carried in passenger aircraft.

In 1970, 130,000 metric tons of cargo were transported in and out of Sea-Tac. By 1993, the cargo tonnage had grown to 382,000 tons, nearly tripling the levels of 1970. In 1993, 65 percent of the cargo transported from Sea-Tac Airport was destined to continental US markets, 10 percent to Alaska, 11 percent to Europe, 9 percent to Asia and 4 percent to Hawaii.

1. Master Plan Update Forecasts

In April 1994, the Port of Seattle completed an update of earlier forecasts for Sea-Tac Airport as part of the Master Plan Update. **Table I-2** lists the Master Plan Update forecasts for the years 2000, 2010 and 2020 in comparison to 1993 actual levels. Because of the growing population and economic conditions in the Puget Sound Region, forecast demand is expected to increase regardless of future airport improvements. This growth directly corresponds with the Puget Sound Regional Council's anticipated growth in the regional economy (population and income). Total enplaned passengers are expected to grow from 9.4 million in 1993 to 11.9 million in 2000 and 19.1 million in 2020. Total aircraft operations are projected to increase from 339,500 in 1993 to 379,200 in 2000 and 441,600 in 2020.

The growth rate of aircraft operations is expected to be slower than the growth of passengers because of increased use of larger aircraft and rising load factors. In the future, the growth of domestic commuter operations is expected to slow due to a greater shift towards short-haul air carrier service and the use of larger (60+ seats) aircraft by commuter airlines. Growth in the future by commuter operations (aircraft with less than 60 seats) is also expected to decline due to the increased seat size of aircraft, which will result in the operations being categorized as air carrier. This re-categorization has affected reported operations levels at Sea-Tac, as Horizon was once listed as a commuter and is now listed as an air carrier.

Over a 20 year period, cargo activity has grown at an annual growth rate of 4.8 percent. However, between 1985 and 1993 cargo grew at an annual rate of 7.8 percent. In comparison, Boeing forecasts that air freight growth will average 4.8 percent in the U.S., 6.7 percent world-wide, and 7.6 percent between the U.S. and Asia. In forecasting future cargo tonnage, the more recent trend was used. As is shown in **Table I-2**, cargo is expected to increase from 381,000 tons in 1993 to 880,000 tons by year 2020, an increase of approximately 131 percent.

About 46 percent of cargo is expected to be carried by passenger aircraft and 54 percent by all cargo carriers.

2. Comparison of Master Plan Update Forecasts to the FAA Terminal Area Forecast

A number of aviation demand forecasts have been performed for Sea-Tac Airport over the last 10 years. A comparison of the Master Plan Update forecasts to the Federal Aviation Administration's 1993 Terminal Area Forecast (TAF) is shown in **Exhibit I-4A**.

AR 038789

TABLE I-2
MASTER PLAN UPDATE FORECASTS

	Actual 1993	Master Plan Update Forecast 2000	2010	2020
Enplaned Passengers:				
Domestic	8,700,000	10,800,000	13,800,000	17,200,000
International	700,000	1,100,000	1,500,000	1,900,000
Total Enplanements	9,400,000	11,900,000	15,300,000	19,100,000
Origin and Destination EPS	6,580,000	8,220,000	10,580,000	13,220,000
Aircraft Operations:				
Air Carrier	188,000	223,000	255,000	287,000
Air Taxi/Commuter	127,000	127,000	118,000	117,000
All-Cargo	16,000	20,000	23,000	27,000
General Aviation	8,100	8,900	9,500	10,300
Military	400	300	300	300
Total Operations	339,500	379,200	405,800	441,600
Tons of Cargo	381,000	510,000	680,000	880,000
Average Day Operations	930	1,040	1,112	1,210
Peak Month/Average Day	1,056	1,163	1,253	1,369
Peak Hour Operations	76	85	91	101

Source: 1994 Master Plan Update Technical Report No. 5 Preliminary Forecast Report, Port of Seattle.
EPS = Enplanements

EXHIBIT I-4A
Comparison of Operations Forecasts

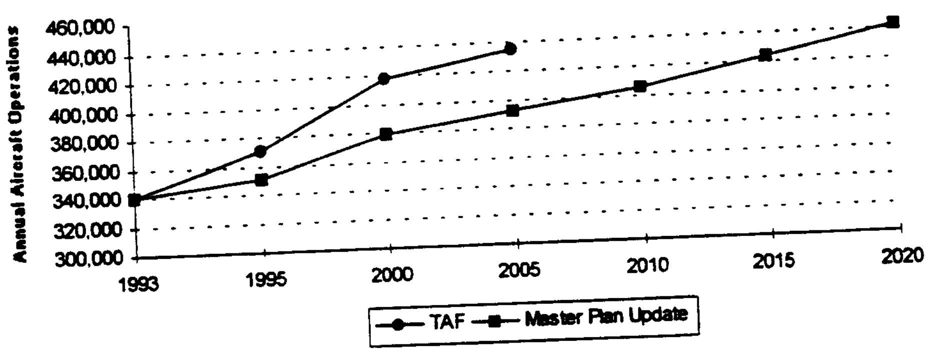
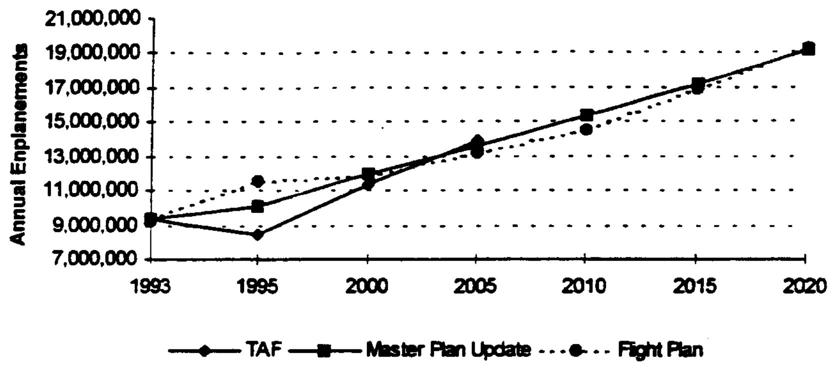


EXHIBIT I-4B
Comparison of Enplanement Forecasts



As **Exhibits I-4A and I-4B** show, the aircraft operations forecast of the Master Plan Update is slightly less than the FAA's Terminal Area Forecast, yet the Master Plan Update reflects more enplaned passengers.

The Master Plan Update enplaned passenger forecast is 4 percent greater than the TAF, yet 9 percent less than the TAF operations forecast. This is a reflection of the Master Plan Update's recognition of the trend toward larger aircraft and greater load factors.

Comparison of projected growth at the 30 busiest air carrier airports shows that, between 1990 and 2005, enplaned passenger levels are expected to grow on the average 4.04 percent annually. The TAF projects that growth at Sea-Tac during this period will be approximately 4.1 percent annually. Domestic air carrier passengers are expected to increase 3.9 percent annually between 1992 and 2004 on a national basis, while aircraft operations are expected to increase 2.2 percent annually during the same period.

In spite of the minor differences, the TAF and the Master Plan Update forecasts are similar in that they both project growth at Sea-Tac to be above the national average. The TAF is believed to be greater in the longer-term, as the basis for the TAF are U.S. Office of Budget projections for growth in the national economy.

3. <u>Comparison of Master Plan Forecast to the Flight Plan Forecast</u>

During the Flight Plan Project, a series of aviation demand forecasts were developed. During Phase I, an initial forecast was prepared. Later, during Phase II, the forecast was revised downward to reflect the airline financial conditions occurring in the industry. The Phase II forecasts were then used in Phase III of the Flight Plan to assess the air services and operating needs of airport system alternatives.

The Phase III forecasts indicated that total passengers (enplanements and deplanements) would grow at Sea-Tac from their 1990 levels of 16.2 million to 21 million in 1995, 21.6 million in 2000, 29 million in 2010 and 38.3 million in 2020. As is shown in **Exhibit I-4B**, the annual enplanement forecast associated with the Flight Plan is slightly lower than the Master Plan Forecast Update through the year 2010. By 2020, the Master Plan Update forecast is slightly below the forecast of the Flight Plan.

3. PURPOSE AND NEED

The overall objective of the Seattle-Tacoma International Airport Master Plan Update Study was to:

> " 'prepare a comprehensive Airport Master Plan (Update) for the airside, terminal and landside needed at Sea-Tac to meet air travel demand to the year 2020 and beyond.' Specifically the master plan update study must fulfill each of the relevant objectives stated in Port Resolution 3125. These are as follows: Design a mechanism and process to promote (land use and community) compatibility through improved coordination, communication and involvement. In addition to the third runway studies, include a reconsideration of a fast rail system together with diversion of all cargo carriers. Fully explore the impacts of peak period pricing and other demand management techniques. Explore land acquisition and redevelopment to compatible uses. Attenuate airport noise through the use of berms and barriers. Promote aggressive on-airport emissions reductions. Promote regional transit and reduction in use of automobiles. Improve the aesthetic appearance of the airport boundary. Develop a comprehensive stormwater management plan."[4]

During the Master Plan Update Study, aviation demand forecasts were prepared to determine how activity would grow and how this growth would affect the ability of the existing facilities to serve this demand. Based on the forecast demand, various airport development needs were identified.

In addition to the Airport operator's planning activities, the Federal Aviation Administration (in concert with the local airport operator and users) also identifies and, on occasion, evaluates facility needs at specific airports. 49 USC Section 47103 (the re-codified section 507(a) of the Airport and Airway Improvement Act - AAIA) requires the Secretary of Transportation to maintain a national plan for the development of public use airports. The National Plan of Integrated Airport Systems (NPIAS) presents airport development data in compliance with AAIA. The 1993-1998 NPIAS states "Experience shows that delays increase gradually with rising levels of traffic until the practical capacity of an airport is reached, at which point the average delay per aircraft operation is in the range of 4 to 6 minutes. Delays increase rapidly if traffic demand increases beyond this level. An airport is considered to be severely congested when average delays exceed 9 minutes per operation."[5] The FAA's <u>1993 Aviation System Capacity Plan</u> identifies Sea-Tac and 22 other airports as currently having 20,000 hours or more of annual delay. According to the 1993 study, delay at Sea-Tac is expected to continue to exceed 20,000 hours annually through the year 2002, assuming that no improvements are undertaken to increase capacity.

Sea-Tac Airport, in its current configuration, is unable to efficiently serve the air travel demands of the Region now and in the future. Relative to the population center of the United States, Washington State is located in the northwest corner of the Country. As a result, air travelers and businesses in the Region and Pacific Northwest rely on the worldwide air service afforded by Sea-Tac Airport. Vacationers access Seattle and the Pacific Northwest through Sea-Tac. Cities in Idaho, Oregon and Washington rely on air service at Sea-Tac as an important transportation link.

As was shown in the Master Plan Update, inefficient airfield operations occur during poor weather conditions, as the airfield is only able to accommodate a single arrival stream. As a result, the number of aircraft operations is presently reduced during poor weather as aircraft are unable to land in an efficient manner. Thus, aircraft are either held on the ground in their originating city, slowed enroute or are placed in holding patterns awaiting clearance to land at Sea-Tac Airport. With or without the proposed airport improvements, airport activity is expected to increase as a consequence of regional population growth. As aviation demand grows, aircraft operating delay will increase exponentially. The increased passenger, cargo and aircraft operations demand will place increasing burdens on the existing terminal and support facilities. Without improvement, the roadway system, terminal space, gates, cargo and freight processing space will operate with greater inefficiency, congestion, and reduced quality of service.

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[4] *Sea-Tac Airport Planning History and Study Relationships*, Master Plan Update, Technical Report No. 3, Port of Seattle, May 1994. The Region defined in the Port Resolution is the four county air service area.

[5] *National Plan of Integrated Airport Systems (NPIAS) 1993-1998*, Federal Aviation Admin., April, 1995, pp. 10.

The provision of efficient airport facilities is essential to the welfare of the Puget Sound Region. Regional population growth will place pressures on the Region's ability to attract economic activity, especially in the service and trade sectors. During the Flight Plan Study, it was found that "As the ability of Sea-Tac to meet the needs of the area becomes exacerbated, the Puget Sound Region will begin to feel the economic consequences of a deteriorating air transportation system."[6] The Region can be a principal gateway to the Pacific Rim, but will be forced to compete for that position with other ports in Washington, as well as throughout the Country and Canada.

The efforts of regional officials, leading up to and including the Master Plan Update, have identified the following needs (which are shown throughout this document in **bold**):

(1) **Improve the poor weather airfield operating capability in a manner that accommodates aircraft activity with an acceptable level of aircraft delay;**

(2) **Provide sufficient runway length to accommodate warm weather operations without restricting passenger load factors or payloads for aircraft types operating to the Pacific Rim;**

(3) **Provide Runway Safety Areas (RSAs) that meet current FAA standards; and**

(4) **Provide efficient and flexible landside facilities to accommodate future aviation demand.**

The needs that are being addressed by this Environmental Impact Statement are summarized below:

(1) Improve The Poor Weather Airfield Operating Capability In A Manner That Accommodates Aircraft Activity with an Acceptable Level of Aircraft Delay.

The present runway system at Sea-Tac Airport, as shown in **Exhibit I-2**, consists of two parallel runways: 16R/34L and 16L/34R. Runway 16L/34R is the longer runway at 11,900 feet, while Runway 16R/34L is 9,425 feet long. Runway 16R/34L is located 800 feet west of Runway 16L/34R. The landing threshold of Runway End 16L is displaced 490 feet.

Weather conditions and their patterns of occurrence are important considerations when evaluating the operational capability of an airfield. The safe spacing between aircraft specified by the FAA's air traffic control standards differs depending upon weather conditions (i.e., the cloud ceiling and visibility). Because of the narrow distance between the existing parallel runways at Sea-Tac, simultaneous arrivals to both runways are permitted only in good weather conditions. The following points define the weather categories which were used at Sea-Tac to evaluate airfield operating performance and their percent occurrence at Sea-Tac:

- Visual Flight Rule 1 (VFR1) - ceiling (height of cloud base above ground) is at least 5,000 feet and visibility at least 5 miles. Based on 10 years of weather conditions ending in 1992, VFR1 occurs at Sea-Tac approximately 56 percent of the time.
- VFR2 - ceiling is between 2,500 and 4,999 feet and visibility is more than 3 miles. These conditions occur about 20 percent of the time at Sea-Tac.
- Instrument Flight Rules (IFR) - ceiling is under 2,500 feet or visibility is under 3 miles. Within the IFR category, there are several levels, where IFR4 is the poorest weather condition. IFR conditions occur about 24 percent of the time.

When poor weather occurs at Sea-Tac, the total number of arrivals that can be accommodated is reduced as shown in **Table I-3.**

[6] *Phase II: Development of Alternatives*, Puget Sound Air Transportation Committee Flight Plan Project, Final Report, June, 1991, Page i

TABLE I-3

Present Runway System Arrival Operating Capability at Sea-Tac Airport

Condition	Hourly Airfield Capability Maximum Arrivals
Good Weather:	
VFR1	60
Poor Weather:	
VFR2	48
IFR1	36
IFR2, 3, and 4	24

Source: P&D Aviation, Inventory Pg. 3-8.

Current FAA air traffic control rules require at least a 2,500-foot separation between parallel runway centerlines for two staggered or dependent[7] arrival streams during poor weather. Therefore, during poor weather (IFR and VFR2), Sea-Tac is limited to a single arrival stream. Based on the 10-year weather analysis performed by the Master Plan Update, poor weather (with the associated single arrival stream at Sea-Tac), occurs about 44 percent of the time.

Exhibit I-5 shows a comparison of the arrival operating capability of the current airfield to the existing and future arrival demand as well as the overall hourly operating capability to the total hourly levels. As was shown in the 1991 Capacity Enhancement Study, 48,000 hours of aircraft operating delay occurred in 1988 or about 13 minutes per average aircraft. Delay is the additional amount of aircraft operating time caused by inefficiencies in the air traffic control system or airfield performance and is not related to flight schedule delay.

There are several changes that have occurred at Sea-Tac since 1989 that have contributed to a recent reduction in delay. These changes have increased the efficiency of the air traffic flow and are:

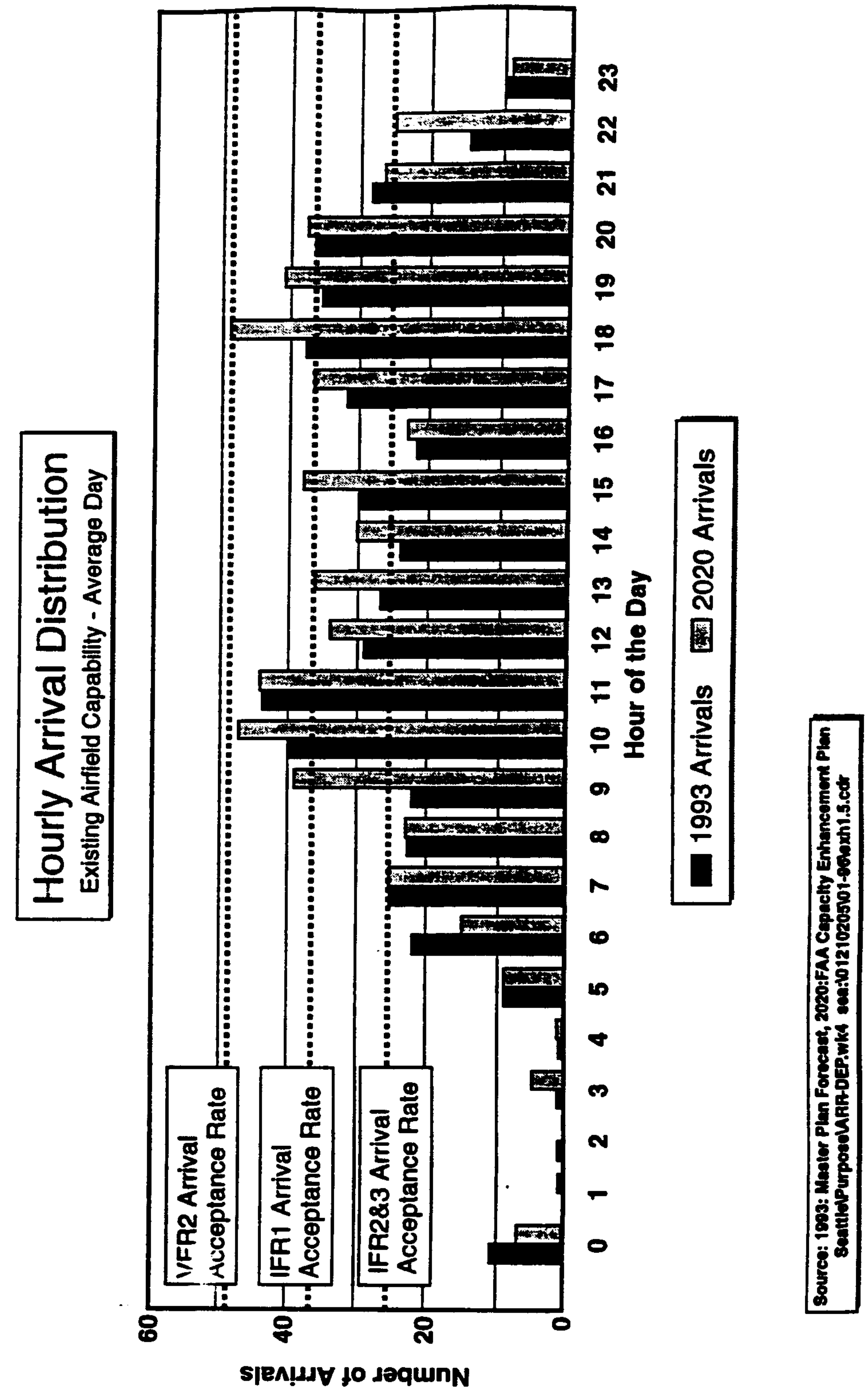
1. FAA's implementation of its 4-Post Plan resulted in a more consistent separation between arriving aircraft and a more balanced use of the runways;
2. Instrument Landing System (ILS) Hold Line for Runway 16R was moved from east of the runway to between the runways. Therefore, the aircraft waiting to depart Runway 16R can wait 800 feet closer to the runway threshold and do not have to cross an active runway. This reduces the time between departures from Runway 16R.
3. Runway centerline lights on Runway 16L were installed, therefore, Runway 16L can be used in more weather conditions for departures. This reduces the amount of time that only Runway 16R is used for arrivals and departures due to poor weather from 7 percent to 0.3 percent annually.
4. Air Traffic Control personnel have concentrated on reducing departure delays and have been more aggressive in monitoring flows.
5. The aircraft fleet is more homogeneous, meaning that there are fewer larger and smaller aircraft using the Airport. Therefore, the average longitudinal separation between aircraft is less.
6. The fleet is more modern resulting in higher average approach speeds. Therefore, the time between arrivals is less.
7. Improved lighting and signage has been installed on the airfield increasing the ease of using the Airport.
8. Reduced in-trail separation was approved for arrivals on 16L and it is anticipated for arrivals on 34R.

These improvements have resulted in substantial reductions in aircraft operating delay. As a result of FAA actions, virtually all of the available air traffic procedural and technological improvements that are currently available, have been implemented at Sea-Tac.

A number of ways exist to measure aircraft delay, depending upon the issue of concern.

[7] Dependent runway operations refer to conditions where aircraft arriving to one runway affect arrivals to a nearby runway. Restrictions are in place during dependent operations due to the proximity of arrival streams and the need to maintain standard air traffic aircraft separations.

EXHIBIT I-5



AR 038795

To aid in assessing air traffic issues, the FAA measures delays by identifying the number of operations that experience 15 minutes or more of delay in any one of the four flight segments. The Air Traffic Management Operations System (ATOMS) data for Sea-Tac indicates that reported delays (delays in excess of 15 minutes) per 1,000 operations have dropped from 30 in 1990 to approximately six in 1994 at Sea-Tac. Between May 1993 and August 1994, the reportable delays per 1,000 operations have stabilized around six.

In addition, the FAA also measures delay at airports based on the Airline Service Quality Performance (ASQP) criteria. This consumer based measurement quantifies on-time performance of flights. The ASQP data indicates that about 30,667 hours of delay are presently experienced every year at Sea-Tac.

Because the ATOMS and ASQP measurement systems do not provide a clear picture of the precise cause of delays at an airport experiencing severe delays, the FAA conducts specialized delay assessment studies. The 1995 Capacity Enhancement Update estimated delay due to airfield performance at Sea-Tac based on three demand scenarios: Baseline (345,000), Future 1 (annual operations of 425,000, approximately the year 2016 of the Master Plan forecast), and Future 2 (525,000 operations, beyond the 2020 horizon of the Master Plan Update). The delays associated with these activity levels are presented in **Table I-4**.

Average all-weather delay is expected to nearly triple as aircraft operations grow 23 percent (from 345,000 to 425,000). When aircraft operations exceed 525,000 annually (after year 2020), aircraft delay will have increased more than 700 percent. Arrival delay represents over 85 percent of total current delay experienced by an average flight. However these averages do not describe thoroughly the disparity that presently occurs between good weather delay and poor weather delay in the arrival operation of Sea-Tac Airport. **Table I-5** presents the arrival delay associated with the various weather conditions.

While Sea-Tac currently has sufficient operating capability during good weather conditions, during poor weather today, the existing runway system produces extensive arrival delays. For instance, when weather transitions from VFR1 to VFR2, average arrival delay increases 1,040 percent (from 1.0 minute to 11.4 minutes). Delays further worsen when IFR1/2/3 conditions occur; arrival delay increases 2,070 percent over VFR1 (at 21.7 minutes in contrast to 1.0 minutes). It is important to note that average delays reflect that some flights would experience less delays, while others would experience substantially greater levels of delay.

Using average aircraft operating costs, delay at Sea-Tac currently costs the airlines about $42 million annually. When aircraft operations reach 425,000 annually, delay costs are expected to exceed $176 million annually.

As is noted earlier, the NPIAS indicates that when average delay exceeds 9 minutes per operation, impacts occur to the national aviation system. However, specific airport planning guidelines have not been established to define an acceptable level of delay. Therefore, the FAA has relied upon the definition of locally acceptable delay levels, determined by airport users working in concert with the FAA and the airport operator.

TABLE I-4

AVERAGE ALL-WEATHER DELAY

Operations	Average Delay (minutes) Existing Airfield Arrival	Departure	Estim. Taxi	Average Operation
345,000	7.7	1.3	0.1	4.5
425,000*	22.2	2.6	0.2	12.4
525,000*	63.7	11.6	0.4	37.7

Source: Capacity Enhancement Update, Data Package No. 12, June, 1995.
* Assumes full implementation of the 2.5 nautical mile separation.

TABLE I-5

ARRIVAL DELAY

Operations	Average Arrival Delay (minutes) Existing Airfield VFR1	VFR2	IFR1	IFR2/3	IFR4	All-Weather
345,000	1.0	11.4	21.7	21.7	333.2	7.7
425,000*	1.6	41.8	71.2	101.0	524.5	22.2
525,000*	3.1	163.6	181.3	219.4	711.9	63.7

Source: FAA Capacity Enhancement Update, Data Package No. 12, June, 1995.
* Assumes full implementation of the 2.5 nautical mile separation.

The maximum "acceptable" delay for any single component of the National Airspace System is extremely subjective and dependent upon a number of factors unique to an individual facility. Factors which typically influence "acceptable" delay levels at an airport include the relative occurrence of poor weather conditions, individual airline cost of delay, and the effect of this airport's delay at other airports throughout the system. Since operating conditions are unique at each airport, a single measure of acceptable delay which applies to all airports has not been established. As a result, the weighted average delay level is often used as an indicator of airports which may be experiencing significant levels of delay during certain conditions, and thus, should consider delay reduction actions.

The average all-weather delay per operation is a convenient way to describe airport efficiency because it is a single number. However, describing the airport efficiency with a single number can lead to poor decision-making because the all-weather average delay does not reveal the large difference in the delay that occurs between good and poor weather. **Table I-5** indicates that the average arrival delay currently exceeds 10 minutes in VFR2 conditions and exceeds 20 minutes in IFR conditions. VFR2 conditions occur 20 percent of the time and IFR conditions occur 24 percent of the time. Nearly 45 percent of the year, the average arrival delay is 10 minutes or greater.

As the number of operations increase, the average delay in VFR2 and IFR weather conditions will increase exponentially, creating further discrepancy between good and poor weather delays, unless action is taken to address the poor weather airfield operating capability.

As is shown in **Table I-4,** current average all-weather delay exceeds 4 minutes. Average all-weather delay at Sea-Tac is expected to reach ten minutes of all-weather delay around the year 2002 based on an interpolation of data from the Capacity Enhancement Update. Because delay rises so quickly when average delay exceeds 4-6 minutes, improvements are needed today and current poor weather related delay is excessive, resulting in an inefficient airport.

As is shown in the preceding tables, the primary cause of current and future delay is associated with poor weather conditions. Thus, to achieve a reduction in overall delay, the poor weather arrival operating constraint must be addressed. To reduce delay during poor weather, a new runway separated by about 2,500 feet west of Runway 16L/34R is proposed to accommodate existing and future aircraft types. Its primary purpose would be to enable two separate arrival streams to Sea-Tac during poor and good weather, thus increasing the efficient operating capability of the Airport during peak periods.

(2) Provide Sufficient Runway Length to Accommodate Warm Weather Operations Without Restricting Passenger Load Factors or Payloads For Aircraft Types Operating to the Pacific Rim.

Present runway lengths at Sea-Tac require airlines to off-load payload (passengers or cargo) to enable takeoff during warm weather conditions when serving the most distant cities. With increased emphasis on direct service to Asian-Pacific cities, this constraint is expected to interfere with efficient air transportation.

The length of runway required by departing aircraft is significantly affected by temperature, especially at higher temperatures and humidity. Aircraft must occasionally depart with less than the desired payload (passengers and/or cargo) due to combinations of high temperature, heavy payload, and long flight distance.

The Master Plan Update examined runway lengths relative to cities currently served from Sea-Tac, as well as cities likely to be served in the future. This analysis showed that flight distances to the Pacific Rim are the greatest. Hong Kong, the economic and trade hub of the Pacific Rim, is the most distant market currently served from Sea-Tac (approximately 6,489 miles). A B747-200B requires approximately 12,500 feet of runway length with a full passenger load to fly non-stop to Hong Kong from Sea-Tac or to reach Shanghai with a full passenger or cargo load at 76°F. Sea-Tac's current runway lengths are:

Length (ft)	Runway
9,425	16R/34L
11,900	16L/34R

Departures at Sea-Tac currently experience takeoff weight penalties due to the runway lengths when the destination distance is over 4,500 miles. By the year 2020, approximately 681 departures annually (0.3 percent of all departures or 1.3 percent of passenger aircraft and 15.3 percent of all-cargo aircraft) will be subject to takeoff weight penalties.

This loss of weight operating capability would result in passengers and cargo not getting to their destinations as desired or increase operations to serve the demand. In the year 2000, this could result in severe interference with air transportation. One measure of the air transportation deficiency is that it could result in an annual economic loss of $1.2 million, growing to $2 million annually by 2010 and $3 million by 2020 to the airlines.[8]

Over 90 percent of the weight restricted departures would be by all-cargo operators. Currently 10 percent of the cargo transported through Sea-Tac is destined for the Pacific Rim. Economists predict that the Pacific Rim will continue to experience above average economic growth in the foreseeable future. To ensure the Region's ability to handle unrestricted current and future passenger and cargo demand for access to the Pacific Rim, the Master Plan Update proposes to meet the need for a runway with a length of 12,500 feet by extending Runway 34R by 600 feet.

8/ "Cost-Benefit Analysis of 600 foot Extension of Runway 34R" memo from P&D Aviation to the Port of Seattle, November 15, 1994.

AR 038798

(3) Provide Runway Safety Areas (RSAs) that Meet Current FAA Standards.

An RSA is "A defined surface surrounding the runway prepared or suitable for reducing the risk of damage to airplanes in the event of an undershoot, overshoot, or excursion from the runway".[9] When the runways at Sea-Tac were originally built, they met then-current FAA design standards. However, as a result of aircraft overruns and incidents at airports in the U.S., the FAA modified the standards. In 1987, the FAA modified Federal Aviation Regulation 139.309(a)(2) that requires:

> "To the extent practicable, each certificate holder shall provide and maintain for each runway and taxiway which is available for air carrier use - (2) If construction, reconstruction, or significant expansion of the runway or taxiway began on or after January 1, 1988, a safety area which conforms to the dimensions acceptable to the Administrator at the time construction, reconstruction, or expansion began ...".

The FAA issued a grant to the Port which includes the following condition:

> "13. By acceptance of this grant, the sponsor agrees that the safety areas for Runway 16L/34R will be improved to dimensions acceptable to the FAA on the following schedule.... September 1996 safety areas to be complete".[10]

Subsequently, the Port requested and received approval to address the RSA alternatives in the Master Plan Update.

The RSA dimension for Sea-Tac is defined as a rectangular area centered about the runway that is 500 feet wide the length of the runway and extends 1,000 feet beyond each runway end. In addition to the two-dimensional standards, FAA has longitudinal and transverse gradient standards for RSAs. The RSA should be cleared, drained and graded, and is usually turfed. Under dry conditions, this area should be capable of supporting occasional aircraft that could overrun the runway without causing structural damage, as well as fire fighting and snow removal equipment.

The existing RSA deficiencies are:

<u>Runway 16L/34R</u> - while the RSAs for the north and south meet the grade standards, they are not of the correct length. Horizontal issues are:[11]

16L The current RSA is 700 feet long, with an irregular width up to 500 feet. South 154th Street is located within the RSA.

34R The present RSA is 535 feet long and 500 feet wide.

Due to the displaced threshold, the available landing length is 10,680 feet.

<u>Runway 16R/34L</u> [12] - The north RSA of this runway does not conform to transverse and longitudinal grade standards and does not meet horizontal standards:[13]

16R The current RSA is 645 feet long with widths varying from 130 feet to 500 feet. The longitudinal grade out to about 645 feet meets FAA standards, but increases to 2:1 out to an airport service road and South 154th Street.

Federal Aviation Regulation (FAR) 139.309(a)(2), and subsequent acceptance of a grant to maintain an existing runway, mandates that the Port of Seattle bring the RSA's for 16L/34R into compliance with FAA standards. To ensure compatibility with the overall airport needs, the FAA agreed to allow the Port to determine the appropriate means of complying during the Master Plan Update. Thus, the Master Plan Update recommends that the RSAs be upgraded to current FAA design standards in accordance with grant assurances and FAR Part 139.

[9] FAA Advisory Circular 150/5300-13, <u>Airport Design</u> Chapter 3, Runway Design.

[10] Grant #33, Page 5.

[11] "Declared Distance Criteria Application Study for Runway 16L-34R at Seattle-Tacoma International Airport", Port of Seattle, September, 1991.

[12] Following completion of a Declaration of Non-Significance, the Port brought Runway End 34L into compliance in 1995.

[13] *Runway Safety Area Expansion Study - Preliminary Engineering Study for Runway 16R/34L*, HNTB, March, 1992

(4) Provide Efficient and Flexible Landside Facilities to Accommodate Future Aviation Demand.

As was described in Chapter I, Section 2 "Aviation Demand Forecasts", regional population and employment growth are expected to fuel growth in aviation demand regardless of the availability of facilities at Sea-Tac Airport. Shown below is the growth in passengers and operations:

	Percentage Growth	
Time span	Passengers	Operations
1993-2000	27%	12%
1993-2010	63	20
1993-2020	100	30

While enplaned passenger volumes are forecast to grow by 100 percent by 2020, air cargo tonnage is expected to grow 131 percent. This anticipated growth will place extreme demands on the existing airport facilities. Congestion currently exists on the Main Terminal roadway during peak hours.

By year 2020, significant congestion could result throughout the day. Therefore, to avoid congestion and passenger inconveniences, improvements to the landside facilities will be necessary. Flexibility will be required to enable airport facilities to be accommodated by varying types of airlines (low-cost operators, shuttle operations, as well as long-haul), cargo operators as well as aircraft maintenance needs. **Table I-6** lists the current facilities and identifies the facilities that will be necessary to meet the forecast demand in the year 2020.

Currently, airport facilities at Sea-Tac provide 90 narrow-body equivalent aircraft gates (NBEG) within 12,100 linear feet of gate frontage.[14] Based on the forecast of aviation demand, Sea-Tac Airport will require 101 NBEG gates by 2000, 111 NBEG gates by 2010 and 120 NBEG gates by the year 2020. Thus, Sea-Tac will require an additional 30 passenger gates by year 2020.

Over the last decade, several airlines have examined the possibility of developing aircraft maintenance bases at various airports throughout the country. In 1990, Northwest Airlines approached the Port concerning the development of the A-320 aircraft maintenance base, a new aircraft being added to the carrier's fleet mix. Later, Northwest Airlines chose Minneapolis for this base. In 1991, Alaska Airlines also approached the Port with a similar request for a maintenance base to accommodate 5 narrow-body aircraft and the ability to accommodate B-757 and B-767 aircraft.

Based on these requests, and anticipated future requests, the Port initiated the necessary planning and design to assure that a base maintenance facility can be accommodated at Sea-Tac Airport. These plans have become known as the South Aviation Support Area (SASA) development plan and were assessed in a 1994 Final Environmental Impact Statement/Record of Decision

While Alaska Airlines has determined that they will not proceed with their maintenance base project at this time, the Port expects that additional proposals of this type are likely to arise, as economic conditions within the airline industry improve. The benefits of such a facility are the resulting high-skill jobs and economic activity which meet the Port of Seattle's mission of fostering regional economic development. See Chapter IV, section 8 "Induced Socio-Economic Impacts" concerning the current impacts of Sea-Tac Airport on the local economy. In addition, because of the Region's dominance in the construction and maintenance of aircraft and aircraft parts, it is likely that the job skills of the Region's populace will attract such development.

To ensure that the Region's primary aviation facility is capable of efficiently accommodating forecast air travel demand generated by area economic activity and population, the Port of Seattle proposes to incrementally expand the passenger terminal, support facilities and landside.

14/ Source: P&D Aviation. Narrow Body Equivalent gates is a theoretical measurement calculated by dividing linear gate frontage by the average frontage required of a narrow-body aircraft. Sea-Tac currently has the following gates: 12 Group IV (B747), 14 Group IV (other wide body), 48 Group III (narrow body), and 1 Group II (commuter).

TABLE I-6

Seattle-Tacoma International Airport
Environmental Impact Statement

EXISTING FACILITIES AND FUTURE FACILITY NEEDS

Facility	Existing	Year 2020 Requirements
Cargo Area		
Warehouse & Office (SF)	626,366	1,314,000
Truck Docks	259	544
DC-10 Parking	18	35
Air Mail Facility site (acres)	9.7	9.7
General Aviation		
Signature (acres)	2	2
Weyerhaeuser (acres)	3	3
Air Traffic Control		
Tower Site (acres)	N/A	3
TRACON Site (acres)	N/A	5
Airport Rescue and Fire Fighting Site (acres)	2.5	4
Airline Maintenance		
Alaska Hangar (SF)	144,000	144,000
Delta Hangar	82,000	82,000
Northwest Hangar	114,000	114,000
Aircraft Gates (Narrow Body Equivalent Gates)	90	120
Passenger Terminal Space (SF)	1.9 million	3.0-3.4 million
Curb Lengths		
Ticketing level (LF)	2,560	5,230
Baggage level (LF)	3,136	6,272
Small Transit Vans(LF)	750	1,500
Subtotal	6,446	13,002
Parking Spaces		
Garage - Short Term	1,000	2,000
Garage - Long Term	7,000	10,750
Garage - Rental Cars	1,000	2,000
Garage - Other/Employees	400	100
Subtotal	9,400	14,850
Large Transit	40	80
Employee Lot	4,500	8,000
Cargo Area	1,173	2,460
Off -Site Private	9,500	N/A

Source: P&D Aviation
LF = Linear Feet
SF = Square Feet

TABLE II-1
Page 1 of 2

Seattle-Tacoma International Airport
Environmental Impact Statement

SUMMARY OF ALTERNATIVES CONSIDERED

(1) Improve The Poor Weather Airfield Operating Capability In A Manner That Accommodates Aircraft Activity With An Acceptable Level of Aircraft Delay

Alternative	Evaluation
A. Use of Other Modes of Transportation	Not considered further, as this alternative will not address the poor weather operating issues at Sea-Tac. Less than 5% of passengers using Sea-Tac are traveling to distances where surface transportation is efficient and cost effective.
B. Use of Other Airports or Construction of a New Airport	Not considered further. Regional consensus has been established through PSRC EB-94-01 as: 1) there is no sponsor or funding for a new airport; 2) Extensive studies of these alternatives indicate that there are no feasible sites; 3) If a site could be identified, market forces and planning/development requirements would prevent the airport from successfully serving regional demand until 2010 or later. The FAA and Port have independently concluded that a new airport would not satisfy the needs addressed by this EIS.
C. Activity/Demand Management	Not considered further, as these actions will not eliminate the poor weather operating need.
D. Runway Development at Sea-Tac	To be considered further: Runway lengths from 7,000 feet to 8,500 feet (Alternatives 2, 3 and 4 in this EIS).
E. Use of Technology	Not considered further. No technologies currently exist, or are planned, to address the poor weather operating constraint at Sea-Tac.
F. Delayed or Blended Alternative (Combination of other modes, use of existing airports, and activity/ demand management)	The net result of this alternative would be a delay in the implementation of the Master Plan Update alternatives. Because there is no commitment to any individual or combination of other alternatives and because aviation activity levels are currently growing at a rate slightly higher than forecast, this alternative was not considered further.
G. Do-Nothing/No-Build	To be considered further (Alternative 1 in this EIS).

(2) Provide Sufficient Runway Length to Accommodate Warm Weather Operations Without Restricting Passenger Load Factors or Payloads For Aircraft Types Operating to the Pacific Rim

Alternative	Evaluation
A. Extension of Runway 16L/34R to 12,500 feet	To be considered further, as this is presently the longest runway.
B. Extension of Runway 16R/34L to 12,500 feet	Not considered further due to the cost of addressing impacts to S. 188th Street.
C. Development of a new 12,500 ft long runway	Not considered further due to substantial community disruption and unnecessary cost that would result.
D. Delayed Alternative	Not considered further, as it would not address the needs of Sea-Tac
E. Do-Nothing/No-Build	To be considered further (Alternative 1 in this EIS)

TABLE II-1
Page 2 of 2

Seattle-Tacoma International Airport
Environmental Impact Statement

SUMMARY OF ALTERNATIVES CONSIDERED

(3) Provide Runway Safety Areas (RSAs) that Meet Current FAA Standards

Alternative	Evaluation
A. Displaced Threshold/Declared Distance Procedures	Considered as the Do-Nothing/No-Build.
B. Clearing, grading and development of areas for 1,000 feet beyond the existing pavement	Considered further.
C. Clearing, grading for 1,000 feet including the 600 ft extension to 34R	Considered further.
D. Delayed Alternative	Not considered further, as it would not address the RSA requirements. However, this would be the same as the Do-Nothing
E. Do-Nothing/No-Build	To be considered further for declared distances (Alternative 1).

(4) Provide Efficient and Flexible Landside Facilities to Accommodate Future Aviation Demand

Alternative	Evaluation
A. Use of Other Modes of Transportation	Not considered further, as less than 5% of the future passengers using Sea-Tac are traveling to distances where surface transportation is efficient and cost effective and likely to be used.
B. Use of Other Airports or Construction of a New Airport	Not considered further. Regional consensus has been established through PSRC EB-94-01 as: 1) there is no sponsor or funding for a new airport; 2) Extensive studies of these alternatives indicate that there are no feasible sites; 3) If a site could be identified, market forces and planning/development requirements would prevent the airport from successfully serving regional demand until 2010 or later.
C. Activity/Demand Management	Not considered further, as these actions will not reduce demand.
D. Landside Development at Sea-Tac	To be considered further. Three primary alternatives to be considered further: Central Terminal Development, North Unit Terminal Development and South Unit Terminal Development (Alternatives 2, 3 and 4, respectively in this EIS).
E. Delayed or Blended Alternative (Combination of other modes, use of existing airports, and activity/demand management)	The net result of this alternative would be a delay in the implementation of the Master Plan Update alternatives. Because there is no commitment to any individual or combination of other alternatives and because aviation activity levels are currently growing at a rate slightly higher than forecast, this alternative was not considered further.
F. Do-Nothing/No-Build	To be considered further (Alternative 1 in this EIS)

Source: Landrum & Brown

AR 038803

TABLE II-2

Seattle-Tacoma International Airport
Environmental Impact Statement

SUMMARY OF SEA-TAC AIRPORT ORIGIN-DESTINATION PASSENGERS FOR THE TOP 25 CITIES

City	% of O&D Passengers [1]	Air Miles [2]	Road Miles [3]
Los Angeles Area	10.6%	830	1,134
San Francisco Bay Area	9.6%	590	816
Hawaiian Islands	4.6%	2,328	N/A
New York/Newark	3.9%	2,081	2,841
Chicago	3.2%	1,510	2,052
Anchorage	3.0%	1,259	2,349
Reno	2.9%	490	754
Portland, OR	***2.7%***	***113***	***174***
Denver	2.7%	886	1,341
Washington, D.C.	2.6%	2,023	2,721
San Diego	2.6%	886	1,341
Phoenix	2.5%	913	1,258
Las Vegas	2.1%	962	1,465
Santa Ana/Laguna Beach	2.1%	830	1,134
Minneapolis/St. Paul	2.1%	1,216	1,653
Spokane	***2.0%***	***194***	***280***
Dallas/Ft. Worth	2.0%	1,459	2,131
Boston	1.8%	2,170	3,016
Atlanta	1.5%	1,897	2,625
Detroit	1.3%	1,689	2,327
Orlando	1.2%	2,215	3,088
Houston	1.1%	1,626	2,369
Salt Lake City	1.1%	599	848
Philadelphia	1.0%	2,068	2,816
Sacramento	1.0%	526	715
Subtotal	71.2%	—	—
Other Cities	28.8%	—	—
TOTAL	100.0%	—	—

1/ Seattle-Tacoma International Airport, *1993 Airport Activity Report*, Port of Seattle.

2/ World City Distance, computer software.

3/ *Rand McNally Road Atlas*. Rand McNally. 1990.

Data compiled by Landrum & Brown: Oct. 20, 1994.

Steering Committee (HSGTSC) completed a comprehensive feasibility assessment of true high speed rail service. The HSGTSC evaluated train service at two maximum speed levels, 185 mph and 300 mph. The two levels of service were projected to provide average train speeds of 105 mph and 135 mph, respectively. Twelve trains a day were used as a baseline for system analysis. The most feasible location for the N-S high speed transportation corridor has been identified by WSDOT as east of Lake Washington and the City of Bellevue, WA, which is substantially east of Sea-Tac International Airport.

A new high speed system would require new rights-of-way, electrification, grade separation, other infrastructure, and stations. The 334 mile N-S corridor between Portland and Vancouver, BC is estimated to cost between $9.03 and $11.95 billion. The 256 mile East-West corridor between Seattle and Spokane is estimated to cost between $5.5 and $7.3 billion. Development of this service is not considered reasonable until after the year 2020 due to the costs.

Ridership forecasts for the 185 mph and 300 mph service included both diversion of existing and projected automobile and air travelers, plus new induced trips. While discretionary travelers would comprise approximately two-thirds of all projected riders, new service in the N-S corridor could be attractive to the business traveler and competitive with air travel.

Despite the potential for true high speed rail to compete with air travel, this rail option has been determined to be infeasible as an alternative to satisfying the poor weather arrival delay needs at Sea-Tac. Data supporting this determination are described in the following points.

- The development horizon for true high speed rail is beyond the planning period for the Sea-Tac International Airport Master Plan Update (2020). This long term planning and implementation period makes high speed rail an infeasible alternative. This conclusion is supported by the PSRC's Expert Arbitration Panel on Noise and Demand/System Management Issues in their December 8, 1995 final order on the demand/ system management issue.

- Based on origin and destination characteristics of Sea-Tac passengers, it is estimated that less than 5% of air passengers could be drawn to use rail by 2020 if an efficient 185 mph high speed rail system were available in that timeframe.

- WSDOT estimates that, if high speed rail were available by 2020, diversions between air and high speed rail would represent 1% of all air travel passengers and less than 2% of airport operations.

- Federal funding support for Amtrak is declining and congressional committees have proposed to phase out federal funds over the next six years, including support for new service improvements.

Improved Conventional Higher Speed Rail Service - maximum speeds of 125 mph

Washington State determined that an incremental approach to establishing higher speed rail service with maximum speeds of 125 mph would be appropriate and cost effective. Improved conventional passenger rail service objectives include: improvements to intermodal facilities, eight daily round trips from Seattle to Portland, and three daily round trips between Seattle and Vancouver, BC. The WSDOT ten-year service improvement program would provide a trip of 2 hours 50 minutes between Seattle and Portland and a trip of 3 hours 55 minutes from Seattle to Vancouver, BC. Program improvements will result in 50 to 60 mph average train speeds in the corridor. Train speeds would continue to vary from 10 mph up to the new maximum limit of 125 mph.

Implementation of the state rail improvement program is contingent upon several factors. These include (1) obtaining state and local governments' consent to increase train speeds and frequency; (2) safety, capacity, and track improvements; (3) increased freight train speeds; (4) continued provision of rail service by Amtrak; and (5) funding of the rail program by the State.

CHAPTER II
ALTERNATIVES

Federal and state guidelines concerning the environmental review process require that all reasonable alternatives which might accomplish the objectives of a proposed project be identified and evaluated. The examination of alternatives is of critical importance to the environmental review process and serves to establish the conclusion that an alternative that addresses the project purpose and might enhance environmental quality (or have a less detrimental effect) has not been prematurely dismissed from consideration. **Table II-1** lists the alternatives that were identified to satisfy the individual needs.

1. INDIVIDUAL ALTERNATIVES TO SATISFYING THE NEEDS

As described earlier, a wide range of alternatives have been considered for meeting the air capacity needs of the Puget Sound Region, including the studies and documents listed in **Appendix B** which are incorporated into this Environmental Impact Statement by reference. This section summarizes and supplements certain information and analysis included in these prior studies, in addition to considering other alternatives to meet the needs identified in the preceding section. In general, it is anticipated that the improvements would occur commensurate with growth in aviation activity.

(1) Improve The Poor Weather Airfield Operating Capability In A Manner That Accommodates Aircraft Activity with an Acceptable Level of Aircraft Delay.

The following alternatives were identified:

(A) Use of Other Modes of Transportation

(B) Use of Other Airports or Construction of a New Airport

(C) Activity/Demand Management

(D) Runway Development at Sea-Tac

(E) Use of Technology

(F) Delayed or Blended Alternative

(G) Do-Nothing/No-Build

The following paragraphs define these alternatives and evaluate them based upon their ability to satisfy the needs identified by this EIS.

(A) Use of Other Modes of Transportation Alternatives

Alternative modes of transportation were evaluated in terms of their capability to divert passengers and cargo from Sea-Tac by offering alternative modes of meeting their needs. Of critical importance to the evaluation are such factors of trip characteristics and travel needs of the freight shippers and air passenger and the feasibility of using alternative modes. Alternative modes considered include: automobile, rail and bus service, and telecommunications/ video conferencing.

1. Bus and Automobile Modes

A review of the trip characteristics of air travelers who utilize the Airport indicates that a majority begin or end their trip at a point more than 500 miles from the Puget Sound Region. As the majority of freight/cargo is transported in the cargo section of passenger aircraft, and about 65 percent of cargo is bound for continental U.S. cities, the profile of cargo destinations is assumed to be the same as for passengers. **Table II-2** lists the origin-destination (O&D) data of the top twenty-five markets for Seattle-Tacoma International Airport travelers and compares the distances to these cities in air miles and highway miles. These top twenty-five markets serve slightly more than 71 percent of the scheduled O&D passengers.

Alternative modes of transportation, such as rail, bus, or automobile, offer feasible alternatives to freight shippers and air travelers, particularly those traveling 500 miles or less. As shown in **Table II-2**, only two of the top twenty-five market cities (Portland and Spokane) fall within both the 250 air mile radius and 500 road miles or less. Beyond 250 air miles or 500 roadway miles, alternative modes of transportation become less desirable. During the winter, road access between eastern-western Washington cities can be undependable because of snow in the mountains. Costs of fuel and the value of time require that people or goods traveling long distances do so in a quick and efficient manner to minimize travel time and associated costs.[1] For those reasons, use of bus or automobile modes as an alternative to Sea-Tac is not reasonable for most air travelers or freight shippers. Thus, it can be concluded that bus and automobile modes are not a feasible alternative to accommodating forecast air traffic demand.

2. **Rail Technology**

Rail service alternatives were evaluated in order to assess their potential to address the increasing air travel demands and poor weather arrival delay issues at Seattle-Tacoma International Airport (Sea-Tac) within the 2020 planning horizon. The feasibility of rail as an alternative is contingent upon the ability of rail service to successfully compete with air transportation in markets within 500 miles of Sea-Tac, thereby diverting some passengers from air to rail and reducing the number of operations at Sea-Tac. The potential of rail to divert air passengers is based upon a series of factors such as time competitiveness and frequency of service. Only two of the top twenty-five markets, Portland and Spokane, fall within 500 road miles of Sea-Tac. Vancouver, BC also meets this distance criterion, but is not a major origin or destination city for air travel from Sea-Tac (less than 1% of O&D passengers).

Three rail alternatives offering different levels of service were reviewed and evaluated. These included:

- High Speed Rail Service, with speeds over 150 mph,
- Higher Speed Conventional Rail Service, with maximum speeds of 125 mph, and
- Current Rail Service, with maximum speeds of 79 mph.

The review and evaluation were based upon Washington State Legislative and WSDOT studies completed since 1989, freight and passenger rail plans, and discussions with the Washington State Department of Transportation (WSDOT) and Amtrak. A more complete summary of this information is presented in **Appendix B - Studies of Alternatives**. Based upon this review and evaluation, it has been concluded that rail service improvements would not have a substantial effect on the level of operations at Sea-Tac International Airport before 2020. This conclusion is valid for true high speed service with speeds over 150 mph., higher speed conventional rail service with speeds up to 125 mph, and current conventional passenger service with train speeds up to 79 mph.

Factors leading to this determination include:

(1) air passengers traveling to markets within 500 miles of the Airport comprise less than 5 percent of all passengers at Sea-Tac, so the potential impact of diversions is limited;

(2) the potential for current or improved conventional rail service to divert a significant number of passengers from air is low, since travel times and frequency of service are not competitive with air travel;

(3) true high speed rail service that could compete with air transportation will not be implemented until after 2020;

(4) increases in rail ridership are projected to continue to come from the pleasure and discretionary travel markets; and

(5) funding for needed rail improvements is not committed beyond the two year appropriation by the State.

The following discussion provides a detailed evaluation of each rail service option.

True High Speed Rail Service, with speeds over 150 mph

Between 1991 and 1992, the WSDOT and the High Speed Ground Transportation

[1] *The Semantics of Air Passenger Transportation.* MacNeal, Edward. 1981.

Higher speed conventional rail service (up to 125 mph) has been determined to be inadequate as an alternative for satisfying the poor weather arrival delay needs at Sea-Tac. This analysis is supported by the PSRCs Expert Panel on Noise and Demand/System Management in their December 8, 1995 final order on system/demand management. Factors leading to this conclusion are identified below:

- After the implementation higher speed conventional train service, WSDOT analysis projects that train ridership would continue to reflect the discretionary and pleasure travel markets. Higher speed trains would operate on schedules of 2 hours 50 minutes for the trip between Seattle and Portland and 3 hours 55 minutes for the Seattle to Vancouver, BC trip. These times would not be competitive with air travel.

- As noted earlier, true high speed rail is the mode that would be the most competitive with air service. WSDOT forecast that true high speed rail might divert 1% of all air passengers. Since higher speed conventional rail would provide slower service than true high speed rail, the potential diversion from air to higher speed conventional rail would be an even smaller percentage of those passengers.

- O&D passengers in markets within 500 miles that would be served by improved conventional rail constitute less than 5% of all passengers at Sea-Tac (the percentage of O&D passengers traveling between Sea-Tac and the top 25 cities is summarized in **Table II-2**). Thus, the potential impact of diversions is limited.

- The provision of higher speed conventional rail service is contingent upon the continued provision of service by Amtrak as well as funding of the Washington State Rail Program. To implement the 20 year rail strategy, it is estimated that $802 million will be needed to meet intercity rail passenger service objectives in the Seattle-Portland corridor alone. The passenger program does not have a dedicated source of funding and is dependent on a state biennial appropriation. The 1995-97 funding allocation is approximately $34.4 million, down from $40.2 million for 1993-95. Twelve million dollars of the current appropriation is designated for the purchase of one tilting trainset. Legislative budget support is described as being dependent upon Amtrak's continued service and funding participation.

Current Rail Service -- maximum speeds of 79 mph

Current intercity passenger rail service is operated in the I-5 corridor by Amtrak. From Seattle, three daily round trip trains serve Portland, OR, one round trip train serves Vancouver, BC and one round trip train serves Spokane. Amtrak estimates travel times of 3 hours 55 minutes, 4 hours 35 minutes, and 7 hours 15 minutes, respectively.

Current train operations are slowed by track conditions, track geometry, speed limitations, slower freight traffic, crossings, station spacing, sight distances, train spacing, siding locations, and siding length. Train speeds in the North-South (N-S) corridor vary from 10 mph up to the current maximum of 79 mph. Passenger trains currently average between 40 and 50 mph within the corridor. The new Vancouver, BC service is using the new tilt train equipment, but because of track conditions and speed limitations the train operates within conventional Amtrak parameters not exceeding 79 mph.

The current frequency and level of intercity passenger rail service is not feasible as an alternative for addressing Sea-Tac's poor weather capacity needs. This conclusion is supported by the December 8, 1995 final order on these issues by the PSRC's Expert Panel on Noise and System/Demand Management. The following data supports this conclusion:

- Current Amtrak scheduled travel times from Seattle to Portland and Seattle to Vancouver, BC are 3 hours 55 minutes and 4 hours 35 minutes, respectively. These travel times and frequencies are not competitive with air travel.

AR 038808

- Current and future train ridership increases will continue to come from automobile and bus operations, where travel times and services are competitive. Ridership will continue to reflect the discretionary and pleasure travel markets.
- Potential reductions in federal support for Amtrak will either cause reductions in the current level of service provided or will necessitate new operating efficiencies and cost reductions in order to retain the level of service. The fall 1995 federal transportation budget debate contains several proposals that, if enacted, would limit future Amtrak funding and operations, including a proposal to end federal funding in six years.

Conclusions

In summary, all three levels of rail service evaluated (true high speed service, higher speed conventional service, and current service) have been determined to be infeasible as alternatives for addressing the need identified by this EIS. Six general conclusions support this determination: (1) true high speed rail is beyond the 2020 planning horizon; (2) less than 5 percent of all Sea-Tac passengers have destinations within 500 miles of Sea-Tac and might consider rail as an alternative to air; (3) current service and higher speed conventional service will not provide travel times that are competitive with air travel; (4) increases in rail ridership are projected to continue to come from the pleasure and discretionary travel markets; and (5) funding for rail improvements is undetermined beyond the current two year state appropriation. This conclusion is also supported by the PSRC's Expert Panel on Noise and Demand/System Management.

3. <u>**Telecommunications and Video Conferencing**</u>

Video technology has been around for almost 30 years, and offers (with service improvements) the potential to serve a portion of the air travel market throughout the country. With technology that has been developed but available in limited quantities, video conferencing and collaborative computing could serve as an alternative mode of satisfying the need for air travel. The following paragraphs summarize the current understanding of the probable impact of such technology on future air travel demand.

Considerable progress has been made in the last decade in improving the reliability and speed of voice and data communication. While high speed communication services can be provided over existing telephone lines, the widespread installation of fiber optics and state-of-the-art electronic signal technology are expected to result in notable technological improvements in the next decades. Similar to the swift pace in which desktop computers have become an integral part of society, high speed communication technology is expected to be available in year 2010 (such that most companies will have access) and 2020 (most workers will have access) time periods.

Two primary studies have been conducted to assess the impact of communication technology on air travel demand.

A Strategic Assessment Report[2/] for the Massachusetts Aeronautics Commission indicated that by 2010, a reduction in air travel passenger demand of 7 percent at Boston Logan could occur as video conferencing is used as a substitute for air travel. By 2030, video conferencing could reduce demand by 15 percent at Logan. Key findings of this study that may be applicable to Sea-Tac:

- For non-discretionary travel (typically a business traveler), video conferencing has the potential to satisfy some portion of trip demand. This study estimated between 5 percent to 30 percent of travel, depending on trip purpose;
- For discretionary travel (i.e., vacations) technology is believed to be very limited (less than 5 percent).

2/ *Strategic Assessment Report*, Massachusetts Aeronautics Commission by Arthur D. Little, July 1993.

Industry-wide, it is anticipated[3] that telecommunication has the potential to reduce business-related air travel demand by 11 percent and overall air travel demand by 4 percent.

At Sea-Tac, approximately 41 percent of air travelers use Sea-Tac for business trips, while 59 percent use the Airport for pleasure/personal trips. Applying the findings of the studies noted above to Sea-Tac, less than 5 percent of air travel demand could be satisfied by communication technologies by the year 2010 (when data and video-conferencing is expected to be available on a limited basis within most companies). By 2020, when such technology is expected to be widespread (on most desks - similar to the availability of desktop computers today), it would reduce air travel by less than 9 percent.

A report also notes that "..it is reasonable to suggest that demand for air travel will increase as workers become more efficient and productive: cost savings and productivity gains will enable a significantly higher number of companies to sell their products and services in areas not targeted before due to higher operating costs. These activities will lead to additional demand for business air travel services."[4]

Therefore, communication technologies are not a reasonable alternative to air service need in the time period of the improvements at Sea-Tac Airport.

* * * *

Based upon the information and analysis discussed above and the studies incorporated herein, it is unlikely that alternative modes of transportation, such as rail (traditional or high speed), automobile/bus and communication technologies, can provide a suitable solution to the needs identified by this EIS.

(B) Use of Other Airports or Construction of a New Airport Alternatives

This section presents a review of the ability of other existing area airports and undeveloped sites to reduce the existing and future poor weather delay constraint at Sea-Tac and to accommodate future air travel demand. During this study, as well as during the Flight Plan Study, three scenarios of new airport development were considered:

<u>Replacement Airport</u> - Through this concept, Sea-Tac would be closed upon the development of a single new airport that would accommodate long-term aviation demand.

<u>Supplemental Airports</u> - A supplemental airport would result in a two or more airport system. During the Flight Plan Study, it was "decided that Sea-Tac should serve as the primary airport", with the supplemental airport serving to relieve Sea-Tac. Two supplemental airport concepts exist:

Major Supplemental - A major supplemental airport would result in two new independent parallel air carrier length runways at either a new or existing airport(s).

Supplemental - This concept would result in the development of one new air carrier length runway at a new or existing airport.

As is shown in the following sections, the development of a new airport will not address the poor weather conditions at Sea-Tac or serve the demand for air travel in the Puget Sound Region for the following key reasons:

1. There is no sponsor, identified source of funds or acceptable site for a new airport;
2. Extensive study of this issue resulted in the consideration of all alternatives for addressing air transportation capacity issues in this Region. Based on this process, the Puget Sound Regional Council (PSRC) adopted Resolution A-93-03 and EB-94-01 confirming that no feasible sites exist; and
3. If a new site could be identified, market forces would not enable it to successfully compete with Sea-Tac until regional origin and destination air travel demand exceeds 10 million enplanements

[3] *Making Connections, How Telecommunications Technologies Will Affect Business and Leisure Air Travel*, by Apogee Research, 1994.

[4] *Making Connections, How Telecommunications Technologies Will Affect Business and Leisure Air Travel*, by Apogee Research, 1994.

annually - currently forecast to occur around the year 2010.

The Port of Seattle and the FAA have reviewed the regional planning studies and have independently concluded that a supplemental airport would not satisfy the needs addressed by this Environmental Impact Statement. The following sections elaborate on why a supplemental or replacement airport is not a reasonable alternative.

1. **Regional New Airport Planning Activities**

Both the 1988 Sea-Tac Airport Comprehensive Planning Review and the 1988 Puget Sound Council of Governments (PSCOG, since renamed Puget Sound Regional Council) Regional Airport System Plan concluded that the existing two Sea-Tac runways would not be adequate to meet regional air travel needs beyond the year 2000. As a result, the Port of Seattle and the PSCOG entered into an interlocal agreement to co-sponsor a process to identify a long-term solution to the Puget Sound Region's air transportation needs. Known as the Flight Plan Study, this effort recommended a multiple airport system that included a new runway at Sea-Tac Airport. Two supplemental airports were suggested: Paine Field in Snohomish County (north of the Airport), and another airport to be located somewhere in Pierce County (south of the Airport).

Also in response to the Flight Plan Study and an additional study by the PSRC, the PSRC General Assembly adopted a Resolution No. A-93-03 in April 1993 to amend the Regional Airport System Plan (RASP). The PSRC resolution states: "...That the region should pursue vigorously, as the preferred alternative, a major supplemental airport and a third runway at Sea-Tac" subject to the six issues identified in Chapter I (Page I-3).

During the first phase of the Major Supplemental Airport Study conducted by the PSRC, a list of 25 potential sites were identified. This list was then narrowed to 12 for more consideration. Based on this more detailed review, three sites were initially recommended for a detailed study during the second phase of the Study. The three sites recommended by the working group were: Tanwax Lake, Marysville East and Arlington, which each included an evaluation of two alternative site locations (**Appendix B** contains a detailed summary of this study and the specific sites considered). However, a substantial amount of opposition arose concerning the feasibility of developing a new airport at these sites due to land use and environmental impact concerns.

The PSRC Executive Board, the group responsible for preparing a study of the need and feasibility of a supplemental airport found: "there are no feasible sites for a major supplemental airport within the four-county region and that continued examination of any local sites will prolong community anxiety while eroding credibility of regional governance."[5]

The reports and findings of the Flight Plan Study and the Major Supplemental Airport Study were used as the basis for evaluating the use of other airports. Therefore, these reports are included by reference.

2. **New Airport Alternatives**

Based on the review summarized in this chapter, a replacement airport is not a reasonable, feasible or prudent solution to the near-term constraints at Sea-Tac Airport. In addition, a major supplemental (two independent runways) and a supplemental (one runway) airport were also found to be unreasonable. Additional details leading to these conclusions are provided below.

a. **Replacement Airport**

The analysis of alternative sites was initiated with the assumption that either an existing airport could replace Sea-Tac Airport or a new airport could be developed with air and surface accessibility similar to the proposed improvements at Sea-Tac. Sites considered during these planning efforts included locations in

[5] Resolution of the Executive Board EB-94091, October 27, 1994.

the four county Region, as well as outside the Region. A replacement airport was assumed to result in the closure of Sea-Tac. If all existing or forecast air carrier traffic were transferred to a new airport, the new airport would require three parallel runways to operate efficiently in the year 2020. Assuming that all air carrier traffic operated at an alternative site, a minimum of 3,000 acres of land could be needed. This would essentially replace the facilities provided by Sea-Tac. Additional land, to provide an environmental buffer, would depend on the location and airport layout.

Several cities across the nation have studied the ability to create a new air carrier airport to replace or supplement an existing facility. However, only one new large airport development in the United States has occurred in two decades, the new Denver International Airport. In 1985, the Denver region came to a consensus that a new airport was needed to replace Stapleton. Such a conclusion was reached after extensive study of the airport capacity and environmental impact issues that would be associated with expanding Stapleton into the adjoining Rocky Mountain Arsenal. Accelerated planning and development was initiated for this facility, which cost over $4 billion when it opened in early 1995. Thus, this fast-track example shows that it is unlikely that a major new airport could be planned and developed in under 10 years, once the time consuming effort of consensus is established.

To complete all of the requisite studies for a Sea-Tac Airport replacement, the following steps would be necessary. Using conservative timing estimates, planning and development of a replacement airport could occur as follows:

- Replacement airport consensus (year 0)
- Site selection study (year 0 to 1)
- Master plan study (year 2-4)
- Environmental assessment/ impact statement (year 4-6)
- Funding and construction plans (year 6-7)
- Acquisition of necessary land (year 7-9)
- Construction of facilities (year 9-15)

Thus, if a consensus (which is a time consuming process) was established to pursue a replacement airport in 1996, a new facility could be available no sooner than 2006-2010. Additional facilities are needed at Sea-Tac Airport to relieve existing poor weather delay and forecast aviation demand growth. Thus, a replacement airport is not a feasible alternative to meeting the existing and future poor weather related needs of Sea-Tac. Expansion of Sea-Tac Airport would be required, even if this timetable could be accelerated by a few years.

b. <u>Supplemental Airport (One or Two Runways)</u>

Off-loading future growth in traffic at Sea-Tac Airport to an alternative supplemental airport would generate the need for a new facility that accommodates about 9.7 million annual enplanements by year 2020. This level represents the forecast growth above Sea-Tac's current 9.4 million enplaned passenger level. Based on generalized airport planning parameters, this activity level would correspond to an airport about the size of Sea-Tac today.

Similar to the replacement airport, a supplemental airport is not a reasonable solution to the poor weather delay issues at Sea-Tac. As is described in this section, a supplemental airport capable of addressing the need (1) is not compatible with regional planning; (2) would not be financially viable in the timeframe to address existing and future poor weather delay and growth in air travel demand; (3) can not be completed in the necessary time frame; and (4) does not have an identified sponsor or source of funding.

Compatibility with Regional Planning - As has been noted previously, the Region sponsored the Flight Plan and Major Supplemental Airport studies which lead to the determination by elected officials of the Region that no feasible site exists. Additional information concerning these planning efforts is provided in Appendix B.

Numerous sites in the Region have received attention as potential supplemental airports. Paine Field in Snohomish County and McChord AFB in Pierce County, presently could serve air carrier demand. In addition, Boeing Field has sufficient runway length to accommodate some portion of scheduled air carrier service. The following briefly summarized the issues associated with these existing facilities:

Paine Field: Located in Snohomish County, Snohomish County Airport (Paine Field) occupies 1,238 acres. This airport functions primarily as a general aviation facility, and is used extensively by Boeing Corporation. The airport has three runways, the longest of which is 9,080 feet. Boeing's Everett plant dominates the north side of airport property, while mixed light industrial development and some residential areas are predominant on the south. Reflecting widespread opposition from county residents, the Snohomish County Council voted in 1994 to oppose use of Paine Field as a supplemental airport.

McChord Air Force Base (AFB) - Joint use at McChord AFB was considered during the PSRC's Supplemental Airport Study. This effort found that due to the increased military mission at the AFB, joint use would not be practical or acceptable to the Air Force at this time. To enable joint use at other Air Force Bases in the country, separate civilian airside and landside facilities must be constructed, including an additional runway. Thus, due to the extensive study and coordination with the military to plan and develop such facilities, the ability of achieving joint use at McChord would likely prevent its use in the foreseeable future.

Boeing Field - King County International Airport is located 4 miles north of Sea-Tac. The airport occupies 647 acres of land, including a 10,001-foot long air carrier runway and a 3,780-foot runway. While this facility is a general aviation airport, it also serves Boeing Corporation, corporate jets, charter, and cargo. The area around Boeing Field is fully developed with commercial and industrial uses. Due to the close proximity of Boeing Field to Sea-Tac, extensive airspace coordination exists especially during poor weather conditions. Therefore, airspace and landside constraints make use of Boeing Field in a supplemental airport capacity infeasible. King County initiated a strategic master plan for Boeing Field in 1995.

Appendix B contains a summary of issues associated with these existing airport facilities, in addition to other airports in the Region.

It is recognized that commercial air service at an existing airport in the Region could be initiated at any time. It is likely that such air service would be by a charter or niche carrier (cargo, low-cost, etc.). However, such activity would not materially affect the demand at Sea-Tac and the resulting facility needs. Low-cost operators have historically initiated new service at an airport with 30 or less aircraft operations. As such, this would represent less than 3 percent of Sea-Tac's current daily aircraft operations - and would likely amount to less than 1 million enplanements a year (10 percent of Sea-Tac's enplaned passengers).

Market Considerations - A second factor leading to the determination that a supplemental airport is not a feasible alternative relates to the capacity of the regional market to support a second airport. A study of multiple airport systems found that origin and destination demand must reach a certain level before a two-airport system can survive economically. With forecast demand levels for the next 15 years, a supplemental airport (that successfully competes with Sea-Tac) would not be effective in serving the commercial passenger demand in the Puget Sound Region. That study found that a two-airport system will not succeed until the origin and destination (O&D) market within a city exceeds 10 million annual enplanements. When O&D enplanements are less, competition entices traffic to stay at the facility with the greater air service:

"These interactions inevitably lead to concentration as the only stable outcome. To visualize the process, imagine a region with two airports. Assume some starting situation as regards the airline schedules. The catchment areas that would correspond to this situation are inevitably unequal, meaning that more passengers would prefer one of the two airports. Some airlines, in deciding how to serve these sites, would naturally decide to provide more service to the busier airport in hopes of gaining a decisive advantage in this more lucrative site. Other airlines would match this attempt, improving overall service to the more popular airport. Passengers would respond to the better service, thus enlarging their catchment area of the more popular site. Airlines would respond next by reinforcing this tendency. And so on until benefits of further concentration are exhausted." Multi-Airport Systems in Metropolitan Regions, Richard deNeufville, Massachusetts Institute of Technology, March, 1986.

The O&D air service area in the Puget Sound Region is long and narrow, due to the geography of the area and distribution and location of population. As a result, the public has suggested, and the PSRC Supplemental Airport Study evaluated, segmenting this air service area into multiple passenger catchment areas - each supporting a commercial airport. During the PSRC study, one of the site evaluation criteria was the percentage of the Puget Sound Region population that was 10 minutes closer to a site than are presently closer to Sea-Tac. The greatest accessibility (associated with the Bothell/Mill Creek site) is 31% of the Puget Sound Region. Thus, it is only likely that 31 percent of the population would have a locational reason for use of a new airport site. As a result, the competitive forces described by deNeufville's study indicate that air service would likely consolidate at Sea-Tac, which would remain the Region's primary airport.

As is noted in **Table I-2**, O&D enplanements are not expected to reach the 10 million level believed necessary to successfully support a two airport system until near the year 2010.

Timeframe Considerations - The development of a supplemental new airport site (with one or two runways) would incur nearly the same lead time as the development of a replacement airport. In all of these instances, it has been demonstrated that it takes 10-15 years from conceptualization to implementation. In Chicago, discussions began in the 1960s to consider an airport to supplement O'Hare International Airport. In 1986, the State of Illinois and the FAA initiated a study to determine the need for a new airport; this study found that a new airport could be needed in the year 2005. In 1993, a Master Plan and Environmental Assessment were initiated and an Environmental Impact Statement is expected to be completed in 1996/7. As is demonstrated in Chicago, the planning alone associated with a supplemental new airport will take approximately 10 years. Construction would be expected to take an additional 5 to 10 years.

Lack of Sponsor or Funding - A fourth and final factor leading to the conclusion that a supplemental airport is not a reasonable alternative is the lack of an identified sponsor or source of funds for such a project. Any general purpose government, including ports, may develop and operate airport facilities. However, at this date, no government (or private interest) in the Region has identified itself as a potential sponsor or made funding available for such a project.

Conclusions - While the Port of Seattle and FAA support continued work among regional officials to examine the feasibility of possible sites for a supplemental airport, this alternative is unreasonable to satisfying the existing and future poor weather and aviation demand growth needs at Sea-Tac before the year 2010.

* * *

Development of a new air carrier airport would be a long-term solution to airport capacity constraints in the Region. This alternative was evaluated to address the needs identified by this EIS. As is shown in the preceding paragraphs, the Region has determined that a replacement or supplemental airport is not feasible to meet these needs.

(C) **Activity or Demand Management Alternatives**

Another group of alternatives which are frequently suggested when considering airport development include traffic demand management and activity restrictions. The primary objective of activity management alternatives is to increase airport efficiency by the airport operator's establishment of pricing or regulatory actions, thereby delaying or eliminating the need for future airport development. During the Flight Plan Study, the following types of demand management were evaluated:

- Discouraging air travel to reduce demand;
- Diverting airline passengers to some other mode of transportation (see earlier alternative discussed in this chapter);
- Shifting a class or classes of aircraft, such as commuters, all-cargo or general aviation within the system of regional airports;
- Encouraging the use of aircraft with larger average seating capacity;
- Requiring or encouraging higher load factors; and
- Shifting aircraft operations to non-peak periods of the day.

Federal law, and assurances in grant agreements that the Port of Seattle has entered into with the Federal government, require that access be permitted to the Airport on fair and reasonable terms, without unjust discrimination, and without imposing an undue burden on interstate commerce. Demand management techniques may not be implemented that unfairly discriminate against types of aircraft or impose an undue burden on interstate commerce.

Several acceptable demand management strategies are in use at Sea-Tac today that affect the number and peaking of aircraft operations. Yield management, which is a ticket-pricing strategy focused on increasing load factors, is a common practice among airlines. The FAA operates Central Flow Control to reduce congestion and delay by holding aircraft on the ground at their origination until they can land at a destination airport, such as Sea-Tac. General aviation operations already have naturally transitioned to using nearby Boeing Field due to its proximity to downtown Seattle.

In reviewing such alternatives, the character of the existing and forecast activity must be considered. As is described in Chapter I, air traveler demand is expected to grow from 9.4 million enplanements to 19.1 million in 2020 - a 100 percent increase over 1993 levels. Aircraft operations are expected to grow at a much slower rate (about 30 percent) between 1993 and 2020. While general aviation activity is expected to increase slightly in the future, it is forecast to naturally decline (as a percentage of total activity) as air carrier activity increases. The demand for air travel to and from the region (O&D enplanements) is expected to grow 100 percent (from 6.6 million in 1993 to 13.2 million in 2020), and the number of connecting passengers is expected to grow at the same rate.

The Flight Plan Study found that "TDM (Transportation Demand Management) cannot be used to stop growth......TDM is most effective for 'buying time'. TDM will not eliminate the ultimate need for capacity improvements."[6].

A demand management strategy that has been suggested is *to reduce the quantity of commuter aircraft operations*, which are primarily connecting passengers, by either limiting access to the Airport or by developing a commuter airport. However, connecting traffic at Sea-Tac is a consequence of airline hubbing. At Sea-Tac,

[6] *The Flight Plan Project, Draft Final Report and Technical Appendices*, Puget Sound Regional Council and Port of Seattle, January 1992.

this connecting/hub activity is clearly demonstrated by the Horizon/Alaska Airlines relationship. Horizon serves a number of smaller cities with smaller aircraft. A substantial quantity of Horizon passengers fly to Seattle to connect with an Alaska Airlines flight to another destination. As a result, if such traffic was prohibited, and not accommodated at any area airport, larger aircraft would likely be used in some markets and other passengers would be forced to drive to Seattle to access air service. A prohibition on commuter traffic might be found discriminatory and thus, it may not be feasible.

A diversion of commuter traffic to another airport would result in the need for ground transportation from the other airport to Sea-Tac such that passengers could connect to flights from Sea-Tac. Without a rail connection, such a diversion would result in unnecessary and undesirable congestion on area roads. As was described earlier, the Region is examining the development of rail service. However, the rail system is not a reasonable alternative in the time frame of the needs at Sea-Tac as discussed in an earlier section.

Some have suggested that a cargo-only airport be developed or that cargo operations be diverted to another existing airport. However, nearly half of all cargo is shipped in passenger aircraft. Thus, some cargo would be required to arrive in the Region at one airport and be transported to Sea-Tac or visa-versa. Because the Region currently has a time advantage over other locations on the west coast, it is likely that the added time to deplane, sort and enplane the cargo would result in unnecessary inefficiencies in operation. For non-connecting cargo, the Region would also experience unnecessary and, thus, inefficient, additional aircraft operations to transport cargo and passengers separately. Because of the nighttime noise limitations program at Sea-Tac, one Alaska Airlines nighttime cargo flight began operating at Boeing Field in late 1995. This one flight has resulted in notable new noise controversy at Boeing Field.

Historically, airport operators have not been successful in changing the operating behavior of major airlines through *pricing policies*. An average of 3-6 percent of airline operating costs are associated with the operating fees charged at airports. The level of charges (fees) that would be necessary to change airline operating behavior (resulting in a reduction in operations with greater load factors) would increase airport revenues dramatically and raise legal issues. Such an increase in fees that would affect the level or type of operations would be highly questionable; it could be viewed as imposing an undue burden on interstate commerce and being contrary to the tenets of airline deregulation.

The Flight Plan Study concluded that "... demand management measures will at best delay for a few years the need for capacity improvements. For purposes of this analysis, therefore, it was assumed the maximum demand management set of measures will delay capacity improvements for five years."

This conclusion has been supported by the PSRC Expert Panel on Noise and Demand/System Management in their December 8, 1995 final order on system/demand management. For these reasons, activity management alternatives were found unreasonable in addressing the needs identified by this EIS.

(D) <u>New Runway Development Alternatives At Sea-Tac Airport</u>

As is described in Chapter I "Background and Purpose and Need", a significant increase in delay currently occurs during poor weather due to the 800 foot spacing between parallel runways. To reduce the existing and future poor weather related arrival delay, an increase in spacing between parallel runways is necessary. The Master Plan Update recommends the development of a new parallel runway to address existing and future poor weather related delay. In examining the possible options for siting a new runway, several FAA design standards must be used. To achieve independent arrival operations on two parallel runways during poor weather requires a runway spacing of 4,300 feet with existing radar. With precision runway monitors (PRM), a runway spacing of 3,400 feet will enable independent parallel arrival streams. The FAA is considering testing technology, such as PRM, at runway lateral separations as low as 2,500 feet for independent parallel arrival streams. To date, testing has only been conducted to 3,000 feet separation.

AR 038816

In examining the ability to address the poor weather operating constraint, two primary new runway concepts were considered:

- provision of a third parallel in the current north-south alignment. The parallel alignment was considered to include a runway system in the current 16/34 orientation as well as an alignment in other orientations. Other orientations were determined unreasonable, as they would result in substantially greater social impacts (relative to a parallel runway) and significantly greater development costs to develop a two parallel runway system, where the runways were 3,400 feet separated.
- the development of a new runway that is not parallel to the existing runway system (converging alignment). This concept would result in the development of a new runway that is at a diagonal to the existing runway system. As the predominant wind direction in the Region is north and south, a crosswind runway would have minimal usage. In addition, a runway that is aligned with Boeing Field was also considered. This alternative would result in non-parallel runway (converging approaches). Current FAA procedures enable dependent parallel arrival streams to converging runways down to certain poor weather conditions. However, to enable the necessary divergence of the missed approach pattern, this alternative would require a substantially greater new runway embankment (relative to a parallel configuration), increased cost, and greater social disruption and environmental impact.

For the reasons noted above, only a third runway that is parallel to the existing runways at Sea-Tac was considered further.

In examining possible runway separations between the proposed new runway and existing Runway 16L/34R the following runway separation alternatives were considered:

- Runway separation less than 2,500 feet: Development of a runway with a separation of less than 2,500 feet would not enable two arrival streams during poor weather conditions due to the requirement of increased lateral spacing when pilots are relying on their instruments and wake vortex (wind turbulence) caused by aircraft landings. Thus, poor weather arrival delay would not be reduced. Two parallel runways separated by less than 2,500 feet apart require that pilots be able to confirm visually that their aircraft are on the proper approach and that the wake vortices from aircraft ahead of them do not interfere. As is described in analysis of technology alternatives, technologies do not exist to eliminate the wake vortex constraint. While this alternative does not meet Sea-Tac's needs, it was considered in the Master Plan Update to test the effectiveness of segregating commuter traffic from the air carrier traffic.
- Runway separation of 2,500 to 3,400 feet (dependent/staggered approach streams): The separation of 2,500 feet is the minimum separation necessary to enable independent simultaneous arrival streams during good weather. During poor weather with 2,500 feet or more, dual arrival streams can occur, but aircraft must be staggered. Based on the results of the FAA Capacity Enhancement Study, which originally found a substantial delay reduction by having two arrival streams during poor weather (although staggered), this separation standard was evaluated in detail.
- Runway separations of 3,400 feet or greater: Currently, a runway spacing of 3,400 feet is the minimum separation that enables independent simultaneous arrivals during good and poor weather. However, it is anticipated that a reduction in this standard will occur in the near-future, possibly as low as 3,000 feet due to new radar technology.

Three poor weather runway separation scenarios exist:

- Independent Dual Parallel Approach Streams
- Dependent Dual Parallel Approaches - staggered
- Do-Nothing/No Build

Only the Independent Dual and Dependent Dual Staggered scenarios would satisfy the need to relieve the poor weather operating delay.

In addition to runway separation, runway length was also evaluated. The length of the runway determines the types (and number) of aircraft operations that can use the runway. To achieve the greatest reduction in poor weather related delay, the greatest number of aircraft types must be capable of using the runway. **Table II-3** shows the percent of 2020 Sea-Tac fleet that would be capable of either landing or taking-off from various length runways and do not reflect how the runway would be used.

As is shown in **Table II-3**, the longer the runway, the more arrival and/or departure activity that is capable of being accommodated. For instance, aircraft operational manuals indicate that less than 33 percent of the Sea-Tac fleet in year 2020 can land on a runway with a length of 5,500 feet or less, while 99 percent of arrivals can land on an 8,500-foot runway.

Table II-3

Year 2020 Aircraft Fleet Runway Length Operating Coverage at Sea-Tac

Runway Length	% Landings	% Takeoffs
5,000	31	31
5,500	33	37
6,000	75	47
6,500	86	54
7,000	91	67
7,500	97	85
8,000	97	90
8,500	99	90
9,000	100	94
9,500	100	95
10,000	100	95
10,500	100	96
11,000	100	98
11,500	100	98
12,000	100	99
12,500	100	100

The percentage of total aircraft capable of using the length and do not reflect the percentage of time that the runway would be used.

Source: P&D Aviation

During the Master Plan Update pilots expressed the need for the maximum length possible for a new runway. While the aircraft operating manuals indicate a certain length for an aircraft, pilots indicated a preference for additional pavement when landing in case it should be needed. As air traffic rules place the pilot in command of the aircraft if two runways are available for use, with one longer than the other, a pilot will frequently ask for assignment to the longer runway.

Thus, this alternative was found to satisfy the needs identified by this EIS. A later section in this EIS provides a detailed description of the further evaluation of this alternative.

(E) Use of Technology Alternatives

A number of technology opportunities exist to reduce delay during poor weather. The 1993 Aviation System Capacity Plan and 1994 Federal Research and Technology for Aviation [7] provide detailed summaries of technology that is being evaluated to reduce delay. These include:

- Airport Surface Capacity Technology (primarily affecting the movement of aircraft while on the ground);
- Terminal Airspace Capacity Technology (primarily affecting aircraft on approach or departure from an airport); and
- Enroute Airspace Capacity Technology (primarily affecting aircraft operating between cities - outside the airspace of the origin/destination city); and
- System Planning, Integration and Control Technology and Vertical Flight Program.

The following paragraphs briefly summarize the technology and how it could be applied to Sea-Tac in the reduction of poor weather related delay.

- Airport Surface Capacity Technology - During the taxi-in or taxi-out of the gate area, flights may be delayed due to taxiway blockage, separations at taxiway intersections, departure queues, etc. The FAA's airport surface traffic automation

[7] Aviation System Capacity Plan, Federal Aviation Administration, 1993; Federal Research and Technology for Aviation, Office of Technology Assessment, U.S. Congress, September, 1994.

program is focused on lighting, radar, and sensors to make ground operations safer and more efficient by providing air traffic controllers with the ability to identify all aircraft and special vehicles on the ground during all-weather conditions. Because of the frequency of poor weather in the Puget Sound Region, Sea-Tac Airport has been the site of several types of low visibility technologies, including Airport Surface Detection Equipment (ASDE-3), infrared vision and heads-up cockpit displays. Such programs include the Surface Movement Guidance and Control System (SMGCS) and various elements of the airport surface automation system. While limited testing of parts of the system has occurred, the FAA anticipates that pre-production units of this technology will be tested in full during the 1997 timeframe.

Taxi delay is a minor part of overall delay at Sea-Tac Airport. While this technology will improve efficiency on the airfield in the future at Sea-Tac, it would not enable dual approaches to Sea-Tac during poor weather conditions or address aviation demand growth.

- Terminal Airspace Capacity Technology - The terminal airspace is the controlled airspace normally associated with aircraft departure and arrival patterns to and from airports within a terminal system and between adjacent terminal system in which tower enroute air traffic control is provided. To permit more closely spaced arrivals and departures in poor weather conditions, improvements will be required in precision navigation, enhanced vision, and improved surveillance capabilities. Such technology includes:

  - **Terminal Air Traffic Control Automation** (such as converging runway[8] display aid, Center TRACON Automation System and integration of terminal automation techniques with other air traffic control and cockpit automation capabilities). The purpose of these technologies is to assist air traffic controllers in enhancing the management of traffic in the terminal airspace and to facilitate the implementation of technology at airports. While Sea-Tac's airfield does not consist of converging runways, Center TRACON Automation Systems offer the potential at Sea-Tac to reduce controller workload and to increase airspace efficiency by enabling controllers to smooth out traffic flows and to coordinate traffic more efficiently. However, this technology will not enable Sea-Tac to operate with two approach streams during poor weather.

  - **Precision Runway Monitor** is an improved radar technology and controller display aid which enables the separation between parallel runways to be reduced and still enable two independent arrival streams. Based on tests of PRM at Raleigh and Memphis, the FAA has published dual simultaneous independent parallel approach procedures under poor weather with runways separated by 3,400 feet or more. Additional analysis is being performed by the FAA Technical Center to determine the minimum spacing below 3,400 feet that PRM approaches can be accomplished. However, without additional technology to address wake vortices associated with aircraft movement, the PRM at Sea-Tac would not be envisioned to enable parallel approaches in poor weather with runways separation less than 3,000 feet.

  - **Microwave Landing System (MLS)** - Current Instrument Landing System (ILS) final approach procedures require long straight approaches and can cause concerns for closely spaced and multiple airport environments, or airports which have tall structures near the runway approach. The MLS enables curved approaches to avoid structures and minimize dependencies between airports. Sea-Tac currently has an MLS which is used by commuter aircraft to enable the FAA to more efficiently sequence commuter aircraft between in-trail air carrier activity.

  - **Traffic Alert and Collision Avoidance System (TCAS) Applications** - TCAS is a system that provides warnings to pilots concerning nearby airborne aircraft that are

[8] A converging runway system is one where runways are not parallel to one another. Thus, CRDA is not applicable to Sea-Tac.

AR 038819

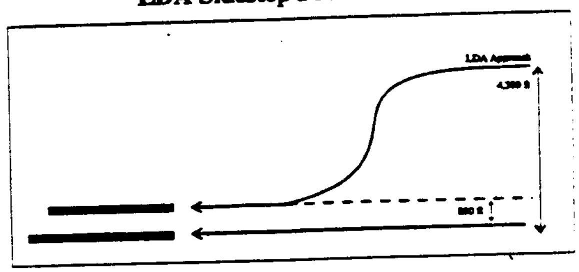
equipped with transponders. The program is expected to be tested in 1996 for use in reducing spacing between aircraft on final approach and to monitor separation between aircraft on approaches. However, due to pilot concerns over false warnings, programs in evaluating the value of TCAS have slowed.

- **Wake Vortex Avoidance/Advisory System** - Vortices begin when an aircraft lifts off and continue throughout the flight, stopping when an aircraft lands. The strength of a vortex is a function of lift needed for flight, and therefore, is correlated to aircraft weight. A better understanding of wake vortex strength, duration and movement created by specific aircraft types under various wind and weather conditions could result in a reduction of aircraft separation criteria. NASA has demonstrated that wake vortices can be dissipated using various combinations of aircraft flaps and spoilers on heavy jets. However, such measures increase the need for longer runways, and increase wear on tires, fuel consumption and noise. Technology is being investigated to aid in the detection of vortices, which would reduce in-trail separation. Such revised criteria could increase airport capacity by 12-15 percent during poor weather conditions. However, current technologies are not anticipated to enable parallel approaches to runways with a separation of less than 2,500 feet. While this technology would result in slight capacity improvements at Sea-Tac, it would not enable dual independent approaches during poor weather conditions.

- **Localizer Directional Aid (LDA) Approaches** - The LDA approaches create the appearance of the availability of widely spaced runways, where one stream is aligned with the runway and the other stream is offset by an established LDA distance. At 2-3 miles from the landing threshold, one stream sidesteps over and is then aligned with the centerline of the runway. Since an LDA approach is offset from the extended runway centerline, visual separation between aircraft on adjacent approaches and the air traffic control tower must exist at the missed approach point (typically 2-3 nautical miles from the runway threshold).

As a result, the approach minima for dual IFR approaches are typically higher than those for basic VFR minima. Due to the frequency of IFR conditions at Sea-Tac, the higher minima associated with an LDA approach would limit the use of this procedure during those conditions when the greatest delays occur. Therefore, this technology could be useful in reducing delays during VFR2, although it would not affect delays during IFR conditions.

LDA Sidestep Procedure



As is described in the preceding chapter, weather is categorized as:

Good Weather		Poor Weather	
VFR1	56.1%	VFR2	19.7%
		IFR1	17.0%
		IFR2	5.4%
		IFR3	1.5%
		IFR4	0.3%

The LDA would assist with addressing dual approaches during one of the five poor weather conditions, it would only be available during VFR2. Thus, the single arrival stream would not be addressed during 65 percent of the poor weather conditions, or 24.2% of weather conditions (all IFR conditions). Currently during VFR1, arrival delay currently averages about 1 minute. Average arrival delay increases to 11.4 minutes in VFR2 and 21.7 minutes or more in IFR conditions. While the LDA would reduce delays during VFR2, it would not reduce the most severe delays that occur during IFR conditions, which make up 60 percent of the arrival delay problem.

	Average Arrival Delay (minutes)	
	Existing Do-Nothing	Existing With LDA
VFR1	1.0	1.0
VFR2	11.4	2.2
IFR1	21.7	21.7
IFR2	21.7	21.7
IFR3	21.7	21.7
IFR4	333.2	333.2
Avg. Arr	7.7	4.4

Source: Capacity Enhancement Plan, Data Package #12, Federal Aviation Admin., June 1995.

Due to the offset centerline type approaches, this technique would require a deviation from the established noise abatement approaches. An LDA would also change the paths that aircraft would use on approach to the existing runways at Sea-Tac. In south flow, which occurs about 70% of the time, instead of arriving aircraft aligning their approach over the Duwamish industrial corridor, arrivals would either overfly the West Seattle ridge or the Beacon Hill ridge and then side step over to the runway within 2-3 miles. Due to the 300-400 feet higher elevation of properties located on these ridges, a substantial increase in arriving aircraft noise would likely be experienced on the ground.

The benefits of the LDA are overstated because:

- The LDA would not be available during 65 percent of the poor weather (it is not usable during IFR conditions); a third parallel runway would address these IFR weather conditions;
- Future departure operations would be affected to a greater degree by the LDA, resulting in greater total future delay. A third parallel runway would enable the outboard runways to be used for arrivals during peak periods, with the inboard runway available for departures;
- As 60 percent of the delays occur during IFR conditions, the LDA would not address a significant majority of the existing and future poor weather delay;

The FAA is presently operating an LDA procedure at St. Louis's Lambert Field and at San Francisco International. The LDA at Sea-Tac would be most similar to the procedure at San Francisco, where the LDA has reduced arrival delays during VFR2 but does not address IFR delay.

While the FAA may pursue the LDA in the future at Sea-Tac Airport as an interim measure to the availability of a proposed new parallel runway, the LDA was found to not satisfy the need for the proposed Master Plan Update airside improvements.

- **Global Positioning System (GPS)** - Over the last few decades, the FAA has pioneered the development of navigation improvements to reduce aircraft delay. Instrumental to the reduction in delay is the development of technology that enables aircraft to fly more precise flight tracks. The most significant development to date is the use of satellite technology as an aid to communication, navigation and surveillance. Developed by the U.S. Department of Defense over the last 20 years, GPS/GNSS (Global Navigation Satellite System) is expected to allow aircraft to fly flexible and highly accurate flight tracks anywhere in the world. The FAA has responded by initiating a comprehensive satellite program involving government, industry and users to expedite research, development and field implementation of improved navigation services. The foundation of the FAA program is the GPS, a satellite-based radio-navigation and time transfer system operated and controlled by the Department of Defense. GPS has essentially replaced the MLS as the next generation precision approach system. It has applicability in reducing delay and congestion at the surface of an airport, in addition to the terminal and enroute airspace.

To date, work is on-going concerning the GPS. FAA has only approved one stand-alone non-precision approach using GPS as the primary navigation aid (Steamboat Springs, Colorado). GPS approaches however, have been approved to supplement ILS approaches and are being tested at a number of airports. While GPS is expected to have significant long-term benefits to the overall aviation system, it is not expected to address the wake vortex issues described previously. Therefore, GPS would not enable dual approaches to the existing runways during poor weather.

- **Flight Management Systems (FMS)** - New computer technology being incorporated into the newer generation aircraft are capable of efficiently performing various navigational functions. At airports such as Sea-Tac, FMS procedures have been used to transition aircraft from an enroute phase of flight to existing charted visual procedures and instrument landing approaches. FMS procedures are expected to allow the reduction of weather minimums for charted visual approaches and offer alternative arrival paths to FMS equipped aircraft. Other benefits of FMS include a reduction in airspace conflicts, a reduction in controller workload, and possible energy reduction and improvements in the precision of noise abatement flight tracks. However, FMS would not enable dual independent approaches to the existing runways during poor weather.

- <u>Enroute Airspace Capacity Technology</u> - Enroute airspace is the controlled airspace above or adjacent to the terminal airspace. Because of non-uniform demand for portions of the enroute airspace, technology is being evaluated to reduce delays and match traffic flow to demand.

- <u>System Planning, Integration and Control Technology</u> - A number of technical tools are being developed to aid in the evaluation of air traffic control procedures and system performance.

- <u>Vertical Flight Performance</u> - This program is evaluating means to improve the safety and efficiency of vertical flight operations and increase the capacity of the national airspace through research, engineering and development efforts focused on vertical flight.

Of the technology listed above, the Precision Runway Monitors (PRM) and Wake Vortex Avoidance/Advisory System have application to addressing the poor weather issues at Sea-Tac. It is expected the PRM will be used at Sea-Tac if the runway lateral separation testing shows that such technology could be applicable to runways with a separation of 2,500 feet or less. However, the primary issue that would remain is the wake-vortex condition. The FAA continues to evaluate wake vortex conditions. However, there are no plans currently envisioned to reduce the wake vortex standards.

(F) <u>Blended or Delayed Alternative</u>

WAC 197-11-440 (5)(vii) states that an EIS must:

> "Discuss the benefits and disadvantages of reserving for some future time the implementation of the proposal, as compared with possible approval at this time. The agency perspective should be that each generation is, in effect, a trustee of the environment for succeeding generations. Particular attention should be given to the possibility of foreclosing future options by implementing the proposal."

The characterization "reserving for some future time" implies purposefully delaying the implementation of the proposed improvements. The net effect of delaying implementation of the proposed improvements would result in the conditions presented in this EIS as Do-Nothing.

To consider the intent of this SEPA provision, this section discusses the benefits and disadvantages of <u>delaying</u> implementation of the Master Plan Update. These benefits and advantages include:

<u>Benefits of delaying implementation</u>:

- Impact on the natural resources would occur later in time.
- Impact on the built and social resources would occur later in time.

<u>Disadvantages of delaying implementation</u>:

- Existing poor weather related aircraft arrival delay would continue, and would increase;
- Unnecessary costs of delays incurred by the airlines of about $24 million annually (in 1994) and growing to $146 million

annually when activity reaches 425,000 operations (near the year 2013).[9]

In addition, actions that might assist with delaying the timing in which the need for airport improvements were also considered and are referred to as the Blended Alternative. As was described in the preceding sections, three alternatives, if available and used, could offer means of reducing aviation demand at Sea-Tac: use of alternative modes, use of existing airports, and activity/demand management. Because of the significant financial investment that airport users experience with airport infrastructure development, such improvements are typically not undertaken until the need has already arisen or the need will arise in near future with a demonstrable benefit relative to cost. Therefore, if these other alternatives, independently or in combination, were implemented and used, the needs would not arise as quickly at Sea-Tac, and thus, implementation of the proposed Master Plan Update improvements could be delayed.

This alternative was considered and dismissed for the following reasons:

- This alternative does not reduce the existing disparity between good and poor weather operating capability and resulting delay. As a result, the delay savings of $24 million annually today would not be achieved, and would escalate to $146 million when activity levels reach 425,000 annually;
- Based on studies of these individual actions, there is no indication that any individual alternative would result in a diversion of 10 percent or more passengers from Sea-Tac in the reasonably foreseeable future;
- No actions exist to alleviate the majority of the existing and future poor weather arrival delay. While the Localizer Directional Aid (LDA) would reduce arrival delays during VFR2, it would not address 60 percent of the existing poor weather (IFR) delay problem.
- The Master Plan Update forecast was prepared in early 1994, based on activity through 1993. Activity levels through October 1995 indicate that passenger levels are growing slightly faster than forecast by the Master Plan Update - giving no indication that demand will be delayed.

None of the actions individually would satisfy the need for the proposed airport improvements. In addition, no actions exist to address the poor weather constraint that exists at Sea-Tac other than the development of a new parallel runway with a separation of 2,500 feet or more. As was shown, technology/procedural actions could reduce the severity of some of the poor weather constraint (only during VFR2). However, no technologies exist to address the IFR single arrival stream constraint. Thus, if a blend of non-development related actions were used to satisfy the poor weather needs at Sea-Tac, the Do-Nothing alternative as presented in this EIS would result.

SEPA poses the question "would their pursuit 'foreclose future options'". None of the proposed airport improvements would prevent another option or other major planned improvements in the Airport area from being pursued. However, airport funding could be limited for use in other improvements. For instance, if funding from traditional airport sources were used to implement some alternative (other than the Do-Nothing and "With Project" alternatives described in this EIS) a shortage in funding could result.

For these reasons, this alternative was not considered further.

(G) Do-Nothing/No-Build

The Do-Nothing alternative would result in Sea-Tac Airport remaining as it is today. Therefore, existing operational congestion and delay would continue and not be relieved. Also, the existing negative environmental and operational impacts of the Airport would not be reduced. Although this alternative may not be prudent, it is feasible, and therefore, is one of the alternatives

[9] *"Seattle-Tacoma International Airport, Capacity Enhancement Update"*, Federal Aviation Admin., July 1995.

considered throughout the Environmental Impact Statement.

(2) Provide Sufficient Runway Length to Accommodate Warm Weather Operations Without Restricting Passenger Load Factors or Payloads For Aircraft Types Operating to the Pacific Rim.

As is described earlier in this chapter, future aviation needs at Sea-Tac include a 12,500-foot long runway to enable service to Hong Kong, the primary economic and trade hub of the Pacific Rim. The following alternatives were considered:

- Extension of Runway 16L/34R - Presently, Runway 16L/34R is 11,900 feet long. To achieve the desired 12,500-foot length, this runway would require a 600-foot extension. Three build options exist: 1) Extend to the North (Runway End 16L) by 600 feet; 2) Extend South (Runway End 34R) by 600 feet; and 3) Extend North and South (both ends) such that 600 feet is added. The full extension to the north (Runway End 16L) would require the relocation of SR 518 and South 154th Street. However, as is noted in the next subsection, the runway safety area for this runway end does not meet current FAA design standards. Thus an extension of the runway to the north would further exacerbate the RSA issues, requiring the relocation of SR 518. Full extension to the south (Runway End 34R) would require grading and fill due to steep terrain. Similar RSA issues exist for this runway end. All of these issues would also be incurred if both ends of the runway were extended. The extension of both ends is not reasonable due to the increased construction costs associated with two construction sites, the need to address expanded RSA in both directions and no perceptible reduction in environment impact.

- Extension of Runway 16R/34L - Presently Runway 16R/34L is 9,425 feet long and is the runway located furthest from the terminal complex. An extension of 3,075 feet would be necessary to achieve the desired runway length. Similar to the options for its adjoining runway, the following options were considered:

  1) Extend Runway 16R by 3,075 feet; The maximum extension that can be conducted to this runway end is approximately 125 feet before wetland (The Lake Reba Detention sites 4 through 8 totaling 20.6 acres as described in Chapter IV, Section 11 - Wetlands) would be affected. In addition, South 154th street is located 900 feet and SR 518 is 2,200 feet north of Runway end 16R. Therefore, maximum extension of this runway end would require the displacement or tunneling of these roads.

  2) Extend Runway 34L by 3,075 feet - This runway could be extended about 1,000 feet south before it would affect wetland (site 28 - about 18 acres). South 188th Street is located approximately 1,200 feet south of the end of Runway end 34L and would also require relocation or tunneling.

  3) Extend both ends such that 3,075 feet is added. As is noted for the previous sub-alternatives, Partial extensions of these runway ends, the maximum extension that can be achieved in either direction without affecting wetlands acreage in excess of 20 acres is under 1,200 feet. Because of the roadway relocations associated with this runway extending this runway would cost at least three times the cost to extend Runway 16L/34R and impact about 4 times the quantity of wetland.

- Development of a new runway with a 12,500 foot length - The development of a new 12,500 foot runway was determined unreasonable at Sea-Tac based on a qualitative review of the alternatives which address the arrival delay issues. Such a runway would need to be parallel to the existing runway system at the Airport, and as such would need to be developed east or west of the existing two parallel runways. Development east of the existing runways would require the runway to be placed parallel and east of International Blvd. (SR 99), thus displacing massive amounts of commercial development and severely disrupting the urban village designation that the City of SeaTac wishes to achieve. Development west of the existing runways, at least 2,500 feet from the easterly parallel would require the relocation of a 4,000 foot segment of SR 509, relocation of the SR 509/South 188th Interchange, and the relocation and/or tunneling of approximately 5,000 feet of South 188th Street. In addition, a substantial displacement of area businesses and residences would be necessary. For these reasons, these alternatives were determined to be unreasonable.

- Delayed Alternative - As is noted earlier, SEPA requires the consideration of the benefits and disadvantages of delaying implementation of the proposed alternative. The benefits of delaying implementation of the runway extension would be avoiding the adverse impacts identified by this EIS. The disadvantages would be continued off-loading of passengers and/or cargo for flights departing during warm summer months.

  Delaying implementation of this element of the Master Plan Update would not foreclose future options, as this element is not likely to be implemented during an early phase of the Master Plan Update development. However, if plans associated with the development of the South Aviation Support Area (SASA) do not recognize the development of this runway extension, the relocation of Des Moines Creek might be necessary twice. Thus, the proposed mitigation included in this EIS incorporates the planned extension of the runway in the layout of the relocated Des Moines Creek. Implementation of the runway extension does not foreclose any other future options.

- Do-Nothing/No-Build - The Do-Nothing alternative would result in the Airport remaining as it is today. Therefore, service to cities at greater distances would result in reduced payload during warm weather conditions. Although this alternative may not be prudent, it is feasible, and therefore, is one of the alternatives considered throughout the Environmental Impact Statement.

Based on the options available to address existing runway RSA issues, the 600 foot extension of Runway 34R is the only reasonable development option to providing a 12,500 foot runway at Sea-Tac.

To address the runway length issue as well as the RSA, described in the next section, the runway would be extended 600 feet and a 1,000 foot runway safety area completed. Given the length of the existing embankment (which extends 535 feet beyond the current threshold), the Master Plan Update improvement would result in an expansion of the embankment by 1,065 feet. This extension and the associated parallel taxiway and taxiway entrance to the South Aviation Support Area will be developed to ensure that the ultimate planned alignment of the South Access/SR-509 extension can be completed.

(3) Provide Runway Safety Areas (RSAs) that Meet Current FAA Standards.

As was described earlier, the RSAs are safety areas that are allocated to provide for possible aircraft overruns, undershoots and excursions. The RSA design criteria is presently not met to the south due to terrain changes. The RSA design criteria is not met to the north due to terrain and to South 154th street.

For airports that cannot meet the RSA standards, the FAA has established guidelines for the use of declared distances. With the declared distance procedures, the FAA requires that an airport operator declare which portions of the runway are available for takeoff and landing calculations so that the 1,000 foot RSA is available. Declared distances were established by the FAA for space constrained airports where the conventional RSA configuration cannot be provided at the ends of the runways. FAA defines declared distances for:

- Takeoff Run Available (TORA) - the length of runway declared available and suitable for satisfying takeoff run requirements;
- Takeoff Distance Available (TODA) - is the TORA plus the length of any remaining runway or clearway beyond the end of the TORA available for satisfying takeoff distance requirements. The TODA length is determined by aircraft operators based on the controlled obstacles in the departure area. At Sea-

Tac, where no clearways are present, TODA is the same as TORA.

- Accelerate-Stop Distance Available (ASDA) - is the runway length available to accelerate to V1 (takeoff speed) and then decelerate to a safe stop.
- Landing Distance Available (LDA) - is the runway length available for landing.

As the RSAs are mandated by Federal Aviation Regulation (FAR) Part 139.309(a) and subsequent grant assurances, only two basic options exist:

- Use of Declared Distances with displaced runway thresholds;
- Clearing, grading, filling and development of the requisite areas for 1,000 feet beyond the existing pavement end.

Since publication of the Draft EIS, the Port of Seattle has completed the grading off the end of Runway End 34L to provide the requisite 1,000 foot RSA. This project, completed per a SEPA Determination of Non-Significance and NEPA Categorical Exclusion, showed that this element would not affect wetlands. It was completed by bringing 14,000 cubic yards of material to the site. In December 1995, the Port completed a DNS for the 34R RSA (clearing and grading approximately 465 feet). As the DNS for this project showed, 0.1 acre of wetland will be filled. The Port received approval from the Army Corps of Engineers (COE) in 1993, subject to a Nationwide COE Permit, to fill this wetland. It will be completed by bringing 500,000 cubic yards of material to the site. This EIS addresses the cumulative impact of the proposed runway extension and completion of the RSA for 34R.

The following summarize these alternatives associated with the RSAs for Runway 16L/34R and 16R:

- <u>Declared Distances/Displace the runway threshold</u>: Recognizing that airports may incur difficulty in achieving the full RSA standard, the FAA has enacted declared distance criteria as defined in the preceding section. With the declared distance criteria, the FAA requires that an airport declare which portions of the runway are available for take-off and landing, so that the full 1,000-foot safety areas are provided for operations on the runway. Those portions of the runway declared not usable for takeoff and landings are then considered part of the RSA.

  - **Runway 16R/34L**[10] was the focus of the RSA issues as the north end of the runway (end 16R) represents the greatest constraint. **Exhibit II-1A** shows the existing conditions. The following identify alternatives to addressing this RSA:

    - *(Alternative RSA-1A)* A 250-foot displacement to the threshold of Runway End 16R. This alternative would include a partial grading and filling for 750 feet of the area north of the existing runway threshold. With the 250-foot displacement, the full 1,000-foot long RSA would be provided. This alternative would avoid the northward relocation of South 154th Street, but would require the construction of a retaining wall along the roadway and relocation of approach lights and other navigational aides. However, when in north flow (arrivals on 34L or departures on 34L) the ASDA (accelerate-stop distance available) and LDA (landing distance available) would be reduced by 250 feet. In south flow, a reduced LDA of 250 feet would occur. The Port estimated that this option would cost between $3-6 million to complete. For these reasons, this alternative was found unreasonable.
    - *(Alternative RSA-2A)* A 450-foot displacement to the threshold of Runway End 16R. This alternative is the same as the above, except with an expansion of the existing RSA out to 550 feet, using a 450 displacement of the north runway end to achieve the requisite 1,000 feet. While

[10] Following the issuance of a Determination of Non-Significance in February 1995, the Port of Seattle cleared, graded and filled the requisite RSA for 34L.

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other lengths could occur, this distance would avoid the development of the retaining wall. As a result, a 450-foot reduced LDA to the south on Runway 16R would occur. The Port estimated that this option would cost between $1.0 and $3.0 million to complete.

The reduced landing distances would restrict the usage of taxiway M to some aircraft, thus increasing the runway occupancy. For these reasons, this alternative was found unreasonable.

- *(Alternative RSA-3A)* A 770-foot displacement to Runway End 16R. This alternative would use the existing 230 feet of full-width RSA with a 770-foot displacement. This alternative would result in a 770-foot reduction in the LDA to the south and a 770-foot reduction in the ASDA to the north. A relocation to South 154th would not be required. The Port estimated that this option would cost between $0.5-1.5 million to complete.

  Because of the reduced available runway length, aircraft landing would not be able to use the existing taxiway exits in an efficient manner. Thus runway occupancy would be increased or additional taxiway exits would need to be developed. For these reasons, this alternative was found unreasonable.

- **Runway 16L/34R, shown in Exhibit II-1B.** Alternatives for this runway RSA are:
  - *(Alternative RSA-1B)* A 300-foot displacement to 16L (which is currently displaced 490 feet - thus the existing displacement would be reduced), and a slight build out of the 16L RSA to 700'. As a result of the displacements, the south flow LDA would be reduced to 11,600 and the ASDA would be 11,900 feet. In north flow, the LDA would be reduced to 11,600 and the ASDA would be reduced to 11,600 feet. Due to the length requirement of 12,500 feet identified in the Master Plan Update, displacement of this runway was not considered a realistic alternative.

Declared Distance Summary: Relative to declared distances, the FAA noted to the Port in a February 1993 letter "The FAA strongly recommends that declared distances not be used at Seattle-Tacoma International Airport. Aircraft operations during low visibility conditions are a major concern. Declared distance lighting would be required in addition to low visibility lighting and result in a confusing lighting system during low visibility operations. We recommend you consider relocating the threshold to adjoin the starting boundary of the RSA".[11/] For these reasons, these alternatives were not found reasonable. However, because the Port must address the RSA compliance issue, if clearance, grading and filling were not undertaken, the declared distances would be the Do-Nothing action.

- <u>Clearance, grading, filling and development of the requisite areas for 1,000 feet beyond the existing pavement end</u>: These alternatives would result in the conventional configurations for the RSAs.
  - *Runway 16R/34L (Alternative RSA-4A)*: To provide the necessary area, the north RSA would require the relocation of South 154th Street around the RSA. No wetlands would be affected in clearing, filling, grading and developing a 1,000-foot RSA on the north or south end of this runway. While conceptually, the road could be tunneled under the RSA, the cost of such tunneling would be far greater than relocating the road. The cost to relocate the road and to complete this alternative is about $20-$30 million. While this cost is greater than the declared distance options, the majority of this cost associated with relocating South

[11/] Letter from Paul Johnson, Civil Engineer, Seattle Airports District Office to the Port of Seattle, February 19, 1993

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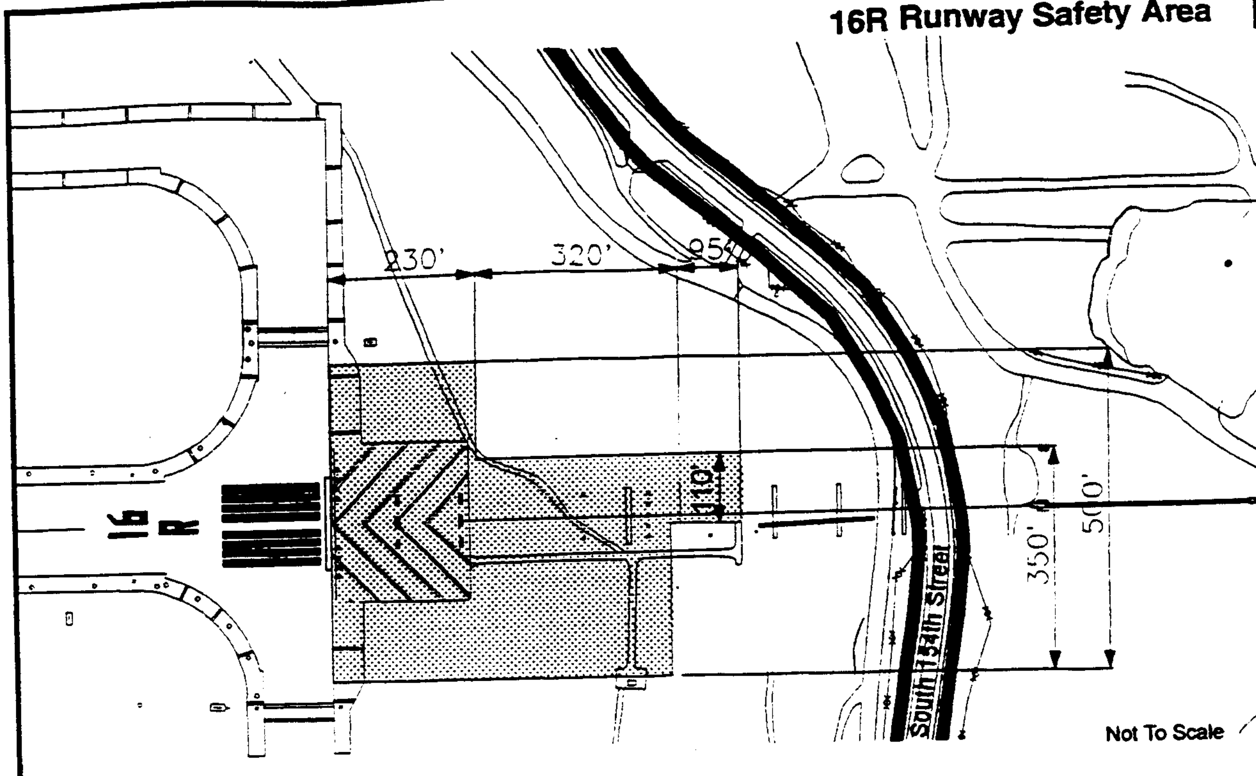
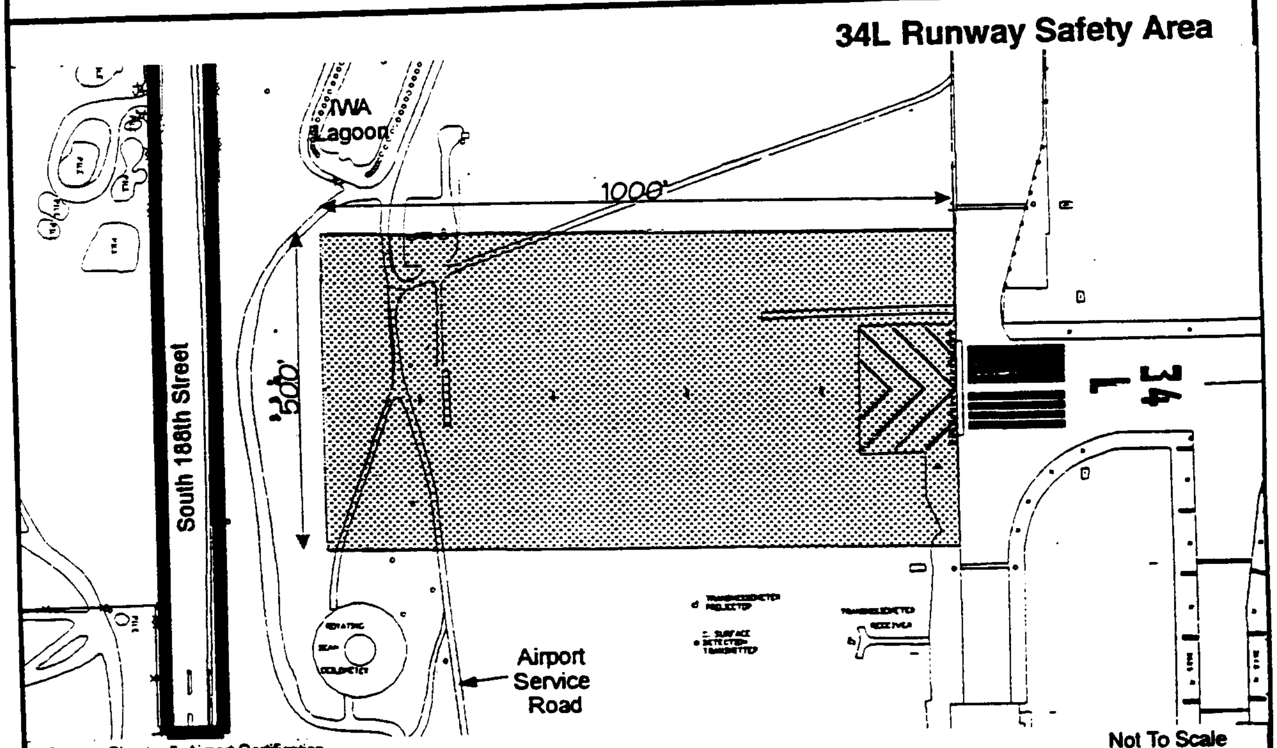
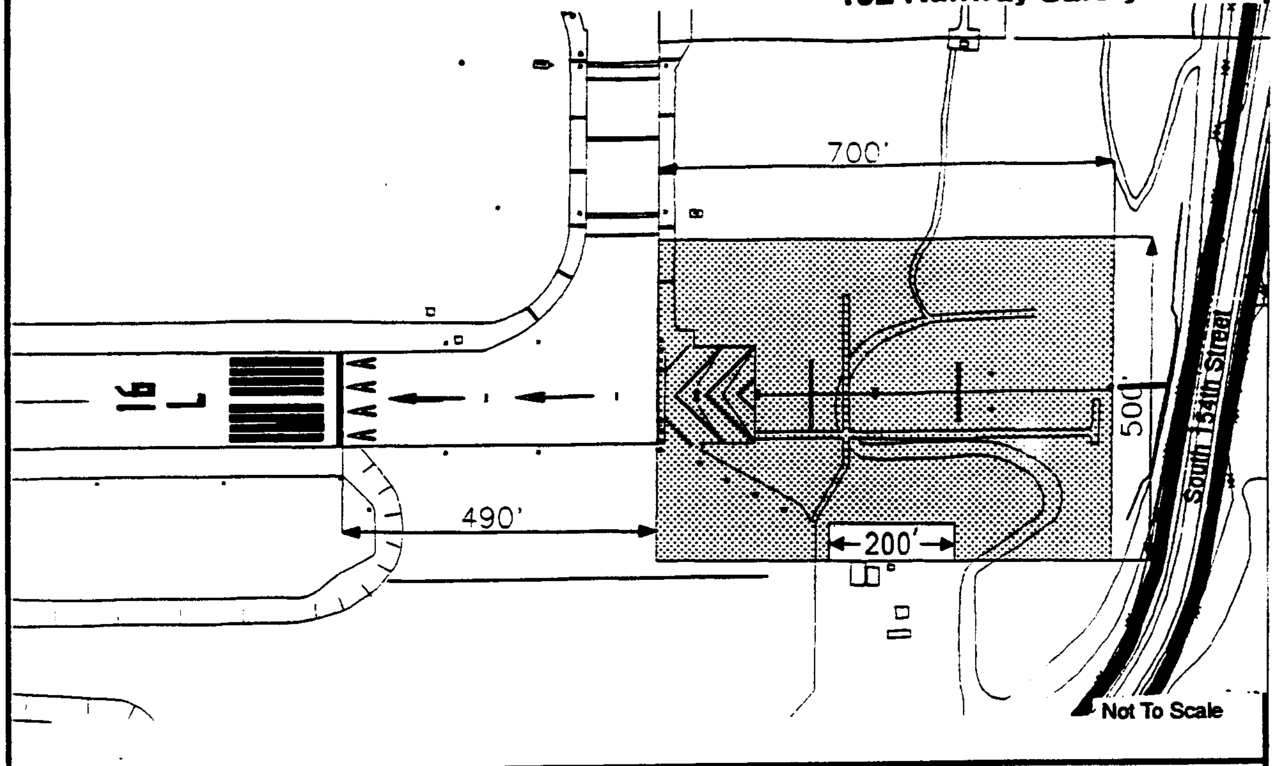




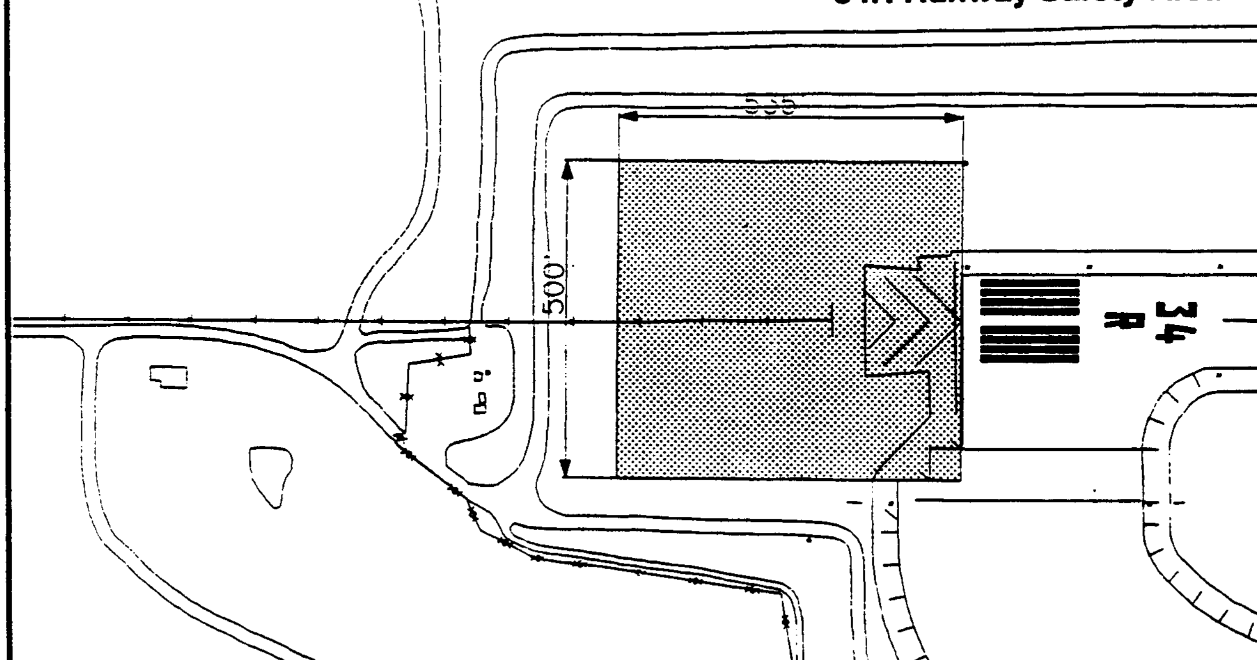
Source: Chapter 5, Airport Certification
Note: The RSA to 34L was corrected in 1995 by clearing, grading, and filling to achieve the 1,000 feet required.

Seattle - Tacoma International Airport	Existing Runway Safety Areas	EXHIBIT: II-1A

16L Runway Safety Area



34R Runway Safety Area



Note: Prior to extending this runway, as proposed, the RSA will be filled and graded in 1996.
Source: Chapter 5, Airport Certification

Seattle - Tacoma International Airport	Existing Runway Safety Areas	EXHIBIT: II-1B

154th Street would be incurred in completing the new parallel runway.

- *Runway 16L/34R (Alternative RSA-2B)*: This alternative would clear, fill, and grade 300 feet in addition to the existing RSA to the north, and relocate South 154th Street. If the 16L landing displaced threshold were removed, a total of 300 additional feet would be needed. The southern RSA would be cleared, filled, and graded an additional 465 feet. This alternative is a viable alternative, but would require two construction efforts, to address the existing RSA issue, and then extend at a later date extend 34R the additional 600 feet. To ensure compatibility of the mitigation, these projects were assessed in one phase.

- Clearance, grading, filling, and development of the requisite area including the 600-foot extension of Runway 34R *(Alternative RSA-3B)*- As is noted in the preceding section, to provide unrestricted payload to aircraft serving the Pacific Rim, a takeoff roll available length of 12,500 is needed. As the only reasonable alternative to satisfying this need is the southern extension of 34R, the cumulative alternative of addressing the RSA was also considered. Therefore, a 600 foot runway extension would require the clearance, filling and grading of 1,600 feet (the extension plus the standard RSA distances). Given the 12,500 foot length need, this clearing, filling, and grading of 1,600 feet off 34R is the only reasonable alternative to addressing the RSA issues on the southern end of Runway 16L/34R. To address the runway length issue described in the previous section, as well as the RSA, the runway would be extended 600 feet and a 1,000 foot runway safety area completed. Given the length of the existing embankment (which extends 535 feet beyond the current threshold), the Master Plan Update improvement would result in an expansion of the embankment by 1,065 feet, for a total length of 1,600 feet.

- Delayed Alternative - As is noted earlier, SEPA requires the consideration of the benefits and disadvantages of delaying implementation of the proposed alternative. Delaying implementation of actions to addressing the RSA issues is not possible, due to the FAA grant assurances. Therefore, the only non-development options would be the establishment of declared distance procedures and displaced runway thresholds. The advantages of this would be a reduction in the amount of fill transported to the site and associated adverse off-airport impacts. The disadvantages would be reduced runway landing lengths, required techniques for low visibility lighting, and reduced airfield efficiency. Implementation of the clearing and grading alternative does not preclude other options in the future.

- Do-Nothing/No-Build [12] This alternative would maintain the current RSA dimensions, which do not meet FAA requirements. As this option may result in the FAA bringing an RSA enforcement action against the Port of Seattle, it is not a reasonable alternative. The result of a Do-Nothing alternative would be the requirement that displaced thresholds be developed, as described previously. While this option is considered to be a last resort action for airports with low visibility conditions, it is technically feasible; declared distances are not recommended due to the low visibility lighting confusion that pilots could experience. Each displacement would require relocation of approach lights and other navigation aides. The following identifies the declared distances associated with the Do-Nothing:

  - *Runway 16L/34R (Alternative RSA-1B)*: Because of the non-standard RSA's, the threshold of 16L would remain displaced. The glideslopes on both ends would be relocated. As a result, in north flow, the maximum available landing distance available (LDA) at Sea-Tac would be 11,145 feet. In the south flow, the maximum LDA would remain as 11,145.

[12] Technically, the literal Do-Nothing is not an option for addressing the RSA issues. The Port of Seattle has two options for addressing RSAs, both of which require some action: grade and develop off the ends of the runways or establish declared distance procedures. The Do-Nothing alternative presented in this EIS reflects the non-development action (declared distances).

- *Runway 16R/34L (Alternative RSA-1A)*: Because the horizontal criteria is only standard at a length of 230 feet, Runway End 16R would be displaced 770 feet. As a result the LDA and ASDA would be reduced an equivalent distance. Therefore, in a south flow, the LDA would be reduced from 9,425 feet to 8,655 feet. This would prevent about 1% of the year 2020 aircraft types from being able to land on this runway. As a result of the displacement to Runway 16R, greater runway occupancy would occur due to the placement of current taxiway exits.

Due to the runway length needs of the Airport, as described in this chapter, the only reasonable alternative to achieving compliance with the FAA's RSA design standards is the clearance and grading of the requisite areas (Alternatives RSA-3B and RSA-4A).

(4) Provide Efficient and Flexible Landside Facilities to Accommodate Future Aviation Demand

Alternatives that could accommodation of future aviation demand include:

(A) Use of Other Modes of Transportation

(B) Use of Other Airport/Development of A New Airport

(C) Activity/Demand Management

(D) Landside Development at Sea-Tac Airport

(E) Delayed or Blended Alternative

(F) Do-Nothing/No-Build

The following summarizes the issues associated with each of these alternatives.

(A) Use of Other Modes of Transportation Alternatives

Alternative modes of transportation were evaluated (on page II-1) in terms of their capability to meet the needs of freight shippers and travelers who presently use Sea-Tac Airport. Based upon the characteristics of freight shipments and travelers from Sea-Tac, alternative modes of transportation, such as rail (traditional or high speed) or automobile/bus, cannot be realistically considered as providing a suitable solution to needs identified in this study at Sea-Tac Airport.

(B) Use of Other Airports or Development of a New Airport Alternatives

As was described beginning on page II-6, an extensive study of the development of a replacement or supplemental airport was conducted by the Puget Sound Regional Council. This study found: "The Executive Board concludes that there are no feasible sites for a major supplemental airport within the four-county region and that continued examination of any local sites will prolong community anxiety while eroding the credibility of regional governance."[13/] Based on the analysis presented earlier and the findings of the Puget Sound Regional Council, it is unlikely that use of other airports or development of a new airport are reasonable alternatives to serving future air travel demands.

(C) Activity/Demand Alternatives

Another group of alternatives which are frequently suggested when considering airport development include traffic demand management and activity restrictions. As was described in a preceding section (starting on page II-11), activity alternatives would not reduce demand such as to prevent the need for improvements at Sea-Tac Airport.

(D) Landside Development at Sea-Tac Airport Alternatives

The Master Plan Update identified numerous alternatives to address the future terminal and support facility requirements. **Table I-6** lists the landside facility requirements. Once the possible runway options were evaluated, the planning process began to focus on existing and forecast conditions in the terminal, cargo, support and roadway system. This effort showed that, in some

13/ PSRC Executive Board Resolution EB-94-01.

cases, the present airport facilities are not efficiently accommodating passengers and aircraft. In other instances, these existing facilities were determined to be insufficient to accommodate future activity. The following summarizes options to addressing terminal, cargo and support facilities.

1. **Terminal Facilities**

One of the primary criteria used in planning future terminal facilities is the need for aircraft gates. Aircraft gate requirements define the general layout of the terminal and the quantity of building space, through the establishment of the number and size of aircraft that can enplane and deplane passengers. Based on the forecast increase in passengers and aircraft operations, the need for aircraft gates is expected to increase about 20% by the year 2020. To recognize the differences between the physical requirements of various gates (i.e., narrowbody versus widebody), the linear frontage (LF) of gate space is also identified. Currently, Sea-Tac Airport has 75 actual gates, within 12,100 linear feet of terminal frontage.

The existing and forecast gate requirement is:

- 1993 - 75 gates in 12,100 LF
- 2000 - 86 gates in 13,800 LF
- 2010 - 94 gates in 15,100 LF
- 2020 - 100 gates in 16,300 LF

Because of the varying dimensions and space requirements of various aircraft, a gate equivalency is often used. The NarrowBody Equivalent Gate (NBEG) would range from 89.9 in 1993 to 120.6 in 2020.

In addition to the gate space, the square footage of additional terminal space was quantified. Using the aviation demand forecasts, a range of additional terminal space was quantified. The lower bounds of the range indicate maximized expansion of existing facilities, while the higher bounds represent development of new terminals. Additional space beyond the current 1.9 million square feet (SF) are:

Additional Passenger Terminal Space Needs

- 2000: 412,000 to 613,000 SF
- 2010: 744,000 to 1,076,000 SF
- 2020: 1,080,000 to 1,533,000 SF

In addition to the provision of terminal and gate facilities, passenger access must be provided. Currently, all passengers access to the Main Terminal is through the Airport roadway system curbfront or parking garage. The Master Plan Update found that currently there is insufficient curbfront to accommodate peak demand, resulting in a poor level of service on some of the access/egress ramps. The Master Plan Update found that "the fundamental problem which remains is that the configuration of the terminal curb has evolved from the original terminal plan in which traffic turns at the midpoint of the roadway. This not only creates a point of congestion at the turn itself, but limits the extent to which the terminal curb may be extended in a linear fashion." This condition is expected to become severely inefficient and congested with a 100 percent increase in passengers by year 2020.

Based on the facility requirements, a series of terminal development options (shown in **Exhibit II-2**) are identified:

Centralized Terminal - To maximize the infill of the existing central core, opportunities to satisfy existing terminal needs were examined within the existing Main Terminal land envelope. However, because of the limited amount of space, only one concept was identified as being viable. This option would result in the development of a passenger Transportation Distribution Center on the site immediately east of the existing main parking garage. This facility could accommodate the regional rail facility, as well as provide supplemental curbfront for

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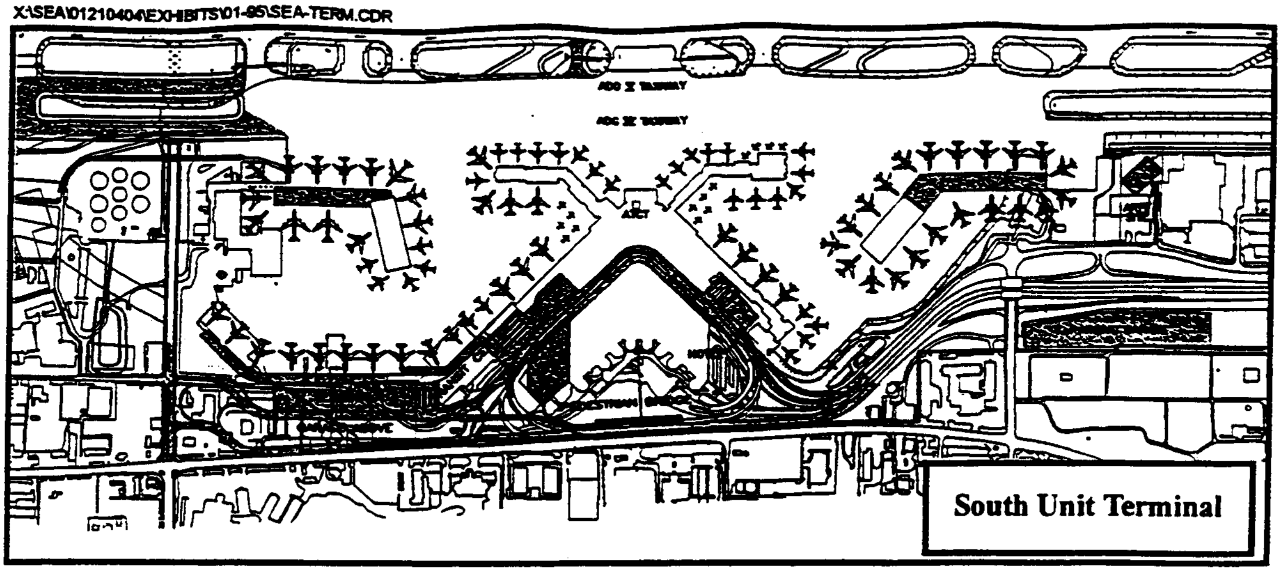

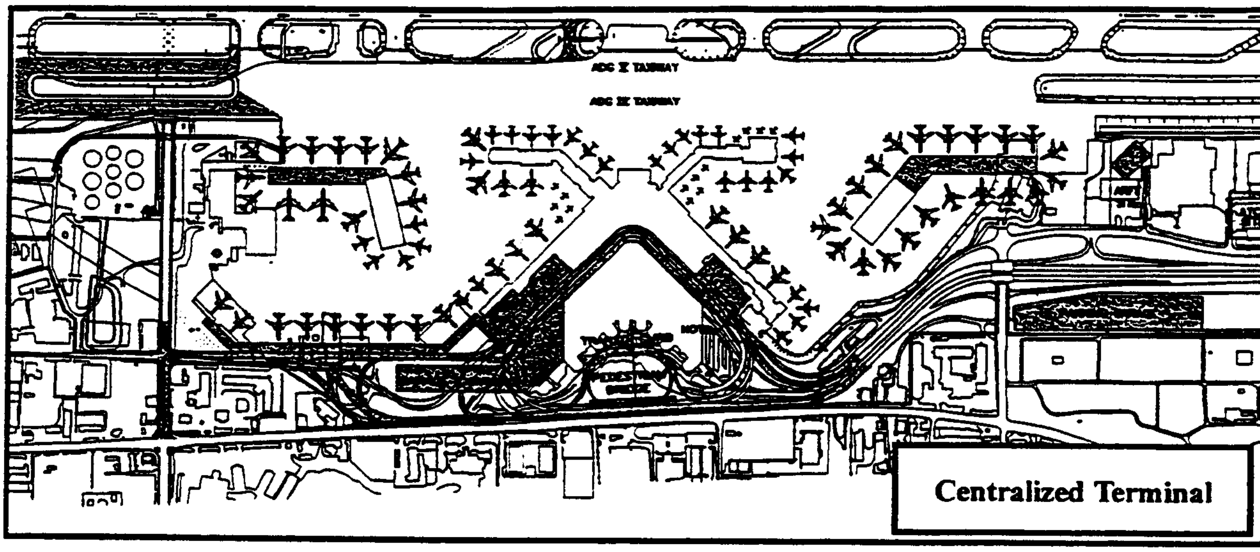

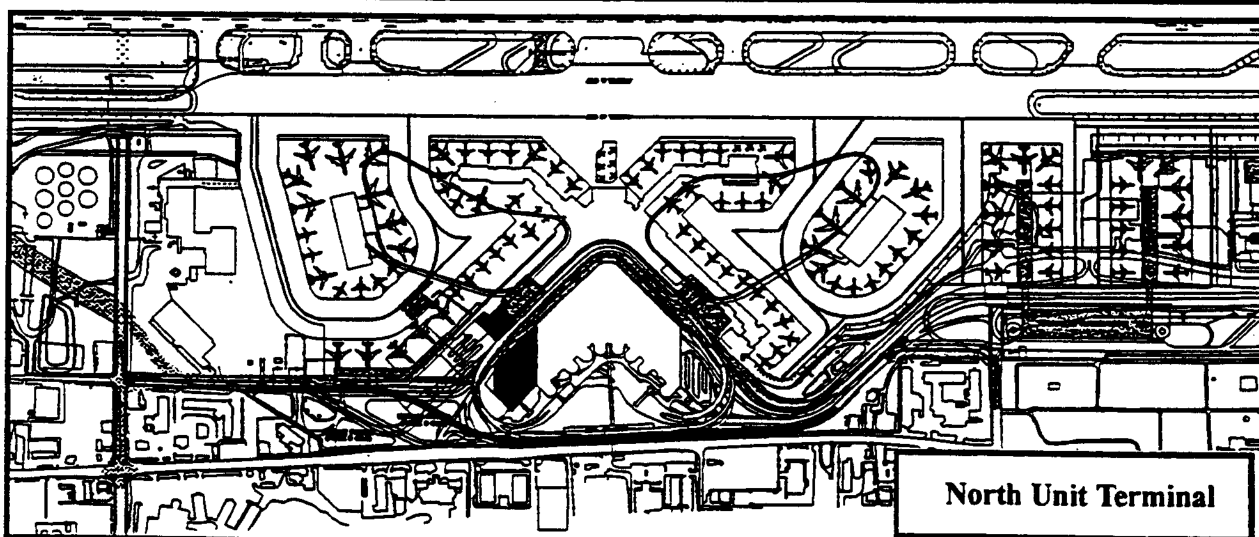

Seattle - Tacoma International Airport	Terminal Options	EXHIBIT: II-2

high occupancy vehicles and busses. Because of the distances between this facility and the existing Main Terminal, it would be connected with a people mover (such as moving sidewalks) to minimize passenger walking distances. This system could require the use of portions of one or more floors of the existing parking garage. Supplemental passenger check-in and baggage claim could also be developed in the distribution center.

Public terminal space would be developed through a significant southern extension of Concourse A, with a Federal Inspection Service (FIS) facility, improved passenger security screening space and expansion of the north and south satellites. A limited ticketing level expansion could also occur to the northern end of the Main Terminal.

This option would focus on the use of high occupancy vehicles for access to the Airport to relieve congestion on the surface roads. Such modes could include shuttles and light rail to divert passengers away from private autos, taxis and limos. Additional public parking would be developed through a southern expansion of the parking garage. To service the transit curb, an elevated roadway, east of the existing garage, would be required. Additional parking requirements could be satisfied through the development of a parking garage on the site of the current Doug Fox parking lot.

While this option would not completely satisfy future terminal and roadway needs, a substantial amount could be met. Therefore, the central terminal option is a viable alternative.

South Terminal - This option would result in the development of expanded terminal facilities to the south of the Main Terminal. Two basic south terminal options are defined by property acquisition approaches:

- *Avoid Acquisition of the commercial property* west of International Blvd., north of S. 188th. This area presently consists of 12 privately held parcels, including the West Coast Hotel, Pizza Hut, Denny's, etc. The cost to acquire these parcels is estimated to be about $32 million.

  Avoiding the acquisition of these parcels would restrict terminal and supporting roadway development, but would require the displacement of virtually all of the aircraft maintenance and hangar facilities currently located to the south of the Main Terminal. Access to the new terminal facilities would result in development of a connection to S. 188th Street at about 24th Avenue South (west of International Blvd.).

  While the commercial avoidance option would achieve the airside and landside requirements, it would not relieve the current curbfront congestion in the Main Terminal area. To avoid the commercial property would result in the development of a roadway system that connects the existing Main Terminal to the new South Terminal. As a result, vehicular congestion currently experienced would be compounded, as this option would concentrate additional traffic in an already congested area. For these reasons, this option is not a reasonable solution to the needs at Sea-Tac.

- *Commercial Acquisition* - Acquisition of the triangular shaped land envelope bound on the south by S. 188th Street, on the east by International Blvd., and on the east by Air Cargo Road would enable the development of a south unit terminal with a roadway system that could bypass the existing Main Terminal. It would enable the development of a south unit terminal roadway system that could allow passengers to separately access either the Main Terminal or the new South Unit Terminal, thus avoiding the congested area. Along with the development of the unit terminal would be the development of a new parking garage.

A number of building concepts exist to develop the separate, but connected South Unit Terminal. The specific location and layout of the building would depend on the number and operating characteristics of the airlines that would use the new South Terminal. Such features could include a reverse flow roadway system to maximize the terminal curbfront. However, due to land envelope constraints, this type of roadway would not be practical.

The proposed Regional Rail System station could be integrated into this new terminal.

Because this option would provide the necessary terminal and roadway congestion relief, it is a viable alternative.

North Terminal Development - Additional passenger terminal facilities could be developed north of the existing Main Terminal. This option would place development in closer proximity to the entrance roadway and could be completed without acquiring land. However, it would result in the displacement of several airport facilities, including the Airport Rescue and Fire Fighting (ARFF) facility, and a number of cargo buildings and the U.S. Airmail facility.

A number of building configuration concepts exist for a North Terminal. Possibilities include an independent unit terminal and a unit terminal with a new satellite concourse. The specific location and layout of the building would depend on the number and characteristics of the airlines that would use the new facility. Configurations could also include a reverse flow roadway system to maximize passenger curbfront. A new parking facility would be developed to support the north terminal. A north unit terminal would divert passengers away from the Main Terminal and roadway system and thus, assist with relieving congestion on the existing ramps.

Passengers could connect to the existing terminal facilities through the development of either an underground people mover system or the provision of a shuttle bus system. The regional rail system could be interfaced with the existing terminal facilities (at the rear of the parking garage) or at the new North Terminal.

Because this option would meet the facility needs and address roadway congestion associated with the existing Main Terminal, it is a viable alternative.

West Terminal Development - While the Master Plan Update did not examine a west terminal option, passenger terminal facilities could be developed west of the existing airfield. However, to provide the necessary roadway system and infrastructure, an extensive amount of acquisition between Des Moines Memorial Drive and SR 509 would be required. In addition, this terminal alternative would substantially increase the amount of earth needed to fill area lowland, to culvert or relocate Miller Creek, and affect additional wetland. An extensive underground transportation system, or surface system would be needed to enable passengers to connect with activities in the existing Main Terminal. Because of the cost, and human and natural resource disruption, a west terminal alternative was not considered further in this Environmental Impact Statement.

Regardless of which terminal alternative is pursued, a number of improvements would be required:

- Expansion of the Main Terminal for ticketing and baggage claim;
- Expansion and refurbishment of Concourse A for additional

aircraft parking and the potential relocation of the FIS to Concourse A from the South Satellite;

- Improvements to the interline and outbound and inbound baggage systems;
- On-Airport Concourse D hotel;
- Expansion of the Parking Garage;
- Expansion of the South Satellite for additional holdroom, in-transit facilities and public circulation; and
- Improvements to the access/egress ramps.

2. Support Facilities

The Master Plan Update evaluated the need for support facilities based on the aviation demand as well as the facilities that would be displaced through the provision of airside and terminal facilities. Support facilities include: cargo and freight forwarder, general and corporate aviation, air traffic control tower, Aircraft Rescue and Fire Fighting (ARFF), aircraft maintenance, airport maintenance, fuel storage, flight kitchens and miscellaneous facilities.

Air Cargo: As is noted in Chapter I, total tonnage of air cargo is expected to increase 131 percent between 1993 and 2020. As a result of the forecast growth, the following additional cargo space will be needed:

Forecast Additional Cargo Needs

Year	Floor Area	Aircraft Hardstands
2000	641,000	5
2010	836,000	11
2020	1,060,000	17

Given the land available after addressing airside and terminal development needs, a limited quantity of land exists to address cargo facility needs. In siting cargo facilities, two characteristics are essential: direct access to the airfield and direct access to surface transportation (public or airport) roads. Options to addressing cargo facilities are:

Centralized Cargo Option - About 176 acres of land would be required to centralize the cargo facilities in a single complex. To centralize the facilities, it is assumed that the existing cargo facilities would be abandoned and redeveloped at another location on-airport. Two locations for centralized facilities were identified: the area known as the South Aviation Support Area (SASA) and a north site. Because of the site characteristics and size requirements and cost, the complete redevelopment of a new centralized cargo complex is not practical.

Decentralized Cargo Option - The decentralized cargo option would result in supplementing existing cargo facilities at new sites on-airport. Decentralized cargo facilities could be developed within the existing cargo development (to the north of the Main Terminal), further north on existing airport property or in the SASA. Within the existing cargo area, all of the year 2010 needs can be served and about 67% of the year 2020 cargo building area needs can be accommodated and about 57% of the hardstand needs. The post year 2010 forecast needs can then be accommodated in the SASA.

Aircraft Maintenance - As is described in the Final EIS and Record of Decision of the South Aviation Support Area (SASA), three principal objectives will be met through the development of the SASA: to accommodate displaced line maintenance facilities, to accommodate future line maintenance facilities, and to accommodate a major base maintenance facility. That EIS addressed three sites for the development of aircraft maintenance needs: northeast, far north and southeast. The northeast was rejected as there is insufficient land to develop the requisite 84 acres. The far north site (located north of SR 518, west of 24th Avenue South) was rejected because of the cost of developing a taxiway bridge over SR 518, and fill requirement costs.

Because of the need to use portions of the SASA site for supplemental cargo facilities, the extent of aircraft maintenance facility development in the SASA would be dictated by the displacement caused by alternative terminal development.

Miscellaneous Facilities - A number of airport facilities would require expansion to serve forecast aviation demand:

Air Traffic Control Facility: Due to insufficient building space necessary to accommodate growing FAA air traffic control requirements, the FAA has been studying the need for expanded facilities at Sea-Tac.

Currently, the FAA's Air Traffic Control Tower (ATCT) is located on top of the Main Terminal Building. The ATCT has the primary function of controlling flight operations within the Airport's designated airspace and for controlling the movement of aircraft on the Airport's runways, taxiways and other designated areas. The Terminal Approach Control (TRACON) is responsible for controlling the approaching and departing aircraft. The existing ATCT provides adequate visibility to all existing runways and taxiways and would exceed the visibility requirements of the proposed new parallel runway located 2,500 feet west of existing Runway 16L/34R. The existing ATCT, however, lacks sufficient floor area to adequately meet future demand for additional controllers and can not be efficiently expanded to accommodate additional controller positions and technology that is anticipated in the future.

The FAA has established criteria for the establishment of air traffic control facilities: FAA Order 6480.4 "Airport Traffic Control Tower Siting Criteria" and 6480.7 "Airport Traffic Control Tower Design". Approximately 5-6 acres of land would be needed for the ATCT, TRACON and FAA personnel parking preferences. Given the function of the ATCT, it should be located near the center of the Airport, on either the east or west side of the Airport. However, Sea-Tac Airport is presently site constrained on the east, limiting the land available for the required space.

The FAA examined 20 different sites for the proposed Air Traffic Control Tower.[14] Through an evaluation process, the unfeasible sites were eliminated if they did not achieve the following goals: 1) maintain a clear and unobstructed view to all aircraft movement areas and to the edge of the taxiway safety areas for the proposed new parallel runway; 2) eliminate or minimize the need to modify existing structures in order to meet the visibility criteria; and 3) eliminate or minimize the impact to existing or future ILS approach minimums. Only two sites meet these goals:

1. Site A3 - would involve a 231-foot control tower and is located in the northern support area, near the existing U.S. Post Office building. This site could house the TRACON and provide some on-site parking and be accessible from the existing public roadway system. However, it would also limit the future poor weather minimums for approaches to Runway 16L; and
2. Site A4 - would locate a 128-foot control tower at the south end of Concourse B. While this site avoids the future poor weather minimums issues, it would require special construction techniques. First, if a standard tower construction specification were used, it would

[14] *Airport Traffic Control Tower Siting Study, Seattle-Tacoma International Airport, Final Report*, HNTB, December 1995.

occupy the space of one existing gate. A non-standard design could be used, however, increasing the cost of the new tower. In addition, the site would not enable on-site parking - ATCT personnel would be required to park in the garage and walk to the tower, and deliveries would require access to the secure aircraft operations area.

- *Airport Maintenance Facility* - Expanded building space to house existing airport maintenance functions and vehicles is needed. In addition, the present airport maintenance facility (located in the existing cargo area) could be displaced to facilitate the infill of cargo needs in the existing cargo area. To address snow facility requirements, a site west of the existing runways near South 188th Street was identified. The remaining facility requirements could be satisfied north of SR 518/east of 24th Street South or in the SASA.

As a result of alternative airside and landside facilities, a number of support facilities will be displaced. Properties that could be displaced include:

- *General Aviation and Corporate Aviation*: Signature Flight Support, located adjacent to the Alaska Airlines maintenance base, would be displaced by the maximum expansion of the South Terminal. Weyerhaeuser Flight Department, located on the southwestern portion of the existing airfield would be displaced by any new runway option. To maintain aircraft and public access requirements, three sites exist: west, north and SASA. The west site is not reasonable due to the high earthwork related costs. A site on the northwest portion of the airfield and SASA site were determined reasonable alternatives.

- *Aircraft Rescue and Fire Fighting (ARFF)*, located north of the North Satellite, would require relocation due to expansion of the North Satellite. Alternative development sites for the ARFF included development to the west, east, northwest and north of the existing airfield. The west site was determined impractical due to the earthwork related costs. To meet FAA safety standards and certification requirements, a split operation would be required if a north or south location were identified. This was also determined unreasonable due to unnecessary costs. Therefore, a site on the east of the airfield was determined to be the only reasonable alternative.

- *Alaska, Delta and Northwest Airlines line maintenance facilities* would be displaced by terminal expansion to the south. Due to land availability and facility location requirements, three replacement locations exist: west, north and southeast. A prior section summarizes the alternatives analysis that was prepared for the 1994 Final Environmental Impact Statement and Record of Decision concerning SASA maintenance facilities. Therefore, displaced maintenance facilities will be developed in the SASA.

- Northwest Airlines (located near the Northwest Maintenance Hangar) and United Airlines *Flight Kitchens* (located north of the North Satellite) would be displaced by the respective terminal expansion.

- *Underground Fuel storage systems* will require relocation and/or upgrade to be compatible with alternative terminal development. To maintain service requirements, replacement storage systems will be developed for the displaced buildings currently served as well as newly developed facilities, such as a new North or South Unit Terminal.

- Air Mail Facility - the North Unit Terminal, if configured with concourse fingers would require the displacement of the U.S. Post Office Air Mail Facility. This facility would likely be relocated to SASA.

While not addressed in this Environmental Impact Statement, it is expected that in future years, that the Port of Seattle will also examine future non-aviation uses of undeveloped airport land or development above aviation uses. This could include additional on-airport hotels, on-airport office development and collateral development.

(E) Delayed/Blended Alternative

As is noted earlier, SEPA requires the consideration of the benefits and disadvantages of delaying implementation of the proposed alternative. Delaying implementation of actions to addressing the future growth in aviation demand would result in the Do-Nothing for some period. Advantages of this approach would be delaying impacts to the human, social and natural character of the airport area. The disadvantages would be reduced quality of service of airport facilities, increased congestion on some on and off-airport roads, and increased passenger and user inconveniences. Implementation of these projects does not foreclose other future options, as these plans have recognized other major planned improvements in the Airport area such as RTA, Sea-Tac's PRT, South Access and the SR 509 Extension.

A combination of actions that would delay or reduce the aviation demand alternatives, called the Blended Alternative, was evaluated in terms of the capability to meet the needs of freight shippers and travelers who presently use Sea-Tac Airport. As was discussed in the preceding section (on page II-18), this alternative is not a reasonable alternative as it would not satisfy the need.

(F) Do-Nothing/No-Build Alternative

The Do-Nothing alternative would result in the Airport remaining as it is today. Therefore, future operational congestion and delay would not be relieved, and would increase. As is described in Chapter I, air travel demand is a direct function of population, employment and income. As the population of the region is expected to continue to grow at a rate greater than the national average, air travel demand is expected to grow, regardless of the facilities that would be available at Sea-Tac. As a result, the efficiency of the Puget Sound air travel system would be eroded.

The level of service afforded passengers would decline substantially in accordance with passenger growth and the peak travel periods would be extended if the improvements are delayed. In summary, it would take passengers longer to enter the Airport, access parking and move to the ticket counters and gates. Similarly, cargo and freight activities would incur greater congestion and delay in deliveries.

Also, the existing environmental and operational impacts of the Airport would not be reduced. Although this alternative may not be prudent, it is feasible, and therefore, is one of the alternatives considered throughout the Environmental Impact Statement.

Later in this chapter and in **Appendix R**, consideration is given to the possibility that the delay and costs inherent to the Do-Nothing alternative could result in fewer passengers and operations than "With Project". Although this scenario is not likely, if it occurred, the spreading of flights in to the nighttime hours, congested landside facilities, and other impacts would be less than depicted here. See **Appendix R** for more detail.

* * * * *

This chapter summarizes various alternatives to the proposed Master Plan development at Sea-Tac Airport. The Master Plan Update Airside Options Report and Landside Options Report provide detailed analysis of all reasonable alternatives. Three development alternatives and the Do-Nothing were identified and carried forward for this Environmental Impact Statement. The proposed development alternatives represent the reasonable alternatives from an environmental, economic and operational standpoint which address the purpose and need for improved airport facilities.

2. THE PROPOSED ALTERNATIVES TO BE ASSESSED

Based on the consideration of individual alternatives to the proposed need, the following cumulative alternatives are carried forward for detailed impact assessment. These alternatives are:

(1) Alternative Expansion at Sea-Tac Airport

A number of on-site alternatives exist to address the proposed needs at Sea-Tac Airport. During the Master Plan Update, these needs were addressed for the following types of airport functional uses:

- Airside
- Landside
  - Passenger terminal
  - Roadways
  - Cargo and Maintenance
  - Support facilities

The Master Plan Update began with the review of airside options, as this functional use is usually the largest land user at any airport. Once options to address these needs were identified, the planning process focused on the landside, with the terminal and roadway needs reviewed first followed by the cargo/maintenance and support facilities. In addition to the three preferred airside options, three preferred landside options were identified. The following summarizes the review of airside and landside options, as described in detail in Master Plan Update Technical Report No. 6 "Airside Options Evaluation", Technical Report No. 7a "Terminal Facility Options", and 7b "Other Facilities Requirements and Options".

(A) Airside Options

Based on the preliminary identification of possible ranges of options, as described above, eight (8) possible Sea-Tac airside development options were identified. **Exhibit II-4** shows the placement of the runways associated with each option. These include:

- Option 1 – Do-Nothing: This option would leave the existing airfield as it is today: Existing Runway 16L/34R with a length of 11,900 feet and existing Runway 16R/34L with a length of 9,425 feet. Two options were considered: A - the Do-Nothing delay does not cause traffic to spill over into the nighttime hours and B - the delay causes shifts to nighttime hours.
- Option 2 – Commuter - Close Spaced: An additional 5,200-foot commuter runway with 1,500 feet separation from existing Runway 16L/34R.
- Option 3 – Commuter Dependent: Implementation of this option would result in the construction of a new 5,200 foot long runway 2,500 feet west of Runway 16L/34R. The north threshold of this runway would be 1,435 feet south of the north ends of the existing runways.
- Option 4A - Programmatic Baseline: [15] Option 4A would result in the development of a new 7,000 foot long parallel runway, located 2,500 feet west of existing Runway 16L/34R. The northern end of the new runway would align with the northern ends of the existing runways. To enable the development of the new runway, and to address existing RSA issues, South 154th Street and South 156th Way would require relocation to the north. Also with Option 4A, Runway End 34R would be extended 600 feet to the south, providing a runway length of 12,500 feet.

  Option 4B - 7,000 Foot – Programmatic Staggered: This option would result in the development of a new 7,000 foot long parallel runway located 2,500 feet west of existing Runway 16L/34R. The northern end of the new runway would be approximately 1,435 feet south of the

[15] Option 4A is the baseline runway discussed and assessed in the Flight Plan Study.

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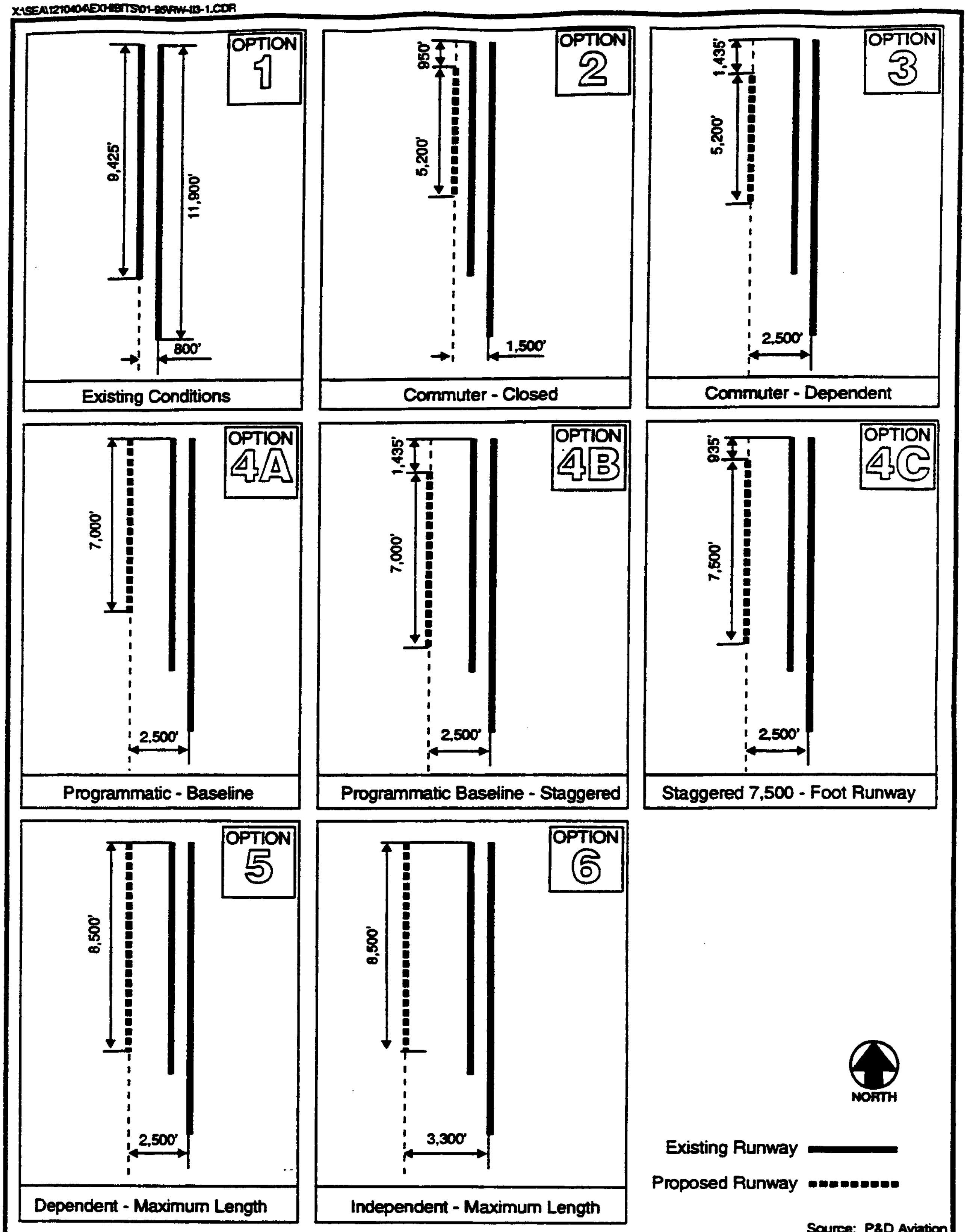

Seattle - Tacoma International Airport	Runway Options	EXHIBIT: II-4

northern ends of the existing runways, resulting in the stagger. To accommodate the RSA for the new runway, South 154th Street would require relocation to the north.

- Option 4C - 7,500 Foot – Staggered: This option would result in the development of a new 7,500 foot long parallel runway located 2,500 feet west of existing Runway 16L/34R. The northern end of the new runway would be approximately 935 feet south of the existing runways' northern threshold, resulting in the stagger. To accommodate the RSA for the new runway, South 154th Street would require relocation to the north.
- Option 5 - Dependent–Maximum Length: Option 5 would entail the development of a new 8,500 foot long runway located 2,500 feet west of existing Runway 16L/34R. The north end of the new runway would be aligned with the north ends of the existing runways, requiring the relocation of South 154th Street and South 156th Way.
- Option 6 - Independent – Maximum Length: A new 8,500 foot long runway would be constructed approximately 3,300 feet west of existing Runway 16L/34R. Because of the length and location of the new runway, a number of roads would require relocation: South 156th Way and South 154th Street would require relocation to the north, and approximately 1 mile of SR 509 (including the interchange at S. 188th) and Des Moines Memorial Way would require relocation to the west.

To facilitate the Master Plan Update's evaluation, a preliminary cost estimate and an operational and environmental screening analysis was conducted. **Table II-5** presents a summary of the analysis. The Master Plan Update Technical Report No. 6, Airside Options Evaluation contains a detailed description of the methodology and results.

As was described earlier, the longer the runway length, the greater the types and thus number of aircraft operations that would be capable of using the runway, especially during poor weather conditions. As expected, the delay reduction achieved with the 2,500-foot separation capable of accommodating air carrier jets (Options 4A, 4B, 4C, and 5) would be greater than the Do-Nothing, lesser spacing or commuter length runways. However, due to terrain changes west of the present runway system, the longer runways result in greater cost. The largest cost, with minimal incremental benefit, is achieved with the widest spacing (3,300 separation). The delay reduction difference between Option 6 and Options 4A through 5 is minimal.

The following environmental conditions were considered in the preliminary screening analysis of the airside options:

- Noise and Land Use
- Aircraft Air Pollution
- Water and Natural Resources
- Construction/Displacement Impacts

As was shown by the environmental screening, there were three primary levels of impacts associated with the various options. Clearly, the wider separation (3,300 feet separation associated with Option 6) resulted in the greatest overall environmental impact. While aircraft air pollutant levels would be the lowest with Option 6, virtually all other impacts were the greatest. The Do-Nothing and commuter lengths (Options 1 through 3) would result in the least impact on the natural resources as well as human environment, yet would result in the greatest air pollution levels due to lesser delay reduction. The impacts varied much less among the 2,500 foot separation runways with lengths of 7,000 feet, 7,500 feet and 8,500 feet.

Based on the results of this screening evaluation, it was determined that Options 2 and 3 did not satisfy the poor weather delay reduction need. Therefore, they were not recommended. Due to the substantial disruption, with minimal incremental benefit, it was determined that a runway separation of 3,300 feet is not desirable (Option 6). Therefore, Options 4A, 4B, 4C and 5 were found to meet the need and thus were recommended for further study.

Subsequent to the Master Plan Update preliminary screening analysis, the FAA's Capacity Enhancement Update Study examined the delay benefits associated with several airfield options. As is shown in **Table II-4**, a new parallel

AR 038840

TABLE II-5
Page 1 of 2

Environmental Impact Statement
Master Plan Update

PRELIMINARY AIRSIDE SCREENING ANALYSIS

	Master Plan Update Airside Options						
	1A	1B	3	4A	4C	5	6
% of year 2020 arrivals which could be accommodated on new runway	N/A	N/A	31	91	97	99	99
% of year 2020 departures which could be accommodated on new runway	N/A	N/A	31	67	85	90	90
Initial Total Average Delay year 2020 per aircraft operation	22.0	22.0	14.2	5.4	4.6	3.8	3.8
Estimated Runway Construction Cost (million $)	$0	$0	$255	$347	$294	$364	$596
Noise: Population Impacts in year 2020 *							
DNL 65 and greater	12,800	13,650	13,050	13,450	13,380	14,030	15,040
60-65 DNL	40,820	42,370	40,440	40,700	40,770	40,760	41,030
Noise: Housing Impacts in year 2020*							
DNL 65 and greater	5,390	5,730	5,480	5,650	5,630	5,870	6,360
60-65 DNL	17,910	18,580	17,690	17,870	17,900	17,920	17,980
Noise Impacted (65+ DNL in year 2020):a/							
Parks	6	6	6	6	6	6	6
Historic/Cultural sites	3	4	3	4	4	4	5
Churches	13	13	13	13	13	13	15
Hospitals/Nursing homes	0	0	0	0	0	0	0
Libraries	1	1	1	1	1	1	1
Schools	8	9	9	8	8	8	8

Note: Impacts presented in this table were prepared as a part of a ***preliminary screening***, based on initial data collection. As was noted in presenting this data in July 1994, the base information was later updated by this Environmental Impact Statement.

* All forecast year 2020 noise impacts are less than the 1994 impacts. The percentage of year 2020 arrivals or departures does not refer to the percentage of time that the runway would be used.

a/ Noise impacted noise sensitive facilities noted above do not include the units displaced by construction.

- Option 1A/B – Do-Nothing
- Option 2 - Commuter Close Spaced - this option was not evaluated due to its similarity to Option 3.
- Option 3 – Commuter Dependent
- Option 4A - Programmatic Baseline (7,000 ft new runway)
- Option 4B - Programmatic Staggered - this option was not evaluated due to its similarity to Options 4A, 4C and 5.
- Option 4C - 7,500 Foot – Staggered
- Option 5 - Dependent–Maximum Length (8,500 ft new runway)
- Option 6 - Independent – Maximum Length

N/A - Not Applicable

Source: Landrum & Brown, Shapiro & Associates, and Gambrell Urban - Population and dwelling units using 1990 census.

TABLE II-5
Page 2 of 2

Environmental Impact Statement
Master Plan Update

PRELIMINARY AIRSIDE SCREENING ANALYSIS

	Master Plan Update Airside Options						
	1A	1B	3	4A	4C	5	6
Air Inventory (tons per day in year 2020)							
Carbon Monoxide	13.86	13.86	10.18	6.82	6.82	5.86	4.86
Nitrogen Oxides	6.82	6.82	6.49	6.19	6.19	6.11	6.02
Particulate Matter (PM10)	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sulfur Oxides	0.33	0.33	0.28	0.23	0.23	0.22	0.20
Wetland Impacts (acres)	0	0	4.2	5.4	5.0	5.4	27.7
100-Year Floodplain Impacts (acres)	0	0	1	7	2	7	30
Stream Relocation (linear feet)	0	0	2,760	2,970	2,760	2,970	12,240
Earth Impacts (million cubic yards)	0	0	12	17	13	17	28
Construction Impact (units displaced):							
Properties	0	0	330	410	400	420	700
Homes	0	0	260	330	300	320	500
Parks	0	0	0	0	0	0	1
Historic/Cultural sites	0	0	1	1	1	1	3
Schools	0	0	0	0	0	0	1

Impacts presented in this table were prepared as a part of a ***preliminary screening***, based on initial data collection. As was noted in presenting this data in July 1994, the base information was later updated by this Environmental Impact Statement.

- Option 1A/B -- Do-Nothing
- Option 2 - Commuter Close Spaced - this option was not evaluated due to its similarity to Option 3.
- Option 3 -- Commuter Dependent
- Option 4A - Programmatic Baseline (7,000 ft new runway)
- Option 4B - Programmatic Staggered - this option was not evaluated due to its similarity to Options 4A, 4C and 5.
- Option 4C - 7,500 Foot -- Staggered
- Option 5 - Dependent--Maximum Length (8,500 ft new runway)
- Option 6 - Independent -- Maximum Length

Source: Landrum & Brown, Shapiro & Associates, and Gambrell Urban - Population and dwelling units using 1990 census.

runway with a separation of 2,500 feet would reduce delay levels during the 25 year planning horizon to acceptable levels. Average all-weather delay would not reach 10 minutes until sometime after the year 2025.

The development of the proposed new parallel runway at Sea-Tac would require the displacement of the ASR-9, the Airport Surveillance Radar which detects the presence and monitors the location of in-flight aircraft within 60 nautical miles of the Airport. The ASR-9 is currently located on the west side of the airfield, about 2,150 feet south of the threshold of Runway 16R and 750 feet west of the runway. The ASR-9 should be located as close to the ATCT as practical. It requires a base facility area of about 60 feet by 60 feet, with the actual radar suspended on a tower. A radius of approximately 1,500 feet from the base of the tower must be free from any buildings or objects that might cause signal reflections, and be at least 0.5 miles from other electronic equipment.

Alternatives locations for the ASR are:

- Site 1 - is located south and west of the threshold of Runway 34L, south of South 188th Street on vacant land not presently owned by the Port of Seattle. The site would require a tall tower to enable radar coverage of the airfield, as the site is 130 feet below the threshold of Runway 16L. Commercial and roadway land uses in the vicinity could represent false target sources. Because of the distance away from other airport facilities, establishment of the ASR-9 at this site would require extensive conduit.
- Site 2 - is also located off-airport, west of SR-509 and north of South 170th Street. This site consists of nearly 30-acres of wetland and would require extensive fill to prevent reflective or obstructive surfaces, which are about 200 feet below the threshold elevation of Runway 16L. Due to the distance away from the existing airfield, this site would require the greatest extension of conduit.
- Site 3 - is located about 1,050 feet west of the exiting ASR-9, within the area that would be acquired to develop the new parallel runway. Because of elevation differences, this site would also require steep fills or retaining walls to raise the elevation of the site.
- Site 4 - is located in south and west of Lake Lora, on land that would be acquired for the development of the new parallel runway. Due to surrounding highways (SR-518 and SR 509), and buildings, the site is believed to not meet acceptable performance criteria for the ASR-9.
- Site 5 - is located on the northwest end of existing Airport land, near the City of Seattle reservoir. Of the sites identified, this is the only site that would be above the ground elevation of the runway thresholds. Further examination would require insurance that the site would not result in false targets due to surrounding buildings.
- Site 6 - is located on the north end of the airport, between Runway 16R and the proposed new parallel runway. Further examination will have to consider the impact of the new runway in the possible creation of false targets. The site is centrally located and would enable easy access for maintenance.
- Site 7 - is located west of the proposed embankment for the new parallel runway near SR 509 at about 173rd street. This would be on land acquired to construct the new runway.

TABLE II-4

DELAY REDUCTION BENEFITS OF A NEW PARALLEL RUNWAY

			New Runways with the following Separation			
	Do-Nothing		2,500 ft Separation		3,000 ft Separation	
Activity	Arrival	Average	Arrival	Average	Arrival	Average
345,000	7.7	4.5	NA	NA	NA	NA
425,000 *	22.2	12.4	4.7	3.8	4.2	3.3
525,000 *	63.7	37.7	13.3	8.3	12.3	7.7

Source: FAA Capacity Enhancement Update, Data Package 12, June, 1995.

* Assumes full use of the 2.5 nm separation.

AR 038843

- Site 8 - is located on a site that would be between existing runway 16R/34L and the new parallel runway, near the middle of the airfield. The site is centrally located.
- Site 9 - is located west of the proposed embankment for the new parallel runway near at about 164th street, east of SR-509. This would be land acquired to build the new runway.

Based on the preliminary evaluation which determined that Site 3, 7, 8 and 9 would meet the siting needs for the ASR-9, all four sites were evaluated in this EIS.

(B) Landside Options

During the landside planning process the initial focus was on the terminal development needs, because additional terminal space and gate development would likely displace adjoining maintenance and cargo development. Once the options for addressing existing and future terminal needs were identified, the roadways necessary for serving these facilities were examined, followed by the consideration of cargo, maintenance and other support facilities.

As was described in the preceding section, three primary terminal options exist: centralized, north and south unit terminal development. Following the identification of the terminal options, alternatives for addressing the remaining landside facilities were identified.

The following alternatives define the grouping of airside and landside development options.

(2) Alternative 1 Do-Nothing (No Build)

This alternative would preserve Sea-Tac as it generally is today. As a result, the existing poor weather related delay would continue, growth in passengers and aircraft operations could occur, but would be accommodated at less efficient levels with increasing levels of delay and congestion. **Table I-6** lists the current airport facility capabilities as well as future needs.

The existing facilities at Sea-Tac are capable of serving the forecast demand for air travel, although very inefficiently. A number of commentors on the Draft EIS questioned whether it is accurate that the number of passengers and aircraft operations would be the same with or without construction of the new runway and overall Master Plan Update improvements. **Appendix R** contains a detailed response to the question of whether the Do-Nothing and "With Project" alternatives are capable of serving the forecast demand.

- Growth in demand for air travel will result from the forecast growth in the Region's population and income levels. If a new runway and other facility improvements are not constructed, the growth in demand for air travel would continue to occur as would the number of operations, because it is expected that the Region will continue to experience growth in population and income;
- The Flight Plan Study found that the capacity of the existing airfield at Sea-Tac is about 380,000 annual operations. It is theoretically possible for more than 380,000 operations to occur at Sea-Tac in a year, as evidenced in the 1992 Flight Plan EIS: "By extending operations into the late evening and early morning hours and with increased average delay, the airport (Sea-Tac) can handle up to 460,000 operations per year."[16]
- Therefore, it is reasonable to assume that the same number of flight operations would occur with and without the new runway.

If the proposed new parallel runway and other Master Plan Update improvements were not constructed, and the increasing delay at Sea-Tac results in fewer annual aircraft operations than would occur with the improvements, the impacts of the Do-Nothing alternative would be different from the impacts of the "With Project" alternatives. In most areas, the impacts of the Do-Nothing alternative would be less, as summarized in **Appendix R**.

16/ Flight Plan Final Environmental Impact Statement, pp. 3-16. Also The Flight Plan Project, Draft Final Report and Technical Appendices including Draft Programmatic Environmental Impact Statement, January 1992 indicates that the passenger capacity of the existing facility ranges between 32 MAP and 38 MAP (p. B-90 Working Paper 7m, p. 11)

As was noted earlier, the No-Build alternative would require that the Runway Safety Area issues be addressed through use of declared distances which would require displacement of the landing thresholds and implementing declared distance procedures. This would reduce the landing distance available on each runway end. The displacements would be 16R-770 feet, 16L-300 additional feet (790 feet total), and 34R-465 feet.

The following improvements are included in the Do-Nothing (Alternative 1):

- Implementation of declared distance procedures and displacements to the thresholds of Runway 16L and 16R to address the FAA mandated runway safety area requirements;
- Installation of an Instrument Landing System (ILS) on Runway 16L capable of Category IIIb visibility down to runway visual range of 300 feet;
- Clearing and grading of the 34L and 34R runway safety area (as studied and approved in 1995 SEPA Determinations of Non-Significance);
- Implementation of the South Aviation Support Areas (SASA) as approved in the 1994 Final Environmental Impact Statement and Record of Decision;
- Development of the South Access Road and Extension of SR 509;
- Implementation of the terminal area ground access improvements and seismic improvements, as assessed in the November 1995 SEPA Determination of Non-Significance;
- Implementation of an On-Airport Hotel (as addressed in the 1995 Final Environmental Impact Statement for the On-Airport Hotel); and
- Development of the Des Moines Creek Technology Campus (as discussed in the 1995 Final Environmental Impact Statement for the Des Moines Creek Technology Campus).

As was described in Chapter I, growth in population of the region is expected to result in a 103% increase in enplaned passengers between 1993 and 2020 and a 30% increase in aircraft operations. The increased air travel demand is expected to occur whether or not further airport facility improvements are pursued at Sea-Tac. **Appendix R** contains a detailed discussion concerning the Do-Nothing and "With Project" forecast assumptions.

Because the existing airport facilities would not be able to accommodate the forecast demand efficiently, the hourly levels of activity (aircraft operations, passengers and vehicular traffic) would differ. Therefore, an analysis of how the demand profile would change with or without airport development was performed.

To test the ability of the existing airside and landside to accommodate the forecast 103% increase in passenger demand and 30% increase in aircraft operations, a review of the operating capability was conducted. First the ability of the existing airfield to accommodate this growth was tested using the FAA's air traffic flow control methodology. As aircraft operations increase, delay will increase exponentially. Such delays will result in a spreading of the peak operating hours. As the activity would be accommodated, the evaluation focused on the quantity of aircraft operations that would be delayed from daytime hours into late evening and nighttime hours.

At Sea-Tac, the good weather acceptance rate is 60 arrivals per hour. During poor weather, the acceptance rate is reduced to 36 or fewer arrivals per hour. Based on the arrival acceptance rates, the hourly demand during the average day in years 2000, 2010 and 2020 was evaluated. Based on the percentage occurrence of poor weather, a slight spreading (less peaks) of the demand would occur between 10 a.m.-1 p.m. and 6 p.m.- 9 p.m. in year 2000. As additional growth in aviation demand occurs, delay associated with the existing airfield would result in additional spreading of activity level peaks. By year 2020, the hourly demand profile would be flattened between 7 a.m. and 12 a.m. **Exhibit II-3** shows the resulting average all-day's hourly activity levels in year 2020 associated with Master Plan Update alternatives.

As is shown in the table, during poor weather, when the arrival acceptance rate is 36 or fewer arrivals per hour, the year 2020 demand would be significantly affected. Between 9 a.m. to 10 a.m. about 39 arrivals are forecast. When the acceptance rate is 36 arrivals per hour (about 24% of the year), three arrivals would be delayed into the adjoining hour. As 47 arrivals are forecast

EXHIBIT II. 3

COMPARISON OF HOURLY ACTIVITY LEVELS OF THE MASTER PLAN ALTERNATIVES

	With Project Alternatives (Alt 2, 3, and 4)								
	Year 2000			Year 2010			Year 2020		
Hour	Arr.	Dep.	Total	Arr.	Dep.	Total	Arr.	Dep.	Total
0	6	6	12	6	6	12	7	7	14
1	1	2	3	1	2	3	1	2	3
2	0	0	0	0	0	0	0	0	0
3	4	0	4	4	0	4	5	0	5
4	1	0	1	1	0	1	1	0	1
5	8	4	12	9	4	13	9	5	14
6	13	24	37	14	26	40	15	28	43
7	21	43	64	22	46	68	25	50	75
8	20	41	61	21	45	66	23	49	72
9	33	21	54	36	22	58	39	24	63
10	39	31	70	43	33	76	47	36	83
11	38	30	68	41	32	73	44	35	79
12	29	38	67	31	41	72	34	44	78
13	32	39	71	34	42	76	37	45	82
14	26	32	58	28	34	62	30	37	67
15	33	26	59	35	28	63	38	30	68
16	20	30	50	21	32	53	23	35	58
17	32	23	55	34	25	59	37	27	64
18	42	34	76	45	36	81	49	40	89
19	35	30	65	38	32	70	41	35	76
20	33	24	57	35	26	61	38	28	66
21	23	16	39	25	17	42	27	19	46
22	22	10	32	23	11	34	26	12	38
23	8	15	23	9	16	25	9	17	26
Total	519	519	1,038	556	556	1,112	605	605	1,210
Day Only	456	458	914	489	491	980	532	534	1,066
Night Only	63	61	124	67	65	132	73	71	144

	Do-Nothing (Alternative 1)								
	Year 2000			Year 2010			Year 2020		
Hour	Arr.	Dep.	Total	Arr.	Dep.	Total	Arr.	Dep.	Total
0	6	6	12	6	6	12	7	7	14
1	1	2	3	1	2	3	1	2	3
2	0	0	0	0	0	0	0	0	0
3	4	0	4	4	0	4	5	0	5
4	1	0	1	1	0	1	1	0	1
5	8	4	12	9	4	13	9	5	14
6	13	24	37	14	26	40	15	28	43
7	21	43	64	22	46	68	25	[illegible]	[illegible]
8	20	41	61	21	45	66	23	[illegible]	[illegible]
9	33	21	54	36	22	58	[illegible]	[illegible]	[illegible]
10	38	31	69	41	33	74	[illegible]	[illegible]	[illegible]
11	38	30	68	40	32	72	[illegible]	[illegible]	[illegible]
12	30	38	68	[illegible]	40	[illegible]	[illegible]	[illegible]	[illegible]
13	32	39	71	[illegible]	41	[illegible]	[illegible]	[illegible]	[illegible]
14	26	32	58	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
15	33	26	59	35	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
16	20	30	50	21	32	[illegible]	[illegible]	[illegible]	[illegible]
17	32	23	55	34	25	59	[illegible]	[illegible]	[illegible]
18	41	34	75	[illegible]	36	[illegible]	[illegible]	[illegible]	[illegible]
19	35	30	65	[illegible]	32	[illegible]	[illegible]	[illegible]	[illegible]
20	34	24	58	[illegible]	26	[illegible]	[illegible]	[illegible]	[illegible]
21	23	16	39	[illegible]	17	[illegible]	[illegible]	[illegible]	[illegible]
22	22	10	32	23	11	34	28	14	42
23	8	15	23	9	16	25	11	18	29
Total	519	519	1,038	556	556	1,112	605	605	1,210
Day Only	456	458	914	489	491	980	528	531	1,059
Night Only	63	61	124	67	65	132	77	74	151

(shaded) Hour of the day where demand exceeds all-weather operating capability of existing airfield

1/ Distribution of Hourly Operations Source: Airport Capacity Enhancement Plan Update Data Package No. 7, September, 1994

2/ Acceptance Rate and % Occurance Source: Sea-Tac ATCT, Plans and Proc edures

Prepared by Landrum & Brown   S:\ACOPS.WK4 - Sheet (Combination)

AR 038846

for the adjoining hour, 14 arrivals would be further delayed. These conditions would continue to ripple through the day until non-peak hours or the poor weather clears. To examine an average day conditions, shifts in activity during poor weather were examined. Delay associated with Alternative 1 would result in shifts in arrivals and departures in years 2000, 2010 and 2020. However, only in year 2020 would delay be so great that the average day distribution of day to night traffic would be affected. From an environmental perspective, the hourly distribution of traffic is one essential element to the assessment of impacts. Nighttime (10 p.m. to 7 a.m.) is of concern due to the added sensitivity to noise during hours when the average population is sleeping. In year 2020, the "With Project" alternatives (Alternatives 2, 3 and 4) would result in 73 nighttime arrivals and 71 nighttime departures. The Do-Nothing 2020 alternative would result in 77 night arrivals and 74 departures.

Exhibit II-5 shows the airport layout associated with Alternative 1.

(3) <u>Alternative 2 (Central Terminal)</u>

Exhibit II-6 shows the layout of Alternative 2. This alternative would result in the development of a new parallel runway, with a length of up to 8,500 feet,[17] located about 2,500 feet west of Runway 16L/34R, and increasing passenger facilities through incremental expansion of the existing Main Terminal.

The elements of this alternative include:

- A new Runway 16X/34X with a length up to 8,500 feet. The runway would be equipped to enable Category IIIb precision approaches on 16X with Cat I precision approach capability on 34X. Instrumentation would include glide slopes, localizers, one Inner Marker, One Middle Marker, one DME, three RVRs, two PAPIs, one ALSF-II, and one MALSR:
  - Relocation of the Airport Surveillance Radar (ASR) and Airport Surface Detection Equipment (ASDE);
  - Relocation of S. 156th Way and 154th Street South;
  - Acquisition of land and relocation of residents and businesses;
- Installation of the CAT III Instrument Landing System (ILS with localizer, glideslope, middle marker, and ALSF-II) on 16L;
- A midfield overnight aircraft parking apron would be developed between the new runway (16X/34X) and existing Runway 16R/34L;
- Development of a new Air Traffic Control Tower and TRACON;
- Dual 34L south parallel taxiway and taxiway bridge over 188th Avenue South;
- Additional taxiway exits on existing runways;
- Extension of Runway 34R by 600 feet and relocation of the glideslope and electrical utilities; and
- Clearance, grading and development of the Runway Safety Areas.

The terminal and support development associated with this alternative represents the maximized expansion within the existing Main Terminal and supporting roadway system. Landside development includes:

- Significant southward expansion of Concourse A and the Main Terminal:
  - Relocation of Northwest Flight kitchen;
  - Development of displaced Northwest, and Delta Aircraft Maintenance facilities in the SASA;
  - Development of the On-Airport hotel on Concourse D;
  - Widening the existing terminal curbfront;
  - Development of the elevated transit curb above the parking lot exit on the east side of the parking garage;
  - Expand the Parking Garage to the south to accommodate about 10,200 vehicles;
  - Provision for RTA (Regional Transit Authority) at a station

[17] The Master Plan Update identified three viable runway lengths, each located 2,500 feet west of existing Runway 16L/34R. Therefore, to evaluate a worst case condition, a runway length of up to 8,500 feet will be assessed. The impacts of a 7,000-foot or a 7,500 foot runway with the 2,500 ft separation are also addressed.

located along the bypass roadway, east of the parking garage;
  - Development of a pedestrian bridge from the RTA station connected to the Main Terminal;
  - Development of the by-pass roadway, serving the south portion of the Concourse A extension, parallel to International Blvd.;
- Expansion of the North and South Satellites:
  - Relocation of the main ARFF facility;
  - Relocation of the Alaska Hangar to the SASA;
- Implementation of the terminal area ground access improvements and seismic Improvements, as assessed in the November 1995 SEPA Determination of Non-Significance;
- Relocation of Airborne Cargo company for the development of the Air Traffic Control facility;
- Development of the general and corporate aviation facilities in the north airfield location between the runway protection zones for 16R and 16X;
- Development of a parking structure on the current Doug Fox parking lot;
- Development of additional airport employee parking north of SR 518/west of 24th Avenue South; and
- Development of the airport maintenance facility north of SR 518/East of 24th Avenue South.

(4) Alternative 3 (North Unit Terminal)

As another alternative to address terminal development requirements, a new unit terminal could be developed north of the Main Terminal. **Exhibit II-7**[18] illustrates the locations of facilities with implementation of this alternative.

- A new Runway 16X/34X with a length up to 8,500 feet. The runway would be equipped to enable Category IIIb precision approaches on 16X with Cat I precision approach capability on 34X. Instrumentation would include glide slopes, localizers, one Inner Marker, One Middle Marker, one DME, three RVRs, two PAPIs, one ALSF-II, and one /MALSR:
  - Relocation of the Airport Surveillance Radar (ASR) and Airport Surface Detection Equipment (ASDE);
  - Relocation of S. 156th Way and 154th Street South;
  - Acquisition of land and relocation of residents and businesses;
- A midfield overnight aircraft parking apron would be developed between the new runway (16X/34X) and existing Runway 16R/34L;
- Development of a new Air Traffic Control Tower and TRACON;
- Installation of the ILS on 16L (localizer, glideslope, middle marker, and ALSF-II);
- Dual 34L south parallel taxiway and taxiway bridge over 188th Avenue South;
- Additional taxiway exits on existing runways;
- Extension of 34R by 600 feet and relocation of the glideslope and electrical utilities; and
- Clearance, grading and development of the Runway Safety Areas.

Landside development includes:

- Limited expansion of Concourse A and the Main Terminal:
  - Relocation of Northwest Flight kitchen north of SR 518;
  - Development of displaced Northwest Aircraft Maintenance facilities in the SASA;
  - Development of the by-pass roadway to connecting the New North Unit Terminal with 188th Street South at 24th Street;
  - Expansion of the Parking Garage to accommodate about 10,900 vehicles; and
  - Development of the On-Airport hotel on Concourse D.
- Development of the North Unit Terminal and parking structure:
  - Development of the North Unit Terminal parking structure to accommodate about 4,000 vehicles

[18] An official Airport Layout Plan (ALP) has been prepared for the Preferred Alternative. It is available on request from the FAA.

and the associated terminal/garage access system;

- Development of access ramps from SR 518 at 20th Avenue for access to the existing cargo area and new cargo facilities;
- Displacement of the Doug Fox Parking facility;
- Displacement of the U.S. Post Office Air Mail Facility to SASA;
- Relocation of the ARFF to the UAL flight kitchen area;

- Implementation of the terminal area ground access improvements and seismic Improvements, as assessed in the November 1995 SEPA Determination of Non-Significance;
- Relocation of Airborne cargo to other portions of the cargo area or SASA for the development of the Air Traffic Control facility;
- Development of a cargo warehouse North of SR 518/east of 24th Avenue South;
- Development of the SASA:
  - Displace Northwest hanger;
  - Expansion capacity for cargo/ maintenance;
  - Cargo facility for 11 hardstand position;
  - General Aviation facilities; and
  - General support equipment.
- Development of the general and corporate aviation facilities in the SASA or at the north airfield location;
- Development of additional airport employee parking north of SR 518/west of 24th Avenue South; and
- Development of the airport maintenance facility at a north field location between the runway protection zones for Runway 16X/34X and 16R/34L or at the existing Caterair location.

(5) **Alternative 4 (South Unit Terminal)**

As is shown in **Exhibit II-8**, the elements of this alternative include:

- A new Runway 16X/34X with a length up to 8,500 feet. The runway would be equipped to enable Category IIIb precision approaches on 16L and Cat I precision approach capability on 34X. Instrumentation would include glide slopes, localizers, one Inner Marker, One Middle Marker, one DME, three RVRs, two PAPIs, one ALSF-II, and one MALSR;
  - Relocation of the Airport Surveillance Radar (ASR) and Airport Surface Detection Equipment (ASDE);
  - Relocation of S. 156th Way and 154th Street South;
  - Acquisition of land and relocation of residents and businesses;
- A midfield overnight aircraft parking apron would be developed between the new runway (16X/34X) and existing Runway 16R/34L;
- Development of a new Air Traffic Control Tower and TRACON;
- Installation of the ILS on 16L (localizer, glideslope, middle marker, and ALSF-II);
- Dual 34L south parallel taxiway and taxiway bridge over 188th Avenue South;
- Additional taxiway exits on existing runways;
- Extension of 34R by 600 feet and relocation of the glideslope and electrical utilities; and
- Clearance, grading and development of the Runway Safety Areas for all runway ends.

The terminal and support development associated with this alternative represent the South Unit Terminal option:

- Limited expansion of Concourse A and the Main Terminal:
  - Displaced Northwest and Delta Hangars to the SASA; and
  - Development of an On-Airport hotel on Concourse D;
- Expansion of the North and South Satellite:
  - Relocate the Alaska hanger to SASA; and
  - Relocate the ARFF.
- Development of the South Unit Terminal, parking garage for about 5,000 vehicles, and elevated access bypass system;

- Relocation of Northwest Flight Kitchen north of SR 518;
- Implementation of the terminal area ground access improvements and seismic Improvements, as assessed in the November 1995 SEPA Determination of Non-Significance;
- Expansion of the main parking garage to accommodate about 9,600 vehicles;
- Development of the general and corporate aviation facilities in the north airfield location;
- Development of additional airport employee parking north of SR 518/west of 24th Avenue South; and
- Development of the airport maintenance facility north of SR 518/East of 24th Avenue South.

The environmental impacts of these alternatives are presented in detail in Chapters IV and V.

* * *

With all "With Project" alternatives, the land acquired by the Port west of the proposed new parallel runway would be designated for future airport compatible land uses. The Master Plan Update has not identified specific uses of this land. Thus, when uses are identified applicable environmental process will be undertaken.

(6) <u>Selected Preferred Alternative</u>

After review of the Draft Environmental Impact Statement, the Port of Seattle staff recommended the implementation of **Alternative 3** (the North Unit Terminal) with a proposed 8,500 foot long new parallel runway located about 2,500 feet west of Runway 16L/34R. However, to aid in public review, the document refers to a runway with a length "up to 8,500 feet" so that the impacts of a 7,000 ft., 7,500 ft., and 8,500 ft. runway are identified. The elements of the improvements included in the Preferred Alternative are listed beginning on page II-39 of this Final EIS and include the following key elements:

- A proposed new parallel runway and with a length up to 8,500 feet, and associated taxiways and navigational aids;
- Relocation of South 154th/156th to the north to enable the clearing, grading and development of the RSAs for the existing runways and the proposed new parallel runway;
- Extension of Runway 34R by 600 feet to the south;
- Terminal improvements in the existing main terminal area and significant new terminal and parking development to be located north of the existing main terminal; and
- Development of the South Aviation Support Area for aircraft maintenance and possible growth in air cargo facilities;

This alternative was recommended for the following reasons:

- Reduces the existing and future disparity between the poor weather and good weather operating capability, enabling dependent parallel arrival streams during poor weather conditions.
- Provides the greatest delay reduction of all alternatives considered. The reduced operating times associated with the implementation of a third parallel runway would result in a substantial cost savings to the airlines. A new parallel runway would have saved the airlines $24 million annually if it had been available for use in 1994. The delays saving is expected to grow to around $59 million per year in 2000, $70 million per year in 2002 and $146 million annually when activity reaches 425,000 operations (near the year 2013). As a result, if the runway were available for use in year 2002, the delay savings would compensate for the cost of construction in a 5 year period. If completed later, the pay-back period would be sooner than 5 years.
- The proposed new runway would accommodate 99% of the possible aircraft types for landing which currently use or are anticipated to be operating at Sea-Tac.
- Enables unrestricted departure weights for aircraft departing to the Pacific Rim countries during warm summer weather.
- Provides efficient and flexible landside facilities to accommodate future aviation demand providing the greatest levels of service to air passengers by improving curb-to-terminal and curb-to-gate access, decreased walking distances, and the lowest cost per new aircraft gate.
- Relieves the surface vehicle congestion on the existing terminal drive system.
- Minimizes disruption of commercial development along International Boulevard.

- Enables future expansion of terminal and support facilities in an incremental fashion to accommodate air travel demand as growth occurs.
- Minimizes the disruption to existing airport facilities during the implementation of the proposed improvements.
- Minimizes aircraft push-back and taxiing conflicts as flights enter and exit the terminal area.

3. FEDERAL, STATE AND LOCAL ACTIONS

Regardless of the development alternative pursued, action will be required at the Federal, State and local level. The next section summarizes the applicable Federal and State laws. The types and groups responsible for the action include the following:

(1) Federal Actions

Action is expected to be required of two primary federal agencies:

- Federal Aviation Administration (FAA): Key actions by the FAA include:
  - A determination under 14 CFR Part 157 (49 USC 40113(a)) as to whether or not it objects to the airport development proposal from an airspace perspective, based on aeronautical studies;
  - Decisions under the authority of 49 USC 40103(b) to develop air traffic control and airspace management procedures to effect the safe and efficient movement of air traffic to and from the proposed runway, including the development of a system for the routing of arriving and departing traffic and the design, establishment, and publication of standardized flight operating procedures, including instrument approach procedures, and standard instrument departure procedures;
  - A determination, through the aeronautical study process, under 14 CFR 77 (49 USC 40103(b), 40113) regarding obstructions to navigable airspace;
  - Decisions regarding project eligibility for Federal grant-in aid funds (49 USC 47101, et seq.) or Passenger Facility funds (49 USC 40117) for land acquisition, site preparation, runway and taxiway construction, and environmental mitigation;
  - Final approval of a revised airport layout plan (49 USC 47107 (a)(16)) and environmental approval (42 USC 4321-4347 and 40 CFR 1500-1508);
  - Certification of air quality conformance of the proposed facility with applicable air quality limitations under National (section 176 (c)(1) of the Clean Air Act as amended (42 USC 7506(e)) and state ambient air quality standards;
  - Approval for and relocation/upgrade of the existing tower, TRACON, and navigational aids (49 USC 44502 (a) (1)); and
  - Certification that the proposed facility is reasonably necessary for use in air commerce or for the national defense (49 USC 44502(b)).
- U.S. Army Corps of Engineers (COE) - The COE will be responsible for permitting work relating to wetlands or Des Moines and Miller Creeks. They are the responsible federal agency which processes permits under the Clean Water Act (Section 404) and Rivers and Harbors Act (Section 10). The COE also initiates the process for a water quality certification (Section 401) with the Washington State Department of Ecology.

(2) Airport Operator Actions

Actions expected by the Port of Seattle include: finalization of the Airport Layout Plan and Master Plan Update documentation; adoption of the Final EIS; application for applicable permits; issuance of General Airport Revenue Bonds; amendment of the Passenger Facility Charge application; application for federal financial assistance; and construction of the preferred alternative, as identified in the Final EIS.

(3) State and Local Actions

It is anticipated that the Port of Seattle will seek certain state and local permits to implement the Master Plan Update improvements. The types of permits would be similar for all alternatives. The following organizations could be involved:

- Washington Department of Ecology
- Washington Department of Fish and Wildlife
- Washington Department of Natural Resources
- Washington Department of Community Development - Office of Archaeology and Historic Preservation
- Puget Sound Air Pollution Control Agency
- Puget Sound Regional Council
- King County
- City of SeaTac

4. FUNDING AND TIMING

The proposed development is expected to cost approximately $1.4-1.5 billion in 1994 dollars, to complete over the next 25 years. Included in this cost are:

- Land Acquisition - $82-147 million
- New Parallel Runway, runway extension, runway safety areas and taxiway improvements - $280-426 million
- Terminal facilities - $ 681 million
- Roadway improvements - $264 million
- Other landside improvements - $74 million

The differences among the Master Plan Update alternatives are:

Alternative 2 (Central Terminal):
- With 8,500-ft new runway: $1,508,300,000
- With 7,500-ft new runway: $1,382,250,000
- With 7,000-ft new runway: $1,398,650,000

Alternative 3 (North Unit Terminal):
- With 8,500-ft new runway: $1,431,400,000
- With 7,500-ft new runway: $1,382,250,000
- With 7,000-ft new runway: $1,398,650,000

Alternative 4 (South Unit Terminal):
- With 8,500-ft new runway: $1,545,570,000
- With 7,500-ft new runway: $1,419,540,000
- With 7,000-ft new runway: $1,435,950,000

The cost estimate includes the on-going capital improvement program and the proposed Master Plan Update improvements. These improvements would be completed using a combination of Port of Seattle, private, and Federal funding. Funding from the following sources may be sought: FAA grants from the Aviation Trust Fund, Special Facility Bonds, General Airport Revenue Bonds, and airline capital expenditures. General Airport Revenue Bonds would be issued by the Port of Seattle. Funding from the Aviation Trust Fund would be requested for capacity and airfield related improvements. The Aviation Trust Fund is funded primarily by a nationwide airline passenger ticket tax. The Port of Seattle also anticipates the collection of user fees to fund expansion projects, such as the Passenger Facility Charge (PFC).

The general phasing associated with the Do-Nothing alternative (Alternative 1) is as follows:

- Phase I (1995-2015):
  - Establishment of the Declared Distance procedures;
  - Construction and grading of the 34L and 34R RSAs;
  - Displacement of Runways 16L and 16R;
  - Improvements to the Main Terminal roadway and recirculation roads;
  - Development of an on-airport hotel;
  - Initiation of development of the South Aviation Support Area (SASA) as approved in the 1994 Final EIS;
  - Development of the CTI facilities at the Des Moines Creek Technology Campus.
- Phase II (2015-2020):
  - Development of the South Access and SR 509 Extension.

Numerous improvements proposed to occur early in the 25-year horizon are included **in all "With Project" alternatives**. The following identifies the general phasing schedule for all common elements of capital improvements and the Master Plan Update "With Project" alternatives:

- Phase 1 (1995-2000):
  - Acquisition of property for the proposed new parallel runway and RPZ's;
  - Removal of the 16L displaced threshold;
  - Initiation of construction of the proposed new parallel runway;
  - Relocation of the ASR and ASDE;
  - Relocation of South 156th Way and 154th Street South;
  - Construction and grading of the 34L and 34R RSAs;
  - Improvements to the Main Terminal roadway and recirculation roads;
  - Development of the CTI facilities at the Des Moines Creek Technology Campus;

- Initiate construction of the midfield overnight aircraft parking apron between Runway 16R/34L and 16X/34X;
- Completion of RSA upgrades for all runway ends;
- Extension of Runway 34R[19];
- Construction of New Tower/ TRACON;
- Relocation of the Airborne cargo facilities within the north cargo complex due to the new tower;
- Expansion or re-development of cargo facilities in the north cargo complex;
- Relocation of general aviation and corporate aviation;
- Development of a new snow equipment storage facility between the RPZs for 34L and 34X;
- Expansion of Concourse A;
- Development of On-Airport hotel;
- Addition of parking stalls to the existing Main Parking Garage;
- Improvements to the existing terminal access and recirculation roads;
- Development of a new parking garage at the site of the Doug Fox parking lot;
- Site preparation and initial development of the South Aviation Support Area (SASA);
  - Development of the ground support equipment facility;
  - Relocation of the Northwest aircraft maintenance facility to SASA[20];
- Overhaul and/or replacement of the Satellite Transit System (STS);

- Phase 2A (2001-2005):
  - Completion of the proposed new parallel runway;
  - Expansion of Main Terminal to south;
  - Construction of the second phase of the midfield overnight parking apron;
  - Improved access and circulation roadway at the Main Terminal;
  - Additional expansion of the existing main parking garage;
  - Expansion of the existing north employee parking lot;
  - Development of a new airport maintenance facility and removal of the existing facility;
  - Relocation of the United Airlines Maintenance facility to SASA; and
  - Continued expansion or re-development of the existing cargo facilities in the north cargo complex.

The following identify the later phases of each "With Project" alternative:

Alternative 2 - Central Terminal

- Phase 2B (2001-2005)
  - Completion of Concourse A

- Phase 3 (2006-2010):
  - Initial expansion of North and South Satellite
  - Parking Garage expansion
  - Extensions to existing terminal roadways
  - Development of southern bypass road east of main terminal parking
  - Development of parking structure at Doug Fox lot

- Phase 4 (2011-2015)
  - Extension of the South Satellite

- Phase 5 (2016-2020)
  - Extension of the North Satellite

Alternative 3 - North Terminal

- Phase 2B (2001-2005)
  - Additional expansion of Concourse A.

- Phase 3 (2006-2010)
  - Initial development of the North Unit Terminal and concourses;
  - Development of the North Unit Terminal roadway system;
  - Extension of the dual parallel taxiways A and B to the south;
  - Construct first phase of parking structure north of SR 518;
  - Additional expansion of the north employee parking lot;
  - Further expansion and re-development within the existing north cargo complex;

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[19] The extension of this runway may occur in a later phase. However, for worst case natural resource impact planning, this element was assessed as part of the Phase I improvements. In this approach, longer-range mitigation planning reflects the cumulative impact of projects occuring in close proximity of one another.

[20] If this facility is not replaced, provision for a new aircraft maintenance base in the SASA location is maintained.

AR 038853

  - Provide an upper roadway transit plaza at the Main Terminal;
  - Relocate the ARFF facility to north of the North Unit Terminal.

- Phase 4 (2011-2015)
  - Additional concourse development at the North Unit Terminal;
  - Development of additional taxiway exists on 16L/34R;
  - Expansion of the north parking structure;
  - Further expansion of the north employee parking lot;
  - Relocation of the Delta Cargo facilities to SASA;
  - Relocation of the USPS Air Mail Facility to SASA;
  - Develop connections to the RTA system at the east side of the main parking garage.

- Phase 5 (2016-2020)
  - Completion of the North Unit Terminal;
  - Expand the north parking structure;
  - Further expansion of the north employee parking lot;
  - Develop site for north cargo building, north of SR-518 east of 24th Avenue S.

Alternative 4 - South Terminal

- Phase 2B (2001-2005)
  - Initial expansion of the North and South Satellites.

- Phase 3 (2006-2010)
  - Development of the new South Unit Terminal;
  - Completion of Concourse A;
  - Parking Garage expansion;
  - Extensions to existing terminal roadways;
  - Development of southern bypass road east of main terminal parking; and
  - Development of parking structure at Doug Fox lot.

- Phase 4 (2011-2015)
  - Extension of the South Satellite.

- Phase 5 (2016-2020)
  - Extension of the North Satellite.

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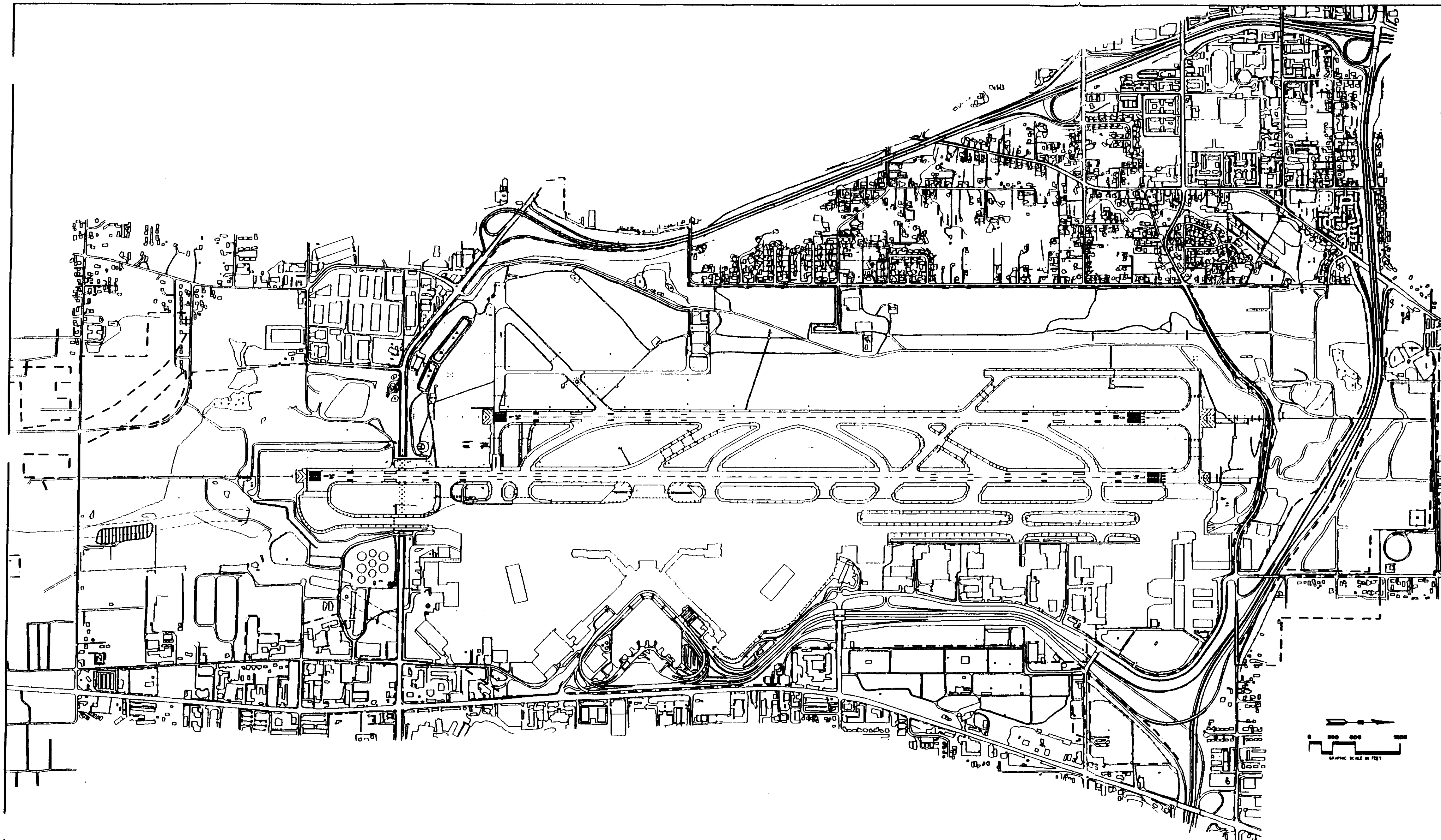

Seattle-Tacoma International Airport

Alternative 1 - Do-Nothing

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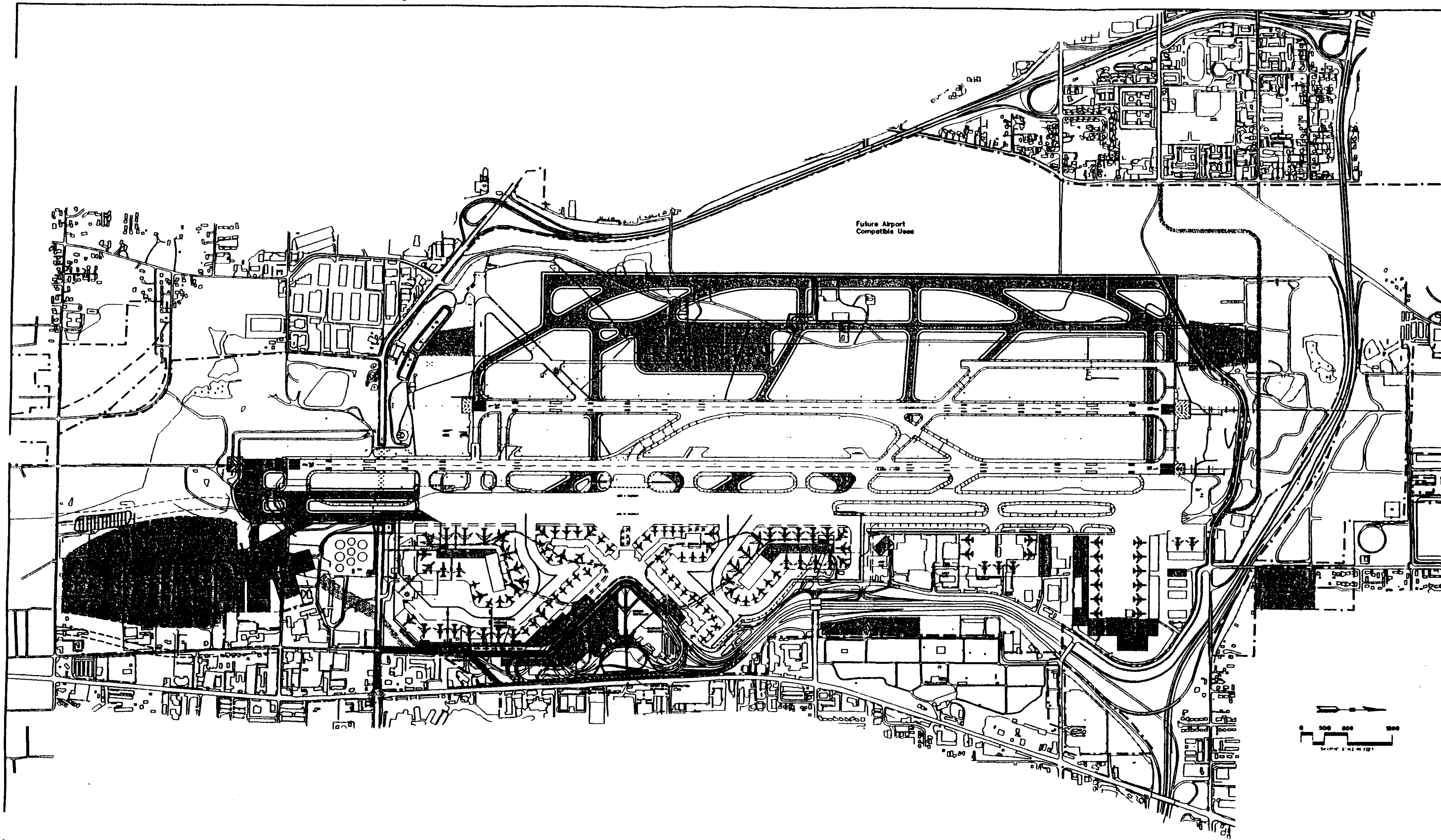

Seattle-Tacoma International Airport

Alternative 2 (Central Terminal)

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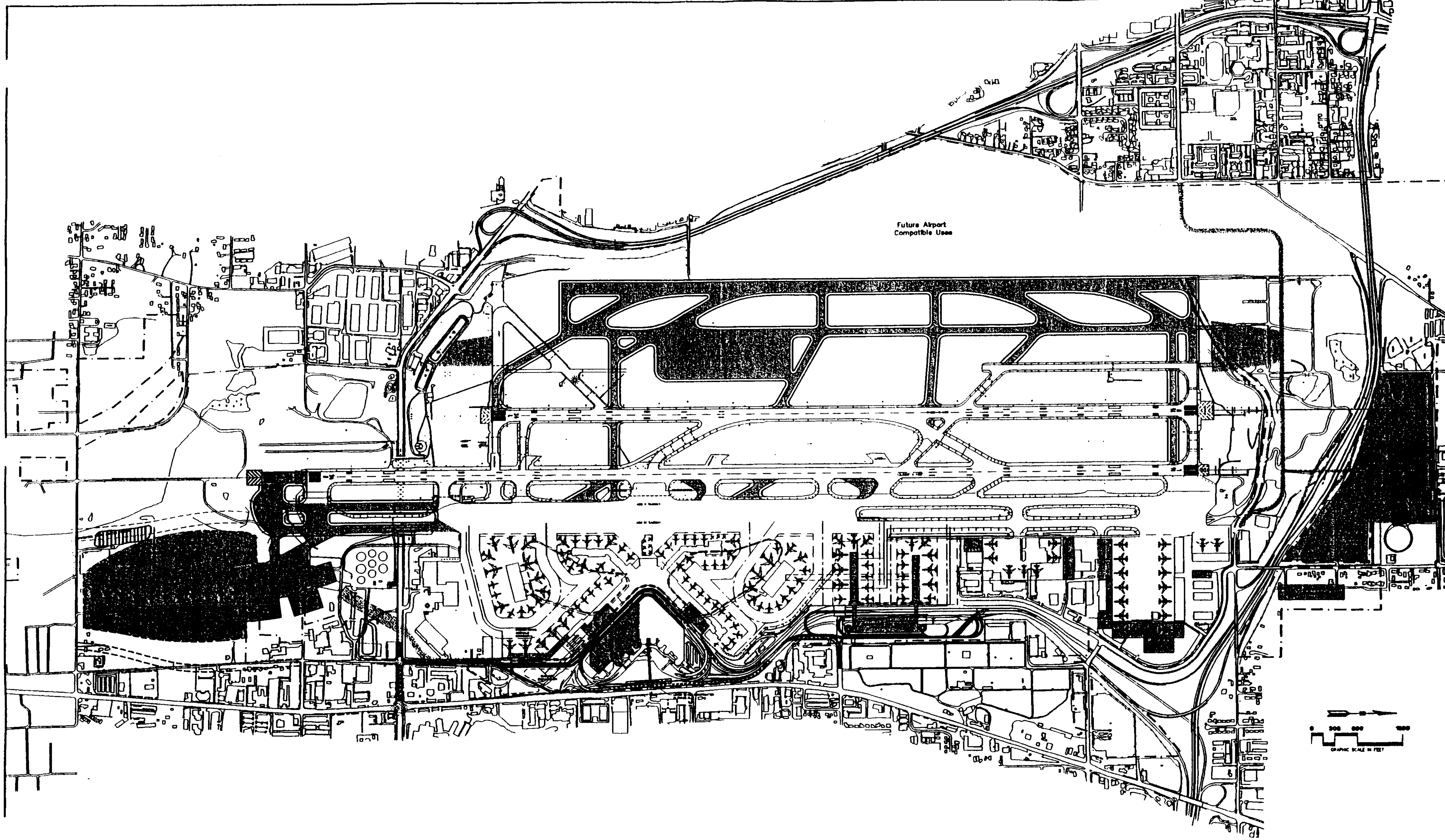

Seattle-Tacoma International Airport

Alternative 3 Preferred Alternative (North Unit Terminal)

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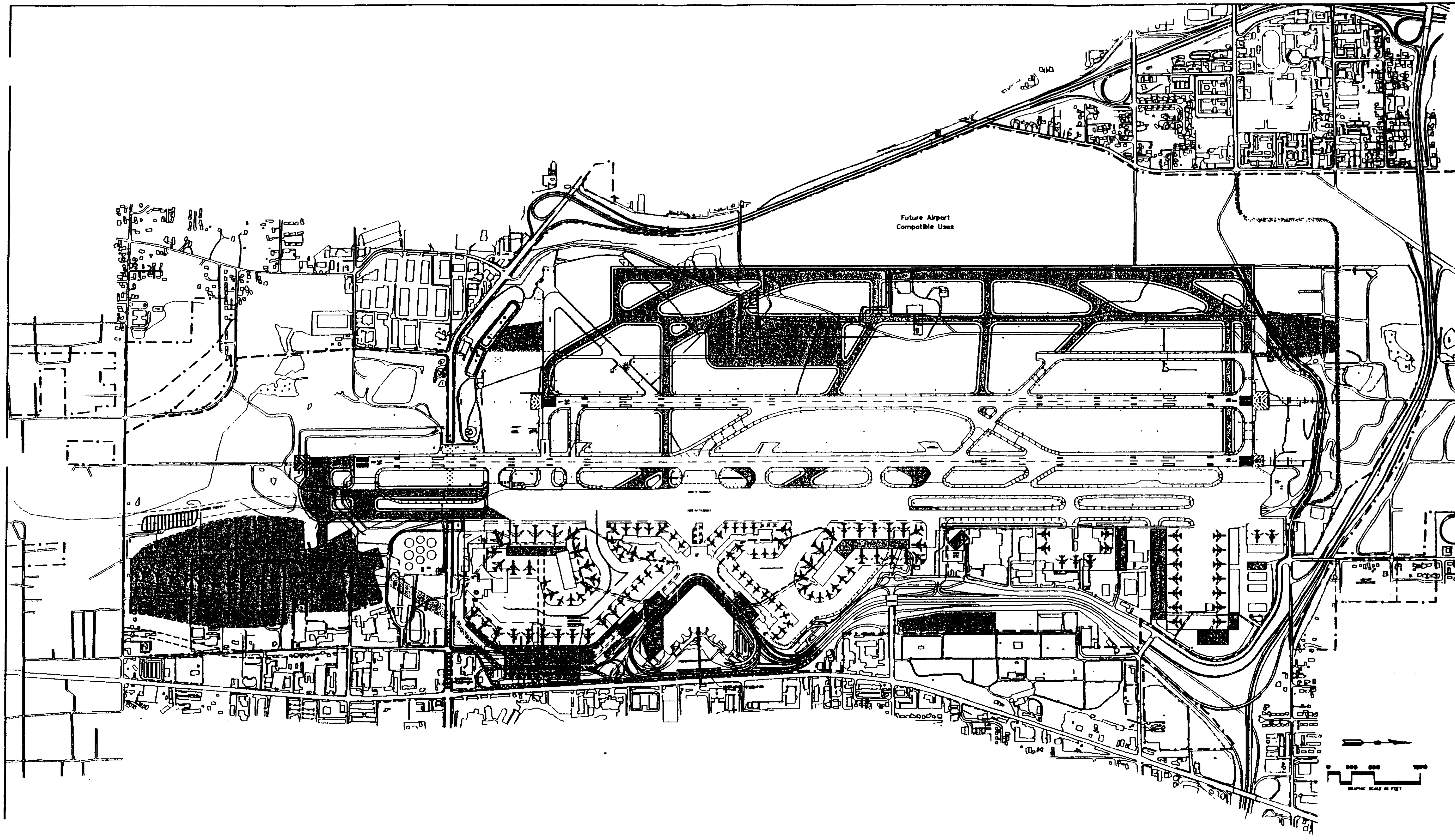

Seattle-Tacoma International Airport

Alternative 4 (South Unit Terminal)

EXHIBIT: II-8

CHAPTER III

AFFECTED ENVIRONMENT

1. LOCATION

Seattle-Tacoma International Airport (Sea-Tac Airport) is located in southern King County, Washington, 12 miles south of downtown Seattle, and is owned and operated by the Port of Seattle. The Airport is generally bound by State Route (SR) 99 to the east, SR 509 and 12th Avenue to the west, SR 518 to the north, and South 200th Street to the south. Additional large areas of land owned by the Port and used for runway protection and noise compatibility extend northward to 128th Street and southward to 216th Street.

Sea-Tac Airport is situated primarily within the City of SeaTac and occupies more than 2,500 acres of land. **Exhibit III-1** shows the location of the Airport and the adjacent communities.

2. SURROUNDING COMMUNITIES AND POLITICAL JURISDICTIONS

Communities which abut the City of SeaTac, in which the Airport is situated, are Des Moines, Tukwila, Kent, and Burien. Unincorporated portions of King County also abut the City of SeaTac. These communities, and others, may be directly or indirectly affected by operations at Sea-Tac Airport, especially by aircraft noise exposure.

A general study area, shown in **Exhibit III-2**, was defined for the purposes of graphically depicting the area potentially affected by existing and future noise exposure of 60 DNL and greater. This area is based on the study area used for the 1991 Noise Exposure Map Update for Sea-Tac Airport.[1/] The general study area encompasses approximately 29,650 acres of land (46.3 sq. mi.), including portions of unincorporated King County and all or portions of eight cities: Seattle, Tukwila, SeaTac, Normandy Park, Des Moines, Burien, Federal Way, and Kent. The general study area encompasses the Port Noise Remedy Program boundaries.

3. BUILT ENVIRONMENT

The following sections summarize the existing land use and zoning characteristics of the general study area, which encompasses the area currently affected by aircraft noise of DNL 60 and greater.

(1) General Land Use and Noise-Sensitive Facilities

The current pattern of land use within the general study area[2/] is shown in **Exhibit IV.2-1** (located in the next chapter in Section 2 "Land Use"). The Port's 1994 land use analysis found the following uses in the general study area:

- Residential: 14,685 acres (22.9 sq. miles), or 49.5 percent of the study area
- Open space/agriculture: 4,955 acres (7.7 sq. miles) or 16.7 percent of the study area
- Commercial/industrial: 3,740 acres (5.8 sq. miles) or 12.6 percent of the study area
- Airports (Sea-Tac and Boeing Field): 3,380 acres (5.3 sq. miles) or 11.4 percent of the study area
- Community and public facilities: 815 acres (1.3 sq. miles) or 2.7 percent of the study area
- Other: 2,065 acres (3.2 sq. miles) or 7.0 percent of the study area

The general study area includes 43,347 single-family homes, 25,702 multi-family dwelling units, and 3,006 mobile homes. Within the area potentially affected by airport expansion, current land use is predominantly single-family residential and open space.

1/ *Noise Exposure Map Update*, Port of Seattle, 1991.

2/ *Sea-Tac Airport Vicinity Land Use Inventory*, Port of Seattle, 1994.

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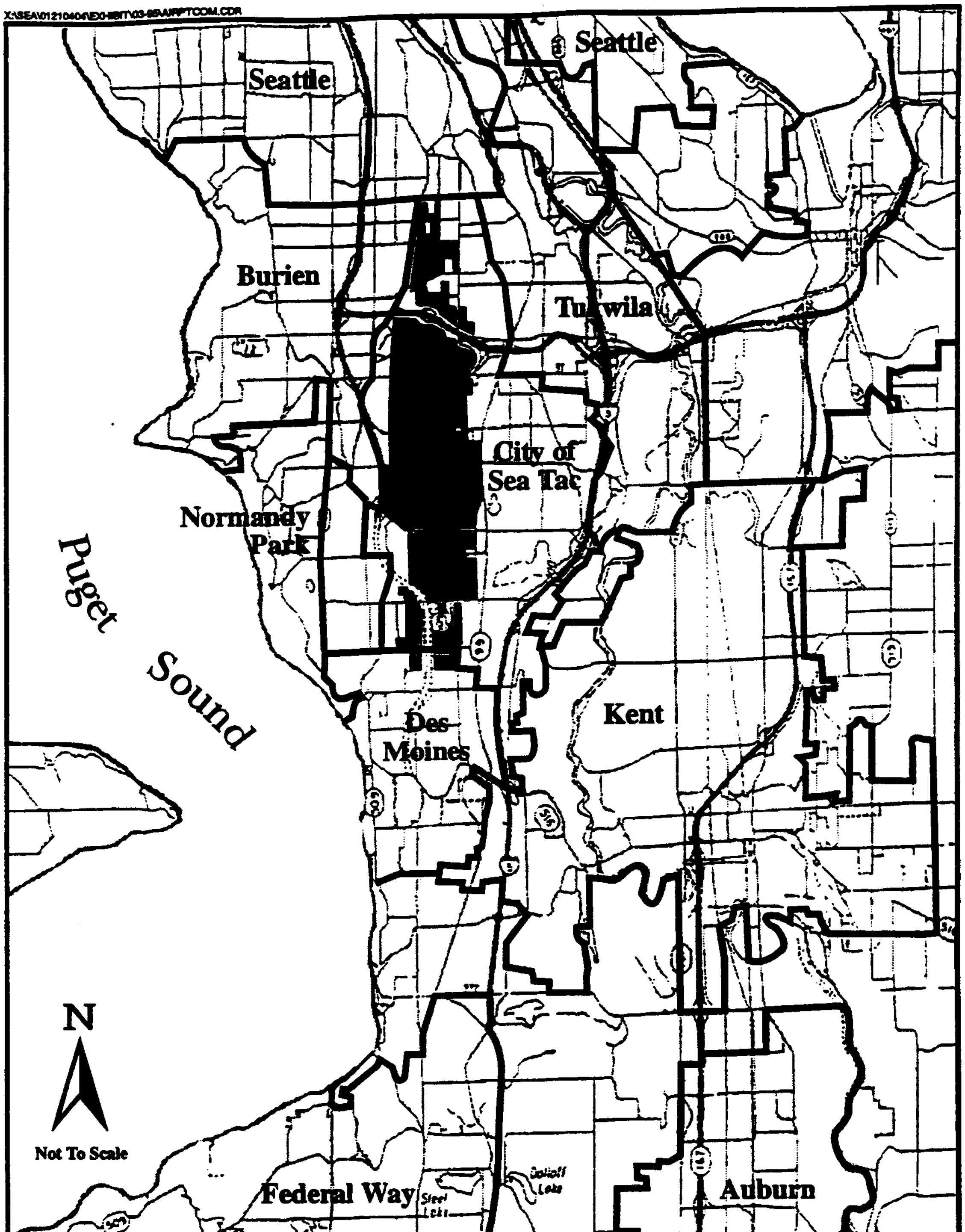

Seattle - Tacoma International Airport | **Airport Vicinity Communities** | **EXHIBIT: III-1**

AR 038861

Seattle-Tacoma International Airport
Environmental Impact Statement
for the Master Plan Update

Exhibit III-2

General Study Area

Jurisdictional Boundary

General Study Area

Source: Gambrell Urban, Inc. and Landrum & Brown, 1994

Scale 1" = 6,000'

0 6000 12000 18000

SCALE IN FEET

Projection: Lambert Conformal Conic
Coordinate System: State Plane NAD27

April 11, 1996

AR 038862

Located within the boundary of the general study area are several classes of land uses that are normally considered to be sensitive to high levels of aircraft noise exposure, as identified by the FAA's Part 150 land use compatibility guidelines. Among these noise-sensitive uses are 108 schools, 65 churches, 9 hospitals, 15 nursing homes, and nine libraries. **Exhibit IV.2-2** shows the location of noise-sensitive facilities in the general study area. Other land uses may also be noise sensitive. These uses will be evaluated on an individual basis later in this report in Chapter IV, Section 2, "Land Use Impacts". Publicly-owned parks and recreation facilities are shown in **Exhibit IV.4-1** and are discussed later in this report in Chapter IV, Section 4 "DOT Section 4(f) Lands". Historic, archaeological and cultural resources are discussed in Chapter IV, Section 3, and are shown in **Exhibit IV.3-1**. See also **Appendices E-A and E-B.**

(2) <u>Community Development</u>

Communities that are located within unincorporated King County do not directly control their local zoning, growth management, or comprehensive planning. Such planning for communities in the county is accomplished through a sub-area planning process which utilizes advisory groups of citizens from the affected areas. Ultimately, however, planning issues are decided on a county-wide basis.

Incorporation into self-governing cities permits those communities to directly adopt and enforce the tools of development and growth management. From 1970 to 1993, South King County experienced rapid growth of residential, commercial, and industrial development. Most of the area around Sea-Tac Airport was still part of unincorporated King County in the early 1980s. By 1993, the situation was completely reversed. Most notably, the cities of Federal Way and SeaTac were incorporated in 1990, and Burien was incorporated as a city in 1993. Together, the incorporation of these three cities created more than 23,000 acres of newly incorporated area in South King County. Within these cities were nearly 50,000 homes and 110,000 residents.

Annexations contributed further to this trend toward incorporation. During the 1980s, Des Moines annexed over 1,400 acres in the North Hill, Des Moines Creek, Zenith, and South Des Moines neighborhoods, and other areas. The most recent annexation by Des Moines in July, 1995 was the North Hill annexation. Tukwila annexed another 3,000 acres in the Thorndyke, Foster, and Riverton neighborhoods, as well as a large manufacturing and industrial area to the north, adjacent to East Marginal Way.

(3) <u>Zoning and Comprehensive Plans</u>

Zoning is one tool available to local communities to regulate the use of their land and to ensure the compatibility of their land uses with airport operations. **Exhibit III-3** reflects the general pattern of anticipated future land use based on existing comprehensive plan designations for the various jurisdictions in the study area. The extent to which the City of SeaTac's zoning will apply to airport improvements is currently the subject of an interlocal negotiations process between the Port of Seattle and City of SeaTac.

The majority of land surrounding Sea-Tac Airport is presently zoned Industrial to permit airport-related land uses, Commercial to permit the types of businesses located along SR 99, Urban High or Medium to permit the multi-family housing adjacent to SR 99, and Airport Use and Aviation Business Center to permit the business park development occurring in areas directly adjacent to the Airport.

Within the City of SeaTac, the Airport and airport-related uses are presently zoned Industrial and Airport use while the single-family areas are primarily zoned Urban Low. Zoning along International Boulevard (SR 99) is primarily Community Business for commercial uses, and Urban Medium and Urban High for multi-family housing. To the north and south of Sea-Tac Airport, the City of SeaTac has adopted Airport Use and Aviation Business Center classifications to permit development of uses which are indirectly related to the Airport. To the west of the Airport, zoning is presently residential, but may change based upon completion of the West SeaTac Subarea planning process (see Chapter IV, Section 2 "Land Use").

Burien's land within the general study area is presently zoned primarily for single- and multi-family housing. Commercial development is permitted along First Avenue South.

Most of the land in Des Moines is zoned for single-family housing except for the downtown and marina area and along Pacific Highway South, I-5, and arterial streets such as Kent-Des Moines Road, where multi-family and commercial uses are permitted.

Tukwila permits a large variety of business and industrial densities and housing densities.

Comprehensive plans are required of each city and county in high growth areas under the Washington State Growth Management Act (GMA) of 1990. According to the Act, with a few exceptions, jurisdictions must adopt comprehensive plans by July 1, 1994, and must adopt developments, regulations, and zoning to implement the comprehensive plans by January 1, 1995. Many jurisdictions have not met either the July, 1994 or January, 1995 deadline but, to date, the State has not assessed penalties upon any jurisdiction.

A detailed discussion of the status of comprehensive planning by local jurisdictions (SeaTac, Des Moines, Burien, Tukwila, Normandy Park) in relation to the Master Plan Update is provided in Chapter IV, Section 2 "Land Use".

The GMA requires each comprehensive plan to contain, at a minimum, elements pertaining to land use, transportation, capital facilities, and utilities. It also requires local plans to address 13 state goals. The Growth Management Hearing Board for the Central Puget Sound will hear adequacy challenges to comprehensive plans, and resolve disputes between local jurisdictions.

The *King County Comprehensive Plan* and the *Countywide Planning Policies*[3] were prepared in response to the GMA. They encourage increased population densities in urban centers and growth areas, identified by local jurisdictions, to accommodate each jurisdiction's expected population and employment growth for the next 20 years. The County's emphasis on in-fill of urban centers is designed to minimize urban sprawl.

3/ The *King County Comprehensive Plan*, November 1994 and *Countywide Planning Policies*, King County, 1992.

Urban centers in King County will likely be connected to the proposed Regional Transit Project (RTP) which would connect Tacoma, Seattle and Everett. Development of urban centers in conjunction with the RTP would permit concentrated areas of development around high-capacity transit stations. Within the EIS study area, the cities of SeaTac, Federal Way, Tukwila, Kent, and Seattle are identified as urban centers. North Tukwila, Seattle's Duwamish and Ballard/Interbay areas, and the Kent industrial area have been identified as manufacturing and industrial centers.

The Draft City of SeaTac Comprehensive Plan was released in September, 1994. A final comprehensive plan was adopted on December 20, 1994. As a designated urban center by King County, the city may have at least one major station on the proposed rail transit line, and as many as three. Other potential station sites are: SR 99/Military Road/SR 518, SR 99/South 200th St., and Downtown SeaTac/Airport area. The three sites are proposed to be linked by a personal rapid transit system. SeaTac's urban center would be located along the International Boulevard (SR 99) corridor near the Airport. An increase in density, both residential and employment, would be anticipated to occur within this urban center.

City of SeaTac Subarea plans will be developed during 1995 and 1996 to address more specific, localized planning issues such as the International Boulevard development. Additionally, the West SeaTac Subarea Plan may evaluate the potential conversion from residential to nonresidential use. A large portion of this subarea is residential land which would be acquired to complete the new runway development portion of the Master Plan Update.

The City of SeaTac has identified Sea-Tac Airport as an essential public facility, as well as SR 509, SR 518, the Federal Detention Center, and the King County Solid Waste Transfer Station. The GMA also requires that local comprehensive plans include a process for identifying and siting essential public facilities, which are facilities that are typically difficult to site. Among such facilities are airports.

Other than the City of SeaTac, Burien would be the city most directly affected by

Sea-Tac Airport Master Plan alternatives, due to acquisition and resulting changes in Land Use. The City of Burien was incorporated in 1993 and initially adopted portions of the 1981 King County Highline Community Plan as their interim comprehensive plan. As a result of the city's recent incorporation, Burien was granted a GMA extension to February, 1997 for adoption of a new comprehensive plan. However, the City expects to have a preferred land-use alternative identified by the end of 1996. Burien adopted a new interim comprehensive plan on April 10, 1995 (see Chapter IV, Section 2 "Land Use").

(3) Socio-Economic Overview

This section identifies region-wide population and employment trends. Aviation activity is created by both the level and type of growth (e.g., manufacturing vs. service businesses; export-oriented goods vs. local market goods) experienced by a region.

(a) Puget Sound Region

Since World War II, the population of the Puget Sound Region has grown erratically in accordance with prevailing economic conditions. Between 1960 and 1993 the Region's population increased by more than 75% from 1.5 million to 2.9 million. Rapid growth occurred in the late 1960s, in the later 1970s, and once again in the later 1980s. In the decade of the 1970s, population increased 15.5%, while in decade of the 1980s population increased 23.6%. Population growth in the 1980s buoyed the Region's housing markets, transportation services, utilities, and retail outlets. Growth also placed pressures on the Region's infrastructure to accommodate new residents and employers. Approximately half of the Region's growth stemmed from a net increase of births over deaths, but the remaining growth came from net in migration. Since 1990, however, the Region's rate of net in migration has declined, due to the sluggish performance of the local economy.[4]

Population growth is expected to be slower between 1990 and 2010 (32%) than in the prior two decades (42%). The Puget Sound Regional Council - PSRC, the area's metropolitan planning organization, forecasts that growth in the Region's population will approach 900,000 from 1990 to 2010, with over 60% of this growth occurring by the year 2000. From 2010 to 2020 the Region will gain nearly half a million residents. Due in part to local growth management policies, most of this population growth is expected to take place in areas already urbanized.[5]

Over the past two decades, employment grew at a faster pace than did population, increasing 36% in the 1970s, and 39% in the 1980s. Forecasts indicate that regional employment will grow at 2.8% annually between 1995 and 2000, twice the average rate of the previous 5 years. The Region's employment base is expected to gain 550,000 new jobs from 1990 to 2010, with nearly 57% this growth occurring by the year 2000. Total employment growth from 2010 to 2020 is projected to increase by 6.3%, a slower rate than any previous time period.

(b) Local Profile

Employment trends in areas surrounding the Airport are influenced by the presence of Sea-Tac Airport. For instance, the City of SeaTac entirely surrounds Airport properties and implements special land use zoning conditions that complement Airport uses and foster Airport-related economic growth (e.g., Aviation Business Center).

Table III-1 displays the general study area population and employment trends from 1970 to 2020. Information in this table also shows growth relative to other general study area cities and sub-areas and for King County. While ultimate development patterns will respond to jurisdictional policies that influence growth (e.g., taxes, regulatory environment, zoning, planning policies)

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[4] *Foundations for the Future*, October, 1994, Puget Sound Regional Council.

[5] PSRC database, November, 1994. VISION 2020, state Growth Management Act, and local Comprehensive Plans encourage population and employment growth in already urbanized areas within designated urban growth area.

and national economic trends, as well as other factors, the PSRC forecasts do provide a clear indication of future economic trends in the general study area.

4. NATURAL RESOURCES

The following paragraphs summarize the existing physiography, water resources and natural resources of the airport environs.

(1) Physiography

Sea-Tac Airport is located within the Puget Lowland subprovince of the Pacific Border physiographic province. The Pacific Border province is a north-south trending structural and topographic depression bordered on the west by the Olympic Mountains and on the east by the Cascade Mountains. The Puget Lowland subprovince is underlain by volcanic and sedimentary bedrock that is covered with glacial and nonglacial sediments on the existing land surface.

The Airport is located along a north-south trending ridge with elevations decreasing to the west toward Puget Sound. Elevation at the Airport runway system is about 400 feet above mean sea level and drops to sea level within approximately two miles to the west. The steepest slopes in the vicinity of Sea-Tac Airport are to the west of the Airport.

Fluvial, lacustrine, and direct ice contact processes of the Vashon Glacier are responsible for most of the land forms in the area as the glacier cut meltwater channels and deposited sediments into low-lying areas. Soils in the vicinity of the Airport belong to the Alderwood Association. These are moderately- well drained, undulating to hilly soils that have dense, very slowly permeable glacial till at depths ranging from 20 to 40 inches.

(2) Water Resources

Sea-Tac Airport is located approximately two miles east of Puget Sound. Because the prevailing winds are from the Pacific Ocean, the general meteorological conditions of the Puget Sound Region are typical of a marine climate. The relatively mild climate is created by the presence of Puget Sound and nearby mountains. The Cascade Range to the east serves as a partial barrier to the temperature extremes of the continental climate of eastern Washington State.

Streams and lakes within the general study area are shown in **Exhibit IV.10-4** and discussed in Chapter IV, Section 10 "Water Quality" There are two independent stream systems that drain the major portions of the airport area, Des Moines Creek and Miller Creek. The Des Moines Creek basin covers an estimated eight square miles including the majority of Sea-Tac Airport, the City of SeaTac, and the City of Des Moines. The Miller Creek basin covers nine square miles and includes a small portion of Sea-Tac Airport, and parts of the cities of SeaTac and Burien. Both creeks and their tributaries flow to Puget Sound. The Airport covers an estimated 27 percent of the Des Moines Creek basin and four percent of the Miller Creek basin.

Existing 100-year floodplains in the Miller and Des Moines Creek drainage basins are identified in **Exhibit IV.12-1**. Development of the urban area has resulted in the channelization of Miller and Des Moines Creeks and the separation of these creeks from historic floodplain areas, which were at one time likely much larger. In Miller Creek, localized flooding has been reported between S.W. 150th and S.W. 152nd Streets just west of First Avenue S., upstream of S.W. 160th Street, and throughout the basin where dumped yard waste constrains streamflow. In Des Moines Creek, wetland filling and undersized drainage facilities contribute to localized flooding of tributaries.

In the Puget Sound Region, the principal aquifers were formed within sand and gravel glacial drift. These aquifers are recharged from precipitation. Aquifer water levels are generally within 100 feet of the ground surface. Discontinuous zones of perched groundwater are also commonly encountered in the glacial deposits. Silt and clay within the glacial soils act as acquitards, allowing water to accumulate in the perched sand and gravel lenses.

A total of 55 wetlands were identified within the area shown in **Exhibit IV.11-1** (See Chapter IV, Section 11). These wetlands range in size from approximately 0.02 acres to 30 acres, with a combined area of nearly 144 acres. A total of 20 emergent, nine scrub-shrub, four open-water, and 22 forested wetlands were identified.

TABLE III-1

General Study Area - Population and Employment

FAZ	Airport Area Places	Population 1970	Population 1980	Population 1990	Average Annual Growth Rate 1970-1980	Average Annual Growth Rate 1980-1990	Employment 1970	Employment 1980	Employment 1990	Average Annual Growth Rate 1970-1980	Average Annual Growth Rate 1980-1990
3045	Redondo/Woodmont	13,036	16,898	22,676	2.7%	3.1%	2,654	1,392	1,781	-4.3%	2.5%
3046	Des Moines	10,901	14,649	20,958	3.1%	3.9%	1,766	2,987	6,116	6.3%	9.5%
3505	Kent CBD/Kent East Hill	12,722	16,797	26,863	2.9%	5.4%	5,490	6,457	11,786	1.6%	7.5%
3600	Kent Industrial	10,492	9,577	12,337	-0.08%	2.6%	4,577	26,873	38,743	44.3%	4.0%
3705	Sea-Tac	30,400	26,867	27,143	-1.1%	0.1%	2,853	24,192	30,284	68.0%	2.3%
3706	Normandy Park	14,332	14,554	14,734	0.1%	0.1%	1,628	2,186	2,333	3.1%	0.6%
3815	Burien/Seahurst	21,365	17,697	17,740	-1.6%	0.0%	10,250	6,225	8,847	-3.6%	3.8%
3816	White Center/Shorewood	18,052	18,273	19,312	0.1%	0.5%	8,283	2,644	3,393	-6.2%	2.6%
3825	Boulevard Park	14,776	13,921	15,153	-0.5%	0.8%	855	4,568	5,681	39.5%	2.2%
3900	South Tukwila	3,178	3,505	4,130	0.9%	1.6%	975	16,005	22,350	140.1%	3.6%
3905	North Tukwila/Riverton	7,600	5,501	6,895	-2.5%	2.3%	11,568	19,930	24,587	6.6%	2.1%
5815	Lower Duwamish/Boeing Field	7,140	3,857	4,047	-4.2%	0.4%	14,923	21,636	22,038	4.1%	0.2%
	Airport Area Totals	163,994	162,096	191,988	-0.1%	1.7%	65,822	135,095	177,939	9.6%	2.9%
	King County Totals	1,159,464	1,269,649	1,507,320	0.9%	1.7%	470,090	697,401	972,567	4.4%	3.6%
	% of County Totals	14.10%	12.80%	12.70%			14.00%	19.40%	18.30%		

FAZ	Airport Area Places	Population 2000	Population 2010	Population 2020	Average Annual Growth Rate 2000-2010	Average Annual Growth Rate 2010-2020	Employment 2000	Employment 2010	Employment 2020	Average Annual Growth Rate 2000-2010	Average Annual Growth Rate 2010-2020
3045	Redondo/ Woodmont	26,844	30,407	33,542	1.2%	0.9%	2,164	2,427	2,690	1.1%	0.6%
3046	Des Moines	22,565	23,218	26,707	0.3%	1.4%	7,987	8,230	7,912	0.3%	-0.4%
3505	Kent CBD/Kent East Hill	33,212	37,367	45,799	1.1%	2.1%	13,348	17,799	20,774	3.0%	1.5%
3600	Kent Industrial	13,934	15,822	18,427	1.2%	1.5%	37,606	36,030	35,984	-0.4%	0.0%
3705	Sea-Tac	28,891	35,514	45,921	2.0%	2.7%	34,165	40,739	43,763	1.7%	0.7%
3708	Normandy Park	15,105	16,392	16,656	0.8%	0.1%	2,319	2,350	2,303	0.1%	-0.2%
3815	Burien/Seahurst	18,000	17,826	18,569	-0.1%	0.4%	8,564	7,550	7,098	-1.1%	-0.5%
3816	White Center/Shorewood	20,309	20,413	20,596	0.0%	0.1%	3,687	3,763	3,162	0.2%	-1.4%
3825	Boulevard Park	16,071	15,948	16,038	-0.1%	0.1%	5,624	5,615	5,125	0.0%	-0.8%
3900	South Tukwila	4,647	6,270	8,171	3.2%	2.8%	25,038	32,140	33,406	2.6%	0.4%
3905	North Tukwila/Riverton	7,361	7,907	8,995	0.7%	1.3%	22,429	22,233	22,146	-0.1%	0.0%
5815	Lower Duwamish/Boeing Field	18,826	4,193	4,498	-7.1%	0.7%	4,518	23,424	23,009	98.0%	-0.2%
	Airport Area Totals	225,665	231,277	263,919	0.2%	1.3%	167,429	202,290	207,272	1.9%	0.2%
	King County Totals	1,730,271	1,844,520	1,963,181	0.6%	0.6%	1,157,191	1,301,823	1,415,015	1.1%	0.8%
	% of County Totals	13.10%	12.50%	13.40%			14.50%	15.50%	14.60%		

Source: Puget Sound Regional Council database, October, 1994.

FAZ refers to forecast and analysis zone.

(3) Biological Resources

Habitat in the airport vicinity consists of isolated parcels of forest, shrub, and grass with scattered wetlands. Approximately 741 acres of upland forest habitat, 191 acres of upland shrub habitat, 1,012 acres of upland herbaceous habitat, and 144 acres of wetland habitat are present within a one-mile radius from the airfield area. The primary vegetation associations are deciduous and mixed forest communities. These second-growth forests are used by a variety of wildlife typical of lowland Puget Sound.

Two federally listed or proposed threatened or endangered species, which may occasionally use the airport area, are the peregrine falcon and bald eagle. The closest bald eagle nests to the Airport are located at Angle Lake (.75 mile southeast) and Seahurst Park (two miles northwest).

Both Des Moines and Miller creeks are classified by the State as Class AA (extraordinary) waters, although stormwater runoff from urban development within the two drainage basins has contributed to water quality degradation. Stream channel geometry and fishery resources in these basins have been altered by urbanization. Modifications of the streams have contributed to increased erosion and downcutting in the ravine reaches, with consequent increased sedimentation and aggradation in lower gradient reaches. Stream channels have become wider to accommodate increases in peak flows, resulting in reduced streambed roughness, reduced bank and bed stability, reduced habitat complexity, and loss of fish habitat.

Degradation of water quality from stormwater runoff has had adverse effects on aquatic biota and the biological integrity of both creeks. Diversity of aquatic life has tended to shift from pollutant-intolerant forms to pollutant-tolerant forms. Additionally, major spills of aviation fuel into Des Moines Creek in the mid-1980s resulted in the mortality of most fish and aquatic life in that creek.

Both streams continue to support reduced numbers of coho salmon, and cutthroat trout. The status of chum salmon and non-salmonid fishes is uncertain. The reduction of water quality due to urban sources also contributes to degradation of populations of fish and other aquatic life.

5. FUTURE PLANNED DEVELOPMENT

As discussed earlier in this section, community comprehensive plans in the general study area are in the process of being revised in response to the Growth Management Act of 1990. These plans will form the general framework for future development. More extensive discussion of this subject is provided later in Chapter IV, Section 2 "Land Use".

Specific planned non-airport related development projects are envisioned by local and county governments in the general study area in addition to those generally described in the comprehensive land use plans. This EIS addresses the possible implementation of these actions when identifying the cumulative impacts, except where noted. These projects are described below.

(1) Transportation Projects

A number of surface transportation planning studies are underway and planned to occur in the near future to address the Region's growing surface transportation congestion. Projects that have been or are under study include:

<u>28th/24th Avenue South Arterial Project:</u> A Final Environmental Impact Statement was completed in early 1993 that studied the development of an arterial to serve existing and expected local access traffic generated by the proposed business park developments in the Cities of SeaTac and Des Moines, south of the Airport. Pending funding, engineering, and design, the project is expected to take 2-3 years to complete.

<u>State Route 509 Extension and South Access Road:</u> The Washington State Department of Transportation, Port of Seattle, Cities of SeaTac and Des Moines, Metro/King County, and property owners are studying an extension of SR 509 from its present terminus at South 188th Street (located directly at the southwest corner of airport property). This study is examining connecting SR 509 with I-5 southeast of Sea-Tac Airport and

developing a south access roadway to link the south end of the Airport with I-5. A corridor-level Draft Environmental Impact Statement was released in December, 1995.

Regional Transit Authority High-Capacity, Light-Rail System: A Regional Transit Authority was formed to address future transit needs for the Puget Sound area. The RTA is examining options of major expansion of existing bus service, additional bus and carpool facilities, and possibly a high-capacity light rail transit system (HCT). Such a light rail system would link Seattle, Tacoma, and communities on the east side of Lake Washington. One of the alignments under consideration is along International Blvd South adjacent to Sea-Tac Airport. Three potential HCT stations are being included in the City of SeaTac's International Boulevard Center land use plans. In March, 1995, voters from the counties of King, Snohomish and Pierce did not approve the proposed RTA Plan. However, the RTA is considered a long-term regional transportation improvement project and is included in the Puget Sound Regional Council's adopted 1995 Metropolitan Transportation Plan. In addition, a revised RTA Plan will likely be presented to the voters of King, Snohomish, and Pierce Counties in 1996.

A number of other roadway improvements are planned for the airport environs. These projects and their planned implementation are described as a part of the Surface Transportation Improvement Project (TIP) discussion in **Appendix O**.

In 1996, King County's transit system will begin implementation of its Six Year Plan, shifting from a downtown Seattle-centered system to one of multiple, interconnected centers. Over the six-year period more local services will be available in each community, new inter-suburban services will be introduced, and regional services will link major destinations. These tiered services could connect at "transit hubs" of varying sizes and designs. Hubs are intended as secure, comfortable places for passengers to transfer and in some cases for buses to layover. The plan also lists a number of employment target areas to implement innovative transit and ridesharing services for the commuter market that would supplement traditional bus services. Metro's plan identifies the SeaTac area as a hub location and Sea-Tac Airport as a major regional destination. The SeaTac area is also identified as one of the employment target areas.

The Port of Seattle, City of SeaTac and METRO have been coordinating on ways to reduce congestion in the Airport area as well as considering ways to meet community, airport and transit system needs as the Six-Year Plan is implemented. Among the issues under consideration are improvements to the current airport bus stop and alternative locations for a transit hub on airport property or elsewhere in SeaTac Current discussions focus on the development of a METRO hub either on-airport or in the immediate vicinity of the Airport. Discussions are expected to continue, as METRO implements the 6-Year Plan. None of the proposed Master Plan Update improvements would adversely affect the ability of METRO to implement the actions within the 6-Year Plan.

The City of SeaTac has also conducted extensive studies of surface transportation congestion within their municipal boundaries. Their Comprehensive Plan calls for the implementation of a transit supportive master plan connecting the city's North Gateway, City Center, and South Gateway.[6] Elements of the transit plan for the city include:

- Rail Transit - connections to the State's future High Capacity Transit System;
- Personal Rapid Transit - a private venture effort using light, elevated guideways to carry up to four passengers in a system that could encircle Sea-Tac;
- Surface Bus - to include improved conventional bus service through the City; and
- Pedestrian - technology such as pedestrian moving sidewalks to connect a city transit center to Sea-Tac facilities.

The Port of Seattle supports and continues to work with the City of SeaTac in the

[6] *City of SeaTac, Transit Supportive Land Use Master Plan*, City of SeaTac, by Hewitt-Isley, 1994.

investigation of cost effective surface travel demand management (TDM) actions.

Typically, the TDM strategies being looked at by the Port target groups such as employees, or are urban area-wide in impact. The Port of Seattle is already implementing several different employer support programs that have ultimately reduced employee traffic levels for terminal area employees (i.e., rideshare matching and information services, preferential parking for ride-sharers, guaranteed ride home, flexible work schedule for ride-sharers, and use of a part- or full-time transportation coordinator). However, there are several other TDM employer incentive programs which include financial support measures that the Port could implement to encourage employees to use alternative higher occupancy modes (i.e., rideshare subsidies and transportation allowances). Other employer based TDM strategies the Port has considered are various work hour arrangements such as flex-time, staggered work hours, compressed work weeks, and telecommuting.

However, of far greater potential for Sea-Tac, is the application of a number of regional and area wide TDM strategies to reduce single-occupant auto traffic. In addition, TDM measures can make existing and future transit operations at the Airport more effective by reducing the number of transit vehicle trips and increasing the number of people carried. These TDM measures could be implemented by the Port or other public agencies on an area wide basis which can affect non-work trips to the terminal, but are almost always multi-jurisdictional and multi-modal. It is these types of strategies that may have the most potential benefit for the Sea-Tac terminal area since they are aimed at the non-work trips which form the vast majority of terminal travel and new trips generated by future growth.

Additionally, the Port of Seattle is looking for ways to improve ground access and mitigate future traffic increases due to passenger growth. Regardless of the continuing state of development in improved ground access programs, most strategies to improve ground access fall into a few broad categories which include:

- HOV Lanes
- Private Passenger Vehicle Constraints
- Pricing Strategies
- Transit Service Improvements

Further discussion on TDM strategies is presented in Chapter IV, Section 15, "Surface Transportation". Additionally, Appendix O includes a copy of the July, 1995 Draft Seattle-Tacoma International Airport Master Plan International Boulevard Access Study and Travel Demand Management Mitigation Policies.

(2) Other Development Projects

Airport Hotel: The Port of Seattle has prepared an EIS for the development of a hotel building on the northeast end of the passenger terminal on the site of the existing United Airlines office building.

Des Moines Creek Technology Campus: During the 1970s and 1980s, the Port of Seattle undertook a noise mitigation program that resulted in the acquisition and relocation of homeowners that were severely affected by aircraft noise. As a result, the Port of Seattle owns land located north and south of the Airport in the City of SeaTac and south of the Airport in the City of Des Moines. Some houses in this area were purchased during the 1980's and some of the remaining properties were acquired in the 1990's. The Port proposes to use land south of the Airport for the development of manufacturing facilities for Cell Therapeutics Inc. (CTI). The CTI development is part of a larger program, known as the Des Moines Creek Technology Campus (DMCTC), an 85 acre development bound on the east by 25th Avenue South, on the south by S. 216th Street, on the north by S. 208th Street, and the west to 20th Avenue S. A Final EIS was completed in 1995 for this proposal.

The Port of Seattle's application package for rezoning and Des Moines Creek Technology Campus Master Plan was submitted to the City of Des Moines in December, 1995. The Des Moines City Council is scheduled to review and act on the applications in the first quarter of 1996.

South Aviation Support Area (SASA): In 1994, the Port of Seattle and the FAA completed a Final Environmental

Impact Statement for planned aircraft maintenance facilities to be located on the southern perimeter of Airport property. The extension of concourse A and the South Satellite, as envisioned in the 1992 Terminal Development Program, would require that the existing aircraft line maintenance hangars located south of the terminal complex be relocated. In addition, during the late 80s/early 90s, several carriers expressed an interest in developing major base maintenance facilities at Sea-Tac. The FEIS (approved in March 1994), and Record of Decision issued on September 13, 1994, presented the environmental impacts of the proposed development.

Aviation Business Center: The Aviation Business Center (ABC) land use designation reflects the existing/potential ABC zoning and related development standards. One purpose of the designation is to promote a major center (located to the southeast of the airfield) supporting high concentrations of customer, visitors, employees, and pedestrian activity to create a quality development area in which people can work, shop and access child care. A second, related purpose is to create a development area with a business orientation to the Airport and compatible with Airport operations.

Federal Detention Center: The federal detention center is located at the southwest quadrant of the intersection of 26th South and South 200th. Funding for the facility was approved and the facility is currently under construction, which began in January, 1995. The facility is expected to be completed and operating by the fall of 1996.

(3) Non-Aviation Related Airport Development Plans

This EIS does not address future collateral non-aviation development at Sea-Tac Airport. As was described in Chapter II (see page II-41), the Port of Seattle will likely pursue financially productive use of its undeveloped land at Sea-Tac. Such development efforts could include:

- Additional on-airport hotels;
- Independent office/retail development;
- Office and/or retail above existing aviation uses (i.e., above parking lots, existing or new terminals) or adjacent to the City of SeaTac PRT station or the RTA station; and
- Airport compatible uses on Port owned land west of the proposed new runway.

6. APPLICABLE FEDERAL AND STATE LAWS

The following statutes and regulations are applicable to the proposed development:

(1) 49 USC 47101 et seq., establishes the airport development grant program and requires that a project may not be approved unless the Secretary of Transportation is satisfied that the project is consistent with plans (existing at the time the project is approved) of public agencies for development of the area in which the airport is located. [49 USC 47106(a)(1)]. Federal policy requires that airport development must also "provide for the protection and enhancement of natural resources and the quality of the environment of the U.S." [49 USC 47101(a)(6)] The Secretary may not authorize a project involving airport location, major runway extension, or runway location found to have a significant adverse effect on natural resources unless it is found, in writing, after full and complete review, that "no possible and prudent alternative exists and that every reasonable step has been taken to minimize the adverse effect." [49 USC 47106 (c)(1)(C)] The Secretary of Transportation may not approve an application for funding of a new runway unless the CEO of the state in which the project will be located certifies in writing that there is reasonable assurance that the project will be located, designed, constructed and operated in compliance with applicable air and water quality standards. [49 USC 47106(c)(1)(B)].

(2) Clean Air Act, as amended, (42 U.S.C. 7401 et seq.) and implementing regulations, requires that the Administrator of the Environmental Protection Agency "review and comment in writing on the environmental impact of any matter relating to duties and responsibilities granted pursuant to this

AR 038871

act or other provisions of the authority of the Administrator, contained in any (1) legislation proposed by any Federal department of agency; (2) newly authorized Federal project for construction and any major Federal agency action (other than a project for construction) to which Section 102(2)(C) of PL 91-190 applies; and (3) proposed regulations published by any department or agency of Federal government." The amended Act also requires that "A Federal agency must make a determination that a Federal action conforms to the applicable implementation plan." Also applicable is the Washington State Clean Air Act, Chapter 70.94 RCW.

(3) Department of Transportation Act, Section 4(f) (49 U.S.C. Section 303(c)) provides that the Secretary shall not approve any program or project which requires the use of any publicly owned land from a public park, recreation area, or wildlife and waterfowl refuge of national, state or local significance, or land of an historic site of national, state or local significance as determined by the officials having jurisdiction thereof unless there is no feasible and prudent alternative to the use of such land and such program or project includes all possible planning to minimize harm resulting from the use.

(4) Executive Order 11988, Floodplain Management (43 FR 6030) and Order DOT 5650.2 April 23, 1979 Floodplain Management and Protection links the need to protect lives and property values with the need to restore and preserve natural and beneficial floodplain values. Agencies are required to make a finding that there is no practicable alternative before taking action that would encroach on a floodplain.

(5) The National Environmental Policy Act of 1969 (42 U.S.C. 4321 et. seq.),establishes a broad national policy to improve the relationship between man and the environment, and sets out policies and goals to ensure that environmental considerations are given careful attention and appropriate emphasis in all decisions of the Federal government.

(6) The Federal Water Pollution Control Act Amendments for 1972 (33 U.S.C. 1344 et. seq.) as amended by the Clean Water Act of 1977 (33 U.S.C. 1251 et. seq.), establishes a permit procedure "Section 404 Permit" for activities involving dredging and filling in waters of the United States, including wetlands. The Secretary of the Army, acting through the Army Corps of Engineers, is responsible for issuing such permits.

(7) The Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970 (42 U.S.C. 4601 et. seq.), as amended, requires consideration of the costs and impacts of residential relocations in judging alternatives in the acquisition of real property.

(8) Council of Environmental Quality Regulation for Implementing the Procedural Provisions of the National Environmental Policy Act (40 CFR 1500-1508).

(9) State Environmental Policy Act (Revised Code of Washington RCW 43.21C) "The purposes of this chapter are: (1) To declare a state policy which will encourage productive and enjoyable harmony between man and his environment; (2) promote efforts which will prevent or eliminate damage to the environment and biosphere; (3) stimulate the health and welfare of man; and (4) to enrich the understanding of the ecological systems and natural resources important to the state and nation."

(10) Washington State Growth Management Act (RCW 36.70A) requires the development of countywide planning policies, a comprehensive plan with mandatory elements, and development regulations, all of which must be consistent with one another. It requires local government decisions be consistent with their plans and that state agencies comply with locally adopted plans and regulations.

In addition, the following laws, regulations and guidance documents, among others, relate to airport improvements:

- Washington State Hydraulic Code, Chapter 75.20 RCW and the Hydraulic Code Rules, Chapter 220-110 WAC;
- Washington State Surface Mining, Chapter 78.44 RCW;
- Washington State Forest Practices Act, Title 76 RCW;

- City of SeaTac Comprehensive Plan, Land Use Code, Building Code, and related regulations;
- Airport Noise and Capacity Act of 1990 (49 U.S.C. 47521 et seq.);
- Archaeological and Historic Preservation Act of 1974 (16 U.S.C. 469 et seq.);
- Aviation Safety and Noise Abatement Act of 1979;
- E.O. 11514 - Protection and Enhancement of Environmental Quality;
- E.O. 11593 - Protection and Enhancement of Cultural Environment;
- E.O. 11990 - Protection of Wetlands;
- E.O. 12372 - Intergovernmental Review of Federal Programs;
- E.O. 12898 - Environmental Justice;
- Federal-Aid Highway Act, as amended, for grants to complete roadway projects;
- Fish and Wildlife Coordination Act;
- National Historic Preservation Act of 1966, as amended, Advisory Council on Historic Preservation Regulations (31 CFR 800), U.S. Department of Transportation Regulations and Procedures (23 CFR 771) and Technical Advisory T6640.8A;
- FAA Advisory Circular 1050.1D "Policies and Procedures for Considering Environmental Impacts";
- FAA Advisory Circular 5050.4A "Airport Environmental Handbook".

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Seattle-Tacoma International Airport Environmental Impact Statement for the Master Plan Update

Exhibit III-3

Generalized Future Land Use: Comprehensive Plan Designations

- Low Density Residential
- Medium and High Density Residential
- Commercial
- Industrial
- Airport
- Parks and Open Space
- Institutional
- Water Body
- Jurisdictional Boundary

Source: Gambrell Urban, Inc. and
Shapiro & Associates, 1995
King County, 1995
City of SeaTac, 1994
City of Burien, 1994
City of Des Moines, 1993
City of Tukwila, 1994
City of Seattle, 1995
City of Kent, 1994
City of Federal Way, 1990
City of Normandy Park, 1987

Scale 1" = 6,000'

0 6000 12000 18000

SCALE IN FEET

Projection: Lambert Conformal Conic
Coordinate System: State Plane NAD27

April 10, 1996

CHAPTER IV

ENVIRONMENTAL CONSEQUENCES OF THE ALTERNATIVES

This chapter presents an assessment of the environmental impacts of the proposed Master Plan Update alternatives for Seattle-Tacoma International Airport. The alternatives assessed include:

- Do-Nothing : Alternative 1
- "With Project" Alternatives
  - Alternative 2 - Central Terminal
  - Alternative 3 - North Unit Terminal
  - Alternative 4 - South Unit Terminal

Included in the assessment of each "With Project" alternative is a new parallel runway with a length up to 8,500 feet, located 2,500 feet (dependent) west of existing Runway 16L/34R. Where the impacts of a runway shorter than 8,500 feet would differ from the 8,500 feet length, impacts are identified:

As required by FAA Orders 1050.1D and 5050.4A and Washington State Environmental Policy Act, the following environmental factors are assessed for each alternative identified above:

1. Noise
2. Land Use
3. Cultural, Historic and Archaeological Resources
4. DOT Section 4(f) Lands
5. Prime and Unique Farmland
6. Social Impacts
7. Human Health
8. Induced Socio-Economic Impacts
9. Air Quality
10. Water Quality
11. Wetlands
12. Floodplains
13. Coastal Zone Management and Coastal Barriers
14. Wild and Scenic Rivers
15. Surface Transportation
16. Plants and Animals (Biotic Communities)
17. Endangered Species of Flora and Fauna
18. Public Services and Utilities
19. Earth
20. Solid Waste
21. Hazardous Waste and Materials
22. Energy Supply and Natural Resources
23. Construction Impacts
24. Aesthetics and Urban Design

The impacts of the alternatives on the environmental factors are assessed relative to the existing conditions (1993 or 1994 if available) and future years 2000, 2010 and 2020.

In the discussion of impacts, the following study areas will be used unless otherwise noted:

- *General Study Area* - encompassing the existing noise exposure area as defined by 60 DNL; and
- *Detailed Focus Area* - area which would be disrupted to construct alternative development. This area includes all lands that might be acquired.

AR 038875

CHAPTER IV, SECTION 1
NOISE IMPACTS

The impact of aircraft and surface transportation noise levels upon the communities surrounding the Airport is presented in this section. The analysis includes determination of impacts on the surrounding area in 1994 and as forecast for the years 2000, 2010 and 2020.

The difference between the noise impacts of the three "With Project" alternatives is very small:

Aircraft Noise
(DNL 65 and Greater)

	Population	Housing	Sq. Mi.
1994	31,800	13,620	9.31
2000			
Altern. 1	8,970	3,870	3.40
Altern. 2	9,890	4,020	2.87
Altern. 3	9,890	4,020	2.86
Altern. 4	9,890	4,020	2.86
2010			
Altern. 1	9,450	4,060	3.54
Altern. 2	9,870	4,190	2.97
Altern. 3	9,860	4,190	2.98
Altern. 4	9.860	4,190	2.98
2020			
Altern. 1	10,800	4,610	3.97
Altern. 2	11,270	4,760	3.31
Altern. 3	11,240	4,740	3.34
Altern. 4	11,270	4,760	3.34

Note: Alternative 1 = Do-Nothing
Alternative 2, 3 & 4 are "With Project".
All "With Project" alternatives include a new dependent (2,500 ft separation) parallel runway with a length up to 8,500 feet. Area is non-airport land.

Because the proposed new dependent parallel runway is proposed to reduce poor weather delay, which is predominantly arrival related, the runway would be expected to be used primarily for arrivals. About 12.1 percent of arrivals in a south flow would occur on the new runway, with about 2.6 percent of departures.

As is shown above, the number of people, housing units, and area affected by DNL 65 and greater sound levels is expected to decline in the future in comparison to 1994 noise exposure regardless of future development at Sea-Tac Airport. This decline in impacts is expected due to the Port's noise reduction program and the Federal mandate to phase-out Stage 2 aircraft no later than the year 2000. This analysis focuses on the impacts within DNL 65 and greater noise exposure; however, areas exposed to DNL 60-65 were evaluated and are presented for information purposes.

The development of the proposed new parallel runway would be expected to result in as much as a 4.4 percent increase in dwelling unit impacts over the Do-Nothing alternative in the year 2000. However, in all instances, these future impacts would be less than the current noise exposure. A 7,000-ft long new runway would result in lesser noise impacts in comparison to the longer 8,500-foot. However, a 7,500-foot long runway, with a north threshold staggered south, could result in even less impacts than the shorter 7,000-foot long runway.

Aircraft ground noise associated with the South Unit Terminal (Alternative 4) would result in the greatest noise exposure, while Alternative 3 (North Unit Terminal) would produce the least "With Project" impacts. Detailed information relative to the level of aircraft noise impacts within each jurisdiction surrounding the Airport is presented in Chapter IV, Section 2 "Land Use".

While this analysis has focused on the areas exposed to DNL 65 and greater sound levels, it is anticipated that changes in noise exposure could also occur outside the DNL 65. For residents that are disturbed by noise less than DNL 65, these effects could continue and change slightly. As is shown by the assessment of noise impacts caused by aircraft flying at altitudes between 3,000 feet and 18,000 feet (provided in **Appendix C**), these impacts are not expected to be significant.

The proposed Master Plan Update alternatives would affect the volume of traffic using area roadways. To evaluate the impact on area roads, the Federal Highway Administrations noise model STAMINA 2.0 was used to assess the peak hour average sound level [$Leq_{(peak-hr)}$]. The proposed new parallel runway would not affect area roadway noise. The terminal and landside development within the Master Plan Update alternatives would alter the use of roads, and result in increased noise at some residential/incompatible locations and decreased noise at other locations. The roadway noise analysis indicates that the greatest change in roadway noise would occur with the development of the SR509 Extension and South Access Road (a Do-Nothing and "With Project" action that is expected to be undertaken by the Region). The greatest increase in noise associated with the "With Project" alternatives relative to the Do-Nothing would range between 1.0 dBA and 2.8 dBA and would occur in the corridor of the South Access Road. Without the South Access Road, the greatest increased noise, in comparison to the Do-Nothing would occur along International Blvd., south of 188th.

(1) AIRCRAFT NOISE EFFECTS

For the purpose of this evaluation, aircraft noise impacts represent the land area and number of people and residences exposed to aircraft noise above predetermined levels. Contour lines representing average annual noise conditions were generated showing the Day-Night Average Sound Level (DNL or Ldn) of 60, 65, 70 and 75 dBA for aircraft operations. The number of existing residents and dwelling units located within the noise exposure pattern of current and each future alternative condition were identified.

The following sections provide a brief summary of the methodology used and the resulting impacts. **Appendix C** provides detailed information related to the methodology used in preparing the noise analysis, statistical information used in the development of noise contours, and information related to the impact of noise on people residing in the vicinity of Sea-Tac. Chapter IV, Section 7 contains a summary of the human health effects due to noise.

(A) Methodology

Day Night Sound Level (DNL) contours were developed using the Integrated Noise Model (INM), Version 4.11. The INM is a sophisticated computer model that evaluates the cumulative noise exposure of all aircraft operating to and from the Airport on an average annual day. Noise associated with the aircraft while on the runway or in flight has been available since the introduction of the model in 1978. Version 4.11 of the INM, released by the FAA in December of 1993, has some new features that allow a standard evaluation of aircraft noise to include the effects of:

- Ground terrain
- Run-up noise
- Departure climbs adjusted for local elevation and temperature
- Aircraft taxiing noise

The new features of the Integrated Noise Model were used in this analysis.

Airfield layout and operational fleet mix for each condition were drawn from data produced for the Airport Master Plan Update. Runway utilization was developed from Airport records and material made available during the FAA's Capacity Enhancement Plan Update for Sea-Tac. The detailed statistical information related to these and other factors important to the development of the noise contours are presented in **Appendix C**.

Appendix C contains a detailed description of the following:

- Measurement of Noise
- Noise footprints of aircraft types (SEL contours)
- Historical Noise Studies at Sea-Tac
- Noise Modeling Assumptions
- Noise Screening of Track Changes above 3,000 feet altitude
- Locational Impact analysis
  - DNL levels
  - Time Above a threshold of A-weighted Sound level
  - Peak Sound Exposure Level (SEL)
  - Equivalent Sound Level (Leq)

(B) Existing Aircraft Noise Reduction Programs

The Port of Seattle was one of the first airport operators in the U.S. to focus on ways to reduce aircraft noise impacts on the residents surrounding its Airport. This section summarizes the noise abatement and airport/aircraft operation actions that have been implemented by the FAA and the Port of Seattle. Each noise contour developed for this Environmental Impact Statement assumes that the existing noise abatement program will remain in effect in the future. The program is the result of many years of continuous noise abatement and mitigation planning efforts which have occurred at Sea-Tac. Among these have been the Sea-Tac Communities Plan, the original and subsequent Part 150

Noise Compatibility Plans, and the innovative Noise Mediation Project. These efforts have resulted in a series of long-term and short-term measures expected to reduce aircraft noise by at least half by the year 2001, as well as to mitigate the effects of such noise on residences.

Existing noise abatement programs include:

- Noise Budget
- Nighttime Stage 2 Aircraft Limitations
- Ground Noise Control
- Flight Corridor Noise Abatement Procedures
- Flight Track and Noise Monitoring

A **noise budget** went into effect on January 1, 1991. It sets forth limitations on the amount of aircraft noise energy which may be generated by the airlines serving the Airport. This level is gradually reduced until 2001 when the Airport will have an all-Stage 3 fleet. This program and others are monitored on a quarterly basis by the Port of Seattle Noise Abatement Staff and reported to the public through Port publications and a noise advisory committee.

A **nighttime limitations program** was implemented in October, 1990, to phase-out all noisier aircraft (Stage 2) during the nighttime hours. During the first two years, only pre-existing Stage 2 flights were allowed between midnight and 6 a.m. In succeeding years, the restricted hours have expanded. As of October 1995, no Stage 2 was allowed between 10 p.m. and 7 a.m. without special permission.

The **ground noise control program** is intended to reduce both the peak levels and duration of ground noise events. Although the focus of the program is to restrict noise events during the nighttime hours, other benefits accrue from the measure. The measures include the prohibition of power back operations at the gates,[1] and restrictions on maintenance engine run-ups at night.

Flight corridor procedures are in place which provide departure instructions to pilots of jet aircraft to follow departure headings which place aircraft along either side of the extended centerlines of the runways until reaching positions several miles to the north or south of the Airport. During periods of low activity (late night), the northbound Duwamish/Elliott Bay departure procedures provide for slight turns at Boeing Field toward Elliott Bay and Puget Sound to depart the local airspace. During periods of high activity, runway heading is maintained until reaching an established altitude.

The Port has installed a sophisticated **flight track monitoring system** which allows its Noise Abatement Office to observe compliance with the noise abatement procedures. The system has the capability to track individual flights. The Port also maintains a **permanent noise monitoring system** which provides continual noise measurements at 11 stations located around the Airport. This system is expected to be updated in the 1996-98 time frame.

Chapter IV, Section 2 "Land Use" describes the **Noise Remedy Program** which has reduced noise and surrounding land use incompatibilities.

(C) <u>Area Affected by Noise</u>

Table IV.1-1 summarizes the area within each contour range for each alternative evaluated.

1. <u>Existing Conditions</u>

The aircraft noise exposure pattern for the average annual day in 1994 is presented in **Exhibit IV.1-1**. The noise levels represented by the contours range from 75 DNL nearest the Airport to 60 DNL furthest from the Airport. The 60 DNL is provided for informational purposes only to assist the reader in better understanding the aircraft noise exposure patterns in the community.

On the basis of scientific surveys and analysis, the FAA has established 65 DNL as the critical level for the determination of noise impacts.[2] The 65 DNL contour incorporates 12.23 square miles (7,827 acres), including much of Airport property. The predominant use of southerly traffic flows at the Airport

1/ A power back operation is conducted when a jet aircraft backs away from the terminal gate under its own reverse thrust power. At Sea-Tac, jet aircraft are pushed away from the gates by tugs.

2/ Federal Aviation Regulation Part 150 and the Federal Interagency Committee on Noise.

results in a larger portion of the contour pattern falling south of the airfield due to the prevailing winds. Owing to the greater thrust levels used, departures are typically several decibels louder than approaches at the same distance from the aircraft, resulting in larger noise contours in the principal direction of departing traffic. Therefore, the noise contours for the existing condition reach farther into communities south of the Airport than into those to the north.

The contour shape also reflects the predominant runway usage during north or south flow. When traffic is in south flow, Runway 16L (the east parallel runway) is used for most departures, while the west parallel runway (16R) is used for most approaches. In north flow, Runway 34L is used for most departures while Runway 34R is used for most approaches.[3] The resulting pattern of existing noise exposure indicated in **Exhibit IV.1-1** clearly shows greater noise exposure along the centerline of the approach to Runway 16R to the north and along the extended centerline of the approach to Runway 34R south of the Airport. This characteristic is further emphasized by compliance with the Standard Instrument Departure headings which are slightly to the left of the extended centerline when in either north or south traffic flow.

The 65 DNL noise exposure contour extends from its north end over the Duwamish River, just south of the Boeing plant at Boeing Field southward to terminate near 280th Street South. To the east, the contour generally follows Pacific Highway (SR 99) south of the passenger terminal complex. North of the terminals, the contour tapers from southeast to northwest across developed residential neighborhoods. West of the Airport, the 65 DNL contour tapers southeasterly across residential neighborhoods from the vicinity of 188th Street and 8th Avenue to its southern end. It remains generally east of and parallel to State Road 509, north of the Airport. Directly east and west of the runway ends, the contour bulges outward from the Airport, reflecting the locations at which thrust is initially applied to begin the takeoff roll for departing aircraft. Between the runway ends, the contour curves in toward the Airport as a result of greater attenuation rates applied to noise dispersion for aircraft which are on the ground.

The 70 DNL contour reaches to between South 112th and 116th Streets at the Rainier Golf Club on the north and nearly to Kent-Des Moines Road on the south. It extends from 12th Avenue on the west to the passenger terminal complex to the east. The shape characteristics demonstrated by the 70 DNL generally repeat those of the 65 DNL, although over a smaller area. The area between 70 and 75 DNL contour covers 1,933 acres, including Airport property.

The 75 DNL contour remains over Airport property or public right-of-way to the east, west and south. To the north, the 75 DNL extends into a residential area just north of 136th Street along the centerline approach to Runway 16R and reaches 215th Street South along the centerline approach to Runway 34R. The effect of noise generated by aircraft taxiing on taxiways is evident in the small protrusions of the east side of the 75 DNL contour over the terminal complex. Elsewhere, the noise levels from aircraft-related ground activity are masked by the overflight noise levels.

2. Future Exposure

The following sections summarize the noise exposure pattern of the alternatives in years 2000, 2010 and 2020. FAA Order 5050.4A, Chapter 5, Paragraph 47e (1)(d)2 states: "FAA's threshold of significance has been determined to be a 1.5 Ldn increase in noise over any noise sensitive area located within the 65 Ldn contour". The following sections summarize the changes in the noise exposure contours and identifies any 1.5 DNL (Ldn) change of noise within the 65 DNL noise exposure contours.

(a) Alternative 1 (Do-Nothing)

Aircraft noise exposure patterns for the future Do-Nothing condition were

[3] The Federal Aviation Administration plans to improve the efficient use of the airfield through increased use of Runway 34R for departures and Runway 34L for arrivals during north flow. At the time of the preparation of this document, that adjustment had not been implemented. As it is anticipated that this increased usage will occur in 1996, it is incorporated into the evaluations of future Do-Nothing Conditions.

prepared for the years 2000, 2010, and 2020, and are shown in **Exhibits IV.1-2, IV.1-3** and **IV.1-4**, respectively. In each case, the noise exposure represents projected noise levels generated by an all Stage 3 fleet, with average daily operations levels growing from current 946 to 1,038, 1,140 and 1,280 respectively.

The noise exposure patterns for interim years are expected to be less than the current impacts. In each future case, the fleet is expected to be composed of less noisy Stage 3 aircraft (e.g., B-757, B-737-300, and MD-80). The operating flight characteristics (runway use, flight track use, approach and departure procedures, etc.) now in place are assumed to be continued with one exception. During good weather conditions (which are predominantly north flow), Runway 34R would be the predominant departure runway, while Runway 34L would be the principal arrival runway.

The level of operations in the year 2020 is expected to sustain sufficient pressure on the capacity of Sea-Tac to cause a small number of evening operations (4 arrivals and 3 departures on an annual average day) to be delayed into the nighttime hours.[4] A discussion of this effect is provided in **Appendix C**. The effect during average (all-weather) conditions is not anticipated in the earlier years evaluated.

The land area exposed to various sound levels for each future year are presented in **Table IV.1-1**. The table indicates that within each contour range, the land area (while less than existing conditions) increases with time and number of aircraft operations.

By the **year 2000**, the area within 65 DNL would shrink from the existing levels to 3,910 acres, a reduction of 50 percent. The 65 DNL extends from just west of Pacific Highway South on the east and lies along 12th Avenue to the west. It reaches from just south of West Marginal Way on the north to 244th Street South at its southern end. Its greatest width is approximately 5,600 feet at South 188th Street. The 70 DNL contour reaches from 128th Street South at its northern end to 216th Street at its southern extremity. Directly east and west of the Airport, the contour remains over the Airport or compatibly-used properties. The 75 DNL contour reaches from 146th Street South southward to a point just north of 200th Street South. The contour remains entirely on Airport property or public right-of-way.

The noise contours for the **year 2010 and 2020** Do-Nothing alternative are only slightly larger than those of the year 2000 Do-Nothing alternative, yet are smaller than the existing condition. By the year 2010, the 65 DNL would increase to 4,032 acres or by 3.9 percent from the year 2000 Do-Nothing. By 2020, the 65 DNL contour would include 4,358 acres and be 11.3 percent larger than the year 2000 contour Between 2000 and 2020, the north end of the 65 DNL contour would move northward by approximately 1,000 feet and the south end will extend by approximately 1,200 feet. The 70 and 75 DNL contours would exhibit similar small increases in their lengths over the 20 year period between 2000 and 2020. However, in no future case would the contour approach the size of the 1994 contour.

In each future year Do-Nothing case, the presence of aircraft ground activity is noticeable in the shape of the 75 and 70 DNL contours in the vicinity of the various terminal facilities, but would generally be masked by flight noise in the 60 and 65 DNL contours.

[4] As is described in Chapter II, delays during IFR conditions would result in a substantial number of operations being delayed into the nighttime hours. However, to represent an average annual condition, the all-weather (combined IFR and VFR) condition was evaluated.

(b) Alternative 2 (Central Terminal)

The noise exposure patterns for Alternative 2 are presented on **Exhibits IV.1-5, IV.1-6 and IV.1-7** for the years 2000, 2010 and 2020 respectively. For noise modeling purposes, this alternative assumes the presence of a new runway (16X/34X) with a length up to 8,500 feet[5] located 2,500 feet west of Runway 16L/34R, the extension of Runway 16L/34R by 600 feet to the south, and taxiway development to accommodate these runway improvements, as well as airside improvements to the terminal complex discussed in the alternatives section of this document.

A comparison between the noise contours associated with Alternative 2 and those associated with Alternative 1 (Do-Nothing) provides insight into the effects related to the operation of the proposed new Runway 16X/34X. Adjustments to the manner in which the Airport would be used if three runways are present are reflected by the changes between the two contour sets. Furthermore, the new runway would alleviate delay slipping flights into the evening and late night hours. While, the presence of the new runway would cause the shape of the contour for each noise exposure level to shorten, it would also result in broadening of the shape, particularly adjacent to the Airport, but also along the approach and departure corridors.

The proposed new parallel runway would allow the use of simultaneous approaches to the two outboard runways (Runways 16L/16X and Runways 34R/34X) during weather conditions when visibility is between 600 feet and 5 miles and the ceiling is between 800 and 5,000 feet, while the center runway (16R/34L) would be used for most departures.[6] When weather is better than 5 miles visibility and 5,000 foot ceilings, the majority of arrivals would be expected on the center runway and departures would be made from the runway nearest the terminal complex (16L/34R), supplemented in both cases by the other existing runway (16R/34L). When weather is worse than 800 foot ceilings and 600 foot visibility, arrivals from the north would be made to the new runway, while Runway 16L would be used for departures. The worst weather condition (visibility less than 1,800 feet) occurs very infrequently at the Airport during north traffic flow. Traffic flows and runway use for all future development alternative are detailed in **Appendix C**.

For the **year 2000**, the effects associated with the construction of the proposed new runway would be as follows: The area exposed to noise above 65 DNL would be greater to the west than for the Do-Nothing alternative, particularly in close proximity to the new runway, but also along the edges of the noise contours to the north and south of the Airport.

The aircraft noise exposure pattern for Alternative 2 also reflects several areas where noise levels are expected to be slightly reduced as a result of the development of the new parallel runway. Notably, the length of each contour would be shorter under the conditions of Alternative 2 than under the Do-Nothing Alternative. This would result from the dispersion of flights on three runways versus two. The effect of this action would be a reduction of the length of each contour by approximately 1,000 to 2,000 feet at both their north and south ends.

The development of passenger and cargo facilities on Airport property would also result in minor shifts of ground noise patterns along the east side of the noise contours immediately east of the runways. All

5/ An evaluation of the noise effects of six different airfield options was presented in Technical Memorandum, Environmental Screening of the Master Plan Update Airside Options, Landrum & Brown, Inc. September, 1994.

6/ 1995 FAA Capacity Enhancement Study, Data Package 7, September, 1994.

aircraft ground noise effects above 65 DNL would occur on Airport property.

A similar comparison of the Do-Nothing and Alternative 2 contours for the **years 2010 and 2020** yields comparable observations, although the extent of the eastward and westward shifts of noise contour lines could be greater by 100 to 200 feet.

As is presented in **Appendix C**, the changes in DNL levels at 1,290 sites were computed. **Table IV.1-2** lists the sites which would be exposed to significant (1.5 DNL) increases in aircraft noise as a result of Alternative 2 in year 2020. As noise increases between 2000 and 2020, the number of sites experiencing a significant increase would grow. Thirty-two (32) sites would experience significant increases in 2000, 39 sites in 2010 and 45 sites in 2020 in comparison to the respective year Do-Nothing. Of these 45 sites, all but 5 would be located in areas that would be acquired or are compatible uses. Chapter IV, Section 2 "Land Use" discusses the compatibility of these uses with the noise exposure.

The noise patterns associated with the construction of proposed Runway 16X/34X with a shorter length were also evaluated. Under these sub-alternatives, the runway would be located 2,500 feet west of Runway 16L/34R, and be either 7,000' or 7,500' in length. Its north end would be located immediately west of the north end of Runway 16R/34L or staggered in a southerly direction. This analysis was extrapolated from the environmental screening evaluation performed for the Master Plan Update, as described in Chapter II.

Runway Length 7,000 feet: As was indicated by **Table II.3-1**, the 7,000-foot runway would be able to accommodate 91 percent of the types of aircraft landing at Sea-Tac in the year 2020 and 67 percent of year 2020 type departing aircraft. This does not refer to the percentage of time that the runway would be used. The departing aircraft which could not be served include nearly all wide-body aircraft over 350 seats (B747, MD11, B-777), as well as many older generation aircraft with Stage 3 engine retrofits (B-727, B737-200) serving long haul markets. The runway length would accommodate landings by all but heavily loaded large aircraft such as the MD-12 and 747-400. Therefore, operations by these aircraft would occur on the two existing runways.

North of the Airport, 0.8 percent of the total aircraft operations (8.3 percent of the runway operations) normally occurring on the new runway would need the longer runway length provided by the two existing runways. To the south, 0.6 percent of the total operations (6.2 percent of Runway 16X/34X operations) would require the longer lengths of Runways 16R/34L or 16L/34R. The effect of such small changes in runway use would create small differences in the noise exposure contour for the 7,000-foot runway in comparison to the 8,500 foot long runway, as was shown in the Master Plan Update and in **Table II.3-1**. Very slight shifts to the east of the flight-related portion of the contour would be expected, balanced by minor extensions of the contours at their northernmost and southernmost ends. Areas immediately west of the new runway would be exposed to slightly lower cumulative ground noise levels and fewer taxiing events by large aircraft.

Although the noise contours prepared for the 7,000 foot long runway option were developed using somewhat different runway use assumptions,[7] the general comparisons between the alternative and Do-Nothing contours are comparable to this case. Based on that evaluation, one may conclude that the noise contours for the 7,000 foot runway option would be wider than those of the Do-Nothing condition (reflecting use of the new

[7] The screening analysis was prepared in mid-1994, using the best information available at the time. Subsequent analysis has resulted in refined operating assumptions.

runway), but narrower than those associated with the 8,500 foot long runway, because fewer large jets would be able to use it.

The stagger of the runway would result in the shift of some ground noise effects from the northernmost portion of the Airport to the north end of the proposed new runway under this alternative. The resultant impact would not be expected to create impacts exceeding 65 DNL off-airport property.

As is presented in Appendix C, the change in DNL levels at 1,219 sites were computed. **Table IV.1-2** lists the sites which would be exposed to significant (1.5 DNL) increases in aircraft noise as a result of Alternative 2 in year 2020. As noise increases between 2000 and 2020, the number of sites experiencing a significant increase will grow. Thirty-two (32) sites would experience significant increases in 2000, 39 sites in 2010 and 46 sites in 2010 in comparison to the respective year Do-Nothing. Of these 46 sites, all but 5 are located in areas that would be acquired or are compatible uses. Chapter IV, Section 2 "Land Use" discusses the compatibility of these uses with the noise exposure.

Runway Length 7,500 feet: The noise effects associated with the construction of a 7,500-ft long Runway 16X/34X located 2,500 feet west of Runway 16L/34R, were evaluated. As indicated by **Table II.3-1**, this runway length option would be able to accommodate 97 percent of the types of aircraft arrivals at Sea-Tac in the year 2020 and 85 percent of aircraft type departures; this does not refer to the actual usage of the runway. Since a greater number of aircraft types may be accommodated, than for the 7,000 ft option, including most landings by heavy aircraft (weight exceeding 300,000 pounds), the noise pattern may be expected to closely approximate the pattern of the 8,500-ft length alternative.

The 7,500' length of the runway would cause the redistribution of 0.5 percent of all arrivals and 0.3 percent of all departures to longer runways. The effect of this small change in runway use on the noise contours and individual noise peaks would be imperceptible to the average person. Very slight shifts of the western edge of the contours to the east and south would be expected, balanced by minor extensions of the contours.

The stagger of the runway would result in the southerly shift of ground noise effects from the northernmost portion of the Airport to the north end of the new runway under this alternative. The resultant impact would not be expected to exceed 65 DNL off-airport property.

(c) **Alternative 3 (North Unit Terminal)**

As is the case with Alternatives 2 and 4, the general pattern of aircraft noise exposure for Alternative 3 would be set by the location of three parallel runways in a north-south orientation. Within the same year of evaluation, the patterns would differ from each other only in minor adjustments to the taxiway noise dispersion over the terminal complex. In no case would these variations relative to Alternative 2 fall beyond the boundaries of Airport property. The aircraft noise exposure pattern associated with Alternative 3 with a length of 8,500 feet is presented for the years 2000, 2010 and 2020 respectively, on **Exhibits IV.1-8, IV.1-9 and IV.1-10.**

As is presented in Appendix C, the change in DNL levels at 1,252 sites were computed. **Table IV.1-2** lists the sites which would be exposed to significant (1.5 DNL) increases in aircraft noise as a result of Alternative 3 in year 2020. As noise increases between 2000 and 2020, the number of sites experiencing a significant increase will grow. Thirty-three (33) sites would experience significant increases in 2000, 40 sites in 2010 and 47 sites in 2010 in comparison to the respective year Do-Nothing. Of these 47 sites, all but 5 are located in areas that would be acquired or are compatible uses. Chapter IV, Section 2 "Land

AR 038883

Use" discusses the compatibility of these uses with the noise exposure.

Runway lengths 7,000 and 7,500 feet: The use of alternative runway lengths and staggers, as discussed under Alternative 2, would have virtually the same effects for Alternative 3 which are identical to those presented above.

(d) Alternative 4 (South Unit Terminal)

As is the case with Alternatives 2 and 3, the general pattern of aircraft noise exposure for Alternative 4 would be set by the location of the new parallel runway. Within the same year of evaluation, the patterns would differ from each other only in minor adjustments to the taxiway noise dispersion over the terminal complex. In no case would these variations from Alternative 2 fall beyond airport property. The sites that would experience significant changes in DNL are identical for this alternative as those of Alternative 2. The aircraft noise exposure pattern associated with Alternative 4 is presented for the years 2000, 2010 and 2020 respectively, on **Exhibits IV.1-11, IV.1-12** and **IV.1-13**.

Runway lengths 7,000 and 7,500 feet. The use of alternative runway lengths and staggers, as discussed under Alternative 2, would have effects for Alternative 4 which are identical to those presented for Alternative 2 at 7,000' and 7,500' runways.

(e) Preferred Alternative (Alternative 3)

The aircraft noise exposure pattern associated with the Preferred Alternative (Alternative 3) is presented for the years 2000, 2010, 2020 respectively, on **Exhibits IV.1-8, IV.1-9 and IV.1-10.** As is presented in Appendix C, the change in DNL levels at 1,252 sites were computed. **Table IV.1-2** lists the sites which would be exposed to significant (1.5 DNL) increases in aircraft noise as a result of Preferred Alternative (Alternative 3) in the year 2020. As noise increases between 2000 and 2020, the number of sites experiencing a significant increase will grow. Thirty-three (33) sites would experience significant increases in 2000, 40 sites in 2010 and 47 sites in 2010 in comparison to the respective year Do-Nothing. Of these 47 sites, all but 5 are located in areas that would be acquired or are compatible uses. Chapter IV, Section 2 "Land Use" discusses the compatibility of these uses with the noise exposure.

* * *

Each "With Project" alternative would result in an increase of 5 percent to 7 percent in the area of noise exposure within 65 DNL over the Do-Nothing alternative during each year of evaluation. The length of the proposed new runway would have little effect on the area within the noise pattern, although the number of operations to the new runway by large aircraft would become progressively less if the length of the runway was reduced. While this analysis has focused on the areas exposed to DNL 65 and greater sound levels, it is anticipated that changes in noise exposure could also occur outside the DNL 65. For residents that are disturbed by noise less than DNL 65, these impacts could continue and change slightly. As is shown by the assessment of noise impacts from aircraft overflights at altitudes between 3,000 feet and 18,000 feet (provided in **Appendix C**), these impacts are not expected to be significant.

The noise patterns associated with each terminal development alternative would be nearly identical, and in fact, cover the same area in the years 2000 and 2010. By 2020, the pattern of the North Unit Terminal (Alternative 3) would be several acres less than that of the two other "with project" alternatives.

Notably, even with the addition of the proposed new parallel runway, the noise exposure pattern of each future alternative would be between 42 percent and 50 percent smaller than the noise exposure pattern of the existing condition.

AR 038884

(2) SURFACE TRANSPORTATION NOISE EFFECTS

The roadway noise assessment identifies the noise impacts associated with the proposed surface transportation changes. The Federal Highway Administration (FHWA) computer program, STAMINA 2.0, was used in this analysis to predict noise levels for existing 1994 conditions, as well as for the Do-Nothing and "With Project" alternatives for the years, 2000, 2010, and 2020.

Chapter IV, Section 15 "Surface Transportation" and **Appendix O** provide a detailed description of the existing and future surface transportation system. Peak hour roadway traffic volumes were used to quantify the road noise-related Equivalent Noise Level (Leq)[8] The Leq depends not only on the loudness of the events but also on the number of single noise events that occur during a measurement period. For example, increased traffic volume (and/or increased speed) increases the Leq.

(A) Methodology

The analysis was conducted using the FHWA-approved roadway noise analysis model, STAMINA 2.0, which calculated the roadway noise levels at 108 user-specified receivers. The model considers the distance of the critical receivers from the surrounding roadways, together with the volume and type of traffic on the roadways and the speeds of the traffic, to compute the noise levels at each receiver. The required input information includes:

- Roadway Description - Sets of roadway segments were defined within a network composed of 16 primary area thoroughfares. The network is the same as is described in detail is Chapter IV, Section 15 "Surface Transportation".
- Traffic Volume - for the Final EIS, the existing and Preferred Airport Master Plan Update alternative (Alternative 3) forecast traffic volumes were updated to reflect the final Metropolitan Transportation Plan. Traffic volume revisions for Alternatives 2 and 4 were not prepared. The traffic on each of the major roadway segments during the peak hour of the day was evaluated.
- Vehicle Classification - the proportion of vehicle types using each traffic segment. These data are divided into three categories: passenger cars, medium trucks and heavy trucks.
- Travel Speeds - the velocity of the traffic flow effects the length of exposure to roadway noise, as well as the loudness of the individual event.

Using the information compiled for each roadway segment, the STAMINA program produces peak hour Leq levels for each location selected by the user. These locations are typically noise sensitive facilities or residential areas near the roadway.

1. Noise Receivers

Roadway noise levels were computed for 108 receiver locations. The locations were selected at a distance of about 50 to 500 feet off the roadway edge in noise sensitive residential areas or near noise sensitive facilities. To enable the development of a composite noise picture, reflecting aircraft and surface transportation noise, the 108 sites were coordinated between the two analyses. The roadway noise-sensitive receiver locations are illustrated in **Exhibit C-21.**

2. Roadway Noise Impact Criteria

State and local governments have the primary responsibility to control use of roadway noise sources. Noise regulations and guidelines have been established by the FHWA, the Washington State Department of Transportation (WSDOT), and local jurisdictions. Surface traffic noise impacts occur when predicted Leq noise levels approach or substantially exceed these guidelines. Although "substantially exceed" is not defined, WSDOT considers an increase in average sound level of 10 dBA or greater to be a significant impact.[9] For residences, parks, schools, churches, and similar areas are sensitive to roadway noise at or above an hourly Leq of 67 dBA. WSDOT considers a noise impact to occur if predicted Leq noise levels approach within 2 dBA of the noise sensitivity criteria. Thus, if a noise level were 65 dBA or higher, it would approach

[8] The average August peak hour traffic volume for each portion of the roadway network was used for this assessment.

[9] Washington State Department of Transportation, Personal Conversation, 1994.

or exceed the FHWA noise sensitivity criterion of 67 dBA.

(B) Surface Transportation Noise Impacts

This section presents the general findings of the surface transportation noise analysis and the changes to the roadway noise pattern which may be expected with and without the Master Plan Update alternatives. **Table IV.1-3** provides Leq noise level information for those locations which experience a peak hour level of 65 dBA of Leq for one or more of the alternatives.

1. Existing Traffic Noise

To provide base year data for comparison, existing (1994) noise levels were calculated for the analysis area. The results were compared to actual ambient noise measurements conducted as part of the SR509/South Access Road Corridor EIS Phase II Study.[10] Based on the results of the comparison, the STAMINA model was calibrated to more closely represent existing conditions.

Based on the existing conditions as shown in **Table C-25**, peak hour surface traffic noise levels range from 48.5 dBA to 73.5 dBA $Leq_{(peak-hr)}$. Under the guidelines provided by the FHWA, 35 sites were identified as being noise-impacted by roadway traffic, with an $Leq_{(peak-hr)}$ of 67 dBA or greater. A total of 51 sites experience an $Leq_{(peak-hr)}$ in excess of 65 dBA. These roadway noise impacted areas are located primarily along SR518, SR509, and I-5/Military Road, South 154th Way, and International Boulevard. Noise levels near these corridors were a result of the combination of high traffic volumes and travel speeds. At several locations along Des Moines Memorial Drive South and Kent-Des Moines Road, traffic volumes and speeds would not generally produce noise levels in excess of 65 dBA, although the modeled levels produced exceed that level. This is believed to have occurred due to imprecision associated with STAMINA modeling.

[10] *SR509/South Access Road Corridor EIS Phase II Study*, CH2M Hill, August, 1994.

2. Future Conditions

Unlike aircraft noise, future roadway noise will increase in the future whether or not improvements are undertaken at Sea-Tac Airport. The increased noise impacts will result from regional population growth and the associated increase in roadway traffic.

(a) Alternative 1 (Do-Nothing)

In addition to the locations where existing impacts occur, the following new receiver locations would experience noise levels at or above 65.0 dBA for the Do-Nothing Alternative.

- By the year 2000, five additional sites would be exposed to peak hour Leq noise levels above 65 dBA. Three sites located along Kent Des Moines Road west of International Boulevard, and two sites along S. 200th Street east of International Boulevard, will experience Leq increases between 2.0 and 3.0 decibels. Otherwise, the change in noise levels will be less than two decibels.
- In year 2010, noise levels at the 108 sites would range between and hourly Leq of 50.8 and 74.8 dBA. If airport improvements are not undertaken (Do-Nothing) all locations having noise levels above 65 dBA in year 2000 would continue to experience the same levels or slightly greater noise and eight additional sites would experience $Leq_{(peak-hr)}$ in excess of 65 dBA. All of these new sites would be located along major arterials such as South 154th Way, Des Moines Memorial Drive South, South 160th Street/Military Road and South 200th Street. Other than a site located along South 24th Avenue which is impacted by the relocation of 156th Way/154th Street, all increases are less than 2.0 dBA above 2000 levels.
- By the year 2020, the most significant change to the area roadway network would be the development of the SR509 and

South Access Road. Of the 108 sites evaluated, 71 would experience $Leq_{(peak-hr)}$ sound levels in excess of 65 dBA. Fifty-Seven sites will experience sound levels at or above 67 dBA. These increases would be due primarily to the gradual growth in the total traffic levels. Noise levels would range from 54.1 dBA to 74.7 dBA during hours of peak roadway traffic activity. Relative to existing conditions, the year 2020 Do-Nothing conditions would incur the greatest roadway related noise increases along the corridor of the new SR509/South Access roadway.

Other than the sites directly impacted by the SR509/South Access Road extension, the increase in peak hour average sound levels from existing noise levels remains within seven decibels of Leq for all sites evaluated. The locations where the noise levels decrease from the existing conditions are in part due to reallocated traffic and reduced travel speeds due to increased traffic congestion. The areas experiencing the greatest increase in noise exposure reflect noise along roads which receive the reallocated traffic.

(b) <u>Alternative 2 (Central Terminal)</u>

Because all of the proposed terminal roadway construction would be concentrated in the terminal core area with Alternative 2, no critical receivers would be located within 500 feet of the new terminal roadways.[11] Therefore, the terminal roadway additions would not impact the noise levels at the existing receiver locations.

Of the sites identified as having roadway noise levels in excess of the FHWA and state guidelines for the existing condition, only one, located on South 154th Street east of Des Moines Memorial Drive would be eliminated due to the relocation of the South 154th Street to construct the new runway. All of the receiver locations identified for the existing conditions experiencing peak hour average roadway noise levels at or above 65.0 dBA would continue to do so under the Central Terminal Alternative.

Among the sites impacted by noise in all three future years, the predicted noise levels associated with the Central Terminal Alternative would result in minor adjustments of peak hour noise levels of two decibels or less in comparison to the Do-Nothing.

(c) <u>Alternative 3 (North Unit Terminal)</u>

Roadway modifications related to the new North Unit Terminal include the development of new access roadways to and from the Airport Expressway, and access from 170th Street. In addition to the new north terminal roadways, 156th Way/154th Street would be relocated north of its existing alignment, and SR518 entrance and exit ramps with 24th Avenue would be constructed. The majority of these changes would occur before the year 2010, and therefore are reflected in the 2010 and 2020 scenarios. Also, the 2020 analysis incorporates the proposed SR509/South Access Road.

Changes in roadway noise impacts for the North Unit Terminal Alternative are nearly identical to those of the Central Terminal (Alternative 2) with the exception of a few locations. All increases in noise would be less than 1.0 dBA except along International Boulevard, where a peak hour Leq increase of 2.8 dBA would be experienced.

(d) <u>Alternative 4 (South Unit Terminal)</u>

Under this alternative, alterations would be made to the existing roadway system which relate to the development of new terminal structures to be located between the existing terminal building and South 188th Street. In addition to terminal roadway modifications, South 156th Way/154th Street would be relocated

11/ STAMINA 2.0 Requirement for roadway noise impact.

north of its existing alignment. Also, the 2020 analysis incorporates the proposed SR509/South Access Road. Because of the location of the new terminal building, no critical receivers would be located within 500 feet of the proposed South Unit Terminal roadway modifications. All of the receiver locations identified for the existing conditions experiencing peak hour average roadway noise levels at or above 65.0 dBA will continue to do so under the South Unit Terminal Alternative. In comparison to the Do-Nothing, the largest average noise level increase associated with Alternative 4 (1.4 dBA) would occur near the new South Access Road in year 2020.

(e) <u>Preferred Alternative (Alternative 3)</u>

As was noted in Chapter II, the Port of Seattle staff have recommended Alternative 3 as the Preferred Alternative. Using adopted **Metropolitan Transportation Plan (MTP)** surface transportation data, the Preferred Alternative (Alternative 3) was re-assessed. With the greater levels of regional surface travel with the MTP, the associated roadway related noise levels would be greater for all alternatives in future years. The greatest increase in noise exposure in year 2000 over the Do-Nothing of 2.5 dBA during the peak hour would occur in the vicinity of 8th Avenue S, north of SR518. However, using the WSDOT criterion outlined earlier, this increase is not considered significant. In year 2010, the comparison of the Preferred Alternative to the Do-Nothing shows that the additional noise would be lessened to 1.7 dBA at this site and by year 2020 would be further reduced to 1.5 dBA.

(3) <u>CUMULATIVE IMPACTS</u>

As is identified in Chapter III "Affected Environment" a number of non-airport related developments are planned in the airport vicinity. These actions would not likely affect aircraft operations or aircraft fleet mix. They could, however, affect surface transportation volumes in the Airport area. As additional surface traffic would occur, increased roadway noise levels beyond those forecast by this analysis would result. However, until specific project plans are completed for these developments, the total cumulative impacts can not be identified. The local project that would be likely to have the greatest impact on noise conditions in the Airport area is the development of a SR509/South Airport Access Road. The impacts of this roadway, which would not likely be available until the year 2020 has been included in the year 2020 Do-Nothing and "With Project" roadway noise analysis described in the preceding paragraphs.

(4) <u>MITIGATION</u>

Two key findings of the aircraft noise analysis are:

- Future impacts will be less than the current noise exposure regardless of which Master Plan Update alternative is pursued;
- The "With Project" alternatives would result in slightly greater noise exposure in comparison to the Do-Nothing.

Section 2 "Land Use" presents the population and dwelling unit impacts associated with each of the alternatives. In each case, the "With Project" alternatives would result in an increase over the "Do-Nothing" alternative in the number of persons and residences exposed to significant aircraft noise.

In all cases, the properties which would be newly incorporated into the 65 DNL contour by the "With Project" alternatives already fall within the boundaries of one or more of the Port's Noise Remedy Programs designed to mitigate existing noise levels. Therefore, no additional (project-related) mitigation would be needed, as is described on page IV.2-6.

Nevertheless, all measures (except the Noise Budget)[12/] now in effect to reduce aircraft noise within the community would be continued in an effort to assure the minimization, to the extent practical, of existing and future noise levels. **Appendix C** provides a summary of previous noise abatement planning efforts and programs which have been periodically conducted since the early 1970's. The measures now in effect include:

12/ The goal of the Noise Budget of an all Stage 3 fleet will be reached by 2001.

- Noise Budget - limiting the total noise energy carriers may generate at the Airport until the fleet is substantially all Stage 3.
- Nighttime Limitations Program - limiting the hours of operation for Stage 2 aircraft.
- Ground Noise Control - reducing the noise of ground events such as powerback operations and run-ups.
- Flight Corridorization - maintenance of runway heading flight tracks by departing jets until reaching specified altitudes.
- Flight Track and Noise Monitoring - maintenance of records of noise levels and flight track location information for identification of deviations and communication with public and users.

As none of the Master Plan Update alternatives would create significant increased roadway noise levels, no mitigation is needed.

Table IV.1-1

Seattle-Tacoma International Airport
Environmental Impact Statement

AREA AFFECTED BY AIRCRAFT NOISE
(Square Miles)

Alternative	DNL 65-70	DNL 70-75	DNL 75 & Greater	DNL 65 and Greater	DNL 60-65	DNL 60 and Greater
Existing	6.58	2.33	0.40	9.31	14.40	23.71
2000						
Alternative 1	2.77	0.63	0.00	3.40	8.12	11.52
Alternative 2	2.62	0.25	0.00	2.87	8.02	10.89
Alternative 3	2.62	0.24	0.00	2.86	8.02	10.88
Alternative 4	2.62	0.24	0.00	2.86	8.02	10.88
2010						
Alternative 1	3.12	0.42	0.00	3.54	8.54	12.08
Alternative 2	2.72	0.25	0.00	2.97	8.44	11.41
Alternative 3	2.73	0.25	0.00	2.98	8.45	11.43
Alternative 4	2.73	0.25	0.00	2.98	8.45	11.43
2020						
Alternative 1	3.18	0.78	0.01	3.97	9.24	13.21
Alternative 2	3.01	0.30	0.00	3.31	9.13	12.44
Alternative 3	3.04	0.30	0.00	3.34	9.07	12.41
Alternative 4	3.04	0.30	0.00	3.34	9.11	12.45

Alternative 1: Do-Nothing/No-Build
Alternative 2: Central Unit Terminal with a new runway length of up to 8,500 feet located 2,500 feet west of existing Runway 16L/34R
Alternative 3: North Unit Terminal with a new runway length of up to 8,500 feet located 2,500 feet west of existing Runway 16L/34R (Preferred Alternative)
Alternative 4: South Unit Terminal with a new runway length of up to 8,500 feet located 2,500 feet west of existing Runway 16L/34R
Excludes Airport land and land acquired to complete the proposed Master Plan Update improvements.

Source: Landrum & Brown, from the Integrated Noise Model, Version 4.11, November, 1994.

TABLE IV.1-2

Seattle-Tacoma International Airport
Environmental Impact Statement

SUMMARY OF SIGNIFICANT CHANGES IN AIRCRAFT NOISE

		Year 2020 Noise Exposure				Change in Noise Exposure		
Grid #	Description	Alt 1	Alt 2	Alt 3	Alt 4	Alt 2-Alt 1	Alt 3-Alt	Alt 4-Alt 1
5	RMS #5 (acquisition area)	62.9	68.0	68.0	68.0	5.1	5.1	5.1
6	RMS #6 (compatible area)	73.3	74.9	74.9	74.9	1.6	1.6	1.6
10	RMS #10 (Compatible area)	64.2	66.0	66.0	66.0	1.8	1.8	1.8
228	Grid E-29 (acquisition area)	63.0	65.3	65.3	65.3	2.3	2.3	2.3
229	Grid E-30 (acquisition area)	63.4	65.9	65.9	65.9	2.5	2.5	2.5
230	Grid E-31 (acquisition area)	64.7	69.1	69.1	69.0	4.4	4.4	4.3
231	Grid E-32 (acquisition area)	64.6	67.9	67.9	67.8	3.3	3.3	3.2
232	Grid E-33 (acquisition area)	64.5	66.9	66.9	66.9	2.4	2.4	2.4
233	Grid E-34 (acquisition area)	63.4	65.9	65.9	65.9	2.5	2.5	2.5
234	Grid E-35 (acquisition area)	62.2	65.5	65.5	65.5	3.3	3.3	3.3
235	Grid E-36 (acquisition area)	62.0	66.5	66.5	66.5	4.5	4.5	4.5
236	Grid E-37 (acquisition area)	62.5	67.6	67.6	67.6	5.1	5.1	5.1
237	Grid E-38 (acquisition area)	64.0	68.1	68.1	68.1	4.1	4.1	4.1
238	Grid E-39 (acquisition area)	64.9	66.9	66.9	66.9	2.0	2.0	2.0
239	Grid E-40 (acquisition area)	64.4	66.2	66.2	66.2	1.8	1.8	1.8
240	Grid E-41 (acquisition area)	63.6	65.3	65.3	65.3	1.7	1.7	1.7
302	Grid F-30 (acquisition area)	68.6	70.2	70.2	70.2	1.6	1.6	1.6
303	Grid F-31 (Existing airfield)	70.2	75.5	75.5	75.5	5.3	5.3	5.3
304	Grid F-32 (Existing airfield)	70.2	74.9	75.0	74.9	4.7	4.8	4.7
305	Grid F-33 (Existing airfield)	71.0	74.7	74.7	74.7	3.7	3.7	3.7
306	Grid F-34 (Existing airfield)	69.8	72.5	72.6	72.5	2.7	2.8	2.7
307	Grid F-35 (Existing airfield)	68.6	72.6	72.6	72.6	4.0	4.0	4.0
308	Grid F-36 (Existing airfield)	68.1	73.2	73.2	73.3	5.1	5.1	5.2
309	Grid F-37 (Existing airfield)	69.2	76.3	76.3	76.3	7.1	7.1	7.0
310	Grid F-38 (Existing airfield)	70.7	75.4	75.4	75.5	4.7	4.7	4.8
377	Grid G-32 (Existing airfield)	86.2	92.3	92.3	92.3	6.1	6.1	6.1
378	Grid G-33 (Existing airfield)	88.0	90.2	90.2	90.3	2.2	2.2	2.3
379	Grid G-34 (Existing airfield)	86.4	88.1	88.1	88.1	1.7	1.7	1.7
450	Grid H-32 (Existing airfield)	80.7	90.0	89.4	88.9	9.3	8.7	8.2
451	Grid H-33 (Existing airfield)	82.6	84.3	84.1	84.2	1.7	1.5	1.6
453	Grid H-35 (Existing airfield)	84.0	85.2	85.2	85.8	1.2	1.2	1.2
528	Grid I-37 (Existing airfield)	68.1	76.4	76.4	75.3	8.3	8.3	7.2
867	Brunelle Resid. (A27)	66.6	68.1	68.1	68.1	1.5	1.5	1.5
939	Sea-Tac Occup. (S102)	62.3	65.4	65.4	65.4	3.1	3.1	3.1
1114	R-4 (Des Moines Way north of 150th)	64.1	67.3	67.3	67.2	3.2	3.2	3.1
1115	R-5 (Des Moines Way south of 150th)	64.4	67.9	67.9	67.9	3.5	3.5	3.5
1119	R-9 (156th Way and 10th Ave S)	66.5	76.7	76.7	76.6	10.2	10.2	10.1
1120	R-10 (156th Way and 9th Pl)	64.9	69.1	69.1	69.0	4.2	4.2	4.1
1123	R-13 (160th and 9th Ave)	64.3	66.8	66.8	66.7	2.5	2.5	2.4
1124	R-14 (160th St. and 9th Ave)	64.3	66.7	66.7	66.6	2.4	2.4	2.3
1200	T-132 (8th S, north of S.174th)	62.3	65.4	65.4	65.4	3.1	3.1	3.1
1202	T-136 (8th Ave S. And 156th St.)	63.6	65.6	65.6	65.4	2.0	2.0	1.8
1209	T-44 (8th Ave north of S. 156th St.)	63.6	65.6	65.6	65.5	2.0	2.0	1.9
1212	Bryan House (A29)	62.8	65.2	65.2	65.2	2.4	2.4	2.4
1217	Vacca Farm (A56)	63.2	66.0	66.0	65.9	2.8	2.8	2.7
1218	Paul House (A57)	63.9	66.0	66.0	65.8	2.1	2.1	1.9

Source: Landrum & Brown, 1994

Table IV.1-3

Page 1 of 3

Seattle-Tacoma International Airport
Environmental Impact Statement

SUMMARY OF SIGNIFICANT ROADWAY NOISE
(Peak Hour Average Sound Level)

				Year 2000				Year 2010				Year 2020			
Site #	Reference	Description	Existing	Alt.1	Alt. 2	Alt.3	Alt. 4	Alt.1	Alt. 2	Alt.3	Alt. 4	Alt.1	Alt. 2	Alt.3	Alt. 4
1111	R-1	Des Moines Way S. north of SR518	65.3	65.5	62.8	65.9	62.8	66.1	63.4	65.2	63.4	66.6	64.1	65.7	63.9
1112	R-2	8th Ave S. north of SR518	64.6	65.4	62.8	70.1	62.8	66.6	63.3	69.9	63.4	71.5	64.5	70.9	64.4
1113	R-3	8th Ave S. north of SR518	61.1	61.6	60.4	64.1	60.4	62.5	60.9	64.2	61.0	65.3	62.6	66.8	62.3
1114	R-4	Des Moines Way S. north of 150th St.	70.2	70.5	67.8	70.9	67.8	71.1	68.4	70.2	68.4	71.6	69.1	70.7	69.0
1115	R-5	Des Moines Way S. north of 150th St.	66.3	66.6	64.3	67.0	64.3	67.2	64.9	66.4	64.9	67.7	65.7	66.8	65.6
1116	R-6	24th Ave S. north of 150th St.	65.3	66.2	64.2	67.5	64.2	68.9	64.2	67.8	64.3	69.9	65.2	69.2	64.9
1117	R-7	154th St. S. and 30th Pl.	67.7	68.2	67.0	68.2	67.0	69.3	67.3	70.5	67.2	69.8	68.1	69.2	67.1
1118	R-8	154th St. S. and 32nd Ave	67.4	67.9	66.4	67.9	66.4	69.1	66.6	70.4	66.6	69.5	67.5	68.9	66.9
1119	R-9	156th Way and 10th Ave S.	72.5	73.0	50.8	54.6	68.6	74.3	51.5	54.8	69.1	74.7	52.7	55.7	69.8
1120	R-10	156th Way and 10th Ave S.	64.4	64.9	53.0	54.9	60.6	66.1	53.7	55.0	61.1	66.6	54.7	56.0	61.8
1122	R-12	160th St. S. and Des Moines Way S.	65.6	66.1	62.2	66.1	62.2	66.7	63.6	65.9	63.7	67.3	64.3	66.6	64.3
1126	R-16	Des Moines Way S. south of 160th St. S.	68.2	68.3	65.9	68.4	65.9	69.0	67.4	69.0	67.4	69.9	68.3	69.9	68.3
1128	R-19	S. 200th St. and Des Moines Way S.	66.1	66.6	64.3	66.6	64.3	67.8	64.8	67.7	64.8	66.4	65.0	66.4	65.0
1129	R-20	S. 200th St. and Des Moines Way S.	64.3	64.9	60.4	64.9	60.4	66.5	60.9	65.0	60.9	65.7	62.8	65.6	62.8
1130	R-21	S. 200th St. and Des Moines Way S.	66.8	67.1	64.5	67.1	64.5	68.4	65.0	68.3	65.0	67.4	65.6	67.4	65.6
1131	R-22	S. 200th St. and Des Moines Way S.	64.3	65.0	60.4	64.9	60.4	66.5	60.9	65.0	60.9	64.8	62.0	64.7	62.0
1132	R-23	Des Moines Way S. south of S. 200th St.	64.4	64.6	61.8	64.6	61.8	65.9	62.3	65.9	62.3	64.5	62.9	64.5	62.9
1133	R-24	Des Moines Way S. south of S. 200th St.	66.4	66.6	63.8	66.6	63.8	67.9	64.3	67.8	64.3	66.4	64.9	66.5	64.9
1134	R-25	Des Moines Way S. and S. 210th St.	68.0	68.2	65.4	68.2	65.4	69.5	65.9	69.5	65.9	68.0	66.5	68.1	66.5
1136	R-27	Des Moines Way S. north of S. 188th St.	64.3	64.5	61.6	64.5	61.6	65.7	62.2	65.7	62.2	64.3	62.7	64.3	62.7
1137	R-28	Des Moines Way S. north of S. 188th St.	64.2	64.4	61.6	64.4	61.6	65.7	62.1	66.7	62.1	64.3	62.6	64.3	62.6
1138	R-29	Des Moines Way S. at Marine View Drive	67.7	68.0	63.5	68.0	63.5	69.3	64.0	69.3	64.0	68.6	64.2	68.6	64.2
1139	R-30	Des Moines Way S. at Marine View Drive	71.3	71.6	66.9	71.6	66.9	72.9	67.4	72.9	67.4	72.2	67.6	72.2	67.6
1140	R-31	North of Kent-Des Moines at 8th Ave	71.2	71.5	66.8	71.5	66.8	72.8	67.2	72.7	67.2	72.1	67.4	72.1	67.4
1141	R-32	North of Kent-Des Moines at 8th Ave	70.0	70.3	65.5	70.3	65.5	71.5	66.0	71.5	66.0	70.9	66.1	70.9	66.1
1142	R-33	North of Kent-Des Moines at 16th Ave S.	70.5	70.8	66.0	70.8	66.0	72.0	66.5	72.0	66.5	71.4	66.7	71.4	66.7
1143	R-34	North of Kent-Des Moines at 16th Ave S.	70.2	70.5	65.7	70.4	65.7	71.7	66.1	71.7	66.1	71.1	66.3	71.1	66.3
1144	R-35	Kent-Des Moines west of 19th Pl	62.3	63.6	57.8	63.5	57.8	64.5	58.3	64.1	58.3	64.8	58.6	64.8	58.6
1145	R-36	Kent-Des Moines west of 19th Pl	71.0	72.3	66.6	72.3	66.6	73.2	67.1	72.8	67.1	73.6	67.4	73.6	67.4
1146	R-37	Kent-Des Moines at 24th Pl	64.3	66.9	61.8	66.8	61.8	67.8	62.3	67.4	62.3	68.1	62.5	68.1	62.5
1147	R-38	Kent-Des Moines at 24th Pl	67.4	70.2	64.7	70.2	64.7	71.1	65.2	70.7	65.2	71.4	65.5	71.4	65.5
1148	R-39	Military Road S. and 160th St. S.	65.8	66.7	63.7	66.6	63.7	68.1	64.2	67.8	64.2	68.7	64.8	68.7	64.6

Table IV.1-3
Page 2 of 3

Seattle-Tacoma International Airport
Environmental Impact Statement

SUMMARY OF SIGNIFICANT ROADWAY NOISE
(Peak Hour Average Sound Level)

Site #	Reference	Description	Existing	Year 2000 Alt.1	Year 2000 Alt. 2	Year 2000 Alt.3	Year 2000 Alt. 4	Year 2010 Alt.1	Year 2010 Alt. 2	Year 2010 Alt.3	Year 2010 Alt. 4	Year 2020 Alt.1	Year 2020 Alt. 2	Year 2020 Alt.3	Year 2020 Alt. 4
1149	R-40	Military Road S. and 160th St. S.	64.7	65.6	62.5	65.5	62.5	67.0	63.0	66.7	63.0	67.6	63.6	67.7	63.4
1150	R-41	Military Road S. and S. 164th St.	63.4	64.4	61.1	64.3	61.1	65.8	61.7	65.5	61.7	66.3	62.1	66.7	62.1
1151	R-42	Military Road S. and S. 164th St.	67.7	68.7	65.3	68.6	65.3	70.1	65.9	69.9	65.9	70.7	66.3	70.8	66.3
1152	R-43	North of S. 170th St. at S. 31st St.	66.3	66.9	62.8	65.7	62.7	68.1	64.2	66.5	64.2	68.9	64.6	67.7	64.5
1153	R-44	South of S. 170th St. at S. 31st St.	66.0	66.7	62.5	65.5	62.5	67.9	63.9	66.2	63.9	68.7	64.3	67.5	64.2
1154	R-45	Military Road S. west of S. 172nd Pl.	66.9	67.7	65.0	67.7	65.0	69.3	65.4	69.2	65.4	70.3	65.0	70.4	65.0
1155	R-46	Military Road S. east of S. 172nd Pl.	62.8	63.5	60.9	63.5	60.9	65.1	61.4	65.0	61.4	66.0	60.9	66.6	60.9
1156	R-47	Military Road S. and 181st Pl.	67.7	68.4	66.1	68.4	66.1	69.9	66.5	69.9	66.5	70.8	66.1	70.9	66.1
1157	R-48	Military Road S. and 181st Pl.	68.0	68.7	66.4	68.7	66.4	70.2	66.8	70.2	66.8	71.2	66.5	71.2	66.5
1158	R-49	186th St. west of Military Road S.	66.4	66.9	66.1	66.9	66.1	67.8	66.3	67.7	66.3	68.5	66.4	68.5	66.4
1159	R-50	186th St. west of I-5	70.9	71.3	70.9	71.3	70.9	72.1	71.1	72.0	71.1	72.7	71.2	72.7	71.2
1160	R-51	S. 188th St. and 32nd Ave	70.6	71.3	67.9	71.3	67.9	72.8	68.5	72.6	68.5	72.7	67.6	72.6	67.6
1161	R-52	S. 188th St. west of 32nd Ave	72.0	72.7	69.2	72.6	69.2	74.2	69.8	73.9	69.8	74.1	68.8	73.9	68.9
1162	R-53	S. 188th St. and 42nd Ave	69.7	69.4	66.4	70.4	66.4	71.1	66.8	71.7	66.8	71.3	66.2	71.7	66.2
1163	R-54	S. 188th St. south of 42nd Ave	71.8	71.5	68.5	72.5	68.5	73.2	68.9	73.8	68.9	73.4	68.2	73.8	68.2
1165	R-56	Military Road S. and S. 194th St.	66.9	67.4	66.4	67.4	66.4	68.4	66.8	68.3	66.8	68.9	67.0	69.0	67.0
1166	R-57	Military Road S. and 40th Pl.	68.2	68.8	67.7	68.7	67.7	69.8	68.1	69.6	68.1	70.3	68.2	70.3	68.2
1167	R-58	28th Ave at 196th St.	54.3	55.8	55.2	55.5	55.2	57.8	55.8	57.6	55.6	70.9	57.5	63.5	57.5
1168	R-59	S. 200th St. at 26th Ave S.	61.9	63.3	60.5	63.2	60.5	64.4	61.6	64.3	61.6	67.2	64.1	67.3	64.1
1169	R-60	S. 200th St. at 26th Ave S.	61.5	62.8	60.1	62.8	60.1	64.0	61.1	63.9	61.1	67.6	64.4	67.5	64.4
1170	R-61	S. 200th St. and 30th Ave	68.5	70.8	64.9	71.8	64.9	72.6	65.4	72.5	65.4	71.3	65.6	71.3	65.6
1171	R-62	S. 200th St. at 32nd Ave S.	65.8	68.0	62.7	69.0	62.7	69.8	63.1	69.7	63.1	68.5	63.4	68.6	63.4
1172	R-63	S. 200th St. at 32nd Ave S.	67.2	69.2	64.3	70.1	64.3	70.9	64.7	70.9	64.7	69.8	64.8	69.8	64.8
1173	R-64	S. 200th St. at Military Road S.	66.2	68.1	63.9	68.9	63.9	69.7	64.3	69.7	64.3	68.7	64.4	68.7	64.4
1174	P-1	S. 156th St. east of SR509	73.5	73.3	70.0	69.9	70.0	72.3	71.4	70.7	71.4	72.2	72.6	72.4	72.6
1176	P-3	SR509 west of 168th S.	65.6	66.1	66.4	66.2	66.4	66.9	67.8	66.9	67.8	68.8	69.1	68.9	69.1
1177	P-4	SR509 east of S. 174th St.	67.9	68.4	68.7	68.4	68.7	69.2	70.1	69.2	70.1	71.1	71.4	71.1	71.4
1181	P-8	SR99 south of S. 192nd St.	67.6	68.7	69.0	68.6	69.0	69.6	69.4	69.2	69.4	68.5	69.9	68.8	69.9
1182	P-9	SR99 south of Angle Lake Rd.	69.8	70.8	71.1	70.8	71.1	71.7	71.5	71.3	71.5	70.6	72.0	70.9	72.0
1183	P-10	North of S. 200th St. at 20th Ave S.	49.8	50.5	46.1	50.4	46.1	52.0	46.6	50.6	46.6	67.4	62.6	67.5	62.6
1184	P-11	South of S. 200th St. at 20th Ave S.	49.4	50.0	45.6	50.0	45.6	51.5	46.2	50.2	46.2	65.3	61.6	65.4	61.6
1186	P-13	Des Moines Way S. at Marine View Drive	67.5	67.8	63.1	67.8	63.1	69.1	63.6	69.0	63.6	68.4	63.7	68.4	63.7

Table IV.1-3
Page 3 of 3

Seattle-Tacoma International Airport
Environmental Impact Statement

SUMMARY OF SIGNIFICANT ROADWAY NOISE
(Peak Hour Average Sound Level)

				Year 2000				Year 2010				Year 2020			
Site #	Reference	Description	Existing	Alt.1	Alt. 2	Alt.3	Alt. 4	Alt.1	Alt. 2	Alt.3	Alt. 4	Alt.1	Alt. 2	Alt.3	Alt. 4
1188	P-15	West of I-5 north of SR516	63.2	63.5	63.3	63.5	63.3	64.0	63.6	63.9	63.6	65.1	63.8	65.1	63.8
1189	P-16	West of I-5 north of SR516	63.4	63.7	63.4	63.7	63.4	64.2	63.7	64.1	63.7	65.3	64.0	65.3	64.0
1190	P-17	Military Road S. east of S. 172nd Pl.	62.2	62.9	60.4	62.9	60.4	64.5	60.8	64.4	60.8	65.4	60.4	66.0	60.4
1194	S-119	SR99 north of S. 224th St.	72.1	71.5	72.1	71.5	72.1	72.3	72.5	72.1	72.5	71.8	72.8	71.7	72.8
1199	S-130	28th Ave north of S. 200th St.	58.2	60.0	58.8	59.6	58.8	62.7	59.6	62.6	59.2	70.1	62.3	70.3	62.4
1201	S-133	Military Road S. north of S. 179th St.	67.2	67.9	65.3	67.9	65.3	69.5	65.8	69.4	65.8	70.4	65.3	70.5	65.3
1202	S-136	8th Ave S. and S. 156th St.	69.7	69.9	66.3	69.9	66.3	70.7	67.1	70.0	67.1	71.3	67.9	71.1	68.0
1207	S-34	Kent-Des Moines at 24th Pl.	63.5	66.1	61.0	66.1	61.0	67.0	61.5	66.6	61.5	67.4	61.8	67.4	61.8
1209	S-44	8th Ave S. and S. 156th St.	68.9	69.1	65.5	69.1	65.5	70.0	66.3	69.2	66.3	70.6	67.1	70.3	67.2
1213	NSF:S-59	Kimble School	69.9	69.6	66.7	65.6	66.7	68.2	68.1	66.3	68.1	68.0	69.3	68.1	69.3
1214	NSF:S-60	Marine View Dr. at S. 223rd St.	64.0	64.3	59.5	64.3	59.5	65.5	60.0	65.5	60.0	64.9	60.2	64.9	60.2
1217	NSF:S-84	Des Moines Way S. north of 156th St.	63.5	63.8	61.1	64.7	60.9	64.4	61.7	64.0	61.6	65.5	62.4	64.7	62.1
1219	NSF:S-88	S. 200th St. west of Des Moines Way S.	60.5	61.2	56.6	61.2	56.6	62.7	57.1	61.2	57.1	65.1	62.6	65.1	62.6

Source: STAMINA 2.0 output
Note: Site numbers are consistent with those indicated on all aircraft noise grid analysis tables.
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Seattle-Tacoma International Airport
Environmental Impact Statement
for the Master Plan Update

Exhibit IV.1-1

1994 Noise Exposure Pattern

File SEA36

- Jurisdictional Boundary
- Generalized Study Area
- Noise Contours of 65 DNL and Above
- 60 DNL Noise Contour

Source: Gambrell Urban, Inc. and Landrum & Brown, 1995

Scale 1" = 6,000'

0 6000 12000 18000
SCALE IN FEET

Projection: Lambert Conformal Conic
Coordinate System: State Plane NAD27

April 08, 1996

Seattle-Tacoma International Airport
Environmental Impact Statement
for the Master Plan Update

Exhibit IV.1-2

Alternative 1 (Do-Nothing)
Aircraft Noise Exposure Pattern - 2000

File SEA51

Jurisdictional Boundary

Generalized Study Area

Noise Contours of 65 DNL and Above

60 DNL Noise Contour

Source: Gambrell Urban, Inc. and Landrum & Brown, 1995

Scale 1" = 6,000'

0 6000 12000 18000
SCALE IN FEET

Projection: Lambert Conformal Conic
Coordinate System: State Plane NAD27

April 06, 1996

-IV.1-14G-

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Seattle-Tacoma International Airport
Environmental Impact Statement
for the Master Plan Update

Exhibit IV.1-3

Alternative 1 (Do-Nothing)
Aircraft Noise Exposure Pattern - 2010

File SEA52

- Jurisdictional Boundary
- Generalized Study Area
- Noise Contours of 65 DNL and Above
- 60 DNL Noise Contour

Source: Gambrell Urban, Inc. and Landrum & Brown, 1995

Scale 1" = 6,000'

0 6000 12000 18000
SCALE IN FEET

Projection: Lambert Conformal Conic
Coordinate System: State Plane NAD27

April 06, 1996

Seattle-Tacoma International Airport
Environmental Impact Statement
for the Master Plan Update

Exhibit IV.1-4

Alternative 1 (Do-Nothing) Aircraft Noise Exposure Pattern - 2020

File SEA53

- Jurisdictional Boundary
- Generalized Study Area
- Noise Contours of 65 DNL and Above
- 60 DNL Noise Contour

Source: Gambrell Urban, Inc. and Landrum & Brown, 1995

Scale 1" = 6,000'

0 6000 12000 18000

SCALE IN FEET

Projection: Lambert Conformal Conic
Coordinate System: State Plane NAD27

April 08, 1996

Seattle-Tacoma International Airport
Environmental Impact Statement
for the Master Plan Update

Exhibit IV.1-5

Alternative 2 (Central Unit Terminal) Aircraft Noise Exposure Pattern - 2000

File SEA58

Jurisdictional Boundary

Generalized Study Area

Noise Contours of 65 DNL and Above

60 DNL Noise Contour

Source: Gambrell Urban, Inc. and Landrum & Brown, 1995

Scale 1" = 6,000'

0 6000 12000 18000

SCALE IN FEET

Projection: Lambert Conformal Conic
Coordinate System: State Plane NAD27

April 06, 1995

Seattle-Tacoma International Airport
Environmental Impact Statement
for the Master Plan Update

Exhibit IV.1-6

Alternative 2 (Central Unit Terminal) Aircraft Noise Exposure Pattern - 2010

File SEA60

Jurisdictional Boundary

Generalized Study Area

Noise Contours of 65 DNL and Above

60 DNL Noise Contour

Source: Gambrell Urban, Inc. and Landrum & Brown, 1995

Scale 1" = 6,000'

0 6000 12000 18000

SCALE IN FEET

Projection: Lambert Conformal Conic
Coordinate System: State Plane NAD27

Seattle-Tacoma International Airport
Environmental Impact Statement
for the Master Plan Update

Exhibit IV.1-7

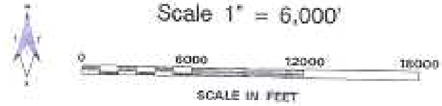
Alternative 2 (Central Unit Terminal) Aircraft Noise Exposure Pattern - 2020

File SEA49

Jurisdictional Boundary
Generalized Study Area
Noise Contours of 65 DNL and Above
60 DNL Noise Contour

Source: Gambrell Urban, Inc. and Landrum & Brown, 1995

Scale 1" = 6,000'



Projection: Lambert Conformal Conic
Coordinate System: State Plane NAD27

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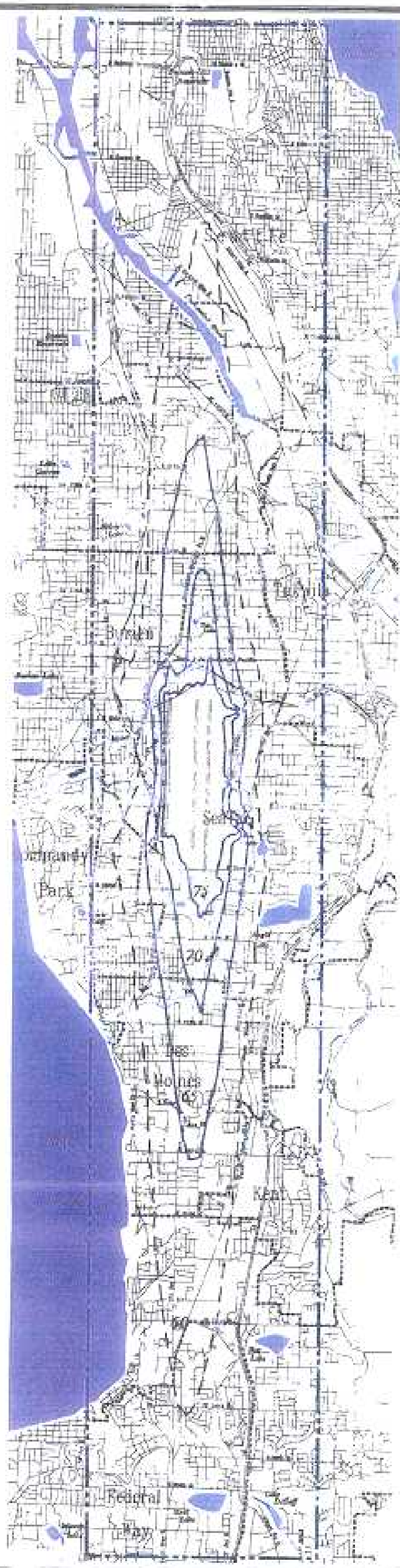

Seattle-Tacoma International Airport
Environmental Impact Statement
for the Master Plan Update

Exhibit IV.1-8

Alternative 3 (North Unit Terminal) Aircraft Noise Exposure Pattern - 2000

File SEA57

- Jurisdictional Boundary
- Generalized Study Area
- Noise Contours of 65 DNL and Above
- 60 DNL Noise Contour

Source: Gambrell Urban, Inc. and Landrum & Brown, 1995

Scale 1" = 6,000'

0 6000 12000 18000

SCALE IN FEET

Projection: Lambert Conformal Conic
Coordinate System: State Plane NAD27

April 06, 1995

Seattle-Tacoma International Airport
Environmental Impact Statement
for the Master Plan Update

Exhibit IV.1-9

Alternative 3 (North Unit Terminal) Aircraft Noise Exposure Pattern - 2010

File SEA59

Jurisdictional Boundary

Generalized Study Area

Noise Contours of 65 DNL and Above

60 DNL Noise Contour

Source: Gambrell Urban, Inc. and Landrum & Brown, 1995

Scale 1" = 6,000'

0 6000 12000 18000

SCALE IN FEET

Projection: Lambert Conformal Conic
Coordinate System: State Plane NAD27

April 08, 1996

Seattle-Tacoma International Airport
Environmental Impact Statement
for the Master Plan Update

Exhibit IV.1-10

Alternative 3 (North Unit Terminal) Aircraft Noise Exposure Pattern - 2020

File SEA56

Jurisdictional Boundary
Generalized Study Area
Noise Contours of 65 DNL and Above
60 DNL Noise Contour

Source: Gambrell Urban, Inc. and Landrum & Brown, 1995

Scale 1" = 6,000'

0 6000 12000 18000
SCALE IN FEET

Projection: Lambert Conformal Conic
Coordinate System: State Plane NAD27

April 06, 1995

Seattle-Tacoma International Airport
Environmental Impact Statement
for the Master Plan Update

Exhibit IV.1-11

Alternative 4 (South Unit Terminal) Aircraft Noise Exposure Pattern - 2000

File SEA57

- Jurisdictional Boundary
- Generalized Study Area
- Noise Contours of 65 DNL and Above
- 60 DNL Noise Contour

Source: Gambrell Urban, Inc. and Landrum & Brown, 1995

Scale 1" = 6,000'

0 6000 12000 18000

SCALE IN FEET

Projection: Lambert Conformal Conic
Coordinate System: State Plane NAD27

April 08, 1996

Seattle-Tacoma International Airport
Environmental Impact Statement
for the Master Plan Update

Exhibit IV.1-12

Alternative 4 (South Unit Terminal) Aircraft Noise Exposure Pattern - 2010

File SEA59

Jurisdictional Boundary

Generalized Study Area

Noise Contours of 65 DNL and Above

60 DNL Noise Contour

Source: Gambrell Urban, Inc. and Landrum & Brown, 1995

Scale 1" = 6,000'

0 6000 12000 18000

SCALE IN FEET

Projection: Lambert Conformal Conic
Coordinate System: State Plane NAD27

April 08, 1996

- IV.1-14Q -

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Seattle-Tacoma International Airport
Environmental Impact Statement
for the Master Plan Update

Exhibit IV.1-13

Alternative 4 (South Unit Terminal) Aircraft Noise Exposure Pattern - 2020

File SEA48

- Jurisdictional Boundary
- Generalized Study Area
- Noise Contours of 65 DNL and Above
- 60 DNL Noise Contour

Source: Gambrell Urban, Inc. and Landrum & Brown, 1995

Scale 1" = 6,000'

0 6000 12000 18000

Scale in Feet

Projection: Lambert Conformal Conic
Coordinate System: State Plane NAD27

November 25, 1995

CHAPTER IV, SECTION 2

LAND USE

Aircraft noise is generally regarded to be the primary impact of an airport on surrounding land uses. This section summarizes the population, housing units, and noise-sensitive facilities that are affected by existing airport operations (1994), and by those of the Master Plan Update alternatives for future years. The compatibility of the alternatives with local and regional land use plans is also evaluated.

Compared to existing conditions, under the Do-Nothing alternative (Alternative 1) there would be a reduction of approximately 66 percent in population affected by noise levels of 65 DNL or greater in the year 2020. This decrease is primarily due to the replacement of the noisier Stage 2 aircraft with quieter Stage 3 aircraft. Fewer noise sensitive public facilities would be affected in the future in comparison to current impacts.

Noise impacts for all Master Plan Update Alternatives will be less in all forecast years relative to existing and historical impacts. Compared to the Do-Nothing alternative for the same years, each of the "With Project" alternatives (with a dependent separated new 8,500-foot runway) would affect about 5 percent more people in the year 2020 with noise levels of 65 DNL or greater. Fewer schools (1) and churches (3) would be affected under the year 2020 "With Project" alternatives compared to the Do-Nothing alternative. The "With Project" alternatives, with the 7,000-ft and 7,500-ft runway options would affect slightly more people than the Do-Nothing alternative.

(1) METHODOLOGY

Noise contours delineating locations of equal noise exposure (60, 65, 70, and 75 DNL) were developed for existing (1994) condition, and for the Do-Nothing and "With Project" alternatives for the years 2000, 2010, and 2020. To determine the amount of noise affected population and housing, the contours were electronically overlaid on the 1990 Census data.[1] The political boundaries were included to enable the quantification of population and housing impacts by jurisdiction. The noise contours for existing conditions and the future alternatives were also electronically overlaid on the Airport environs database of noise-sensitive facilities (schools, churches, hospitals, and nursing homes, libraries, parks and recreation facilities, and historical sites) to determine which uses are affected by noise.

The degree of noise impact within the noise contour was determined using Part 150 of the Federal Aviation Regulations which contains guidelines for determining the sensitivity of specific land uses to various levels of aircraft noise.[2] **Table IV.2-1** lists these land use compatibility guidelines and notes that residences and certain public-use facilities are not compatible with high levels of aircraft noise. These Federal guidelines show that residential land uses are normally incompatible in areas exposed to noise levels in excess of 65 DNL. With appropriate soundproofing, however, residential structures may be compatible with noise exposure levels of 65-75 DNL. Other noise-sensitive land uses such as medical, educational, religious and cultural facilities, areas of public assembly, resorts, and group camps follow these same patterns of compatibility. As discussed later in Chapter IV, Section 4 "DOT Section 4(f) Lands", park and recreation uses are normally considered to be compatible with noise exposure levels below 75 DNL.

The Part 150 land use compatibility guidelines indicate that most land uses, including residences, are compatible with noise exposure levels below 65 DNL. The area within DNL 65 and greater noise exposure is considered significantly impacted by aircraft noise exposure by the FAA's land use compatibility guidelines. It is also generally recognized that some residents, especially owner-occupants of single-family homes, may be highly annoyed by exposure to noise below 65 DNL (yet circumstances can vary with individual residents). In view of this sensitivity, areas affected by 60 to 65 DNL are also included in this report for the information of the reader. However, there are no generally recognized standards for characterizing the actual

[1] 1990 STF1-B File, U.S. Bureau of Census.

[2] *Noise Control and Compatibility Planning for Airports, Appendix 1*, FAA Advisory Circular AC 150/5020-1, August 5, 1983.

effect of such noise exposure on these individuals. Accordingly, areas exposed to less than 65 DNL are described as being marginally impacted, but these impacts are not judged to be significant.

(2) EXISTING CONDITIONS

The existing land uses in the general study area are shown in **Exhibit IV.2-1.** Nine jurisdictions are either partially or wholly contained within this study area: Seattle, Tukwila, SeaTac, Burien, Des Moines, Normandy Park, Federal Way, Kent, and King County (unincorporated). Existing land use consists of the following:[3]

- residential (49 %)
- open space/agriculture (17 %)
- commercial/industrial (13 %)
- airports (11 %), which includes Sea-Tac Airport and Boeing Field
- community and public facilities (3 %)
- other (7 %).

All sides of the Airport abut the City of SeaTac. Land use within the City of SeaTac, adjacent to the Airport, is primarily residential to the west, commercial to the east in the vicinity of International Blvd., open space and park land to the north, and open space/park, golf course, and commercial to the south.

Existing land use and zoning in the various jurisdictions in the study area is discussed in Chapter III. **Exhibit III-3** shows anticipated future land use, based on existing comprehensive plan designations.

Table IV.2-2 lists noise-sensitive facilities in the general study area. These land uses include 108 schools, 65 churches, 9 hospitals, 15 nursing homes, 9 libraries, and 84 parks and recreation facilities. These facilities are shown in **Exhibit IV.2-2.**

Existing land use impacts are categorized into two groups: residential uses and noise-sensitive facilities. All residential land uses, with the exception of motels and hotels, are considered to be sensitive to aircraft noise levels above 65 DNL.

The aircraft noise exposure pattern for existing conditions is shown in the previous section "Noise" in **Exhibit IV.1-1.** As shown in **Tables IV.2-4 and IV.2-5,** there are currently 31,800 people residing in 13,620 housing units affected by 65 DNL or greater noise levels, the level of significant impact. Of these people, the greatest proportion (34 percent, or 10,780 people) reside in the City of Des Moines. An almost equal proportion (31 percent, or 9,920 people) reside in unincorporated areas of King County, north and south of the Airport.

Table IV.2-3 indicates that the following noise-sensitive facilities are affected by 65 DNL or greater noise levels under existing conditions: 28 schools, 24 churches, 2 libraries, and 3 nursing homes. Only two parks or recreational facilities are affected by 75 DNL or greater noise levels, the normal threshold of compatibility for such uses. No historical or cultural sites on, or eligible for, the National Register of Historic Places are currently affected. Impacts to public parks or recreational facilities are discussed later in Section 4 "DOT Section 4(f) Lands".

(3) FUTURE CONDITIONS

For each alternative, noise-affected population and housing units by jurisdiction are shown for the years 2000, 2010, and 2020 in **Tables IV.2-4, IV.2-5, and IV.2-6.** *It is important to note that these tables include all homes affected by 65 DNL or greater noise exposure, regardless of whether or not they have been made noise-compatible through participation in the Port's Noise Remedy Program or through building code sound insulation requirements.* Since the Noise Remedy Program has insulated over two thousand units to date, with more planned in the future (see mitigation), the numbers of noise-affected population and housing units in these tables overstate the extent of current and future land use incompatibility.

As with existing conditions, 1990 population and housing census data were used to estimate future impacts on population and housing. Anticipated population changes from 1990 to 2020 are based on PSRC Forecast Analysis Zones (FAZs) which are discussed in Chapter III. For the area affected

[3] *Sea-Tac Airport Vicinity Land Use Inventory,* Port of Seattle, 1994.

AR 038910

by 65 DNL and greater noise levels, little or no population growth is anticipated.

(A) Alternative 1 (Do-Nothing)

As was described earlier, noise exposure is expected to decline in the future. A total of 8,970 people in 3,870 housing units would be affected by 65 DNL or greater noise levels in the year 2000. This would be a 72 percent reduction in population affected from existing conditions. By year 2010, a total of 9,450 people in 4,060 housing units would be affected by 65 DNL and greater noise levels. This would be a 71 percent reduction from existing conditions in population affected. By year 2020, a total of 10,800 people in 4,610 housing units would be affected by 65 DNL and greater noise levels, a 67 percent reduction from existing conditions in terms of population affected.

Compared to existing conditions, the number of affected noise-sensitive facilities (65 DNL and greater) in 2020 would be reduced from 28 to 13 schools, from 24 to 13 churches, from 2 libraries to no libraries, and from 3 nursing homes to 1 nursing home (see **Table IV.2-6**). Parks and recreational facilities impacted by 75 DNL and greater noise levels would decrease from 2 to 1. No inventoried historical or cultural sites on, or eligible for the National Register, would be affected by noise levels of 65 DNL or greater under the Do-Nothing alternative.

(B) Alternative 2 (Central Terminal)

Compared to the Do-Nothing alternative (Alternative 1) in the year 2000, this alternative would affect about 11 percent more people, and an additional 150 housing units with noise of 65 DNL or greater. Compared to the Do-Nothing alternative, about 5 percent, or 420 more people, would be affected in the year 2010, and an additional 130 housing units would fall within 65 DNL or greater noise contours. Compared to the Do-Nothing alternative, about 4 percent, or 470 more people, and 150 housing units would be affected in the year 2020, within 65 DNL or greater noise contours. While this would be an increase over the Do-Nothing (Alternative 1), it would be less than the existing impacts.

Compared to the Do-Nothing alternative in year 2020, the number of noise-sensitive facilities affected by 65 DNL and greater noise exposure could change as follows: 2 less schools, 3 less churches, 1 more public park or recreational facility (see **Table IV.2-3 and Table IV.2-6**). The number of libraries and nursing homes affected (1 each) would be the same as for Alternative 1 (Do-Nothing). No inventoried historical or cultural sites on or eligible for the National Register would be affected by the 65 DNL or greater noise levels under Alternative 2.

There would be a significant change in noise levels (1.5 DNL or greater) within 65 DNL and greater for three school buildings or educational facilities in the year 2020. These are: Sea-Tac Occupational Skills Center (S102: increase 3.1 DNL); Woodside Elementary School (S105: increase 1.7 DNL); and Sunny Terrace Elementary (S106: increase 2.6 DNL). It should be noted, however, that Woodside Elementary is currently an administrative center and does not have children in a teaching environment. Sunny Terrace is currently a mental health facility and is not being used as an elementary school.

Runway lengths 7,000 and 7,500 feet: These options would affect approximately 5 percent fewer people and housing units than the 8,500 foot new runway.

(C) Alternative 3 (North Unit Terminal)

Compared to the 2000 Do-Nothing alternative, this alternative would affect about 11 percent more people with noise exposure levels of 65 DNL or greater. Compared to the Do-Nothing alternative, about 4 percent more people would be noise impacted in 2010 and 2020 with implementation of Alternative 3.

Affected noise-sensitive facilities (65 DNL and greater in the year 2020) for Alternative 3 would be the same as Alternative 2.

There would be a significant change in noise levels (1.5 DNL or greater) within DNL 65 and greater for three schools or educational facilities in the year 2020. These are: Sea-Tac Occupational Skills Center (S102: increase 3.1 DNL); Woodside Elementary School (S105: increase 1.7 DNL); and Sunny Terrace Elementary (S106: increase 2.6 DNL). It should be noted, however, that Woodside Elementary is currently an administrative center and does not have children in a teaching environment. Sunny Terrace is currently a mental health facility and is not being used as an elementary school.

Runway lengths 7,000 and 7,500 feet: These options would affect approximately 5 percent less people and housing units than the 8,500 foot new runway.

(D) Alternative 4 (South Unit Terminal)

When compared to options with the same runway length, this alternative would result in the same noise impacts as Alternative 2 and only 0.03 percent greater than for Alternative 3. Compared to the Do-Nothing alternative, noise impacts of 65 DNL and greater in the year 2020 would be about 4 percent greater.

There would be a significant change in noise levels (1.5 DNL or greater) within DNL 65 and greater for three schools or educational facilities in the year 2020. These are: Sea-Tac Occupational Skills Center (S102: increase 3.1 DNL); Woodside Elementary School (S105: increase 1.7 DNL); and Sunny Terrace Elementary (S106: increase 2.6 DNL). It should be noted, however, that Woodside Elementary is currently an administrative center and does not have children in a teaching environment. Sunny Terrace is currently a mental health facility and is not being used as an elementary school.

Runway lengths 7,000 and 7,500 feet: These options would affect approximately 5 percent fewer people and housing units than the 8,500 foot new runway.

(E) Preferred Alternative (Alternative 3)

As described in Chapter II, the Port of Seattle staff have recommended the implementation of Alternative 3 (North Unit Terminal) with a new parallel runway with a length of 8,500 feet. Compared to the 2000 Do-Nothing alternative, the Preferred Alternative would affect about 11 percent more people with noise exposure levels of 65 DNL or greater. Compared to the Do-Nothing alternative, about 4 percent more people would be noise impacted in 2010 and 2020 under the Preferred Alternative (Alternative 3).

There would be a significant change in noise levels (1.5 DNL or greater) within DNL 65 and greater for three schools or educational facilities in the year 2020. These are: Sea-Tac Occupational Skills Center (S102: increase 3.1 DNL); Woodside Elementary School (S105): increase 1.7 DNL); and Sunny Terrace Elementary (S 106: increase 2.6 DNL). It should be noted, however, that Woodside Elementary is currently an administrative center and does not have children in a teaching environment. Sunny Terrace is currently a mental health facility and is not being used as an elementary school.

(4) MITIGATION

As described in the preceding section, the proposed Master Plan Update "With Project" alternatives (Alternative 2, 3 or 4) would result in a slightly greater noise impact than would occur with the Do-Nothing alternative. These impacts would be less than those of the existing conditions. The following sub-sections summarize measures that could be implemented to mitigate the noise related land use impacts of the Master Plan Update alternatives.

(A) Current Noise Remedy and Relocation Programs

In March, 1990, the Sea-Tac Noise Mediation Agreement was completed by the Sea-Tac Noise Mediation Committee. The committee was organized to develop new Airport noise programs and to improve existing programs.[4] The committee was comprised of residents of noise-impacted communities, and representatives of the airlines, the FAA, the Airline Pilots Association, airport users, and the Port of Seattle. The following noise remedy and relocation programs, monitored by the Port of Seattle, are in place.[5] The Noise Remedy Program (NRP) is keyed to the boundaries shown in **Exhibit IV.2-3** and is based on the noise exposure of 65 DNL and greater for the year 2000, as forecast in the Port's first Part 150 Study (1985).

As of December 31, 1995, the two noise programs coordinated through the Port of Seattle (i.e. the noise insulation, and transaction assistance, including special purchase option programs) included assistance to residents in 7,576 residential land parcels. Of these, 1,644 residences were actively awaiting insulation. Residents in 3,733 parcels had their units completely insulated; residents in another 110 parcels

4/ *Noise Exposure Map Update*, Port of Seattle, 1991.

5/ *Sound Information, Fact Sheet #12*, Port of Seattle, 1992.

had completed the process of transaction assistance; and residents in another 47 parcels had completed the special purchase option program, in addition to the 1,328 homes that have already been purchased by the Port since the inception of the program. In addition, residents in 714 parcels were in the process of having their homes insulated.

1. **Acquisition and Relocation**

The Acquisition and Relocation Program applied to the area of the Port's program forecast to be affected by noise exposure of 75 DNL and greater in the year 2000. This area is called the "Remedial Acquisition Area". It allows the purchase of the most severely impacted homes in exchange for fair market value and relocation assistance. This includes (where applicable) closing costs, moving costs, interest differentials, and replacement housing payments or rental differential payments. Vacated houses are either resold and removed from the property or demolished. The land is then held in reserve for future compatible uses. By the end of the program period in 1993, the Port had acquired 1,328 homes and relocated 3,900 residents.

2. **Insulation and Transaction Assistance**

The insulation program applies to the forecast year 2000 65-75 DNL noise exposure area of the Port's current Noise Remedy Program. The area found affected by 65-70 DNL is called the Standard Insulation Area and the area from 70-75 DNL exposure is called the Neighborhood Reinforcement Area. The goal of the insulation program is to significantly reduce noise within homes around the Airport, thereby reducing noise impacts on area residents and supporting the residential nature of the neighborhoods. As a result of the Noise Mediation Agreement, the program for the cost-share insulation area has been modified to a full 100 percent Port cost participation. Depending on residential location, insulation treatment varies from standard (in areas of exposure to 65-70 DNL) to extensive (in areas which exceed 70 DNL exposure). The level of noise reduction design must, however, meet FAA criteria (i.e., interior noise levels should not exceed 45 DNL and reduction with the insulation should be at least 5 dB).

The rate of insulation treatment by the Port of Seattle was increased in 1994 from 30 to over 100 homes a month. The Port plans to spend about $100 million over the next six years to complete the program. All eligible residences from which applications are received are scheduled to be sound insulated by the year 2000.

If a residence is in the Neighborhood Reinforcement Area of the Port's program and has participated in the sound insulation program, the owner of that residence is then eligible for transaction assistance, if desired. The Port coordinates the Transaction Assistance Program which ensures that residences of willing participants are sold and that owners receive a fair market value for their homes.

3. **Community Involvement**

Citizen committees have been provided an active role in solving noise problems for many years. These committees include: the Noise Mediation Committee, the Sea-Tac Noise Advisory Committee, which monitors the implementation and results of the Noise Mediation Agreement, and the technical review committees, which reviews noise contour updates. Other committees have included the Insulation Demonstration Project Committee, the Joint Committee on Aircraft Overflights, and the Public Building Insulation Program Committee. All committee meetings are open to the public.

(B) Adequacy of Noise Remedy Program for Mitigation

To identify potential deficiencies of the current program in meeting future noise mitigation needs of the Master Plan Update alternatives, the current Noise Remedy Program was compared to the noise contours prepared for this Environmental Impact Statement. In making this comparison, it was noted that the existing conditions (1994) are larger than those of any forecast year. Of the future contours, the year 2020 "With Project" contours are the largest. From this comparison, the following conclusions can be reached:

- The existing conditions (1994) contour for 65 DNL falls within the current Noise Remedy Program boundary, except to the northwest of the Airport and at the southernmost tip of the contour.

- The 2020 "With Project" noise contours for 65 DNL lie entirely within the current Noise Remedy Program boundaries.

- With limited exceptions, the 2020 "With Project" noise contours for 65, 70 and 75 DNL fit within Noise Remedy Program boundaries of 5 DNL higher (see **Exhibit IV.2-3**). That is, the 70 DNL contours for 2020 fit within the Remedial Acquisition Area (which is based on 75 DNL), the 65 DNL contours fit within the Neighborhood Reinforcement Area (which was defined based on 70 DNL), etc.

From this comparison, it could be concluded that the current program would provide noise mitigation for projected 2020 noise levels by approximately an additional 5 DNL beyond current Port noise reduction plans.

To conclude that the current Noise Remedy Program measures could adequately provide noise mitigation for the "With Project" alternatives, other conditions must be met, including:

- The Noise Remedy Program would have to be completed for those areas affected by the runway development actions prior to opening the new runway. The Port is presently scheduling completion of the residential portion of the Noise Remedy Program by 2000, with public buildings and schools anticipated to be completed by 2003.

- Residences which have been previously sound insulated must have adequate noise level reduction from operations on the proposed new runway. Approximately 60 to 70 residences, located on the west side of the current flight tracks and which were sound insulated prior to 1992, were treated more on one side than on the other. These structures will be audited to determine if the new flight tracks would expose their untreated west sides to excessive noise levels.

(C) Mitigation Strategies

Several mitigation strategies are currently anticipated:

Mitigating Significant Noise Impacts: The following five public facilities or historic sites would experience significant increased noise impacts (i.e. an increase of 1.5 DNL or more) in the year 2020 in comparison to the Do-Nothing alternative:

- Sea-Tac Occupational Skills Center (S102) would experience an increase of 3.1 DNL;
- Woodside Elementary School (S105) would experience an increase of 1.7 DNL;
- Sunny Terrace Elementary School (S106) would experience an increase of 2.6 DNL;
- Brunelle Residence (A27) would experience an increase of 1.5 DNL; (the house no longer exists on the property);
- Bryan House (A29) would experience an increase of 2.4 DNL;

Impacts on these facilities will be mitigated by acoustical insulation that would allow their uses to be compatible with increased noise levels. Two of the schools are currently not being used for educational uses, and future plans for these buildings need to be confirmed with the Highline School District. Port Commission Resolution 3125 and the 1993 Update to Sea-Tac's Part 150 Noise Compatibility Program contain Port intentions to expand the Airport's insulation programs for public buildings. The Port has been discussing school insulation with the Highline School District. Depending upon the District's designation of the long-term use of the two impacted schools and on the District's desire to have these buildings insulated, they would undergo insulation treatment as needed for compatibility independent of a formal school or public building insulation program. The residences would be addressed by the existing Noise Remedy insulation program if the owners agree.

Provide Directional Soundproofing: Residences that were insulated prior to 1992 may need additional directional soundproofing to mitigate noise generated from a new flight path from the operation of the proposed new third runway. To mitigate noise caused by the proposed airport improvements, these facilities would be further insulated. The Port of Seattle estimates that some 60 to 70 houses were evaluated and/or insulated prior to 1992 and could require additional soundproofing at a cost of about $6,000 to $10,000 per residence. The additional sound insulation measures that could be required include new windows, new doors, and thicker walls.

Acquisition in the Approach Transitional Area - In recognition of the fact that the standard Runway Protection Zone (RPZ) dimensions do not always provide sufficient noise and safety buffer to the satisfaction of nearby residents, the FAA has indicated that funding could be available to airport operators acquiring "up to 1,250 feet laterally from the runway centerline, and extending 5,000 feet beyond each end of the primary surface.[6]

The acquisition of properties within the approach and transitional areas north and south of the proposed runway may serve as a feasible and appropriate mitigation measure. This measure would involve the acquisition of all residential uses, and any vacant, residentially zoned properties which cannot be compatibly zoned, within selected areas both to the north and the south of the new runway ends. Commercial land uses, which make up most of the eligible area to the south, need not be acquired and may remain in place on both runway ends.

The FAA Memorandum provides funding eligibility for a box up to 5,000-feet long and 2,500-feet wide, centered on the runway and beginning 200 feet from the physical end of the runway. Based on the configuration of current airport land, local streets, and residential development patterns, the approach and transitional area selected for use as a mitigation area includes the standard Runway Protection Zone and a rectangular extension of the RPZ outward another 2,500 feet. The limit of coverage of the proposed approach and transitional areas are shown in **Exhibit IV.2-3**.

In the northern approach and transitional area, 82 single-family residential parcels, 2 apartment buildings (with 28 units), and 2 mobile home parks, with 96 units, would be acquired. To the south, 71 single-family residential parcels and 6 apartment buildings (with 32 units) would be acquired. Based on the current assessed value of these 309 residential homes and multi-family buildings, it is estimated that the cost of acquisition and relocation would be approximately $35 million.

As was noted in the Draft EIS, input from the affected residents is necessary to design and initiate an acceptable relocation program. Such input was solicited during the Draft EIS's 90-day public comment period and through display boards, which were created and used at the June 1, 1995 Public Hearing for the express purposes of soliciting feedback from the affected residents concerning this action. As is shown in **Appendices R and T** few comments concerning the program were received. Therefore, as the probable impact of low flying aircraft would not be experienced until the opening of the proposed new parallel runway, this option will receive further consideration during the forthcoming Sea-Tac Airport FAR Part 150 Update, which the Port anticipates undertaking during 1996. It is anticipated that during the Part 150 Update, the Port would further explore this action with the specific residents within the Approach Transition Area, and, if the residents so desire, establish a program including relocation objectives, timing and funding priorities.

(5) COMPATIBILITY OF THE SEA-TAC AIRPORT MASTER PLAN UPDATE WITH LOCAL AND REGIONAL LAND USE PLANS

This section examines the compatibility of the Master Plan Update alternatives with relevant local and regional land use plans available

[6] FAA Memorandum, Action: Land Acquisition - eligible Runway Protection, Object Free Area and Approach and Transitional Zones, dated April 30, 1991.

through December 1, 1995. The following are discussed: City of SeaTac Comprehensive Plan; adopted and interim comprehensive plans, elements and code amendments for Des Moines, Normandy Park and Burien; the Tukwila Comprehensive Plan; The King County Comprehensive Plan; The King County Countywide Planning Policies; VISION 2020: Growth and Transportation Strategy for the Central Puget Sound Region, Puget Sound Council of Governments (1990); and the 1995 Update of VISION 2020 and 1995 Metropolitan Transportation Plan; applicable resolutions of the PSRC[7] including the PSRC's Multi-County Framework Policies under GMA.

(A) <u>City of SeaTac Comprehensive Plan</u>

Sea-Tac International Airport lies wholly within the City of SeaTac except for a portion of property acquired for noise mitigation which is located in Des Moines. Thus, the City would be directly affected by development proposed in the Master Plan Update, particularly the construction of a new parallel runway, which also would lie wholly within the City. It is important to note that the City of SeaTac Comprehensive Plan (adopted December 20, 1994) does not specifically address the issue of a new parallel runway for the following reason:

"The Port of Seattle is a separate governmental agency, which has taken lead agency status regarding the potential construction of a third runway. 2. Construction of a third runway is a project specific proposal. Separate environmental studies specifically related to the proposal will be done."[8]

The final draft of the SeaTac Comprehensive Plan was issued in March 1995.[9]

Other planning and policy making efforts of the City deal more directly with the Airport and its relationship to the City. The extent to which the comprehensive plan policies summarized below will govern the Master Plan Update development is currently the subject of an interlocal process between the Port and the City of SeaTac.

<u>West SeaTac Subarea Planning Process</u>

The adopted comprehensive plan for the City of SeaTac retains the existing residential zoning in the West SeaTac area between 12th Avenue S. and Des Moines Memorial Drive. In the Draft Comprehensive Plan,[10] this residential area had been proposed as primarily "business park" designation in the "City Center" and the "Urban Villages" alternatives considered by the City. Because a consensus could not be reached with regard to future land use in West SeaTac, the existing residential zoning was not changed. The West SeaTac Subarea planning process, which had begun prior to the preparation of the comprehensive plan, has reconvened with a new citizen advisory committee. The West SeaTac Subarea Plan, and appropriate environmental review, is expected to be completed in approximately Spring of 1996.

<u>Comment</u>: As a result of the continuing land use planning process for West SeaTac, the compatibility of the Master Plan Update and the proposed new parallel runway with planned future land use for this area cannot be fully assessed until the West SeaTac Subarea Plan is completed and adopted.

Any existing inconsistencies between the Master Plan Update and the current City of SeaTac Comprehensive Plan will be addressed to the extent required as part of the future amendments to the City of SeaTac's Comprehensive Plan.

<u>Airport-Related Land Use Goals and Policies</u>

The City of SeaTac Comprehensive Plan specifies one goal and two policies in regard to "Airport-Related Land Use." Policy 1.6A is to "Encourage land uses adjacent to Sea-Tac International Airport that are compatible with airport operations."[11] The Plan notes:

"Improving land use compatibility in [areas immediately adjacent to the Airport] enables the City to take better advantage of the job and tax revenue benefits of the Airport, maintain and enhance the Airport's role as an essential public facility, and help reduce negative impacts to City residents. Some appropriate land uses near airports include

[7] See Appendix A for copies of PSRC resolutions A-93-03 and EB 94-01.

[8] City of SeaTac Comprehensive Plan - Final EIS, City of SeaTac, December 2, 1994.

[9] City of SeaTac Comprehensive Plan - Final Draft, City of SeaTac, March, 1995.

[10] City of SeaTac Comprehensive Plan Draft, City of SeaTac, September 6, 1994.

[11] City of SeaTac Comprehensive Plan - Final Draft, City of SeaTac, March, 1995.

open space and passive park land, parking, transportation-related activities, and some manufacturing or business park uses. Multi-family housing that is constructed to meet the applicable noise standards and designed to recognize noise issues would also be appropriate for areas within the 65 to 75 DNL area. Single-family residential use, on the other hand, is an example of a land use type that is not generally recommended for such areas."

Comment: The Master Plan Update, and the development of the proposed new parallel runway, would maintain and enhance Sea-Tac Airport's role as an essential regional public facility as recognized in SeaTac's Airport-Related Land Use Goal 1.6. It would also potentially enable the City to take better advantage of the job and tax revenue benefits of the Airport as result of induced business and economic development. The rezone of this area and construction of the proposed new parallel runway, while displacing residences, could also result in greater long-term land use compatibility than presently exists in the West SeaTac area. This would occur over-time as a result of the transition from residential uses to non-residential uses including airport operations ("Airport Industrial" designation in the SeaTac Comprehensive Plan), and adjacent business park and other non-residential uses that could be developed along the fringe of the expanded Airport in the West SeaTac subarea.

Policy 1.6B "encourages the development of airport compatible activities in the Aviation Business Center (ABC) area." The ABC district was created in 1991 to encourage a wide mix of airport-related businesses in the area southeast of the Airport. The Plan states that "this district will provide needed space for airport-related activities, which play a key role in the City's economy".

Comment: The Aviation Business Center would be compatible with Master Plan Update alternatives which would occur adjacent to the center. Both would be mutually-supportive, located near the proposed High Capacity Transit (HCT) station at International Blvd. and S. 200th Street, and create additional job and tax revenue benefits for the City.

Essential Public Facilities

As noted in Chapter III "Affected Environment", the Washington Growth Management Act (GMA) requires that jurisdictional comprehensive plans include a process for identifying and siting essential public facilities. It is also important to note that GMA states that "no local comprehensive plan or development regulations may preclude the siting of essential public facilities."[12] The City of SeaTac has identified Sea-Tac International Airport as an essential public facility.[13] In it's comprehensive plan, the City of SeaTac also has established a special siting process to be used by the City for essential public facilities which may apply to certain components of the Master Plan Update. Criteria to be used for the siting process include the following: evaluation of any viable alternatives, interjurisdictional analysis, financial analysis, and physical and infrastructure analysis. The comprehensive plan states that an ad hoc review committee will be established by the City Council, as needed, in response to a request to site an essential public facility in SeaTac. The committee would assess the proposed facility using the adopted criteria previously discussed. Once the committee has completed its review, it would forward its findings and recommendations to the City Council for final action.

Comment: It is unclear at this time whether or how this process would be applied to the Master Plan Update or to the construction of the proposed new parallel runway. The application and implementation of these and other City regulatory provisions to the Master Plan Update improvements is currently the subject of negotiation through interlocal processes between the Port and the City of SeaTac. This process will probably not be completed prior to the issuance of the Final EIS for the Master Plan Update.

12/ Washington State Growth Management Act, 1990. RCW 36.70A.200

13/ City of SeaTac Comprehensive Plan - Final, March, 1995.

(B) Adopted, Draft, and Interim Comprehensive Plans, Elements, and Land Use-Related Code Amendments of Jurisdictions Adjoining the City of SeaTac: Des Moines, Normandy Park, Burien, and Tukwila

The applicability of the policies in these jurisdictions which are adjacent to the City of SeaTac is limited due to the fact that these cities have limited, if any, direct regulatory authority over the principal permits and approvals required to construct the improvements associated with the Master Plan Update. These cities do, however, play an important role in the public comment process associated with the permit and approval process given their proximity to the Airport.[14] As discussed below, the policies and regulations in each of these cities, as well as in King County and other regional bodies, (such as the PSRC's resolutions) adopted pursuant to Washington's Growth Management Act (GMA), Chapter 36.70A RCW have some applicability to certain elements of the Master Plan Update. For example, the consistency requirements of GMA impose a responsibility on these cities to take into account and consult with neighboring municipalities, King County, and any applicable regional bodies and planning documents in drafting their plan policies (RCW 36.70A.100). As the Airport has been identified as an "essential public facility" by the City of SeaTac, all nearby municipalities, including SeaTac, are required to adopt policies which do not preclude the operations associated with the Airport and the siting of essential public facilities (RCW 36.70A.200).

Each of the individual municipality's interim and adopted policies must also be evaluated in the context of County and regional policies relating to air transportation capacity and pertinent siting issues. As discussed in this Final EIS, the 1995 Update of VISION 2020, Puget Sound Regional Council actions, policies and resolutions, the Countywide Planning Policies, and the King County Comprehensive Plan, all contain pertinent siting policies which relate to the Master Plan Update.

PSRC is currently engaged in a process for certification of transportation elements in local comprehensive plans that will be based on the following: (1) conformity with requirements in GMA for comprehensive plan elements; (2) consistency with the Regional Transportation Plan; and (3) since July 1, 1995, consistency with established regional guidelines and principles as required by Substitute House Bill 1928. The certification requirement in GMA is described in RCW 47.80. The City of SeaTac's Transportation Element in the adopted 1994 SeaTac Comprehensive Plan was recommended by PSRC for certification in November 1995. As of January 1, 1996, PSRC had not completed its certification review for the cities of Des Moines, Burien, Tukwila, or Normandy Park (Burien's Comprehensive Plan required under GMA has not yet been prepared as discussed later in this section). In addition to this certification review, which is mandatory, PSRC is also engaged in a process of coordination and consultation with local jurisdictions regarding the consistency of local plans with adopted VISION 2020 policies. This process is voluntary on the part of local jurisdictions, and consists of the jurisdiction completing a checklist and PSRC providing comments on the checklist to the jurisdiction. This voluntary coordination process between PSRC and the cities of Des Moines, Burien, and Normandy Park has not been completed.

At the time of preparation of this Final EIS, the cities of Des Moines, Normandy Park. Tukwila, and Burien were in various stages of adopting comprehensive plans under GMA as discussed in the following portion of this section. Each of these jurisdictions (except Tukwila), however, adopted a number of interim land use elements, policies, and code amendments, primarily in March and April of 1995 which are of direct relevance to the Master Plan Update. These have been, or are expected to be incorporated into the comprehensive plans of each jurisdiction when they are adopted pursuant to GMA. The adopted ordinances and code amendments are referenced and evaluated in relation to the Airport Master Plan Update in the following discussion.

City of Des Moines

The City of Des Moines on December 7, 1995 adopted a comprehensive plan under GMA. A Draft EIS for the Greater Comprehensive Plan was issued on October 18, 1995 and the Final EIS was issued on

[14] Similarly, the Port of Seattle has coordinated with and commented on many of the policies and plans of the local communities, as enumerated in Port correspondence.

AR 038918

November 29, 1995. Des Moines has previously adopted interim elements of the Greater Des Moines Comprehensive Plan. These elements, and the associated policies and code amendments, are discussed below. The City's intent was to re-adopt all the elements as one unified document in fulfillment of GMA requirements. The City notes that the "new" Greater Des Moines Comprehensive Plan does not contain substantive changes from the adopted interim elements.[15]

Overall Comments: While many of the adopted policies relate to impacts that include those generated by aircraft noise, Des Moines may not have any direct regulatory authority over the permits and approvals associated with actions proposed in the Master Plan Update. Moreover, to the extent these policies seek to preclude the expansion of the Airport, which has been deemed an essential public facility under the adopted City of SeaTac Comprehensive Plan, these policies may be inconsistent with Countywide Planning Policies, the 1995 Update of VISION 2020 PSRC resolutions,[16] the essential public facility provisions of GMA, and King County's Comprehensive Plan. The inconsistencies of these policies with existing and proposed Airport expansion are discussed below.

Community Character Plan Element and Ordinance (Ordinance No. 1125)

Ordinance No. 1125 was adopted by the Des Moines City Council on April 6, 1995.

Policy 3 states: "The City shall adopt appropriate plans, zoning, development and building regulations and review procedures to ensure that designated residential neighborhoods will not be exposed to environmental noise levels which exceed Ldn of 55 dBA, or existing noise levels as of the effective date of this element, whichever is greater." Similarly, Policy 7 calls for protecting historic properties and sites of local significance from noise levels that exceed 55 DNL or existing noise levels.

The adopted Greater Des Moines Comprehensive Plan has incorporated these policies reflecting the following language:

Policy 8-03-01 (3): "Adopt appropriate plans, zoning, development and building regulations and review procedures to ensure that designated residential neighborhoods will not be exposed to environmental noise levels that exceed an Ldn of 55 dBA, or existing noise levels as of April 20, 1995, whichever is greater. A reduction in the environmental noise level (greater than 55 Ldn) that existed as of April 20, 1995 should become the new maximum environmental level (chapter 18.08 DMMC, chapter 18.19 DMMC, chapter 18.38 DMMC)."

Policy 8-03-02 (3): "In order to minimize adverse impacts related to noise, protect historic properties and archaeological sites of local significance from environmental noise exposure levels that exceed an Ldn of 55 dBA, or existing levels as of April 20, 1995, whichever is greater. A reduction in the environmental noise level (greater than 55 Ldn) that existed as of April 20, 1995 should become the new maximum environmental level."

Strategy 8-04-02 (d): "Oppose land use and transportation proposals that would subject historic and archaeological sites of local significance to environmental noise exposure levels of Ldn of 65 dBA, or existing levels as of April 20, 1995, whichever is greater. A reduction in the environmental noise level (greater than 65 Ldn) that existed as of April 20, 1995 should become the new maximum environmental level."

Comment: The FAA's Part 150 Land Use Compatibility guidelines (see previous discussion in Chapter IV, Section 2 and **Table IV.2-1**) generally provide that residential land use is compatible at or below 65 DNL (note: 65 DNL is used in this Draft EIS and is assumed to be the same as the notation used by Des Moines and other jurisdictions: Ldn 65 dBA). It should be noted that existing noise levels in much of Des Moines exceed 55 DNL, including noise from sources typically found in suburban areas, other than aircraft noise. Historic properties are also generally considered compatible at or below 65

[15] Judith Kilgore, City of Des Moines, cover letter to Greater Des Moines Comprehensive Plan and Draft Environmental Impact Statement, October 18, 1995.

[16] The Regional Council is currently engaged in a process to review 10 comprehensive plans. The plans for Des Moines, Normandy Park and Burien have not been reviewed for consistency with VISION 2020 policies.

AR 038919

DNL according to federal guidelines (see Chapter IV, Section 3).

Policy 4 states: "The city shall establish and adopt restrictions on the use of surface streets in residential neighborhoods to assure that extraordinary increases in commercial traffic do not damage residential roads or subject residential neighborhoods to unusual congestion and noisy surface street traffic."

In addition, the City of Des Moines adopted Ordinance No. 1129 on April 13, 1995, which relates to the traffic code and prohibits operation of vehicles of excessive weight on city streets. Specifically, this ordinance authorizes the Public Works Director to survey city streets not part of the state highway system and restrict those streets in such a condition that operation of vehicles exceeding 30,000 pounds would cause serious damage or destruction.

> Comment: Policy 4 and Ordinar. : could significantly limit the number and size of trucks that can use these streets. Depending on the type of trucks required for the existing and future construction needs at the Airport, these policies may create an inconsistency with the effective operation of the Airport (or require use of off-site borrow - increasing the cost of improvements) and thus conflict with applicable County, regional, and City of SeaTac policies and designations of the Airport as an essential public facility.

Parks, Recreation, and Open Space Element (Ordinance No. 1122), and Textual Code Amendment Regarding the Designation and Protection of Parks (Ordinance No. 1123)

Ordinance 1122 and Ordinance 1123 were adopted on April 6, 1995.

The Parks and Open Space ordinance addresses what are termed "excessive exterior noise levels generated by... transportation activities or facilities..." The policies in this element call for protection from exterior noise exposure levels in excess of 55 DNL or the DNL in existence on the effective date of this element, whichever is higher. The 55 DNL threshold applies to "parks and recreational areas of local significance" except for golf courses, ball fields, outdoor spectator areas, amusement areas, riding stables, nature trails, and wildlife refuges. For these exempt park and recreation facilities, the draft ordinance calls for protection of exterior noise levels which exceed 60 DNL.

Ordinances No. 1122 and 1123 have been incorporated into the Greater Des Moines Comprehensive Plan as Policy 6-03-23 and Strategy 6-04-09 (4) and (5).

> Comment: FAA's Part 150 Land Use Compatibility guidelines generally provide that park and recreational facilities are compatible with exterior noise levels at or below 75 DNL. For parks and recreational facilities with noise-sensitive facilities such as outdoor amphitheaters, the guideline generally is 65 DNL according to FAA Part 150 Land Use Compatibility guidelines (see **Table IV.2-1**).

Code Amendment Relating to Properties Acquired by Public Entities for Public Purposes (Ordinance No. 1126)

Ordinance 1126 was adopted on April 6, 1995.

This ordinance states: (1) "Except to the extent otherwise provided in state law, all land within the city of Des Moines acquired and owned by public entities is designated for use as open space land or for public facilities designed to benefit the city and its residents (e.g., fire station, school building) except for land rezoned through established procedures. (2) Except to the extent otherwise provided in state law, property within the city of Des Moines acquired and owned by public entities may not be used for new commercial activities, unless the city makes a finding that such land uses are of value to the city and should be permitted."

Ordinance 1126 has been incorporated into the draft Greater Des Moines Comprehensive Plan as Policy 8-03-03 (5).

> Comment: To the extent this amendment inhibits operations at the Airport, which has been deemed an essential public facility under the adopted City of SeaTac plan, it may be inconsistent with the essential public facility provisions of GMA, King County's comprehensive plan, and 1995 Update of VISION 2020 policies.

AR 038920

Essential Public Facilities

The Greater Des Moines Comprehensive Plan contains a policy addressing the siting of essential public facilities. Policy 5-03-05 states the following:

Policy 5-03-05 "City plans and development regulations should identify, and provide a process for consideration of, the siting of essential public facilities. Essential public facilities should include: (A) domestic water, sanitary sewer, public schools, and fire protection; B) difficult-to-site facilities such as those identified by RCW 36.70A.200 and County-wide Planning Policies; and C) essential state facilities specified by the Office of Financial Management. Des Moines should not accept a disproportionate share of the adverse impacts resulting from air transportation."

> Comment: The City of Des Moines has not yet developed a process for the siting of essential public facilities. To the extent that the adjacent Sea-Tac Airport is deemed to be an essential public facility, the City's Comprehensive Plan only addresses in passing its adverse impacts. In violation of the GMA, the Plan does not indicate in what way the City's GMA Comprehensive Plan policies and regulations may purport to inhibit or preclude either existing or future Sea-Tac Airport operations.

City of Normandy Park

Normandy Park is located west of the Airport and the City of SeaTac, and is not adjacent to Airport property. Normandy Park adopted an Interim Land Use Element on March 28, 1995, including the following ordinances: Residential Neighborhood Protection (Ordinance No. 607), Historic Preservation (Ordinance No. 608), Park Preservation (Ordinance No. 609), Property Acquisition (Ordinance No. 610) Normandy Park issued a Draft 1995 Comprehensive Plan in August 1995. The City adopted a Comprehensive Plan under GMA on December 12, 1995. Normandy Park will have no direct regulatory authority over the permits and approvals required for development identified in the Master Plan Update. However, given its relative proximity to the Airport, the City will play an important role in the public comment process associated with some of the permits, approvals, and related environmental review that is associated with the Master Plan Update.

It should be noted that similar or identical policy language is included in the comprehensive plans and adopted ordinances of both Normandy Park and Des Moines in areas related to airport impacts. As a result, many of the same comments noted previously regarding Des Moines ordinances also apply equally to Normandy Park.

Interim Land Use Element

Policy 1.6.3 of the Interim Land Use Element states: "The city shall adopt appropriate plans, zoning, development and building regulations and review procedures to ensure that designated residential neighborhoods will not be exposed to exterior noise levels which exceed an Ldn of 55 dBA, or existing noise levels as of the date of adoption, whichever is greater." Policy 1.7.3 states: "In order to minimize adverse impacts related to noise, historic properties of local significance shall be protected from exterior noise levels which exceed an Ldn of 55 dBA, or existing levels as of the date of adoption, whichever is greater." Policy 1.10.4 outlines a similar goal for park and recreation areas. The same noise standards (either 55 DNL of 60 DNL depending on the type of park and recreational facility) and the same language are used for this policy as was discussed previously for the Des Moines parks and open space ordinances (Ordinances No. 1122 and No. 1123).

The same policies for 1.6.3, 1.7.3, and 1.10.4 are contained in the comprehensive plan adopted by the City in December, 1995.

> Comment: As discussed previously in regard to Des Moines policies and ordinances, these Normandy Park policies differ from the general FAA Part 150 Land Use Compatibility guidelines. The policies in each of these areas contain new exterior sound exposure noise levels which, when applied to aircraft noise, are substantially stricter than the noise guidelines generally established by the FAA Part 150 Land Use Compatibility guidelines. Thus the applicability of these far stricter noise criteria proposed in the policies may be inconsistent with the general FAA standards, as well as the policies of King County and regional (PSRC and VISION 2020) planning bodies which place a

priority on assuring adequate air transportation capacity in this region in the future.[17] These possible inconsistencies also raise questions with regard to GMA's consistency requirements and its essential public facility provisions.

Policy 1.8.4 states "all land acquired within the City for public purposes by public entities shall be designated for use as open space land or for public facilities designed to benefit the city and its residents (e.g., fire station, parks, school building, etc.) and shall be subject to the zoning requirements applicable to open space and public facilities. The open space land use and open space zoning designation shall allow only parks, recreational areas, or other public land uses."

Comment: To the extent this amendment seeks to preclude existing and/or future operations at the Airport, which has been deemed an essential public facility under the adopted City of SeaTac plan, it may be inconsistent with the essential public facility provisions of GMA, King County's comprehensive plan, PSRC resolutions, and VISION 2020 policies.

City of Burien

The City of Burien is located west of, and adjacent to the City of SeaTac. Burien was granted an extension (to February 28, 1997) by the State for adoption of a new comprehensive plan due to its recent incorporation (February 28, 1993). Burien adopted an Interim Comprehensive Plan as well as text amendments to existing code provisions on April 10, 1995. Code amendment ordinances include the following: Protection of Residential Areas; Protection of Environmentally Sensitive Areas; Surface Water Management; Protection and Preservation of Landmarks in the City of Burien; Land Within the City of Burien Acquired for Public Purposes; and Designation of Parks of Local or Regional Significance. The Interim Comprehensive Plan contains a number of policies and strategies that are included in the code amendments discussed below. The language of these policies and code amendments is identical in many cases to those cited previously for Des Moines and Normandy Park.

Residential Area Protection Ordinance (Ordinance No. 134)

Sec. 3 states: "Residential neighborhoods shall not be subject to adverse land uses, activities, or traffic which generate exterior noise levels exceeding 55 dBA Ldn."

Sec. 4 states: "Proponents of projects which will increase exterior noise levels to which residential areas are exposed above an Ldn of 55 dBA, must submit a noise mitigation plan to the city of Burien Department of Community Development for review and approval before required permits are issued to allow the project to proceed."

Sec. 5 details "restrictions on non-routine commercial vehicles."

Comment: Sec. 3 and Sec. 4 differs from the FAA Part 150 Land Use Compatibility guidelines. To the extent these changes are as part of the City's planning responsibilities under GMA, the inconsistency issues in the area of aircraft noise identified previously for Normandy Park and Des Moines may also apply.

It should be noted that Burien's roads are anticipated to be used to only a limited extent by trucks hauling material to the Airport. The roads used may be limited to only several city blocks (see Chapter IV, Section 23, "Construction Impacts", for further discussion). Nevertheless, these draft amendments appear to significantly limit the number and size of trucks that can use these streets. Depending upon the type of trucks required for the existing and future needs of the Airport, these policies may be inconsistent with the effective operation of the Airport and thus conflict with applicable County, Regional, and City of SeaTac policies and designations of the Airport as an essential public facility for the Region.

Protection and Preservation of Landmarks in the City of Burien (Ordinance No. 130 which establishes new Chapter 18.120 entitled "Historic Preservation")

Chapter 18.120.030 states: "Significant sites, districts, buildings, structures, and objects

[17] The Regional Council is currently engaged in a process to review 10 comprehensive plans. The plans for Des Moines, Normandy Park and Burien have not been reviewed for consistency with VISION 2020 policies.

shall not be subject to adverse land uses which generate exterior noise exposure levels exceeding 55 dBA Ldn."

Chapter 18.120.040 states: "Proponents of projects which will increase exterior noise levels to which significant sites, districts, buildings, structures, and objects are exposed above an Ldn of 55 dBA, must submit a noise mitigation plan to the city of Burien Department of Community Development for review and approval before required permits are issued to allow the project to proceed."

> Comment: FAA Part 150 Land Use Compatibility guidelines and accepted federal practices generally provide for different criteria in evaluating aircraft noise impacts on historical sites.

Land Within the City of Burien Acquired by Public Entities for Public Purposes (Ordinance No. 133 which establishes new Chapter 18.130 entitled "Property Acquisition by Public Entities")

Chapter 18.130.020 states: (1) "Except to the extent otherwise provided in state law, all land within the city of Burien acquired for public purposes by public entities shall be designated for use as parks and recreational land or for community facilities designed to benefit the city and its residents (e.g., fire station, school building) and shall be subject to the zoning requirements applicable to park and recreation or public facilities. The open space land use and open space zoning designation shall allow only parks, recreational areas, or other public land uses. (2) Except to the extent otherwise provided in state law, property within the city of Burien acquired for public purposes by public entities may not be used for new commercial activities, unless the city makes a finding that such land uses are of value to the city and should be permitted."

> Comment: The Master Plan Update identifies the potential for property acquisition in the City of Burien within the northern RPZ (Runway Protection Zone) and the mitigation area for the proposed new runway (see Chapter IV, Section 6 "Social Impacts"). These properties may be used for purposes other than those permitted in this draft ordinance. To the extent this amendment seeks to preclude existing and/or future operations of the Airport, which has been deemed an essential public facility under the adopted City of SeaTac plan, it may be inconsistent with the essential public facility provisions of GMA, King County's comprehensive plan, and VISION 2020 policies and resolutions of the PSRC.[18]

Designating Parks of Local or Regional Significance (Ordinance No. 131 which establishes new Chapter 12.30)

Chapter 12.30.110 establishes maximum exterior noise level criteria for "parks of local or regional significance" which are the same as those discussed previously for the cities of Des Moines and Normandy Park. Except for outdoor amphitheaters and music shells, golf courses, ball fields, outdoor spectator sports areas, amusement areas, riding stables, nature trails, and wildlife refuges, the ordinance states that "park and recreational areas designated as being of local or regional significance as specified by the city shall not be subjected to adverse land uses which result in exterior noise level exposures which exceed 55 dBA Ldn." For "outdoor amphitheaters and music shells designated as being of local or regional significance", the maximum noise level is 50 dBA Ldn. For "golf courses, ball fields, outdoor spectator sports areas, amusements areas, riding stables, nature trails, and wildlife refuges designated as being of local significance as specified by the city", the maximum noise level would be 60 dBA Ldn.

> Comment: As was discussed previously for the cities of Des Moines and Normandy Park, these noise criteria may be inconsistent with FAA Part 150 Land Use Compatibility guidelines for park and recreational facilities (see Chapter IV, Section 4 of this Final EIS).

Tukwila

The City of Tukwila adopted a Comprehensive Plan under GMA on December 4, 1995. This Plan proposes the development of an urban center in the Southcenter area (at the intersection of I-5 and I-405). This area of Tukwila had been designated as an urban center by King County In addition, the northwest portion of

[18] The Regional Council is currently engaged in a process to review 10 comprehensive plans. The plans for Des Moines, Normandy Park and Burien have not been reviewed for consistency with VISION 2020 policies.

Tukwila in the vicinity of East Marginal Way (Duwamish/Green River corridor) has been designated as a manufacturing/industrial center by King County and Tukwila. The Economic Development element of the Comprehensive Plan discusses the strong role that business activity plays in Tukwila and emphasizes that the City is a major commercial activity center.

Comment: The proximity of Sea-Tac Airport is a key asset to the continued maintenance and growth of a strong Tukwila business community, especially for the urban center and manufacturing/industrial center.

(C) **King County Comprehensive Plan and the Countywide Planning Policies**

The Countywide Planning Policies (discussed in Chapter 3) were adopted in 1992 and amendments adopted in 1994.[19] The Countywide Planning Policies emphasize growth within designated urban centers. The 1994 amendments to the Policies identified the City of SeaTac as an urban center. The emphasis on urban centers and urban in-fill is designed to help preserve rural, resource, and sensitive-area lands from development, promote non-auto, rapid transit by linking urban centers with a high capacity transit (HCT) system, and minimize costly urban sprawl and extension of services and utilities to outlying areas.

The King County Comprehensive Plan[20] contains several policies that address proposed new essential public facilities or expansions of existing facilities. These would include the following ("F" policies are those relating to essential public facilities, and "T" policies are those relating to transportation):

F-217: "Proposed new or expansions to existing essential public facilities should be sited consistent with the King County Comprehensive Plan."

F-218: "King County and neighboring counties, if advantageous to both, should share essential public facilities to increase efficiency of operation. Efficiency of operation should take into account the overall value of the essential public facility to the region and the County and the extent to which, if properly mitigated, expansion of an existing public facility located in the County might be more economically and environmentally efficient to County residents."

F-219: "King County should ensure that no racial, cultural or class group is unduly impacted by essential public facility siting or expansion decisions."

F-220: "King County should strive to site essential public facilities equitably. No single community should absorb an inequitable share of the facilities and their impacts. Siting should consider environmental equity and environmental, economic, technical and service area factors. The net impact of siting new essential public facilities should be weighed against the net impact of expansion of existing essential public facilities, with appropriate buffering and mitigation. Essential public facilities that directly serve the public beyond their general vicinity shall be discouraged from locating in rural areas."

F-221: "A facility may be determined to be an essential public facility if it has one or more of the following characteristics:

a. The facility meets the Growth Management Act definition of an essential public facility;
b. The facility is on a state, county, or local community list of essential public facilities;
c. The facility serves a significant portion of the County or metropolitan region or is part of a Countywide service system; or
d. The facility is difficult to site or expand.

F-222: "Siting analysis for proposed new, or expansions to existing essential public facilities shall consist of the following:

a. An inventory of similar existing essential public facilities in King County and neighboring counties, including their locations and capacities;
b. A forecast of the future needs for the essential public facilities;
c. An analysis of the potential social and economic impacts and benefits to jurisdictions receiving or surrounding the facilities;

[19] Countywide Planning Policies, Growth Management Planning Council, July, 1992.

[20] King County Comprehensive Plan, adopted November, 1994.

d. An analysis of the proposal's consistency with policies F-217 through F-221;

e. An analysis of alternatives to the facility including decentralization, conservation, demand management, and other strategies;

f. An analysis of economic and environmental impacts, including mitigation, of any existing essential public facility, as well as of any new site(s) under consideration as an alternative to expansion of an existing facility;

g. Extensive public involvement; and

h. Consideration of any applicable prior review conducted by a public agency, local government, or citizen's group."

T-540: Regional aviation facilities play a foundation role in promoting a strong economy as well as providing significant direct and indirect employment opportunities to residents of the County and Puget Sound region. Consistent with this plan's policies concerning the siting of essential public facilities, King County should work with the Puget Sound Regional Council and its members to ensure that any regional projected capacity problems, and the air transportation needs of the region's residents and economy are addressed in a timely manner. Siting decisions must be consistent with the Regional Airport System Plan, the Countywide Planning Policies and this plan.

Comment: The Master Plan Update, and the proposed new parallel runway, by supporting the planned growth within a designated urban center (SeaTac) are compatible with the Countywide Planning Policies. The expansion of an existing facility (Sea-Tac International Airport) provides an alternative to locating a new essential public facility in a rural area (see Chapter II for discussion of Puget Sound Regional Council (PSRC)[21] Supplemental Airport Study). With three potential HCT stations on the proposed light rail line to serve Sea-Tac Airport and the City of SeaTac, expansion of the Airport facility would serve to promote rail transit and alternatives to the automobile. Issues of demand management are addressed in Chapter II of this document. Mitigation for adverse impacts of the Master Plan and proposed new parallel runway would be required and are detailed for each appropriate element of the environment in Chapter IV.

(D) VISION 2020 (1990) and 1995 Update of VISION 2020

VISION 2020 Growth and Transportation Strategy for the Puget Sound Region [22] is a long-range plan for the central Puget Sound area, including King, Kitsap, Pierce, and Snohomish counties. The Plan, completed in 1990, proposes containment of growth and concentration of employment into about 15 centers connected with a regional rapid transit system. A range of central places is described by the VISION 2020 Plan as a means of identifying where various levels of growth and types of transportation could be located. Within the range identified, higher order places are expected to receive relatively high growth and be well connected to their regional transportation system.

Comment: In the VISION 2020 plan, the Airport area was classified as a Subregional Center. This was the highest order place of any of the potential Airport sites considered in the Flight plan Project Final EIS.[23] Other potential Airport sites considered were Paine Field, Arlington, McChord, Central Pierce (South Hill), Fort Lewis, and Olympia/Black Lake. As a Subregional Center, the Sea-Tac International Airport/City of SeaTac area is identified as a "focus of regional growth" in the VISION 2020 Plan. Improvements in the Master Plan Update for the Airport, including the construction of the proposed new parallel runway, are compatible with the growth envisioned for this Subregional Center.

An update to VISION 2020 has been prepared by the Puget Sound Regional

21/ It is important to note that the PSRC has an important role under GMA in reviewing local GMA plans and policies. Thus, the PSRC resolutions discussed in Chapter II are an important policy framework for evaluation for the consistency of local transportation-related policies with regional policies.

22/ *VISION 2020 Growth and Transportation Strategy for the Puget Sound Region*, Puget Sound Council of Governments, 1990.

23/ *Flight Plan Project Final EIS*, Puget Sound Regional Council, 1992.

Council.[24] The 1995 Update of VISION 2020 Update adopted new and revised policies addressing growth management, transportation, and the economy that are integrated throughout eight topic areas: Urban Growth Areas; Contiguous and Orderly Development; Regional Capital Facilities; Housing; Open Space, Resource Protection and Critical Areas; Rural Areas; Economic Development; and Transportation. The state GMA requires the region to have multi-county policies to deal with growth and transportation issues that extend beyond the boundaries of the individual jurisdictions. The key multi-county policies in the 1995 Update of VISION 2020 Update document related to regional capital facilities are the following:

RT-8.31: "Support effective management and preservation of existing regional air transportation capacity and ensure that future air transportation capacity and phasing of existing airport facilities needs are addressed in cooperation with responsible agencies. Coordinate this effort with long-range comprehensive planning of land use, surface transportation facilities for effective access, and development of financing strategies."

RF-3: "Strategically locate public facilities and amenities in a manner that adequately considers alternatives to new facilities (including demand management) implements regional growth planning objectives, maximizes public benefit and minimizes and mitigates adverse impacts."

RF-3.1: "Invest in major public facilities and urban amenities in a manner that supports the development of urban and manufacturing/industrial centers."

RF-3.3: "Site specifically defined regional capital facilities in a manner that (1) reduces adverse societal, environmental and economic impacts on the host community, (2) equitably balances locations of new facilities, and (3) addresses regional growth planning objectives. Regionally share the burden and provide mitigation to communities impacted by regional capital facilities."

RF-3.4: "Regional capital facilities proposed to be located in rural areas must either demonstrate that a non-urban site is the only appropriate location for the facility (for example, a dam) or (in the case of urban facilities) demonstrate that no urban sites are feasible. If rural siting is necessary, measures should be taken to mitigate adverse impacts and prohibit development incompatible with rural character."

Comment: The Master Plan Update, and the new parallel runway, would be compatible with regional growth planning objectives, and by expanding an existing facility, would provide an alternative to construction of a new facility. Further, it would provide an alternative to constructing a new facility in a rural area. The Master Plan Update would support the development of a designated urban center (SeaTac). Issues of demand management are considered in Chapter II of this document. Measures to mitigate adverse impacts of the Master Plan Update are discussed as a part of each applicable element of the environment in Chapter IV and Chapter V.

Please also refer to the Response to Comment R-7-31 located in **Appendix R** of the Final EIS, which discusses the relationship of the Master Plan Update to the following 1995 VISION 2020 Update adopted policies: RC-2.6; RC-2.7; RC-2.10; RH-4.4; RO-6.6; RE-7.11; RT-8.6; RT-8.11; RT-8.14; and RT-8.40.

[24] *VISION 2020: 1995 Update and 1995 Metropolitan Transportation Plan*, Puget Sound Regional Council, adopted by Resolution No. PSRC-A-95-02, May 15, 1995.

TABLE IV.2-1

Seattle-Tacoma International Airport
Environmental Impact Statement

PART 150 LAND USE COMPATIBILITY GUIDELINES

Page 1 of 4

Land Use	Yearly Day-Night Average Sound Level (DNL) in Decibels: Below 65	65-70	70-75	75-80	80-85	Over 85
RESIDENTIAL:						
Residential, other than mobile homes and transient lodgings	Y	N[1]	N[1]	N	N	N
Household units (11)						
Single units-detached (11.11)						
Single units-semidetached (11.12)						
Single units-attached row (11.13)						
Two units-side-by-side (11.21)						
Two units-one above the other (11.22)						
Apartments-walk up (11.31)						
Apartments-elevator (11.32)						
Group quarters (12)						
Residential hotels (13)						
Other residential (19)						
Mobile home parks (14)	Y	N	N	N	N	N
Transient lodgings (15)	Y	N[1]	N[1]	N[1]	N	N
PUBLIC USE:						
Schools, hospitals, and nursing homes	Y	25	30	N	N	N
Educational services (68)						
Hospitals, nursing homes (65.13, 65.16)						
Churches, auditoriums, and concert halls	Y	25	30	N	N	N
Cultural activities (including churches) (71)						
Auditoriums, concert halls (72.1)						
Governmental services (67)	Y	Y	25	30	N	N
Transportation	Y	Y	Y[2]	Y[3]	Y[4]	Y[4]
Railroad, rapid transit and street railway transportation (41)						
Motor vehicle transportation (42)						
Aircraft transportation (43)						
Marine craft transport (44)						
Highway and street right-of-way (45)						
Parking (46)	Y	Y	Y[2]2	Y[3]	Y[4]	N

Footnotes contained on page 4 of table.

TABLE IV.2-1

Seattle-Tacoma International Airport
Environmental Impact Statement

PART 150 LAND USE COMPATIBILITY GUIDELINES
Page 2 of 4

Land Use	Below 65	65-70	70-75	75-80	80-85	Over 85
	Yearly Day-Night Average Sound Level (DNL) in Decibels					
COMMERCIAL USE:						
Offices, business, and professional	Y	Y	25	30	N	N
Finance, insurance and real estate services (61)						
Personal services (62)						
Business services (63)						
Professional services (65)						
Other medical facilities (65.1)						
Miscellaneous services (69)						
Wholesale and retail-building materials, hardware and farm equipment	Y	Y	Y[2]	Y[3]	Y[4]	N
Wholesale trade (51)						
Retail trade-building materials, hardware and farm equipment (52)						
Repair services (64)						
Contract construction services (66)						
Retail Trade - general						
Retail trade-general merchandise (53)	Y	Y	25	30	N	N
Retail trade-food (54)						
Retail trade-automotive, marine craft, aircraft and accessories (55)						
Retail trade-apparel and accessories (56)						
Retail trade-furniture, home furnishings and equipment (57)						
Retail trade-eating and drinking establishments (58)						
Other retail trade (59)						
Utilities (48)	Y	Y	Y[2]	Y[3]	Y[4]	N
Communication (47)	Y	Y	25	30	N	N
MANUFACTURING AND PRODUCTION						
Manufacturing, general	Y	Y	Y[2]	Y[3]	Y[4]	N
Food and kindred products - manufacturing (21)						
Textile mill products-manufacturing (22)						
Apparel and other finished products made from fabrics, leather and similar materials-manufacturing (23)						
Lumber and wood products (except furniture) - manufacturing (24)						
Furniture and fixtures-manufacturing (25)						
Paper and allied products-manufacturing (26)						
Printing, publishing, and allied industries (27)						
Chemical and applied products-manufacturing (28)						
Petroleum refining and related industries (29)						
Rubber and misc. plastic products-manufacturing (31)						

AR 038928

TABLE IV.2-1

Seattle-Tacoma International Airport
Environmental Impact Statement

PART 150 LAND USE COMPATIBILITY GUIDELINES
Page 3 of 4

Land Use	Below 65	65-70	70-75	75-80	80-85	Over 85
	Yearly Day-Night Average Sound Level (DNL) in Decibels					
Stone, clay and glass products-manufacturing (32)						
Primary metal industries (33)						
Fabricated metal products-manufacturing (34)						
Miscellaneous manufacturing (39)						
Photographic and optical	Y	Y	25	30	N	N
Professional, scientific, and controlling instruments, photographic and optical goods; watches and clocks manufacturing (35)						
Agriculture (except livestock) and forestry	Y	Y[6]	Y[7]	Y[8]	Y[8]	Y[8]
Agriculture (except livestock) (81)						
Agriculture related activities (82)						
Forestry activities and related services (83)						
Livestock farming and breeding (81.5 - 81.7)	Y	Y[6]	Y[7]	N	N	N
Mining and fishing, resource production and extraction	Y	Y	Y	Y	Y	Y
Fishing activities and related services (84)						
Mining activities and related services (85)						
Other resource production and extraction (89)						
RECREATIONAL:						
Outdoor sports arenas and spectator sports (72.2)	Y	Y[5]	Y[5]	N	N	N
Outdoor music shells, amphitheaters (72.11)	Y	N	N	N	N	N
Nature exhibits and zoos (72.1)	Y	Y	N	N	N	N
Amusements, parks, resorts and camps	Y	Y	Y	N	N	N
Amusements (73) Parks (76)						
Public assembly (72)						
Resorts and group camps (75)						
Other cultural, entertainment and recreation (79)						
Golf course, riding stables and water recreation (74)	Y	Y	25	30	N	N

Numbers in parentheses refer to Standard Land Use Coding Manual (SLUCM)

* The designations contained in this table do not constitute a Federal determination that any use of land covered by the program is acceptable or unacceptable under Federal, State, or local law. The responsibility for determining the acceptable and permissible land uses remains with the local authorities. FAA determinations under Part 150 are not intended to substitute federally determined land uses for those determined to be appropriate by local authorities in response to locally determined needs and values in achieving noise compatible land uses.

TABLE IV.2-1

Seattle-Tacoma International Airport
Environmental Impact Statement

PART 150 LAND USE COMPATIBILITY GUIDELINES
Page 4 of 4

KEY TO TABLE

Number in ( )	Standard Land Use Coding Manual (SLUCM).
Y (Yes)	Land Use and related structures compatible without restrictions.
N (No)	Land Use and related structures are not compatible and should be prohibited.
25, 30, or 35	Land Use and related structures generally compatible; measures to achieve Noise Level Reduction (NRL), outdoor to indoor, of 25, 30, or 35 must be incorporated into design and construction of structure.

NOTES FOR TABLE

1. Where the community determines that residential uses must be allowed, measures to achieve outdoor to indoor Noise Level Reduction (NLR) of at least 25 dB and 30 dB should be incorporated into building codes and be considered in individual approvals. Normal construction can be expected to provide a NLR of 20 dB, thus, the reduction requirements are often stated as 5, 10 or 15 dB over standard construction and normally assume mechanical ventilation and closed windows year round. However, the use of NLR criteria will not eliminate outdoor noise problems.
2. Compatible where measures to achieve NLR of 25 are incorporated into the design and construction of portions of these buildings where the public is received, office areas, noise sensitive areas or where the normal noise level is low.
3. Compatible where measures to achieve NLR of 30 are incorporated into the design and construction of portions of these buildings where the public is received, office areas, noise sensitive areas or where the normal noise level is low.
4. Compatible where measures to achieve NLR of 35 are incorporated into the design and construction of portions of these buildings where the public is received, office areas, noise sensitive areas or where the normal noise level is low.
5. Land use compatible provided special sound reinforcement systems are installed.
6. Prime use only, any residential buildings require NLR of 25 to be compatible.
7. Prime use only any residential buildings require an NLR of 30 to be compatible.
8. Prime use only, NLR for residential buildings not normally feasible, and such uses should be prohibited.
   g. Designations contained in the table do not constitute a Federal determination that any use of land covered by the program is acceptable or unacceptable under Federal, State, or local law. The responsibilty for determining the acceptability and permissible land uses remain with the local authorities.
   h. Although Table 2 of FAR Part 150 defines the compatibility or noncompatibility of various land uses for the purposes of Federal Aid, programs, or sanctions under the ASNA Act, adjustments or modifications of the descriptions of the land use categories may be desirable after consideration of specific local conditions.

Source: Federal Aviation Administration Advisory Circular AC 150/5020-1, **Noise Control and Compatibility Planning For Airports**, Appendix 1, August 5, 1983.

TABLE IV.2-2
(Page 1 of 8)

Seattle - Tacoma International Airport
Environmental Impact Statement

NOISE SENSITIVE FACILITIES IN THE STUDY AREA
(Day Night Average Sound Level Range)

		1994	Year 2000			Year 2010			Year 2020			
Site No	Alternative	Existing	Alt. 1	Alt. 2	Alt. 3 & 4	Alt. 1	Alt. 2	Alt. 3 & 4	Alt. 1	Alt. 2	Alt. 3	Alt. 4
	Schools											
S1	Beverly Park/Glendale	65-70	60-65	60-65	60-65	60-65	60-65	60-65	60-65	60-65	60-65	60-65
S2	Bow Lake	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60
S3	Cedarhurst	60-65	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60
S4	Des Moines	60-65	<60	60-65	60-65	<60	60-65	60-65	<60	60-65	60-65	60-65
S5	Gregory Heights	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60
S6	Hazel Valley	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60
S7	Hill Top	60-65	<60	<60	<60	<60	<60	<60	60-65	60-65	60-65	60-65
S8	Madrona	65-70	60-65	<60	<60	60-65	<60	<60	60-65	60-65	60-65	60-65
S9	MarVista	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60
S10	McMicken Heights	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60
S11	Midway	70-75	65-70	60-65	60-65	65-70	60-65	60-65	65-70	60-65	60-65	60-65
S12	Mount View	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60
S13	North Hill	60-65	<60	60-65	60-65	<60	60-65	60-65	60-65	60-65	60-65	60-65
S14	Olympic	60-65	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60
S15	Parkside	65-70	60-65	60-65	60-65	60-65	60-65	60-65	60-65	60-65	60-65	60-65
S16	Riverton Heights	60-65	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60
S17	Salmon Creek	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60
S18	Seahurst	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60
S19	Shorewood	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60
S20	Southern Heights	65-70	65-70	65-70	65-70	65-70	65-70	65-70	65-70	65-70	65-70	65-70
S21	Sunnydale	65-70	60-65	60-65	60-65	60-65	60-65	60-65	60-65	60-65	60-65	60-65
S22	Valley View	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60
S23	White Center Heights	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60
S24	Cascade	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60
S25	Chinook	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60
S26	Pacific	65-70	65-70	60-65	60-65	65-70	60-65	60-65	65-70	60-65	60-65	60-65
S27	Sylvester	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60
S28	Evergreen	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60
S29	Highline	60-65	<60	<60	<60	<60	<60	<60	<60	60-65	60-65	60-65
S30	Mount Rainier	70-75	65-70	65-70	65-70	65-70	65-70	65-70	65-70	65-70	65-70	65-70
S31	Tyee	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60
S32	Satellite Alternative H.S.	60-65	<60	60-65	60-65	60-65	60-65	60-65	60-65	60-65	60-65	60-65
S33	Highline Community College	65-70	60-65	60-65	60-65	60-65	60-65	60-65	60-65	60-65	60-65	60-65
S34	Highline Childrens Center	60-65	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60
S35	Performing Arts Center	60-65	<60	60-65	60-65	<60	60-65	60-65	60-65	60-65	60-65	60-65
S36	Indian Education	60-65	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60

AR 038931

TABLE IV.2-2
(Page 2 of 8)

Seattle - Tacoma International Airport
Environmental Impact Statement

NOISE SENSITIVE FACILITIES IN THE STUDY AREA
(Day Night Average Sound Level Range)

		1994	Year 2000			Year 2010			Year 2020			
Site No	Alternative	Existing	Alt. 1	Alt. 2	Alt. 3 & 4	Alt. 1	Alt. 2	Alt. 3 & 4	Alt. 1	Alt. 2	Alt. 3	Alt. 4
S38	Marine Technology Lab	65-70	60-65	60-65	60-65	60-65	60-65	60-65	60-65	65-70	65-70	65-70
S39	Tukwila Elementary	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60
S40	Thorndyke Elementary	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60
S41	Cascade View Elementary	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60
S42	Showalter Middle School	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60
S43	Foster High School	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60
S44	Camelot School	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60
S45	Mark Twain School	60-65	60-65	<60	<60	60-65	<60	<60	60-65	<60	<60	<60
S46	Nautilus School	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60
S47	Star Lake	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60
S48	Sunnycrest	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60
S49	Valhalla	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60
S50	Wildwood	60-65	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60
S51	Woodmont	65-70	60-65	60-65	60-65	60-65	60-65	60-65	60-65	60-65	60-65	60-65
S52	Meredith Hill (opens in 1995)	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60
S53	Sacajawea	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60
S54	Totem	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60
S55	Federal Way	60-65	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60
S56	Thomas Jefferson	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60
S58	Graham Hill	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60
S59	Kimball	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60
S60	Muir	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60
S61	Hawthorne	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60
S62	Maple	60-65	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60
S63	Dearborn Park	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60
S64	Whitworth	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60
S65	Brighton	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60
S66	Van Asselt	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60
S67	Wing Luke	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60
S68	Dunlap	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60
S69	Emerson	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60
S70	Rainier View School	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60
S71	Highland Park School	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60
S72	Concord	60-65	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60
S73	Mercer	60-65	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60
S74	South Shore	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60
S76	Franklin	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60
S77	Rainier Beach	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60

TABLE IV.2-2
(Page 3 of 8)

Seattle - Tacoma International Airport
Environmental Impact Statement

NOISE SENSITIVE FACILITIES IN THE STUDY AREA
(Day Night Average Sound Level Range)

		1994	Year 2000			Year 2010			Year 2020			
Site No	Alternative	Existing	Alt. 1	Alt. 2	Alt. 3 & 4	Alt. 1	Alt. 2	Alt. 3 & 4	Alt. 1	Alt. 2	Alt. 3	Alt. 4
S78	Cleveland	60-65	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60
S79	Orca/Columbia	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60
S80	Sharples	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60
S81	Amazing Grace Lutheran School	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60
S82	Burien Adventist	70-75	65-70	65-70	65-70	65-70	65-70	65-70	65-70	65-70	65-70	65-70
S83	Catskins Montesorri	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60
S84	Christian Faith	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60
S85	Colonial Christian School	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60
S86	Comm Chapel Christian School	65-70	60-65	60-65	60-65	60-65	60-65	60-65	60-65	60-65	60-65	60-65
S87	Holy Innocents	60-65	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60
S88	Holy Trinity Lutheran School	65-70	60-65	60-65	60-65	60-65	60-65	60-65	60-65	60-65	60-65	60-65
S89	Pegasus	<60	-60	<60	<60	<60	<60	<60	<60	<60	<60	<60
S90	Rainier Valley Christian School	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60
S91	St. Francis of Assisi School	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60
S92	St. Philomenas School	70-75	65-70	65-70	65-70	65-70	65-70	65-70	65-70	65-70	65-70	65-70
S93	St. Vincents School	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60
S94	SeaTac Christian Acad.	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60
S95	Seattle Christian	65-70	60-65	60-65	60-65	60-65	60-65	60-65	65-70	60-65	60-65	60-65
S96	Evergreen Lutheran High School	65-70	60-65	60-65	60-65	60-65	60-65	60-65	60-65	60-65	60-65	60-65
S97	John F. Kennedy Mem HS	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60
S98	Dominion	70-75	65-70	65-70	65-70	65-70	65-70	65-70	65-70	65-70	65-70	65-70
S99	Hamlin Robinson S. of Dyslexia	65-70	60-65	60-65	60-65	60-65	60-65	60-65	60-65	60-65	60-65	60-65
S100	New Life Christian Academy	70-75	65-70	60-65	60-65	65-70	60-65	60-65	65-70	60-65	60-65	60-65
S101	Normandy Park Acad. Montessori	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60
S102	Sea-Tac Occupational Skills Ct	65-70	60-65	60-65	60-65	60-65	60-65	60-65	60-65	65-70	65-70	65-70
S103	Bloulevard Park Elementary	70-75	65-70	65-70	65-70	65-70	65-70	65-70	65-70	65-70	65-70	65-70
S104	Glacier High	65-70	60-65	60-65	60-65	60-65	60-65	60-65	60-65	60-65	60-65	60-65
S105	Woodside Elementary	65-70	60-65	60-65	60-65	60-65	60-65	60-65	60-65	65-70	65-70	65-70
S106	Sunny Terrace Elementary	65-70	60-65	60-65	60-65	60-65	65-70	65-70	60-65	65-70	65-70	65-70
S107	Angle Lake Elementary	70-75	65-70	60-65	60-65	65-70	60-65	60-65	65-70	65-70	65-70	65-70
S108	Maywood Elementary	70-75	65-70	65-70	65-70	65-70	65-70	65-70	65-70	65-70	65-70	65-70
S109	Zenith School	65-70	60-65	60-65	60-65	60-65	60-65	60-65	60-65	60-65	60-65	60-65
S110	Des Moines Assembly of God Sch	70-75	65-70	60-65	60-65	65-70	60-65	60-65	65-70	60-65	60-65	60-65
Libraries												
L1	Boulevard Park Library	65-70	60-65	65-70	65-70	60-65	65-70	65-70	65-70	65-70	65-70	65-70
L2	Burien Library	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60
L3	Columbia Library	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60

AR 038933

TABLE IV.2-2
(Page 4 of 8)

Seattle - Tacoma International Airport
Environmental Impact Statement

NOISE SENSITIVE FACILITIES IN THE STUDY AREA
(Day Night Average Sound Level Range)

		1994	Year 2000			Year 2010			Year 2020			
Site No	Alternative	Existing	Alt. 1	Alt. 2	Alt. 3 & 4	Alt. 1	Alt. 2	Alt. 3 & 4	Alt. 1	Alt. 2	Alt. 3	Alt. 4
L4	Des Moines Library	65-70	60-65	60-65	60-65	60-65	60-65	60-65	60-65	60-65	60-65	60-65
L5	Foster Library	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60
L6	Holly Park Library	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60
L7	Rainier Beach Library	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60
L8	Tukwila Library	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60
L9	Valley View Library	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60
Hospitals												
H1	Highline Community Hospital	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60
H2	Highline Riverton Comm. Hosp.	60-65	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60
H3	Highline Community Hospital	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60
H4	Pacific Medical Center	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60
H5	Shorewood Osteopathic Hosp.	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60
H6	Veterans Affairs Medical Bldg.	60-65	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60
H7	Cascade Kidney Center	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60
H8	Valley Medical Center	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60
H9	Northwest Reg. Hosp. for Respi	60-65	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60
Nursing Homes												
N1	Midway Manor	60-65	60-65	<60	<60	60-65	<60	<60	60-65	<60	<60	<60
N2	Monarch Care Center	65-70	60-65	60-65	60-65	60-65	60-65	60-65	60-65	60-65	60-65	60-65
N3	Burien Terrace Nursing Center	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60
N4	Federal Way Convalescent Ctr	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60
N5	Hallmark Manor	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60
N6	Highline Care Center	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60
N7	Judson Park Retirement	60-65	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60
N8	Riverton Heights Convalescent	60-65	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60
N9	Seatoma Convalescent	65-70	60-65	60-65	60-65	60-65	60-65	60-65	60-65	60-65	60-65	60-65
N10	Wesley Care Center	60-65	<60	<60	<60	<60	<60	<60	<60	60-65	60-65	60-65
N11	Abba Senior Family Home	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60
N12	Harmony Gardens	65-70	65-70	60-65	60-65	65-70	65-70	65-70	65-70	65-70	65-70	65-70
N13	Hillhaven Rehab. & Health Care	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60
N14	Helping Hands	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60
N15	Masonic Nursing Home	60-65	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60
Churches												
C1	All Saints Lutheran Ch.	60-65	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60
C2	Angle Lake Neighborhood Ch.	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60
C3	Apostolic Ch. of Jesus Christ	70-75	65-70	65-70	65-70	65-70	65-70	65-70	65-70	65-70	65-70	65-70
C4	Assembly of God of Des Moines	70-75	65-70	60-65	60-65	65-70	60-65	60-65	65-70	60-65	60-65	60-65
C5	Associated Churches	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60

TABLE IV.2-2
(Page 5 of 8)

Seattle - Tacoma International Airport
Environmental Impact Statement

NOISE SENSITIVE FACILITIES IN THE STUDY AREA
(Day Night Average Sound Level Range)

Site No	Alternative	1994	Year 2000			Year 2010			Year 2020			
		Existing	Alt. 1	Alt. 2	Alt. 3 & 4	Alt. 1	Alt. 2	Alt. 3 & 4	Alt. 1	Alt. 2	Alt. 3	Alt. 4
C6	Atonement Lutheran Ch.	60-65	<60	60-65	60-65	<60	60-65	60-65	<60	60-65	60-65	60-65
C7	Bahai of Normandy Park	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60
C8	Beautiful Saviour Lutheran Ch.	60-65	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60
C9	Bethel Baptist Korean Ch.	60-65	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60
C10	Bible Baptist	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60
C11	Bible Fellowship	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60
C12	Bethel Chapel	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60
C13	Beth Ha Shofar Temple	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60
C14	Christian Faith Center	70-75	65-70	65-70	65-70	65-70	65-70	65-70	65-70	65-70	65-70	65-70
C15	Christs Church	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60
C16	Christ Church at Federal Way	60-65	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60
C17	Church of Christ Southwest	65-70	<60	60-65	60-65	<60	60-65	60-65	<60	60-65	60-65	60-65
C18	Community Chapel - E. Campus	65-70	60-65	60-65	60-65	60-65	60-65	60-65	60-65	60-65	60-65	60-65
C19	Community Chapel - S. Campus	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60
C20	Community Syn. of S. King Cty	60-65	60-65	60-65	60-65	60-65	60-65	60-65	60-65	60-65	60-65	60-65
C21	Cornerstone Comm. Baptist Ch.	60-65	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60
C22	Des Moines Foursquare Church	70-75	65-70	65-70	65-70	65-70	65-70	65-70	65-70	65-70	65-70	65-70
C23	Des Moines Gospel Chapel	60-65	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60
C24	Des Moines United Methodist Ch	60-65	<60	<60	<60	<60	60-65	60-65	<60	60-65	60-65	60-65
C25	Family Worship Center	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60
C26	Federal Way Ch. of the Nazaren	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60
C27	Federal Way Free Methodist	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60
C28	Federal Way Mission Church	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60
C29	First Baptist Ch. of Des Moine	70-75	65-70	65-70	65-70	65-70	65-70	65-70	65-70	65-70	65-70	65-70
C30	First Baptist Ch. Federal Way	60-65	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60
C31	Good Sheperd Episcopal Church	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60
C32	Grace Church of Federal Way	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60
C33	Grace Lutheran Church	65-70	60-65	60-65	60-65	60-65	60-65	60-65	60-65	60-65	60-65	60-65
C34	Grace & Peace Korean Church	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60
C35	Highline Ch. of the Nazarene	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60
C36	Holy Trinity Lutheran	65-70	60-65	60-65	60-65	60-65	60-65	60-65	60-65	60-65	60-65	60-65
C37	Jehovahs Witnesses	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60
C38	Lutheran Ch. of the Resurrection	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60
C39	Marcus Whitman Presbyterian	65-70	60-65	60-65	60-65	60-65	60-65	60-65	60-65	60-65	60-65	60-65
C40	Midway Comm. Covenant Ch.	65-70	65-70	60-65	60-65	65-70	60-65	60-65	65-70	60-65	60-65	60-65
C41	Normandy Christian Church	65-70	60-65	60-65	60-65	60-65	60-65	60-65	60-65	60-65	60-65	60-65
C42	Parks of the Pines	60-65	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60
C43	Pierce King Christian Ministries	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60

AR 038935

TABLE IV.2-2
(Page 6 of 8)

Seattle - Tacoma International Airport
Environmental Impact Statement

NOISE SENSITIVE FACILITIES IN THE STUDY AREA
(Day Night Average Sound Level Range)

		1994	Year 2000			Year 2010			Year 2020			
Site No	Alternative	Existing	Alt. 1	Alt. 2	Alt. 3 & 4	Alt. 1	Alt. 2	Alt. 3 & 4	Alt. 1	Alt. 2	Alt. 3	Alt. 4
C44	Prince of Peace Lutheran	65-70	60-65	60-65	60-65	60-65	60-65	60-65	60-65	60-65	60-65	60-65
C45	Rose of Sharon Christian Church	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60
C46	SeaTac Baptist Church	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60
C47	Seattle Full Gospel Church	60-65	60-65	<60	<60	60-65	<60	<60	60-65	60-65	60-65	60-65
C48	Seventh Day Adventist Ch.	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60
C49	Sound View Baptist Ch.	70-75	65-70	65-70	65-70	65-70	65-70	65-70	70-75	65-70	65-70	65-70
C50	Southminster Presbyterian	60-65	60-65	60-65	60-65	60-65	60-65	60-65	60-65	60-65	60-65	60-65
C51	St. Daid of Wales Anglican	65-70	60-65	60-65	60-65	60-65	60-65	60-65	60-65	60-65	60-65	60-65
C52	St. Philomena Catholic Church	70-75	65-70	65-70	65-70	65-70	65-70	65-70	65-70	65-70	65-70	65-70
C53	St. Vincent de Paul	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60
C54	Steel Lake Presbyterian Church	60-65	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60
C55	Unitarian Univ. Ch. of Seattle	60-65	60-65	60-65	60-65	60-65	60-65	60-65	60-65	60-65	60-65	60-65
C56	Victory Baptist Church	70-75	65-70	65-70	65-70	65-70	65-70	65-70	65-70	65-70	65-70	65-70
C57	West Campus Ch. of Christ	60-65	<60	<60	<60	60-65	60-65	60-65	60-65	60-65	60-65	60-65
C58	Voice of Zion Chapel	65-70	60-65	60-65	60-65	60-65	60-65	60-65	65-70	60-65	60-65	60-65
C59	Calvary Christian	60-65	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60
C60	Boulevard Park Presbyterian	70-75	65-70	65-70	65-70	65-70	65-70	65-70	65-70	65-70	65-70	65-70
C61	Burien Adventist	70-75	65-70	65-70	65-70	65-70	65-70	65-70	65-70	65-70	65-70	65-70
C62	Woodmont Christian	65-70	60-65	60-65	60-65	60-65	60-65	60-65	60-65	60-65	60-65	60-65
C63	Way Salvation	65-70	65-70	65-70	65-70	65-70	65-70	65-70	65-70	65-70	65-70	65-70
C64	Burien Methodist	60-65	<60	60-65	60-65	<60	60-65	60-65	60-65	60-65	60-65	60-65
C65	Riverton Heights Baptist	65-70	60-65	60-65	60-65	60-65	60-65	60-65	60-65	60-65	60-65	60-65
Parks and Recreation												
P1	Mt. Baker/Stan Sayres Mem.	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60
P2	Columbia Park	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60
P3	Dearborn Park	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60
P4	Brighton Playground	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60
P5	Maple Wood Playground	60-65	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60
P6	Cleveland Playground	60-65	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60
P7	S. Homer St. Playground	60-65	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60
P9	Othello Playground	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60
P10	Atlantic City Park	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60
P11	Kubota Gardens	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60
P12	S. Norfolk St. Playground	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60
P13	S. Sullivan St. Playground	60-65	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60
P14	Southern Heights Park	70-75	65-70	65-70	65-70	65-70	65-70	65-70	65-70	65-70	65-70	65-70
P15	Arbor Lake Park	60-65	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60
P16	[illegible]	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60

TABLE IV.2-2
(Page 7 of 8)

Seattle - Tacoma International Airport
Environmental Impact Statement

NOISE SENSITIVE FACILITIES IN THE STUDY AREA
(Day Night Average Sound Level Range)

		1994	Year 2000			Year 2010			Year 2020			
Site No	Alternative	Existing	Alt. 1	Alt. 2	Alt. 3 & 4	Alt. 1	Alt. 2	Alt. 3 & 4	Alt. 1	Alt. 2	Alt. 3	Alt. 4
P17	White Center Heights Park	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60
P18	White Center Park	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60
P19	Lakewood Park	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60
P20	Salmon Creek Park	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60
P21	S. 133rd St. Park	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60
P22	Southgate Park	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60
P23	Crystal Springs Park	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60
P24	Crestview Park	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60
P25	Bow Lake Park	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60
P26	Hilltop Park	60-65	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60
P27	S. 142nd St. Park	60-65	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60
P28	North SeaTac Park	70-75	70-75	70-75	70-75	70-75	70-75	70-75	70-75	70-75	70-75	70-75
P29	Mashier Park	60-65	<60	<60	<60	<60	60-65	60-65	60-65	60-65	60-65	60-65
P30	Hazel Valley Park	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60
P31	Ed Munro Seahurst Park	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60
P32	Chelsea Park	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60
P33	Burien Park	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60
P34	Lakeview Park	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60
P35	Kiwanis Park	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60
P36	City Hall Park	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60
P37	Private Park	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60
P38	Valley Ridge Park	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60
P39	Brisco Meander Park	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60
P40	Van Dorans Landing Park	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60
P41	Grandview Park	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60
P42	West Canyon Park	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60
P43	Angle Lake Park	65-70	60-65	60-65	60-65	60-65	60-65	60-65	60-65	60-65	60-65	60-65
P44	Des Moines Creek Park	75-80	70-75	70-75	70-75	70-75	70-75	70-75	70-75	70-75	70-75	70-75
P45	Des Moines Beach Park	60-65	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60
P46	Des Moines Park	60-65	<60	60-65	60-65	<60	60-65	60-65	60-65	60-65	60-65	60-65
P47	Nature Trails Park	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60
P48	Normandy Park	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60
P49	Marine View Park	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60
P50	Fishing Hole Park	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60
P51	Lake Fenwick Park	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60
P52	Linda Heights Park	60-65	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60
P53	Parkside Park	65-70	60-65	60-65	60-65	60-65	60-65	60-65	60-65	60-65	60-65	60-65
P54	Parkside Wetlands	65-70	60-65	60-65	60-65	60-65	60-65	60-65	60-65	60-65	60-65	60-65

TABLE IV.2-2
(Page 8 of 8)

Seattle - Tacoma International Airport
Environmental Impact Statement

NOISE SENSITIVE FACILITIES IN THE STUDY AREA
(Day Night Average Sound Level Range)

		1994	Year 2000			Year 2010			Year 2020			
Site No	Alternative	Existing	Alt. 1	Alt. 2	Alt. 3 & 4	Alt. 1	Alt. 2	Alt. 3 & 4	Alt. 1	Alt. 2	Alt. 3	Alt. 4
P55	Glenn Nelson Park	60-65	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60
P56	Saltwater State Park	60-65	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60
P57	Woodmont Park	60-65	<60	<60	<60	<60	60-65	60-65	60-65	60-65	60-65	60-65
P58	Woodmont Beach	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60
P59	Camelot Park	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60
P60	A Park in Federal Way	60-65	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60
P61	Wildwood Park	60-65	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60
P62	Sacajawea Playground	60-65	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60
P63	Steel Lake Park	60-65	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60
P64	Barnes Creek Nature Trail	65-70	60-65	60-65	60-65	60-65	60-65	60-65	60-65	65-70	65-70	65-70
P65	Big Catch Plaza	60-65	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60
P66	Cecile Power Park	60-65	60-65	60-65	60-65	60-65	60-65	60-65	60-65	60-65	60-65	60-65
P67	Des Moines City/Kiddie Park	65-70	60-65	60-65	60-65	60-65	60-65	60-65	60-65	60-65	60-65	60-65
P68	Des Moines Marina	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60
P69	Des Moines Marina Pier	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60
P70	Des Moines Memorial Park	60-65	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60
P71	Midway Park	65-70	60-65	<60	<60	60-65	<60	<60	60-65	<60	<60	<60
P72	Mt. Rainier Pool	70-75	65-70	65-70	65-70	65-70	65-70	65-70	65-70	65-70	65-70	65-70
P73	Overlook Park 1	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60
P74	Overlook Park 2	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60
P75	Redondo Waterfront/Wooton	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60
P76	Sonju Park	65-70	60-65	60-65	60-65	60-65	60-65	60-65	60-65	60-65	60-65	60-65
P77	S. 239th St. Beach	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60
P78	South Marina Park	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60
P79	Zenith Park	65-70	60-65	60-65	60-65	60-65	60-65	60-65	60-65	60-65	60-65	60-65
G1	Jefferson Park Golf Course	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60
G2	Glen Acres Golf Club	65-70	60-65	60-65	60-65	60-65	60-65	60-65	60-65	60-65	60-65	60-65
G3	Rainier Golf Course	65-70	60-65	60-65	60-65	60-65	65-70	65-70	65-70	65-70	65-70	65-70
G4	Foster Golf Links	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60
G5	Tyee Valley Golf Course	75-80	75-80	75-80	75-80	75-80	75-80	75-80	75-80	75-80	75-80	75-80
G6	Riverbend Golf Complex	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60

Note: Noise sensitive facilities that are located near the contour boundary were defined based on the DNL grid analysis (See Appendix C).

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TABLE IV.2-3
(Page 1 of 3)

Seattle - Tacoma International Airport
Environmental Impact Statement

NOISE SENSITIVE FACILITIES IN THE STUDY AREA
(Affected by 65 DNL and greater sound levels)

		1994	Year 2000			Year 2010			Year 2020			
Site No	Alternative	Existing	Alt. 1	Alt. 2	Alt. 3 & 4	Alt. 1	Alt. 2	Alt. 3 & 4	Alt. 1	Alt. 2	Alt. 3	Alt. 4
	Schools											
S1	Beverly Park/Glendale	65-70	60-65	60-65	60-65	60-65	60-65	60-65	60-65	60-65	60-65	60-65
S8	Madrona	65-70	60-65	<60	<60	60-65	<60	<60	60-65	60-65	60-65	60-65
S11	Midway	70-75	65-70	60-65	60-65	65-70	60-65	60-65	65-70	60-65	60-65	60-65
S15	Parkside	65-70	60-65	60-65	60-65	60-65	60-65	60-65	60-65	60-65	60-65	60-65
S20	Southern Heights	65-70	65-70	65-70	65-70	65-70	65-70	65-70	65-70	65-70	65-70	65-70
S21	Sunnydale	65-70	60-65	60-65	60-65	60-65	60-65	60-65	60-65	60-65	60-65	60-65
S26	Pacific	65-70	65-70	60-65	60-65	65-70	60-65	60-65	65-70	60-65	60-65	60-65
S30	Mount Rainier	70-75	65-70	65-70	65-70	65-70	65-70	65-70	65-70	65-70	65-70	65-70
S33	Highline Community College	65-70	60-65	60-65	60-65	60-65	60-65	60-65	60-65	60-65	60-65	60-65
S38	Marine Technology Lab	65-70	60-65	60-65	60-65	60-65	60-65	60-65	60-65	65-70	65-70	65-70
S51	Woodmont	65-70	60-65	60-65	60-65	60-65	60-65	60-65	60-65	60-65	60-65	0-65
S82	Burien Adventist	70-75	65-70	65-70	65-70	65-70	65-70	65-70	65-70	65-70	65-70	65-70
S86	Comm Chapel Christian School	65-70	60-65	60-65	60-65	60-65	60-65	60-65	60-65	60-65	60-65	60-65
S88	Holy Trinity Lutheran School	65-70	60-65	60-65	60-65	60-65	60-65	60-65	60-65	60-65	60-65	60-65
S92	St. Philomenas School	70-75	65-70	65-70	65-70	65-70	65-70	65-70	65-70	65-70	65-70	65-70
S95	Seattle Christian	65-70	60-65	60-65	60-65	60-65	60-65	60-65	65-70	60-65	60-65	60-65
S96	Evergreen Lutheran High School	65-70	60-65	60-65	60-65	60-65	60-65	60-65	60-65	60-65	60-65	60-65
S98	Dominion	70-75	65-70	65-70	65-70	65-70	65-70	65-70	65-70	65-70	65-70	65-70
S99	Hamlin Robinson S. of Dyslexia	65-70	60-65	60-65	60-65	60-65	60-65	60-65	60-65	60-65	60-65	60-65
S100	New Life Christian Academy	70-75	65-70	60-65	60-65	65-70	60-65	60-65	65-70	60-65	60-65	60-65
S102	Sea-Tac Occupational Skills Ct	65-70	60-65	60-65	60-65	60-65	60-65	60-65	60-65	65-70	65-70	65-70
S103	Bloulevard Park Elementary	70-75	65-70	65-70	65-70	65-70	65-70	65-70	65-70	65-70	65-70	65-70
S104	Glacier High	65-70	60-65	60-65	60-65	60-65	60-65	60-65	60-65	60-65	60-65	60-65
S105	Woodside Elementary	65-70	60-65	60-65	60-65	60-65	60-65	60-65	60-65	65-70	65-70	65-70
S106	Sunny Terrace Elementary	65-70	60-65	60-65	60-65	60-65	65-70	65-70	60-65	65-70	65-70	65-70
S107	Angle Lake Elementary	70-75	65-70	60-65	60-65	65-70	60-65	60-65	65-70	65-70	65-70	65-70
S108	Maywood Elementary	70-75	65-70	65-70	65-70	65-70	65-70	65-70	65-70	65-70	65-70	65-70
S109	Zenith School	65-70	60-65	60-65	60-65	60-65	60-65	60-65	60-65	60-65	60-65	60-65
S110	Des Moines Assembly of God Sch	70-75	65-70	60-65	60-65	65-70	60-65	60-65	65-70	60-65	60-65	60-65
	Libraries											
L1	Boulevard Park Library	65-70	60-65	65-70	65-70	60-65	65-70	65-70	65-70	65-70	65-70	65-70
L4	Des Moines Library	65-70	60-65	60-65	60-65	60-65	60-65	60-65	60-65	60-65	60-65	60-65

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TABLE IV.2-3
(Page 2 of 3)

Seattle - Tacoma International Airport
Environmental Impact Statement

NOISE SENSITIVE FACILITIES IN THE STUDY AREA
(Affected by 65 DNL and greater sound levels)

		1994	Year 2000			Year 2010			Year 2020			
Site No	Alternative	Existing	Alt. 1	Alt. 2	Alt. 3 & 4	Alt. 1	Alt. 2	Alt. 3 & 4	Alt. 1	Alt. 2	Alt. 3	Alt. 4
Nursing Homes												
N2	Monarch Care Center	65-70	60-65	60-65	60-65	60-65	60-65	60-65	60-65	60-65	60-65	60-65
N9	Seatoma Convalescent	65-70	60-65	60-65	60-65	60-65	60-65	60-65	60-65	60-65	60-65	60-65
N12	Harmony Gardens	65-70	65-70	60-65	60-65	65-70	65-70	65-70	65-70	65-70	65-70	65-70
Churches												
C3	Apostolic Ch. of Jesus Christ	70-75	65-70	65-70	65-70	65-70	65-70	65-70	65-70	65-70	65-70	65-70
C4	Assembly of God of Des Moines	70-75	65-70	60-65	60-65	65-70	60-65	60-65	65-70	60-65	60-65	60-65
C14	Christian Faith Center	70-75	65-70	65-70	65-70	65-70	65-70	65-70	65-70	65-70	65-70	65-70
C17	Church of Christ Southwest	65-70	<60	60-65	60-65	<60	60-65	60-65	<60	60-65	60-65	60-65
C18	Community Chapel - E. Campus	65-70	60-65	60-65	60-65	60-65	60-65	60-65	60-65	60-65	60-65	60-65
C22	Des Moines Foursquare Church	70-75	65-70	65-70	65-70	65-70	65-70	65-70	65-70	65-70	65-70	65-70
C29	First Baptist Ch. of Des Moine	70-75	65-70	65-70	65-70	65-70	65-70	65-70	65-70	65-70	65-70	65-70
C33	Grace Lutheran Church	65-70	60-65	60-65	60-65	60-65	60-65	60-65	60-65	60-65	60-65	60-65
C36	Holy Trinity Lutheran	65-70	60-65	60-65	60-65	60-65	60-65	60-65	60-65	60-65	60-65	60-65
C39	Marcus Whitman Presbyterian	65-70	60-65	60-65	60-65	60-65	60-65	60-65	60-65	60-65	60-65	60-65
C40	Midway Comm. Covenant Ch.	65-70	65-70	60-65	60-65	65-70	60-65	60-65	65-70	60-65	60-65	60-65
C41	Normandy Christian Church	65-70	60-65	60-65	60-65	60-65	60-65	60-65	60-65	60-65	60-65	60-65
C44	Prince of Peace Lutheran	65-70	60-65	60-65	60-65	60-65	60-65	60-65	60-65	60 65	60-65	60-65
C47	Seattle Full Gospel	65-70	60-65	60-65	60-65	60-65	60-65	60-65	60-65	60-65	60-65	60-65
C49	Sound View Baptist Ch.	70-75	65-70	65-70	65-70	65-70	65-70	65-70	70-75	65-70	65-70	65-70
C51	St. Daid of Wales Anglican	65-70	60-65	60-65	60-65	60-65	60-65	60-65	60-65	60-65	60-65	60-65
C52	St. Philomena Catholic Church	70-75	65-70	65-70	65-70	65-70	65-70	65-70	65-70	65-70	65-70	65-70
C56	Victory Baptist Church	70-75	65-70	65-70	65-70	65-70	65-70	65-70	65-70	65-70	65-70	65-70
C58	Voice of Zion Chapel	65-70	60-65	60-65	60-65	60-65	60-65	60-65	65-70	60-65	60-65	60-65
C60	Boulevard Park Presbyterian	70-75	65-70	65-70	65-70	65-70	65-70	65-70	65-70	65-70	65-70	65-70
C61	Burien Adventist	70-75	65-70	65-70	65-70	65-70	65-70	65-70	65-70	65-70	65-70	65-70
C62	Woodmont Christian	65-70	60-65	60-65	60-65	60-65	60-65	60-65	60-65	60-65	60-65	60-65
C63	Way Salvation	65-70	65-70	65-70	65-70	65-70	65-70	65-70	65-70	65-70	65-70	65-70
C65	Riverton Heights Baptist	65-70	60-65	60-65	60-65	60-65	60-65	60-65	60-65	60-65	60-65	60-65
Parks and Recreation												
P14	Southern Heights Park	70-75	65-70	65-70	65-70	65-70	65-70	65-70	65-70	65-70	65-70	65-70
P28	North SeaTac Park	70-75	70-75	70-75	70-75	70-75	70-75	70-75	70-75	70-75	70-75	70-75
P43	Angle Lake Park	65-70	60-65	60-65	60-65	60-65	60-65	60-65	60-65	60-65	60-65	60-65
P44	Des Moines Creek Park	75-80	70-75	70-75	70-75	70-75	70-75	70-75	70-75	70-75	70-75	70-75
P53	Parkside Park	65-70	60-65	60-65	60-65	60-65	60-65	60-65	60-65	60-65	60-65	60-65
P54	Parkside Wetlands	65-70	60-65	60-65	60-65	60-65	60-65	60-65	60-65	60-65	60-65	60-65

TABLE IV.2-3
(Page 3 of 3)

Seattle - Tacoma International Airport
Environmental Impact Statement

NOISE SENSITIVE FACILITIES IN THE STUDY AREA
(Affected by 65 DNL and greater sound levels)

		1994	Year 2000			Year 2010			Year 2020			
Site No	Alternative	Existing	Alt. 1	Alt. 2	Alt. 3 & 4	Alt. 1	Alt. 2	Alt. 3 & 4	Alt. 1	Alt. 2	Alt. 3	Alt. 4
P64	Barnes Creek Nature Trail	65-70	60-65	60-65	60-65	60-65	60-65	60-65	60-65	65-70	65-70	65-70
P67	Des Moines City/Kiddie Park	65-70	60-65	60-65	60-65	60-65	60-65	60-65	60-65	60-65	60-65	60-65
P71	Midway Park	65-70	60-65	<60	<60	60-65	<60	<60	60-65	<60	<60	<60
P72	Mt. Rainier Pool	70-75	65-70	65-70	65-70	65-70	65-70	65-70	65-70	65-70	65-70	65-70
P76	Sonju Park	65-70	60-65	60-65	60-65	60-65	60-65	60-65	60-65	60-65	60-65	60-65
P79	Zenith Park	65-70	60-65	60-65	60-65	60-65	60-65	60-65	60-65	60-65	60-65	60-65
G2	Glen Acres Golf Club	65-70	60-65	60-65	60-65	60-65	60-65	60-65	60-65	60-65	60-65	60-65
G3	Rainier Golf Course	65-70	60-65	60-65	60-65	60-65	65-70	65-70	65-70	65-70	65-70	65-70
G5	Tyee Valley Golf Course	75-80	75-80	75-80	75-80	75-80	75-80	75-80	75-80	75-80	75-80	75-80

Note: Noise sensitive facilities that are located near the contour boundary were defined based on the DNL grid analysis (See Appendix C).

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TABLE IV.2-4

Seattle-Tacoma International Airport

POPULATION AFFECTED BY AIRCRAFT NOISE

JURISDICTION	1994 Population	2000 Alt 1	2000 Alt 2	2000 Alt 3	2000 Alt 4	2010 Alt 1	2010 Alt 2	2010 Alt 3	2010 Alt 4	2020 Alt 1	2020 Alt 2	2020 Alt 3	2020 Alt 4
60-65 DNL													
Burien	4,180	2,420	3,390	3,390	3,390	2,750	3,700	3,700	3,700	3,950	3,970	3,940	3,970
Des Moines	6,820	8,400	8,950	8,950	8,950	8,390	8,980	8,980	8,980	8,460	9,010	9,010	9,010
Federal Way	12,070	4,270	3,560	3,560	3,560	4,760	4,010	4,010	4,010	5,490	4,490	4,490	4,490
Kent	1,090	780	680	680	680	780	680	680	680	830	710	710	710
Normandy Park	70	0	0	0	0	0	0	0	0	0	0	0	0
SeaTac	9,570	5,200	3,730	3,730	3,730	5,400	3,860	3,870	3,870	5,950	4,410	4,390	4,410
Seattle	6,430	1,060	1,220	1,220	1,220	1,180	1,400	1,400	1,400	1,510	1,610	1,610	1,610
Tukwila	320	0	0	0	0	0	0	0	0	0	0	0	0
Unincorp. King	12,660	10,190	11,270	11,280	11,280	10,420	11,650	11,650	11,650	11,060	11,770	11,790	11,780
TOTAL	53,210	32,320	32,800	32,810	32,810	33,680	34,280	34,290	34,290	37,250	35,970	35,940	35,980
65-70 DNL													
Burien	2,180	640	1,230	1,230	1,230	640	1,330	1,330	1,330	660	1,560	1,530	1,560
Des Moines	8,570	3,990	3,460	3,460	3,460	4,100	3,590	3,590	3,590	4,540	3,870	3,870	3,870
Federal Way	1,050	0	0	0	0	0	0	0	0	0	0	0	0
Kent	710	0	0	0	0	0	0	0	0	0	0	0	0
SeaTac	4,780	1,270	1,860	1,860	1,860	1,360	1,950	1,940	1,940	1,680	2,090	2,090	2,090
Seattle	330	0	0	0	0	0	0	0	0	0	0	0	0
Unincorp. King	8,610	2,350	2,670	2,670	2,670	2,590	2,320	2,320	2,320	2,980	2,960	2,960	2,960
TOTAL	26,230	8,250	9,220	9,220	9,220	8,690	9,190	9,180	9,180	9,860	10,480	10,450	10,480
70-75 DNL													
Burien	860	60	0	0	0	70	0	0	0	90	0	0	0
Des Moines	2,210	140	50	50	50	140	50	50	50	190	70	70	70
SeaTac	1,190	520	620	620	620	530	630	630	630	560	720	720	720
Unincorp. King	1,310	0	0	0	0	20	0	0	0	100	0	0	0
TOTAL	5,570	720	670	670	670	760	680	680	680	940	790	790	790
75 DNL and greater	0	0	0	0	0	0	0	0	0	0	0	0	0
65 DNL and Greater													
Burien	3,040	700	1,230	1,230	1,230	710	1,330	1,330	1,330	750	1,560	1,530	1,560
Des Moines	10,780	4,130	3,510	3,510	3,510	4,240	3,640	3,640	3,640	4,730	3,940	3,940	3,940
Federal Way	1,050	0	0	0	0	0	0	0	0	0	0	0	0
Kent	710	0	0	0	0	0	0	0	0	0	0	0	0
SeaTac	5,970	1,790	2,480	2,480	2,480	1,890	2,580	2,570	2,570	2,240	2,810	2,810	2,810
Seattle	330	0	0	0	0	0	0	0	0	0	0	0	0
Unincorp. King	9,920	2,350	2,670	2,670	2,670	2,610	2,320	2,320	2,320	3,080	2,960	2,960	2,960
TOTAL	31,800	8,970	9,890	9,890	9,890	9,450	9,870	9,860	9,860	10,800	11,270	11,240	11,270
65-70 DNL	26,230	8,250	9,220	9,220	9,220	8,690	9,190	9,180	9,180	9,860	10,480	10,450	10,480
70-75 DNL	5,570	720	670	670	670	760	680	680	680	940	790	790	790
75 DNL and greater	0	0	0	0	0	0	0	0	0	0	0	0	0
65 DNL and Greater	31,800	8,970	9,890	9,890	9,890	9,450	9,870	9,860	9,860	10,800	11,270	11,240	11,270

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Source: 1990 Census, Gambrell Urban, Shapiro & Associates Landrum & Brown, Inc

TABLE IV.2-5

Seattle-Tacoma International Airport

HOUSING AFFECTED BY AIRCRAFT NOISE

10-Jun-96

JURISDICTION	1994 Housing	2000 Alt 1	2000 Alt 2	2000 Alt 3	2000 Alt 4	2010 Alt 1	2010 Alt 2	2010 Alt 3	2010 Alt 4	2020 Alt 1	2020 Alt 2	2020 Alt 3	2020 Alt 4
60-65 DNL													
Burien	1,970	1,150	1,670	1,670	1,670	1,340	1,830	1,830	1,830	1,960	1,960	1,950	1,960
Des Moines	2,860	3,430	3,670	3,670	3,670	3,430	3,700	3,700	3,700	3,470	3,720	3,720	3,720
Federal Way	5,360	2,330	2,040	2,040	2,040	2,520	2,220	2,220	2,220	2,790	2,410	2,410	2,410
Kent	480	310	260	260	260	310	260	260	260	330	270	270	270
Normandy Park	30	0	0	0	0	0	0	0	0	0	0	0	0
SeaTac	4,640	2,180	1,590	1,600	1,600	2,280	1,670	1,680	1,680	2,560	1,940	1,930	1,950
Seattle	2,600	480	550	550	550	550	640	640	640	680	750	750	750
Tukwila	180	0	0	0	0	0	0	0	0	0	0	0	0
Unincorp. King	5,250	4,250	4,630	4,630	4,630	4,350	4,770	4,770	4,770	4,620	4,860	4,860	4,860
TOTAL	23,370	14,130	14,410	14,420	14,420	14,780	15,090	15,100	15,100	16,410	15,910	15,890	15,920
65-70 DNL													
Burien	1,010	260	510	510	510	260	560	560	560	270	670	650	670
Des Moines	3,630	1,800	1,530	1,530	1,530	1,840	1,580	1,580	1,580	2,010	1,700	1,700	1,700
Federal Way	640	0	0	0	0	0	0	0	0	0	0	0	0
Kent	280	0	0	0	0	0	0	0	0	0	0	0	0
SeaTac	2,030	510	730	730	730	550	770	770	770	690	830	830	830
Seattle	170	0	0	0	0	0	0	0	0	0	0	0	0
Unincorp. King	3460	970	960	960	960	1,060	980	980	980	1,190	1,210	1,210	1,210
TOTAL	11,220	3,540	3,730	3,730	3,730	3,710	3,890	3,890	3,890	4,160	4,410	4,390	4,410
70-75 DNL													
Burien	350	20	0	0	0	30	0	0	0	40	10	10	10
Des Moines	980	70	20	20	20	70	20	20	20	100	30	30	30
SeaTac	490	240	270	270	270	240	280	280	280	260	310	310	310
Unincorp. King	580	0	0	0	0	10	0	0	0	50	0	0	0
TOTAL	2,400	330	290	290	290	350	300	300	300	450	350	350	350
75 DNL and greater	0	0	0	0	0	0	0	0	0	0	0	0	0
65 DNL and Greater													
Burien	1,360	280	510	510	510	290	560	560	560	310	680	660	680
Des Moines	4,610	1,870	1,550	1,550	1,550	1,910	1,600	1,600	1,600	2,110	1,730	1,730	1,730
Federal Way	640	0	0	0	0	0	0	0	0	0	0	0	0
Kent	280	0	0	0	0	0	0	0	0	0	0	0	0
SeaTac	2,520	750	1,000	1,000	1,000	790	1,050	1,050	1,050	950	1,140	1,140	1,140
Seattle	170	0	0	0	0	0	0	0	0	0	0	0	0
Unincorp. King	4,040	970	960	960	960	1,070	980	980	980	1,240	1,210	1,210	1,210
TOTAL	13,620	3,870	4,020	4,020	4,020	4,060	4,190	4,190	4,190	4,610	4,760	4,740	4,760
65-70 DNL	11,220	3,540	3,730	3,730	3,730	3,710	3,890	3,890	3,890	4,160	4,410	4,390	4,410
70-75 DNL	2,400	330	290	290	290	350	300	300	300	450	350	350	350
75 DNL and greater	0	0	0	0	0	0	0	0	0	0	0	0	0
65 DNL and Greater	13,620	3,870	4,020	4,020	4,020	4,060	4,190	4,190	4,190	4,610	4,760	4,740	4,760

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Source: 1990 Census, Gambrell Urban, Shapiro & Associates, Landrum & Brown, Inc

TABLE IV.2-6

Seattle - Tacoma International Airport
Environmental Impact Statement

NOISE SENSITIVE FACILITIES

	Impacted by 65 DNL and greater Noise Exposure				
DNL 65 & Greater	Schools	Churches	Libraries	Hospitals/ Nursing Homes	Public Parks/Recreation
Existing	28	24	2	3	12
2000 Alt 1	12	12	0	1	4
2000 Alt 2, 3 & 4	7	10	1	0	4
2010 Alt 1	11	12	0	1	4
2010 Alt 2, 3, & 4	8	10	1	0	4
2020 Alt 1	13	13	1	1	4
2020 Alt 2, 3 & 4	11	10	1	1	5

Source: Gambrell Urban, Shapiro and Associates, Inc., and Landrum and Brown, 1994.

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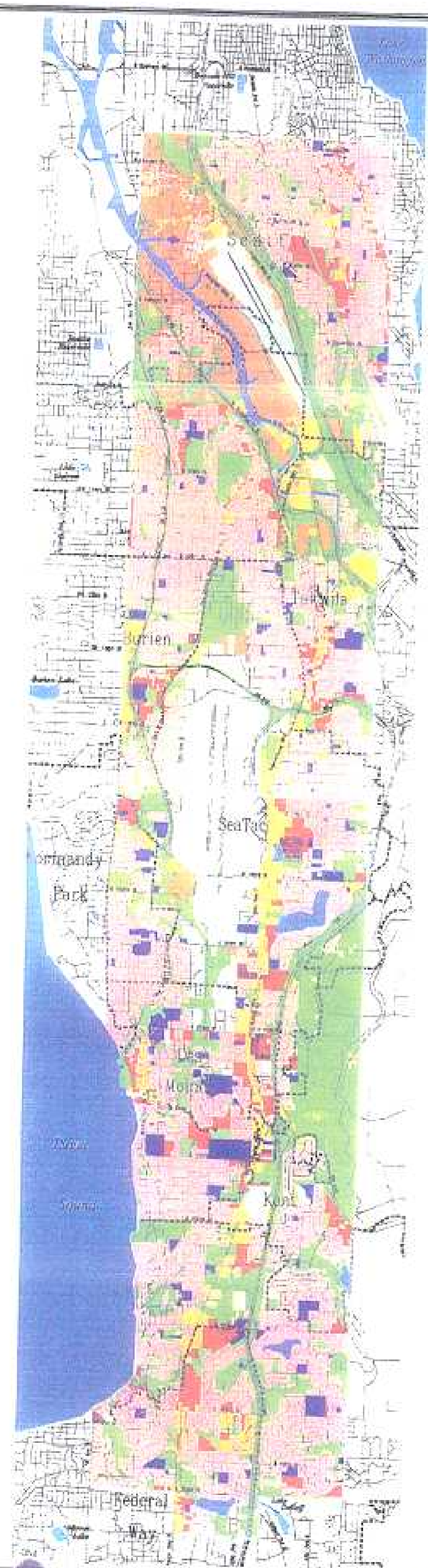
Seattle-Tacoma International Airport
Environmental Impact Statement
for the Master Plan Update

Exhibit IV.2-1

Generalized Existing Land Use



- Single Family Residential
- Multi-Family Residential
- Mobile Home Park
- Commercial
- Manufacturing/Light Industry
- Public Facilities
- Government Services
- Parks, Agricultural Lands, Freeways
- Water Resources and Recreation
- Airport
- Jurisdictional Boundary

Source: Gambrell Urban, Inc. 1995
City of SeaTac, 1994
Parametrix, Inc. 1992

Scale 1" = 6,000'

0 6000 12000 18000
SCALE IN FEET

Projection: Lambert Conformal Conic
Coordinate System: State Plane NAD27

April 10, 1996

Seattle-Tacoma International Airport
Environmental Impact Statement
for the Master Plan Update

Exhibit IV.2-2

Noise Sensitive Facilities

- School
- Library
- Church
- Hospital or Nursing Home
- Section 4(f) Park/Recreation Area
- Non-Section 4(f) Park/Rec. Area
- Archaeological Site
- National Historic Site
- State Historic Site
- Inventoried Historic Site

Source: Gambrell Urban, Inc. and
Shapiro & Associates, 1994
Part 150 Noise Exposure Map Update, 1991
Thomas Brothers Map Guide, 1994
Washington State Office of Archaeology and Historic Preservation, 1994
King County Cultural Resources Division, 1994

Section IV.3 should be consulted for further information on potential historic sites within the project acquisition area (not shown here). Section IV.3 contains a complete numbered list and maps of all potential historic sites in the study area and project acquisition area.

Scale 1" = 6,000'

0 6000 12000 18000

Scale in Feet

Projection: Lambert Conformal Conic
Coordinate System: State Plane NAD27

December 20, 19[illegible]

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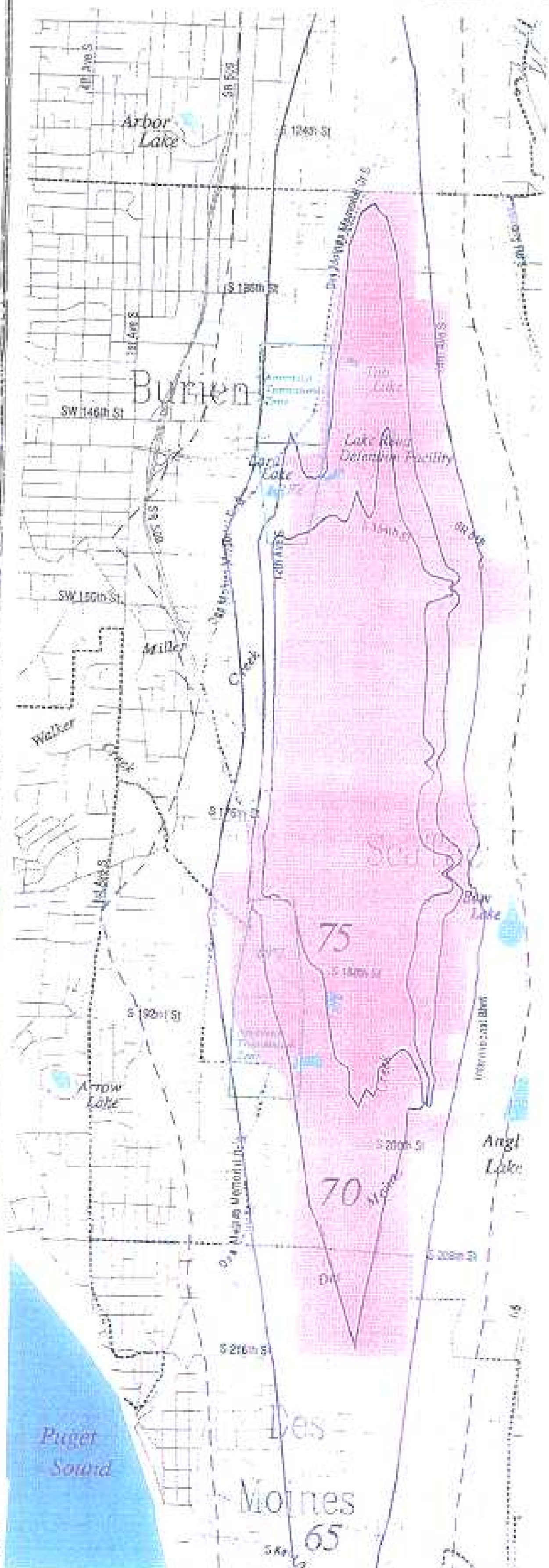

Seattle-Tacoma International Airport
Environmental Impact Statement
for the Master Plan Update

Exhibit IV.2-3

Proposed Approach Transitional Zone with 2020 Noise Contours and Noise Remedy Area

Jurisdictional Boundary

Noise Contours of 65 DNL and Above (2020 Alternative 3)

60 DNL Noise Contour (2020 Alternative 3)

Proposed Approach Transitional Zone and RPZ for the New Parallel Runway

Noise Remedy Program Zones:

Remedial Acquisition

Custom Remedial Measures

Standard Remedial Measures

Source: Gambrell Urban, Inc. and Landrum & Brown, Inc. 1995
Port of Seattle, 1991

Scale 1" = 2,500'

0 2500 5000

Scale in Feet

CHAPTER IV, SECTION 3

ARCHAEOLOGICAL, CULTURAL, AND HISTORICAL RESOURCES

Impacts to archaeological, cultural, and historical resources, both on and off-airport, can be caused by airport development and airport activity. Examples of impacts often encountered at airports are:

- Acquisition or relocation of resources (direct impacts)
- Disruption of sites caused by construction (direct impacts)
- Alteration of surface transportation patterns (indirect impacts)
- Adverse environmental impacts, such as noise, air pollution, and water pollution, that change the use of the site (indirect impacts)

In this section, the Master Plan Update alternatives were evaluated in terms of potential impacts to objects, buildings, structures, and sites of archaeological, cultural, and historical importance. The primary requirements for the protection of the resources are stipulated in the National Historic Preservation Act of 1966 (particularly Section 106) and its implementation regulations for "Protection of Historic Properties (36 CFR Part 800)."[1] The purpose of the legislation is to ensure that cultural resources are inventoried, evaluated, and considered in analyzing proposed development and that steps are taken to avoid or mitigate any adverse effects.

Subject to continued coordination under the Section 106 process, it was concluded that there are a number of historic and archaeological sites in the Airport area, but none would be adversely affected by the proposed Master Plan Update alternatives.

(1) METHODOLOGY

For purposes of this analysis, the following study areas were identified:

- *General Study Area* which is the same as used in Chapter IV, Section 2 "Land Use" and encompasses the existing 60 DNL noise exposure contour. The potential exists within this area for indirect effects from an Airport. The project impact area, as referenced below, is the DNL 65 and greater noise exposure.
- *Acquisition Area* to be acquired to enable construction of the alternatives. The potential exists for any structure within this area to be demolished or moved to permit airport development.

For purposes of this analysis the general study area was assessed based on inventory records on file at King County and the State Office of Historic Preservation for previously inventoried properties that are listed or eligible for the National Register, as of June 1994.[2] Each structure identified within the existing 65 DNL contour was field verified. A noise exposure level of 65 DNL was selected for this evaluation based on the noise compatibility criteria discussed earlier in Chapter IV, Section 2 "Land Use". Noise impacts on historical structures and sites are considered to be related to the interference with the use of the structure or site. As noted earlier, most land uses, including residences, are compatible with noise exposure below 65 DNL.

The acquisition area was evaluated in three steps: a literature search, an evaluation of previously inventoried properties, and a site visit. For the first step, the King County Cultural Resources Division and the Washington State Office of Archaeology, Historic Preservation, and other sources were consulted, and all identified resources were noted. The second step consisted of a historical integrity evaluation of all previously inventoried properties located within the existing 65 DNL and greater noise exposure area. Previously inventoried properties that would possibly be disrupted or acquired as a result of a Master Plan Update alternatives or located in the 65 DNL noise contour were researched at the King County Tax Assessment Office for verification of the date of construction and other noted characteristics. All structures

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1/ *National Historic Preservation Act*, Section 106. 1966 (as amended).

2/ *The National Historic Landmarks, National Register of Historic Places, Determined Eligible for National Register, State Register of Historic Places* (with supplements), Washington State Office of Archaeology and Historic Preservation, January 31, 1993.

within these areas were then assessed in accordance with National Register criteria. The criteria for listing on the National Register of Historic Places are sites, districts, or objects of historical, archaeological, or cultural significance:[3]

- Associated with events that made significant contributions to our history, or are
- Associated with the lives of persons significant in our past, or
- That are of a particular type, period, or method of construction that possess high artistic value, or
- That provide important information about history or prehistory.

As determined by the State Historic Preservation Office (SHPO), all properties of federal, state, or local significance would be required to comply with the U.S. Department of Transportation Section 4(f) requirements.

The third step included a field survey of the entire acquisition area, which was completed in December, 1994. **Appendix E-A** contains a detailed summary of the survey methodology. A complete field reconnaissance for existing historical structures was conducted for all acquisition areas affected by the Master Plan Update alternatives. An inventory form was completed for each structure that was constructed before 1945, as determined from the county tax records. These forms are included in **Appendix E-A**. A total of 67 sites (2 sites previously recorded and 65 newly identified) were recorded within the acquisition area. These properties are listed in **Table IV.3-2**. Of the 67 properties evaluated, approximately 57 properties had been previously moved or modified extensively and were determined to exhibit no historical integrity. Inventory forms and photographs were submitted to the SHPO for review. Based on the materials submitted, it was concluded that none of the 67 properties are eligible for listing in the National Register of Historic Places.[4] Information in the Draft EIS, including the SHPO letter of March 8, 1995 confirms that none of the 67 properties within the acquisition area constructed before 1945 are eligible for the National Register.

[3] *National Register Bulletin No. 15, "How to apply National Register Criteria"*, National Parks Service. 1991.

[4] Letter from Greg Griffith, Washington State Office of Archaeology and Historic Preservation, March 8, 1995.

In the spring of 1995, the Cities of Burien, Des Moines, and Normandy Park designated a number of historic resources that had been included in the Airport Community Coalition (ACC) *Historic Properties Survey* as locally significant. Of these properties 62 were found to be affected by 65 DNL and greater noise levels for existing conditions (1994) and future Master Plan Update alternatives. The information included in the ACC *Historic Properties Survey* was sent to SHPO for review[5] (see **Table 1**).

(2) EXISTING CONDITIONS

Table IV.3-1 lists previously recorded properties within the general study area that have been identified as archaeological sites, national or state historic sites, or local historic sites as inventoried by King County[6] or SHPO.[7] It should be noted that, for these properties, termed "local historic sites," none are currently identified as being on or eligible for the State or National Register. **Exhibit IV.3-1** shows the locations of sites within the general study area.

Table IV.3-1 lists existing and future DNL noise levels for the historic sites. A review of previously recorded sites in step two showed the existence of two historic (Vacca Farm and the Albert Paul House) and no archaeological sites within the acquisition area. An additional ten previously recorded sites (9 historic and 1 archaeological) were identified in the existing 65 DNL or greater noise exposure. These sites are: 14th Avenue South Bridge (A2); Sunnydale School (A16); Homer Crosby Home (A22); Brunelle Residence (A27); Bryan House (A29); Rayback House (A38); Walsworth House (A39); Chesney House (A42); Hillgrove Cemetery (A60); Muckleshoot Indian Campground (A68). The 14th Avenue South Bridge is listed on the National Register of Historic Places.

The detailed field survey in step three resulted in the identification of 65 additional historic sites (not previously recorded) within the acquisition area. The total number of historic properties in the acquisition area (defined as residences over 50 years old) totals 67 (two previously recorded

[5] Letter from Greg Griffith, Washington State Office of Archaeology and Historic Preservation, November 22, 1995.

[6] Personal Communication with Charles Sundberg, King County Office of Historic Preservation. September, 1994.

[7] Personal Communication with Sara Steel, Washington State Office of Archaeology and Historic Preservation. May, 1994.

AR 038949

sites plus an additional 65 other residential sites). These sites are listed in **Table IV.3-2** and shown in **Exhibit IV.3-2**.

(3) FUTURE IMPACTS

The assessment of future impacts of the Master Plan Update alternatives included both direct and indirect impacts which are presented in this section. The impact on archaeological, cultural and historical resources for Alternative 1 (Do-Nothing) and Alternatives 2, 3, and 4 ("With Project") were assessed. Assessment and review by the SHPO has concluded that the sites recorded within the potential acquisition area do not meet the criteria for nomination to the National Register.

The impacts of each alternative on archaeological, cultural or historic resources are summarized in the following points:

(A) Do-Nothing (Alternative 1)

Under the Do-Nothing alternative, no direct impacts to resources of archaeological, cultural or historical significance would be anticipated. The proposed SR509/South Access Road project, which requires the relocation of residences and businesses along the selected corridor, would not affect any historical resources listed on or eligible for the National Register of Historic Places. Within the general study area, two historic sites would be affected by 65 DNL or greater noise levels under the Do-Nothing alternative for any of the future years evaluated: Brunelle Residence (A27) and Hillgrove Cemetery (A60).

(B) "With Project" Alternatives (Alternatives 2, 3, and 4)

No known archaeological or cultural sites would be physically impacted as a result of the proposed new parallel runway or landside development of any "With Project" alternative. Therefore, no direct impacts to archaeological or cultural resources would occur.

No significant historical resources would be physically impacted as a result of Alternatives 2, 3, and 4. Seventy-five properties greater than 50 years old could potentially be displaced through acquisition. However, the Washington State Office of Archaeology and Historic Preservation (SHPO or OAHP) have determined that the properties within the acquisition site are not eligible for the National Register.[8] Therefore, no direct impacts to significant historical resources would occur.

No previously inventoried properties located within the 65 DNL and greater noise exposure (year 2000, 2010, and 2020) are currently listed in the State or National Registers.

As is shown in **Table IV.3-1**, three previously inventoried properties would be affected by DNL 65 and greater sound levels for any future year evaluated by the "With Project" alternatives. These include the same two sites affected by the Do-Nothing (Brunelle Residence and Hillgrove Cemetery) and the Bryan House.

Also as indicated in **Table IV.3-1**, in comparison to the Do-Nothing, two sites would experience DNL increases of 1.5 or more with the "With Project" alternatives: Brunelle Residence (1.5 DNL increase) and Bryan House (2.4 DNL increase). The 1.5 DNL increase in areas affected by DNL 65 and greater is an FAA guideline (as identified in FAA Order 5050.4A, Chapter 5, paragraph 47e.

The SHPO has determined that the Brunelle House and the Bryan House are not eligible for the National Register of Historic Places.[9]

As discussed in Appendix E-B (see Table 1) and Chapter IV. Section 3, none of the historic properties designated as locally significant by adopted ordinances of Burien, Des Moines, or Normandy Park and exposed to noise levels of 65 DNL and greater would experience a 1.5 DNL or greater increase under any of the Master Plan Update alternatives for the years 2000, 2010, or 2020. Consequently, they would not be affected by the proposed improvements. Therefore, no indirect impacts are anticipated to occur with the proposed airport improvements.

Other than noise, no indirect impact of significance to historical, archaeological or cultural resources were identified.

8/ Letter from Greg Griffith, Washington State Office of Archaeology and Historic Preservation, March 8, 1995.

9/ Letter from Greg Griffith, Washington State Office of Archaeology and Historic Preservation, November 22, 1995.

(C) Preferred Alternative (Alternative 3)

No known archaeological or cultural sites would be physically impacted as a result of the preferred alternative. Therefore, no direct impacts to archaeological or cultural resources would occur. No significant historical resources would be physically impacted as a result of Alternative 3. Seventy-five properties greater than 50 years old could potentially be displaced through acquisition. However, the Washington State Office of Archaeology and Historic Preservation (SHPO or OAHP) have indicated that the properties within the acquisition site are not eligible for the National Register. Therefore, no direct impacts to significant historical resources would occur.

No previously inventoried properties located within the 65 DNL and greater noise exposure (year 2000, 2010, and 2020) are currently listed in the State or National Registers. As is shown in **Table IV.3-1 and IV.3-2**, only one previously recorded historic site would be exposed to DNL 65 or greater in any future time frame. In comparison to the Do-Nothing, the preferred alternative would result in a 1.5 DNL increase, which is considered by FAA guidelines a significant change in noise. Based on a preliminary assessment, it has been recommended that this site (Brunelle Residence) would not be eligible for the Federal Register and is not considered to be a significant historic resource. Therefore, no indirect impacts are anticipated to occur with the proposed airport improvements.

(4) CUMULATIVE IMPACTS

The cumulative impact of the SeaTac Master Plan and other proposed local projects within the vicinity could create direct and indirect impacts on historical, archaeological and cultural resources. However, until project specific plans are developed for these developments, the cumulative impacts can not be identified.

(5) MITIGATION MEASURES

Because no direct or indirect impacts to cultural, historic, and archaeological resources listed on or eligible for the National Register of Historic Places were identified, no mitigation measures are anticipated to be nece[illegible]y at this time. It is possible that unknown cultural, historical or archaeological sites could be discovered during construction. In the event that any artifacts are discovered during construction activities, construction in such areas will be halted immediately and the SHPO and other proper authorities will be contacted within 24 hours. This will be done so that the findings could be recorded and the level of significance determined. If findings of significance were made, mitigation measures would be developed through a Memorandum of Agreement among FAA, the Washington State Office of Archaeology and Historic Preservation, Advisory Council on Historic Preservation, and others.

AR 038951

Table IV.3 -1
Page 1 of 4

Seattle-Tacoma International Airport
Environmental Impact Statement

DNL NOISE LEVELS FOR ARCHAELOGICAL, HISTORICAL, AND CULTURAL RESOURCES

Site #	Site	Jurisdiction	1994 Exist.	Year 2000 Alt. 1	Year 2000 Alt. 2	Year 2000 Alt. 3	Year 2000 Alt. 4	Year 2010 Alt. 1	Year 2010 Alt. 2	Year 2010 Alt. 3	Year 2010 Alt. 4	Year 2020 Alt. 1	Year 2020 Alt. 2	Year 2020 Alt. 3	Year 2020 Alt. 4
National Register of Historic Places															
A2	14th Ave S. Bridge	King County	64.7	61.8	61.6	61.6	61.6	62.1	61.9	61.9	61.9	62.7	62.3	62.3	62.3
A5	Old Georgetown City Hall	Seattle	62.9	59.7	59.6	59.6	59.6	60.0	59.9	59.9	59.9	60.5	60.3	60.3	60.3
A7	Georgetown Steam Plant	Seattle	62.0	58.9	58.9	58.9	58.9	59.2	59.2	59.2	59.2	59.8	59.8	59.8	59.8
A13	Columbia City Historic District	Columbia City	50.7	47.2	47.3	47.3	47.3	47.2	47.3	47.3	47.3	47.6	47.6	47.6	47.6
Archaeological Sites															
A4	Allentown Shell Midden	Tukwila	52.3	47.9	48.0	48.0	48.0	48.2	48.3	48.3	48.3	48.9	49.0	49.0	49.0
A8	Boeing Airplane Co. Building	Seattle	59.5	56.0	56.2	56.2	56.2	56.0	56.2	56.2	56.2	56.4	56.4	56.4	56.4
A9	Maddocksville Landing	Kent	53.3	51.0	50.2	50.2	50.2	50.0	49.3	49.3	49.3	50.3	49.7	49.7	49.7
A68	Muckleshoot Indian Campground	King County	66.4	62.4	61.9	61.9	61.9	62.5	62.0	62.0	62.0	62.8	62.1	62.1	62.1
A901	Boeing Field Archeological Site		60.8	56.9	57.5	57.5	57.5	57.1	57.7	57.7	57.7	57.3	58.0	58.0	58.0
A902	Duwamish Archaeological Site		58.9	54.9	55.3	55.3	55.3	55.2	55.7	55.7	55.7	55.3	55.7	55.7	55.7
A903	Tukwila Archaeological Site		63.2	59.2	59.4	59.4	59.4	59.2	59.4	59.4	59.4	59.7	59.8	59.8	59.8
A904	Kent Archaeological Site		51.1	46.6	46.2	46.2	46.2	46.8	46.4	46.4	46.4	47.6	47.1	47.1	47.1
State Historic Sites															
A14	Covenant Beach Church Camp	Des Moines	61.7	57.5	58.6	58.6	58.6	57.7	58.8	58.8	58.8	57.8	58.9	58.9	58.9
A15	Maple Donation Claim	Seattle	62.2	59.1	59.3	59.3	59.3	59.4	59.6	59.6	59.6	60.1	60.2	60.2	60.2
A16	Sunnydale School	Burien	65.8	61.2	63.1	63.1	63.1	61.8	63.6	63.6	63.6	63.0	64.5	64.5	64.2
A17	Homer Webster Home	Burien	53.7	51.1	52.7	52.7	52.7	51.8	53.1	53.1	53.1	53.2	54.0	54.0	53.6
A18	Dodds Homestead	Burien (KCLM)*	63.7	58.0	58.9	58.9	58.9	58.1	59.0	59.0	59.0	58.5	59.4	59.4	59.4

Table IV.3 -1
Page 2 of 4

Seattle-Tacoma International Airport
Environmental Impact Statement

DNL NOISE LEVELS FOR
ARCHAEOLOGICAL, HISTORICAL, AND CULTURAL RESOURCES

Site #	Site	Jurisdiction	1994 Exist.	Year 2000 Alt. 1	Year 2000 Alt. 2	Year 2000 Alt. 3	Year 2000 Alt. 4	Year 2010 Alt. 1	Year 2010 Alt. 2	Year 2010 Alt. 3	Year 2010 Alt. 4	Year 2020 Alt. 1	Year 2020 Alt. 2	Year 2020 Alt. 3	Year 2020 Alt. 4
Local Historic Sites (continued)															
A19	Teague House	Burien	62.5	56.9	57.9	57.9	57.9	57.0	57.9	57.9	57.9	57.5	58.5	58.5	58.5
A20	Woods House	Burien	61.6	57.4	58.9	58.9	58.9	58.0	59.5	59.5	59.5	59.1	60.4	60.4	60.3
A21	Haselton Home	Burien	53.7	51.7	52.7	52.7	52.7	51.7	52.6	52.6	52.6	52.9	53.3	53.3	53.3
A22	Homer Crosby Home	Burien	67.2	51.0	62.6	62.6	62.6	61.3	62.9	62.9	62.9	61.8	63.3	63.3	63.3
A23	Clubhouse (Highline Mens Prog.)	Burien	58.7	55.6	56.7	56.7	56.7	56.4	57.3	57.3	57.3	58.1	58.6	58.6	58.0
A24	Kromasoff House	Burien	57.6	53.3	54.6	54.6	54.6	53.8	55.0	55.0	55.0	54.9	55.9	55.8	55.8
A25	F.W. Dashley Home	Burien	56.5	53.4	54.5	54.5	54.5	54.2	55.1	55.1	55.1	55.9	56.3	56.3	55.7
A26	Schoening Home	Burien	58.2	55.3	56.4	56.4	56.4	56.1	57.0	57.1	57.0	57.9	58.3	58.3	57.7
A27	Brunelle Residence	Burien	72.4	66.5	67.6	67.6	67.6	66.4	67.8	67.8	67.8	66.6	68.1	68.1	68.1
A28	Burien Historic Business District	Burien	58.8	55.1	56.5	56.5	56.5	56.0	57.2	57.2	57.2	57.6	58.3	58.3	57.9
A29	Bryan House	Burien	68.6	62.2	64.5	64.5	64.5	62.4	64.8	64.8	64.8	62.8	65.2	65.2	65.2
A30	George Albee Estate	Burien	56.8	53.6	54.6	54.6	54.6	54.3	55.2	55.3	55.2	56.0	56.4	56.4	55.9
A31	Highline High School	Burien (KCLM)*	61.9	57.5	59.2	59.2	59.2	58.2	59.7	59.7	59.7	59.6	60.6	60.6	60.3
A32	Community Club Hall	Des Moines	60.7	56.5	57.5	57.5	57.5	56.7	57.8	57.8	57.8	56.8	57.9	57.9	57.9
A33	Van Gasken House	Des Moines	58.8	54.7	55.4	55.4	55.4	54.7	55.6	55.6	55.6	54.9	55.7	55.7	55.7
A34	Latimer House	Des Moines	62.1	57.9	58.8	58.8	58.8	57.9	58.9	58.9	58.9	58.1	59.0	59.0	59.0
A35	Finnell House	Des Moines	59.7	55.5	56.4	56.4	56.4	55.6	56.6	56.6	56.6	55.8	56.7	56.7	56.7
A36	Elsey House	Des Moines	62.6	58.4	59.5	59.5	59.5	58.5	59.7	59.7	59.7	58.7	59.8	59.8	59.8
A37	Case Home	Des Moines	64.2	59.8	60.9	60.9	60.9	59.9	61.1	61.1	61.1	60.1	61.2	61.2	61.2
A38	Rayback House	Des Moines	65.3	60.9	62.1	62.1	62.1	61.1	62.3	62.3	62.3	61.3	62.4	62.4	62.4
A39	Walsworth House	Des Moines	65.4	61.1	62.2	62.2	62.2	61.3	62.4	62.4	62.4	61.4	62.5	62.5	62.5
A40	L. H. Smith House	Des Moines	63.5	59.2	60.2	60.2	60.2	59.3	60.5	60.5	60.5	59.5	60.6	60.6	60.6
A41	Lindahl House	Des Moines	58.1	54.6	55.5	55.5	55.5	54.1	55.0	55.0	55.0	54.6	55.7	55.7	55.7

Table IV.3 -1
Page 3 of 4

Seattle-Tacoma International Airport
Environmental Impact Statement

DNL NOISE LEVELS FOR ARCHAEOLOGICAL, HISTORICAL, AND CULTURAL RESOURCES

Site #	Site	Jurisdiction	1994 Exist.	Year 2000 Alt. 1	Year 2000 Alt. 2	Year 2000 Alt. 3	Year 2000 Alt. 4	Year 2010 Alt. 1	Year 2010 Alt. 2	Year 2010 Alt. 3	Year 2010 Alt. 4	Year 2020 Alt. 1	Year 2020 Alt. 2	Year 2020 Alt. 3	Year 2020 Alt. 4
Local Historic Sites (continued)															
A42	Chesney House	Des Moines	67.8	63.5	64.4	64.4	64.4	63.6	64.5	64.5	64.5	63.9	64.6	64.6	64.6
A43	WPA Park Building	Des Moines (KCLM)*	63.9	59.6	60.7	60.7	60.7	59.7	60.9	60.9	60.9	59.9	61.0	61.0	61.0
A44	Old Star Lake School	Federal Way	64.1	60.0	59.5	59.5	59.5	60.1	59.6	59.6	59.6	60.3	59.9	59.9	59.9
A45	Redondo Heights Grocery	Federal Way	63.8	60.4	60.3	60.3	60.3	60.7	60.6	60.6	60.6	61.0	60.7	60.7	60.7
A46	Steele Lake Schoolhouse	Federal Way	62.2	58.5	58.3	58.3	58.3	58.7	58.4	58.4	58.4	59.1	58.7	58.7	58.7
A47	Maddocksville Landing	Kent	52.4	49.3	49.3	49.3	49.3	48.6	48.2	48.1	48.1	48.9	48.4	48.4	48.4
A48	Greene Residence	Kent	53.4	49.8	49.7	49.7	49.7	49.3	48.9	48.9	48.9	49.7	49.2	49.2	49.2
A49	Biggar House	Kent	53.8	50.0	49.9	49.9	49.9	49.6	49.2	49.2	49.2	50.1	49.5	49.5	49.5
A50	Kent Highlands House	Kent	53.5	51.3	50.3	50.3	50.3	50.7	50.0	50.0	50.0	51.2	50.7	50.7	50.7
A51	Kent Highlands House II	Kent	56.9	53.1	52.6	52.6	52.6	52.8	52.0	52.0	52.0	53.2	52.5	52.5	52.5
A52	Winston House	Kent	51.5	47.6	47.6	47.6	47.6	47.3	47.0	47.0	47.0	47.7	47.3	47.3	47.3
A53	Hughett House	Normandy Park	56.0	53.2	53.1	53.1	53.1	53.7	54.0	54.0	54.0	54.6	55.0	55.0	55.3
A54	Clark House	Normandy Park	55.9	53.0	52.9	52.9	52.9	53.5	53.8	53.8	53.8	54.4	54.8	54.8	55.1
A55	Gustin House	Normandy Park	56.0	53.2	53.1	53.1	53.1	53.7	54.0	54.0	54.0	54.6	55.0	55.0	55.3
A58	Farmstead (unidentified)	SeaTac	57.3	53.4	52.8	52.8	52.8	53.1	52.3	52.3	52.3	53.5	52.7	52.7	52.7
A59	L. Mayer Residence	SeaTac	61.5	55.4	55.8	55.8	55.8	55.7	56.1	56.1	56.1	56.6	56.9	56.9	56.9
A60	Hillgrove Cemetery	SeaTac (Comm LM)**	73.5	69.6	70.0	70.0	70.0	69.8	70.0	70.0	70.0	70.1	70.1	70.1	70.1
A62	Georgetown Poor Farm Annex	Tukwila	62.4	59.1	59.2	59.2	59.2	59.3	59.5	59.5	59.5	59.6	59.8	59.8	59.8
A63	Riverton Park United Methodist	Tukwila	55.8	51.1	51.3	51.3	51.3	51.3	51.5	51.5	51.5	51.9	52.1	52.1	52.1
A64	Nash House	Tukwila	53.7	49.0	49.2	49.2	49.2	49.2	49.4	49.4	49.4	49.9	50.1	50.1	50.1

Table IV.3 -1
Page 4 of 4

Seattle-Tacoma International Airport
Environmental Impact Statement

DNL NOISE LEVELS FOR ARCHAEOLOGICAL, HISTORICAL, AND CULTURAL RESOURCES

Site #	Site	Jurisdiction	1994 Exist.	Year 2000 Alt. 1	Year 2000 Alt. 2	Year 2000 Alt. 3	Year 2000 Alt. 4	Year 2010 Alt. 1	Year 2010 Alt. 2	Year 2010 Alt. 3	Year 2010 Alt. 4	Year 2020 Alt. 1	Year 2020 Alt. 2	Year 2020 Alt. 3	Year 2020 Alt. 4
Local Historic Sites (continued)															
A65	Delta Masonic Temple	Tukwila	53.8	49.0	49.3	49.3	49.3	49.2	49.5	49.5	49.5	49.9	50.1	50.1	50.1
A66	Albert Tutt Property	Tukwila	54.5	49.7	49.9	49.9	49.9	49.9	50.1	50.1	50.1	50.5	50.7	50.7	50.7
A67	Gus Johnson Residence	Tukwila	53.1	48.2	48.5	48.5	48.5	48.4	48.7	48.7	48.7	49.2	49.4	49.4	49.4
A69	Lumber Mill Office	King County	55.2	51.9	52.5	52.5	52.5	52.2	52.8	52.8	52.8	52.4	52.9	52.9	52.9
A70	Betts General Store	King County	57.7	54.3	54.9	54.9	54.9	54.6	55.2	55.2	55.2	54.8	55.2	55.2	55.2
A71	Long Farmhouse	King County	57.5	51.2	50.7	50.7	50.7	51.3	50.7	50.7	50.7	51.6	51.1	51.1	51.1
A72	Star Lake School	King County	60.4	55.5	54.9	54.9	54.9	55.6	55.0	55.0	55.0	55.8	55.2	55.2	55.2
A73	Lenhart House	King County	55.4	52.0	52.6	52.6	52.6	52.3	52.9	52.9	52.9	52.5	53.0	53.0	53.0
A74	F.W. Morse Summer House	King County	55.3	52.0	52.6	52.6	52.6	52.3	52.9	52.9	52.9	52.5	52.9	52.9	52.9
A75	W. D. Cotter Summer House	King County	55.3	52.0	52.5	52.5	52.5	52.2	52.9	52.9	52.9	52.4	52.9	52.9	52.9

Inventory as of November, 1994.

Shaded area indicates that a 1.5 DNL increase would occur within DNL 65 and greater noise exposure.

* King County Landmark Designation
** Community Landmark Designation (honorary designation only)
@ On or eligible for National Historic Register (NR) or State Historic Register (SR)

Source: Shapiro and Associates, Inc. 1994.

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Table IV.3-2
Page 1 of 3

Seattle-Tacoma International Airport
Environmental Impact Statement

PROPERTIES IN THE ACQUISITION AREA (CONSTRUCTED BEFORE 1945)

Site #	Address	Date	Condition	National Register Eligible	Style	Zone (and sub Area, if Applicable)
1	14811 Des Moines Way S., Burien	1939	Modified	No	Vernacular Pyramidal Family	A, RPZ[1/]
2	853 148th Street, Burien	1939	Modified	No	Modern Ranch	A, RPZ
3	14644 11th Avenue S., Burien	1926	Modified	No	Vernacular-Cross Gable	A, RPZ
4	1004 S. 150th Street, Burien	1918	Intact	No	Craftsman	A, RPZ
5	15060 Des Moines Way S., SeaTac	1930	Intact, Rundown	No	Vernacular-Gable Front	A, P
6 (A56)[2/]	Vacca Farms 15208 Des Moines Way S., SeaTac	1915	Modified Moved	No	Commercial Flat Roof	A, M
7	15416 Des Moines Way S., SeaTac	1906	Intact, Moved	No	Vernacular-Gable Front	A, M
8	15416 Des Moines Way S., SeaTac	1935	Moved	No	Gable Front-Garage and Shed	A, M
9	15446 Des Moines Way S., SeaTac	1906	Intact	No	Craftsman	A, M
10	15454 Des Moines Way S., SeaTac	1939	Modified	No	Craftsman	A, M
11	14644 11th Avenue S., Burien	1926	Intact, Moved	No	Vernacular-Pyramidal Family	A, P
12	1004 S. 150th Street, Burien	1918	Modified	No	Vernacular-Pyramidal Family	A, RPZ
13	15060 Des Moines Way S., SeaTac	1930	Modified	No	Vernacular-Side Gable	A, P
14	15208 Des Moines Way S., SeaTac	1915	Modified	No	Modern-Minimal Traditional	A, M
15	15427 12th Avenue S., SeaTac	1941	Modified	No	Modern-Minimal Traditional	A, P
16	15433 12th Avenue S., SeaTac	1941	Intact	No	Modern-Minimal Traditional	A, P
17	15441 12th Avenue S., SeaTac	1941	Intact	No	Modern-Minimal Traditional	A, P
18	1066 S. 156th Way, SeaTac	1932	Intact Outbuilding	No	Vernacular-Front Gable	A, P
19	1066 S. 156th Way, SeaTac	1937	Minimal Modifications	No	Vernacular Massed Plan, Side Gable	A, P
20	15453 12th Avenue S., SeaTac	1941	Intact	No	Modern-Minimal Traditional	A, P
21	15618 Des Moines Way S., SeaTac	1918	Modified	No	Combination of Modifications	A, P
22	844 S. 157th Place, SeaTac	1927	Intact	No	Vernacular-Side Gable	A, P
23	1019 S. 157th Place, SeaTac	1937	Intact	No	Modern-Minimal Traditional	A, P
24	1131 S. 154th Place, SeaTac	1941	Modified	No	Modern-Minimal Traditional	A, P
25	15631 12th Avenue S., SeaTac	1937	Intact	No	Vernacular- Side Gabled	A, P
26	15653 12th Avenue S., SeaTac	1937	Modified	No	Vernacular-Front & Side Gable	A, P
27	1037 S. 156th Way, SeaTac	1915	Modified	No	Craftsman	A, P
28	1009 S. 157th Place, SeaTac	1924	Modified	No	Vernacular Massed Plan,side gabled	A, P

Seattle-Tacoma International Airport
Environmental Impact Statement

PROPERTIES IN THE ACQUISITION AREA
(CONSTRUCTED BEFORE 1945)

Site #	Address	Date	Condition	National Register Eligible	Style	Zone (and sub Area, if Applicable)
29	15718 9th Place S., SeaTac	1942	Modified	No	Minimal Traditional	A, P
30 (A57)	Albert Paul House 839 S. 157th Place, SeaTac	1904	Minimal Modifications	No	Craftsman	A, P
31	819 S. 157thPlace, SeaTac	1918	Modified	No	Vernacular Gable Front & Wing	A, M
32	15811 9th Avenue S., SeaTac	1927	Modified	No	Vernacular, Front and Wing Gable	A, P
33	15904 Des Moines Way S., SeaTac	1938	Modified	No	Vernacular, Front and Wing Gable	A, P
34	15914 Des Moines Way S., SeaTac	1937	Modified	No	National, Front and Wing Gable	A, P
35	906 S. 160th Street, SeaTac	1934	Modified	No	Vernacular, Front and Wing Gable	A, P
36	15822 9th Avenue S., SeaTac	1934	Modified	No	Vernacular, Massed Plan, Side Gable	A, P
37	15823 9th Avenue S., SeaTac	1933	Modified	No	Vernacular, Massed Plan with Additions	A, M
38	15864 Des Moines Way S.,SeaTac	1926	Could not Locate	Und.	Undetermined	Could not Locate/
39	16451 12th Avenue S., SeaTac	1942	Modified	No	Modified Minimal Traditional	A, P
40	16429 12th Avenue S., SeaTac	1942	Modified	No	Combined Modifications	A, P
41	16235 12th Avenue S., SeaTac	1937	Modified	No	Vernacular, Massed Plan/side Gable	A, P
42	16033 12th Avenue S., SeaTac	1944	Modified	No	Vernacular, Gable Front	A, P
43	16032 9th Avenue S.SeaTac	1939	Intact	No	Vernacular-Side Gable-Craftsman	A, P
44	15914 Des Moines Way S., SeaTac	1930	Modified	No	Vernacular, Front Gable	A, M
45	16244 8th Avenue S., SeaTac	1939	Modified	No	Modified Combination	A, M
46	16422 8th Avenue S., SeaTac	1935	Modified	No	Vernacular, Massed Plan	A, P
47	16412 8th Avenue S., SeaTac	1933	Intact	No	Vernacular, Front and Wing Gable	A, M
48	16436 8th Avenue S., SeaTac	1937	Modified	No	Vernacular, Front and Wing Gable	A, P
49	16452 8th Avenue S., SeaTac	1935	Modified	No	Vernacular, Pyramidal Family	A, P
50	16602 8th Avenue S., SeaTac	1936	Modified	No	Vernacular, Gable Front	A, P
51	16616 8th Avenue S., SeaTac	1933	Modified	No	Vernacular, Massed Plan	A, M
52	16628 8th Avenue S., SeaTac	1933	Modified	No	Vernacular, Massed Plan	A, M
53	16623 8th Avenue S., SeaTac	1944	Modified	No	Vernacular, Massed Plan	A, M
54	644 S. 168th, SeaTac	1939	Modified	No	Combination of Modifications	A, M
55	632 S. 168th Street, SeaTac	1935	Modified	No	Vernacular, Front and Wing Gable	A, M
56	16463 8th Avenue S., SeaTac	1938	Modified	No	Vernacular, Massed Plan	A, M
57	16444 Des Moines Way S., SeaTac	1922	Intact	No	French Eclectic	A, M
58	16444 Des Moines Way S., SeaTac	1922	Unknown Outbuilding	No	Unknown, Unable to access property	A, M
59	16412 Des Moines Way S., SeaTac	1908	Modified	No	Vernacular, Gable Front Family	A, M
60	16404 Des Moines Way S., SeaTac	1943	Modified	No	Minimal Traditional	A, M
61	16247 8th Avenue S., SeaTac	1934	Modified	No	Vernacular, Side Gabled Family	A, M

Table IV.3-2
Page 3 of 3

Seattle-Tacoma International Airport
Environmental Impact Statement

PROPERTIES IN THE ACQUISITION AREA (CONSTRUCTED BEFORE 1945)

Site #	Address	Date	Condition	National Register Eligible	Style	Zone (and sub Area, if Applicable)
62	16223 8th Avenue S., SeaTac	1939	Modified	No	Vernacular, Front and Side Gable Family	A, M
63	16002 Des Moines Way S., SeaTac	1933	Modified	No	Vernacular, Front and Side Gabled Family	A, M
64	16874 8th Avenue S., SeaTac	1926	Modified	No	Vernacular, Front and Side Gabled Family	A, M
65	16841 8th Place S., SeaTac	1933	Modified	No	Major Modifications	A, P
66	16854 8th Avenue S., SeaTac	1936	Modified	No	Vernacular, Massed Plan Family	A, M
67	16842 8th Avenue S., SeaTac	1942	Modified	No	Minimal Traditional	A, M

Source: Shapiro and Associates, Inc. 1994

1/ A = Acquisition, RPZ = Runway Protection Zone, M= Mitigation, P=Primary
2/ Previously Recorded (PR)

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Seattle-Tacoma International Airport Environmental Impact Statement for the Master Plan Update

Exhibit IV.3-1

Inventoried Historic, Archaeological and Cultural Sites within Study Area

National Historic Site

State Historic Site

Inventoried Historic Site

Archaeological Site

Source: Gambrell Urban, Inc. and
Shapiro & Associates, 1994
Part 150 Noise Exposure Map Update, 1991
Thomas Brothers Map Guide, 1994
WA State Office of Archaeology
& Hist. Preservation (SHPO), 1994
King County Cultural Resources Division, 1994

Potential historic sites within the project acquisition area are not included - see Exhibit IV.3-2.

Scale 1" = 6,000'

0 6000 12000 18000
SCALE IN FEET

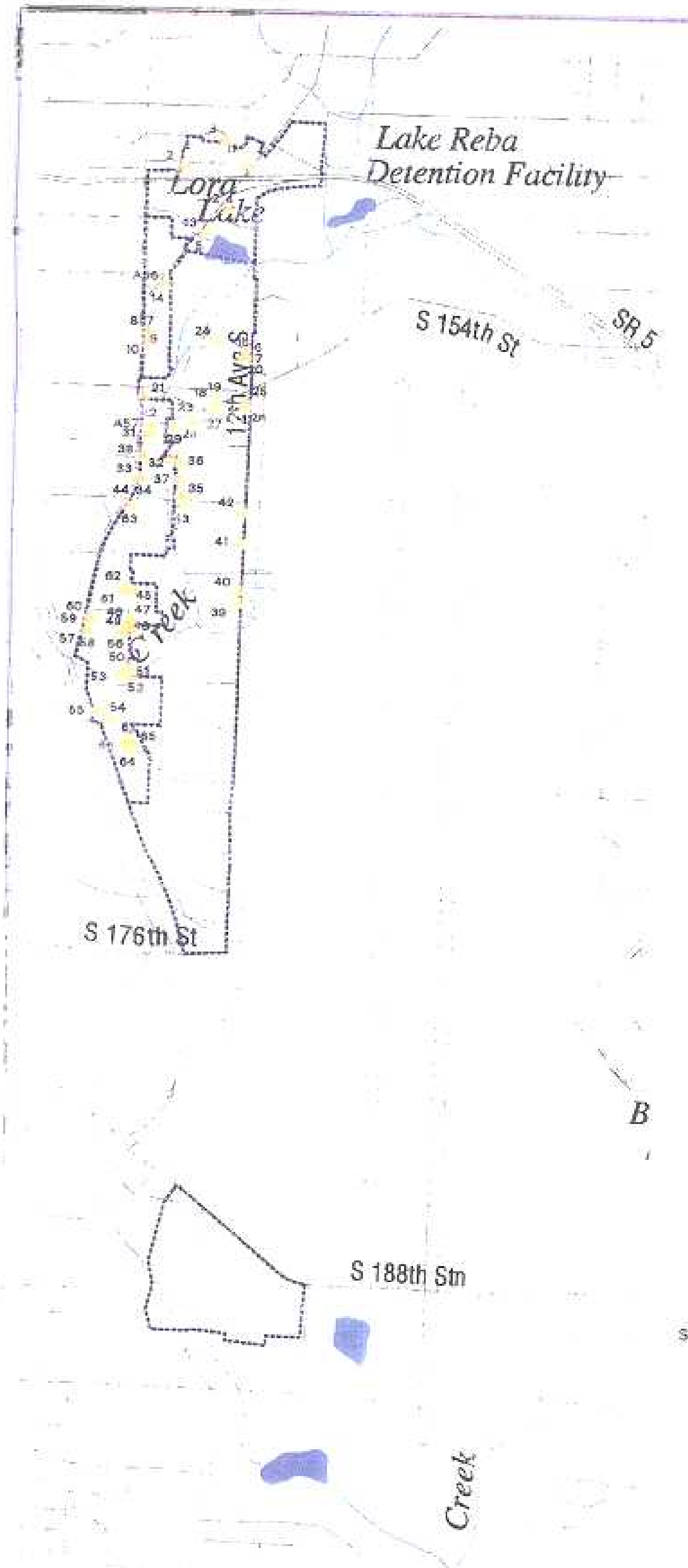
Projection: Lambert Conformal Conic
Coordinate System: State Plane NAD27

April 13, 1996

Seattle-Tacoma International Airport
Environmental Impact Statement
for the Master Plan Update

Exhibit IV.3-2

Inventoried Historic Sites within Acquisition Area



Source: Gambrell Urban, Inc. 1995
Shapiro & Associates, Inc. 1994
Landrum & Brown, Inc. 1994

Projection: Lambert Conformal Conic
Coordinate System: State Plane NAD27

December 15, 1996

CHAPTER IV, SECTION 4

DEPARTMENT OF TRANSPORTATION SECTION 4(F) RESOURCES

This section discusses the impacts of the Master Plan Update alternatives for Sea-Tac Airport on applicable U.S. Department of Transportation (DOT) Section 4(f) resources.[1/] The U.S. Department of Transportation Act of 1966, specifically Section 4(f), provides for the protection of certain publicly owned resources. DOT Section 4(f) resources include public parks; recreational areas; wildlife and waterfowl refuges of federal, state, or local significance; or any land from an historic site of federal, state, or local significance. Chapter IV, Section 3 "Cultural, Historic, and Archaeological Resources", provides a detailed description of the resources discussed in this section.

Special procedures are required when development would affect lands purchased or developed using Land and Water Conservation funds. The Land and Water Conservation Fund Act of 1965 (Public Law 88-578), 16 U.S.C. 601-8(f)(3), commonly known as LAWCON Section 6(f) requires that:

> "No property acquired or developed with assistance under this section shall, without the approval of the Secretary (of the Department of the Interior), be converted to other than public outdoor recreational uses. The Secretary shall approve such conversion only if he finds it to be in accord with the then existing comprehensive statewide outdoor recreation plan and only upon such conditions as he deems necessary to assure the substitution of other recreation properties of at least equal fair market value and of reasonable equivalent usefulness and location."

As is described in this section, no DOT Section 4(f) or LAWCON Section 6(f) resources would be directly or indirectly impacted by any of the Master Plan Update alternatives.

(1) METHODOLOGY

Programs or projects will not be approved by the federal government if they require the use of DOT Section 4(f) or LAWCON Section 6(f) resources, unless there is no feasible and prudent alternative to the use of such land. In such a case, programs must include all possible planning to minimize harm resulting from the use.

Airport development can adversely impact Section 4(f) or 6(f) resources either directly or indirectly. A direct impact, or direct use, would involve acquisition of all or a portion of the resource. An indirect impact, or constructive use, may be created by adverse noise impacts, surface traffic impacts, air pollution impacts or others. Federal Agency land use compatibility guidelines identify adverse incompatible noise impacts on most urban recreation resources as noise levels above 75 DNL, unless the resource contains a receptor of unusual noise sensitivity such as an auditorium or outdoor performing arts center, in which case the threshold would be a noise level of 65 DNL or greater.

Parks, recreational areas, wildlife and waterfowl refuges, and historic sites were inventoried and identified in **Exhibit IV.4-1**. In total, 79 public parks, six private recreation uses, and various historic sites were identified within the general study area in the following jurisdictions: unincorporated King County, Burien, Des Moines, Federal Way, Kent, Normandy Park, SeaTac, Seattle, and Tukwila.

(2) DIRECT IMPACTS

The following section summarizes direct impacts on 4(f) and 6(f) resources.

(A) Existing Conditions

Parks and recreation areas that were identified in the general study area (the area currently affected by 65 DNL and greater sound levels) are shown in **Exhibit IV.4-1**. As shown, a total of 84 parks and recreational facilities (including 6 private golf courses) are located within the study area. Currently, Sea-Tac Airport has no direct impacts on these facilities.

No land in the study area has been purchased with Land and Water Conservation funds or designated for conversion under Section 6(f).

1/ 49 USC Section 303.

AR 038962

(B) Future Conditions

The direct impact of future airport activities on DOT Section 4(f) lands is described in the following subsections.

1. **Do-Nothing (Alternative 1)**

No public parks, recreation areas, or historical or cultural sites would be acquired or otherwise directly impacted as a result of Airport improvement by the Port of Seattle under the Do-Nothing alternative. The development of a SR 509/South Airport Access Road by WSDOT would likely have the largest direct and indirect impact of all planned improvements on land use in the area. These impacts for the various alternatives under consideration are detailed in the Draft EIS for SR 509/South Access (issued in December 1995). Depending on the alternative chosen, the construction of the SR 509/South Access would directly or indirectly affect one or more of the following Section 4(f) resources: Des Moines Creek Park, the proposed Des Moines Creek Trail, and Zenith Park.

2. **"With Project" (Alternatives 2, 3, and 4)**

The acquisition area is the same for each "With Project" alternative at a given runway length. Within the acquisition areas that vary by the shorter runway lengths (7,000-ft and 7,500-ft vs. the longer 8,500-ft), there are no 4(f) properties. Therefore, the following discussion summarizes the direct impact of all "With Project" alternatives. No acquisition of any DOT Section 4(f) properties would be anticipated.

As shown in **Exhibit IV.4-1**, a small portion of the Des Moines Creek Park (noted as site P44) would be located in the expanded Runway Protection Zone (RPZ) in the event of extension of Runway 34R. Because this property would not need to be acquired and because the RPZ would not physically prevent the property's intended use as a park, the location of Des Moines Creek Park in the RPZ would not constitute a direct Section 4(f) impact. A portion of the privately operated Tyee Valley Golf Course would need to be used for the Runway 34R extension. Because the Port of Seattle leases the property for private use, the Tyee Valley Golf Course does not qualify as a DOT Section 4(f) resource.

Three baseball diamonds located north of SR 518 and east of Des Moines Way South, would be affected. These facilities are partially located in the RPZ for the existing runways and partially in the RPZ for the proposed new parallel runway. They are owned by the Port of Seattle and leased on a month-to-month basis to the Highline East Little League. The baseball diamonds are used for interim recreational purposes only and could be relocated.. Because this location is used for recreational purposes on a temporary basis, the baseball diamond sites would not qualify as a DOT Section 4(f) resource.[2]

Sixty-seven residences of 50 years in age or more would be acquired to implement any of the "With Project" alternatives. Gregory Griffith, Comprehensive Planning Specialist at the State Office of Archaeology and Historic Preservation, however, confirmed that none of these properties are eligible for the State or National Register of Historic Places. **Appendix E-A** contains detailed information on these properties.

3. **Preferred Alternative (Alternative 3)**

No acquisition of any DOT Section 4(f) properties is anticipated. As shown in **Exhibit IV.4-1**, a small portion of the Des Moines Creek Park (noted as site P44) would be located in the expanded Runway Protection Zone (RPZ) in the event of extension of Runway 34R. Because this property would not need to be acquired and because the RPZ would not physically prevent the property's intended use as a park, the location of Des Moines Creek Park in the RPZ would not constitute a direct Section 4(f)

[2] FAA Order 5050.4A, Chapter 5, Paragraph 47, e (7) a3 states "Where property is owned by and currently designated for use by a transportation agency and a park or recreation use of the land is made only on an interim basis, a section 4(f) determination would not ordinarily be required."

impact. A portion of the privately operated Tyee Valley Golf Course would need to be used for the Runway 34R extension. Because the Port of Seattle leases the property for private use, the Tyee Valley Golf Course does not qualify as a DOT Section 4(f) resource.

Three baseball diamonds located north of SR 518 and east of Des Moines Way South, would be affected. These facilities are partially located in the RPZ for the existing runways and partially in the RPZ for the proposed new parallel runway. Because this location is used for recreational purposes on a temporary basis, the baseball diamond sites would not qualify as a DOT Section 4(f) resource.[3]

As was noted earlier, numerous properties of local significance are located in the airport vicinity. The State Office of Archaeology and Historic Preservation, however, confirmed that none of these properties are eligible for the State or National Register of Historic Places. Consequently, there are no cultural structures that qualify for protection under DOT Section 4(f).

(3) INDIRECT IMPACTS

Table IV.4-1 lists existing and projected noise levels at the parks and recreation facilities in the study area (shown in **Exhibit IV.4-1**) for 1994, 2000, 2010, and 2020.

(A) Existing Conditions

As shown in **Table IV.4-1,** a total of 15 parks and recreation facilities are currently affected by aircraft noise levels of 65 DNL or greater. Two of these are privately owned golf courses (Glen Acres Golf Club and the Rainier Golf Course) and are not DOT Section 4(f) land. Another facility (Tyee Valley Golf Course) is not a Section 4(f) resource because it is leased from the Port of Seattle for private use. The lease has at all times contained a special termination provision that provides the Port of Seattle the option to reclaim all or a portion of the land for the purpose of expanding airport operations or facilities into the leased area.

There are 12 publicly-owned parks within the general study area that are currently affected by noise levels of 65 DNL and greater and that could qualify as DOT Section 4(f) resources. These include the following:

- *Southern Heights Park (P14)*: This small neighborhood park is operated by King County. Southern Heights Park has two tennis courts, play equipment, and a large grassy area. There are no trails in this park.
- *North SeaTac Park (P28):* The City of SeaTac is currently in the process of completing a construction document describing its plan to invest $9 million on capital improvements for these two parks (North SeaTac Park and South 142nd Street Park), which are adjacent to one another. Currently, North SeaTac Park has an equestrian center, a BMX facility (an off-road bicycle course), a new community center building, three soccer fields, four baseball fields, and several open space trails. At the center of North SeaTac Park, two additional buildings (a gymnasium and a one-story building previously used as a ceramics activity center and currently owned by the Department of Public Works) have been abandoned for ten years. Both buildings were closed for asbestos abatement. Initial park proposals discussed the need to demolish these buildings but, with the increasing cost of demolition, the City of SeaTac is considering renovating the structures. A final decision is not expected in the near future. These parks are operated by the City of SeaTac.
- *Angle Lake Park (P43)*: Angle Lake Park provides swimming opportunities in Angle Lake. There are restrooms, concessions, a children's play equipment area, a small lifeguard structure, and a park maintenance storage facility. There is an area of unique Douglas fir trees, several trails, and a residential structure belonging to a previous park caretaker. Angle Lake Park is operated by the City of SeaTac.

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[3] FAA Order 5050.4A, Chapter 5, Paragraph 47, e (7) a3 states "Where property is owned by and currently designated for use by a transportation agency and a park or recreation use of the land is made only on an interim basis, a section 4(f) determination would not ordinarily be required."

- *Des Moines Creek Park (P44)*: Des Moines Park covers an area of over 100 acres and includes bike trails and hiking trails. This park is jointly operated by the Cities of Des Moines and SeaTac.
- *Parkside Park (P53)*: This park is a very small rest area park which is operated by the City of Des Moines. There are no recreational facilities at this park.
- *Parkside Wetlands (P54)*: Parkside Wetlands is an undeveloped park, with a few unpaved trails. The park is jointly operated by the City of Des Moines and the City of Kent.
- *Barnes Creek Nature Trail (P64):* The Barnes Creek Nature Trail is a gravel and natural pedestrian trail in the heart of residential Des Moines. The trail follows Barnes Creek through a wooded area with both canopy and understory vegetation. Children and adults heavily use this trail for jogging and mountain bike activities. The 1.2 acre, 0.6 mile trail runs north-south to SR-509 right-of-way between Kent-Des Moines Road and South 223rd Street, and is owned by the City of Des Moines. The trail will be an important section of a planned north-south pedestrian trail from Saltwater Park to the City of SeaTac. Barnes Creek Trail is already impacted by existing airport flight noise.
- *City Park/Kiddie Park (P67)*: City Park/Kiddie Park is an older, family park of lawn, trees, play structures, picnic tables and nature trails. The active areas overlook and provide access to the Massey Creek ravine with a beautiful strand of trees and understory vegetation. The park is used primarily by children and families from the surrounding neighborhood. The 3.2 acre park is located at 21st Avenue South and South 231st Street. The park is severely impacted by existing airport flight noise, which diminishes its tranquil attributes.
- *Midway Park (P71)*: Midway Park is a small neighborhood park with play structures, a basketball court, play fields, picnic tables, and walking paths. The park is heavily used by children from nearby low-income housing units and preschool children from at least three daycare facilities. The 1.6 acre park is located southeast of South 221 Street and 28th Avenue South, and is owned by the City of Des Moines.
- *Mount Rainier Pool (P72):* Mount Rainier Pool provides year-round swimming activities through organized swim teams, lap swimming, free swim and classes. Mount Rainier Pool is located adjacent to Mount Rainier High School at 22450 19th Avenue South, and is owned and operated by King County.
- *Sonju Property (P-76 future park site):* The Sonju property is an undeveloped natural, wooded area with potential future use as part of the north-south pedestrian trail. The property contains numerous trees and understory vegetation. The property is located south of South 245th Street between 16th and 20th Avenues South. The 9.5 acre property is owned by the Sonju family, and is under negotiation for purchase by the City of Des Moines.
- *Zenith Park (P79):* Zenith park is a neighborhood park with significant open space and heavily used sports fields. The 11.6 acre park is located northwest of South 240th Street and 16th Avenue South, and is leased by the City of Des Moines from the Highline School District.

None of these parks and recreational facilities include noise-sensitive facilities. As indicated in Chapter IV, Section 2, parks without unusually noise-sensitive facilities or activities are considered compatible uses (and thus would not be indirectly impacted) unless they are affected by noise levels of 75 DNL or greater. The only facilities that are currently affected by noise levels of 75 DNL and greater are Des Moines Creek Park, and the Tyee Valley Golf Course. As discussed previously, the Tyee Valley Golf Course does not constitute a Section 4(f) resource, as it is privately used.

(B) <u>Parks and Recreation Areas and Historic Properties Designated as Locally Significant by Local Jurisdictions</u>

In spring 1995, Burien, Des Moines, and Normandy Park designated a number of parks and recreation areas and historic properties within their respective city limits as locally or regionally significant. These facilities have been assessed in this Final EIS.

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Parks and Recreation Areas

As discussed in Chapter IV, Section 2 (Land Use), the ordinances discussed below relating to the protection of parks and recreation areas were recently adopted by Burien, Des Moines, and Normandy Park. All three of these ordinances state that park and recreation areas designated by the respective city as locally or regionally significant should generally be protected from noise levels that exceed 55 DNL. In addition, these ordinances also state that noise levels should not exceed 60 DNL for specific park and recreational facilities (e.g., golf courses, ball fields, outdoor spectator sports areas, amusement parks, riding stables, nature trails, and wildlife refuges) designated as locally significant. The Burien ordinance also states that for outdoor amphitheaters and music shells designated as being of local or regional significance by the City, noise levels should not exceed 50 DNL.

All of these ordinances sets noise level criteria below those specified by 14 CFR Part 150 guidelines. According to Part 150 of the Federal Aviation Regulations noted previously in this section, public parks and recreational areas are normally considered compatible with air operations at or below 75 DNL. If the public park or recreational area contains a noise-sensitive use, such as an auditorium or outdoor performance center, the use would be compatible at or below 65 DNL.

Many of these parks are presently affected by noise levels in excess of the recently adopted local noise guidelines. For purposes of this EIS, the evaluation focused on determining the existing and future noise exposure with and without the proposed improvements. In accordance with FAA Orders 1050.1D and 5050.4A, significant impacts are considered to occur if an increase in noise exposure of 1.5 DNL occurs to sites exposed to 65 DNL or greater noise exposure. Thus, the following section presents the assessment of noise impacts on park and recreational facilities under this Federal standard of significance.

- *Burien:* Ordinance No. 131 (adopted April 10, 1995) designated 10 parks and recreation areas as locally significant and one as regionally significant. Designated locally significant parks and recreation areas included in **Table IV.4-1**, which lists existing and future DNL noise levels, are the following: Burien Park (P33); Chelsea Park (P32); Des Moines Memorial Park (P70); Lakeview Park (P34); Moshier Park (P29); Salmon Creek Park (P20) and Seahurst Park (P31). Seahurst Park was designated by Ordinance No. 131 as regionally significant. Four other parks designated as locally significant in Ordinance No. 131 (Highline Community Center Park, Lake Burien Park, Seola Beach Park, and Shorewood Park) are located west of First Avenue South and thus are outside the general study area for the Master Plan Update. None of these five parks are located within the existing (1994) 65 DNL noise contour nor would they be exposed to 65 DNL or greater noise levels under any of the future Master Plan Update alternatives.
- *Des Moines:* Ordinance No. 1123 (adopted April 6, 1995) designates 13 parks and recreation areas as locally significant. Designated locally significant parks and recreation areas included in **Table IV.4-1**, which lists existing and future DNL noise levels, are the following: Des Moines Beach Park (P45); Des Moines Creek Park (P44); Des Moines Marina and Fishing Pier (P68 and P69); Big Catch Plaza (P65); Mt. Rainier Pool (P72); Parkside Wetlands (P54); Redondo Waterfront Park (P75); Saltwater State Park (P56); Woodmont Park (P57); and Zenith Park (P79). One other designated locally significant park, Des Moines Field House Park, is located at 1000 220th Street South in Des Moines Park (P46) and would not be exposed to noise levels exceeding 65 DNL under current conditions or under any of the Master Plan Update alternatives.

Two other proposed parks and recreation areas are designated as locally significant in Ordinance 1123: "Proposed Sports Park" and "Proposed Des Moines Creek Trail." The proposed Sports Park would be located at the northwest corner of 216th Street South and 24th Avenue, primarily on land owned by the Port of Seattle. This City of Des Moines development is planned to include several baseball fields, soccer fields, tennis courts, and possibly a golf driving range. No noise-sensitive uses, such as an outdoor performing hall, are planned. The Des Moines City Council has approved the Sports Park, and the project is currently in negotiations between the Port of Seattle and Des Moines. DNL noise levels for this proposed park would be similar, but slightly less, than for Des Moines Creek Park (P44), which is located closer to the Airport (about one-half mile to the north of the proposed site). Consequently, the proposed Sports Park would not be exposed to noise levels that exceed 75 DNL (or 1.5 DNL additional noise when comparing the Do-Nothing to the "With Project") under any of the Master Plan Update alternatives. The draft *Greater Des Moines Comprehensive Plan* (October 18, 1995) contains a policy (6-03-24) that allows the City to waive the maximum noise limitations for parks of local significance "when it is determined by the City Council that the public interest would be better served by allowing the establishment of a park or recreation area of local significance within an area with excessive noise levels." The "Proposed Des Moines Creek Trail" would link Des Moines Creek Park with Des Moines Beach Park. Maximum noise levels for the proposed trail would be the same as those for Des Moines Creek Park (P44). As a result, the proposed trail would not be exposed to noise levels that exceed 75 DNL under any of the Master Plan Update alternatives and the change in noise levels for facilities within 65 DNL would be less than 1.5 DNL.

- *Normandy Park*: Ordinance No. 609 (adopted March 28, 1995) designated seven parks as locally significant. These are the following: Brittany Park; Decorative Parks; City Hall Park; Civic Center Park; Marine View Park; Nature Trails Park; and Walker Preserve. As the entire city of Normandy Park is located outside of the general study area as well as the 65 DNL for existing conditions (1994) or any of the Master Plan Update alternatives, none of these parks would be exposed to noise levels that exceed 65 DNL.

Historic Properties

As discussed in Chapter IV, Section 2 (Land Use), ordinances relating to the protection and preservation of historic resources were recently adopted by Airport-vicinity jurisdictions. The following ordinances were adopted: Burien (Ordinance No. 130, adopted April 10, 1995); Des Moines (Ordinance 1125 adopted April 6, 1995); and Normandy Park (Ordinance No. 608 adopted March 28, 1995).

Appendix E-B of this Final EIS lists and evaluates these properties designated as locally significant in each of these ordinances that are affected by noise levels of 65 DNL and greater for existing conditions (1994) or under any of the Master Plan Update alternatives. The adopted ordinances for all three of these jurisdictions generally provide for protection of historic properties of local significance from noise levels that exceed 55 DNL. These ordinances set noise-level criteria below those specified by federal guidelines. According to Part 150 of the Federal Aviation Regulations (as explained in Chapter IV, Section 3), historic properties are normally considered compatible with air operations at or below 65 DNL.

(C) Future Impacts

The following paragraphs summarize the potential DOT Section 4(f) impacts in the years 2000, 2010 and 2020.

1. Do-Nothing (Alternative 1)

As noise decreases in the future as a result of quieter aircraft, indirect aircraft noise impacts on parks and recreation land would also decrease. In 1994, 12 potentially eligible Section 4(f) resources and three non-eligible resources were affected by aircraft noise of 65 DNL or greater. Under the Do-Nothing alternative, in 2000, 2010 and 2020, only four potentially eligible Section 4(f) resources (North SeaTac Park: P28, Southern Heights Park: P14, Des Moines Creek Park: P44, and Mt. Rainier Pool: P72) and two non-eligible resources (Tyee Valley Golf Course and Rainier Golf Course) would be affected by noise levels of 65 DNL or greater under the Do-Nothing alternative.

Since none of these parks contain noise-sensitive facilities, their recreational use would remain compatible. Only the Tyee Valley Golf Course, which is not a Section 4(f) property, would be affected by incompatible noise levels over 75 DNL.

2. **"With Project" Alternatives 2, 3, and 4**

Year 2000: A total of five parks and recreational facilities would be noise impacted by the "With Project" alternatives at DNL 65 and greater noise levels. Four of the five facilities are potential DOT Section 4(f) resources: Southern Heights Park, North SeaTac Park, Des Moines Creek Park, and Mt. Rainier Pool. In addition, one non-eligible resource, Tyee Valley Golf Course, would be exposed to a noise level of 75.4 DNL.

Of the four eligible DOT Section 4(f) resources, none contain noise-sensitive uses; thus all are considered compatible uses since the noise levels at these sites do not exceed DNL 75.

Year 2010: A total of six parks and recreational facilities would be noise impacted by the "With Project" alternatives at 65 DNL and greater noise levels. Four of the six facilities are potential DOT 4(f) resources: Southern Heights Park, North SeaTac Park, Des Moines Creek Park, and Mt. Rainier Pool. In addition, two non-eligible resources (Rainier Golf Course and Tyee Valley Golf Course) would be exposed to noise levels of 65.1 DNL and 75.1 DNL, respectively.

Of the four eligible resources, none contain noise sensitive uses and are thus, compatible with the noise exposure.

Year 2020: A total of seven parks and recreational facilities would be impacted by DNL 65 and greater noise levels. Five of the seven facilities could be DOT Section 4(f) resources: Southern Heights Park, North SeaTac Park, Des Moines Creek Park, Barnes Creek Tail, and Mt. Rainier Pool. In addition, Rainier Golf Course and Tyee Valley Golf Course would be exposed to 65.6 DNL and 75.5 DNL respectively.

Of the five eligible resources, none contain noise sensitive facilities and are thus, compatible with the respective noise levels.

As is shown in **Table IV.4-1**, by comparing each of the "With Project" alternatives (Alternatives 2, 3, and 4) to the Do-Nothing (Alternative 1), none of the alternatives would result in a 1.5 or more DNL increase at a DOT Section 4(f) site exposed to DNL 65 or greater sound levels.[4/]

As discussed in Appendix E-B (see Table 1) and Chapter IV Section 3, none of the historic properties designated as locally significant by adopted ordinances of Burien, Des Moines, or Normandy Park that are exposed to noise levels of 65 DNL and greater would experience a 1.5 DNL or greater increase under any of the Master Plan Update alternatives for the years 2000, 2010, or 2020. Consequently, they would not be impacted by project improvements.

As indicated in **Table IV.4-1**, none of the parks designated as locally or regionally significant in the adopted ordinances of Burien, Des Moines, or Normandy Park that are exposed to noise levels of DNL 65 or greater under any of Master Plan Update alternatives for 2000, 2010, or 2020 would experience a 1.5 or greater DNL increase. None of the parks designated as locally or regionally significant in the adopted ordinances of Burien, Des Moines, or Normandy Park would be exposed to noise levels exceeding 75 DNL under any of Master Plan Update alternatives for 2000, 2010, or 2020. Additionally, there are no designated parks of local or regional significance with noise-sensitive uses that would be exposed to noise levels exceeding 65 DNL under any of the Master Plan Update alternatives.

Other than noise, no indirect impact of significance to DOT Section 4(f) resources were identified.

There would be no significant adverse effects to Section 4(f) resources. Therefore, no mitigation would be required.

4/ The 1.5 DNL increase for sites affected by DNL 65 and greater is a guideline used by the FAA to determine a significant change in aircraft noise exposure, per FAA Order 5050.4A, Chapter 5, Paragraph 47 e (1) (f).

The Washington State Office of Archaeology and Historic Preservation confirmed that no historical or cultural sites would be directly affected. Therefore no mitigation would be required.

3. Preferred Alternative (Alternative 3)

A total of 9 parks and recreational facilities would be impacted by 65 DNL or greater sound levels with the preferred alternative. Six of the nine facilities are potential Section 4(f) resources: Southern Heights Park (affected by 65-70 DNL), North SeaTac Park (70-75 DNL), Des Moines Creek Park (70-75 DNL), Barnes Creek Nature Trail (65-70 DNL), Mt. Rainier Pool (65-70 DNL) and Zenith Park (65-70 DNL). The three non-eligible resources include: Glen Acres Golf Club, Rainier Golf Club, and Tyee Valley Golf Course. The only park that would be exposed to noise levels of 75 DNL and greater in any future year is Tyee Valley Golf Course, which is not a Section 4(f) land.

Of the three potentially eligible Section 4(f) resources, none contain noise-sensitive facilities; thus, all are considered to be compatible uses. Each of these noise levels represents about a 2-5 DNL decrease over existing conditions. None of the sites within 65 DNL noise exposure would experience a 1.5 or more DNL increase when comparing the Preferred Alternative to the Do-Nothing.[5] Of these three parks, Southern Heights Park would experience no change with the preferred alternative over the Do-Nothing alternative. North SeaTac Park would experience a 0.8 DNL increase in the year 2000, decreasing to a 0.6 DNL increase in year 2020 when comparing the preferred alternative impact to the Do-Nothing. Des Moines Creek Park would experience a 0.7 DNL decrease in noise exposure in year 2000 and a 0.8 DNL decrease in year 2020 with any of the preferred alternative in comparison to the Do-Nothing.

No historical or cultural resources that are eligible or potentially eligible for the State or National Register would experience significant noise impacts. There are no significant adverse effects to Section 4(f) resources. Therefore, no mitigation will be required.

The Washington State Office of Archaeology and Historic Preservation confirmed that no historical or cultural sites will be directly affected. Therefore no mitigation will be required.

(4) CUMULATIVE IMPACTS

As is identified in Chapter III "Affected Environment" a number of non-airport related developments are planned in the airport vicinity. These actions, in combination with the Master Plan Update at Sea-Tac Airport, could affect DOT Section 4(f) land in the airport area. However, until specific project plans are completed for these developments, the total cumulative impacts can not be identified.

(5) MITIGATION

There are no significant adverse effects to Section 4(f) resources. Therefore, no mitigation is expected to be required.

[5] The 1.5 DNL increase is a guideline used by the FAA to determine a significant change in aircraft noise exposure, per FAA Order 5050.4A Paragraph 47(e) (l) (f).

Table IV.4-1
Page 1 of 3

Seattle-Tacoma International Airport
Environmental Impact Statement

DNL NOISE LEVELS IN PARKS AND RECREATIONAL RESOURCES

Park #	Park	Jurisdiction	1994 Exist.	Year 2000 Alt. 1	Year 2000 Alt. 2	Year 2000 Alt. 3	Year 2000 Alt. 4	Year 2010 Alt. 1	Year 2010 Alt. 2	Year 2010 Alt. 3	Year 2010 Alt. 4	Year 2020 Alt. 1	Year 2020 Alt. 2	Year 2020 Alt. 3	Year 2020 Alt. 4
P1	Mt. Baker/Stan Sayres Mem.	Seattle	45.7	42.5	42.6	42.6	42.6	42.6	42.6	42.6	42.6	43.0	43.0	43.0	43.0
P2	Columbia Park	Seattle	51.8	48.3	48.3	48.3	48.3	48.3	48.3	48.3	48.3	48.7	48.7	48.7	48.7
P3	Dearborn Park	Seattle	55.3	51.7	51.7	51.7	51.7	51.7	51.7	51.7	51.7	52.1	52.1	52.1	52.1
P4	Brighton Playground	Seattle	49.8	46.5	46.5	46.5	46.5	46.5	46.5	46.5	46.5	46.9	46.9	46.9	46.9
P5	Maple Wood Playground	Seattle	60.9	57.7	57.8	57.8	57.8	57.9	58.0	58.0	58.0	58.3	58.3	58.3	58.4
P6	Cleveland Playground	Seattle	62.1	59.1	58.9	58.9	58.9	59.4	59.2	59.2	59.2	59.9	59.6	59.6	59.6
P7	S. Homer St. Playground	Seattle	61.3	57.9	58.1	58.1	58.1	58.1	58.3	58.3	58.3	58.4	58.6	58.6	58.6
P8	Van Asselt Playground	Seattle	55.3	51.7	51.7	51.7	51.7	51.7	51.7	51.7	51.7	52.1	52.1	52.1	52.1
P9	Othello Playground	Seattle	45.3	45.3	45.3	45.3	45.3	45.0	45.0	45.0	45.0	45.7	45.6	45.6	45.6
P10	Atlantic City Park	Seattle	44.3	42.5	42.5	42.5	42.5	42.0	42.0	42.0	42.0	43.1	43.0	43.0	43.0
P11	Kubota Gardens	Seattle	46.2	43.5	43.5	43.5	43.5	44.1	44.1	44.1	44.1	45.1	45.1	45.1	45.1
P12	S. Norfolk St. Playground	Seattle	42.8	40.5	40.6	40.6	40.6	41.8	41.8	41.8	41.8	43.2	43.1	43.1	43.1
P13	S. Sullivan St. Playground	Seattle	61.6	57.8	58.5	58.5	58.5	58.0	58.8	58.8	58.8	58.1	58.9	58.9	58.9
P14	Southern Heights Park	King Cnty	70.0	65.5	65.6	65.6	65.6	65.6	65.7	65.7	65.7	65.7	65.9	65.9	65.9
P15	Arbor Lake Park	King Cnty	60.2	55.2	55.6	55.6	55.6	55.5	56.0	56.0	56.0	55.5	56.0	56.0	56.0
P16	Westcrest Park	Seattle	54.1	50.3	50.5	50.5	50.5	50.6	50.8	50.8	50.8	50.8	51.0	51.0	51.0
P17	White Center Heights Park	King	52.8	49.1	49.3	49.3	49.3	49.6	49.8	49.8	49.8	49.6	49.7	49.7	49.7
P18	White Center Park	King	49.3	46.5	46.7	46.6	46.8	47.3	47.4	47.4	47.5	47.3	47.3	47.3	47.4
P19	Lakewood Park	King Cnty	52.3	48.6	48.8	48.8	48.8	49.2	49.4	49.4	49.4	49.2	49.3	49.3	49.3
P20	Salmon Creek Park	Burien	52.5	48.9	49.3	49.2	49.3	49.5	49.7	49.7	49.8	49.8	49.8	49.8	49.8
P21	S. 133rd St. Park	Tukwila	53.7	48.9	49.1	49.1	49.1	49.1	49.3	49.3	49.3	49.8	50.0	50.0	50.0
P22	Southgate Park	Tukwila	54.6	49.8	49.8	49.8	49.8	49.7	50.0	50.0	50.0	50.4	50.7	50.7	50.7
P23	Crystal Springs Park	Tukwila	51.9	48.3	47.7	47.7	47.7	48.7	48.1	48.1	48.1	49.7	49.0	49.0	49.0
P24	Crestview Park	Tukwila	53.2	50.2	49.3	49.3	49.3	50.6	49.6	49.6	49.6	51.6	50.4	50.4	50.4
P25	Bow Lake Park	Tukwila	51.8	47.0	47.0	47.0	47.0	47.3	47.3	47.3	47.3	48.2	48.2	48.2	48.2
P26	Hilltop Park	King Cnty	62.8	58.6	58.7	58.7	58.7	58.7	58.8	58.8	58.8	59.2	59.2	59.2	59.2
P27	S. 142nd St. Park	SeaTac	62.8	59.0	59.1	59.1	59.1	59.2	59.3	59.3	59.3	59.5	59.6	59.6	59.6
P28	North SeaTac Park	SeaTac	74.2	70.6	71.2	71.2	71.2	70.8	71.5	71.5	71.5	71.3	71.9	71.9	71.9
P29	Mosier Park	Burien	62.4	58.3	59.9	59.9	59.9	59.1	60.4	60.4	60.4	60.5	61.4	61.4	61.0

Table IV.4-1
Page 2 of 3

Seattle-Tacoma International Airport
Environmental Impact Statement

DNL NOISE LEVELS IN PARKS AND RECREATIONAL RESOURCES

			1994	Year 2000				Year 2010				Year 2020			
Park #	Park	Jurisdiction	Exist.	Alt. 1	Alt. 2	Alt. 3	Alt. 4	Alt. 1	Alt. 2	Alt. 3	Alt. 4	Alt. 1	Alt. 2	Alt. 3	Alt. 4
P30	Hazel Valley Park	King Cnty	56.3	51.8	52.2	52.1	52.2	52.0	52.3	52.3	52.4	52.3	52.6	52.6	52.7
P31	Ed Munro Seahurst Park (N)	Burien	50.4	48.7	51.9	51.9	51.4	50.0	52.9	52.9	52.4	51.7	53.8	53.8	53.3
P31	Ed Munro Seahurst Park (S)	Burien	51.3	47.7	48.7	48.7	48.5	48.5	49.4	49.4	49.2	49.8	50.4	50.4	50.2
P32	Chelsea Park	Burien	54.6	51.8	53.9	53.9	53.6	52.6	54.5	54.5	54.2	54.0	55.1	55.1	54.9
P33	Burien Park	Burien	56.4	52.7	54.7	54.7	54.7	53.7	55.4	55.4	55.4	55.2	56.3	56.3	56.1
P34	Lakeview Park	Burien	58.2	55.2	56.1	56.1	56.1	55.9	56.7	56.7	56.7	57.4	57.8	57.9	57.4
P35	Kiwanis Park	Kent	57.0	53.9	55.0	55.0	55.0	54.5	55.5	55.5	55.5	55.7	56.4	56.4	56.1
P36	City Hall Park	Norm. Park	55.2	51.5	51.7	51.7	51.7	51.9	52.2	52.2	52.2	52.7	53.1	53.1	53.2
P37	Private Park	Norm. Park	53.1	50.1	49.7	49.7	49.7	50.5	50.3	50.3	50.3	51.3	51.2	51.2	51.3
P38	Valley Ridge Park	SeaTac	57.1	51.8	51.7	51.7	51.7	52.1	52.1	52.1	52.1	53.1	52.9	52.9	52.9
P39	Brisco Meander Park	Kent	49.2	44.7	44.6	44.6	44.6	45.0	44.8	44.8	44.8	45.9	45.7	45.7	45.7
P40	Van Dorans Landing Park	Kent	53.4	50.2	50.0	50.0	50.0	49.6	49.0	49.0	49.0	49.9	49.4	49.4	49.4
P41	Grandview Park	SeaTac	57.8	54.5	53.5	53.5	53.5	54.4	53.6	53.6	53.6	55.2	54.3	54.3	54.3
P42	West Canyon Park	Kent	54.5	51.6	50.9	50.9	50.9	51.7	51.1	51.1	51.1	52.6	52.0	52.0	52.0
P43	Angle Lake Park	SeaTac	66.2	61.3	60.2	60.2	60.2	61.7	60.5	60.5	60.5	62.3	61.1	61.0	61.0
P44	Des Moines Creek Park	SeaTac	75.6	71.6	70.9	70.9	70.9	71.6	70.8	70.8	70.8	71.8	71.0	71.0	71.0
P45	Des Moines Beach Park	Des Moines	61.9	57.7	58.5	58.5	58.5	57.6	58.6	58.6	58.6	57.9	58.8	58.8	58.8
P46	Des Moines Park	Des Moines	63.9	59.5	60.6	60.6	60.6	59.6	60.8	60.8	59.8	60.9	60.9	60.9	60.9
P47	Nature Trails Park	Norm. Park	54.0	52.4	53.8	53.8	53.8	53.3	54.4	54.3	54.4	54.7	55.5	55.5	55.5
P48	Normandy Park	Norm. Park	55.4	52.7	54.5	54.5	54.5	53.2	54.5	54.4	54.5	54.0	55.0	55.0	55.0
P49	Marine View Park	Norm. Park	53.9	52.0	51.3	51.3	51.3	50.8	51.1	51.1	51.1	52.1	51.6	51.6	51.6
P50	Fishing Hole Park	Kent	51.8	49.3	48.4	48.4	48.4	49.5	48.7	48.7	48.7	50.6	49.7	49.7	49.7
P51	Lake Fenwick Park	Kent	52.6	48.8	48.0	48.0	48.0	49.0	48.3	48.3	48.3	49.7	48.9	48.9	48.9
P52	Linda Heights Park	Kent	60.0	55.6	54.9	54.9	54.9	55.7	55.0	55.0	55.0	56.1	55.3	55.3	55.3
P53	Parkside Park	Des Moines	66.1	62.0	61.1	61.1	61.1	62.0	61.1	61.1	61.1	62.2	61.2	61.2	61.2
P54	Parkside Wetlands	Des Moines	66.3	62.2	61.4	61.4	61.4	62.2	61.4	61.4	61.4	62.4	61.5	61.5	61.5
P55	Glenn Nelson Park	Kent	61.2	56.5	55.8	55.8	55.8	56.6	55.9	55.9	55.9	56.8	56.1	56.1	56.1
P56	Saltwater State Park	Des Moines	60.9	57.4	58.1	58.1	58.1	57.6	58.3	58.3	58.3	57.8	58.4	58.4	58.4
P57	Woodmont Park	King Cnty	63.0	59.5	59.8	59.8	59.8	59.8	60.1	60.1	60.1	60.0	60.2	60.2	60.2
P58	Woodmont Beach	King Cnty	58.3	54.6	55.3	55.3	55.3	54.8	55.6	55.6	55.6	55.0	55.6	55.6	55.6

Table IV.4-1
Page 3 of 3

Seattle-Tacoma International Airport
Environmental Impact Statement

DNL NOISE LEVELS IN PARKS AND RECREATIONAL RESOURCES

Park #	Park	Jurisdiction	1994 Exist.	Year 2000 Alt. 1	Year 2000 Alt. 2	Year 2000 Alt. 3	Year 2000 Alt. 4	Year 2010 Alt. 1	Year 2010 Alt. 2	Year 2010 Alt. 3	Year 2010 Alt. 4	Year 2020 Alt. 1	Year 2020 Alt. 2	Year 2020 Alt. 3	Year 2020 Alt. 4
P59	Camelot Park	King Cnty	56.6	50.2	49.5	49.5	49.5	50.2	49.6	49.6	49.6	50.6	50.1	50.1	50.1
P60	A Park in Federal Way	Federal Way	64.1	59.7	59.1	59.1	59.1	59.7	59.1	59.1	59.1	59.8	59.3	59.3	59.3
P61	Wildwood Park	Federal Way	62.5	58.7	58.3	58.3	58.3	58.1	58.2	58.2	58.2	59.3	58.6	58.6	58.6
P62	Sacajawea Playground	Seattle	60.3	57.7	57.8	57.8	57.8	58.1	58.2	58.2	58.2	58.4	58.4	58.4	58.4
P63	Steel Lake Park	Federal Way	60.3	56.8	56.5	56.5	56.5	56.9	56.5	56.5	56.5	57.3	56.7	56.7	56.7
P64	Barnes Creek Nature Trail	Des Moines	68.2	64.4	64.8	64.8	64.8	64.5	64.9	64.9	64.9	64.7	65.0	65.0	65.0
P65	Big Catch Plaza	Des Moines	61.7	57.5	58.3	58.3	58.3	57.4	58.4	58.4	58.4	57.7	58.5	58.5	58.5
P66	Cecile Power Park	Des Moines	64.0	60.6	61.1	61.1	61.1	60.8	61.3	61.3	61.3	61.1	61.4	61.4	61.4
P67	Des Moines City/Kiddie Park	Des Moines	69.1	64.8	63.8	63.8	63.8	64.7	63.7	63.7	63.7	64.9	63.9	63.9	63.9
P68	Des Moines Marina	Des Moines	58.3	54.2	55.0	55.0	55.0	54.3	55.2	55.2	55.2	54.5	55.3	55.3	55.3
P69	Des Moines Marina Pier	Des Moines	57.3	53.2	53.9	53.9	53.9	53.2	54.0	54.0	54.0	53.5	54.2	54.2	54.2
P70	Des Moines Memorial Park	Burien	64.8	60.2	62.2	62.2	62.2	60.8	62.7	62.7	62.7	62.0	63.5	63.5	63.3
P71	Midway Park	Des Moines	65.3	60.6	59.3	59.3	59.3	60.7	59.4	59.4	59.4	61.0	59.7	59.7	59.7
P72	Mt. Rainier Pool	Des Moines	71.6	67.8	67.5	67.5	67.5	67.9	67.6	67.6	67.6	68.1	67.8	67.8	67.8
P73	Overlook Park 1	Des Moines	59.2	54.9	55.8	55.8	55.8	55.1	56.0	56.0	56.0	55.3	56.1	56.1	56.1
P74	Overlook Park 2	Des Moines	59.2	55.0	55.8	55.8	55.8	55.1	55.9	55.9	55.9	55.3	56.1	56.1	56.1
P75	Redondo Waterfront/Wooton	Des Moines	57.9	54.6	55.1	55.1	55.1	54.9	55.4	55.4	55.4	55.0	55.5	55.5	55.5
P76	Sonju Park	Des Moines	67.6	64.2	64.0	64.0	64.0	64.4	64.2	64.2	64.2	64.7	64.4	64.4	64.4
P77	S. 239th St. Beach	Des Moines	59.2	55.4	56.3	56.3	56.3	55.6	56.5	56.5	56.5	55.8	56.7	56.7	56.7
P78	South Marina Park	Des Moines	59.2	55.0	56.0	56.0	56.0	55.2	56.2	56.2	56.2	55.4	56.3	56.3	56.3
P79	Zenith Park	Des Moines	66.8	63.7	63.9	63.9	63.9	63.9	64.0	64.0	64.0	64.2	64.2	64.2	64.2
G1	Jefferson Park Golf Course	Seattle	59.5	56.8	56.7	56.7	56.7	57.1	57.1	57.1	57.1	57.8	57.7	57.7	57.7
G2	Glen Acres Golf Club	King Cnty	66.7	63.1	63.4	63.4	63.4	63.3	63.6	63.6	63.6	63.5	63.9	63.9	63.9
G3	Rainier Golf Course	King Cnty	68.1	64.7	64.9	64.9	64.9	64.9	65.1	65.1	65.1	65.4	65.6	65.6	65.6
G4	Foster Golf Links (North)	Tukwila	48.4	43.5	43.7	43.7	43.7	43.8	43.9	43.9	43.9	44.8	44.9	44.9	44.9
G4	Foster Golf Links (South)	Tukwila	47.1	42.3	42.4	42.4	42.4	42.6	42.7	42.7	42.7	43.7	43.7	43.7	43.7
G5	Tyee Valley Golf Course	SeaTac	79.6	75.9	75.4	75.4	75.4	75.8	75.1	75.1	75.1	76.2	75.5	75.5	75.5
G6	Riverbend Golf Complex (N)	Kent	52.4	49.7	49.0	49.0	49.0	50.0	49.3	49.3	49.3	51.0	50.3	50.3	50.3
G6	Riverbend Golf Complex (S)	Kent	49.6	47.7	47.3	47.3	47.3	47.9	47.7	47.7	47.7	49.1	48.9	48.9	48.9

Source: Shapiro and Associates, Inc., 1995

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Seattle-Tacoma International Airport
Environmental Impact Statement
for the Master Plan Update

Exhibit IV.4-1

Parks and Section 4(f) Lands

Section 4(f) Park/Recreation Area

Non-Section 4(f) Park/Rec. Area

Source: Gambrell Urban, Inc. and
Shapiro & Associates, 1994
Part 150 Noise Exposure Map Update, 1991
Thomas Brothers Map Guide, 1994

Scale 1" = 6,000

CHAPTER IV, SECTION 5

PRIME AND UNIQUE FARMLAND

Throughout the 20th century, the nation's prime and unique farmland has decreased dramatically because of urban development throughout the country. In response, the U.S. Department of Agriculture Soil Conservation Service (SCS) has attempted to identify and preserve such land for agricultural purposes. The Farmland Protection Policy Act (FPPA) of 1981 was enacted to minimize the extent to which federal programs contribute to unnecessary and irreversible conversion of farmland to non-agricultural uses. This section discusses the impact of the Master Plan Update alternatives on prime and unique farmland. No prime or unique farmlands were identified within the acquisition or construction areas of any "With Project" alternative. Thus, no such farmlands would be affected.

(1) METHODOLOGY

The area considered for impacts to prime and unique farmlands includes lands potentially requiring acquisition in fee simple, purchase of easements which change land use, or relocation of people, improvements, or economic activities resulting from the proposed alternatives. Areas where soundproofing measures are under way or where the Port of Seattle acquired aviation easements would not be considered prime farmland; nor would properties involved in the Sales Assistance Program, provided those properties remain in private hands. Agricultural land in this area was then evaluated to determine its eligibility for protection under the FPPA.

(A) Eligibility Criteria for FPPA Lands

If a proposed Federal action involves farmland acquisition that will be converted to a non-agricultural use, it must be determined whether any of that land is protected by FPPA. Protected farmlands under FPPA comprise either (1) prime farmlands (i.e., those that have the best physical and chemical characteristics for producing items such as food, feed, or fiber and which have not already been targeted for urban development or water storage); or (2) unique farmlands, determined to be of state or local importance according to the appropriate state or local agency with the concurrence of the U.S. Secretary of Agriculture. Generally, the FPPA is not applicable if:[1]

1) The land was purchased before August 6, 1984, for the purposes of redevelopment. In other words, land is not considered prime farmland if it has been committed to urban development (i.e., commercial, industrial or residential).
2) The acquired area does not directly or indirectly convert farmland. Indirect conversion includes using farmland in such a way as to preclude the land from being farmed or plans to convert the land within the foreseeable future.
3) The land is not defined as prime farmland by the FPPA. That is, "...land that has the best combination of physical and chemical characteristics for producing food, feed, fiber ... without intolerable soil erosion as determined by the Secretary (of Agriculture). Prime farmland includes land that possesses the above characteristics but is being used currently to produce livestock and timber. It does not include land already in or committed to urban development or water storage." Urban development is defined as land with a density of 30 structures in each 40-acre area.
4) The land is not unique farmland (i.e., land other than prime farmland that is used for production of specific high-value food and fiber crops, as determined by the Secretary). Unique farmlands must economically sustain high quality and high yields of specific crops and be managed according to acceptable farming methods.

[1] FAA Order 5050.4A, "Airport Environmental Handbook", Federal Aviation Administration, 1985.

5) The land has not been determined by a state or local agency to be of statewide or local importance, with concurrence of the Secretary of Agriculture.

(2) EXISTING CONDITIONS

The only agricultural land use that currently exists in the immediate airport area is the Felix Vacca Farm, located at 15208 Des Moines Avenue S. in the City of SeaTac. Although currently in farm use, the Vacca Farm property is zoned residential non-farm use (RM-900) and is considered a legal non-conforming use by the City of SeaTac.[2] According to City officials, the Vacca farm is the City's only active farm operation.

(3) FUTURE CONDITIONS

In the future, impacts on prime and unique farmland would be expected to change as follows:

(A) Do-Nothing (Alternative 1)

As the Do-Nothing alternative would not result in any acquisition of land, no impacts to prime or unique farmland would result.

(B) "With Project" Alternatives (Alternatives 2, 3, and 4)

The Vacca Farm would be acquired through implementation of any of the "With Project" alternatives. The Vacca Farm does not qualify for protection under FPPA criteria either as a prime farmland or as a unique farmland. First, it is not considered a prime farmland, as the site has been rezoned to non-farm use. Moreover, the farm is used as a small pumpkin patch and market, rather than as an economically viable crop, producing a high-yield harvest. Pumpkins are not included in the FPPA list of economically viable crops. Economically viable crops include citrus fruits, tree nuts, olives, cranberries, fruits, and vegetables that are consumed in great volumes.

Secondly, Vacca Farm fails to meet the criteria of a unique farmland, which is based on local cultural significance. After completion of an initial field investigation and classification of all structures that are 50 years and older was completed, preliminary assessments indicated that none of the sites, including Vacca Farm, met the criteria for eligibility for inclusion in the State or National Register.

There are no agricultural lands in the City of Burien portion of the area that would be acquired to complete the "With Project" alternatives. As a result, no prime and unique farmland would be affected under any of the Master Plan Update alternatives.

(C) Preferred Alternative (Alternative 3)

As noted earlier, the "With Project" alternative, including the Preferred Alternative, would not result in prime and unique farmland impacts.

(4) CUMULATIVE IMPACTS

As no prime or unique farmland exist in the immediate airport area, no cumulative direct impacts would be expected. Indirect cumulative impacts could occur through the construction of other urban development in the Region.

(5) MITIGATION MEASURES

As no impacts to prime or unique farmland would exist with the propose Master Plan Update alternatives, no mitigation is necessary.

[2] Letter from Michael Booth, City of SeaTac Senior Planner, City of SeaTac, December 12, 1994.

CHAPTER IV, SECTION 6
SOCIAL IMPACTS

The primary purpose of this section is to examine the potential effect of the Master Plan Update alternatives on adjacent residential communities, and businesses. Social impacts considered in this section include the following: residential and business displacement, and disruption of existing communities and planned development. Impacts on surface transportation are also considered to be social impacts; however, they are addressed separately in Chapter IV, Section 15, "Surface Transportation".

The following number of properties could be acquired under the "With Project" alternatives to complete construction, to clear the runway protection zones (RPZs), and to mitigate adverse environmental impacts:

8,500-ft	Number to be Acquired: Single Family	Condos/ Apartments	Business
Runway related:			
Alternative 1	0	0	0
Alt. 2, 3, & 4	388	260	105
Non-Runway related:			
Alternative 1	3	0	0
Alternative 2 & 3	3	0	0
Alternative 4	3	0	12

Note: The acquisition noted above assumes development of a new runway length up to 8,500 feet.

If a proposed new 7,000-foot parallel runway were constructed, 348 single-family residences, 26 apartment or condominium units, and 96 businesses would be acquired. A 7,500-foot runway would require the acquisition of 361 single-family residences, 26 apartments or condominiums units, and 104 businesses. Under any of the "With Project" alternatives, some vacant parcels would also be acquired. All acquisition would comply with the Uniform Relocation Act.[1]

(1) METHODOLOGY

In evaluating the impact of acquisition on the social fabric of the airport environs, the following types of acquisition were considered:

- Primary - the area necessary to physically construct elements of an alternative;
- RPZ - the area encompassed by the Runway Protection Zone. FAA standards for this area indicate that such properties must not obstruct the approach/departure activity from a runway end. Thus, in some instances, depending upon terrain, acquisition may not be necessary if no obstructions would occur.
- Mitigation - the area acquired exclusive of the primary and RPZ acquisition, to mitigate for adverse impacts of construction. The mitigation area is located to the west of the primary acquisition area and east of SR509 and Des Moines Memorial Drives. SR509 and Des Moines Memorial Drives would be considered an existing boundary which would protect properties to the west from adverse impacts and also minimize splitting of neighborhoods.

Land parcels to be acquired in these three areas were identified using September 1994, King County Assessor's Office data and the Seattle Common Land Database. A list and map of those properties were generated for use in this analysis.

(2) EXISTING CONDITIONS

The urban residential area surrounding the Airport experienced substantial growth from the 1940s to the 1960s. Residential growth has slowed since the mid-1970s.[2]

To mitigate for adverse noise impacts, the Port of Seattle has acquired a substantial number of homes immediately north and south of Sea-Tac. The Port's Acquisition and Relocation Program (a part of the Port's Noise Remedy Program) has resulted in the fair market value purchase of the most severely noise-impacted homes. Relocation

1/ U.S. Department of Transportation, 49 CFR Part 24.

2/ *Sea-Tac Area Update Draft EIS*, King County Planning and Community Development, 1988.

assistance has been provided by the Port to these occupants. Vacated houses have either been resold and removed from the property or demolished. The land is then held in reserve for future compatible uses, such as the North SeaTac Park, located north of the Airport and SR 518. Under the *Sea-Tac Communities Plan of 1974*, approximately 950 houses were designated for acquisition; in 1985 the Part 150 Program added approximately 400 more houses to the acquisition list of the noise remedy program and the purchase assurance program was started. A total of 1,328 acquisitions was completed between 1974 and 1993. The Port's Noise Remedy Program completed the planned acquisition in 1994 and is currently focusing on insulating noise-impacted residences. The residential portion of the noise remedy program (which presently consists of home sound insulation) is scheduled to be completed by 2000, with schools and public buildings anticipated to be completed by 2003.[3]

The general study area is made up of 38 census tracts, shown in **Exhibit IV.6-1. Table IV.6-1** presents socio-economic data, by census tract, within the study area based on 1990 census data.

Median household income of the study area ranges from $15,900 in tract #110 (east of Boeing Field) to $53,395 in tract #286 (Normandy Park). The non-white population varies from 5.9 percent in tract #286 to 84.1 percent in tract #110. The over 65 years of age ("Elderly") population ranges from 3.8 percent in tract #299 (in unincorporated King County) to 26.6 percent in tract #290.01 (in Des Moines).

The immediate environs of the Airport consists of eight census tracts. Census tracts #274, #280, and #285 are primarily in Burien, tracts #273, #281, #284.01, and #288.01 are primarily in the City of SeaTac, and tract #287 is primarily in unincorporated King County. The tracts also include sections of Tukwila and Des Moines.

A total of 27,067 people live in the eight census tracts, as listed in **Table IV.6-2**. Fifty-nine percent of those people own their residence, while the remaining 41 percent rent. Median income ranges from $26,339 in tract #284.01 to $39,272 in tract #287. The non-white population varies from 6.4 percent in tract #287 to 20.5 percent in tract #284.01 (tract #284.01 contains only 474 persons). The over 65 years of age population ranges from 4.9 percent in tract #284.01 to 17 percent in tract #288.01. The overall residential (single and multi-family) vacancy rate for the eight census tracts in 1993 was 3.8 percent.[4] The vacancy rate for apartments in the SeaTac area was reported as 7 percent by the Seattle Times October 22, 1995. The newspaper article was based on a semi-annual apartment vacancy survey conducted by Dupre + Scott Apartment Advisors, Incorporated for the entire Region which compiles information reported by companies managing buildings with 20 or more units. A more detailed breakdown of social and housing characteristics of the immediate airport area, by tract, is listed in **Table IV.6-2.**

(3) FUTURE CONDITIONS

The following sections summarize the potential social impacts of each Master Plan Update alternative for the years 2000, 2010 and 2020. **Exhibit IV.6-2** shows the acquisition areas. **Table IV.6-4** lists the owners of the parcels that could be acquired to complete the Master Plan Update alternatives. At this time, all parcels encompassed by the Runway Protection Zone (RPZ) for the new parallel runway are included in the listing. FAA guidelines recommend that these areas be acquired or be under the control of the Airport Operator. As commercial development is compatible with the noise levels experienced in these areas, the Port may acquire avigation easements from these owners rather than acquire outright.

(A) Do-Nothing (Alternative 1)

Major property acquisition and displacements of residences and businesses would not occur under the Do-Nothing Alternative. Depending upon the outcome of the West SeaTac Subarea planning process (see Chapter IV, Section 2 "Land Use"), the West SeaTac community could experience a gradual transition from residential to business park use or other nonresidential uses more compatible with Airport operations, or it could remain in residential use for current or greater density.

Three residential properties associated with the South Aviation Support Area require acquisition.

[3] Phone conversation with Earl Munday, Port of Seattle Noise Remedy Office. October 25, 1995.

[4] *PSRC Economic and Demographic Database for 1993*, Puget Sound Regional Council, 1994.

AR 038978

The roadway project that is likely to have the greatest impact on the social character of the Airport area is the development of a South Airport Access Road (also called the SR 509 extension). From 55 to 184 single family residences, 55 to 209 multi-family units, 11 to 15 mobile homes, and 9-30 businesses (depending on the alternative) could be acquired in the cities of Des Moines and SeaTac by SR509/South Access.[5]

(B) **"With Project" Alternatives (Alternatives 2, 3, and 4)**

Table IV.6-3 provides a summary of the residential and commercial parcels that would be acquired under Alternatives 2, 3, and 4. The acquisition among the alternatives associated with the new parallel runway is the same. The terminal development associated with the South Unit Terminal (Alternative 4) is the only other acquisition that would be incurred with the "With Project" alternatives. **Table IV.6-4** provides a list of the properties—by owner, address, and land use—which would be acquired under Alternatives 2, 3, and 4.

Acquisition of property can be accomplished through purchase; condemnation (also known as eminent domain, a right of the government to take private property for public use by virtue of the superior dominion of the government over land within its jurisdiction); or establishment of an easement, by donation, or exchange. Unless received by donation, acquisition of private property requires the payment of just compensation to the property owner. It is expected that the majority of the property acquired for construction of the new parallel runway or establishment of RPZ areas will be acquired through outright (or fee simple) purchase of property; regardless, all property acquisitions will comply with the Uniform Relocation Assistance Act.

1. **Displacements**

Alternative 2 (Central Terminal) with New Runway Length 8,500 feet: This alternative, with a proposed new parallel runway of 8,500 feet in length, would require acquisition as shown in **Exhibit IV.6-2.** No acquisition would be required for the terminal area expansion. A total of 648 residential units and 105 businesses would be displaced by this alternative, as shown by category in **Table IV.6-3.** Also, 87 vacant residentially zoned and 5 vacant commercially zoned parcels would be acquired. The 648 residential units include 388 single-family residential units and 260 apartment or condominium units, including the 234 units at Lake Lora Apartments. This apartment complex is located in the runway protection zone of the proposed new parallel runway.

Alternative 2 with New Runway Length 7,500 feet: The future impacts of this runway option would be similar to those found under the 8,500-foot option, except that 27 fewer single-family residences, 234 fewer apartments or condominium units, and one less business would be acquired. Six fewer vacant residential parcels would be acquired. The acquisition area for the 7,500 foot runway is shown in **Exhibit IV.6-3.**

Alternative 2 with New Runway Length 7,000 feet: The future impacts of this runway option would be similar to those found under the 8,500-foot option, except that 40 fewer single-family residences, 234 fewer apartments or condominium units, and 9 fewer businesses would be displaced. Seven fewer vacant residential parcels would be displaced. The acquisition area for the 7,000 foot runway is shown in **Exhibit IV.6-4.**

Alternative 3 (North Unit Terminal) All Runway Lengths: The impacts of Alternative 3 would be the same as those resulting from the implementation of Alternative 2 except in the terminal area. An additional displacement of the Doug Fox parking facility (land owned by the Port) would occur as a result of the expansion of the North Satellite and the new North Unit Terminal.

Alternative 4 (South Unit Terminal) All Runway Lengths: The impacts of Alternative 4 would be the same as those resulting from implementation of Alternative 2 except in the terminal area. An additional 12 commercial properties (including the West Coast Hotel, Pizza Hut, Dennys, Jack in the Box, and other businesses) would be affected north of S.

[5] SR509/South Access Draft EIS, issued December 1995.

188th Street and west of International Blvd.

In 1990, there were an estimated 10,189 housing units in the City of SeaTac.[6] Approximately 6 percent of all housing units in the City of SeaTac would be potentially displaced by alternatives with an 8,500 foot runway. Relocations of this magnitude have occurred in the past as a result of airport relocation projects and comparable housing in nearby areas have been found. The current Port of Seattle estimated time line for acquisition would be three to four years. The acquisition would most likely start soon after receipt of environmental approval. The estimated acquisition period of three to four years is based on the Port of Seattle's typical acquisition rate of about 10 residences per month, which has been the norm for the previous acquisition program. Acquisition would be completed in groups and would most likely start at properties nearest the Airport and proceed west. A specific schedule for acquisition would be established in advance, as required by the Uniform Relocation Assistance Act. The current noise remedy program is not anticipated to be affected by implementation of the proposed new parallel runway, and the schedule for that program will proceed regardless of the outcome of this study.

With consideration given to the 3.8 percent vacancy rate[7] in the SeaTac area, and the fact that some people may choose to leave the area, it appears that SeaTac, Des Moines, Kent, Federal Way, and other nearby communities, contains adequate comparable housing stock or developable land to absorb the demand created by displacements under any of the alternatives. However, finding replacement housing within the City of SeaTac for all displaced residents likely would not be possible. Generally, construction of single family housing in the City of SeaTac has declined in recent years. Further decreases in single family housing are likely if land located along SR 99 is rezoned for Central Business District or Aviation Business Center use. In addition, the results of current planning for the West SeaTac subarea also may affect the availability of single family housing in the City. Local real estate agent sources indicate that if the housing market continues at its present course, and relocations occur over a period of two to four years, relocation of residents to similar housing in nearby areas would be feasible.[8]

2. <u>Disruption of Community Character</u>

The greatest disruption of community character would occur in the primary acquisition area, located within the West SeaTac neighborhood, to the west of the Airport. This disruption would occur equally for all of the "With Project" alternatives. Construction of the new parallel runway, with a 2,500 ft separation, would result in the displacement of a substantial portion of the West SeaTac area between 12th Avenue S. and SR 509.

The acquisition and relocation of established residences and expansion of the Airport west of its present location would alter existing community character, which is primarily single-family residential. Areas of displacement would be converted from residential use to primarily Airport and industrial/ commercial uses and possibly some park/recreation/open space uses. SR 509 and Des Moines Memorial Drive South would be the western boundary of the acquisition area and would serve as a buffer for remaining residences to the west of SR 509 and Des Moines Memorial Drive South. Community cohesion in the West SeaTac area would be affected as residents relocate, disengage from the community, and establish ties to other neighborhoods and communities. Residences that remain on the west side of SR 509 and Des Moines Memorial Drive South would notice the effects of acquisition on the east side of SR 509 and Des Moines Memorial Drive

[6] City of SeaTac Comprehensive Plan, *Final Environmental Impact Statement*, City of SeaTac, January, 1995.

[7] *PSRC Economic and Demogrphic Database for 1993*, PSRC, 1994.

[8] Phone conversation with Don Greenup, Real Estate Agent, All American Realtors, January 18, 1995.

South visually. Conversion of some of the acquired land to park or open space areas would help to counteract some of the potential losses in community cohesion by providing a location for other community activities.

Typically after a public works program has been announced, residents voice concerns about the impact of the announced plan on property values. Residences in the area needed to build the proposed runway will be acquired at fair market value and residents relocated in accordance with the Uniform Act. The Port anticipates that acquisition can be completed in a 4 year period.

No minority, age or income group would be disproportionately affected by displacements that would occur as a result of the "With Project" alternatives. Likewise, such groups are not currently disproportionately affected by the noise environment of the Airport, nor would any be disproportionately adversely affected in the future. This conclusion is based on the finding of eight census tract population, as shown in **Table IV.6-2**[9] and illustrated in **Exhibit IV.6-1** as well as a more detailed census block level analysis. Using the King County average non-white figure of 15.3 % as a basis for comparison, **Exhibit IV.6-1** compares census tract non-white percentages to primary, runway protection zone, and mitigation displacement areas and projected Ldn noise contours. Noise contours generated for the "With Project" alternatives do not appear to disproportionately affect any minority groups. Furthermore, 1990 census data for the acquisition areas analyzed on a block level produced the following racial breakdowns: White, 91%; Hispanic, 4%; Asian, 3%; Black, 2%; American Indian, 2%; Other 2%.[10] The population in the acquisition areas is approximately 9% non-white, which is less than the King County average of 15.3%. Analysis also shows that approximately 10% of the population is elderly (65 years and older) and another 14% is school-age (5 to 17 years old).

Therefore, it is concluded that all of the alternatives would meet the intent of Executive Order 12898.[11]

3. Disruption of Planned Development

The compatibility of the Master Plan Update alternatives with the new City of SeaTac Comprehensive Plan (adopted December 20, 1994) and the West SeaTac Subarea Planning Process is discussed in Chapter IV, Section 2 "Land Use". The West SeaTac Planning process is continuing and is expected to be completed in Spring of 1996.

4. Affordable Housing in West SeaTac Acquisition Area

The King County Growth Management Planning Council's Countywide Planning Policies have established targets for affordable housing in King County. The targets aim for 20% of new units to be affordable to households earning below 50% of the King County median income, and for another 17% of new units to be affordable to households earning between 50% and 80% of King County median income. Housing that costs no more than 30% of gross monthly income per month is considered affordable.

As part of its 1994 Comprehensive Plan, the City of SeaTac documented city- and county-wide affordability issues. They noted that households earning below 50% of the median income in King County can afford houses up to $81,300 or rent and utility payments of $452 per month; households earning between 50% and 80% of median income in King County can afford houses between $81,300 and $130,100, or rent and utility payments of $724 a month. The City of SeaTac has a set target of 198 new housing units affordable to people making 50% of the median income and 168 new housing units affordable to people making between 50% and 80% of the median

[9] *PSRC Economic and Demographic Database for 1993*, 1994.

[10] Note: Percentages do not add to 100% because of the overlap of census racial parameters

[11] Executive Order 12898, "Environmental Justice".

income for a total of 366 affordable housing units by the year 2000.

For this EIS, affordable housing is considered housing affordable to households with 80% of the median income in King County. 1990 census block data for the acquisition areas were analyzed to estimate the quantity of affordable housing affected by acquisition. Census block data were factored to match acquisition areas. Using this type of analysis, it is estimated that approximately 77% of the houses in the acquisition areas would be considered affordable, and 91% of the apartments in the acquisition area would be considered affordable. This translates to between 270 to 300 acquired affordable houses and 24 to 237 acquired affordable apartments or condominiums under the "With Project" alternatives.

5. **Development Potential of West SeaTac Acquisition Area**

In the Do-Nothing Alternative, residents located in the West SeaTac Subarea would not be acquired, as the proposed third parallel runway would not be undertaken. This area is a well established residential neighborhood. Thus, without airport development, it is not likely to undergo significant re-development pressures. Gradual re-development might be expected, as residents make home improvements and replace aging housing stock.

As a consequence of the "With Project" alternatives, some vacant land would result in the acquisition area for the proposed new parallel runway. This land would have excellent development potential for airport compatible uses (as noted on the official future airport layout plan). At this time the Port of Seattle does not have specific development plans for these areas and is coordinating with the City of SeaTac in the development of the West SeaTac Subarea Plan.

(C) **Preferred Alternative (Alternative 3)**

As is described in Chapter II, the Port of Seattle staff have recommended the implementation of Alternative 3 (North Unit Terminal) with a new parallel runway with a length of 8,500 feet. **Table IV.6-3** contrasts the acquisition associated with the Preferred Alternative with the other alternatives assessed.

1. **Displacements**

A total of 649 residential units and 105 businesses would be displaced by this alternative. The 649 residential units include 389 single-family residential units and 260 apartment or condominium units, including the 234 units at Lake Lora Apartments. This apartment complex is located in the runway protection zone of the proposed new parallel runway. An additional displacement of the Doug Fox parking facility (land owned by the Port) would occur as a result of the new North Unit Terminal.

Approximately 4 percent of all housing units in the City of SeaTac would be acquired by the completion of the proposed new parallel runway. Port of Seattle officials estimate that acquisition could be completed within three to four years of a decision of project go-ahead.

With consideration given to the 3.8 percent vacancy rate in the area, and the fact that some people may choose to leave the area, it appears that nearby neighborhoods would be able to absorb the displaced residents. Local real estate agent sources indicate that if the housing market continues at its present course, and relocation occur over a period of two to four years, relocation of residents to similar housing in to nearby areas would be feasible.

The Port of Seattle proposes to purchase avigation easements from commercial properties located in the runway protection zone (RPZ) of the proposed new parallel runway, unless the uses on such properties conflict with the safety guidelines for RPZs. However, for purposes of conducting a worst-case analysis, this EIS assesses the impacts of purchasing and relocating these businesses.

AR 038982

2. **Disruption of Community Character and Environmental Justice**

The greatest disruption of community character would occur in the primary acquisition area, located within the West SeaTac neighborhood, to the west of the Airport. Construction of the proposed new parallel runway, with a 2,500 ft separation, would result in the acquisition of a substantial portion of the West SeaTac area between 12th Avenue S. and SR 509.

Typically after a public works program has been announced, residents voice concerns about the impact of the announced plan on property values. Residences in the area needed to build the runway will be acquired at fair market value and residents relocated in accordance with the Uniform Act. The Port anticipates that acquisition can be completed in a 4 year period.

No minority, age or income group would be disproportionately affected by displacements that would occur as a result of the Preferred Alternative, as described previously. Therefore, it is concluded that all of the alternatives would meet the intent of Executive Order 12898.[12]

3. **Disruption of Planned Development**

The compatibility of the Preferred Alternative with the new City of SeaTac Comprehensive Plan (adopted December 20, 1994) and the West SeaTac Subarea Planning Process is discussed in Chapter IV, Section 2 "Land Use". The West SeaTac Planning process is continuing and is expected to be completed in Spring of 1996.

4. **Affordable Housing in the Acquisition Area**

About 77 percent of the houses that would be acquired to complete the Preferred Alternative would be considered affordable, and 91 percent of the apartments would be considered affordable. This translates to between 270 and 300 acquire affordable houses and 24 to 237 acquired affordable apartments or condominiums.

5. **Development Potential of the West SeaTac Acquisition Area**

As was noted earlier, the completion of the proposed new parallel runway will require substantial acquisition in the West SeaTac Subarea. At this time, the Port of Seattle does not have specific plans for the development of this area. However, this land has been noted for possible airport compatible development.

(4) CUMULATIVE IMPACTS

As is identified in Chapter III "Affected Environment" a number of non-airport related developments are planned in the airport vicinity. These actions would not likely affect aircraft operations or aircraft fleet mix. They could, however, affect the quantities of displaced residences and surface transportation volumes in the airport area. However, until specific project plans are completed for these developments, the total cumulative impacts can not be identified.

(5) MITIGATION

All acquisition associated with the Master Plan Update will comply with the Uniform Relocation Assistance Act.[13] Currently, the Port determines an acquisition price and enables owners to arrange for an independent appraisal if they disagree with the acquisition price. The Act requires that relocation benefits must be made available when an acquisition is involuntary on the part of the owner. Relocation benefits could include payment of moving costs, potential for a housing or rental supplement to cover any increased costs of a comparable replacement dwelling, an interest differential to cover interest rate and loan balance differences, and payment of closing costs.

[12] Executive Order 12898, "Environmental Justice".

[13] U.S. Department of Transportation, 49 CFR Part 24.

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TABLE IV.6-1

Page 1 of 2

Seattle-Tacoma International Airport
Environmental Impact Statement

SOCIAL AND SOCIO-ECONOMIC CHARACTERISTICS CENSUS TRACTS BY JURISDICTIONAL AREA (1990)

Jurisdiction		Race				Age				Housing Units					Occupancy (3)					Median Value	Median	Median
		White		Non-White		School Age (1)		Elderly (2)			Single Family		Multi-Family			Own		Rent		Units Owner		
Census Tract	Population	No.	%	No.	%	No.	%	No.	%	Total	No.	%	No.	%	Total	No.	%	No.	%	Occupied ($)	Rents ($)	Income ($)
Seattle																						
103	5,363	1,500	28.0	3,863	72.0	1,057	19.7	588	11.0	2,283	1,371	60.1	912	39.9	2,070	925	44.7	1,145	55.3	74,900	347	19,783
104 (4)	7,832	2,070	26.4	5,762	73.6	1,318	16.8	1,302	16.6	2,696	2,593	96.2	103	3.8	2,617	2,086	79.7	531	20.3	90,600	427	31,660
109 (5)	1,238	856	69.1	382	30.9	142	11.5	165	13.3	671	399	59.5	272	40.5	611	184	30.1	427	69.9	58,200	289	21,023
110	6,251	997	15.9	5,254	84.1	1,460	23.4	560	9.0	2,170	1,344	61.9	826	38.1	2,061	796	38.6	1,265	61.4	92,700	161	15,900
111 (4)	8,182	2,257	27.6	5,925	72.4	1,774	21.7	1,103	13.5	2,850	1,956	68.6	894	31.4	2,686	1,539	57.3	1,147	42.7	91,700	346	26,378
112	2,809	1,874	66.7	935	33.3	496	17.7	323	11.5	1,230	794	64.6	436	35.4	1,116	468	41.9	648	58.1	65,200	339	20,497
117 (5)	4,232	1,033	24.4	3,199	75.6	780	18.4	499	11.8	1,533	1,366	89.1	167	10.9	1,470	1,080	73.5	390	26.5	88,900	345	33,665
Tukwila																						
263 (5)	1,172	965	82.3	207	17.7	146	12.5	207	17.7	598	506	84.6	92	15.4	554	319	57.6	235	42.4	73,300	375	19,659
272 (4)	2,086	1,766	84.7	320	15.3	371	17.8	178	8.5	913	633	69.3	280	30.7	866	392	45.3	474	54.7	81,300	406	27,273
282 (4)	3,637	2,964	81.5	673	18.5	458	12.6	260	7.1	1,843	712	38.6	1,131	61.4	1,762	590	33.5	1,172	66.5	98,700	466	29,570
King Co.																						
264	5,143	4,115	80.0	1,028	20.0	627	12.2	720	14.0	2,308	991	42.9	1,317	57.1	2,223	1,005	45.2	1,218	54.8	97,700	432	30,309
269	1,421	1,185	83.4	236	16.6	273	19.2	141	9.9	553	468	84.6	85	15.4	532	366	68.8	166	31.2	85,500	465	32,415
270	3,010	2,615	86.9	395	13.1	585	19.4	293	9.7	1,116	1,000	89.6	116	10.4	1,089	813	74.7	276	25.3	87,800	421	35,507
271 (6)	2,609	2,307	88.4	302	11.6	419	16.1	366	14.0	1,156	703	60.8	453	39.2	1,099	526	47.9	573	52.1	82,400	393	30,143
287 (7)	4,960	4,645	93.6	315	6.4	887	17.9	529	10.7	1,899	1,849	97.4	50	2.6	1,873	1,618	86.4	255	13.6	103,600	540	39,272
299 (8)	7,547	6,719	89.0	828	11.0	1,766	23.4	284	3.8	2,461	2,284	92.8	177	7.2	2,418	1,959	81.0	459	19.0	119,500	510	47,500
City of SeaTac																						
273 (6)	4,764	3,978	83.5	786	16.5	854	17.9	456	9.6	1,964	1,286	65.5	678	34.5	1,877	1,000	53.3	877	46.7	85,700	393	32,316
281 (6)	1,865	1,554	83.3	311	16.7	248	13.3	172	9.2	874	445	50.9	429	49.1	835	331	39.6	504	60.4	92,400	388	27,523
283 (9)	2,839	2,599	91.5	240	8.5	399	14.1	399	14.1	1,130	1,121	99.2	9	0.8	1,112	946	85.1	166	14.9	103,700	472	41,404
284.01 (10)	474	377	79.5	97	20.5	65	13.7	23	4.9	266	85	32.0	181	68.0	227	54	23.8	173	76.2	90,800	397	26,339
284.02	3,205	2,782	86.8	423	13.2	494	15.4	332	10.4	1,410	999	70.9	411	29.1	1,351	798	59.1	553	40.9	87,500	406	33,158
284.03	4,390	3,768	85.8	622	14.2	504	11.5	595	13.6	2,352	1,195	50.8	1,157	49.2	2,177	1,119	51.4	1,058	48.6	92,400	395	27,055
288.01 (11)	3,169	2,926	92.3	243	7.7	469	14.8	564	17.8	1,255	1,105	88.0	150	12.0	1,133	791	69.8	342	30.2	90,600	429	31,187
288.02	5,475	4,578	83.6	897	16.4	772	14.1	551	10.1	2,442	1,045	42.8	1,397	57.2	2,281	839	36.8	1,442	63.2	114,100	459	31,892
Burien (12)																						
274 (5)	4,391	3,916	89.2	475	10.8	663	15.1	552	12.6	1,761	1,698	96.4	63	3.6	1,707	1,313	76.9	394	23.1	86,500	421	34,082
280 (7)	3,801	3,272	86.1	529	13.9	439	11.5	341	9.0	1,943	419	21.6	1,524	78.4	1,873	403	21.5	1,470	78.5	98,000	472	30,921
285 (13)	3,643	3,349	91.9	294	8.1	555	15.2	376	10.3	1,620	1,049	64.8	571	35.2	1,540	972	63.1	568	36.9	105,300	444	34,982
Des Moines																						
289 (14)	9,007	7,970	88.5	1,037	11.5	1,155	12.8	1,314	14.6	4,135	1,629	39.4	2,506	60.6	3,910	1,533	39.2	2,377	60.8	116,100	448	29,303
290.01	4,288	3,967	92.5	321	7.5	549	12.8	1,141	26.6	1,763	1,218	69.1	545	30.9	1,699	1,179	69.4	520	30.6	109,800	504	39,613
290.02 (15)	7,663	6,482	84.6	1,181	15.4	1,315	17.2	403	5.3	3,216	1,599	49.7	1,617	50.3	3,053	1,328	43.5	1,725	56.5	92,500	418	28,475

(##) Indicates a footnote - all footnotes are listed on page 2.

AR 038985

TABLE IV.6-1
Page 2 of 2
Seattle-Tacoma International Airport
Environmental Impact Statement

SOCIAL AND SOCIO-ECONOMIC CHARACTERISTICS
CENSUS TRACTS BY JURISDICTIONAL AREA (1990)

Jurisdiction		Race				Age				Housing Units					Occupancy (3)					Median Value		
		White		Non-White		School Age (1)		Elderly (2)			Single Family		Multi-Family			Own		Rent		Owner	Median	Median
Census Tract	Population	No.	%	No.	%	No.	%	No.	%	Total	No.	%	No.	%	Total	No.	%	No.	%	Occupied	Rents ($)	Income ($)
Kent																						
291 (13)	5,036	4,463	88.6	573	11.4	835	16.6	332	6.6	1,909	1 438	75.3	471	24.7	1,836	1,280	69.7	556	30.3	102,400	533	46,750
298.01 (17)	6,158	5,502	89.3	656	10.7	1,154	18.7	268	4.4	2,421	1,484	61.3	937	38.7	2,310	1,326	57.4	984	42.6	122,000	509	45,152
298.02 (4)	6,179	5,705	92.3	474	7.7	1,344	21.8	294	4.8	2,071	2,046	98.8	25	1.2	2,032	1,766	86.9	266	13.1	99,600	576	45,152
Federal Way																						
300.01 (5)	10,962	9,389	85.7	1,573	14.3	1,606	14.7	513	4.7	5,185	2,227	43.0	2,958	57.0	4,612	1,969	42.7	2 643	57.3	112,000	467	32,442
300.02 (4)	6,821	5,903	86.5	918	13.5	1,153	16.9	450	6.6	2,897	1,656	57.2	1,211	42.8	2,675	1,439	53.8	1,236	46.2	98,900	423	31,854
301 (16	7,062	6,425	91.0	637	9.0	1,315	18.6	666	9.4	2,707	2,209	81.6	498	18.4	2,622	2,058	78.5	564	21.5	158,100	433	51,090
302.01 (17)	4,652	4,167	89.6	525	11.3	937	20.1	202	4.3	1,872	1,286	68.7	586	31.3	1,768	1,048	59.3	720	40.7	85,400	483	35,544
302.02 (8)	5,941	5,123	86.2	818	13.8	1,157	19.5	627	10.6	2,311	1,469	63.6	842	36.4	2,132	1,296	60.8	836	39.2	93,800	507	37,174
Normandy Park (18)																						
286	6,131	5,767	94.1	364	5.9	1,067	17.4	948	15.5	2,403	2,010	83.6	393	16.4	2,344	1,871	79.8	473	20.2	195,900	406	53,395

(1) Age 5-17
(2) Age 65+
(3) The source gives occupancy in percentages, number of units is estimated
(4) Part outside study area
(5) Part King County
(6) Part Tukwila
(7) Part City of SeaTac
(8) Greater than half of census tract outside study area.
(9) Part King Co., Kent, Tukwila, out of study area. Majority of census tract population is in City of SeaTac.
(10) Part Burien
(11) Part Des Moines
(12) Incorporated in 1993
(13) Part King County and Part City of SeaTac
(14) Part Normandy Park
(15) About equal parts Des Moines, Kent, King County. Majority of Census tract population is Des Moines.
(16) Part King County, greater than half of census tract outside study area.
(17) Out of study area; included so split tract data can be aggregated to whole tract level.
(18) Normandy Park, except for a small portion adjacent to Des Moines, is outside study area. The primary census tract for Normandy Park (286) is included here, however, for informational purposes.

Source: Puget Sound Council of Governments, 1991. 1990 Census STF1A Vol. 1, King County.
Puget Sound Regional Council, 1992. 1990 Census STF3A Table P80/P80A Household Income and Median Household Income in 1989.

TABLE IV.6-2

Seattle-Tacoma International Airport
Environmental Impact Statement

SOCIAL AND HOUSING CHARACTERISTICS OF THE DETAILED STUDY AREA

Census Tract	Primary Jurisdiction	Population	Race				Age				Housing Units					Occupancy (8)					Median Value Owner Occupied	Median Rents ($)	Median Income ($)
			White		Non-White		School Age (6)		Elderly (7)		Total	Single Family		Multi-Family		Total	Own		Rent				
			No.	%	No.	%	No.	%	No.	%		No.	%	No.	%		No.	%	No.	%			
287	King County (3)	4,960	4,645	93.6	315	6.4	887	17.9	529	10.7	1,899	1,849	97.4	50	2.6	1,873	1,618	86.4	255	13.6	103,600	540	39,272
273	City of SeaTac (1)	4,764	3,978	83.5	786	16.5	854	17.9	456	9.6	1,964	1,286	65.5	678	34.5	1,877	1,000	53.3	877	46.7	85,700	393	32,316
281	City of SeaTac (1)	1,865	1,554	83.3	311	16.7	248	13.3	172	9.2	874	445	50.9	429	49.1	835	331	39.6	504	60.4	92,400	388	27,523
284.01	City of SeaTac (4)	474	377	79.5	97	20.5	65	13.7	23	4.9	266	85	32.0	181	68.0	227	54	23.8	173	76.2	90,800	397	26,339
288.01	City of SeaTac (5)	3,165	2,926	92.4	243	7.7	469	14.8	564	17.8	1,255	1,105	88.0	150	12.0	1,133	791	69.8	342	30.2	90,600	429	31,187
274	Burien (2)	4,391	3,916	89.2	475	10.8	663	15.1	552	12.6	1,761	1,698	96.4	63	3.6	1,707	1,313	76.9	394	23.1	86,500	421	34,082
280	Burien (3)	3,801	3,272	86.1	529	13.9	439	11.5	341	9.0	1,943	419	21.6	1,524	78.4	1,873	403	21.5	1,470	78.5	98,000	472	30,921
285	Burien (2) (3)	3,643	3,349	91.9	294	8.1	555	15.2	376	10.3	1,620	1,049	64.8	571	35.2	1,540	972	63.1	568	36.9	105,300	444	34,982

(1) Also include a section of Tukwila
(2) Also includes a section of unincorporated King County
(4) Also include a section of City of SeaTac
(4) Also include a section of Burien
(5) Also include a section of Des Moines
(6) Age 5-17
(7) Age 65+
(8) The source gives occupancy in percentages, number of units is estimated

Source: Puget Sound Council of Governments, 1991. 1990 Census STF1A Vol. 1, King County.
Puget Sound Regional Council, 1992. 1990 Census STF3A Table P80/P80A Household Income and Median Household Income in 1989.

AR 038987

TABLE IV.6-3

Seattle - Tacoma International Airport
Environmental Impact Statement

SUMMARY OF PARCELS PROPOSED TO BE ACQUIRED FOR ALTERNATIVES 2, 3, AND 4
(Port Of Seattle Parcels Excluded)

		New Runway Options	
	8,500 ft.	7,000 ft.	7,500 ft.
Primary-Runway			
Single-Family Residential	266	198	247
Apartments or Condominium	12	0	12
Businesses	1	0	0
Vacant Residential	56	51	56
Vacant Commercial	0	0	0
Primary-SASA			
Single-Family Residential	3	3	3
Apartments or Condominium	0	0	0
Businesses	0	0	0
Vacant Residential	1	1	1
Vacant Commercial	2	2	2
Mitigation			
Single-Family Residential	81	94	79
Apartments or Condominium	14	26	14
Businesses	15	8	14
Vacant Residential	24	28	24
Vacant Commercial	0	0	0
RPZ-North			
Single-Family Residential	38	53	32
Apartments or Condominium	234	0	0
Businesses	1	0	2
Vacant Residential	6	0	0
Vacant Commercial	0	0	0
RPZ-South			
Single-Family Residential	0	0	0
Apartments or Condominium	0	[illegible]	0
Businesses	88	88	88
Vacant Residential	0	0	0
Vacant Commercial	3	3	3
PARCEL TOTALS			
Single-Family Residential	388	348	361
Apartments or Condominium	260	26	26
Businesses[1]	105-117	96-108	104-116
Vacant Residential	87	80	81
Vacant Commercial	5	5	5
TERMINAL-RELATED			
Central	0	0	0
North Unit	1	1	1
South Unit	12	12	12

Note: Commercial property within the RPZ may not be acquired - avigation easements may be purchased.
Source: Gambrell Urban, 1995.

[1] Depending on Terminal Option

TABLE IV.6-4
Page 1 of 12

Seattle-Tacoma International Airport
Environmental Impact Statement

PROPERTIES PROPOSED FOR ACQUISITION

Taxpayer	Property Address	Land Use Status	Number of Businesses
Runway (8,500 ft length)			
Manley, Carolyn M	1001 S 168th ST	SF Resid.	
Smith, Gerald M&Barbara A VO	1001 S 170th ST	SF Resid.	
Gestner, D A	1002 S 170th ST	SF Resid.	
Harms, Todd D	1003 S 168th ST	SF Resid.	
Kazmirski, Loretta G&Michael	1003 S 170th ST	SF Resid.	
Miller, Jack F & Violet M	1004 S 170th ST	SF Resid.	
Kaapana, Douglas	1004 S 174th ST	SF Resid.	
Latimer, Steven P&Coleen E	1005 S 168th ST	SF Resid.	
Meyer ,Ilene	1005 S 171st ST	SF Resid.	
Gehring, Kathleen M	1006 S 170th ST	SF Resid.	
Rigney, James A	1006 S 173rd ST	SF Resid.	
Schuh, Charles A	1006 S 174th ST	SF Resid.	
Wilcoz, William W	1007 S 168th ST	SF Resid.	
Krantz, Glenn E&Rosemary	1007 S 173rd ST	SF Resid.	
Cornish, Daniel B	1008 S 156th WY	SF Resid.	
Zielinski, Brian	1009 S 157th PL	SF Resid.	
Wallin, Kurt R & Tamara K	1009 S 170th ST	SF Resid.	
Orban, Ferenc	1009 S 171st ST	SF Resid.	
Eepps, Michael D	1010 S 171st ST	SF Resid.	
Lavin, June	1010 S 172nd ST	SF Resid.	
Berwald, Rudolph WM	1010 S 174th ST	SF Resid.	
Sisco, William J	1012 S 173rd ST	SF Resid.	
Hardwick, Harold E&Ina R	1013 S 160th ST	SF Resid.	
Winders, Hugh W	1013 S 173rd ST	SF Resid.	
Braach, Laura M	1014 S 156th ST	SF Resid.	
Godfrey, Kenneth J	1014 S 160th ST	SF Resid.	
Dall, Rigmor	1015 S 157th PL	SF Resid.	
Anaka, Ross W&Connie J	1016 S 156th ST	SF Resid.	
Summers, Harry R	1016 S 174th ST	SF Resid.	
Oban, Steven T&Laurel D	1017 S 170th ST	SF Resid.	
Wood, David K&Virginia L	1017 S 171st ST	SF Resid.	
Dickson, Jack B	1018 S 156th WY	SF Resid.	
Von Wald, Gary Alan	1018 S 170th ST	SF Resid.	
Favro, M S & Favro E C	1018 S 171st ST	SF Resid.	
Cerino, Diana M	1019 S 157th PL	SF Resid.	
Palmer, A J	1020 S 156th ST	SF Resid.	
Kollars, Duane F	1020 S 160th ST	SF Resid.	
Nelson, Noel E&Barbara E	1021 S 173rd ST	SF Resid.	
Russell, AL H&Karen A	1022 S 173rd ST	SF Resid.	
Johnson, Kimberly Ann	1024 S 156th ST	SF Resid.	
Kiliz, Shirlee N	1024 S 174th ST	SF Resid.	
Dahlstrom, David P	1025 S 156th WY	SF Resid.	
Bailey, Darla J	1025 S 170th ST	SF Resid.	
Sacco, P A	1025 S 171st ST	SF Resid.	
Chick Ron&Laurie	1026 S 160th ST	SF Resid.	
Hurst, Melvin F	1026 S 171st ST	SF Resid.	
Horton, Tommy D & Judy	1028 S 172nd ST	SF Resid.	

TABLE IV.6-4
Page 2 of 12

Seattle-Tacoma International Airport
Environmental Impact Statement

PROPERTIES PROPOSED FOR ACQUISITION

Taxpayer	Property Address		Land UseStatus	Number of Businesses
Turner, Marsha A	1028 S 173rd ST		SF Resid.	
Kreger, Gregory R & Cheryl R	1029 S 173rd ST		SF Resid.	
Trintiy Church INC	1031 S 158th ST		SF Resid.	
Leighton, Ronald I	1032 S 160th ST		SF Resid.	
Videen, Robert	1032 S 174th ST		SF Resid.	
Blackburn, Jim R&Carolina	1033 S 170th ST		SF Resid.	
Sacco, Joseph J&ET AL	1033 S 171st ST		SF Resid.	
Goff, Glenn O	1034 S 171st ST		SF Resid.	
Dean, Jacquelyn K ET AL	1035 S 174th ST		SF Resid.	
Townsend Family Trust	1036 S 156th WY		SF Resid.	
Wright, Jerome L	1036 S 172nd ST		SF Resid.	
Gomez, Joseph R & Martha G	1036 S 173rd PL		SF Resid.	
Schwerdtfeger, Harry W	1036 S 173rd ST		SF Resid.	
Day, Jonathan T & Shelia	1037 S 156th WY		SF Resid.	
Fader, Les R&Holly R	1037 S 173rd ST		SF Resid.	
Daum, Gary T & Karen M	1038 S 160th ST		SF Resid.	
Austin, Frank	1039 S 160th ST		SF Resid.	
Walker, Eugene R	1039 S 174th ST		SF Resid.	
Bonney, Jesse C	1040 S 156th WY		SF Resid.	
Dean, Francis R	1040 S 171st ST		SF Resid.	
Hamilton, Roy M	1040 S 172nd ST		SF Resid.	
Markham, Melvin C & Bonnie J	1040 S 173rd PL		SF Resid.	
Burnett, Robert L	1040 S 174th ST		SF Resid.	
Breeze, Jimmie Irene	1041 S 150th ST		SF Resid.	
Conrad, John H	1041 S 158th ST		SF Resid.	
Pavao, David A&Cynthia A	1041 S 170th ST		SF Resid.	
Underwood, Richard D&Renee P	1041 S 171st ST		SF Resid.	
Castelluccio, Joseph Sr & Juan	1042 S 173rd ST		SF Resid.	
Beard, Phillip C & Denise J	1044 S 160th ST		SF Resid.	
Kennett, Ida Living Trust	1045 S 156th WY		SF Resid.	
Sofie, Louis E JR	1045 S 160th ST		SF Resid.	
Holton, M D	1045 S 173rd ST		SF Resid.	
Noll, D M	1046 S 174th ST		SF Resid.	
Senteney, Linda E	1047 S 173rd PL		SF Resid.	
Gilkerson, Andrew J&Kathleen	1047 S 174th ST		SF Resid.	
Creech, Ernest Clark	1049 S 160th ST		SF Resid.	
Reyes, Leo C	1049 S 171st ST		SF Resid.	
McPherren, Dennis L&	1050 S 160th ST		SF Resid.	
Tyler, Beverly S	1052 S 170th ST		SF Resid.	
Barnes, Thomas E	1054 S 172nd ST		SF Resid.	
Litras, Judy A&Comer,Jodi L	1055 S 174th ST		SF Resid.	
Mortenson	1066 S 156th WY	(2 residences)	SF Resid.	
Gendreau, Oliver O&Terri J	1102 S 166th PL		SF Resid.	
Von Wald, Dale	1103 S 168th ST		SF Resid.	
Goodpaster, Louis R	1109 S 168th ST		SF Resid.	
Ratcliffe, Michael	1110 S 166th PL		SF Resid.	
Harwood, Richard & JeannE	1110 S 176th ST		SF Resid.	
Miller, Thomas D	1112 S 168th ST		SF Resid.	

TABLE IV.6-4

Page 3 of 12

Seattle-Tacoma International Airport
Environmental Impact Statement

PROPERTIES PROPOSED FOR ACQUISITION

Taxpayer	Property Address	Land Use Status	Number of Businesses
Payne, W G	1113 S 168th ST	SF Resid.	
Wipperfurthg, C	1114 S 167th PL	SF Resid.	
Pham Hieu Ngoc	1115 S 166th PL	SF Resid.	
Ratcliffe, Michael M	1118 S 166th PL	SF Resid.	
Parker, A R	1118 S 167th PL	SF Resid.	
Razor, Terry A	1118 S 176th ST	SF Resid.	
Brown, Jack L	1120 S 168th ST	SF Resid.	
Jones, Osburn N III & Diana D	1120 S 176th ST	SF Resid.	
Partosa, Redentor O & Tamara J	1121 S 167th PL	SF Resid.	
Stroh, Kenneth P	1121 S 168th ST	SF Resid.	
Mohamed, Abdullehe I&Ali Mar	1123 S 166th PL	SF Resid.	
Kanongataa, Loka L&Taiana	1126 S 166th PL	SF Resid.	
Higgins, Dennis B	1127 S 154th PL	SF Resid.	
Colbry, D G	1130 S 167th PL	SF Resid.	
Simone, Stephen&Susan M	1131 S 154th PL	SF Resid.	
Gartner, Richard	1131 S 168th ST	SF Resid.	
Walker, Glen L & Anita S	1134 S 166th PL	SF Resid.	
Bird, Marion B &Mason,Scott E	15127 12th AV S	SF Resid.	
Genzale, Anthony,Trustee	15225 12th AV S	SF Resid.	
Brown, Beverlee A	15307 12th AV S	SF Resid.	
Forsythe, William D	15313 12th AV S	SF Resid.	
Patterson, Shawn D	15322 10th AV S	SF Resid.	
Anderson, Karenh R	15323 12th AV S	SF Resid.	
Boston, Donald W	15324 10th AV S	SF Resid.	
Scarsella, Tony	15325 10th AV S	SF Resid.	
Wheller, Neola	15326 10th AV S	SF Resid.	
Moloney, Martin T SR	15331 12th AV S	SF Resid.	
Spear, Marilyn F	15332 10th AV S	SF Resid.	
Scarsella, Tony	15337 10th AV S	SF Resid.	
Norwood, Robert A&Nancy	15338 10th AV S	SF Resid.	
Jones, Margaret Ruth TTEE	15404 10th AV S	SF Resid.	
Regan, D C	15410 10th AV S	SF Resid.	
Kehrer, Howard W	15413 9th PL S	SF Resid.	
Christensen, Neil H	15416 10th AV S	SF Resid.	
Pihlstrom, L	15417 10th AV S	SF Resid.	
Goodmansen, Helen V	15419 9th PL S	SF Resid.	
Purks, Merlin R	15422 10th AV S	SF Resid.	
Pomeroy, Freda L	15423 10th AV S	SF Resid.	
Espinosa, Lisa A	15424 9th PL S	SF Resid.	
Gronote, Jeffrey W&Tonya D	15427 12th AV S	SF Resid.	
Pope, Christy L	15428 10th AV S	SF Resid.	
Byers, Cheryl M	15429 10th AV S	SF Resid.	
Kamp, William B&Julia M	15429 12th AV S	SF Resid.	
McCabe, Emmett B	15429 9th PL S	SF Resid.	
McGuinn-Smith, Jo A & Dale I	15430 9th PL S	SF Resid.	
Barnes, Donald J SR	15431 12th AV S	SF Resid.	
Casebolt, Mark	15433 12th AV S	SF Resid.	
Sloboden, Edward G	15433 9th PL S	SF Resid.	
Prill, Mickel R&Michelle M	15434 10th AV S	SF Resid.	

TABLE IV.6-4

Seattle-Tacoma International Airport
Environmental Impact Statement

PROPERTIES PROPOSED FOR ACQUISITION

Taxpayer	Property Address	Land Use Status	Number of Businesses
Dena, Martha J	15435 10th AV S	SF Resid.	
Richard, John A	15436 9th PL S	SF Resid.	
Froiland. Edward I	15437 12th AV S	SF Resid.	
Devick, John M	15439 12th AV S	SF Resid.	
Schubert. Kurtis&Lisa	15440 10th AV S	SF Resid.	
Rinker, Lucille L	15441 10th AV S	SF Resid.	
Ponder. Thomas D	15441 12th AV S	SF Resid.	
Quigley, Robert N	15442 9th PL S	SF Resid.	
Grant, Eric W	15443 12th AV S	SF Resid.	
Roche, John H	15443 9th PL S	SF Resid.	
Gudmundson, Michael C	15446 10th AV S	SF Resid.	
Ricker, A P	15447 10th AV S	SF Resid.	
Young, D Y	15449 9th PL S	SF Resid.	
Vandevender, L	15453 12th AV S	SF Resid.	
Walther. Lila J	15455 9th PL S	SF Resid.	
McBreen, Scott	15458 Des Moines WY S	SF Resid.	
Hansen, Wesley C	15459 9th PL S	SF Resid.	
Condominium	15600 Des Moines WY S	Condominium	12 units
Marciniak, William J	15605 12th AV S	SF Resid.	
Rindal, Betty J	15619 12th AV S	SF Resid.	
Lee, Lois B	15631 12th AV S	SF Resid.	
Goodsel. Steven E	15653 12th AV S	SF Resid.	
Thurman, Marilyn Joan&Edwin	15706 9th PL S	SF Resid.	
Weaver, Lori A	15712 9th PL S	SF Resid.	
Finnegan ,T D	15714 10th AV S	SF Resid.	
Dennison, Daniel N&Jan M	15718 9th PL S	SF Resid.	
Furney, Robert A	15722 10th AV S	SF Resid.	
Shourek, John J & Iris	15730 10th AV S	SF Resid.	
Gagnat, Hazel N	15803 12th AV S	SF Resid.	
Seablom, Eric L	15811 12th AV S	SF Resid.	
Bliven, Margaret M	15811 9th AV S	SF Resid.	
Rose, Timothy J&Barker,Ann M	15812 9th AV S	SF Resid.	
Heath, A E	15821 12th AV S	SF Resid.	
Senger, Paul F	15822 9th AV S	SF Resid.	
Johnson, Terrence C	15826 9th AV S	SF Resid.	
Quitiquit, Max	15835 12th AV S	SF Resid.	
Behn, Ray E	15840 9th AV S	SF Resid.	
LeCompte, Howard & Eulalia M	15843 12th AV S	SF Resid.	
Smith, Gordon L&Betty Lunos	15850 9th AV S	SF Resid.	
Wood, William W	15851 12th AV S	SF Resid.	
Wilson Rozanne R	15856 9th AV S	SF Resid.	
Hiller, Larry R	15857 12th AV S	SF Resid.	
Grondahl, Sandra	16005 12th AV S	SF Resid.	
Varon Mitchel A	16015 12th AV S	SF Resid.	
Coberly, Warren G	16018 9th AV S	SF Resid.	
Lyons, P L	16022 9th AV S	SF Resid.	
Handran, Margaret M	16031 12th AV S	SF Resid.	
Thorson, JR George R	16032 9th AV S	SF Resid.	
Maclellan, Gary A	16033 12th AV S	SF Resid.	

TABLE IV.6-4
Page 5 of 12

Seattle-Tacoma International Airport
Environmental Impact Statement

PROPERTIES PROPOSED FOR ACQUISITION

Taxpayer	Property Address	Land Use Status	Number of Businesses
Conradi, D	16035 12th AV S	SF Resid.	
Zmaeff, J & McCart M J	16037 12th AV S	SF Resid.	
Graue, Mary Ann	16043 12th AV S	SF Resid.	
Morell, Gary R	16155 12th AV S	SF Resid.	
Gehring, Brad J	16205 12th AV S	SF Resid.	
Hom, Douglas L	16208 8th AV S	SF Resid.	
Myers, Leona G TTEE	16213 1/2 12th AV S	SF Resid.	
Jarisch, Brian L&Diane M	16213 12th AV S	SF Resid.	
Clement, Bradley J&Diane K	16224 8th AV S	SF Resid.	
Jones, Randolph M & Jane E	16241 12th AV S	SF Resid.	
Bardon, William C&Mary F	16406 8th AV S	SF Resid.	
Olson, John P	16408 8th AV S	SF Resid.	
Rhoton, Clifford C	16422 8th AV S	SF Resid.	
Lopez, Alfredo & RobertA	16429 12th AV S	SF Resid.	
Lopez, Alfredo & RobertA	16431 12th AV S	SF Resid.	
Roullard, Richard H	16436 8th AV S	SF Resid.	
Fauske, David Arne	16437 12th AV S	SF Resid.	
Palmer, Kenneth W	16441 12th AV S	SF Resid.	
Roullard, Richard H	16452 8th AV S	SF Resid.	
McClean, Teresa	16602 8th AV S	SF Resid.	
Hosey, Nancy C	16603 10th AV S	SF Resid.	
Oviatt, Eugene E	16605 10th AV S	SF Resid.	
Dickey, Cecil Eric&Cathy Lynn	16607 10th AV S	SF Resid.	
Billings, Betty L	16608 11th AV S	SF Resid.	
Konsak, Chad M	16623 10th AV S	SF Resid.	
Neumann, Willard A	16631 10th AV S	SF Resid.	
Brownlow, Doris M	16633 10th AV S	SF Resid.	
Hamper Gary, L&Dorothy A	16637 10th AV S	SF Resid.	
Patterson Donald S&Barbara	16651 11th AV S	SF Resid.	
Turner, Marsha A	16655 12th AV S	SF Resid.	
Dutton, Christopher B&Barbara	16657 11th AV S	SF Resid.	
Weisz, John T	16663 11th AV S	SF Resid.	
Bruce, Clare H	16664 11th AV S	SF Resid.	
McDonald, John L&Nancy L	16671 11th AV S	SF Resid.	
OSullivan, William C	16679 11th AV S	SF Resid.	
Cowles, Gerald R&Donna L	16680 11th AV S	SF Resid.	
Mugford, Allen H	16687 11th AV S	SF Resid.	
Duncan, Thoma E&Layton,Rhonda	16690 11th AV S	SF Resid.	
Howatt, Thomas M	16695 11th AV S	SF Resid.	
Kunnanz, Rodney G&Lisa Ann	16759 12th AV S	SF Resid.	
Bottorff, Ted A&Patricia M	16802 8th PL S	SF Resid.	
Goodposter, Ken & Barbara	16821 12th AV S (parcel 1)	SF Resid.	
Goodposter, Ken & Barbara	16821 12th AV S (parcel 2)	SF Resid.	
Dyre, Bonita Virginia	16841 8th PL S	SF Resid.	
Raub, Jack	16852 8th PL S	SF Resid.	
James, John L	16862 8th PL S	SF Resid.	
Morris, Esther L	16869 8th PL S	SF Resid.	
Ellis, William M & Margie A	17011 12th AV S	SF Resid.	
Markham, Melvin C &Bonnie J	17309 12th AV S	SF Resid.	

AR 038993

TABLE IV.6-4

Seattle-Tacoma International Airport
Environmental Impact Statement

PROPERTIES PROPOSED FOR ACQUISITION

Taxpayer	Property Address	Land Use Status	Number of Businesses
Markham, Mel &Bonnie	17315 12th AV S	SF Resid.	
Rio, Peter T&Shirley M	17333 12th AV S	SF Resid.	
Abbey, Wayne G&Yvonne	17405 12th AV S	SF Resid.	
Graue, Mary Ann	17411 12th AV S	SF Resid.	
Monroe, Sylvia	17417 12th AV S	SF Resid.	
Thackrey, Robert A	17433 12th AV S	SF Resid.	
Millington, George	17437 12th AV S	SF Resid.	
Perry, James S	17441 12th AV S	SF Resid.	
Grimstad, Robert F	839 S 157th PL	SF Resid.	
Ruffino, Joe A	841 S 157th PL	SF Resid.	
Swanson, Armond G	844 S 157th PL	SF Resid.	
Warner, Lee B	849 S 164th ST	SF Resid.	
Rivera, Luis I	903 S 156th ST	SF Resid.	
Whittington, Edgar B	903 S 160th ST	SF Resid.	
Hipps, Donald R&Patricia R	906 S 156th ST	SF Resid.	
Smith, Brenda L	906 S 160th ST	SF Resid.	
Neill, Raquel A	910 S 156th ST	SF Resid.	
Mertel, Robert D& Priscilla	911 S 160th ST	SF Resid.	
Chung, Ho Min&Wu,Cheong JA	915 S 156th ST	SF Resid.	
Johnson, Thomas H & Suzanne	918 S 160th ST	SF Resid.	
Cosa, Anthony	924 S 170th ST	SF Resid.	
Gale, James E	928 S 170th ST	SF Resid.	
Decoteau, David P&Wagner,EL	931 S 156th ST	SF Resid.	
Kearney, Paul C	941 S 156th ST	SF Resid.	
Vacca, Tony & Betty J	15060 Des Moines WY S	Commercial	1 business
Brougham, Marlene	No address	SF Resid. Vacant	
Chung, Ho Min & WUu Cheong Ja	No address	SF Resid. Vacant	
Trinity Chruch, Inc.	No address	SF Resid. Vacant	
Christensen, Neil H.	No address	SF Resid. Vacant	
Evergreen Enterprise Assoc.	No address	SF Resid. Vacant	
Vacca, Tony & Betty J.	No address	SF Resid. Vacant	
Scarsella, Tony	No address	SF Resid. Vacant	
Ponder, Thomas David	No address	SF Resid. Vacant	
Froiland, Edward	No address	SF Resid. Vacant	
Hansen, Wesley C.	No address	SF Resid. Vacant	
Cubbins, Dorothy	No address	SF Resid. Vacant	
Behm, Ray E.	No address	SF Resid. Vacant	
Cassel, James E.	No address	SF Resid. Vacant	
Beard, Phillip C. & Denise J.	No address	SF Resid. Vacant	
Lillis, James	No address	SF Resid. Vacant	
Looney, William A.	No address	SF Resid. Vacant	
Chung, Ho Min&Wu,Cheong JA	No address	SF Resid. Vacant	
Hoskin, Glenna B.	No address	SF Resid. Vacant	
Morrell, Gary R.	No address	SF Resid. Vacant	
Morrell, Gary R.	No address	SF Resid. Vacant	
Conradi, Dale C.	No address	SF Resid. Vacant	
Conradi, Dale C.	No address	SF Resid. Vacant	
Elial, Donald J.	No address	SF Resid. Vacant	
Elias Donald J.	No address	SF Resid. Vacant	

AR 038994

TABLE IV.6-4
Page 7 of 12

Seattle-Tacoma International Airport
Environmental Impact Statement

PROPERTIES PROPOSED FOR ACQUISITION

Taxpayer	Property Address	Land Use Status	Number of Businesses
Elias, Donald J.	No address	SF Resid. Vacant	
Albedyll, Walter G.	No address	SF Resid. Vacant	
Brown, Warren E.	No address	SF Resid. Vacant	
Roullard, Richard H.	No address	SF Resid. Vacant	
Roullard, Richard H.	No address	SF Resid. Vacant	
Maulolo, Amani F&Vienna T.	16016 9th AV S 148	SF Resid. Vacant	
Hardwich, Ina Ruth	No address	SF Resid. Vacant	
Childers, Scott Paul&	No address	SF Resid. Vacant	
Abel, Don G.	No address	SF Resid. Vacant	
Morrison, Carla & E. Beverly	No address	SF Resid. Vacant	
Schuh, Charles A.	No address	SF Resid. Vacant	
State of Washington	No address	SF Resid. Vacant	
Harwood, Richard L.	17203 Ambaum BL S 148	SF Resid. Vacant	
Meyer, Ilene	No address	SF Resid. Vacant	
Emmett Construction	No address	SF Resid. Vacant	
Thackrey, Robert A.	No address	SF Resid. Vacant	
Kulp, Donald E.	No address	SF Resid. Vacant	
Kulp, Donald E.	No address	SF Resid. Vacant	
Gale, James E.	No address	SF Resid. Vacant	
Harwood, Richard L.	No address	SF Resid. Vacant	
Tyler, Robert D. & Beverly Sue	No address	SF Resid. Vacant	
Ryland, Keith F. & Bonnie E.	No address	SF Resid. Vacant	
Stark, Ben G.	653 S 168th ST 148	SF Resid. Vacant	
Stark, Ben G.	653 S 168th ST 148	SF Resid. Vacant	
Stark, Ben G.	653 S 168th ST 148	SF Resid. Vacant	
Rio, Petr T. & Shirley M.	No address	SF Resid. Vacant	
Peters, Kingston	No address	SF Resid. Vacant	
Peters, Kingston	No address	SF Resid. Vacant	
Peters, Kingston	No address	SF Resid. Vacant	
Chiristie, William B.	No address	SF Resid. Vacant	
Niemi, Holland & Scott	No address	SF Resid. Vacant	
Litras, Judy A. & Comer, Jodi L.	1055 S 174th ST 148	SF Resid. Vacant	
SASA			
Turay, Arnold G	2702 S 200th ST	SF Resid.	
Rickard, Mary A	19453 28th AV S	SF Resid.	
Sithar, Jeronimo B & JanetT	19908 27th AV S	SF Resid.	
Tibeau, Maxine M.	No address	SF Resid. Vacant	
Turay, Arnold	2708 200th ST	Commercial Vacant	
Highline Water District	19900 28th AV S	Commercial Vacant	
Construction Mitigation			
RST Enterprises, INC	15416 Des Moines WY S (2 resid.)	SF Resid.	
RST Enterprises INC	15446 Des Moines WY S	SF Resid.	
Smith, Roy C	15454 Des Moines WY S	SF Resid.	
Brate, David P&Frances D	15618 Des Moines WY S	SF Resid.	
Pearson & Associates, Inc.	15626 Des Moines WY S	Apartment	14 units
Ravander, William OR Janette	15818 Des Moines WY S	SF Resid.	
Illes, Paul	15820 Des Moines WY S	SF Resid.	
Berry, Carl M & Nanny E	15823 9th AV S	SF Resid.	

TABLE IV.6-4
Page 8 of 12

Seattle-Tacoma International Airport
Environmental Impact Statement

PROPERTIES PROPOSED FOR ACQUISITION

Taxpayer	Property Address	Land Use Status	Number of Businesses
Tinker, M Jane	15829 9th AV S	SF Resid.	
Arne, Harriet Jane	15831 9th AV S	SF Resid.	
Ruggenberg, J K	15833 9th AV S	SF Resid.	
Nye, Frank F	15855 9th AV S	SF Resid.	
Simmons, Gary L	15864 Des Moines WY S	SF Resid.	
Wright, Wendell L&Denise L	15904 Des Moines WY S	SF Resid.	
Parker, Oren	15914 Des Moines WY S	SF Resid.	
Lapin, John E	15926 Des Moines WY S	SF Resid.	
Bivins, Sonny L	16002 Des Moines WY S	SF Resid.	
Wattles, Ella Mae&Wattles RA	16005 9th AV S	SF Resid.	
Bartenetti, Glenn D&Julie M	16017 9th AV S	SF Resid.	
Huffman, Echo	16019 9th AV S	SF Resid.	
Strand, M J	16028 Des Moines WY S	SF Resid.	
P[illegible], Lisa L	16032 8th AV S	SF Resid.	
Hanrahan,Brian C	16038 Des Moines WY S	SF Resid.	
Lobdell, George U	16054 Des Moines WY S	SF Resid.	
Warner, Lee	16056 Des Moines WY S	SF Resid.	
So, Pyong Chun	16062 Des Moines WY S	SF Resid.	
Loftus, Mark D&Loftus,Robin	16207 8th AV S	SF Resid.	
Curtright, Marie	16222 Des Moines WY S	SF Resid.	
Dettler, Mandrid R	16223 8th AV S	SF Resid.	
Horn, Donald L	16228 Des Moines WY S	SF Resid.	
Peterson, Steven E&Debra A	16232 Des Moines WY S	SF Resid.	
Rollwagen, Ardeth N	16240 Des Moines WY S	SF Resid.	
L[illegible]rd, Don L	16244 8th AV S	SF Resid.	
Z[illegible] Martin E&	16247 8th AV S	SF Resid.	
Scarsella Ida	16252 Des Moines WY S	SF Resid.	
Rottler, Donald A	16255 8th AV S	SF Resid.	
Morrow, Michelle M	16404 Des Moines WY S	SF Resid.	
Gordon, Claire & Gretchen	16405 8th AV S	SF Resid.	
Woods, Everett L	16410 8th AV S	SF Resid.	
Alseth, Lorene M	16412 8th AV S	SF Resid.	
Gray, John R	16412 Des Moines WY S	SF Resid.	
Scarsella, Frank&KIM	16418 Des Moines WY S	SF Resid.	
Lawson, David M&Jacqueime Y	16425 8th AV S	SF Resid.	
Enck, Richard D&Steward, Doro	16430 Des Moines WY S	SF Resid.	
Barth, Anne	16441 8th AV S	SF Resid.	
Cooper, Lin C	16444 Des Moines WY S (2 resid.)	SF Resid.	
Williamson, John A&Kristi E	16445 8th AV S	SF Resid.	
Roullard, Richard H	16454 8th AV S	SF Resid.	
Olson, Curtis	16455 8th AV S	SF Resid.	
Galando, Mike	16463 8th AV S	SF Resid.	
Randall, Earl D	16609 8th AV S	SF Resid.	
Chamberlin, Charles R	16609 8th AV S	SF Resid.	
Ruetten, Theodore L	16613 8th AV S	SF Resid.	
Beaudin, II CDR F X	16616 8th AV S	SF Resid.	
McClung, Jeffrey L	16623 8th AV S	SF Resid.	
Mjelde, Lynn L&Jane T	16628 8th AV S	SF Resid.	
Nelson, Kathryn J	16638 8th AV S	SF Resid.	

TABLE IV.6-4
Page 9 of 12

Seattle-Tacoma International Airport
Environmental Impact Statement

PROPERTIES PROPOSED FOR ACQUISITION

Taxpayer	Property Address	Land Use Status	Number of Businesses
Routt, Russell A&Anna M	16646 8th AV S	SF Resid.	
Longthorpe, Paul L&Katherine	16650 8th AV S	SF Resid.	
Grasso, Martha	16662 8th AV S	SF Resid.	
Ricci, Phillip J	16665 8th AV S	SF Resid.	
Josie, Frank JR	16815 8th PL S	SF Resid.	
English, Janice	16818 8th AV S	SF Resid.	
State of Washington	16823 8th AV S	SF Resid.	
Delgado, Agustin & Waters, Robe	16823 8th PL S	SF Resid.	
Opao, Rolando	16828 8th AV S	SF Resid.	
Knauss, Frank W	16833 8th AV S	SF Resid.	
Whitney David A&Lorna M	16842 44 8th AV S	SF Resid.	
Stocks, Ronald & Pamela	16846 8th AV S	SF Resid.	
Martin, Stanley W	16854 8th AV S	SF Resid.	
Singer, Norman H	16862 8th AV S	SF Resid.	
Park, JR James T&Michelle	16866 8th AV S	SF Resid.	
Pound, Beverly H	16874 8th AV S	SF Resid.	
Kobela, PEGI	632 S 168th ST	SF Resid.	
Provo, Napoleon J JR	638 S 168th ST	SF Resid.	
Rodda, John B	644 S 168th ST	SF Resid.	
Benda, Leonita (Mercy)	813 S 157th PL	SF Resid.	
Small, Jeffrey S	819 S 157th PL	SF Resid.	
Strand, Darrell T	819 S 160th ST	SF Resid.	
Brate, David P&Frances D	820 S 157th PL	SF Resid.	
Morrison, Rose F	832 S 157th PL	SF Resid.	
Genzale, Anthony	15045 Des Moines WY S	Commercial	4 businesses
Erickson, Ronald Olympic Bowl	15051 Des Moines WY S	Commercial	1 business
Winter, Charles & Susan Shell Gas Station	15041 Des Moines WY S	Commercial	1 business
Vacca, Tony & Betty J	15208 Des Moines WY S	Commercial	1 business
RST Enterprise INC - Raffo Garage	15418 Des Moines WY S	Commercial	2 businesses
RST Enterprises INC	15424 Des Moines WY S	Commercial	2 businesses
Cromie, James M - Chevron Station	15804 Des Moines WY S	Commercial	1 business
Jovanovich, John - Jovanovich & Sones Marine Sypply	15636 Des Moines WY S	Commercial	1 business
Tucker, Charles W - Tucker's Upholstery Shop	15217 Des Moines WY S	Commercial	1 business
Vistaunet, David T, Chris A - Red Apple Grocery	808 S 152nd ST	Commercial	1 business
Cromie, James M.	No address	SF Resid. Vacant	
RST Enterprises, Inc.	146 8th AV S 0	SF Resid. Vacant	
Wright, Wendell, L & Denise L	159 Des Moines WY S 148	SF Resid. Vacant	
Leonard, Don L	16256 8th AV S 148	SF Resid. Vacant	
Routt, Russell, A & Anna M	16646 8th AV S 148	SF Resid. Vacant	
Longthorp, Paul L & Katherine	No address	SF Resid. Vacant	
Grasso, Martha	16662 8th Av S 148	SF Resid. Vacant	
Reynolds, David C	No address	SF Resid. Vacant	
Scoccolo, Armondo	No address	SF Resid. Vacant	
Scoccolo, Armondo	16016 9th AV S 148	SF Resid. Vacant	
Childs, Rober D	No address	SF Resid. Vacant	
Barth , Anne	No address	SF Resid. Vacant	

AR 038997

TABLE IV.6-4
Page 10 of 12

Seattle-Tacoma International Airport
Environmental Impact Statement

PROPERTIES PROPOSED FOR ACQUISITION

Taxpayer	Property Address	Land Use Status	Number of Businesses
Barth, Anne	No address	SF Resid. Vacant	
Rollwagen, Ardeth N	No address	SF Resid. Vacant	
Zink, Martin E &	No address	SF Resid. Vacant	
Woods, Everett R & Pamela Jane	649 S 168th ST 148	SF Resid. Vacant	
Woods, Everett R	16845 8th AV S 148	SF Resid. Vacant	
Woods, Everett R	16845 8th AV S 148	SF Resid. Vacant	
Woods, Everett R & Pamela Jane	653 S 168th ST 148	SF Resid. Vacant	
Woods, Everett R & Pamela Jane	16807 8th AV S 148	SF Resid. Vacant	
Josie, Frank Jr	No address	SF Resid. Vacant	
Woods, Everett R	16876 8th AV S 148	SF Resid. Vacant	
Woods, Everett R	16876 8th AV S 148	SF Resid. Vacant	
Woods, Everett R & Pamela Jane	16872 8th AV S 148	SF Resid. Vacant	
New Runway RPZ - North			
Noland, Leroy Dean	1023 S 147th ST	SF Resid.	
Cinklin, Tina L	14703 11th AV S	SF Resid.	
Pearce, John N	14715 11th AV S	SF Resid.	
Runing, Roger N&Sharon C	1004 S th ST	SF Resid.	
Slavik, F R	14714 10th PL S	SF Resid.	
Yellam, Michael &Shirley	14710 10th PL S	SF Resid.	
Collins, C C	14733 10th PL S	SF Resid.	
Running, Clifford L	14723 10th PL S 168	SF Resid.	
Bear, Lester M	14706 11th AV S 168	SF Resid.	
Elliott, Bobbie L&Christine	14700 11th AV S 168	SF Resid.	
Anderson, Douglas	14811 Des Moines WY S 168	SF Resid.	
McCamish, Kevin C&Teresa K	853 S th ST 168	SF Resid.	
Arndt, Waldo D	14644 11th AV S 168	SF Resid.	
Olson, Marlo L	1004 S 150th ST 168	SF Resid.	
Yung , Vang & Va, Her	14809 9th AV S	SF Resid.	
Eisiminger, William F	15028 Des Moines WY S	SF Resid.	
Walter, Russell E & Judith C	15040 Des Moines WY S	SF Resid.	
Eisiminger, William F	15016 Des Moines WY S	SF Resid.	
Yellam, Frank	15052 Des Moines WY S	SF Resid.	
Higgginbotham, Richard&Miller	15010 Des Moines WY S	SF Resid.	
Robbins, Simon V	863 S th ST 168	SF Resid.	
Robbins, S V	869 S th ST 168	SF Resid.	
Wilcher, James W & Virginia	15006 Des Moines WY S	SF Resid.	
Eisiminger, William F	1003 S 150th ST	SF Resid.	
Wardall, Georgia	1009 S 150th ST	SF Resid.	
Hoxie, Darryl L	1021 S 150th ST	SF Resid.	
Ventimiglio, Robert	1029 S 150th ST	SF Resid.	
Wooding, Kenneth E&Leona	1033 S 150th ST	SF Resid.	
Young, Duwayne A&Susan A	1042 S 150th ST 168	SF Resid.	
James, Corrine M	1034 S 150th ST 168	SF Resid.	
Geise, R D	14915 12th AV S 168	SF Resid.	
Christianson, Marlyn&Mary	14907 12th AV S 168	SF Resid.	
Smith, Daniel E & Ronna Q.	840 S th ST	SF Resid.	
Warfield, Raymond O	850 S th ST	SF Resid.	

TABLE IV.6-4

Page 11 of 12

Seattle-Tacoma International Airport
Environmental Impact Statement

PROPERTIES PROPOSED FOR ACQUISITION

Taxpayer	Property Address	Land Use	Number of Businesses
Ewoldt, Ronald D	858 S th ST 168	SF Resid.	
Terwillegar, Morgan	847 S 147th ST	SF Resid.	
Mayner, Ronald R&Christine V	853 S 147th ST 168	SF Resid.	
Durante, marie Virginio	861 S 147th ST 168	SF Resid.	
Pacific Gulf Properties - Lora Lake Apartments	15001 Des Moines WY S	Apartment	234 units
Seike Shu Benjamin&Kiyoski - Des Moines Way Nursery	14634 Des Moines WY S	Commercial	1 Business
Christianson, Maryline L & Mary	No address	Sf. Resident Vacant	
Robbins, Siman V	No address	Sf. Resident Vacant	
Robbins, Siman V	No address	Sf. Resident Vacant	
State of Washington	No address	Sf. Resident Vacant	
King County	No address	Sf. Resident Vacant	
King, Calvin I	No address	Sf. Resident Vacant	
New Runway RPZ - South			
Parezanin, Don J - Office and Deli	18521 Des Moines WY S	Commercial	1 business
Alaska Airlines, Inc. - Alaska Airlines Stores Annex	18724 Des Moines WY S	Commercial	1 business
Chu, Sho Mei - Jim's Detail Shop	18429 Des Moines WY S	Commercial	1 business
Hertz Realty Cor - Hertz Auto Sales & Service	18625 Des Moines WY S	Commercial	1 business
Bjorneby, Robert	18800 Des Moines WY S	Commercial Vacant	
Combined Transport Services	18905 Des Moines WY S	Commercial Vacant	
Chu, Sho Mei	18435 Des Moines WY S	Commercial Vacant	
All-American Homes INC	18624 12th AV S	Commercial	1 business
H J Gwinn & CO - Jerry's Auto Detailing	18451 Des Moines WY S	Commercial	1 business
Avis Rent A Car System INC	18811 16th AV S	Commercial	1 business
H J Gwinn & CO - Ron's Auto Rebuild	18451 Des Moines WY S	Commercial	1 business
Bjorneby, Robert G&Anna M - A-1 Collision	1273 188th ST	Commercial	1 business
Pacific Gulf Properties INC - Warehouse	18915 16th AV S	Commercial	6 businesses
U S West INC	18800 Des Moines WY S	Commercial	1 business
Chu, Sho Mei	18441 Des Moines WY S	Commercial	1 business
Grorek, Matt & Aew - SeaTac Industrial Park	18902 13TH PL S	Commercial	24 businesses
Bjorneby Robert G - A-1 Collision	1265 188th ST S	Commercial	1 business
Weona Building Corp - NEL Tech	18634 Des Moines WY S	Commercial	16 businesses
Gworek, Matt & Aew - SeaTac Industrial Park	19002 Des Moines WY S	Commercial	18 businesses
Gworek, Matt & Aew - SeaTac Industrial Park	19010 Des Moines WY S	Commercial	12 businesses
Alternative 4 - South Unit Terminal			
West Coast Gateway Hotel	18415 Pacific HW S	Commercial	1 business
Sharp's Raster Ale House	18425 Pacific HW S	Commercial	1 business
Parking	2806 S 188th ST	Commercial	1 business
LA Quinta Inn	2824 S 188th ST	Commercial	1 business

TABLE IV.6-4

Page 12 of 12

Seattle-Tacoma International Airport
Environmental Impact Statement

PROPERTIES PROPOSED FOR ACQUISITION

Taxpayer	Property Address	Land Use	Number of Businesses
Airport Plaza Hotel	18601 International Blvd S.	Commercial	1 business
Jack-in-the-Box	2840 S 188th ST	Commercial	1 business
Budget Rent A Car	2806 S 188th ST	Commercial	1 business
Denny's	18623 Pacific HW S	Commercial	1 business
Parking	18445 Pacific HW S	Commercial	1 business
Pizza Hut	18605 Pacific HW S	Commercial	1 business
Barrett's SeaTac Mini Mart	18613 Pacific HW S	Commercial	1 business
WA STATE Liquor Store	18616 Pacific HW S	Commercial	1 business

Note: Commercial properties in the RPZ may not be acquired. Subject to FAA approval, an avigation easement may be purchased in lieu of acquisition.

Source: King County.

Seattle-Tacoma International Airport
Environmental Impact Statement
for the Master Plan Update

Exhibit IV.6-1

Displacement Areas and Percentage of Non-White Population

- Census Tract Boundary
- Generalized Study Area Boundary
- Focus Area Boundary
- Jurisdictional Boundary
- 2020 Central Terminal Alternative 65 LDN Noise Contour
- Displacement Areas (Primary, RPZ, and Mitigation)
- % Non-White Population Exceeding King Co. Average of 15.3%
- % Non-White Population Less than King Co. Average of 15.3%
- 284.02 / 16.4 — Census Tract Number / % of Non-White Population

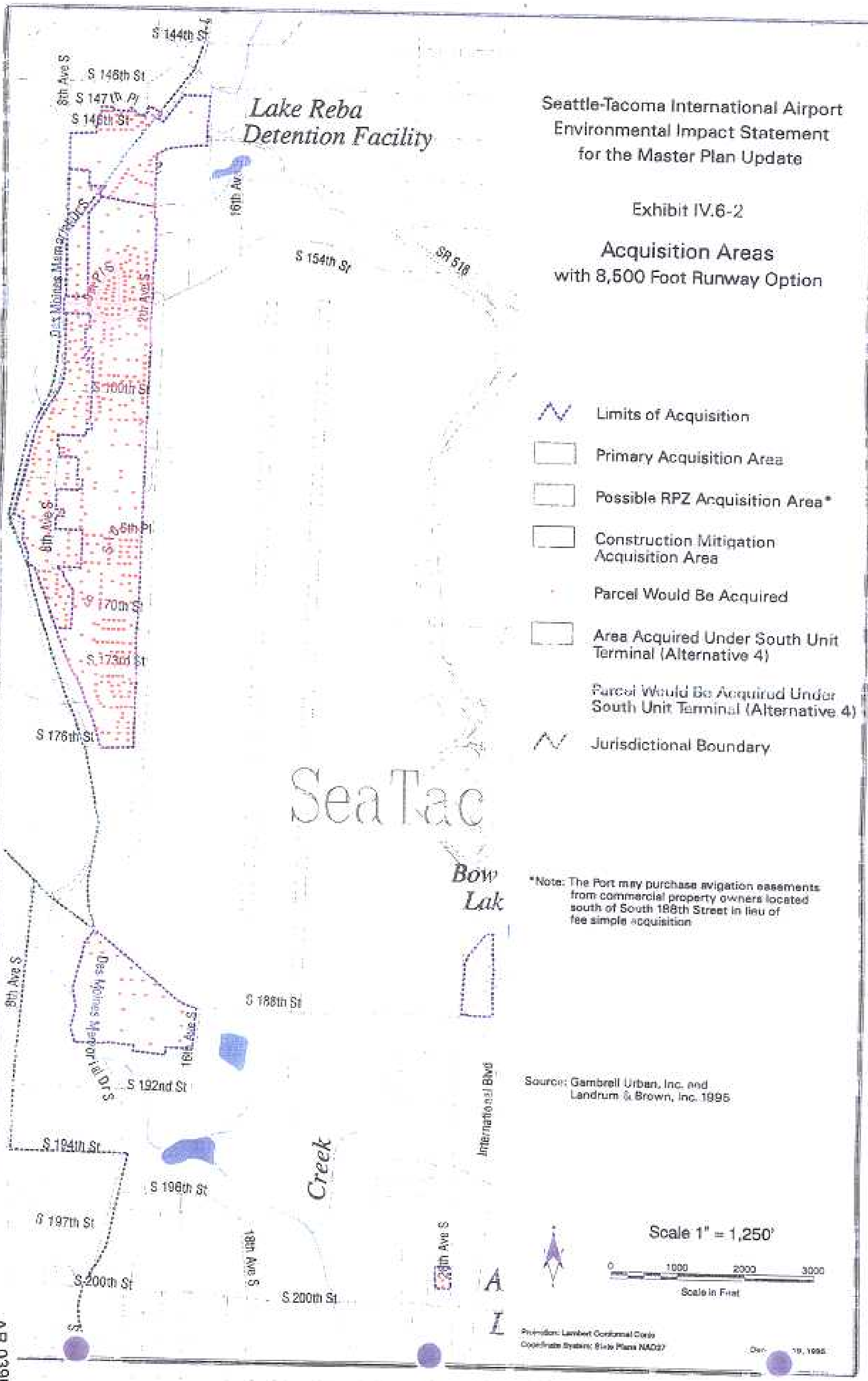
Source: Gambrell Urban, Inc. and Shapiro & Associates, 1995
Landrum & Brown, Inc. 1995
U.S. Bureau of the Census, 1991

Scale 1" = 6,000'

0 5000 12000 18000
SCALE IN FEET

Projection: Lambert Conformal Conic
Coordinate System: State Plane NAD27

13, 1996



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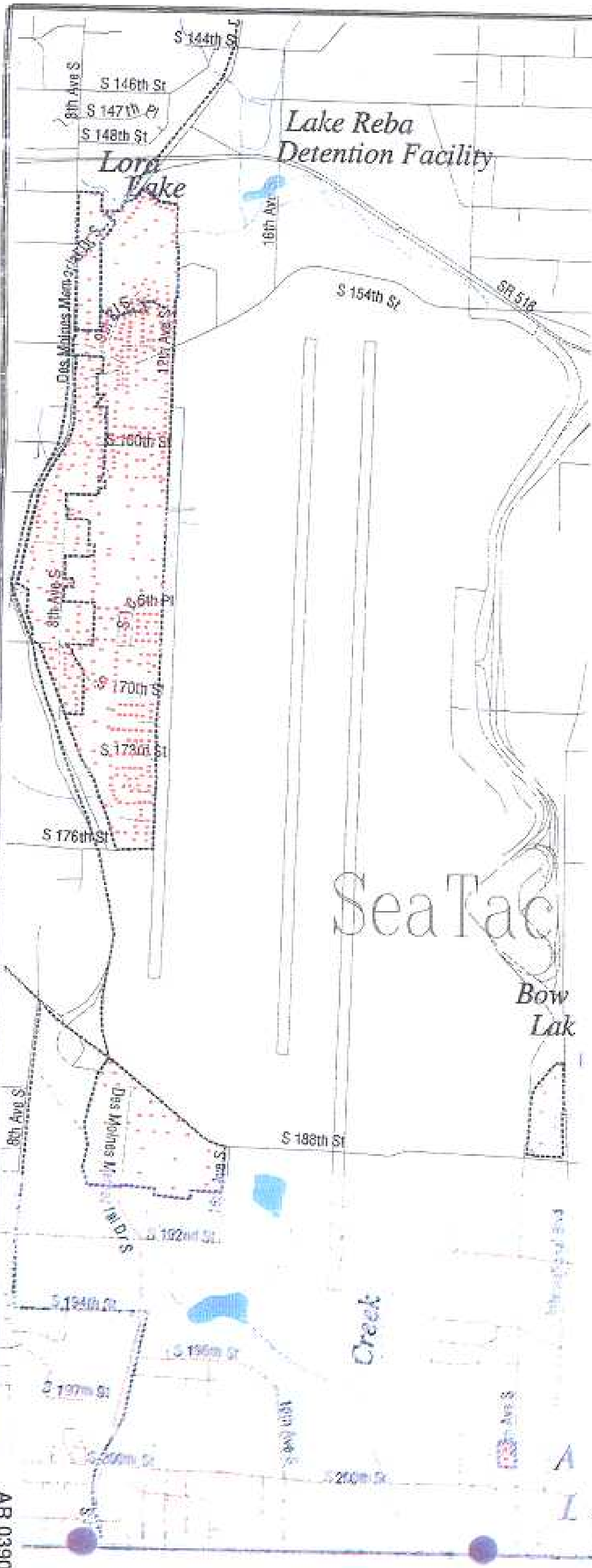

Seattle-Tacoma International Airport
Environmental Impact Statement
for the Master Plan Update

Exhibit IV.6-3

Acquisition Areas
with 7,500 Foot Runway Option

Limits of Acquisition

Primary Acquisition Area

Possible RPZ Acquisition Area*

Construction Mitigation Acquisition Area

Parcel Would Be Acquired

Area Acquired Under South Unit Terminal (Alternative 4)

Parcel Would Be Acquired Under South Unit Terminal (Alternative 4)

Jurisdictional Boundary

*Note: The Port may purchase avigation easements from commercial property owners located south of South 188th Street in lieu of fee simple acquisition

Source: Shapiro and Associates, Inc. and Landrum & Brown, Inc. 1995

Scale 1" = 1,250'

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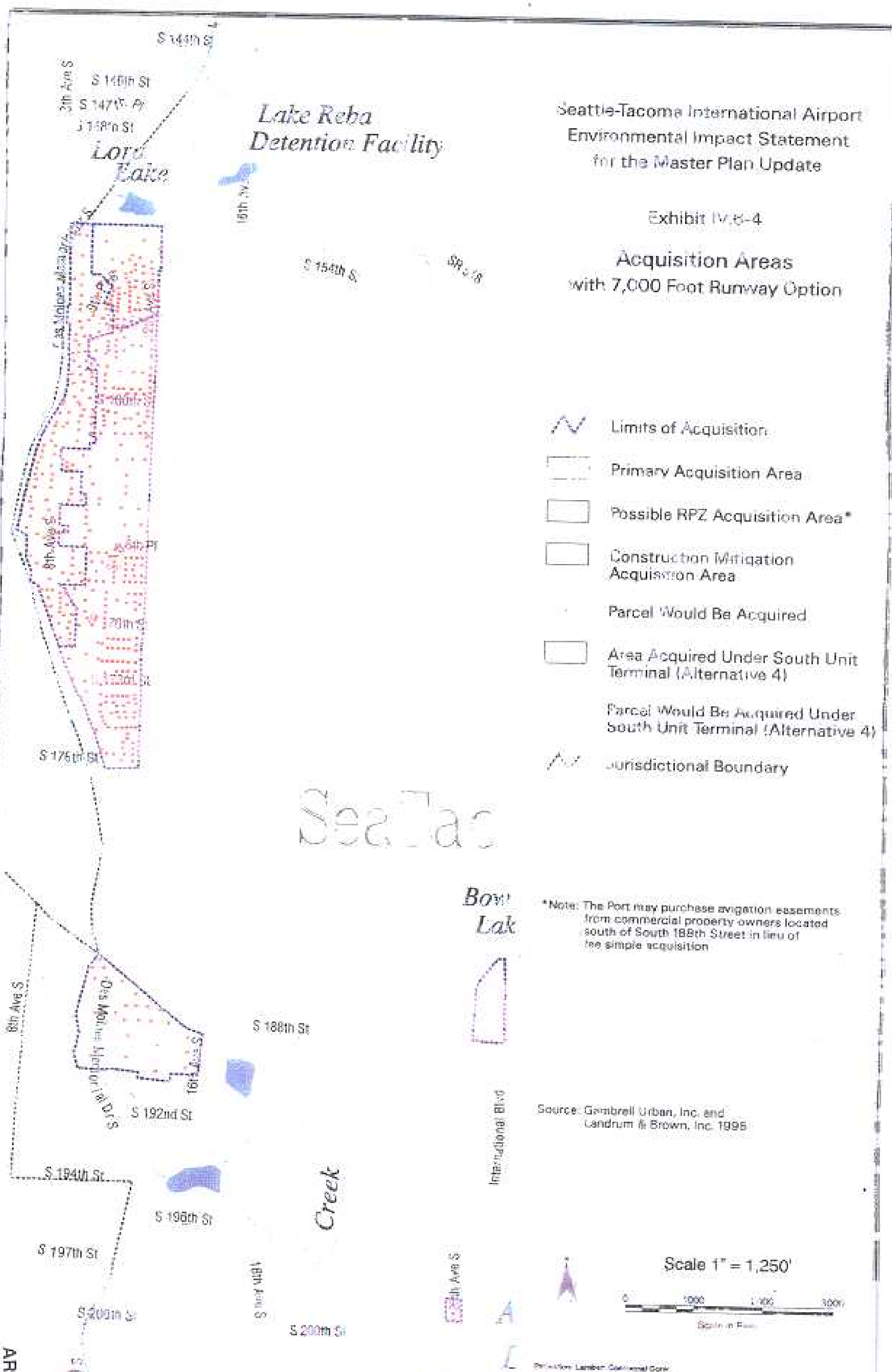
Seattle-Tacoma International Airport
Environmental Impact Statement
for the Master Plan Update
Exhibit IV.8-4
Acquisition Areas
with 7,000 Foot Runway Option
Limits of Acquisition
Primary Acquisition Area
Possible RPZ Acquisition Area*
Construction Mitigation Acquisition Area
Parcel Would Be Acquired
Area Acquired Under South Unit Terminal (Alternative 4)
Parcel Would Be Acquired Under South Unit Terminal (Alternative 4)
Jurisdictional Boundary
*Note: The Port may purchase avigation easements from commercial property owners located south of South 188th Street in lieu of fee simple acquisition
Source: Gambrell Urban, Inc. and Landrum & Brown, Inc. 1996
Scale 1" = 1,250'
Lake Reba
Detention Facility
SeaTac
Creek
S 144th St
S 146th St
S 154th St
S 188th St
S 192nd St
S 194th St
S 198th St
S 197th St
S 200th St
S 175th St
8th Ave S
16th Ave S
International Blvd

CHAPTER IV, SECTION 7
HUMAN HEALTH

This section presents the human health related issues associated with:

- Noise
- Air Quality
- Water Quality
- Radio Transmissions and Light Emissions
- Air Traffic Safety

The Airport presently creates environmental impacts that have the potential to affect human health. This impact is characterized as potential since many research studies indicate conflicting reports of human health impacts. However, in general, adverse environmental impacts are expected to decrease in the future as technology results in lower air, noise and water pollutant emissions. The proposed airport improvement alternatives are expected to result in slightly increased noise and water pollutant levels over the Do-Nothing. However, the impacts of the future "With Project" alternatives are expected to be less than the existing conditions.

(1) NOISE

Noise by definition is unwanted sound. In general, noise can interfere with activities such as face-to-face conversation, radio and telephone use, sleep, etc. It may also have detrimental impacts on human health. Noise can cause actual physical harm such as hearing loss, and it may have an adverse effect on mental health. All of these issues have been studied, but there are few clear cut conclusions relative to airport noise.

The majority of the literature divides community noise into two types, indigenous and transportation. Indigenous noise is typically low-level noise generated by the normal activity of daily living, such as traffic on local streets, lawn mowers, air conditioner compressors, outdoor residential activity, etc.-- and is essentially a function of population density. Transportation noise is related to aircraft, railroads, and traffic on major roadways. The major sources of community noise are transportation related and emanate from highways, railroads, and airports.

(A) Physiological Effects

The most immediate and verifiable health danger presented by high sound levels is loss of hearing. To relate hearing loss to sound exposure, the total sound level energy entering the ear is used. Noise metrics, such as the DNL and Leq are measures of sound energy. The U.S. Environmental Protection Agency (EPA)'s Levels Document,[1/] indicates that exposure to sound levels of 70 $Leq_{(24\text{-}hr)}$ (approximately 75 DNL or 74.6 dBA for 8 hours) or higher on a continuous basis, over a very long period, at the human ear's most damage-sensitive frequency may result in a very small but permanent loss of hearing.

The Bureau of Labor workplace related noise standards permit unprotected workers to be exposed to *average* noise levels of 90 dBA for eight hours per day. There has been pressure from medical researchers to lower the eight-hour standard to 85 dBA. As is shown in Chapter IV, Section 1 "Noise", *average* aircraft noise levels do not reach or exceed 85 to 90 dBA (as measured in DNL).

The single-event noise levels from many aircraft which operate from runways at the Airport commonly exceed 85 dBA on neighboring residential land uses. However, on the basis of the single-event noise analysis and aircraft noise measurements, it is concluded that such levels would be exceeded for a daily total of a fraction of one hour, as opposed to the eight hours of the OSHA standards. Furthermore, aircraft noise levels of 115 dBA, permitted by OSHA for 15 minutes per day, would never be experienced by

1/ *Information on Levels of Environmental Noise Requisite to Protect Health and Welfare with an Adequate Margin of Safety*, EPA, Office of Noise Abatement and Control, Washington, DC, March, 1974.

residents around Sea-Tac Airport as shown in **Appendix C**. Appendix C shows that the peak sound exposure level (SEL) currently impacting residents closest to Sea-Tac is 111.7 dBA, at site #299 (grid site F29). Thus, hearing damage would not be expected for residents near Sea-Tac.

Noise is generally considered a stressor. While there is no clear evidence that community noise as a stressor results in permanent physiological impairment, the cumulative effect of noise with other stressors may cause health impacts.[2] In addition, some researchers believe that noise induced stress may cause physiological harm. Such conditions could impact mortality rates, birth defects, achievement scores, and psychiatric admissions.

In spite of years of study attempting to isolate the effects of airport noise on humans, the impacts appear to be so low that they cannot be related to the general satisfaction of the research community, particularly below DNL 70 dB.[3] According to a recent summary of aviation noise research[4] some international researchers have published data indicating that a significant physiological risk exists. However, the summary of such research indicates that virtually all of the studies have had serious methodological problems and therefore questionable results. Several problems that occur in trying to associate exposure to airport noise with adverse health effects are 1) oriented measurements of noise yield a poor indication of personal noise exposure, and 2) long latency periods between exposure and disease greatly complicate interpretation of research findings.[5]

The following summarizes the physiological risk issue: "The evidence of non-auditory effects is more ambiguous, leading to differences of opinion regarding the burden of proof for noise control. It seems unlikely...that research in the near future will yield findings which are either a positive or negative direction. Consequently, arguments for transportation noise control will probably continue to be based primarily on welfare criteria such as annoyance and activity disturbance."[6]

(B) Psychological Effects

The effects of noise on the mental and emotional health of residents are not so clear as those for hearing loss. Most survey reports on this subject find that there is little reliable evidence on the relationship between noise exposure and mental health.[7] Studies conducted since the late 1960s have found that in communities impacted by aircraft noise, the interruption of communication, rest, relaxation and sleep are among the most important causes for registering complaints and suggesting potential psychological effects.

In addition, when people perceive a threat to their well-being, they are apt to feel stress which, in turn could affect emotional health. Such perceived threats could result from a loss of property value and personal financial security, and fear of aircraft accidents.

In absence of more conclusive research on the psychological effects of aircraft noise on residents around airports, this analysis focuses on the potential impact on speech communication and sleep, as well as perceived threats to property values and personal safety.

A large body of research exists which documents the effect of noise on sleep interruption and sleep disturbance, but the long-range effects of sleep disturbance by typical night airport

[2] "Airport Noise Report", July 9, 1990, pp., 1041-8318/90.

[3] *Federal Agency Review of Selected Airport Noise Analysis Issues*, Federal Interagency Committee on Noise (FICON) - August, 19[illegible].

[4] *Report on Aviation Noise Research Conducted by U.S. Federal Agencies*, FICON, June, 1994 pp. B-22.

[5] *If Adverse Effects Exist, They are Weak, Fidell Says*, "Airport Noise Report", Interview with Sanford Fidell of BBN Systems and Technologies, August 14, 1994, pp., 117-118.

[6] *Health Effects*, Martin Taylor and Peter A. Wilkins, Transportation Noise Reference book: ed. P. M. Nelson; Butterworths, 1987.

[7] *Aviation Noise Effects*, J. Steven Newman and Kristy R. Beattie, Report No. FAA-EE-85-2, March, 1985.

operations are not conclusive. It is certainly clear that sleep is essential for good physical and emotional health and that loss of sleep can lead to emotional distress such as depression, fatigue, and irritability which in turn can lead to hypertension, alcoholism, heart attacks, sclerosis of the liver, increased use of tranquilizers, and violence.

A recent study of aircraft noise and sleep disturbance prepared in December, 1992 has been received with great interest by the medical community and those interested in the effects of aircraft noise. The document published by the British Civil Aviation Authority[8] reported interviews of people from eight study areas around four major United Kingdom (UK) airports. The UK study showed that, below outdoor event levels of 90 dBA SEL, there is not likely to be any measurable increase in overall rates of sleep disturbance during normal sleep. At 90-100 dBA SEL (outdoors), the chance of the average person being awakened is about one in seventy-five. The UK study also showed that individual rates of sleep disturbance varied markedly; the two to three percent most sensitive individuals were disturbed over 60 percent more than average. Men were found to be somewhat more easily disturbed than women, but there was no statistical relationship to the subject's age. In addition, there appeared to be little relationship between sleep disturbances and the time of night. A much stronger relationship was found with the sleep cycles that occur for each individual approximately every 90 minutes.

Reaction to the UK study in the United States has been both mixed and guarded, in part because the findings appear to contradict many earlier studies, including a major study prepared for the same agency in 1979. However, a recent U.S. Air Force study[9] is in the process of confirming many of the findings of the UK study.

Probably the most significant impact of noise on human activities, other than sleep disturbance, is the interference with speech communication. Besides disrupting recreational and social activities, the masking of speech by airport noise can reduce education time and the performance of work involving speech communication. Speech interruption may also lead to accidents in shops, offices, and homes near an airport.[10] This affects a number of common activities including conversations in the home and outdoors, classroom teaching, listening to radio and television, and telephone conversations.

Speech interference associated with aircraft noise is a primary source of annoyance to individuals on the ground. **Exhibit IV.7-1** shows the impact of noise on speech communications. The disruption of leisure activities such as listening to the radio, television, music and conversation gives rise to frustration and irritation. Adequate speech communication is important in the classroom, home, office and industry setting. The degree to which noise interferes with indoor speech depends not only on physical factors, such as noise levels, distance between the speaker and listener and room acoustics, but also non-physical factors such as the speaker's enunciation and the listener's interest in and familiarity with the topic. A 1963 study, sponsored by the British government, found that aircraft noise of 75 dB annoyed the highest percentage of the population when it interfered with the television sound.[11] In general, people begin to experience difficulty with speech communication when background noise levels exceed 55 dBA.[12] Once the

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8/ *Report of a Field Study of Aircraft Noise and Sleep Disturbance*, A study commissioned by the Dept. of Transport from the Dept. of Safety, Environment and Engineering Civil Aviation Authority, Dec. 1992.

9/ *Field Study of Aircraft Noise-Induced Sleep Disturbance*, USAF (Armstrong Laboratory), final report is being prepared for publication (contact Major Robert Kull 513-255-3605).

10/ *Aviation Noise Effects*, J. Steven Newman and Kristy R. Beattie, Report No. FAA-EE-85-2, March, 1985.

11/ *Great Britain Committee on the Problem of Noise*. Noise, Final Report. Presented to Parliament by the Lord Minister for Science by Command of Her Majesty. London, H.M. Stationery Office, July, 1963.

12/ *Airport Noise Report*, July 9, 1990, pp., 1041-8318/90.

A-weighted sound pressure level of a noise event increases above 70 dBA, telephone communication becomes difficult and people talking at distances greater than 3 feet apart may have to shout. The highest noise that allows conversation with 100 percent intelligibility at normal voice levels throughout an average room is 45 dB, but 99% intelligibility is possible at 55 dB and 95% is possible at 65 dB.

A typical cold climate home, such as those in the Sea-Tac vicinity can reduce outdoor noise levels by approximately 20 to 25 dB or more. Therefore, to achieve 100 percent intelligible speech indoors, the preferred maximum outdoor noise level is 65 dBA or less. This noise level would allow for 95 to 100 percent sentence intelligibility in a normal voice indoor conversation in which the speaker and listener are 2 meters (approximately 6.5 feet) or less apart. Residences located in areas receiving sustained levels of exterior noise of 75 to 80 dBA would incur interior speech intelligibility in the range of 97 percent to 99 percent (interior level of 55 dBA - 60 dBA). This noise level would allow normal conversations at a comfortable voice effort at typical conversational distance.[13/]

There is no known research on the mental effects on airport neighbors which might result from perceived threats to financial security or personal safety. However, the likelihood of such stress effects is supportable based on the comments routinely received from the public in forums conducted for airport noise studies around the nation.

One of the stressors that could affect residents of a noise exposed area is the possible impact of noise on real estate values. A limited number of studies has attempted to measure the impact (if any) of noise on property values. Studies conducted at airports other than sea-Tac have concluded that airport noise has only a slight impact on property values. Additionally, comparison of older studies to more recent studies indicates that the impact was greater in the 1960's, when jet aircraft first entered the fleet, than in the 1980's. This presumably is the result of stabilization of real estate markets following an initial adjustment to noisier jets, and of noise reduction in more modern State 3 planes.

An FAA summary report on aviation noise effects states:

> "Studies have shown that aircraft noise does decrease the value of residential property located around airports. Although there are many socio-economic factors which must be considered because they may negatively affect property values themselves, all research conducted in this area found negative effects from aviation noise, with effects ranging from 0.6 to 2.3 percent decrease in property value per decibel increase of cumulative noise exposure ... The studies can be divided into two groups and some conclusions drawn. The first group of estimates ... was based on 1960 data (and included New York, Los Angeles and Dallas) and suggests a range of 1.8 to 2.3 percent decrease in value per decibel (DNL). The second group of estimates, covering the period from 1967 to 1970, suggests a mean of 0.8 percent devaluation per decibel change in DNL...... The bottom line is that noise has been shown to decrease the value of property by only a small amount -- approximately 1 percent decrease per decibel (DNL). At a minimum, the depreciation of a home due to aircraft noise is equal to the cost of moving to a new residence. Because there are many other factors that affect the price and desirability of a residence, the annoyance of aircraft noise remains just one of the considerations that affect the market value of a home."[14/]

Recent comparisons of appreciation rates for residential, commercial, and industrial property in noise-impacted areas near Sea-Tac Airport to non-noise-impacted areas in the *Sea-Tac Airport Vicinity Land Use Inventory Project* found no impacts attributable to the proximity of Sea-Tac Airport. Additionally, in February 1995, claims of 12 plaintiffs alleging devaluation of property because of airplane noise were

13/ *Information on Levels of Environmental Noise Requisite to Protect Public Health and Welfare with an Adequate Margin of Safety*, Environmental Protection Agency, March, 1974.

14/ *Aviation Noise Effects*, J. Steven Newman and Kristy R. Beattie, Report No. FAA-EE-85-2, March, 1985.

tried before a jury in Federal District Court. The jury failed to award damages to the plaintiffs. Similar claims by other plaintiffs are pending.

(C) **Existing Conditions**

Under the current airfield configuration and operating procedures, approximately 31,800 people in 13,620 homes are impacted by noise levels 65 DNL and greater. Many of the homes in these neighborhoods are currently enrolled in the Noise Remedy Program which is aimed at mitigating the effects of airport noise. This represents a 52 percent reduction in population exposed over the 1991 conditions presented in the Noise Exposure Map Update. In 1991, about 67,000 people in 29,119 housing units were exposed to aircraft noise levels of 65 DNL and greater.

As is shown in **Appendix C** "Noise", Southern Heights Park (Park P14, grid point site #1052) currently experiences noise levels in excess of 65 dBA 96.5 minutes (1.6 hours) per day, aircraft sound of 75 dBA for 23.6 minutes a day, and sound in excess of 85 dBA for 2.9 minutes a day.

(D) **Future Conditions**

Each Master Plan Update alternative would change sound patterns around the Airport, as a result many residences may encounter new or different levels of sound generating from the Airport. While these shifting sound levels would not be significant enough to cause any adverse health effects, some residences would encounter higher sound levels than they might have incurred with the Do-Nothing and others could actually experience lower sound levels. For example, Southern Heights Park would experience noise in excess of 65 dBA for 103.3 minutes (1.7 hours) a day with the Do-Nothing alternative in year 2020. This represents a 7 percent increase compared to the existing conditions. However, with any of the new runway alternatives in the year 2020, this same park would experience these noise levels 100.6 minutes (1.7 hours) per day, representing a 4.2 percent increase from the existing condition or a 2.6 percent decrease from the year 2020.

To assess one element of stress, a worst case evaluation of property value impact was performed. This assessment was based on the assumption of 1 percent decrease in property value per DNL over 65 dBA. As discussed earlier, this overstates the impact of noise at Sea-Tac on property values. To assess the potential effect on property values due to changes in aircraft noise levels which could be caused by the "With Project" alternatives, property value impacts were estimated at in comparison to the Do-Nothing alternative. **Table IV.7-1** assumes that the average value of residential property in the noise impacted area is $150,000. Property affected by 65-70 DNL was assumed to be impacted by $3,750 and property affected by 70-75 DNL by $11,250. No impacts were assumed for DNL 75 and greater impacts, as these residential units would be purchased. In addition, if property values were assumed to decrease as a result of increased noise levels, the properties no longer affected by DNL 70-75 were assumed to appreciate by the values noted.

As is shown in **Table IV.7-1**, noise exposure would increase to some residences as a consequence of "With Project" alternatives and decrease to others. Thus, it is anticipated that airport noise property value related stress could continue in the future upon implementation of the Master Plan Update alternatives.

* * *

Literature pertaining to the noise effects on human health are often contradictory. Some studies suggest that there are clear indicators that noise, particularly aircraft noise, has a detrimental effect on the cardiovascular system, mortality rates, birth defects, achievement scores, psychiatric admissions, sleep disturbance and overall psychological well being. However, none of these studies have gained acceptance from researchers that would allow the studies to be used as a basis for impact assessments.

TABLE IV.7-1

CHANGES IN PROPERTY VALUE IN COMPARISON TO THE FUTURE DO-NOTHING (ALTERNATIVE 1)

	DNL 65-70			DNL 70-75			
Altern.	Decreased Value/ Increased Noise	Increased Value/ Decreased Noise	Subtotal	Decreased Value/ Increased Noise	Increased Value/ Decreased Noise	Subtotal	DNL 65 and greater Total
Housing Units							
Year 2000 Alt 2,3,4	470	280	190	40	70	-30	160
Year 2010 Alt 2,3,4,	520	340	180	40	90	-50	130
Year 2020 Alt 2,4	560	310	250	50	150	-100	150
Alt 3	540	310	230	50	150	-100	130
Property Values							
Year 2000 Alt 2,3,4	$1,762,500	($1,050,000)	$712,500	$450,000	($787,500)	($337,500)	$375,000
Year 2010 Alt 2,3,4,	$1,950,000	($1,275,000)	$675,000	$450,000	($1,012,500)	($562,000)	$112,500
Year 2020 Alt 2,4	$2,100,000	($1,162,500)	$937,500	$562,500	($1,687,500)	($1,125,000)	($187,500)
Alt 3	$2,025,000	($1,162,500)	$862,500	$562,500	($1,687,500)	($1,125,000)	($262,500)

Notes: Assumes an average property value of $150,000. Assumes that property values decrease/increase in value by 1% per decibel increase/decrease above DNL 65. Values ($xxxxx) indicate that the properties would appreciate in value due to a lessening of noise exposure.

Source: Landrum & Brown, 1995

In general, the research community has cited methodological and epidemiological problems within the studies. The only clear-cut conclusion is that prolonged exposure to extremely high levels of noise will cause hearing damage, but only unprotected airport workers in close proximity to operating aircraft are exposed to these levels.

(E) Mitigation

The proposed land use mitigation described in Section 2 "Land Use" contains a detailed description of mitigation which would help alleviate increased health impacts which might arise due to the "With Project" alternatives.

(2) AIR QUALITY

This section examines the potential adverse effects to human health associated with increased future levels of aircraft emissions. The air toxics evaluation provides two ways to compare changes in air toxics emissions:

- An air toxic emissions inventory
- Comparison to Acceptable Source Impact Levels (ASILs).

The purpose of this analysis is to evaluate the potential change in air toxic emissions associated with present and future aircraft activity levels, with and without the proposed improvements.

The air toxics levels are based on the relationships between hydrocarbons and three air toxics identified by a more detailed study by the U.S. Environmental Protection Agency at Chicago Midway Airport. This study, entitled "*Estimation and Evaluation of Cancer Risks Attributed to Air Pollution in Southwest Chicago*", was used as it is the only known study of possible cancer effects of an airport, and is the most current evaluation of air toxics in an airport area.

It has been estimated that as many as 1,800 to 2,400 cancer cases per year nationally can be attributed to air pollution, not including radon. Individual industrial operations and facilities that congregate large numbers of fossil fuel burning equipment and vehicles present high localized risks. However, a higher level of cumulative risk from air toxins are produced by activities that are more population oriented, such as driving motor vehicles, and operating non-road equipment and vehicles, and heating with fireplaces and wood burning stoves. The Midway Study found that the major contributor to risk is the emissions by roadway vehicles.

Monitoring in some larger cities has indicated that risk levels in residential areas has approached levels comparable to the highest risk industrial facilities.[15] As society becomes more urbanized, the level of risk associated with everyday lifestyles will increase our exposure to health deteriorating airborne pollutants.

(A) Methodology

The air toxics analysis is based on the results of the emissions inventory and dispersion modeling presented in Chapter IV, Section 9 "Air Quality". This analysis is based on use of the FAA's Emissions and Dispersion Modeling System (EDMS). The modeling methodology, input assumptions and sources considered are identified in **Appendix D**. The output of the EDMS model are an emissions inventory and a dispersion analysis by modeled receptor location.

Based on the pollutant relationships identified in the Midway study, hydrocarbons (Volatile Organic Compounds) were converted to levels for three air toxics: Benzene, 1,3-Butadiene, and Formaldehyde. The conversion factors used in the analysis are presented in **Appendix D**.

As determined in the Midway Study, the primary contributor in terms of pollutant risk are the air toxics: 1,3-butadiene, formaldehyde and benzene. As demonstrated by that study, these toxic pollutants are characterized as either probable or possible human carcinogens.

The concentrations were then compared to the Washington State Department of Ecology Acceptable Source Impact Levels (ASILs). The ASILs are established for known or probable carcinogens; the cancer threshold is based on the probability of developing one cancer case per 1,000,000 population over an individuals lifetime. The ASILs are not regulatory standards, and concentrations above the ASILs are allowable and are found in urban areas, and are considered "overprotective". Nonetheless, predicted concentrations above the ASILs may trigger more refined health risk analysis or control technology reviews.

(B) Port of Seattle's Air Toxic Monitoring Program

During 1993, the Port of Seattle conducted a sampling program at Sea-Tac to measure benzene, formaldehyde, and 53 additional air toxics. Samples were collected at 13 on and off-airport locations during October through December. The results of this study are presented in **Appendix D**. The purpose of the air monitoring program was to collect samples of air toxics in and around the Airport. Concentrations of the various air toxics monitored were compared to the Washington Department of Ecology Acceptable Source Impact Levels (ASIL).

The air toxics monitoring program concluded the following:

- Several air toxics at all monitored locations were above the ASILs.
- No differences in upwind versus downwind concentrations (i.e., contributions from the Airport) were observed.
- Monitored concentrations for Benzene and Carbon Monoxide were well below levels predicted by a 1991 Ecology modeling study.
- Benzene concentrations were highest along International Boulevard.
- Pollutant profiles for most of the air toxics were indicative of automobile exhaust.
- Concentrations at Sea-Tac were within a range exhibited in other similarly sized urban areas such as St. Louis, Houston, and Boston.

Benzene, toluene, xylenes and other toxic VOCs are present in fuel and are contained in jet and auto fuel exhaust due to

[15] *The Air Toxics Problem in the United States: An Analysis of Cancer Risks for Selected Pollutants*, U.S. EPA, 1985.

incomplete combustion. Evaporative loss of the fuel during storage, refueling, and fuel handling operations also result in emissions of these VOCs. These same compounds are also contained in gasoline and elevated levels observed in many urban areas have been attributed to automobiles.

As the air toxics monitoring program was a preliminary, short-term survey of air toxics over a four day period, it is difficult to assign meaningful significance to short-term measurements as compared to longer-term guidelines. Therefore, as the monitored data was for a limited, short-term period, it is not certain if the actual levels would be exceeded on an annual basis.

The study confirms that air toxics are present throughout the Region, and suggests that air toxics would be high with or without airport development due particularly to the influence of automobile exhaust.

Information gathered as part of the Port of Seattle's Air Quality Sampling program does provide an air toxic-to-hydrocarbon relationship. As established by the Air Quality Sampling program, the use of the conversion factors identified in the Midway Study would result in higher concentrations (or, the conversion ratio would be slightly less based on actual emissions at Sea-Tac). Therefore, the conversion factors identified in the Midway Study were used as a reasonable worst case analysis.

(C) Air Toxics Modeling Inventory

Table IV.7-2 presents the results of the air toxics emissions inventory for benzene, 1,3-butadiene, and formaldehyde. The emissions inventory is presented for the on-airport sources only. As shown, air toxic emissions would be expected to increase with or without the project. Air toxic emissions are expected to initially decrease by the year 2000 due to the phase-out of the older, more polluting Stage 2 aircraft. As identified in the Draft EIS, each of the "With Project" alternatives (Alternatives 2, 3, and 4) would result in equal or less air toxic emissions than for the Do-Nothing condition. The Preferred Alternative (Alternative 3) would result in comparable or slightly less emissions than for the other "With Project" alternatives.

(D) Air Toxics Dispersion/Lifetime Cancer Probability

The Draft EIS analysis also included a cancer risk assessment. Cancer risk was defined based on population, the concentration for a particular air toxic, and known cancer risk conversion factors. The number of potential cancer cases was based on the probability that an individual would develop cancer when continuously exposed to a pollutant at an ambient concentration of one microgram per cubic meter (ug/m3) for 70 years (the average lifetime). As indicated in the Draft EIS, less than one cancer case might be attributable to all pollutant sources (roadway and air traffic) at the modeled receptor locations.

However, in consultation with the air quality agencies, it was determined that insufficient information is available to adequately conduct a meaningful risk assessment. Therefore, for the Final EIS, a risk analysis was not conducted.

(F) Acceptable Source Impacts Levels

As observed for the Port of Seattle Air Quality Sampling program, the maximum air toxics concentrations at all modeled receptors exceeded the annual Acceptable Source Impact Levels (ASILs). **Table IV.7-3** presents a comparison of the air toxic concentrations for the existing (1994) condition for roadway, parking, and airport sources. As shown, the majority of air toxic emissions at each receptor are produced by motor vehicles.

In comparison to contributions by motor vehicles, aircraft are a minor source of toxic emissions within the Airport environment. Motor vehicles (cars, trucks, buses, etc.) contribute over 70 percent of the toxic emissions. Aircraft contribute about 20 percent of the air toxic related emissions; aircraft ground support vehicles produce six percent. Other on-airport activity such as heating plants, training fires, maintenance activities, and fueling systems produce minimal air toxic emissions.

In the future, emissions from roadway sources will continue to contribute the majority of air toxic emissions in the Airport environment. Improvements in future motor vehicle emissions can, however, offset continued growth in traffic. At the same time, aircraft activity will continue to grow. By the year 2020, aircraft-related emissions are expected to represent about 25 percent of these air toxics emissions, as compared to motor vehicles' 65 percent.

Each of the "With Project" alternatives (Alternatives 2, 3, and 4) would result in similar air toxic emissions, as presented in **Table IV.7-4**. The Preferred Alternative (Alternative 3) would result in comparable or slightly less air toxic concentrations at most receptors in comparison to the Do-Nothing condition.

(3) WATER QUALITY

Human health was also evaluated in terms of water quality of surface water and groundwater sources used for drinking water, and the potential effects of the alternatives on water quality. A summary of existing surface and ground water quality is presented in Chapter IV, Section 10 "Water Quality and Hydrology". The assessment of potential impacts on surface and groundwater resources from the proposed alternatives can be avoided or mitigated through effective implementation of stormwater and pollution control design standards. Potential impacts on human health from waterborne pollutants generated from the proposed Master Plan Update alternatives is based on pollutant types, pollutant fate and transport, and risks of exposure to contaminated surface water and groundwaters. Federal, state, and local regulations would be complied with under all alternatives to minimize (1) pollutant loads to surface and groundwaters, (2) risks of pollutant exposure, and (3) risks to human health.

Surface waters in the vicinity of the Airport that would receive minor amounts of pollutants from stormwater runoff or accidental spills of petroleum products include Miller and Des Moines Creeks and Puget Sound. Although unlikely, shallow and regional groundwater aquifers could be affected by the proposed Master Plan Update alternatives. Because proposed mitigation would prevent significant pollution in water resources, human health risks are not likely to occur as a result of the alternatives.

(A) Existing Conditions

There are a number of surface water and ground water resources within the airport area. Surface waters include Miller and Des Moines Creeks (and their tributaries) and Puget Sound. Miller and Des Moines Creeks are Class AA (extraordinary) with regard to water quality standards. Existing surface water quality generally appears to be good. Class AA standards, however, occasionally are not met for selected water quality parameters.

In addition to surface water resources, there are perched, shallow, intermediate, and deep ground water resources in the vicinity of the Airport. Groundwater occurs in discontinuous, perched zones at various locations. Although it has not been demonstrated, the intermediate level and deeper regional aquifers may be interconnected beneath the Airport.

Groundwater found in perched zones is not a drinking water resource due to its discontinuous nature, relatively small volume and low flow rates. Perched groundwater quality has been impacted in several locations by airport operations. These sites are in various stages of investigation, remediation, monitoring and/or assessment. Quality of groundwater resources in the shallow regional aquifer has not been generally demonstrated, but is assumed to be good, except for five localized areas beneath the Airport where impacts of leaking underground storage tanks and/or fuel distribution lines have been identified by the Port (See Chapter IV, Section 10). These impacts are in various stages of the investigation-remediation process.

Deeper aquifer groundwater quality is excellent, as shown by regular monitoring of two wells in the deep Aquifer. There have been no violations of state or federal drinking water standards (i.e., maximum contaminant levels) in either of these two wells. Furthermore, there have been no detectable levels of any priority pollutants or other pollutants of concern.[16]

(B) Future Conditions

Potential human health risks related to water involve pollutant use/release, pollutant concentrations and transport, and human exposure to contaminated waters. The potential human health risks from exposure to water pollution resulting from construction and operation of the proposed alternatives is presented below.

1. Do-Nothing (Alternative 1)

If proposed airside and landside improvements are not pursued, surface water and groundwater quality in Miller and Des Moines Creek basins would be subject to continued operation of the existing Airport facilities. Future urban development in these basins and the associated generation of pollutants would be subject to existing federal, state, and local pollution control requirements. Pollution-control facilities, best management practices, and environmental studies required under an NPDES permit would reduce existing pollutant loading from the Airport. Therefore, human health risks from exposure to polluted surface waters or groundwaters associated with Sea-Tac could diminish in the future.

2. "With Project" Alternatives (Alternatives 2, 3, and 4)

Construction activities, if not properly managed, could adversely affect surface waters through temporary increases in suspended solids, caused by erosion and sedimentation. Minor quantities of fuels, solvents, or lubricants in accidental spills could result in elevated levels of volatile organic compounds (VOC). Stormwater pollution prevention measures, however, are expected to protect receiving waters from releases of such contaminants at construction sites. If such measures are not effectively implemented, there is a low probability that VOCs, a potential human health risk, could enter Miller or Des Moines Creeks or groundwater aquifers.

Airport operations are not anticipated to result in significant levels of pollution in surface water or groundwater resources. Potential spills of fuel, petroleum products, and other environmentally hazardous materials, and stormwater discharges resulting from Airport operations, would be managed by implementing federal, state, and local standards for spill prevention and control and stormwater management. This is expected to significantly protect Miller and Des Moines Creeks and shallow and deeper groundwater. In addition, because there is 25 feet or more of low-permeability clays and glacial till lying above the shallow regional aquifer and the deeper, regional Highline aquifer, contamination of drinking water from Airport operations appears unlikely.

Potential human health risks from polluted surface water and groundwaters are directly related to the specific pollutant, route of exposure, level of exposure, duration of exposure, and frequency of exposure. There are generally two routes of exposure to polluted surface water and groundwaters: ingestion or consumption, and skin contact (e.g., contact recreation). The greatest risk of exposure to polluted surface waters is through skin contact, since neither Miller or Des Moines Creeks or their tributaries is used as a drinking water source. Airport stormwater runoff generally contains low concentrations (a few parts per billion) of pollutants, except for total zinc, which may occur at several hundred parts per billion. These concentrations are diluted once the stormwater mixes with receiving waters. Therefore, the concentrations of waterborne pollutants available for human exposure are very low. Because little or no contact recreation (e.g., wading and swimming) occurs in Miller and Des Moines Creeks (especially during high flow,

[16] Personal communication with Jay Gibson, Planning and Construction Manager, Water District No. 75, November 15, 1994.

stormwater runoff events), it is unlikely that people would be exposed for any significant duration to these low levels of pollutants. For these reasons, the potential human health risks from water contact or consumption appear to be extremely low.

Other potential routes of exposure to pollutants are through consumption of contaminated fish and shellfish or skin contact with contaminated sediments. Miller and Des Moines Creeks do not support commercial fisheries and most forms of metals do not bioaccumulate or bioconcentrate in fish or shellfish. Therefore, it is unlikely that consumption of fish is a significant potential source of exposure to pollutants bound to suspended solids would be deposited and accumulate on the bottom of Puget Sound where potential for human contact would be negligible, Furthermore, even if contaminated sediments were deposited in accessible areas (e.g., in pools or at the mouths of these creeks) these pollutants are not in forms that would be adsorbed through the skin. Therefore, none of these sources are expected to be a likely route of exposure to contaminants found in Airport stormwater runoff and they do not appear to represent a significant potential risk to human health.

In several locations, perched groundwater beneath the Airport, have been polluted by fuel leaking from distribution lines and underground storage tanks. Similar contamination of shallow-perched groundwater could occur in the future. Human exposure to contaminated shallow perched groundwater would occur if shallow groundwater eventually emerges and discharges to surface water (Miller and Des Moines Creeks) or wetlands (i.e., seeps). Because perched groundwater that could become polluted by Airport operations is typically confined and perched in depressions on glacial till, it is unlikely that polluted groundwater would be discharged to Miller and Des Moines Creeks. In addition, as polluted groundwater moves through the soil, many pollutants (e.g., petroleum hydrocarbons) become bound to soil particles through the process of adsorption. Through this process, polluted groundwater is naturally purified and cleansed of many pollutants. In the event that shallow groundwaters that discharge to Miller or Des Moines Creeks become polluted, it is likely that such pollutant concentrations would be very low as groundwaters are diluted with receiving surface waters. For these reasons, the potential human health risk from contact with polluted groundwater is extremely low.

The greatest potential risk to human health involving groundwater is from pollution of a source of drinking water supply (i.e., from the two Highline Aquifer wells). Historically, there has been no measurable pollution of the Highline wells. Geotechnical explorations around the Airport indicate that the Highline Aquifer is generally separated from potential pollutant sources and the perched and Upper Aquifer groundwaters by layers of glacial till, silt loams, and clay that have very low permeabilities and high pollutant filtration capabilities. Therefore, there is a low risk of pollution to the deeper Highline Aquifer and Deep Aquifer from leaking fuel distribution systems or fuel spills at Sea-Tac Airport. Significant contamination of these drinking water supplies could occur from accidental and uncontrolled release of pollutants to soils in areas of permeable strata (e.g., advance and recessional outwash). Pollutants released in advance and recessional outwash likely would be adsorbed or removed by soil particles; therefore, it is unlikely that they would reach the Highline Aquifer or Deep Aquifer. Furthermore, implementation of spill prevention control and countermeasure plans and the wellhead protection plan, which are required by federal and state laws, would prevent pollutant sources from reaching the Highline Aquifer.

3. Preferred Alternative (Alternative 3)

Airport operations associated with the Preferred Alternative are not anticipated to result in significant levels of pollution in surface water or groundwater resources. Potential spills of fuel, petroleum products, and other environmentally hazardous materials, and stormwater discharges resulting from Airport operations, would be managed by implementing federal, state, and local standards for spill prevention and control and stormwater management. This is expected to significantly protect Miller and Des Moines Creeks and shallow and deeper groundwater. In addition, because there is 25 feet or more of low-permeability clays and glacial till lying above the shallow regional aquifer and the deeper, regional Highline aquifer, contamination of drinking water from Airport operations appears unlikely.

The greatest potential risk to human health involving groundwater is from pollution of a source of drinking water supply (i.e., from the two Highline aquifer wells). Geotechnical explorations around the Airport indicate that the Highline aquifer is generally separated from potential pollutant sources and the perched and upper aquifer groundwaters by layers of glacial till, silt loams, and clay that have very low permeabilities and high pollutant filtration capabilities. Therefore, there is a low risk of pollution to the deeper Highline aquifer and Deep aquifer from leaking fuel distribution systems or fuel spills at Sea-Tac Airport. Significant contamination of these drinking water supplies could occur from accidental and uncontrolled release of pollutants to soils in areas of permeable strata (e.g., advance and recessional outwash). Pollutants released in advance and recessional outwash would likely be adsorbed or removed by soil particles; therefore, it is unlikely that they would reach the Highline aquifer or Deep Aquifer. Furthermore, implementation of spill prevention control and countermeasure plans and the wellhead protection plan, which are required by federal and state laws, would prevent pollutant sources from reaching the Highline aquifer.

(C) Mitigation

Compliance with construction design standards and various environmental management plans would reduce the potential that contamination of surface water and groundwater would result from construction and operation of the proposed alternatives. Human health risk related to exposure to polluted surface water and groundwater could be mitigated by implementation of:

- Construction erosion and sediment control plan;
- Construction waste handling and disposal plan;
- Spill prevention, control, and countermeasures plan;
- Stormwater pollution prevention plan;
- Wellhead protection plan; and
- State and federal surface- and drinking-water standards.

State and federal drinking-water standards establish Maximum Contaminant Levels (MCLs) for drinking water supplies.[17] In the event that MCLs are violated, state regulations (i.e., referenced sections of the WAC) identify specific actions that are required to protect human health. Specifically, the water supplier is required to:

- Notify the Washington State Department of Ecology (Ecology) when a violation of an MCL has occurred.
- Notify the consumers served by the system.
- Determine the cause of contamination.
- Take action as directed by Ecology.

As previously stated, there have been no violations of MCLs or detectable levels of

[17] Washington Administrative Code (WAC) 246-290-310(3) *Primary and Secondary MCLs for Inorganic Chemical and Physical Parameters.* Washington State Department of Health, Olympia, Washington. July, 1994.

AR 039016

substances with established MCLs in either of the two drinking water wells.

(4) RADIO TRANSMISSIONS AND LIGHT EMISSIONS

This section examines the potential effects of radio interference and electromagnetic fields associated with airport operations on the surrounding population.

(A) Radio Interference

"Radio interference" is a generic term used to describe signal disruption to an electronic transmitting or receiving device (e.g., AM/FM radio, television, citizens band radio, etc.). There are many causes of interference to electronic devices. However, they each have relatively the same effect on transmitted signals in that they interrupt a signal's ability to be received in its entirety. Although radio interference due to the operation of an Airport does not adversely impact human health, at least in any direct way, it could cause inconvenience, and consequently, emotional stress to the surrounding population.

The FCC[18] provided a summary of complaints received since 1992 from within an area of a one-mile radius surrounding the Airport. Since 1992, there has been only one complaint that the FCC could link to the operation of aircraft in the vicinity of Sea-Tac. The complaint was defined as aircraft radio transmissions interfering with a resident's home entertainment equipment. However, no attempt was made by the FCC to determine which airport or which aircraft operation resulted in the interference. The vast majority of the FCC reported complaints were related to interference caused by operation of citizens band (CB) and ham radios by residents of the area.

Numerous radio frequencies and users are associated with the daily operation of the Airport, including: airport operations, FAA air traffic control, approach/departure control, ground control, emergency response, aircraft navigational/approach aids, etc. The operating ranges utilized by these entities vary from extremely high to extremely low frequencies. Given the forecast growth in aviation activity, the FCC was asked if there is the potential for capacity constraints that could limit the number of additional users/facilities. It is the feeling of the local FCC office that existing and future technologies provide adequate means for additional frequency usage without adversely impacting the operation of the Airport. Narrower band-width transmissions is one method that would create additional channels for use. Another method would be to petition the FCC through a proposed rule-making to allocate more frequency spectrum to cover the particular needs of the users. In conclusion, based on the interview with the FCC, it was determined that existing and future operation of the Airport would cause no adverse impacts to the surrounding population and that future requirements can be adequately and safely accommodated.

(B) Electromagnetic Fields

The term electromagnetic fields (EMF) refers to both electric and magnetic fields that occur both naturally and as a result of the generation, delivery, and use of electric power. Electric fields are created whenever power lines are energized or even whenever an electric cord to an appliance is plugged into an outlet. Magnetic fields result from the motion of the electrical charge or current, such as when there is current running through a power line or an appliance cord. With the vast array of electrical appliances and equipment, building wiring, distribution lines, and transmission lines, exposure to EMF is nearly a continuous event. Around airports, the public often is concerned with the quantity of radar and other electronic equipment.

Over the past three decades, there has been both public and scientific uncertainty as to the potential adverse effects to human health associated with exposure to EMF. Early studies of the effects of electromagnetic fields on humans examined cardiovascular, digestive, and central nervous system disorders expected to be related to EMF exposure in the

[18] Telephone interview with Donald Roberson, Electronics Engineer, Federal Communications Commission (FCC) Field Operations Bureau, Seattle Office, August 4, 1994.

occupational environment.[19] Recently, concern has been focused on possible carcinogenic effects related to environmental EMF exposure from electrical distribution lines.

Numerous studies have been conducted in an attempt to positively prove or disprove the relationship between EMF exposure and numerous forms of cancer, birth defects, mental disorders, and other adverse health conditions. There have been studies that have provided some statistical relationships between EMF exposure and adverse health conditions. However, there are a multitude of variables that make it extremely difficult to positively relate the adverse health conditions to a particular EMF source, the most significant variable being the inability to contrast an "exposed" population with an "unexposed" population since some exposure to EMF is universal. Even though some studies have statistically related EMF to adverse health, it has been concluded that exposure to EMF does not appear to cause direct damage to DNA or other genetic material. Thus, it is believed that exposure to EMF could not initiate cancer.[20]

(C) Light Emissions

Airport facilities are illuminated by various types of lighting which can impact residential areas in the vicinity of an airport. These lights can emanate from any of the following sources:

- Airfield lighting
- Apron lighting
- Terminal and facilities lighting
- Roadway and parking lot lighting
- Visual navigation aids

Two potential adverse impacts to human health related to airport light emissions include sleep disturbance and eye damage. Sleep disturbance could be caused by light emissions that create an environment considered to be unsuitable for some individuals to obtain the required amount of sleep. Extended periods of sleeplessness or interrupted sleep can adversely impact the health of an individual. Exposure to bright lights can also cause irreversible damage to the retina portion of the eye and, in extreme cases, can cause blindness.

Airport-related light emissions are only considered to have a notable impact if intense light is directed towards or is located within a residential area. The following briefly discusses the potential adverse health impacts and complaints received by the Port and the FAA related to airport light emissions.

(D) Existing Conditions

The area surrounding Sea-Tac is heavily developed. The area immediately west of airport property is a heavily populated residential area, while the areas immediately to the north, south, and east are occupied by either industry, roadways, and a golf course. All residential areas near Sea-Tac are located far enough from the terminal, parking, airfield, aprons, and support facility lighting source so as to limit the impacts due to these light sources.

The following summarize the types of lights in uses as navigational aids to the existing runways at Sea-Tac:

- *Touchdown Zone Lights* are rows of flush white three-light installations on either side of the runway centerline starting at 100 feet past the landing threshold and extending 3,000 feet down the runway. The lights are designed to provide depth information for touchdown and directional information during the roll-out phase of a landing aircraft. They are needed on wide runways because the runway edge lights do not provide sufficient reference. Because each light fixture is covered by a steel grid capable of supporting aircraft weight, the light is not blinding. Heating elements in each unit remove ice and snow. These lights are used on runways 16L/34R and 16R.
- *Visual Approach Slope Indicator System* (VASI-6) is a system of three

[19] *Monitoring of Ongoing Research on the Health Effects of High Voltage Transmission Lines (Reports one through nine)*, Bureau of Toxic Substances, Virginia Department of Health et al, Ninth Annual Report, April 20, 1994.

[20] *Monitoring of Ongoing Research on the Health Effects of High Voltage Transmission Lines*, Bureau of Toxic Substances, Virginia Department of Health et al, Ninth Annual Report, April 20, 1994.

rows of two lights on either the left or right side of the touchdown end of the runway. Each light contains a split-filter which emits either a red or white light beam depending on the angle between the light and the pilot. This approach system provides visual guidance during the approach to a runway and is visible to the pilot along the flight path from 3 to 5 miles out during daylight and up to 20 miles or more at night. The visual path of a VASI-6 provides safe obstruction clearance within ten degrees on either side of the extended centerline, up to six nautical miles from the runway threshold. These lights are used on runways 16L and 34L.

- *High Intensity Approach Lighting System with Sequenced Flashing Lights, Category I* (ALSF-1) Configuration consists of a continuous row of green lights spaced five feet apart at the runway threshold, three red, five-light bars and two red, three-light bars at 100 feet from the runway end, and 23 white, five-light bars at 100 foot spacing along the extended runway centerline to a distance of 2,400 feet from the runway end. At 1,000 feet from the runway end, a single set of eight white lights is located on both sides of the centerline light bars. Starting 1,000 feet from the threshold, the centerline light bars are augmented with a sequenced flasher. These flashers emit a bluish-white light in sequence toward the threshold at a rate of twice per second. These lights are used on runway 34R.
- *High Intensity Approach Lighting System with Sequenced Flashing Lights, Category II* (ALSF-2) configuration consists of a continuous row of green lights spaced five feet apart at the runway threshold, and 24 white, five-light bars at 100 foot spacing along the extended runway centerline to a distance of 2,400 feet from the runway end. On either side of the centerline light bars are nine red, three-light bars out to a distance of 900 feet from the runway end. At 500 feet from the runway end, a single white, four-light bar is located equidistant between the centerline light bar and the red light bars on both sides. At 1,000 feet from the runway end, a single set of eight white lights is located on both sides of the centerline light bars. Starting 1,000 feet from the threshold, the centerline light bars are augmented with a sequenced flasher. These flashers emit a bluish-white light and flash in sequence toward the threshold at a rate of twice per second. These lights are used on Runway 16R.
- *Medium Intensity Approach Lighting System with Sequenced Flashing Lights* (MALSF) are mounted on pedestals of varying heights, consisting of a series of seven, five-light bars spaced at 200 foot intervals along the runway centerline to a distance of 1,400 feet. The series of lights at a distance of 1,000 feet from the runway end is three light bars wide. All lights in the system are white, except for the threshold lights, which have green filters. These lights are used off 16L.
- *Medium Intensity Approach Lighting System with Runway Alignment Indicator Lights* (MALSR) are the same as MALSF with the addition of runway alignment indicator lights extending in a row-like manner beyond the 1,400 foot set of lights at 200 foot intervals out to 2,400 feet from the runway threshold. These white lights flash in sequence towards the threshold at the rate of twice per second. These lights are used on Runway 34L.
- *High Intensity Runway Lights* (HIRL) are used to outline the edges of runways during periods of darkness or restricted visibility conditions. They are located approximately 200 feet apart with a maximum height of 24 inches above pavement elevation. The lights are white, except the last 2,000 feet of the runway where split amber/white lights designate a caution zone for landings. The lights marking the ends of the runway emit red light toward the runway to indicate the end of runway to a departing aircraft and emit green outward from the runway end to indicate the threshold to landing aircraft. These lights are used on 16R/34L and 16L/34R.
- *Runway centerline lights* - flush white lights spaced at 50-foot intervals

beginning 75 feet from the landing threshold and extending to within 75 feet of opposite end of the runway. Because each light fixture is covered by a steel grid capable of supporting aircraft weight, the light is not blinding. Heating elements in each light remove ice and snow. Both runways at Sea-Tac have centerline lights.

- *Taxiway edge lights* are blue low-power output light fixtures. They are located not more than ten feet from the edge of the pavement at no more than 200-foot intervals along the taxiway edges. Taxiway lights emit little illumination beyond a 25-foot radius. *Taxiway turnoff lights* are flush lights spaced at 50 foot intervals, defining the curved path of aircraft travel from the centerline of the runway to a point on the taxiway. These lights are steady burning and emit green light. The lights are designed to support the weight of aircraft and melt snow and ice from the lens. All taxiways at Sea-Tac have such lights. Taxiways A, B, D, N and Q are equipped with centerline lights for low visibility conditions.
- *Taxiway Centerline Lights* occur on all taxiways at Sea-Tac except taxiway C. In addition, other low visibility lighting, such as hold position lights, and stop bar lights, facilitate aircraft movement on the airfield.
- *Rotating Beacon* identifies the location of the Airport at night and is identified by projecting a green and white beam of light 180 degrees apart. This beacon is located atop the Air Traffic Control Tower in the Main Terminal area.
- Obstructions in the vicinity of the Airport are also marked or lighted to warn pilots of their presence. These obstructions may be identified by a steady-red, flashing-red, or white strobe light.

Representatives of the Port[21] and the FAA[22] indicated that one complaint has been received over the past six years relating to light emissions associated with the operation of the Airport. The complaint was filed in 1988 by a nearby hotel concerning the operation of the airport reference beacon. The complainant indicated that the light shined in the guest rooms at the hotel resulting in complaints from the guests. Since an airport reference beacon is required by all Part 139 airports[23] its location and function are fixed by function.

(E) <u>Future Conditions</u>

The following summarize the impacts in the future of the Master Plan Update alternatives.

1. <u>Do-Nothing (Alternative 1)</u>

The Do-Nothing alternative would result in the existing lighting mechanism. As there are minimal concerns with light emissions to date, no changes would be expected in the future.

2. <u>"With Project" Alternatives (Alternative 2,3, and 4)</u>

The proposed airfield improvements are expected to result in airfield lighting such as occurs today. This would include an ALSF-2 on new runway 16X/34X. As is noted previously, this consists of a continuous row of green lights spaced five feet apart at the runway threshold, and 24 white, five-light bars at 100 foot spacing along the extended runway centerline to a distance of 2,400 feet from the runway end. On either side of the centerline light bars are nine red, three-light bars out to a distance of 900 feet from the runway end. At 500 feet from the runway end, a single white, four-light bar is located equidistant between the centerline light bar and the red light bars on both sides. At 1,000 feet from the runway end, a single set of eight white lights is located on both sides of the centerline

[21] Telephone interviews with James Serrill, Port of Seattle; Rachel Garson, Port of Seattle, August 3, 1994; and Diane Summerhays, Port of Seattle, August 15, 1994.

[22] Telephone interview with Richard Meyer, Federal Aviation Administration, Northwest Mountain Region, September 10, 1994.

[23] 14 CFR Part 139.

light bars. Starting 1,000 feet from the threshold, the centerline light bars are augmented with a sequenced flasher. These flashers emit a bluish-white light and flash in sequence toward the threshold at a rate of twice per second. These lights would be placed in a way, and incorporate shielding techniques to prevent any off-airport light emission impacts. The new runway would also be constructed with low visibility lighting, including in pavement centerline lights, edge lighting, etc.

The ASR-9 would be relocated as a result of any "With Project" alternative. The ASR-9 emits EMF at 2.7 to 2.9 gigahertz. As the ASR-9 does not emit a fixed beam (it rotates every 4-5 seconds), this intensity would not pose a threat to humans. In addition, the clearance around the structure ensures that reflective surfaces do not jeopardize the surrounding area.

3. Preferred Alternative (Alternative 3)

The proposed airfield improvements associated with the Preferred Alternative expected to result in airfield lighting such as occurs today. This would include an ALSF-2 on new runway 16X/34X. This consists of a continuous row of green lights spaced five feet apart at the runway threshold, and 24 white, five-light bars at 100 foot spacing along the extended runway centerline to a distance of 2,400 feet from the runway end. On either side of the centerline light bars are nine red, three-light bars out to a distance of 900 feet from the runway end. At 500 feet from the runway end, a single white, four-light bar is located equidistant between the centerline light bar and the red light bars on both sides. At 1,000 feet from the runway end, a single set of eight white lights is located on both sides of the centerline light bars. Starting 1,000 feet from the threshold, the centerline light bars are augmented with a sequenced flasher. These flashers emit a bluish-white light and flash in sequence toward the threshold at a rate of twice per second. These lights would be placed in a way, and incorporate shielding techniques to prevent any off-airport light emission impacts. The new runway would also be constructed with low visibility lighting, including in pavement centerline lights, edge lighting, etc.

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4. Mitigation

Lighting associated with the Master Plan Update alternatives are not expected to result in any off-airport impacts due to the use of shielding techniques.

(5) AIR TRAFFIC SAFETY

To address the possible health impacts from aircraft operations, air traffic safety was assessed. To assess such safety conditions, a review of data between 1984 and 1993 concerning aircraft accidents, incidents and pilot deviations at Seattle-Tacoma International Airport was conducted. Based on the existing conditions, forecast conditions with and without future airport development were forecast. As is shown, Sea-Tac Airport is currently operated with a low accident, incident and pilot deviation rate. In 1992, the FAA and Port of Seattle enacted extensive low visibility condition equipment, focused on addressing the period when the greatest potential exists for safety infractions. Air traffic and pilot aids were enacted, making Sea-Tac one of the more advanced airports in the Country. While activity levels are expected to grow in the future, safety is not anticipated to be adversely affected. The proposed Airport Master Plan Update alternatives would increase the number of runway crossings, but is not anticipated to adversely affect the air traffic control or ground control personnel's ability to safely handle this traffic.

(A) Aircraft Accidents and Incidents

Federal aviation statutes define the responsibility for safe and efficient air travel as a partnership with all users and service providers in the national aviation system. The FAA is the prime agency charged with the task of providing the regulation, promotion, development, and safety of civil aviation. Additionally, the FAA is mandated to provide safe and efficient airspace for use by civilian and military aircraft. In 1974, Congress created the National Transportation Safety Board (NTSB). The NTSB is an independent Government agency, within the Department of Transportation designed to promote transportation safety. The NTSB is charged with conducting independent, unbiased investigations of accidents involving all modes of transportation regulated by governmental agencies and the formulation of safety improvement recommendations based on their findings.[24]

In evaluating safety, the number and type of aircraft accidents and incidents were considered. An aircraft *accident* is defined as an occurrence associated with the operation of an aircraft which takes place between the time any person boards the aircraft with the intention of flight and until such time as all such persons have disembarked, and in which any person suffers death or serious injury, or in which the aircraft receives substantial damage. An *incident* is defined as an occurrence other than an accident associated with the operation of an aircraft, which affects or could affect the safety of operations.[25] The FAA oversees the investigation of most incidents, except where the NTSB chooses to act as lead investigator.

1. Existing Conditions

Records were obtained from the NTSB Analysis and Data Division. which indicates that Sea-Tac Airport has a very good safety record. There have only been 3 accidents in the 10 year period between 1984 and 1993, with no loss of life or human injury. Of these accidents, one was attributed to mechanical failure and two to pilot error. Thus, in considering potential causes of accidents and incidents, mechanical issues, pilot error, and weather must be considered.

Data provided by the FAA, Information Management Section of the Regulatory Support Division concerning the occurrence of incidents at Sea-Tac between 1984 and 1993 included:

- 39 - involving air carrier aircraft
- 13 - involving commuter aircraft
- 9 - involving general aviation
- 5 - involving aircraft (type of operation unavailable)

Noted in **Table IV.7-5** is a flat rate in the number of accidents and a low ratio of incidents when factored with the steady increase in the number of aircraft operations over this ten-year time period.

2. Future Conditions

No direct correlation exists between accidents and incidents and the number of aircraft operations at a particular airport. Any correlation between accidents/incidents and operations does not take into account increased maintenance requirements, experience of future aircraft crews, aging aircraft, and mechanical failures or fatigue. However, if a correlation between the numbers of incidents per 1,000 aircraft operations is assumed, the probability of an increase in the number of accidents and incidents at Sea-Tac would be expected as aircraft operations grow. Therefore, an estimate of the number of future accidents and incidents was estimated based on the existing rate.

a. Do-Nothing (Alternative 1)

As described in Chapter I, aircraft operations are expected to increase in the future due to an increase in the population of the Region.

[24] Independent Safety Board Act of 1974, P.L. 93-633, 88 State. 2166; 49 U.S.C. Section 1111 et seq.

[25] Chapter VIII - National Transportation Safety Board, Part 830.2

TABLE IV.7-5

COMPARATIVE ANALYSIS OF ACCIDENT/INCIDENTS TO CORRESPONDING OPERATIONS

Year	Accidents	Incidents	Total Operations
1984	0	7	224,052
1985	0	8	234,957
1986	1	2	260,199
1987	0	5	292,337
1988	0	7	316,260
1989	1	4	335,259
1990	0	6	355,007
1991	0	9	338,607
1992	1	8	345,995
1993	0	9	339,459

Source: FAA and NTSB. Aircraft operations from: Airport Master Plan Update, Technical Report No. 5, Preliminary Forecast Report, Table 3-1, P&D Aviation, April 1994.

As is shown in **Table IV.7-6**, regardless of future airport development, there is the potential for increased accident and incidents. Sea-Tac's rate of accidents are approximately 1 accident per 1,014,044 aircraft operations. Thus, about 0.4 accidents could be expected each year in the future. Similarly, during the 10 year period, 1 incident occurred for every 46,802 operations. Therefore, the number of average incidents per year could increase from 7.5 in 1994 to 9.4 by 2020.

b. "With Project" Alternatives (Alternatives 2, 3, and 4)

The proposed Master Plan Update alternatives are expected to result in the same number of aircraft operations as the Do-Nothing (Alternative 1). As all of the alternatives would accommodate forecast growth in activity, the alternatives would not be expected to adversely affect the future probability of incidents and accidents.

c. Preferred Alternative (Alternative 3)

The proposed Master Plan Update alternatives are expected to result in the same number of aircraft operations as the Do-Nothing (Alternative 1). As all of the alternatives would accommodate forecast growth in activity, the alternatives would not be expected to adversely affect the future probability of incidents and accidents.

(B) Pilot Deviations

Federal Aviation Regulation (FAR) 91.123 instructs pilots to comply with Air Traffic Control (ATC) clearances and instructions. No pilot may deviate from an ATC clearance which has been obtained, except in an emergency, unless the pilot obtains an amended clearance. Any variation from FAR 91.123 by a pilot is a "pilot deviation". Data relating to pilot deviations which have occurred at Sea-Tac was gathered from the FAA Facility Operations Branch, FAA Northwest Mountain Region Air Traffic Division. The data included identification of traffic complexity and types of aircraft in the fleet mix for the subject years. Since October

1987, deviations are identified by specific categories:

- Order 8020-11 Report - when requested by Flight Standards District Office, an 8020-11 Report is filed for events that occur which are not included in the violations below.
- TCA Violation - A Class B Airspace violation is when an aircraft enters Class B Airspace without prior ATC approval or clearance. Class B Airspace is defined as controlled airspace extending up from the surface or higher to specific altitudes.
- Altitude Violations - is when a pilot deviates from the ATC assigned altitude given for the assurance of safe flight controlled airspace;
- Runway Incursion: is defined as an incident between aircraft, vehicles, or any other obstacle which occurs within the runway and taxiway area.

1. Existing Conditions

Pilot Deviations which occurred within Sea-Tac Air Traffic Control Tower Terminal Control Area (Class B Airspace) since 1987 include:

- 8020-11 Report: 23
- TCA Violations: 62
- Altitude Violations: 28
- Runway Incursions: 9

All but one of the 62 TCA violations were by general aviation pilots. The cause of the pilot deviations ranged from the pilot being too busy, weather conditions, malfunctions in radio communications, a break in routine, etc.

2. Future Conditions

Factors influencing the occurrence of a pilot deviation include: 1) Too busy, 2) Weather, 3) Radio Quality, 4) Lost/Not paying attention, and 5) Skill. Because there is no direct correlation between any one of these characteristics and aircraft operations, there is no clear way to anticipate how pilot deviations would change in the future. However, if a correlation is assumed between the number of pilot deviations and aircraft operations, future conditions can be identified.

a. Do-Nothing (Alternative 1)

Using the rate per 1,000 aircraft operations of pilot deviations, the future Do-Nothing conditions were forecast based on forecast annual operations, and are shown below.

The forecast growth in aircraft operations is expected to result in an increased number of pilot deviations regardless of future Airport improvements.

TABLE IV.7-6

FORECAST ACCIDENTS AND INCIDENTS

	Do-Nothing (Alt 1)			With Project (Alts 2, 3, 4)		
Year	Operations	Accidents	Incidents	Operations	Accidents	Incidents
Existing	353,052	0.4	7.5	353,052	0.4	7.5
2000	379,200	0.4	8.1	379,200	0.4	8.1
2010	405,800	0.4	8.7	405,800	0.4	8.7
2020	441,600	0.4	9.4	441,600	0.4	9.4

Source: Metro Communications based on the historic rate of accidents and incidents.

	Do-Nothing (Alternative 1)			
Year	8020-11 Violations	TCA Violations	Altitude Violations	Runway Incursions
1994	3.5	9.4	4.3	1.4
2000	3.8	10.1	4.6	1.5
2010	4.0	10.8	4.9	1.6
2020	4.4	11.8	5.3	1.7

Source: Metro Communications, based on existing conditions projected in proportion to forecast operations.

b. "With Project" (Alternatives 2, 3, and 4)

The proposed Master Plan Update "With Project" alternatives would increase the number of runway crossings, as arriving aircraft land on the new parallel runway and then taxi to the terminal/ cargo facilities. The FAA's 1995 Capacity Enhancement Study performed a detailed assessment of the airfield operating performance associated with the runway options.

As the new runway would affect the number of runway crossings, the number of runway incursions could be affected. This analysis showed the average number of all-weather crossings would change as follows:

Number of All-Weather Average Runway Crossings

	Existing Airfield	With New Runway
1993	432	NA
2000	483	695
2010	564	812
2020	619	878

Source: 1995 Capacity Enhancement Plan Data Package 7, September , 1994.

No direct correlation exists between the increase in runway crossings and safety, as the separation standards used by air traffic control will ensure adequate separation between aircraft, and aircraft and service vehicles. The effect of separation standards will be the experience of delay. The review of aircraft accidents, incidents and pilot deviations between 1984 and 1993 for Sea-Tac show evidence that the Airport will continue to operate with the same low accident/incident ratios. No direct correlations have been found to suggest that increased aircraft operations will adversely affect the ratios of accidents and incidents in the future.

	With Project (Alternatives 2, 3, and 4)			
Year	8020-11 Violations	TCA Violations	Altitude Violations	Runway Incursions
1994	NA	NA	NA	NA
2000	3.8	10.1	4.6	2.2
2010	4.0	10.8	4.9	2.3
2020	4.4	11.8	5.3	2.4

Source: Metro Communications, forecast based on existing conditions and changes in runway crossings.

However, aircraft separation standards used by air traffic control will continue to ensure adequate separation and safety between aircraft and service vehicles. Further, upon construction of the new air traffic control tower, the ground control position will be supplemented with another position. Ground control may then be split for inbound and outbound traffic or may possibly be between gate hold/push back - ground, and movement control-ground.

As is shown in this analysis, Sea-Tac is one of the more advanced airports in the United States. While the National Transportation Safety Board does not compare safety records among airports, this analysis shows that the Master Plan Update will enable the existing low incident and accident and pilot deviation rate to be maintained.

C. Preferred Alternative

The Preferred Alternative would increase the number of runway crossings, as arriving aircraft land on the new parallel runway and then taxi to the terminal/ cargo facilities. This analysis showed the average number of all-weather crossings would change as follows:

Number of All-Weather Average Runway Crossings

	Existing Airfield	With New Runway
1993	432	NA
2000	483	695
2010	564	812
2020	619	878

Source: 1995 Capacity Enhancement Plan Data Package 7, September , 1994.

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(C) MITIGATION

As no significant degradation of safety would result, no mitigation is necessary.

Table IV.7-2

Seattle-Tacoma International Airport
Environmental Impact Statement

AIR TOXIC EMISSIONS INVENTORY AIRPORT SOURCES 1/ TONS/YEAR

Year/Alternative	VOC'S	Benzene	1,3-Butadiene	Formaldehyde
1994 Existing	519	11	10	87
2000 Alternative 1 (Do-Nothing)	370	8	7	62
2000 Alternative 2	370	8	7	62
2000 Alternative 3	370	8	7	62
2000 Alternative 4	372	8	7	62
2010 Alternative 1 (Do-Nothing)	498	11	10	83
2010 Alternative 2	497	11	10	83
2010 Alternative 3	496	11	10	83
2010 Alternative 4	503	11	10	84
2020 Alternative 1 (Do-Nothing)	764	17	15	128
2020 Alternative 2	752	16	15	126
2020 Alternative 3	751	16	15	126
2020 Alternative 4	756	16	15	127

1/ Airport sources include: Heating Plant, Training Fires, Surface Coating, Fuel Farms, Ground Support Equipments, and Aircraft.

VOC = Volatile Organic Compounds

VOC emissions determined with Emission Dispersion Modeling System (EDMS) Version 944. The methodology for converting VOC to the air toxics is described in Appendix D.

Source: Landrum & Brown Inc., 1995

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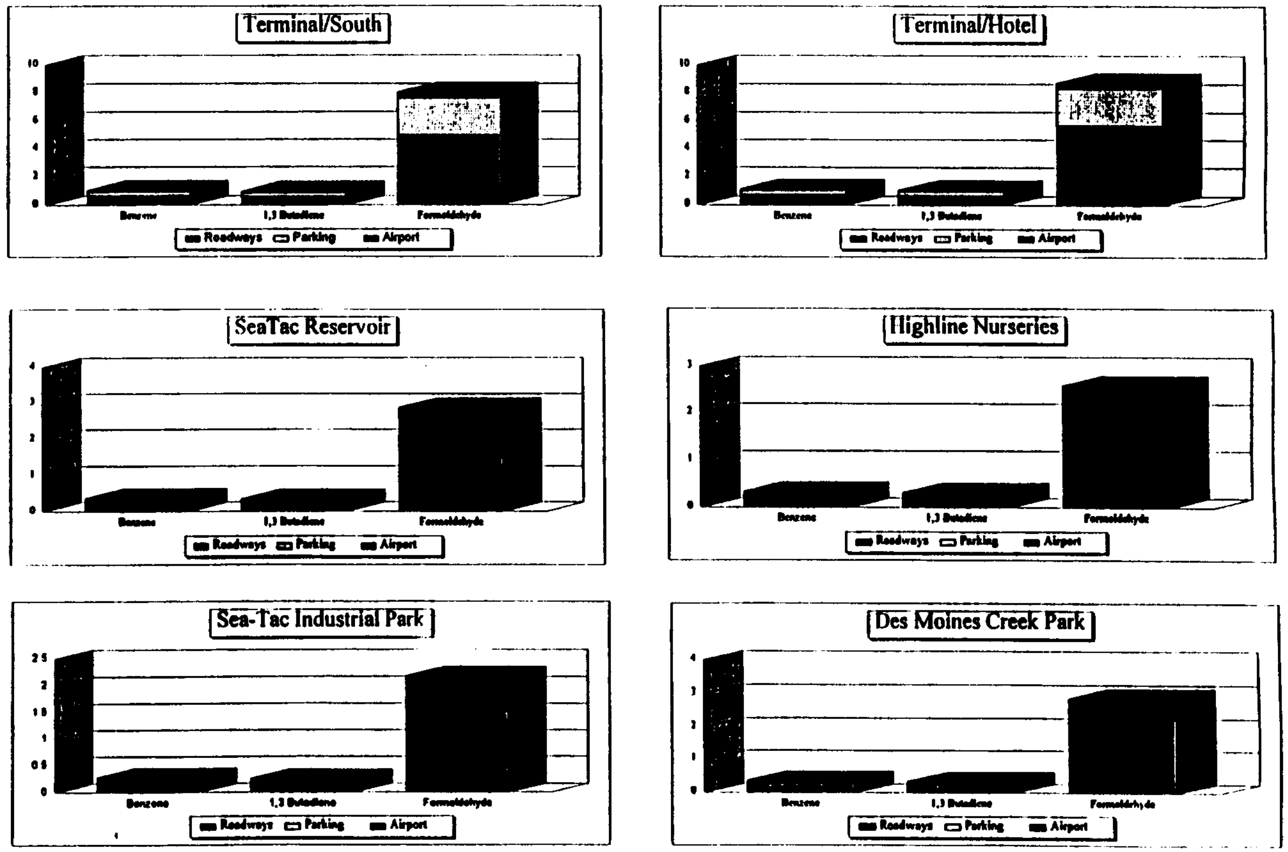
Table IV-7-3

Seattle-Tacoma International Airport
Environmental Imact Statement

EXISTING CONDITIONS (1994)
AIR TOXICS BY SOURCE (ug/m3)



ASILs: Acceptable Source Impact Levels established by Washington State Department of Ecology.
ASILs: Benzene = 0.120; 1,3 Butadiene = 0.0036; Formaldehyde = 0.077 (units = ug/m3).
Appendix D, Table D-16 presents the data for all sources for the existing condition.
Receptor locations are shown on Exhibit IV.9-1.
Source: Landrum & Brown, 1995.

Table IV.7-4
Page 1 of 3

Seattle-Tacoma International Airport
Environmental Impact Statement

COMPARISON TO ASILS

2000 Do-Nothing Alternative 1 Total All Sources	Receptor Source	VOC ug/m^3	Benzene	1,3 Butadiene	Formaldehyde
Terminal/South	Roadways	28.600	0.620	0.575	4.794
	Parking	15.200	0.329	0.306	2.548
	Airport	1.741	0.037	0.035	0.292
	Total	45.541	0.986	0.916	7.634
Terminal/Hotel	Roadways	35.100	0.760	0.706	5.883
	Parking	15.200	0.329	0.306	2.548
	Airport	1.729	0.038	0.035	0.289
	Total	52.029	1.127	1.047	8.720
SeaTac Reservoir	Roadways	11.800	0.256	0.237	1.978
	Parking	0.104	0.002	0.002	0.017
	Airport	2.609	0.056	0.052	0.437
	Total	14.513	0.314	0.291	2.432
Highline Nurseries	Roadways	13.400	0.290	0.269	2.246
	Parking	0.051	0.001	0.001	0.009
	Airport	0.937	0.021	0.018	0.157
	Total	14.388	0.312	0.288	2.412
Sea-Tac Industrial Park	Roadways	9.450	0.205	0.190	1.584
	Parking	0.156	0.003	0.003	0.026
	Airport	1.636	0.035	0.033	0.274
	Total	11.242	0.243	0.226	1.884
Des Moines Creek Park	Roadways	13.300	0.288	0.267	2.229
	Parking	0.135	0.003	0.003	0.023
	Airport	2.233	0.048	0.045	0.374
	Total	15.668	0.339	0.315	2.626
Existing 154th Street	Roadways	16.200	0.351	0.327	2.715
	Parking	0.129	0.003	0.003	0.022
	Airport	14.220	0.308	0.285	2.384
	Total	30.549	0.662	0.615	5.121
188th St. East	Roadways	26.600	0.576	0.535	4.459
	Parking	0.547	0.012	0.011	0.092
	Airport	6.409	0.140	0.128	1.074
	Total	33.556	0.728	0.674	5.625
188th St. West	Roadways	17.100	0.370	0.344	2.866
	Parking	0.221	0.005	0.004	0.037
	Airport	2.373	0.052	0.049	0.398
	Total	19.694	0.427	0.397	3.301

2000 "With Project" Alternatives 2,3,4 Total All Sources	Receptor Source	VOC ug/m^3	Benzene	1,3 Butadiene	Formaldehyde
Terminal/South	Roadways	28.4	0.615	0.571	4.760
	Parking	15.3	0.331	0.308	2.565
	Airport	1.791	0.038	0.036	0.300
	Total	45.491	0.984	0.915	7.625
Terminal/Hotel	Roadways	35.1	0.760	0.706	5.883
	Parking	15.2	0.329	0.306	2.548
	Airport	2.064	0.045	0.041	0.345
	Total	52.364	1.134	1.053	8.776
SeaTac Reservoir	Roadways	12	0.260	0.241	2.011
	Parking	0.171	0.004	0.003	0.029
	Airport	2.403	0.052	0.048	0.402
	Total	14.574	0.316	0.292	2.442
Highline Nurseries	Roadways	13.5	0.292	0.271	2.263
	Parking	0.058	0.001	0.001	0.010
	Airport	0.91	0.020	0.018	0.152
	Total	14.468	0.313	0.290	2.425
Sea-Tac Industrial Park	Roadways	9.64	0.209	0.194	1.616
	Parking	0.16	0.003	0.003	0.026
	Airport	1.57	0.033	0.031	0.263
	Total	11.365	0.245	0.228	1.905
Des Moines Creek Park	Roadways	13.3	0.288	0.267	2.229
	Parking	0.135	0.003	0.003	0.023
	Airport	1.971	0.043	0.039	0.330
	Total	15.406	0.334	0.309	2.582
Future 154th Street	Roadways	18.500	0.401	0.372	3.101
	Parking	0.084	0.002	0.002	0.014
	Airport	4.363	0.094	0.088	0.730
	Total	22.947	0.497	0.462	3.845
188th St. East	Roadways	26.800	0.581	0.539	4.492
	Parking	0.551	0.012	0.011	0.092
	Airport	6.842	0.149	0.138	1.147
	Total	34.193	0.742	0.688	5.731
188th St. West	Roadways	17.400	0.377	0.350	2.917
	Parking	0.220	0.005	0.004	0.037
	Airport	3.723	0.081	0.075	0.623
	Total	21.343	0.463	0.429	3.577

ASILs: Acceptable Source Impact levels established by Washington State Department of Ecology.
ASILs: Benzene = 0.120; 1,3 Butadiene = 0.0036; Formaldehyde = 0.077 (units = ug/m3).
Receptor locations are shown on Exhibit IV.9-1.
Source: Landrum & Brown, 1995.

Table IV.7-4
Page 2 of 3

Seattle-Tacoma International Airport
Environmental Impact Statement

COMPARISON TO ASILS

2010 Do-Nothing Alternative 1 Total All Sources	Receptor Source	VOC ug/m^3	Benzene	1,3 Butadiene	Formaldehyde
Terminal/South	Roadways	35.700	0.773	0.718	5.984
	Parking	17.100	0.370	0.344	2.866
	Airport	2.480	0.054	0.049	0.416
	Total	55.280	1.197	1.111	9.266
Terminal/Hotel	Roadways	40.000	44.668	0.804	6.705
	Parking	17.100	12.096	0.344	2.866
	Airport	2.278	2.545	0.046	0.382
	Total	59.378	66.309	1.194	9.953
SeaTac Reservoir	Roadways	12.900	0.279	0.259	2.162
	Parking	0.128	0.003	0.003	0.021
	Airport	5.324	0.116	0.108	0.892
	Total	18.352	0.398	0.370	3.075
Highline Nurseries	Roadways	14.400	0.312	0.289	2.414
	Parking	0.065	0.001	0.001	0.011
	Airport	1.870	0.041	0.039	0.312
	Total	16.335	0.354	0.329	2.737
Sea-Tac Industrial Park	Roadways	10.600	0.230	0.213	1.777
	Parking	0.212	0.005	0.004	0.036
	Airport	3.239	0.070	0.065	0.543
	Total	14.051	0.305	0.282	2.356
Des Moines Creek Park	Roadways	14.700	0.318	0.295	2.464
	Parking	0.242	0.005	0.005	0.041
	Airport	3.891	0.084	0.078	0.651
	Total	18.833	0.407	0.378	3.156
Existing 154th Street	Roadways	18.100	0.392	0.364	3.034
	Parking	0.158	0.003	0.003	0.026
	Airport	29.549	0.640	0.594	4.953
	Total	47.807	1.035	0.961	8.013
188th St. East	Roadways	30.700	0.665	0.617	5.146
	Parking	1.310	0.028	0.026	0.220
	Airport	11.790	0.255	0.237	1.976
	Total	43.800	0.948	0.880	7.342
188th St. West	Roadways	19.700	0.427	0.396	3.302
	Parking	0.397	0.009	0.008	0.067
	Airport	4.676	0.102	0.094	0.782
	Total	24.773	0.538	0.498	4.151

2010 "With Project" Alternatives 2,3,4 Total All Sources	Receptor Source	VOC ug/m^3	Benzene	1,3 Butadiene	Formaldehyde
Terminal/South	Roadways	28.000	0.607	0.563	4.693
	Parking	15.300	0.331	0.308	2.565
	Airport	2.260	0.048	0.045	0.378
	Total	45.560	0.986	0.916	7.636
Terminal/Hotel	Roadways	31.500	0.682	0.633	5.280
	Parking	15.400	0.334	0.310	2.581
	Airport	2.462	0.053	0.049	0.412
	Total	49.362	1.069	0.992	8.273
SeaTac Reservoir	Roadways	12.400	0.269	0.249	2.078
	Parking	0.186	0.004	0.004	0.031
	Airport	4.792	0.104	0.096	0.804
	Total	17.378	0.377	0.349	2.913
Highline Nurseries	Roadways	14.000	0.303	0.281	2.347
	Parking	0.068	0.001	0.001	0.011
	Airport	1.867	0.040	0.038	0.313
	Total	15.935	0.344	0.320	2.671
Sea-Tac Industrial Park	Roadways	10.200	0.221	0.205	1.710
	Parking	0.175	0.004	0.004	0.029
	Airport	3.136	0.068	0.063	0.524
	Total	13.511	0.293	0.272	2.263
Des Moines Creek Park	Roadways	14.300	0.310	0.287	2.397
	Parking	0.151	0.003	0.003	0.025
	Airport	3.756	0.082	0.075	0.630
	Total	18.207	0.395	0.365	3.052
Future 154th Street	Roadways	18.400	0.399	0.370	3.084
	Parking	0.095	0.002	0.002	0.016
	Airport	8.694	0.188	0.175	1.456
	Total	27.189	0.589	0.547	4.556
188th St East	Roadways	29.600	0.641	0.595	4.961
	Parking	0.565	0.012	0.011	0.095
	Airport	12.583	0.273	0.253	2.109
	Total	42.748	0.926	0.859	7.165
188th St. West	Roadways	19.100	0.414	0.384	3.201
	Parking	0.231	0.005	0.005	0.039
	Airport	7.409	0.160	0.149	1.241
	Total	26.740	0.579	0.538	4.481
15A - North Terminal Receptor	Roadways	23.200	0.503	0.466	3.889
	Parking	3.530	0.076	0.071	0.592
	Airport	0.934	0.020	0.019	0.156
	Total	27.664	0.599	0.556	4.637

ASILs: Acceptable Source Impact levels established by Washington State Department of Ecology
ASILs: Benzene = 0.120; 1,3 Butadiene = 0.0036; Formaldehyde = 0.077 (units = ug/m3).
Receptor locations are shown on Exhibit IV.9-1.
Source: Landrum & Brown, 1995

Table IV.7-4
Page 3 of 3

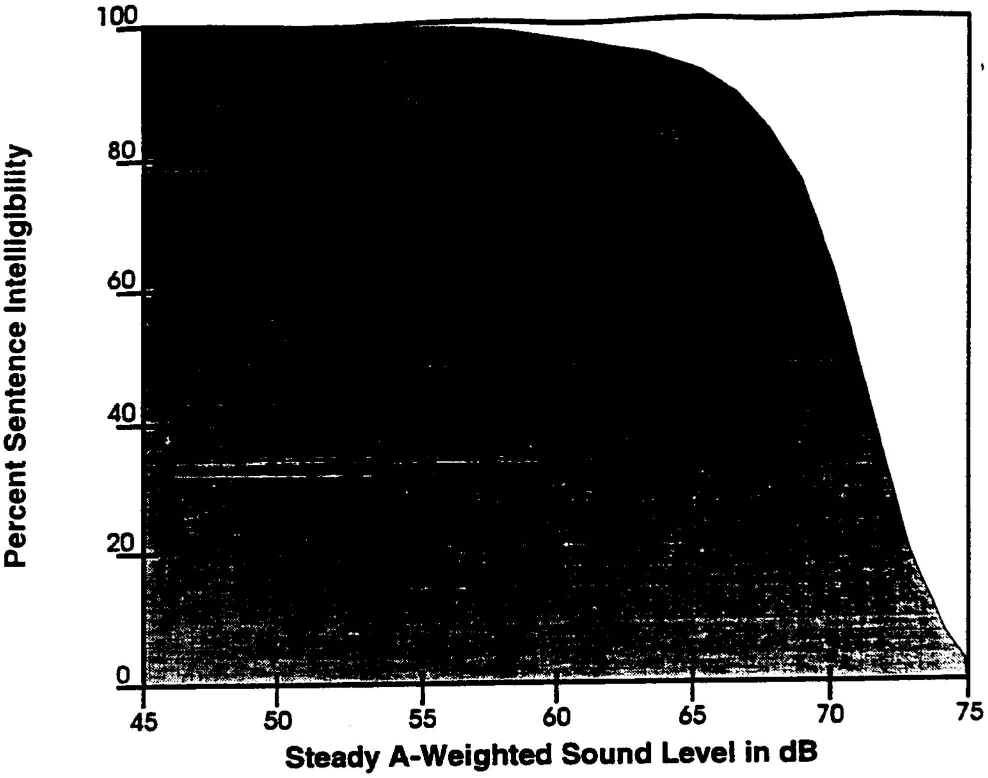
Seattle-Tacoma International Airport
Environmental Impact Statement

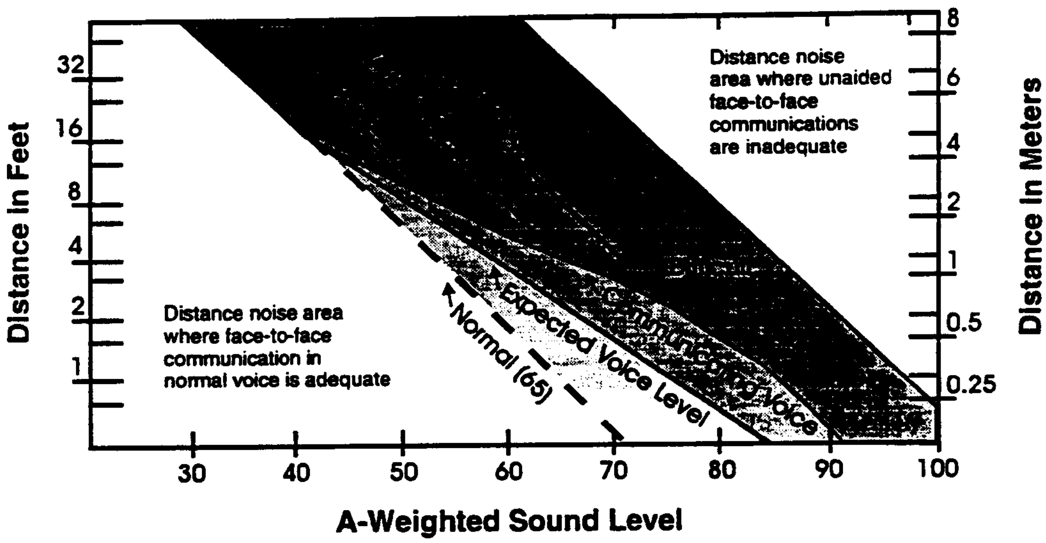
COMPARISON TO ASILS

2020 Do-Nothing Alternative I Total All Sources	Receptor Source	VOC ug/m^3	Benzene	1,3 Butadiene	Formaldehyde
Terminal/South	Roadways	44.000	0.953	0.884	7.375
	Parking	18.500	0.401	0.372	3.101
	Airport	2.537	0.055	0.050	0.425
	Total	65.037	1.409	1.306	10.901
Terminal/Hotel	Roadways	49.200	1.066	0.989	8 247
	Parking	18.600	0.403	0.374	3.118
	Airport	2.349	0.051	0.048	0.394
	Total	70.149	1.520	1.411	11.759
SeaTac Reservoir	Roadways	14.400	0.312	0.289	2.414
	Parking	0.139	0.003	0.003	0.023
	Airport	11.893	0.258	0.239	1.994
	Total	26.432	0.573	0.531	4.431
Highline Nurseries	Roadways	16.300	0.353	0.328	2.732
	Parking	0.071	0.002	0.001	0.012
	Airport	4.025	0.087	0.081	0.675
	Total	20.396	0.442	0.410	3.419
Sea-Tac Industrial Park	Roadways	15.100	0.327	0.304	2.531
	Parking	0.229	0.005	0.005	0.038
	Airport	6.404	0.140	0.128	1.073
	Total	21.733	0.472	0.437	3.642
Des Moines Creek Park	Roadways	23 210	0.503	0.467	3.890
	Parking	0.231	0.005	0.005	0.039
	Airport	7.493	0.162	0.150	1.255
	Total	30.934	0.670	0.622	5.184
Existing 154th Street	Roadways	20.500	0.444	0.412	3.436
	Parking	0.172	0.004	0.003	0.029
	Airport	67.712	1.467	1.361	11.350
	Total	88.384	1.915	1.777	14.815
188th St. East	Roadways	29.200	0.633	0.587	4.894
	Parking	1.350	0.029	0.027	0.226
	Airport	13.689	0.297	0.275	2.294
	Total	44 239	0.958	0.889	7.415
188th St West	Roadways	20.400	0.442	0.410	3.419
	Parking	0 417	0.009	0 008	0.070
	Airport	7.833	0.170	0.157	1 313
	Total	28.650	0.621	0.576	4 802

ASILs: Acceptable Source Impact levels established by Washington State Department of Ecology
ASILs: Benzene = 0.120; 1,3 Butadiene = 0.0036; Formaldehyde = 0.077 (units = ug/m3).
Receptor locations are shown on Exhibit IV.9-1.
Source: Landrum & Brown, 1995.

2020 "With Project" Alternatives 2,3,4 Total All Sources	Receptor Source	VOC ug/m^3	Benzene	1,3 Butadiene	Formaldehyde
Terminal/South	Roadways	31.100	0.674	0.625	5.213
	Parking	18.500	0.401	0.372	3.101
	Airport	2.370	0.051	0.047	0.397
	Total	51.970	1.126	1.044	8.711
Terminal/Hotel	Roadways	34.900	0.756	0.702	5.850
	Parking	18.600	0.403	0.374	3.118
	Airport	2.603	0.056	0.053	0.436
	Total	56.103	1.215	1.129	9.404
SeaTac Reservoir	Roadways	11.400	0.247	0.229	1.911
	Parking	0.252	0.005	0.005	0.042
	Airport	10.453	0.226	0.210	1.752
	Total	22.105	0.478	0.444	3.705
Highline Nurseries	Roadways	16.400	0.355	0.330	2.749
	Parking	0.074	0.002	0.001	0.012
	Airport	3.998	0.088	0.080	0.670
	Total	20.472	0.445	0.411	3.431
Sea-Tac Industrial Park	Roadways	15.300	0.331	0.308	2.565
	Parking	0.289	0.006	0.006	0.048
	Airport	5.960	0.129	0.120	0.998
	Total	21.549	0.466	0.434	3.611
Des Moines Creek Park	Roadways	22.600	0.490	0.454	3.788
	Parking	0.169	0.004	0.003	0.028
	Airport	6.758	0.146	0.136	1.133
	Total	29.527	0.640	0.593	4.949
Future 154th Street	Roadways	22.200	0.481	0.446	3.721
	Parking	0.105	0.002	0.002	0.018
	Airport	19.222	0.416	0.386	3.222
	Total	41.527	0.900	0.835	6.961
188th St. East	Roadways	27.700	0.600	0.557	4.643
	Parking	1.040	0.023	0.021	0.174
	Airport	15.456	0.335	0.311	2.591
	Total	44.196	0.957	0.888	7.408
188th St. West	Roadways	20.200	0.438	0.406	3.386
	Parking	0.394	0.009	0.008	0.066
	Airport	13.887	0.301	0.279	2.328
	Total	34.481	0.747	0.693	5.780
15A - North Terminal Receptor	Roadways	29.900	0.648	0.601	5.012
	Parking	4.370	0.095	0.088	0.732
	Airport	0.977	0.021	0.020	0.164
	Total	35.247	0.764	0.709	5.908





Necessary voice levels as limited by ambient noise for selected distances between talker and listener for satisfactory face-to-face communication.

Source: Federal Aviation Administration, 1992.

Seattle - Tacoma International Airport	Impacts on Speech/ Communication	EXHIBIT: IV.7-1

CHAPTER IV, SECTION 8

INDUCED SOCIO-ECONOMIC EFFECTS

A major passenger and cargo transportation facility such as Sea-Tac Airport directly and indirectly contributes to the economic structure of the Puget Sound Region. Induced socio-economic impacts are generated in the Region by changes in employment opportunities, payroll generation, business expenditures for goods and services, property tax receipts, and sales tax revenue. The existing and forecast induced socio-economic impacts are shown below:

	Airport Activity Related Impacts Alternatives 1, 2, 3, and 4		
	1993	2010	2020
Total Jobs	205,690	335,344	418,632
Personal Income (Millions)	2,585.6	4,215.4	5,262.4
Earnings/Dir Jobs (Millions)	15,910	25,938.7	32,380.9
Business Revenue (Millions)	6,355.7	10,361.9	12,935.5
State & Local Taxes (Millions)	406.6	662.9	827.5

All of the Master Plan Update alternatives would result in construction related socio-economic impacts. Further elaboration of these impacts is provided in Section 23 "Construction Impacts". Construction related jobs would be approximately 8,200 for the Do-Nothing (Alternative 1) - as the Do-Nothing includes actions such as implementation of the actions noted in Chapter II. Construction-related jobs would be about 45,500 for the "With Project" alternatives.

Through implementation of the "With Project" alternatives, the induced socio-economic impacts would change in the future relative to the Do-Nothing. The activity related induced socio-economic impacts would be the same for all Master Plan Update alternatives. However, the acquisition effects would differ among alternatives. The following summarize the impacts of the "With Project" alternatives relative to the Do-Nothing (Alternative 1), which would result in no acquisition effects:

	Impacts Due to:		
	Alt 2	Alt 3	Alt 4
Annual Loss in Property Tax (Thousands)	$227.5	$227.5	$291.9
Annual Lost Taxable Sales Transactions (Millions)	$2.2	$2.2	$15.6
Jobs Displaced	627	627	822

Assumes the 8,500 ft new dependent parallel runway. Assumes that commercial property in the RPZ is acquired.

Through implementation of a new parallel runway with a length up to 8,500 feet, property acquisitions would displace several businesses and numerous residences, reducing the existing property tax receipts, sales tax revenue, and employment. This would occur primarily in the City of SeaTac and, to a lesser extent, in the City of Burien. The only landside development that would result in the acquisition of property is the South Unit Terminal (Alternative 4), which would acquire 12 properties located on the northwest corner of International Blvd. and South 188th Street. As the property tax and sales tax impacts to an individual community are less than five percent, they are not considered significant. Reductions in property tax receipts would be partially offset by positive net gains in future tax receipts as property is more intensely developed in the Airport vicinity. Negative fiscal impacts also would be partially offset by local sales tax revenues generated by people directly employed at Sea-Tac Airport and induced revenues due to airport activity (e.g., taxable spending on goods and services by people employed at the Airport, air cargo businesses, hotel and commercial uses).

(1) METHODOLOGY

The analysis and information presented in this section was based on published reports; consultation with the Port of Seattle; State agencies (i.e., Washington Department of Revenue and Department of Employment Security); local jurisdictions' finance or budget offices; and King County Department of Assessments. Field investigation of areas in the vicinity of the Airport was also undertaken. A discussion of methodology is presented below.

(A) Master Plan Update Operation Effects

The employment, income, and expenditures created by operation of the Airport can be characterized as follows:

- Direct Effects - Direct effects are consequences of economic activities carried out at the Airport by airlines, airport management, fixed-base operators and other tenants with a direct involvement in aviation. Employing labor, purchasing locally-produced goods and services, and contracting for airport construction and capital improvements are examples of Airport activities that generate direct impacts.[1]
- Indirect Effects are the first round of local purchases by off-site economic activities that are attributable to the Airport's operation. These activities include services provided by travel agencies, hotels, cargo and freight forwarders and retail establishments.
- Induced effects are the result of the multiplier influences of the direct and indirect effects. Induced effects include activities of the service sector of the economy, such as grocers and gas station attendants who receive benefits of the local purchases of those directly and indirectly employed.
- Other Effects are components of the direct/indirect effects of Airport operations:
  - Air-traveler effects, which include expenditures made by travelers for food, lodging, retail goods, ground transportation and other goods and services. In addition to the original expenditures, air travelers also induce additional effects in terms of employment, payroll and output.
  - Business-revenue effects, which consist of revenue received by firms providing services to airlines, passengers and air cargo shippers/consignees; and
  - Tax effects, which include state and local tax effects as well as taxes paid to airport-specific Federal tax funds.

The aggregate economic effects associated with improvements envisioned in the Sea-Tac Airport Master Plan Update were calculated based on the direct and indirect employment and income, and expenditures created under each proposed alternative. Economic effects were based on existing studies completed by the Port of Seattle. The most recent analysis was published in May 1994.[2] An extensive number of jobs with airlines and the Airport are dependent on the number of flights and passengers at Sea-Tac International Airport; thus, impacts in future years were estimated in proportion to changes in forecast aviation activity levels. Effects are presented for years 2000, 2010, and 2020 based on the maximum aviation activity that can be accommodated.

(B) Airport Master Plan Construction Effects

Direct and indirect jobs generated by construction of facilities at the Airport are discussed in Chapter IV, Section 23, "Construction Impacts".

(C) Property Acquisition Effects

Property acquisitions for the Sea-Tac Master Plan Update would occur mainly in the cities of SeaTac and Burien. The direct effects that would result from acquisition and displacement of businesses and residences are of two types: (1) removal of properties from the tax base; and (2) loss of sales tax revenues from businesses unable to relocate in their respective city. Property and sales taxes constitute the largest sources of revenue for a typical city.

The extent of lost property tax receipts was estimated from the assessed valuation of acquired property and the tax allocation formula found in the Property Levy Codes as reported by King County Department of Assessments. The long-term fiscal impacts presented in this section do not take into account the effects of property revaluation over time.

The loss of sales tax revenue from the displacement of businesses is estimated by applying an average taxable sales transaction per establishment over time. The estimate is

[1] *Measuring the Economic Significance of Airports*, Federal Aviation Administration, 1986.

[2] *The Local and Regional Economic Impacts of the Port of Seattle*, Martin O'Connell Associates, May 31, 1994.

based on information available from the Washington Department of Revenue. The primary source of information on parcels affected by the Master Plan Update is from the September, 1994, King County Assessor's data files.

Employment effects can result from the loss of jobs associated with acquired properties. These effects were estimated based on a telephone survey and applying employment density factors for each type of active business establishment in the study area.[3]

(2) EXISTING CONDITIONS

Sea-Tac Airport is a diverse economic system that influences various sectors of the local and regional economy. These sectors include: airline and airport services, freight transportation, passenger ground transportation, contract construction and consulting services, and the visitor industry.

(A) Total Existing Economic Influences

Table IV.8-1 shows the total economic effects that were generated in 1993 by passenger and air cargo activity at Sea-Tac Airport. The total employment impact of 205,690 jobs generated by Airport activity represents nearly 12% of total jobs in the central Puget Sound region.

A total, of 78,711 jobs were generated directly by activity at the Airport and as a result of local purchases by visitors arriving at the Airport. This figure represents nearly 5% of the region's total employment. Of the 78,711 direct jobs, there were 14,381 direct Airport jobs, or less than 1% of the region's total jobs, distributed within the following economic sectors: Airline/airport sector provided 11,896 jobs, of which passenger airlines provided 8,197 jobs. The freight transportation sector provided 995 jobs; the ground transportation sector provided 1,199 jobs; and construction/consulting provided 292 jobs.

Of the 78,711 direct jobs, the purchases of passengers arriving at the Airport generated the remaining 64,330. The majority of these direct visitor industry jobs were generated with restaurants in the Seattle area, followed by jobs in area hotels.[4] As a result of local and regional purchases by these individuals, nearly 20,000 induced jobs were supported in the local and state economies. As a result of the local purchases by firms dependent upon the Airport, about 1,500 jobs were also indirectly generated in the local economy. Because of the demand for the products shipped by air, more than 100,000 jobs in the Region were related to air freight that was shipped through Sea-Tac.

Nearly $1.3 billion of direct earnings were received by the 78,711 direct employees, and the multiplier effect generated by these employees created a total income and consumption expenditure of $2.6 billion. Businesses providing services at the airport, as well as those local visitor industry businesses providing services to the air visitors, received $6.4 billion of total, direct revenue.

Federal, state, and local taxes are generated by individuals and business which make expenditures in the Region. State and local governments, especially those municipalities nearest the Airport, received $406.6 million of property tax receipts and sales tax revenue. Also, $199 million of Federal aviation-related tax revenue was generated. This consists of the 10 percent ticket tax, the Federal tax on enplaned cargo, the Federal Inspection Service fees and the International Departure tax. In addition, $45 million of customs receipts were also collected by the federal government at Sea-Tac Airport.

[3] *Trip Generation Handbook*, 4th Edition, Institute of Transportation Engineers, 1990.

[4] *The Local and Regional Economic Impacts of the Port of Seattle*, Martin O'Connell Associates, May 31, 1994. p 61 and 74.

TABLE IV.8-1

SUMMARY OF EXISTING (1993) AIRPORT-RELATED ECONOMIC IMPACTS

Airport & Visitor Industry Impacts

Jobs	
Direct	78,711
Induced	19,482
Indirect	1,497
Related	106,000
TOTAL	205,690
Personal Income (Millions)	
Direct	$1,252.3
Re-spending	$1,333.3
TOTAL	$2,585.6
Earnings/Direct Jobs (Millions)	$15,910.0
Business Revenue (Millions)	$6,355.7
State & Local Taxes (Millions)	$406.6
Federal Aviation Taxes (Millions)	$199.0
U.S. Customs (Millions)	$45.0

Source: *The Local and Regional Economic Impacts of the Port of Seattle*, Martin O'Connell Associates, May 31, 1994, page 56. In 1993 dollars.

(B) **Employment Influences by Jurisdiction**

Sea-Tac Airport is the center of aviation activity for the Puget Sound Region. **Table IV.8-2** lists the 1993 distribution of jobs by jurisdiction. The majority of the 14,381 direct Airport jobs (82%) were held by residents of King County. Residents of the City of Seattle hold 25% of direct jobs at the Airport, while 57% of the jobs are contained within jurisdictions in the immediate surroundings of the Airport. **Table IV.8-2** also shows the proportion of direct airport employment to each jurisdiction's total employment.

(3) **FUTURE CONDITIONS**

Sea-Tac Airport will continue to influence the socio-economic character of the Region in the future, with or without expanded and improved landside and airside facility developments. The following paragraphs summarize the impacts in the years 2000, 2010, and 2020.

(A) **Airport Activity Related Impacts**

Future impacts from airport operations were derived by using the existing ratio of economic impact to airport activity and applying the ratios to future activity levels. As enplanements increase, most economic impacts are expected to increase proportionately. **Table IV.8-3** displays the estimated economic impacts of future airport operations.

1. **Do-Nothing (Alternative 1)**

The Do-Nothing alternative would result in airport facilities at Sea-Tac remaining as they are today, with a few exceptions, such as completion of the South Aviation Support Area and Des Moines Creek Technology Campus. Aircraft operations are expected to grow 30% while enplaned passengers are expected to grow 100% by 2020, regardless of the future facilities available at Sea-Tac Airport. Based on the forecast growth in airport activity, the economic impacts were estimated.

As is shown in **Table IV.8-3**, the employment levels in the Region associated with airport activity are expected to grow from 205,690 jobs in 1993 to 260,823 in 2000 and 418,632 in 2020, a 26 percent and 103 percent increase respectively.

2. **"With Project" Alternatives (Alternative 2, 3, and 4)**

Each of the "With Project" alternatives would result in the same level of total airport activity as the Do-Nothing. Therefore, the activity related socio-economic impact of these alternatives would be the same as the Do-Nothing (Alternative 1).

As is described in Chapter II, the "With Project" alternatives would reduce the economic costs to the airlines associated with forecast increases in congestion, delay, and declining air service efficiency compared to the Do-Nothing alternatives.

An increase in the physical space at the Airport would be expected to result in an increase in employment. Such employment could result from the need to maintain and protect the new facilities. In addition, new facilities could enable the Port and airport tenants to improve the services afforded to the traveling public and shippers. However, until more detailed space allocation plans are prepared, a definition of these additional employment opportunities cannot be prepared.

3. Preferred Alternative (Alternative 3)

As is noted earlier, the Preferred Alternative (Alternative 3) would result in the same activity related induced socio-economic impact as the Do-Nothing (Alternative 1). As is described in Chapter II, the Preferred Alternative would reduce the economic costs to the airlines associated with forecast increases in congestion, delay, and declining air service efficiency compared to the Do-Nothing alternative. In addition, an increase in the physical space at the Airport would be expected to result in an increase in employment. Such employment could result from the need to maintain and protect the new facilities. In addition, new facilities could enable the Port and airport tenants to improve the services afforded to the traveling public and shippers. However, to present a worst-case assessment, this assessment shows that same level of Airport activity related impacts as the Do-Nothing.

(B) Population Growth and Movement

In addition to economic impacts, future Airport activity may also have an impact on population growth and movement based on the assumption that most employees live near their place of employment. Therefore, airport employment may influence population levels in the General Study Area regardless of other land use and employment-generating dynamics anticipated to occur in the future. In turn, growth in population directly affects local housing demand and property values.

1. Do-Nothing (Alternative 1)

The employment levels in the Puget Sound Region associated with airport activity are expected to grow 26 percent and 103 percent respectively between 1993-2000 and 1993-2020. Therefore, it is anticipated that housing demand will continue to grow in the Region with or without improvements at Sea-Tac Airport. However, assuming that surface transportation congestion continues in the Region, it is possible that airport related employees will seek housing in closer proximity to the Airport. Therefore, additional housing pressures could occur in the airport area in the future.

2. "With Project" Alternatives (Alternative 2, 3, and 4)

Because airport related induced socio-economic impacts are expected to be the same with implementation of the "With Project" as the Do-Nothing alternative, airport improvements are not anticipated to adversely affect population growth and movement.

3. Preferred Alternative (Alternative 3)

Because airport related induced socio-economic impacts are expected to be the same with implementation of the Preferred Alternative as the Do-Nothing alternative, airport improvements are not anticipated to adversely affect population growth and movement.

(C) Property Acquisition Effects

Airport improvements can have an effect on real property taxes, sales taxes and employment as a result of acquisition requirements. The following paragraphs summarize these impacts.

1. Do-Nothing (Alternative 1)

Property acquisition and residential and business displacement at Sea-Tac Airport beyond that currently planned would not occur under Alternative 1. Thus, there would be no related fiscal and employment impacts from Airport development. Depending on the outcome of the West SeaTac Subarea planning process (as described in Chapter IV, Section 2 "Land Use"), the West SeaTac community could experience a gradual transition from residential to business park uses or other non-residential uses more compatible with Airport operations.

The SR 509/South Access Road may entail significant residential and business displacements from property acquisitions within the right-of-way corridor. Loss in annual property tax receipts by Des Moines and other affected jurisdictions and taxing districts could range from $412,000 to $674,000 depending on the alternative selected. These effects are discussed in detail in the SR-509/South Access Road Draft EIS, issued in December, 1995. This project would likely enhance market potential of under-developed properties and increase commercial development that is better served by improved transportation access.

The Des Moines Creek Technology Campus, sponsored by the City of Des Moines and Port of Seattle, is an 85-acre site south of the Airport. The site is now vacant. It is planned to generate a cluster of biomedical manufacturing, high-tech, and aviation-related businesses that would thrive in a location near the Airport and air cargo infrastructure. The evolution of this Technology Campus would likely generate significant localized agglomeration of new businesses and create an employment center close to a large residential population served by all utilities and transportation systems.

2. **"With Project" Alternatives (Alternative 2, 3, and 4)**

Table IV.6-3 provides a summary, by area, of the residential and commercial parcels that would be acquired under Alternatives 2, 3, and 4 for the various runway lengths. The acquisition area is the same for each alternative (for each runway length) and differs only in the terminal area.

A variety of business types would be displaced, such as neighborhood retail and food establishments, small local service establishments, automotive services, airline businesses, and warehousing and shipping firms that are directly connected to the freight and goods enterprises at the Airport. The potential impacts of property acquisition are discussed below.

Property and sales taxes are the two major sources of revenues cities receive. Cities also receive lesser amounts of revenue from excise taxes, including leasehold and real estate excise taxes, and from licenses and permits, intergovernmental sources, charges for services, fines and forfeits, and miscellaneous items.[5] Revenue issues specific to the Master Plan Update are property tax receipts and sales tax revenues.

Property Tax Receipts Effects: Property taxes constitute the largest revenue source for the cities of SeaTac and Burien. The City of SeaTac has a considerable number of State Public Services (SPS) properties. These were assessed at $710 million in 1993. Burien's SPS properties were assessed at $32.1 million for the same year. These values are part of the city's assessed value base.

The properties affected by the Sea-Tac Airport Master Plan Update are of ten levy codes and several regular property levy rates corresponding to the acquisition areas.[6]

a. **Runway Length 8,500 feet:** Alternative 2, with a new dependent parallel runway with a length of 8,500 feet, would require off-airport acquisition. Properties not already owned by the Port in these areas would be acquired as part of the Master Plan Update improvements. In the primary acquisition area, a total of 270 residences, one condominium (containing 12 units), and five businesses would be

[5] Leasehold revenues are derived by a city from airport property within a city's boundaries. These properties are called SPS properties and include airlines and other utilities operating in Washington. Under RCW 84.12 the State Department of Revenue annually assesses the value of all airlines operating in Washington for property tax purposes. Publicly owned property, including Port property generates leasehold excise taxes from the lease or rent of publicly owned property by private parties. The tax rate levied is about 12.8% of which the State receives 6.8%, cities receive 4%, and counties receive 2%.

[6] Levy codes designated by the King County Assessor are 0932 for the City of Burien, and 2201, 2205, 2206, 2210, 2212, 2218, 2219, 2222, and 2231 for the City of SeaTac.

acquired. In the north and south RPZs planned for the new runway, as well as for the Runway 34R extension, additional acquisition would be required. This would include 38 residences, one apartment with 234 units, and 89 businesses.

Table IV.8-4 presents the effects on the cities of SeaTac and Burien and displays the total assessed property valuation. The overall total assessed value of residential property that would be acquired is $54.08 million and $21.3 million for business/commercial properties. The breakdown by city is as follows:

TABLE IV.8-4

TOTAL ASSESSED PROPERTY VALUATION TO BE ACQUIRED
(8,500 ft dependent parallel runway)

	Valuation
Burien	
Residential	$12,773,200
Businesses	$ 2,473,300
Total Valuation	$15,246,500
SeaTac	
Residential	$41,306,131
Businesses	$18,809,000
Total Valuation	$60,115,131

Source: Based on King County Assessor database. Assumes the 8,500 ft dependent parallel runway located 2,500 feet west of existing Runway 16L/34R.

The taxable assessed value base for the City of SeaTac was nearly $2 billion. Property acquisitions occurring within the City of SeaTac would reduce the city's AV base by $60 million, or 3%. The City of SeaTac receives property tax receipts on a rate of $3.02811 for each $1,000 of assessed value.[7] If these residential and business properties are fully displaced, the City would lose approximately $181,687 in property tax receipts annually. This figure represents approximately 2.8% of the City's property tax revenues.[8] Analysis conducted by the City of SeaTac indicates that the 1995 General Fund property tax loss would be 3.68%.[9]

The taxable assessed value base for the newly formed City of Burien was $1.6 billion. Property acquisitions occurring within the City of Burien would reduce the city's AV base by $15.2 million, or 0.95%. The City of Burien receives property tax receipts on a rate of $3.00838 for each $1,000 of assessed value. If these residential and business properties are fully displaced, Burien would forego less than one percent or $45,867 in property tax receipts annually.[10]

Property acquisitions would reduce property tax receipts to the Highline School District by $254,882. This figure represents 1.4% of the School District's revenues that are derived from local property taxes.[11]

Other taxing districts also would forgo revenues based on the property levy rates shown in **Table IV.8-5.** However, the fiscal impacts are not considered significant because of the small contributions these forgone tax receipts comprise of a taxing district's total budget.

7/ King County Assessor's database for year 1993. For the purposes of estimating allocation among various taxing agencies of property tax revenues paid by these properties, property tax rates have been averaged across the levy code areas contained within the acquisition areas. The City of SeaTac's levy rate per thousand dollars of assessed value is an average of eight levy codes. The City of SeaTac has $710 million AV from SPS properties which are exempt from property taxes.

8/ Personal Conversation, Mike McCarty, City of SeaTac, Finance Department. The City of SeaTac Budget shows 1993 budgeted revenues from property taxes at $6,388,149.

9/ City of Sea-Tac, Memo to Scott Rohlfs from Galen May 16, 1995.

10/ City of Burien, Budget for 1993-94, property tax receipts represent 44% (at $4,623,708 collected) of General Fund revenues.

11/ Highline School District Budget, 1995. Local property taxes comprise 18%, State funds comprise 72%, and Federal special purpose funds comprise 6% of the $103,900,000 total revenues of the School District. This analysis presents a baseline estimate of fiscal impacts to the School District assuming a constant levy rate.

The property levy rates for each tax district are as follows:

Table IV.8-5

PROPERTY LEVY RATES

Consolidated levy	5.91873
State School Fund	3.39960
King County	2.21546
Port of Seattle	0.30367
City levy	3.01824
Highline School District levy	3.38213
Library	0.57899
EMS	0.24972

Levy rate per $1,000 of assessed value.

City levy is the average of Burien and SeaTac rates.

Source: King County Department of Assessment, 1994.

b. **Runway Length 7,500 feet:** The future effects to the Cities of SeaTac and Burien's revenue base would be similar to those found under the 8,500-foot option, except that 27 fewer residences, 234 fewer apartments or condominium units, and one less business would be displaced in Burien. In the west side runway-related mitigation area, 81 residences, one apartment with 14 units, and 15 businesses would be acquired. Acquisitions would reduce the City of SeaTac's AV base by $59 million, or 2.9%; and the City of Burien's AV base by $2,473,300, or 0.15%.

   Property acquisitions would reduce property tax receipts to the Highline School District by $207,910, or 1.1% of the District's revenues that are derived from local property taxes. The fiscal impacts to other taxing districts would be similar to those found under the 8,500-foot option.

c. **Runway Length 7,000 feet:** The future effects to both cities' revenue base would be similar to those found under the 8,500-foot option, except that 40 fewer residences, and 234 fewer apartments or condominium units, and nine fewer businesses would be displaced. Notably for the City of Burien, acquisitions would reduce the city's AV base by $142,800.

   Because fewer residences and businesses would be displaced under this alternative, reductions in property tax receipts to the Highline School District would be less than 0.5% of the District's revenues derived from local property taxes. The magnitude of the fiscal impacts to other taxing districts also would be less than those found under the 8,500-foot option.

The estimated loss in property tax revenues represents potential maximum effect and assumes that a business or residence would be unable to relocate within the same city. Depending on a property's location, property values could decrease adjacent to the proposed buyout areas, resulting in lower property tax receipts to a jurisdiction. Potential decreases in property values west of SR 509 might be reduced by the separation from the acquisition area provided by the roadway's physical buffer. Values of properties near the buyout areas in Burien, between SR 509 and Des Moines Way, also could be affected. Additionally, any decline in a city's AV base would be partially offset by expected future increases in the area's AV base resulting from increases in airport-compatible development occurring within SeaTac and Burien. For instance, greater land use compatibility than presently exists in the West SeaTac area could result in the transition from residential uses to non-residential uses including Airport operations and business park. These commercial properties typically hold a higher assessed value than residential uses, require less public services (i.e., schools), and also would generate greater revenues to SeaTac.[12]

[12] Refer to Section 2 "Land Use" for discussion of West SeaTac Planning Process.

d. **Terminal Development:** Only one alternative would require the acquisition of non-airport properties to complete the terminal development: South Unit Terminal (Alternative 4).

As is described earlier, the Alternative 4 would require the acquisition of 12 additional commercial properties located in the City of SeaTac north of S. 188th Street and west of International Blvd. These properties contain the following businesses:

- West Coast Gateway Hotel (a 145 room hotel),
- Sharp's Roaster Ale House Restaurant
- La Quinta Inn (142 room hotel)
- Airport Plaza Hotel (123 room with attached Zorro's Restaurant)
- Jack-in-the-Box fast food;
- Denny's Restaurant;
- Pizza Hut Restaurant;
- Barrett's SeaTac Mini Mart;
- Washington State Liquor Store;
- 3 parking lots

As these commercial properties support Airport activity, other local business activities and area residents, it is reasonable to assume that they will be relocated to other properties in the general vicinity. However, to present a worst-case evaluation, the impact on assessed valuations was performed to determine the impacts if the properties were not relocated in the immediate area. The overall assessed value of these commercial properties would reduce the City of SeaTac's AV by $21.3 million (1.07%). Property acquisitions from terminal development would reduce property tax receipts to the Highline School District by $72,039, or 0.4% of the District's revenues from local property taxes. The cumulative impact of the airside and landside development (assuming an 8,500 foot new parallel runway) on the City of SeaTac would be $81.4 million or 4.6% of the AV. The loss of these commercial properties would reduce the City's property tax receipts by $64,348 annually, with a cumulative impact from airport improvements of $246,035.

The cumulative impact from property acquisitions from airside and landside developments would reduce property tax receipts to the Highline School District by $275,356, or 1.4% of the District's revenues that are derived from local property taxes. The magnitude of the fiscal impacts to other taxing districts would be similar to those found under other runway length options.

Sales Tax Revenue Effects: Sales tax is levied on taxable sales within a county or city at a total rate of 8.2%. Of this amount, the cities of SeaTac and Burien receive a net of 0.852%.[13] Typically, sales tax receipts are the second largest revenue source for a city. Taxable retail sales generated within these cities were $432.7 million and $242.8 million for SeaTac and Burien, respectively.[14] The average taxable sales generated per establishment in SeaTac and Burien was $202,892 and $116,318, respectively.

The Sea-Tac Airport Master Plan Update acquisition areas would displace business/commercial properties for each proposed runway option. **Table IV.6-3** provides a summary of the number of parcels acquired under these runway options, and **Table IV.6-4** lists these parcels with the number of businesses.

* * *

As the tax revenue impacts to each individual jurisdiction is less than 5%, the impact is not considered significant.

a. **Runway Length 8,500 feet: Table IV.8-6** shows estimated taxable sales generated by properties within the acquisition areas. The properties to be acquired generated an estimated $2.2 million in taxable sales transactions. This figure is distributed at $1.6 million and $0.6 million in taxable sales for the cities

13/ Washington Department of Revenue net sales tax averages reflect state administrative percent on the 1% sales rate for local jurisdictions.

14/ Washington State Department of Revenue, 1993 data.

of Burien and SeaTac, respectively. For the City of Burien, the potential loss of taxable sales represents 0.65% of total taxable sales generated. The loss of taxable sales from acquired businesses represents 0.14% of total sales generated in the City of SeaTac.

b. **Runway Length 7,500 feet:** The future effects on the revenues derived from taxable sales for the cities of SeaTac and Burien would be similar to those found under the 8,500-foot option. The differences between the 7,500- and 8,500-foot options are that the Shell Gas Station and a portion of the Vacca farm also are located within RPZ-North in the 7,500-foot option.

c. **Runway Length 7,000 feet:** The future effects on both the cities of SeaTac and Burien's taxable revenue base would be slightly less in terms of lost sales revenues than those found under the 8,500-foot option. Both the Primary-SASA and RPZ-South acquisitions are identical to the 8,500 foot and 7,500 foot options. The major difference between the 7,000-foot and 8,500-foot options occur in the Mitigation area and RPZ-North area. In the Mitigation area, adverse effects on taxable sales are diminished to the extent that Genzale Commercial Building (Burien), Olympic Bowl (Burien), Shell Gas Station (Burien), and Red Apple Grocery are not displaced. There are also no acquisition properties under the Primary-Runway and RPZ-North acquisition areas.

d. **Terminal Development:** Only one terminal development option would require the acquisition of non-airport properties - the South Unit Terminal (Alternative 4).

As is described earlier, the Alternative 4 would require the acquisition of 12 additional commercial properties located in the City of SeaTac north of S. 188th Street and west of International Blvd. Because these commercial properties are supporting Airport activity, other area businesses and residents, it is reasonable to assume that they will relocate to other properties in the airport area. However, to present the worst-case impacts, the loss of sales were estimated. These commercial properties generate $13.4 million in taxable sales. The displacement of these facilities could represent a loss to the City of SeaTac of 3.1% of total sales generated in the City of SeaTac. Combined with development of the new 8,500-foot dependent parallel runway, the City of SeaTac could incur a cumulative loss of 3.2% of total sales.

* * *

As the tax revenue impacts to each individual jurisdiction is less than 5%, the impacts are not considered significant.

Employment Effects: Sea-Tac Airport Master Plan Update acquisition areas would displace businesses for each proposed runway option. **Table IV.6-3** (presented earlier) provides a summary of the number of parcels acquired under these runway options, and **Table IV.6-4** lists these parcels with the number of businesses at the location.

a. **Runway Length 8,500 feet: Table IV.8-6** shows the estimated number of jobs provided by the businesses that would be acquired to complete the 8,500-foot new dependent parallel runway. Total acquisition properties employ an estimated 627 people with Burien employers providing 40 jobs and SeaTac employers providing 587 jobs.[15] For the City of Burien, the maximum potential loss of these jobs represent 0.29% of total employment. For the City of SeaTac, the decline in jobs from acquired businesses could

[15] Employment figures derived from telephone survey of businesses from December - January 1995; and in some case applying employment density factor per land use category.

represent 4.4% of total employment.[16]

b. **Runway Length 7,500 feet:** The future effects on the employment base from acquired properties and displaced businesses for the cities of SeaTac and Burien would be similar to those found under the 8,500-foot option. The differences between the 7,500- and 8,500-foot options are the Shell Gas Station and a portion of the Vacca farm that are located within the RPZ-North in the 7,500 foot option.

c. **Runway Length 7,000 feet:** The effects on the employment base from acquired properties for the cities of SeaTac and Burien would be slightly less in terms of lost employment than those found under the 8,500-foot option. Both the Primary-SASA and RPZ-South acquisitions are identical for the 8,500-foot and 7,500-foot options. The major difference between the 7,000-foot and 8,500-foot options occurs in the Mitigation area and RPZ-North. In the Mitigation area, adverse effects on employment are diminished to the extent that Genzale Commercial Building (Burien), Olympic Bowl (Burien), Shell Gas Station (Burien), and Red Apple Grocery are not displaced. There are also no acquisition properties under the Primary-Runway and RPZ-North acquisition areas.

Overall, the number of jobs affected would remain nearly the same across each runway option, because the largest concentration of jobs is contained within the RPZ-South acquisition area. The estimated loss in these jobs represents potential maximum effects and assumes that businesses would be unable to relocate within the same city. Finally, any decline in employment would be partially offset by future increases in employment-generating uses generated by airport-compatible development occurring within the cities of SeaTac and Burien. Thus, any potential effect would be partially offset by growth-inducing effects generated from Airport development.

d. **Terminal Development:** As is described previously, only the South Unit Terminal (Alternative 4) would result in the displacement of businesses. While it is reasonable to assume that these business would relocate to nearby properties, if they were permanently displaced the airport development would displace 195 jobs, representing 1.5% of employment within the City of SeaTac. With the new 8,500 foot parallel runway, the cumulative job displacement could be 6.3% (822 jobs) of the City's employment base.

3. Preferred Alternative (Alternative 3)

Table IV.6-3 provides a summary, by area, of the residential and commercial parcels that would be acquired under Alternative 3, the Preferred Alternative. A variety of business types would be displaced, such as neighborhood retail and food establishments, small local service establishments, automotive services, airline businesses, and warehousing and shipping firms that are directly connected to the freight and goods enterprises at the Airport. The potential impacts of property acquisition are discussed below.

Property Tax Revenues: The Preferred Alternative would require off-airport acquisition. In the primary acquisition area, a total of 270 residences, one condominium (containing 12 units), and five businesses would be acquired. In the north and south RPZs planned for the proposed new runway, as well as for the Runway 34R extension, additional acquisition would be required. This would include 38 residences, one apartment with 234 units, and 89 businesses. The overall total assessed value of residential property that would be acquired is $54.08 million and $21.3

[16] Washington Department of Employment Security database, Burien provided a total of 13,600 jobs; SeaTac provides a total of 13,400 jobs (figures exclude resource and construction-related jobs).

million for business/commercial properties.

The taxable assessed value base for the City of SeaTac was nearly $2 billion. Property acquisitions occurring within the City of SeaTac would reduce the city's AV base by $60 million, or 3%. The City of SeaTac receives property tax receipts on a rate of $3.02811 for each $1,000 of assessed value. If these residential and business properties are fully displaced, the City would lose approximately $181,687 in property tax receipts annually. This figure represents approximately 2.8% of the City's property tax revenues.

The taxable assessed value base for the newly formed City of Burien was $1.6 billion. Property acquisitions occurring within the City of Burien would reduce the city's AV base by $15.2 million, or 0.95%. The City of Burien receives property tax receipts on a rate of $3.00838 for each $1,000 of assessed value. If these residential and business properties are fully displaced, Burien would forego less than one percent or $45,867 in property tax receipts annually.

Sales Tax Revenue Effects: The properties to be acquired generated an estimated $2.2 million in taxable sales transactions. This figure is distributed at $1.6 million and $0.6 million in taxable sales for the cities of Burien and SeaTac, respectively. For the City of Burien, the potential loss of taxable sales represents 0.65% of total taxable sales generated. The loss of taxable sales from acquired businesses represents 0.14% of total sales generated in the City of SeaTac.

Employment Effects: **Table IV.8-5** shows the estimated number of jobs provided by the businesses that would be acquired to complete the proposed new parallel runway. Total acquisition properties employ an estimated 627 people, with Burien employers providing 40 jobs and SeaTac employers providing 587 jobs. For the City of Burien, the maximum potential loss of these jobs represents 0.29% of total employment. For the City of SeaTac, the decline in jobs from acquired businesses could represents 4.4% of total employment.

* * *

As is noted throughout this section, the Preferred Alternative is not expected to create significant impacts on the local municipal tax based as a result of acquisition.

(3) CUMULATIVE IMPACTS

Cumulative impacts can occur if the Airport Master Plan Update alternatives are implemented in combination with other major non-airport related projects. At this time, the long-term and combined impact from the construction and operation of a number of facilities planned for the Sea-Tac Airport vicinity cannot be fully assessed or quantified with any degree of precision.

Cumulative displacement impacts may occur if the Airport Master Plan Update is implemented as other major projects are underway. The Regional Transit System proposal currently anticipates two planned transit stations (one at the airport, the other at the intersection of I-5 and SR 518) near the Airport. Preliminary station area plans call for the intensification of land uses and transit-compatible residential and commercial development. Transit stations in combination with supportive land uses improve regional accessibility, and lead to higher land values around stations. Higher values, in turn give rise to higher commercial rents, densification, and a fairly rapid absorption of building space.

There are no other known plans for major redevelopment by either SeaTac or Burien that would lead to significant residential or business displacements in those communities.

(4) MITIGATION MEASURES

All property acquisition associated with the Master Plan Update would comply with the Uniform Relocation Assistance and Real Property Acquisition Policies Act. Currently, the Port of Seattle determines an acquisition price and provides for an owner to get an independent appraisal if they disagree with the proposed acquisition price. The procedure provides that relocation benefits must be made available when an acquisition is involuntary on the part of the owner.

While location decisions may vary from business to business, the criteria generally includes the costs of doing business, location and access, local quality of life and amenities. The ability of a business establishment to relocate within the same jurisdiction and/or area is a function of many factors, including the availability of business relocation sites; alternative site rents; existing operating expense and costs; whether the store/business is a chain, franchise, or sole proprietorship; number of customers; and size of the market area it serves.

The majority of the businesses that could be affected by the "With Project" alternatives have been in operation for many years. Most of the retail stores serve customers within the immediate area and very few of these businesses serve customers passing through the area.

A small retail establishment would likely be able to relocate easily because of the greater supply of alternative retail space and land uses. Fast food and convenience store establishments would be easy to relocate within the area, since the area is still growing and many alternative sites are available.

There are no mitigation measures proposed to compensate for socio-economic effects on the study area, because no significant adverse effects are expected to occur. While the "With Project" alternatives could result in an initial lowering of property tax and sales tax revenue and jobs, these impacts are expected to be mitigated by the induced socio-economic impacts from construction and operation of improved airport facilities.

Table IV.8-2

DISTRIBUTION OF DIRECT AIRPORT JOBS BY RESIDENCE

Jurisdiction	Percentage by Jurisdiction	Existing Airport Jobs	% of Jurisdiction's Total Employment
King County	82.13 %	11,811	1.3
Airport Area Cities	56.81 %	8,170	2.0
Burien	3.38 %	486	3.6
Des Moines	3.03 %	436	4.7
Federal Way	12.49 %	1,796	4.6
Kent	7.72 %	1,110	4.9
Normandy Park	0.86 %	124	3.7
SeaTac	2.75 %	395	3.0
Seattle	25.50 %	3,667	1.2
Tukwila	1.08 %	155	2.1
Kitsap County	NA	NA	NA
Pierce County	11.36 %	1,634	0.8
Snohomish County	2.14 %	308	0.2
Puget Sound Region	96.00 %	13,806	1.0

Source: *The Local and Regional Economic Impacts of the Port of Seattle*, Martin O'Connell Associates, May 1994, page 63; employment data for wage and salary workers comes from the Washington Department of Employment Security for 1993.

NA = Not applicable

TABLE IV.8-3

FUTURE AIRPORT ACTIVITY RELATED EFFECTS 2000-2020

	Master Plan Update Alternatives 1, 2, 3 and 4		
	2000	2010	2020
Jobs			
Direct	99,809	128,325	160,197
Induced	24,704	31,762	39,651
Indirect	1,898	2,441	3,047
Related	134,412	172,816	215,737
TOTAL	260,823	335,344	418,632
Personal Income (Millions)			
Direct	$1,588.0	$2,041.7	$2,548.8
Re-spending	$1,690.7	$2,173.7	$2,713.6
TOTAL	$3,278.6	$4,215.4	$5,262.4
Earnings/Direct Jobs (Millions)	$20,174.5	$25,938.7	$32,380.9
Business Revenue (Millions)	$8,059.3	$10,361.9	$12,935.5
State & Local Taxes (Millions)	$515.6	$662.9	$827.5
Federal Aviation Taxes (Millions)	$252.3	$324.4	$405.0
U.S. Customs (Millions)	$57.1	$73.4	$91.6

Source: Factors derived from Port of Seattle, The *Local and Regional Economic Impacts of the Port of Seattle*, Martin O'Connell Associates, May 31, 1994, page 94; and aviation activity levels contained in 1994 Master Plan Update, Technical Report No. 5. All figures are in 1993 dollars.

TABLE IV.8-6

CURRENT TAXABLE SALES AND EMPLOYMENT FROM BUSINESSES THAT COULD BE ACQUIRED DUE TO THE MASTER PLAN UPDATE IMPROVEMENTS

City	Business	Owner	Sales	Employees
Runway Related Construction Mitigation Acquisition (Alternatives 2, 3 and 4)				
Burien	Commercial Building	Genzale, Anthony	$ 465,272	20
Burien	Olympic Bowl	Erickson, Ronald	Closed	for lease
Burien	Shell Gas Station	Winter, Charles & Susan	113,899	4
Burien	Tucker's Upholstery Shop	Tucker, Charles W.	15,000	4
Burien	Red Apple Grocery	Cistaunet, David T. & Chris A.	994,646	12
SeaTac	Agricultural/Farming	Vacca, Tony & Betty J.	NSG	NA
SeaTac	Raffo Garage	RST Enterprises Inc	NA	NA
SeaTac	Commercial/Office	RST Enterprises Inc	NSG	NA
SeaTac	Chevron Station	Cromie, James M.	114,899	6
SeaTac	Jovanovich & Sons Marine	Jovanovich, John	65,000	4
SeaTac	Agricultural/Farming	Vacca, Tony & Betty	NSG	NA
	RPZ Acquisition [1]			
SeaTac	Des Moines Way Nursery	Seike Shu Benjamin & Kiyoshi	47,043	12
SeaTac	Office & Deli	Paarezanin, Don J.	35,000	24
SeaTac	Alaska Airlines Stores Annex	Alaska Airlines	NA	8
SeaTac	Jim's Detail Shop	Chu Sho Mei	75,000	12
SeaTac	Hertz Auto Sales & Service	Hertz Realty Corp	80,000	15
SeaTac	All-American Homes	All-American Homes Inc.	NA	6
SeaTac	Jerry Auto Detail	H J Gwinn & Co	30,000	8
SeaTac	Avis Rent A Car	Avis Rent A Car System Inc	60,000	12
SeaTac	Rons Auto Rebuild	H J Gwinn & Co	80,000	6
SeaTac	A-1 Collision	Bjorneby, Robert G & Anna M	20,000	8
SeaTac	Warehouse/Shipping	Pacific Gulf Properties Inc.	NA	30
SeaTac	Telephone Co. Building	U S West Inc.	NSG	NA
SeaTac	Sea Tac Industrial Park	Grorek, Matt & Aew	NA	140
SeaTac	A-1 Collision	Bjorneby, Robert G	30,000	8
SeaTac	Nel-Tech	Weona Building Corp	NA	128
SeaTac	Sea Tac Industrial Park	Gworek, Matt & Aew	NA	90
SeaTac	Sea Tac Industrial Park	Gworek, Matt & Aew	NA	40
SeaTac	Alaska Airlines Warehouse	Alaska Airlines	NA	30
		Acquisition Area Total	$2,225,759	627

Source: Shapiro & Associates. Taxable retail sales per business estimated from data provided by Washington Department of Revenue and employment figures from telephone survey and application of employment density factors. 1994.

The estimated loss in these jobs represents potential maximum effects and assumes that businesses would be unable to relocate within the same city.

[1] Commercial properties in the Runway Protection Zone of the new parallel runway may not be acquired - avigation easements may be purchased.

NA= Not available NSG = No Sales Transactions Generated.

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CHAPTER IV, SECTION 9

AIR QUALITY

The air quality analysis presented in the Draft EIS has been updated to account for changes in the surface transportation analysis (Chapter IV, Section 15 "Surface Transportation", and Appendix O). Additionally, in response to numerous comments concerning the assumptions used in the air quality analysis and the presentation of results in the Draft EIS, this chapter and the associated Appendix D have been revised. In re-examining the modeling assumptions used in the analysis, several 'test case' analyses were conducted to evaluate the effect of various levels of aircraft activity on air pollutant levels (presented in Appendix D). Each of the individual comments concerning the EIS analysis are responded to in Appendix R (See response to comments R-10-1 through R-10-68).

The proposed Master Plan Update improvements at Sea-Tac conforms to the requirements for the Puget Sound Region and to the State of Washington's plan for "eliminating or reducing the severity and number of violations of the national ambient air quality standards and achieving expeditious attainment of such standards." This was determined through the preparation of an airport emissions inventory, an areawide dispersion analysis, and a roadway intersection analysis. Additionally, the analysis includes an evaluation of air toxic emissions (see Section 7 "Human Health"), and construction vehicle impacts (see Section 23 "Construction Impacts").

The majority of the pollutant emissions in the Puget Sound Region--75 percent--is generated by motor vehicles (i.e., cars, trucks, buses, taxis, motorcycles). Aircraft operating at Sea-Tac contribute less than one percent of the carbon monoxide emissions, nitrogen oxides, and volatile organic compounds for all mobile sources within the Puget Sound Region. Whether a new runway is built or not, air pollutant emissions from roadway vehicles and aircraft would be expected to increase in the Region as population increases.

Key findings of this analysis are:

- *Air Pollutant Inventory:* Airport-related pollutant emissions from Sea-Tac are less than the levels established by the State Implementation Plan for reducing air pollutants. They would continue to be less than forecast, with or without airport improvements.
- *Area Dispersion Analysis*: The dispersion analysis performed for the airport area indicates that exceedances of the Ambient Air Quality Standards would occur with or without Airport improvements. Development of the proposed third parallel runway would not worsen air pollution in the Airport area. In fact, use of a third runway would result in a reduction in pollutant concentrations at most locations.
- *Roadway Intersection Analysis*: Pollutant concentrations at several highly congested intersections on International Boulevard (SR 99) currently exceed the 8-hour carbon monoxide standard. The addition of the proposed North Unit Terminal would result in changes in traffic volumes and patterns which would increase pollutant levels above already high levels. However, proposed mitigation would alleviate the increased pollutant concentrations.

Mitigation actions can help curtail the additional carbon monoxide levels at those intersections that would experience a change in traffic with the proposed improvements. Other mitigation plans and improvements--such as new aircraft and automobile technology, restructured ground traffic patterns, more efficient poor-weather landing operations--can also help alleviate projected pollution levels for the airport and the Puget Sound Region. Mitigation measures are discussed at the end of this section.

Projects involving the location of a new runway may not be approved unless there is "reasonable assurance" that the project will be located, designed, constructed, and operated in compliance with applicable air quality standards (the AAQS). Certification in the form of a "Governor's Air Quality Certificate", issued by the Washington State Governor's Office, is required indicating that the proposed project will comply with all applicable air quality standards.

(1) AIR QUALITY STANDARDS

The U.S. Environmental Protection Agency (USEPA) has adopted air quality standards that specify the maximum permissible short-term and long-term concentrations of air contaminants. The National, State, and local Ambient Air Quality Standards (AAQS) consist of a primary and secondary standard for each pollutant as presented in **Table IV.9-1**. Air quality standards are the levels established to protect the public health from harm within a margin of safety. All areas of the country are required to demonstrate attainment with the AAQS.

The Washington State Department of Ecology (Ecology) and the Puget Sound Air Pollution Control Agency (PSAPCA) have established state and local ambient air quality standards that are at least as stringent as the national standards. Local standards that are more stringent than the national standards for sulfur dioxide have been in effect since 1968.

The air quality standards focus on limiting the quantity of six criteria pollutants:

- Ozone (O_3)
- Carbon Monoxide (CO)
- Nitrogen Dioxides (NO_2)
- Particulate Matter (PM_{10})
- Sulfur Dioxide (SO_2)
- Lead (Pb)

Hydrocarbons (HC) are not a criteria pollutant and therefore no ambient air standards have been established for this pollutant. Since hydrocarbons, however, react with nitrogen oxides in sunlight to form ozone, hydrocarbon and nitrogen oxide emissions are included in the analysis performed for this EIS. Because air monitoring in the Puget Sound Region has indicated compliance with the lead standard since 1980, lead was not examined in this study.

(2) PUGET SOUND REGION

The Clean Air Act requires states with areas that exceed the AAQS to develop plans for each area that, when implemented, will reduce air pollutants and attain the standards. These attainment plans must be adopted by the state and submitted to the USEPA in the form of a State **Implementation Plan** (SIP). Compliance with the AAQS (i.e., establishing the area as attainment or nonattainment) is determined by long-term monitoring throughout the Region.

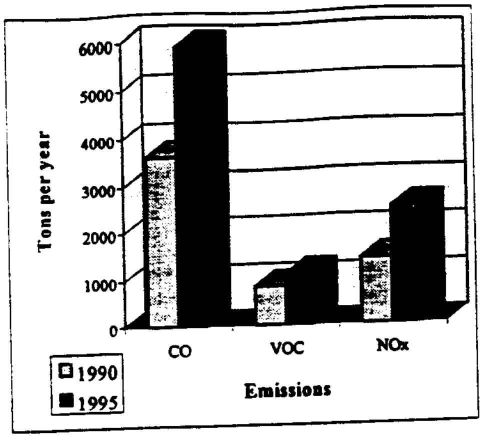
The severity classifications for non-attainment areas are in increasing order of severity: marginal, moderate, serious, severe, and extreme. The Puget Sound Region has been designated as a 'high-moderate' non-attainment area for carbon monoxide, and as a 'marginal' ozone non-attainment area. The CO non-attainment area extends from north of Everett to Tacoma. The ozone non-attainment area comprises all of Pierce County, all of King County except for a small portion in the northwest corner, and the western portion of Snohomish County.

Accordingly, Ecology has prepared implementation plans for reducing CO and ozone levels within the Puget Sound Region. For areas designated marginal non-attainment for ozone, the State must demonstrate through its SIP that it will reduce ozone pollutants 15 percent over 1990 levels by 1996, and meet the ambient air quality standards by November 15, 1999.

As found by the State's emission inventory, motor vehicles (i.e., cars, trucks, buses, taxis, motorcycles) are the primary air pollutant generator in the Region. Motor vehicles contribute 75 percent of the total pollutant levels in King County, while non-road activity such as lawn and garden equipment, construction equipment and airport activity represent 20 percent of the pollutant emissions in the Region. Accordingly, the greatest source of CO emissions in the Region are motor vehicles.

The SIP "inventories" pollutant levels by a variety of sources within the Region including airports. Once all the pollutant sources are inventoried, then the SIP focuses on measures to reduce pollutant levels in order to meet pollutant reduction goals for the Region. The SIP inventories do not mean that activity within the Region cannot grow. For example, the SIP accounts for growth in aircraft activity at Sea-Tac as shown below (1990 and forecast 1995 emissions):

STATE IMPLEMENTATION PLAN AIRCRAFT EMISSIONS INVENTORY



By 1995, overall emissions within the Region are expected to decrease by 37 percent over 1990 levels. At the same time, the SIP planned for aircraft emissions at Sea-Tac to increase by 63 percent for Carbon Monoxide, 77 percent for Nitrogen Dioxides, and 31 percent for Volatile Organic Compounds (hydrocarbons). Because motor vehicles are expected to remain the largest contributor of pollutants, the SIP focuses on reducing emissions from motor vehicles to achieve the Region's goals for reducing air pollutants. The anticipated decrease in emissions from motor vehicles is expected to result from increased use of oxygenated fuels, continuation of the vehicle inspection and maintenance program, and by the replacement of older automobiles with newer, cleaner models.

Appendix D summarizes the air monitoring conducted in the Region. Additionally, several specific air monitoring programs have been conducted at the Airport and within the Region. The most recent air monitoring program conducted at the Airport was along the terminal curbfront to assess the potential impact of a planned on-airport hotel from December to January 1994/1995. This monitoring focused on carbon monoxide and found no violations of the 1-hour and 8-hour CO standards. Each of the air monitoring programs are more fully described in **Appendix D**.

Residents have long expressed concern over the source of 'black speckles' or 'black residues' at their homes. Therefore, a residue sampling program was conducted as part of this EIS. The results of the sampling program are described in Appendix D, and in Appendix R (R-10-43).

(3) SEA-TAC AIR POLLUTANT INVENTORY

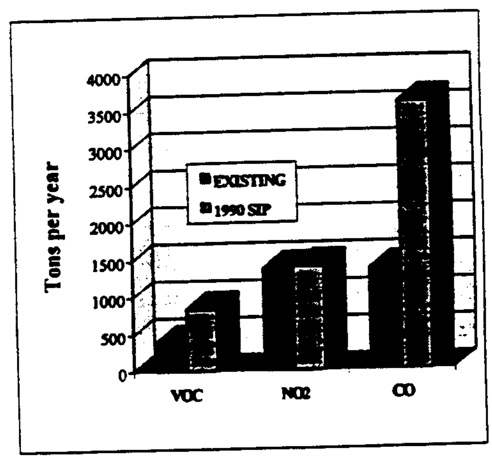
For the EIS, an aircraft pollutant inventory was prepared similar to the SIP inventory. The aircraft pollutant inventory summarizes the *total* quantity of each pollutant emitted by aircraft operating at the Airport. The aircraft emissions inventory was performed using the FAA's Emissions and Dispersion Modeling System (EDMS) computer model. The following present the existing inventory levels and future pollutant emissions for the Airport for the years 1994, 2000, 2010, and 2020. The emissions levels are shown in comparison to the SIP inventory levels.

For a more detailed comparison of the SIP and EIS inventory, as well as the 1991 Ecology Study analysis methodologies, refer to Appendix R (R-10-2).

(A) Existing (1994) Inventory

The Airport's existing pollutant emissions are consistently below the State's inventoried emissions for Sea-Tac. The following chart compares the emissions for 1994 with the State's 1990 emissions inventory levels for Sea-Tac.

EXISTING EMISSIONS INVENTORY



(B) Future Pollutant Inventory

For each project alternative and time period, aircraft emissions are below SIP levels. Nonetheless, emissions are expected to increase as aircraft activity increases, whether or not a new runway is built.

AR 039051

Starting with the year 2000, **Table IV.9-2** places side-by-side the emission levels of the four alternatives–the Do-Nothing (Alternative 1) and the three "With Project" options (Alternative 2 through 4). Included is the Preferred Alternative (Alternative 3).

The results show that there would be little difference in total emissions between each of the alternatives. The differences would be due primarily to minor changes in aircraft taxiing patterns associated with each alternative and an overall slight reduction in departure delay time. The future emissions levels show that use of the proposed third parallel runway would result in increased aircraft taxiing, but also a reduction in departure delay time.

CHEMICAL ABBREVIATIONS and UNITS OF MEASUREMENT	
CO	Carbon Monoxide
HC	Hydrocarbons
PM_{10}	Particulate Matter
NO_2	Nitrogen Dioxides
O_3	Ozone
SO_2	Sulfur Dioxide
VOC	Volatile Organic Compounds
ppm	parts per million

(4) AREA DISPERSION ANALYSIS

An areawide air pollution dispersion analysis was performed to determine the impact of airport-related activity on pollutant levels in the vicinity of the Airport. This analysis was undertaken to ensure that the proposed Master Plan Update alternatives would not increase the frequency or level of pollution, particularly in the communities surrounding the Airport. The analysis concluded that development of the proposed third parallel runway would not worsen existing exceedances, or create new exceedances of the ambient air quality standards for all forecast periods.

The area dispersion analysis encompasses a wider range of sources than the air pollution inventory, which focused solely on aircraft emissions. The dispersion analysis accounts for emissions from aircraft and aircraft support equipment, on and off-airport parking lots, roadways, training fires, fuel systems, terminal heating and cooling, and aircraft maintenance activities.

The FAA's Emissions and Dispersion Modeling System (EDMS) computer model was utilized to perform the dispersion analysis. Modeled pollutant levels were compared to the National, state, and local Ambient Air Quality Standards (AAQS) presented in **Table IV.9-1**.

EDMS can be used to produce two levels of detail: a screening analysis which incorporates "worst case" operational and hypothetical meteorological conditions; and, a more detailed 'refined' analysis that considers actual operational patterns and historical meteorological conditions.

The *screening dispersion analysis* helps to identify locations in the Airport environment where possible exceedances of the air quality standards could result. The screening analysis produces a peak hour pollutant concentration that assumes that the peak activity for aircraft, roadways, and other sources occurs at the same time. The analysis also considers that the "worst" weather conditions for pollutant dispersion also occurs at the same time. This situation produces a highly unlikely if not improbable combination of events.

Receptor locations for all alternatives were selected based on air pollutant contours (pollutant contours or isopleths represent lines of equal pollutant concentration). The pollutant contours were created using a grid of 400 receptor locations equally spaced at 300 meters apart. The pollutant contours help identify locations at which the highest possible concentrations could be found and where the air quality standards might be exceeded. **Exhibit IV.9-1** identifies the receptor locations identified by the screening analysis and for which a more detailed, refined dispersion analysis was then conducted. **Appendix D** presents the pollutant contours and receptor locations.

The *EDMS refined analysis* includes two primary enhancements over the screening analysis. The first incorporates "temporal" factors that describe hourly, weekly, and monthly activity for each of the different pollutant sources (aircraft, roadways, etc.). In comparison to the screening analysis, the 'temporal' factors assign activity according to when it actually occurs. The second component uses actual meteorological conditions for each of the five most recent years (1988-1993) for the Puget Sound Region. Each year includes 8,760 hours of actual weather data. Use of the temporal factors and actual weather data produces pollutant emission levels more closely linked to "real world" conditions.

In 1991, the Washington State Department of Ecology prepared a screening level analysis for Sea-Tac. The EIS takes the analysis to the next, more detailed level of analysis beyond the Ecology study.

The following sections describe the results of the areawide refined dispersion analysis. Background concentrations were included in this analysis. The background concentration is a level of pollutant concentration that is not directly attributable to any one source. Background concentrations for CO, NO_2, SO_x, and PM_{10} were added to the estimated concentrations determined by the dispersion modeling. Even before airport sources are considered, the recommended background concentrations account for 30 to 60 percent of the levels allowed by the ambient air quality standards.

(A) Existing Pollutant Concentrations

The highest concentrations of carbon monoxide occur along the terminal curbfront. There were no exceedances of the short-term 1-hour and 8-hour standards for carbon monoxide identified by the areawide dispersion analysis.

Table IV.9-3 shows the concentrations of carbon monoxide and nitrogen dioxide with the addition of background levels for each receptor location for the existing condition. For each receptor location, the source (airport, roadways, background) of the pollutant concentrations is illustrated. As shown, airport sources are generally not the major contribution to receptor concentrations.

For existing condition, no exceedances of the 1-hour and 8-hour CO standard were identified by the areawide dispersion analysis. The highest CO concentrations occurred in the terminal roadway area.

An exceedance of the NO_2 ambient air quality standard was identified at one receptor location. The receptor located at South 154th Street indicated potential NO_2 concentrations substantially higher than the standard (0.08 ppm as compared to the annual 0.053 ppm standard). This receptor is located just 650 feet (200 meters) north of the end of Runway 16L. Airport property is located on either side for the entire length of South 154th Street in the Airport area. There are no homes, parks or businesses located in this area. Pollutant concentrations at this location are influenced by emissions from aircraft takeoffs. There were no exceedances of the NO_2 standard in any of the community areas surrounding the Airport.

As this area requires security clearance, prolonged public exposure along South 154th Street would not be expected relative to the longer-term annual NO_2 standard. Receptors within the surrounding community areas are below the ambient air quality standards for all pollutants.

(B) Future Pollutant Concentrations

Tables IV.9-4, IV.9-5, and IV.9-6 present the results for the future Do-Nothing and "With Project" alternatives for CO and NO_2. The main distinction between the Do-Nothing and "With Project" conditions is the lower maximum concentration of NO_2 with the proposed third parallel runway. Some receptor locations may experience a slight increase in pollutant concentrations, although concentrations would continue to be well below the standards.

As for the existing condition, the highest concentrations of NO_2 in the future would occur along South 154th Street. With the proposed airport improvements, South 154th would be relocated further to the north. Still, this receptor would be located in close proximity to the runway ends. For carbon monoxide, the highest 8-hour concentrations would occur in the terminal areas. All future 1-hour CO concentrations would be well below the standard.

1. Alternative 1 (Do-Nothing)

Including background, the highest NO_2 concentration identified by the refined dispersion analysis would be along South 154th Street. By 2010, NO_2 concentrations along 188th Street would also exceed the standard. No other receptor locations would exceed the annual NO_2 standard.

Including background, the highest CO concentrations would occur in the terminal area. The highest concentrations occur along the Airport terminal roadway in the area of the planned hotel and along the south-terminal area curbfront.

AR 039053

2. **"With Project" Alternatives (Alternatives 2, 3 and 4)**

Development of the proposed third parallel runway would result in similar NO_2 concentrations as for the Do-Nothing condition. For each alternative, the highest concentration of NO_2 for all receptor locations would be along South 154th Street. Except for 154th Street and along 188th Street, all other receptor concentrations would be below the NO_2 standard.

Each of the terminal development options would result in changes in traffic volumes and movements. These changes are fairly localized and would focus on changes in CO concentrations. As presented in the Draft EIS, for each alternative, the highest concentrations of CO would occur in the existing terminal area. All concentrations would be below the 1-hour and 8-hour CO standards. Additional changes would occur in how vehicles access the Airport. These changes are evaluated in the roadway intersection analysis presented in the next section.

3. **Preferred Alternative (Alternative 3 - North Unit Terminal)**

As is described in Chapter II, the Port of Seattle staff have recommended the implementation of Alternative 3 (North Unit Terminal) with a new parallel runway with a length up to 8,500 feet. As the previous paragraphs indicate, the highest concentration of NO_2 for all receptor locations would be along South 154th Street. However, with the Preferred Alternative, the maximum concentrations would be less than for the Do-Nothing condition. As the proposed improvements include the extension of the primary Runway 16L/34R, concentrations south of the Airport would increase slightly. Except along 154th Street and South 188th Street by the year 2020, all other receptor concentrations would be less than for the NO_2 air quality standard.

The Preferred Alternative would result in changes in traffic volumes and movements. The highest concentrations of CO would occur in the existing terminal area. All concentrations would be below the 1-hour and 8-hour CO standards. Additional changes would occur in how vehicles access the Airport. These changes are evaluated in the roadway intersection analysis presented in the next section.

(5) **ROADWAY INTERSECTION ANALYSIS**

Because motor vehicles are the major source of air pollutants, a separate, more detailed air quality analysis was conducted for several highly congested roadway intersections in the Airport area. The intersection analysis focuses on emissions generated by motor vehicles in the immediate vicinity of four of the most highly congested intersections along International Boulevard (SR 99) as follows: at South 160th Street; South 170th Street; South 188th Street; and at South 200th Street. Additionally, the proposed relocation of Airport employee related parking to north of SR 518 along 24th Street was also considered. The location of the relocated employee parking lot and intersections modeled are shown in **Exhibit IV.9-2**.

Carbon monoxide is the pollutant of greatest concern at roadway intersections because it is the pollutant emitted in the greatest quantity by motor vehicles for which short-term health standards exist. The intersection dispersion analysis used the CAL3QHC air quality computer model. The modeling methodology used in the analysis is further described in **Appendix D**.

Pollutant concentrations are for locations at 3 meters (12 feet) from the edge of each roadway, for the maximum concentrations identified.

The analysis bases its results on two standard CO measurement levels--one-hour and eight-hour concentrations. The air quality standards for one hour is 35 ppm; for eight hours, 9 ppm. In total, thirty-two receptor locations were modeled in the vicinity of each intersection. How existing and future levels would compare to the standards is presented in **Table IV.9-7** and **Table IV.9-8** and summarized below.

(A) **Existing Impacts**

The already high traffic volumes at these intersections and poor meteorological conditions contributed to high 8-hour CO concentrations at all intersections considered. The 1-hour CO concentrations are below the 35 ppm ambient air quality standard.

AR 039054

For the International Boulevard (SR 99) (SR 99) and South 188th Street intersection, the highest concentration was with a peak 8-hour concentration of about 18 ppm, including background, with a worst case wind angle of 20 degrees from the northeast. For International Boulevard (SR 99) and South 170th Street, the highest 8-hour concentration was just over 12 ppm. For South 160th Street, the highest 8-hour concentration was about 10 ppm, and 15 ppm at South 200th Street. These concentrations are all well above the 8-hour 9 ppm standard.

(B)Future Impacts

In the future, these intersections would continue to experience high traffic volumes. Although improvements in vehicle emissions are expected and would have a positive effect on CO concentrations, the increase in traffic volume would counter the beneficial effect of these improvements. The proposed changes in terminal roadways and employee parking would begin by the year 2000. Employee parking currently located south of the existing terminal (the South Lot), would begin to be relocated to north of SR 518.

As is noted in Chapter III, other regional development efforts are anticipated in the future. These planned development actions, or other smaller developments, in combination with proposed Master Plan Update improvements, could affect area surface transportation and air quality.

The roadway project that is likely to have the greatest impact on air pollutant conditions in the airport area is the development of an extension of SR 509 and South Airport Access Road. These roadway improvement projects have been included in the year 2020 Do-Nothing and "With Project" air pollutant analysis.

As presented in the Draft EIS, Alternative 3 resulted in the lowest overall CO concentrations for the intersections modeled.

As shown in **Tables IV.9-7 and IV.9-8**, in the future, CO concentrations for the 1-hour concentration would be below the standard, while the 8-hour concentrations would exceed the standard similar to conditions that exist today.

1. Alternative 1 (Do-Nothing)

For all four intersections along International Boulevard (SR 99), the future Do-Nothing CO concentrations would exceed the 8-hour standard.

For the year 2000, the highest CO concentration for International Boulevard (SR 99) at South 188th Street would be 15 ppm including background; 11 ppm at South 170th Street; 10 ppm at South 160th Street; and 13 ppm at South 200th Street. By 2010, emissions would be expected to increase as traffic levels increase, with or without development. By 2020, emissions would start to decrease as reductions in vehicle emissions noticeably compensate for increases in roadway traffic. The exception is at South 170th Street.

Tables IV.9-7 and IV.9-8 illustrate the maximum 1 and 8-hour CO concentrations at each intersection. The 8-hour CO standard would be exceeded at each intersection.

2. "With Project" Alternatives (Alternatives 2, 3, and 4)

As indicated, each of the terminal development options would result in changes in traffic volumes and movements, and in how vehicles access the Airport. These changes are fairly localized and would focus on changes in CO concentrations.

As presented in the Draft EIS, each of the alternatives resulted in exceedances of the 8-hour carbon monoxide standard at the intersections of South 188th Street and International Boulevard (SR 99), and at South 170th Street and International Boulevard (SR 99). Concentrations for each alternative were generally at or below the future Do-Nothing concentrations.

By 2020, however, Alternatives 2 and 4 would increase the severity of the 8-hour exceedances over the Do-Nothing condition, particularly at South 170th Street and International Boulevard (SR 99). Generally, the Alternative 4 concentrations were equal to the concentrations identified for Alternative 2. Alternative 3 resulted in the lowest overall CO concentrations for the intersections modeled.

3. Preferred Alternative (Alternative 3)

Development of the Preferred Alternative would result in changes in the way traffic accesses the Airport and affect traffic movement in the airport area. As for the Do-Nothing condition, each of the heavily congested intersections along International Boulevard (SR 99) would continue to exceed the 8-hour standard.

(A) International Boulevard (SR 99) and South 188th Street

Concentrations of CO at the International Boulevard (SR 99) and South 188th Street intersection would be at or below the future Do-Nothing concentrations. There would be exceedances of the 8-hour standard, but they are less severe than for the Do-Nothing condition.

(B) International Boulevard (SR 99) and South 170th Street

For the International Boulevard (SR 99) and South 170th Street intersection, the Preferred Alternative (North Unit Terminal), CO concentrations would begin to increase slightly over the Do-Nothing condition by 2010. The maximum concentrations at this intersection would exceed the ambient standard. The increase in CO concentrations "With Project" as compared to the Do-Nothing condition would be very minimal with a difference of one-tenth of one part per million.

(C) International Boulevard (SR 99) and South 160th Street

Concentrations of CO at the International Boulevard (SR 99) and the South 160th Street intersection would begin to increase slightly over the D-Nothing condition by 2010. A difference of approximately 0.2 ppm (two tenths of one ppm) would occur "With Project" as compared to the Do-Nothing Condition.

(D) International Boulevard (SR 99) and South 200th Street

At South 200th Street, concentrations of CO would not exceed the Do-Nothing concentrations. There would be exceedances of the 8-hour standard, but they would not worsen over the Do-Nothing condition.

(E) South 154th Street and 24th Street: Relocated Employee Parking

Beginning in the year 2000, employee parking will be relocated from south of the existing terminal (the South Lot), to north of SR 518 along 24th Street (the North Lot). The relocation in employee parking will occur with or without the proposed improvements. Overall, the number of employees using the lot, and the volume of traffic along 24th Street would be low. By 2020, a total of 128 vehicle trips would use the lot for the Do-Nothing condition during the peak hour. "With Project", a total of 329 vehicle trips would use the lot, with 1,523 vehicle trips occurring along 24th Street in the peak hour.

Pollutant concentrations along 24th Street reflect the low traffic volumes. Receptors were located three meters (12 feet) on either side of the roadway. The results indicated that the maximum 1-hour CO concentration would be less than 8 ppm, as compared to the 35 ppm standard. The 8-hour CO concentration would be less than 6 ppm as compared to the 9 ppm standard. The relocated employee parking lot would contribute approximately five percent of the total emissions.

(6) MITIGATION MEASURES

The proposed landside improvements included in the "With Project" alternatives--improved terminal facilities and public and employee parking--would result in changing vehicular traffic movement and patterns in the immediate airport area. For the Preferred Alternative, (Alternative 3), the majority of employee parking within the terminal area shifts to a new lot located north of SR 518, reducing congestion and pollutant concentrations.

The intersection "hot spot" analysis for carbon monoxide indicated that potential exceedances of the standards might occur with the Preferred Alternative (North Unit Terminal). The North Unit Terminal alternative would change how motor vehicles access the Airport. Accordingly,

AR 039056

these changes would result in increases in motor vehicle traffic, and result in possible exceedances of the AAQS at International Boulevard (SR 99) and South 170th Street, and at South 160th Street. This added Airport-related traffic further contributes to these already heavily congested roadway intersections.

The analysis contained in this document represents a worst case evaluation. Thus, the Port of Seattle will commit to an air monitoring program to determine if such current conditions exist on the roadway system. Based on the actual measurements, the probable impact of the proposed improvements will be evaluated. If such exceedances would likely occur, the Port of Seattle will undertake appropriate action, such as those identified below.

(A) Mitigation for International Blvd. and South 170th Street

The Preferred Alternative increases pollutant concentrations over the Do-Nothing alternative at this intersection. This is due primarily to changes in how airport-related traffic would access the Airport in the future.

Because of the high traffic volumes and unacceptable level of vehicle delay, several improvements in this intersection could be undertaken to reduce air pollutant concentrations. The mitigation measures include the addition of an additional northbound left-turn lane (2 total); the construction of high capacity right-turn lanes in the southbound and eastbound directions; and the construction of a westbound right-turn lane. These improvements would occur by 2010 when relief would be needed to substantially decrease the time vehicles idle at this intersection. By 2020, an additional lane along International Boulevard (SR 99) would also be added.

Tables IV.9-7 and IV.9-8 present the effect of these changes on carbon monoxide concentrations. As shown, these improvements would address the air quality and increased traffic volumes anticipated at this intersection. The CO concentrations would be below the Do-Nothing condition for the Preferred Alternative.

(B) Mitigation for International Blvd. and South 160th Street

The Preferred Alternative increases pollutant concentrations over the Do-Nothing alternative at this intersection. Pollutant concentrations at this intersection are only marginally higher by the year 2020 (as shown in **Table IV.9-8**, a difference of two-tenths of one ppm or less).

Mitigation measures proposed would include adding an additional southbound left-turn lane (2 total); and improvements to the westbound right-turn lane. These improvements would occur by 2010. An additional lane along International Boulevard (SR 99) would be needed by 2020 to provide additional relief at this intersection.

Tables IV.9-7 and IV.9-8 present the effect of these measures. As shown, the improvements would reduce the CO concentrations and would not exceed the Do-Nothing condition.

(C) Additional Initiatives For Reducing Air Pollutants within the Airport Area

The Port of Seattle continues to support the air quality initiatives which have been enacted in the Puget Sound Region to improve air quality. These initiatives have included the growth management planning mandated by the Growth Management Act; the wood burning stove curtailment initiative of the 1990's; the seasonal use of oxygenated or reformulated fuels (between November 1 through March 1); and the Inspection/Maintenance program which monitors emissions and compliance with air quality pollution control equipment on motor vehicles. These measures are enforced as part of the USEPA's vehicular emission standards which require progressively more stringent tailpipe emission standards. Restrictions on commercial and residential outdoor burning and mandatory use of oxygenated fuels are measures used to decrease ambient CO concentrations in the Puget Sound Region.

The Port of Seattle is also committed to reducing emissions from various sources at the Airport. On-going considerations have focused on reducing the number of vehicles accessing the airport by providing alternatives to single-occupancy vehicle access to and from the Airport. Other actions have addressed motor vehicle idling along the terminal curbfront. Airport staff rigorously monitor access and idling by taxi's, limousines, and buses within the terminal area.

The Port of Seattle has supported a trip reduction strategy which has several components: employee shuttle bus service to remote public and employee parking to reduce vehicle trips in the terminal area; regional light-rail transit system; limiting passenger drop-off and pickup, and providing short-term parking alternatives.

Additional actions that could further reduce air pollutant concentrations at Sea-Tac:

- Financial disincentives for single occupancy driving to the Airport
  - Raise short-term parking rates
  - Implement toll system on the airport roadway with lower fees for High Occupancy Vehicles (HOV).
- Convenience disincentives/incentives:
  - Development of remote Park'n'Fly operations
  - Require private autos to use third floor plaza instead of terminal curbfront
  - Require use of alternative fuels by courtesy vehicles
- Improved airport access roads that attract users off the area arterials (i.e., South Access Road).

The Port of Seattle's plans are to continue to explore ways in which to reduce pollutant levels at the Airport.

(7) CLEAN AIR ACT CONFORMITY

The Clean Air Act Amendments of 1990 require Federal agencies to ensure their actions conform to the appropriate State Implementation Plan (SIP). The SIP is a plan which provides for implementation, maintenance, and enforcement of the Ambient Air Quality Standards (AAQS), and includes emission limitations and control measures to attain and maintain the AAQS. Conformity is defined as demonstrating that a project conforms to the State Implementation Plan's purpose of "eliminating or reducing the severity and number of violations of the ambient air quality standards and achieving expeditious attainment of such standards". The determination of conformity is governed by the following principles:

- That the project will not cause or contribute to any new violations of any of the ambient air quality standards (AAQS) in the project area or the metropolitan area;
- That the project will not increase the frequency or severity of any existing violations of any AAQS; and
- That the project will not delay timely attainment of the AAQS or any required interim emission reduction in the project area.

The purpose of the air quality analysis, therefore, is to demonstrate that the proposed improvements at Sea-Tac conform to the SIP requirements for the Puget Sound Region. Because the Master Plan Update includes proposed changes to the airfield, landside, terminal and off-airport roadways, two forms of conformity have been addressed: Transportation and general conformity. Transportation conformity applies to all roadway and transit projects to be funded or approved by the Federal Highway Administration (FHWA) or Federal Transit Administration (FTA). The Port of Seattle and the FAA have determined that transportation conformity does not apply. However, if transportation conformity does apply, as is shown by the analysis in this section, all proposed airport improvements conform to the State Implementation Plan and thus transportation conformity could be demonstrated.

Non-roadway transportation projects, such as the proposed improvements at Sea-Tac, are governed by the "general conformity" regulations (40 CFR Part 93, Subpart B). General conformity applies to Federal Actions occurring in areas designated nonattainment for any of the criteria pollutants as identified in **Table IV.9-1**. The designation of nonattainment is based on the exceedances or violations of the air quality standards. As indicated, the Puget Sound Region has been designated nonattainment for carbon monoxide and ozone.

The USEPA has issued rules for determining general conformity of airport related projects. Although the conformity determination is a Federal responsibility, State and local air agencies are provided notification and their expertise consulted. The Federal agency must provide a 30-day notice of the Federal action and draft conformity determination to the appropriate USEPA Region, and State and local air agencies. The Federal agency must also make the draft determination available to the public to allow opportunity for review and comments. This Final

EIS serves that purpose. All public comments on the draft conformity determination will be responded to in the FAA's Record of Decision. The Final Conformity determination is anticipated to be included in the FAA's Record of Decision.

To meet the air quality criteria of conformity, the analysis relies on air quality modeling as specified in 40 CFR Section 93.158(a)(3). The results of the modeling effort are used to demonstrate whether the Federal action will cause or contribute to a violation of the AAQS or delay the timely attainment of a standard. As indicated in this section, an emissions inventory and dispersion analysis were performed for the proposed improvements at Sea-Tac. The results of the dispersion analysis indicate that, with mitigation, the proposed improvements would not result in any new exceedances, nor increase the frequency or severity of any existing violations of the ambient air quality standards for carbon monoxide (CO) or nitrogen dioxide (NO_2) at any modeled receptor locations. The addition of the proposed Federal action to the existing conditions results in fewer emissions than for the Do-Nothing condition, thereby demonstrating conformity with the State's SIP by not increasing emissions with respect to the baseline condition.

Therefore, it has been demonstrated, by USEPA standards, that the Federal action for proposed improvements at Sea-Tac conform to the applicable SIP for the Puget Sound Region. This conclusion of a positive general conformity determination for the Federal action planned at Sea-Tac fulfills the FAA's obligation and responsibility under 40 CFR Part 93, Subpart B. This General Conformity Determination has been prepared as specified in Section 176(c)[42 USC 7506c] of the Clean Air Act Amendments of 1990. The determination has been made in accordance with the final rule of the U.S. Environmental Protection Agency (EPA), "Determining Conformity of General Federal Actions to State or Federal Implementation Plans" as published in the Federal Register on November 30, 1993. The final rule (40 CFR Part 93, Subpart B) was effective January 31, 1994.

Public notices announcing the availability of the draft conformity determination are being published in four local newspapers (Post Intelligencer, Seattle Times, Tacoma News Tribune, and Highline Times) concurrent with issuance of this Final EIS. It is anticipated that the final conformity determination and commitments for mitigation will be included in the FAA's Record of Decision (ROD).

The Clean Air Act Amendments of 1990 require Federal agencies to ensure their actions conform to the appropriate State Implementation Plan (SIP). Therefore, mitigation measures must be identified and the process and schedule for implementation and enforcement described. Sponsors of airport projects must provide written commitments to any mitigation plans. *See Appendix R (R-10-51).*

(8) AIR CERTIFICATION

49 USC 47106(c)(1)(B) requires that Airport Improvement Program applications for airport projects involving the location of a new runway may not be approved unless the Chief Executive Officer of the state in which the project is located, or the appropriate state official certifies in writing that there is "reasonable assurance" that the project will be located, designed, constructed, and operated in compliance with applicable air quality standards (the AAQS). Therefore, certification from Washington State's Governor's Office is required indicating that the proposed project will comply with all applicable air quality standards. Certification is issued in the form of a Governor's Air Quality Certificate.

It is anticipated that the Governor's Certificate will be issued before completion of the FAA's Record of Decision.

TABLE IV.9-1

Seattle - Tacoma International Airport
Environmental Impact Statement

AMBIENT AIR QUALITY STANDARDS

POLLUTANT	NATIONAL		WASHINGTON STATE	PUGET SOUND REGION
	PRIMARY	SECONDARY		
CARBON MONOXIDE				
8 Hour Average	9 ppm	N/A	9 ppm	9 ppm
1 Hour Average	35 ppm	N/A	35 ppm	35 ppm
PARTICULATE MATTER (PM_{10})				
Annual Arithmetic Ave.[b]	50 $\mu g/m^3$	50 $\mu g/m^3$	50 $\mu g/m^3$	50 $\mu g/m^3$
24 Hour Average[c]	150 $\mu g/m^3$	150 $\mu g/m^3$	150 $\mu g/m^3$	150 $\mu g/m^3$
PARTICULATE MATTER (TSP)				
Annual Geometric Average	N/A	N/A	60 $\mu g/m^3$	60 $\mu g/m^3$
24 Hour Average	N/A	N/A	150 $\mu g/m^3$	150 $\mu g/m^3$
OZONE				
1 Hour Average[d]	0.12 ppm	0.12 ppm	0.12 ppm	0.12 ppm
SULFUR DIOXIDE				
Annual Average[e]	0.03 ppm	N/A	0.02 ppm	0.02 ppm
30 Day Average	N/A	N/A	N/A	0.04 ppm
24 Hour Average	0.14 ppm[a]	N/A	0.10 ppm[a]	0.10 ppm[e]
3 Hour Average	N/A	0.50 ppm	N/A	N/A
1 Hour Average[f]	N/A	N/A	0.25 ppm	0.25 ppm
1 Hour Average	N/A	N/A	0.40 ppm[a]	0.40 ppm[e]
LEAD				
Calendar Quarter Average[e]	1.5 $\mu g/m^3$	1.5 $\mu g/m^3$	N/A	1.5 $\mu g/m^3$
NITROGEN DIOXIDE				
Annual Average[e]	0.053 ppm	0.053 ppm	0.053 ppm	0.053 ppm

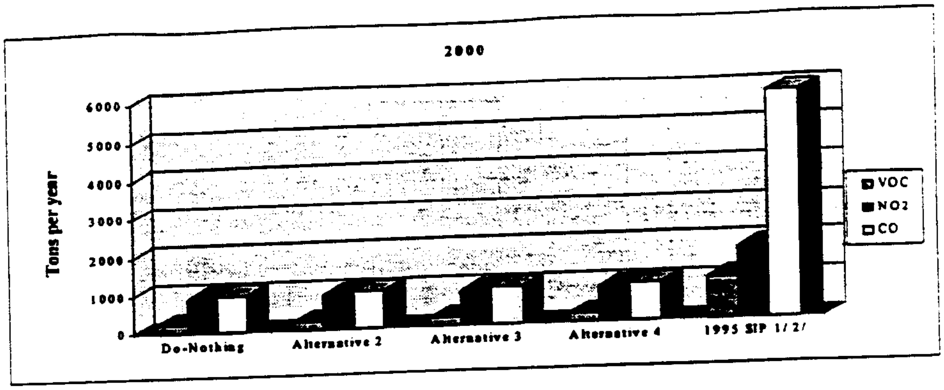
Notes:
ppm = parts per million
$\mu g/m^3$ = micrograms per cubic meter
Annual, Quarter and 30 Day standards never to be exceeded; shorter term standards not to be exceeded more than once per year unless noted.
N/A - Not Applicable

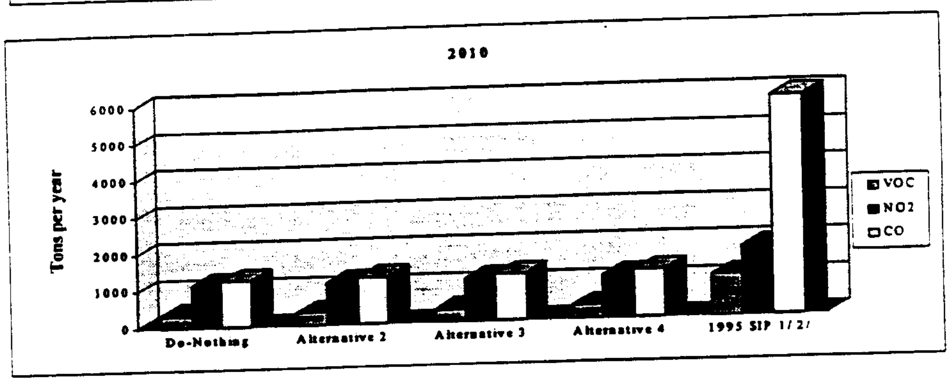
a. Not to be exceeded more than once a year.
b. Standard attained when the expected annual arithmetic mean concentrations is less than or equal to 50$\mu g/m^3$.
c. Standard attained when the expected number of days per calendar year with a 24 hour average concentration above 150 $\mu g/m^3$ is equal to or less than one.
d. Standard attained when expected number of days per calendar year with maximum hourly average concentration above 0.12 ppm is equal to or less than one.
e. Never to be exceeded.
f. Not to be exceeded more than twice in seven consecutive days

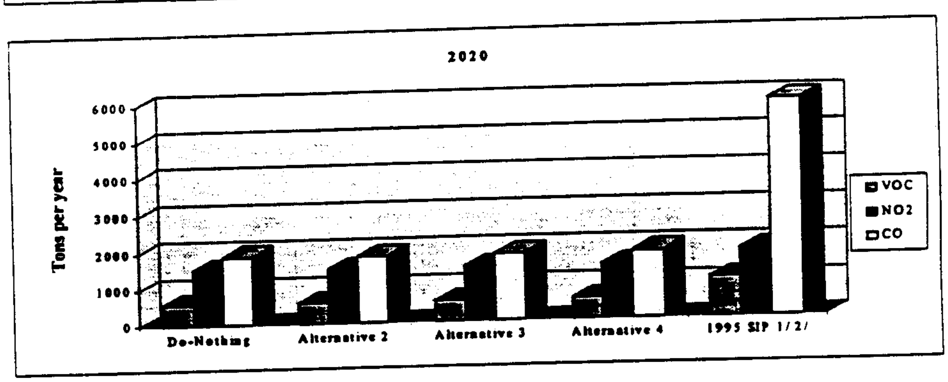
Table IV.9-2

Seattle-Tacoma International Airport
Environmental Impact Statement

AIRCRAFT EMISSIONS INVENTORY







1/ *Non-highway mobile projections for 1995, Emissions Inventory for Carbon Monoxide and Precursors of Ozone for King, Pierce and Snohomish Counties, Washington State*, Puget Sound Air Pollution Control Agency, September, 1994.

2/ Includes military, commercial, general aviation, and commuter aircraft for Seattle-Tacoma International Airport..

Note: Alternative 3 is the Preferred Alternative.

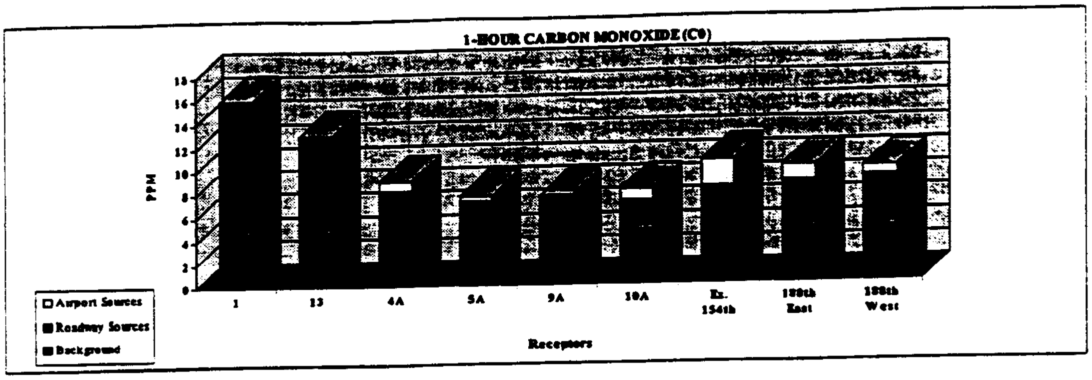
Note: Volatile Organic Compounds (VOC's) are non-methane organic compounds that react with NO2 and sunlight to form ozone.

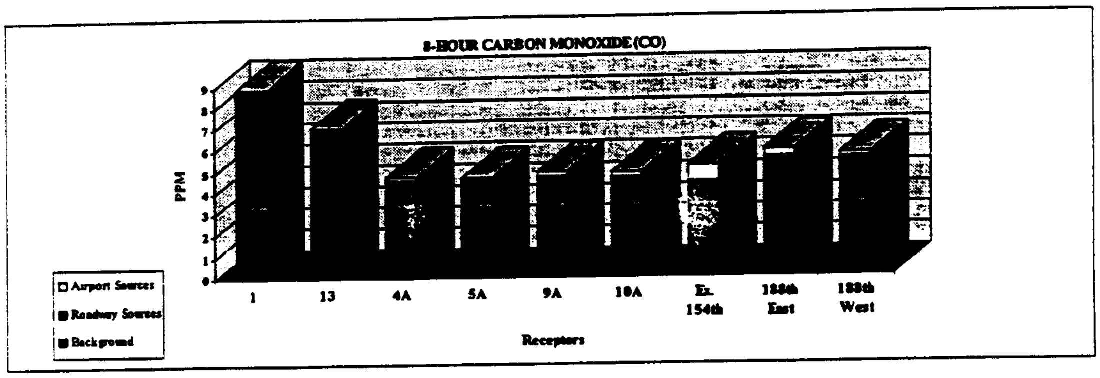
Source: Landrum & Brown, using the EDMS Version 944

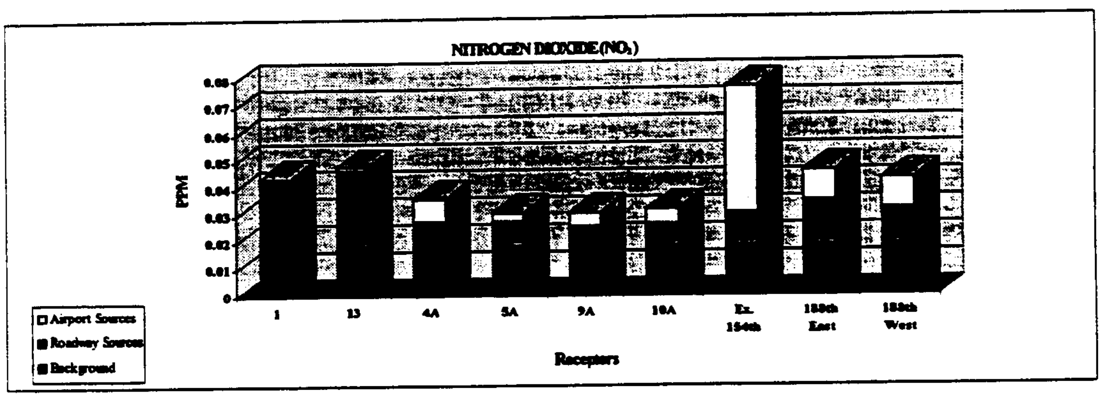
Table IV.9-3

Seattle-Tacoma International Airport
Environmental Impact Statement

EXISTING CONDITIONS (1994)
REFINED DISPERSION ANALYSIS







Receptors: 1 = Terminal-South; 13 = Terminal Hotel; 4A = Highline Nurseries; 5A = SeaTac Reservoir; 9A = Sea-Tac Industrial Park; 10A = DesMoines Creek Park; Ex. 154th = Existing South 154th Street; 188th East = South 188th Street, East Receptor; 188th West = South 188th Street, West Receptor. Receptor locations are shown on Exhibit IV.9-1.

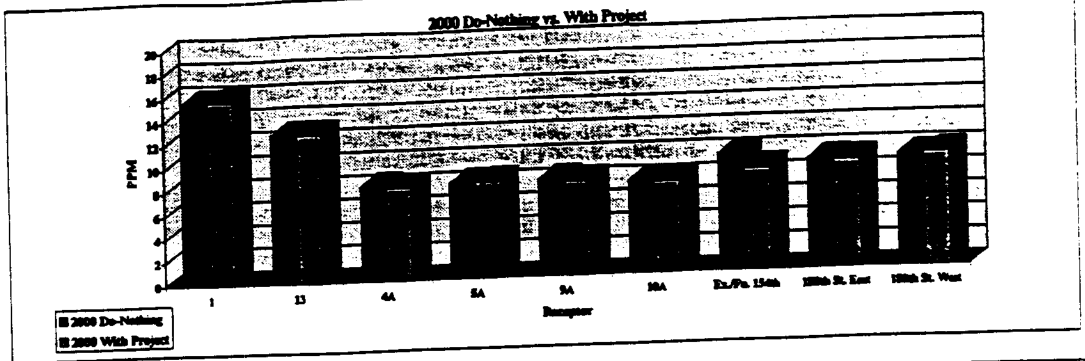
Source: Landrum & Brown, Inc., using EDMS Version 944

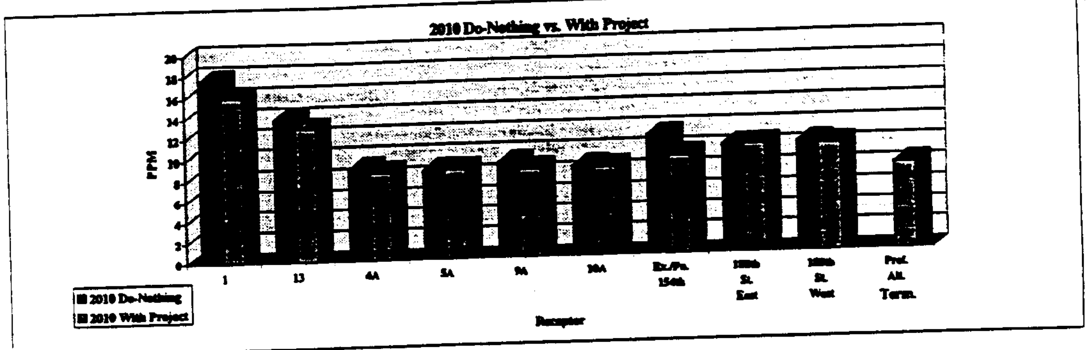
AAQS: 1-hour CO =3 5ppm; 8-hour CO = 9 ppm; NO_2= 0.053 ppm

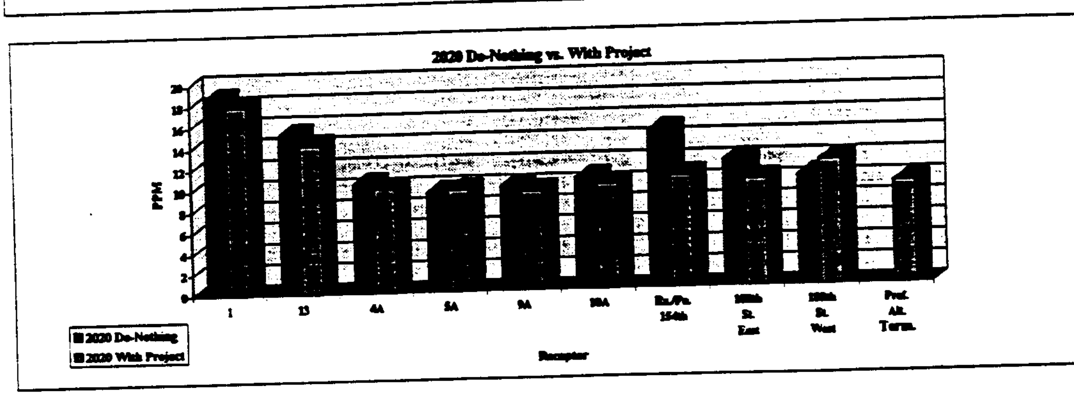
Table IV.9-4

Seattle-Tacoma International Airport
Environmental Impact Statement

1-HOUR CARBON MONOXIDE (CO) REFINED DISPERSION ANALYSIS







Receptors: 1=Terminal-South; 13=Terminal Hotel; 4A=Highline Nurseries; 5A=SeaTac Reservoir; 9A=Sea-Tac Industrial Park; 10A=DesMoines Creek Park; Ex./Fu. 154th=Existing vs. Future South 154th Street; 188th East=South 188th Street, East Receptor; 188th West=South 188th Street, West Receptor; Pref. Alt Term.=Proposed North Unit Terminal. Receptor Locations are shown on Exhibit IV.9-1.

Note: AAQS = 35.0 ppm
Background = 5.0 ppm

Source: Landrum & Brown, Inc., using EDMS Version 944

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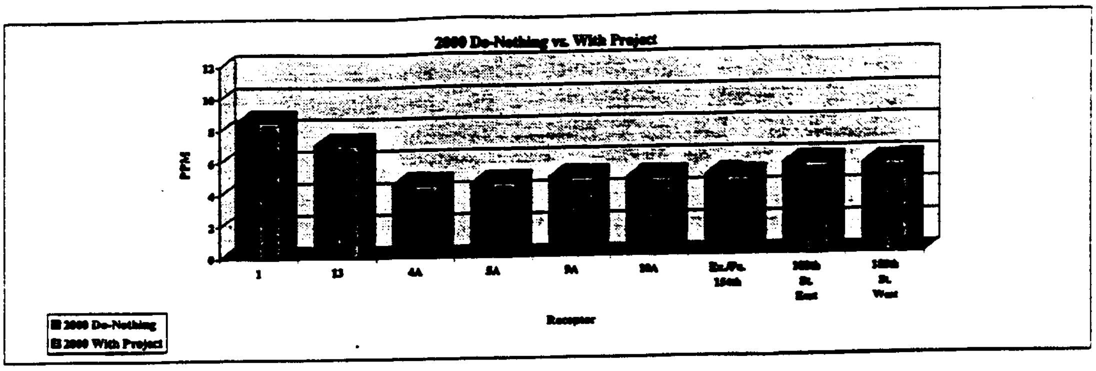
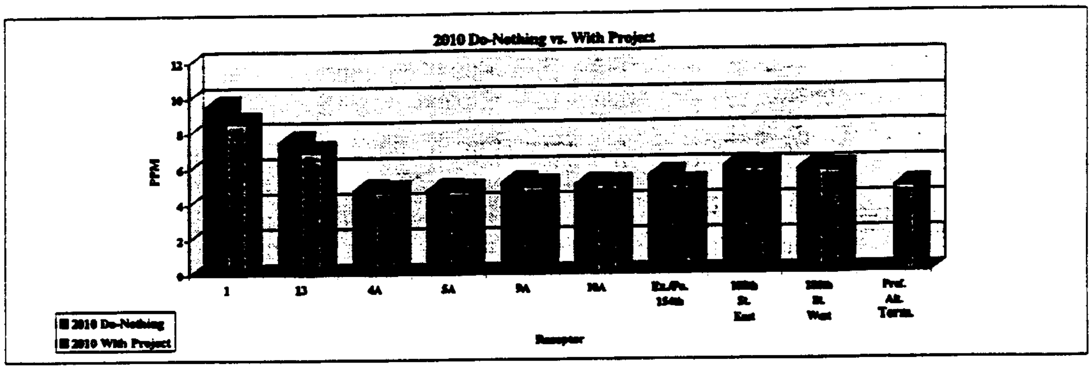
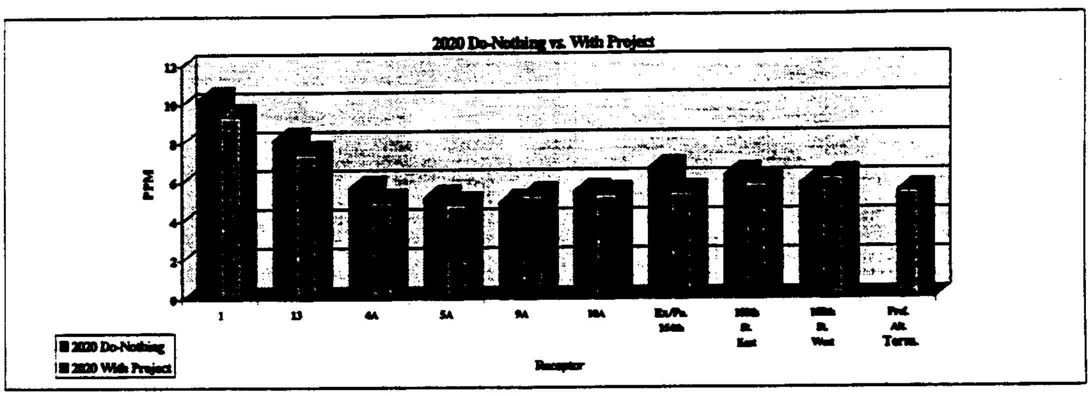
Table IV.9-5

Seattle-Tacoma International Airport
Environmental Impact Statement

**8-HOUR CARBON MONOXIDE (CO)
REFINED DISPERSION ANALYSIS**







Receptors: 1=Terminal-South; 13=Terminal Hotel; 4A=Highline Nurseries; 5A=SeaTac Reservoir; 9A=Sea-Tac Industrial Park; 10A=DesMoines Creek Park; Ex./Fu. 154th=Existing vs. Future South 154th Street; 188th East=South 188th Street, East Receptor; 188th West=South 188th Street, West Receptor; Pref. Alt Term.=Proposed North Unit Terminal. Receptor Locations are shown on Exhibit IV.9-1.

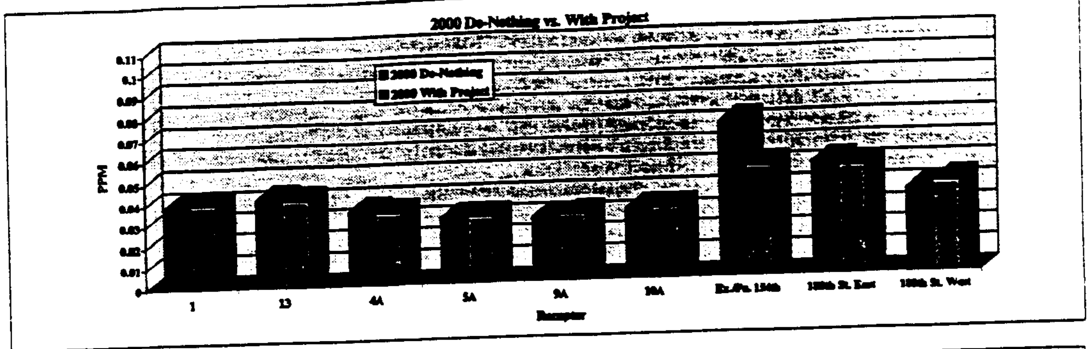
Note: AAQS = 9.0 ppm
Background = 3.5 ppm

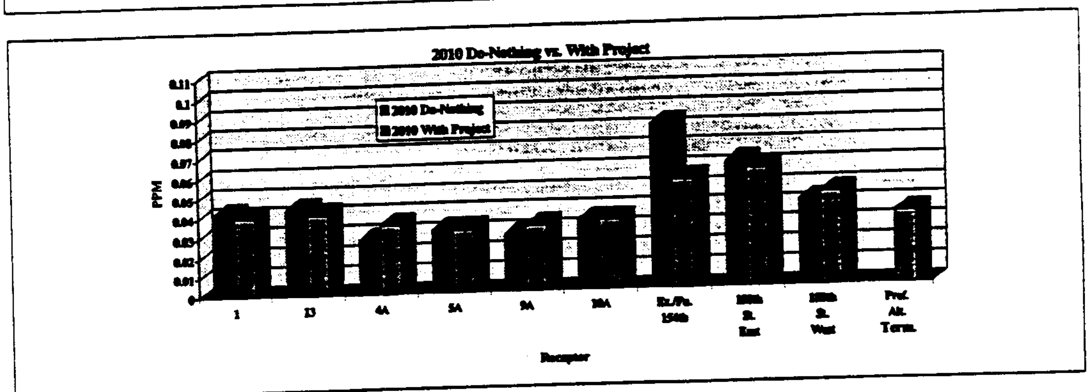
Source: Landrum & Brown, Inc., using EDMS Version 944

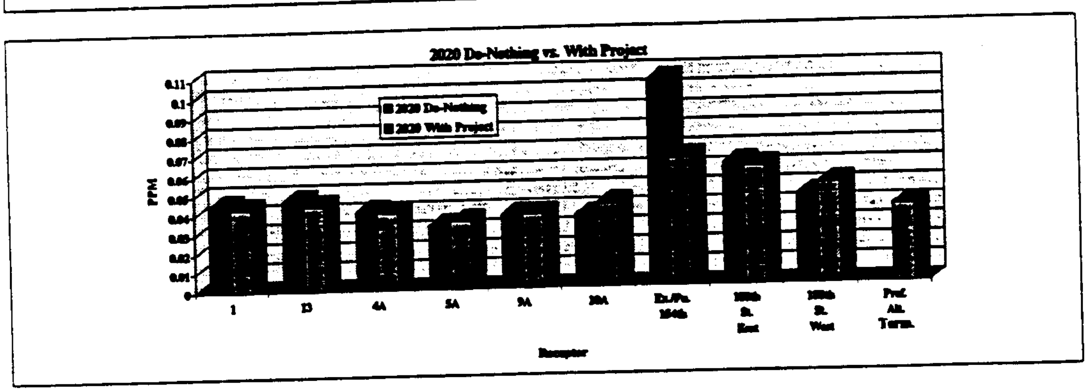
Table IV.9-6

Seattle-Tacoma International Airport
Environmental Impact Statement

**NITROGEN DIOXIDE (NO_2)
REFINED DISPERSION ANALYSIS**







Receptors: 1=Terminal-South; 13=Terminal Hotel; 4A=Highline Nurseries; 5A=SeaTac Reservoir; 9A=Sea-Tac Industrial Park; 10A=DesMoines Creek Park; Ex./Fu. 154th=Existing vs. Future South 154th Street; 188th East=South 188th Street, East Receptor; 188th West=South 188th Street, West Receptor; Pref. Alt Term.=Proposed North Unit Terminal. Receptor Locations are shown on Exhibit IV.9-1.

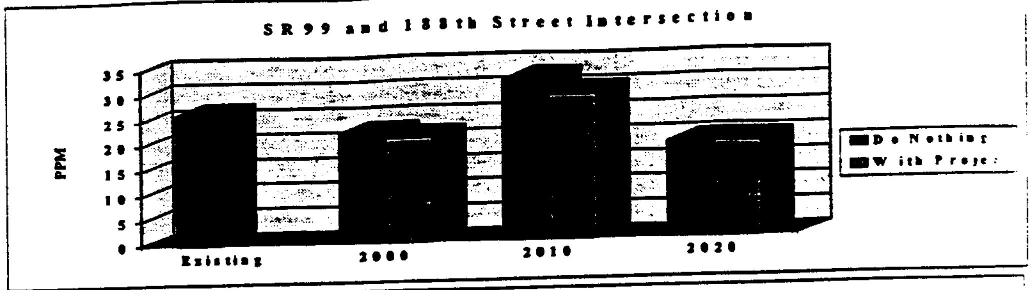
Note: AAQS =0.053 ppm
Background = 0.02 ppm

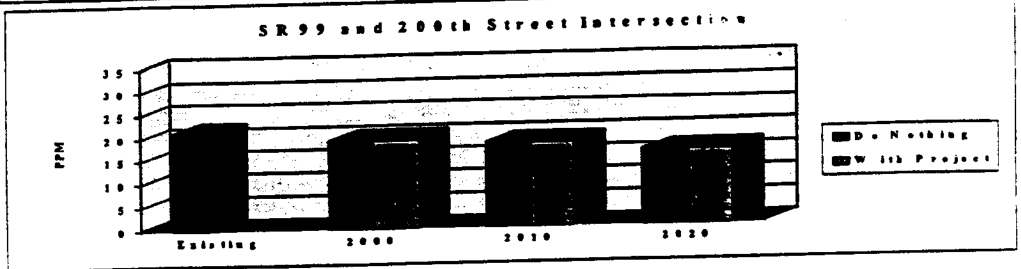
Source: Landrum & Brown, Inc., using EDMS Version 944

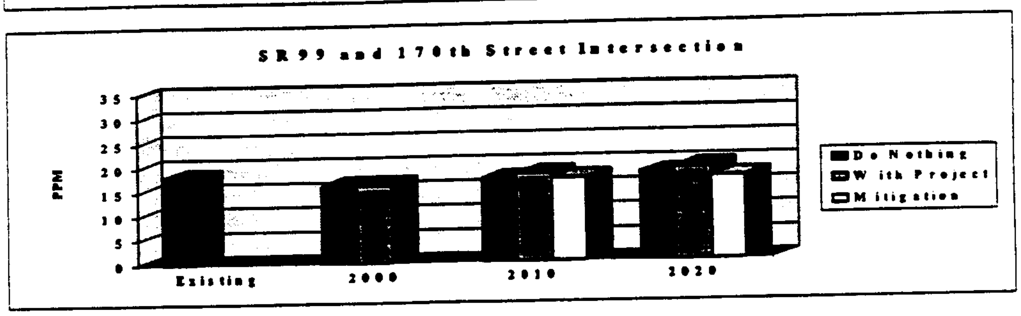
Table IV.9-7

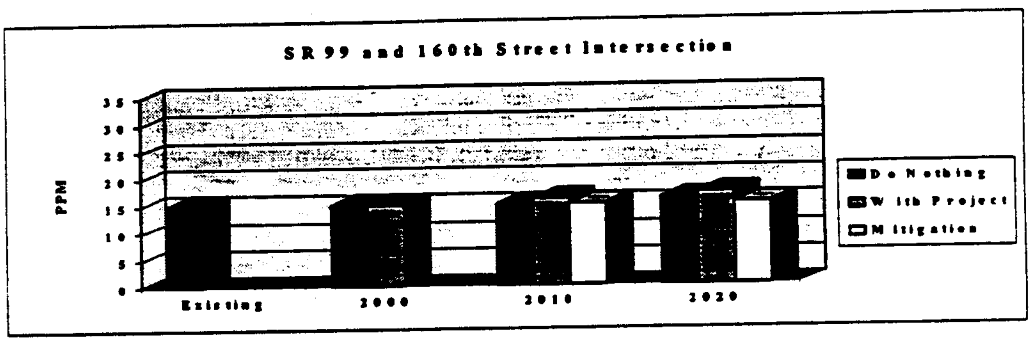
Seattle-Tacoma International Airport
Final Environmental Impact Statement

INTERSECTION DISPERSION ANALYSIS
1-HOUR CARBON MONOXIDE (CO) WITH BACKGROUND LEVEL[1]









Source: Landrum & Brown, Inc., December, 1995
Note: AAQS=Ambient Air Quality Standards (1-Hour CO=35 ppm)
Intersections modeled are shown on Exhibit IV.9-2.

[1] Background level - 5.0 ppm

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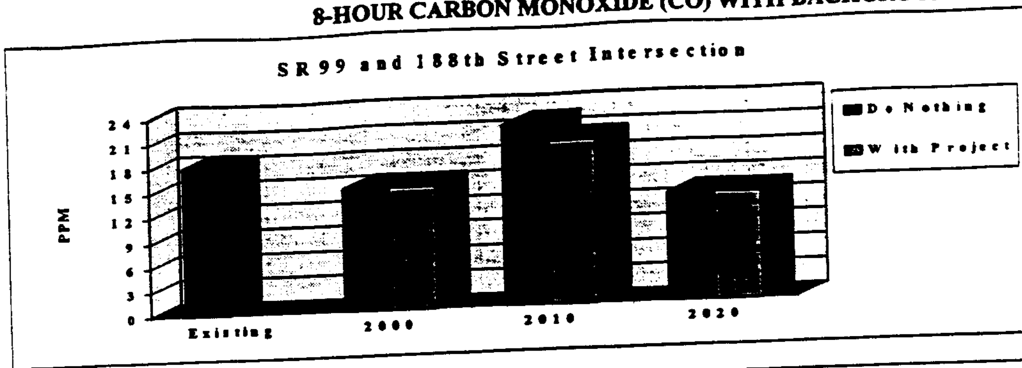
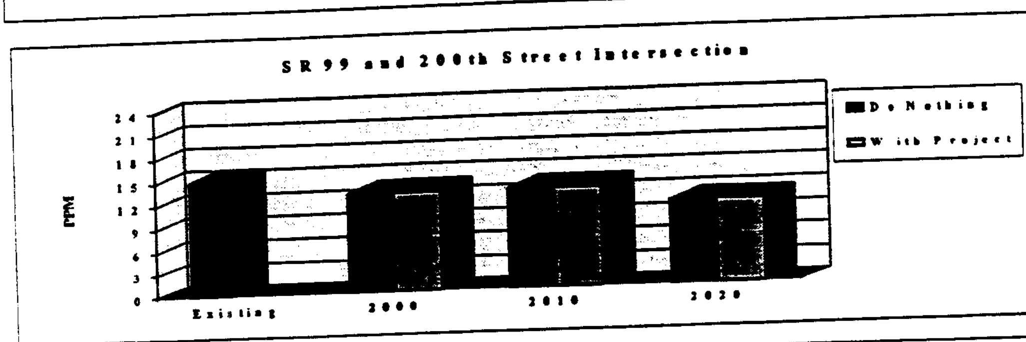
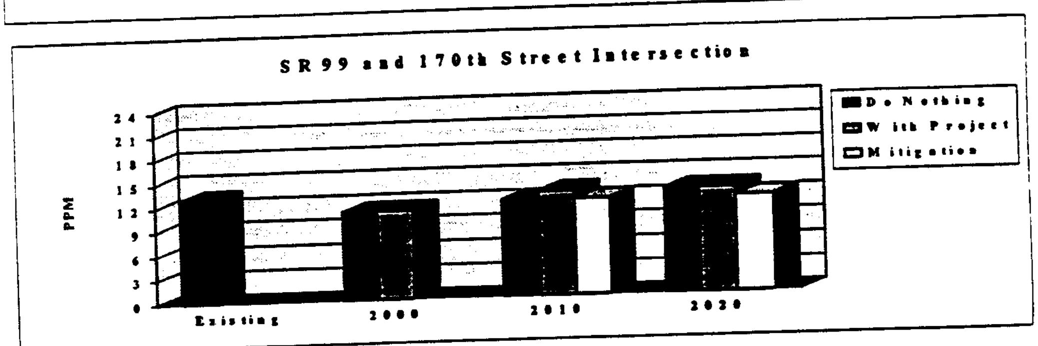
Table IV.9-8

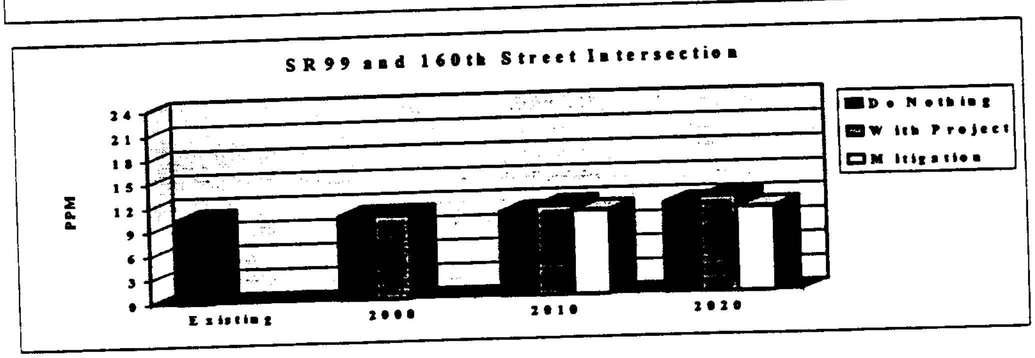
Seattle-Tacoma International Airport
Final Environmental Impact Statement

INTERSECTION DISPERSION ANALYSIS
8-HOUR CARBON MONOXIDE (CO) WITH BACKGROUND LEVELS[1/]



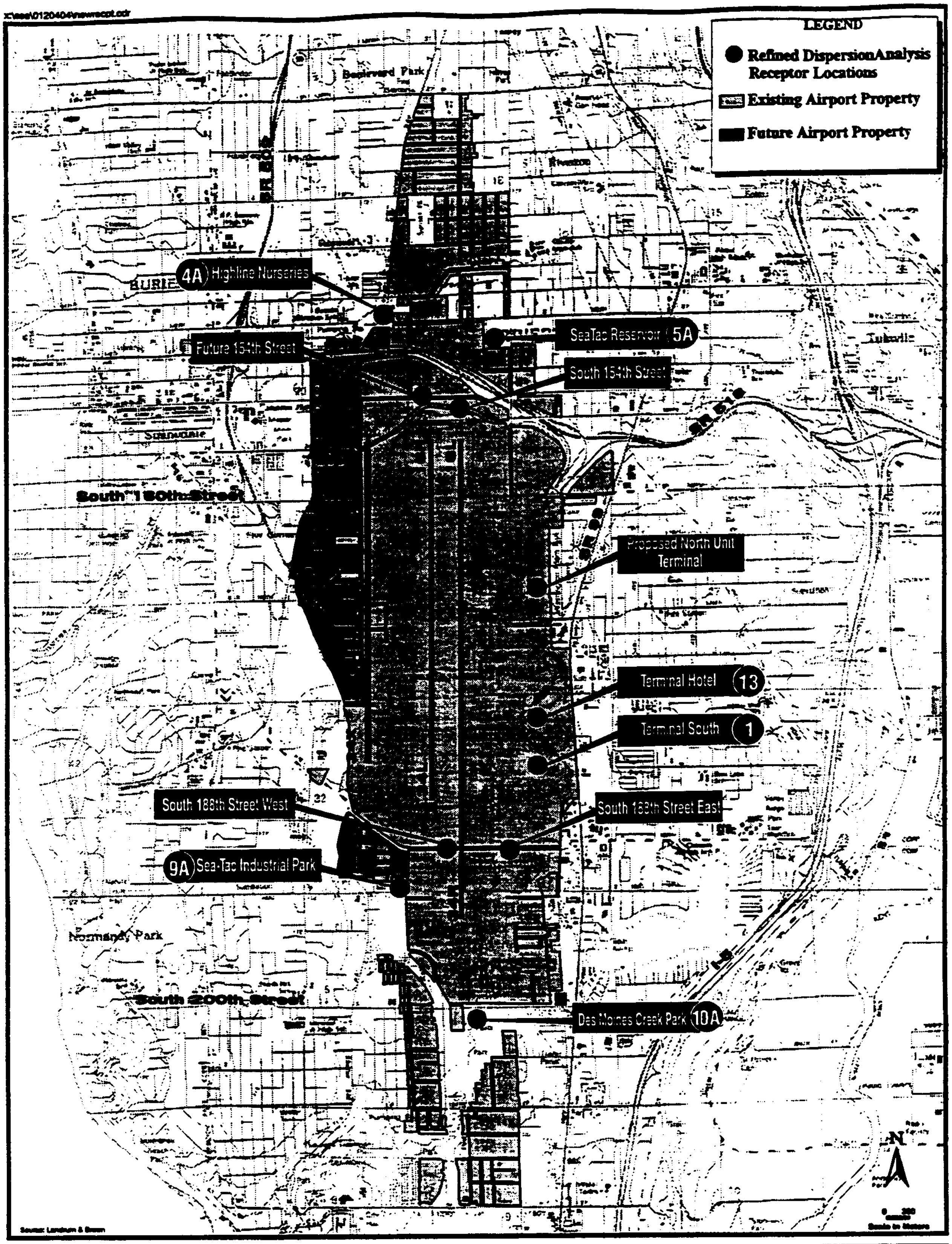




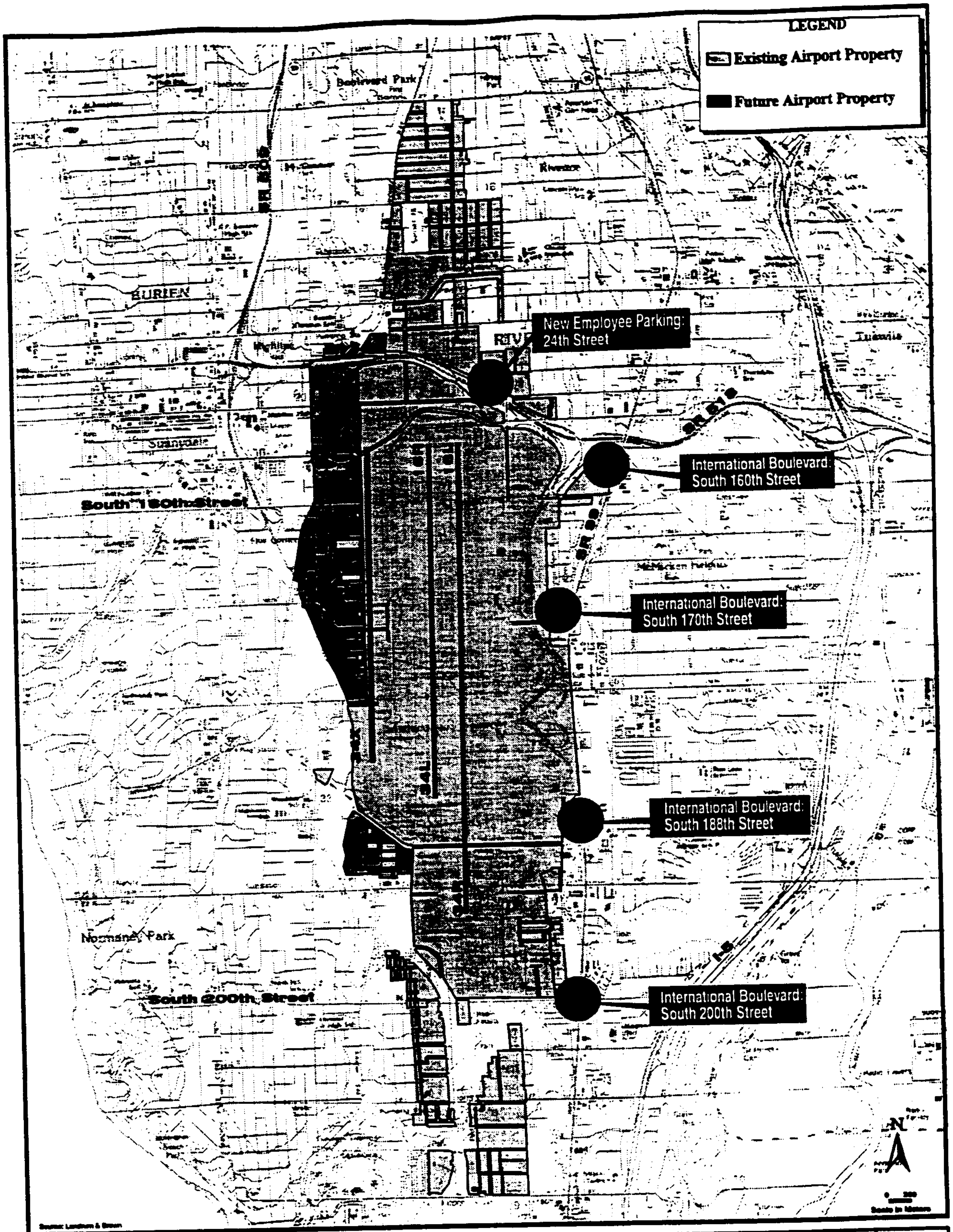


Source: Landrum & Brown, Inc., December, 1995
Note: AAQS=Ambient Air Quality Standards (8-hour CO = 9 ppm)
Intersections modeled are shown on Exhibit IV.9-2.

[1/] Background level - 3.5 ppm



Seattle - Tacoma International Airport	Refined Dispersion Analysis Receptor Locations	EXHIBIT: IV.9-1



Seattle - Tacoma International Airport	Roadway Intersection Dispersion Analysis	EXHIBIT: IV.9-2

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CHAPTER IV, SECTION 10

WATER QUALITY AND HYDROLOGY

Changing the Airport's landscape, as would happen with the proposed Master Plan Update alternatives, could affect the hydrology of the Airport area as well as the downstream systems. Alternatives 2, 3, and 4 (the "With Project" alternatives) would include earthwork and the addition of impervious land surface area. These factors would decrease the amount of rainfall infiltrating the soil and increase stormwater runoff flow rates and volumes. Unmitigated, these changes in hydrology could cause downstream flooding, channel erosion, and degraded in-stream habitat. Detailed hydrologic modeling of the Airport and its surrounding watersheds was performed to quantify the magnitude of downstream impacts and to determine appropriate mitigation strategies.

Preliminary estimates indicated that 61 acre-feet of new on-site detention storage volume would be required for proposed developed areas draining to Miller Creek, and 31 acre-feet of storage would be required for areas draining to Des Moines Creek. These detention volumes would attenuate peak runoff rates from the Airport to provide protection from downstream flooding for storms having up to a 100-year return period. New impervious areas would increase annual runoff volumes to lower Miller Creek by 6 to 8 percent and volumes to Des Moines Creek by 1 to 2 percent. Most of the additional volume would flow through the downstream systems at rates that have low erosion potential. Higher runoff volumes could be partially offset by stormwater infiltration where on-site soils are suitable. Stormwater infiltration also would recharge shallow groundwater. In both creeks, low and median flow rates would be largely unaffected throughout the year, and high flows would increase slightly, most likely with no adverse impacts on stream channel characteristics.

Although Miller and Des Moines Creeks occasionally violate Class AA (extraordinary) water quality standards for selected parameters during storm flow conditions, water quality generally appears to be good. Some shallow and perched groundwater has been contaminated by leaking fuel distribution systems and underground storage tanks at the Airport. Other shallow, perched groundwater is assumed to be good quality. Deeper, regional groundwater resources used as drinking water are excellent quality and have no history of detectable levels of pollution.

Although pollutant loading would increase somewhat because of greater amounts of stormwater runoff associated with the "With Project" alternatives, compliance with mitigation requirements would be expected to prevent significant pollution or degradation of surface and groundwater resources.

(1) METHODOLOGY

The objectives of this analysis were to characterize existing hydrologic conditions in downstream systems, to evaluate hydrologic impacts, and to determine appropriate mitigation. HSP-F[1] Version 10.0, a continuous simulation hydrologic model, was used to model the hydrology of the Airport, Miller Creek, and Des Moines Creek.[2] Data included in this document were generated as part of the modeling analysis contained in **Appendix G.**

The HSP-F model for Miller Creek was based on an earlier HSP-F model of the entire watershed developed for King County to use to evaluate the Lake Reba Detention facility for stormwater control.[3] Flood frequency estimates from this earlier model were subsequently used in FEMA floodplain studies for Miller Creek.[4] For this analysis, the previously developed HSP-F model was upgraded with stream channel characteristics data from the FEMA studies and calibrated with five years of stream flow data (July 1989 to June 1994) collected by King County Surface Water Management Division from gages at the Lake

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1/ *User Manual for Release 10. Hydrologic Simulation Program - FORTRAN (HSP-F), Environmental Protection Agency, 1993.*

2/ *HSP-F Hydrologic Modeling Analysis For Sea-Tac Airport Master Plan Update EIS*, Montgomery Water Group, 1995. (currently in Preliminary Draft version)

3/ *Miller Creek Regional Stormwater Detention Facilities Design Hydrologic Modeling*, Northwest Hydraulics Consultants, 1990.

4/ *Miller Creek, Normandy Park, Washington, Limited Map Maintenance Study*, Northwest Hydraulics Consultants, 1991.

Reba Detention facility and lower Miller Creek (as shown in **Exhibit IV.10-1**).

The HSP-F model for Des Moines Creek was based on recent hydrologic studies including a hydrologic model developed for the 1994 SASA EIS and another model used to design Tyee Pond.[5] Data from the *Des Moines Creek Watershed Plan*[6] also were used in developing the HSP-F model. The Des Moines Creek model was extended downstream to South 208th Street and calibrated with five years of stream flow data (October 1989 to July 1994) collected by King County Surface Water Management Division at the inlet to Tyee Pond (**Exhibit IV.10-1**).

Hydrologic simulations were based on 47 years of hourly precipitation records collected at the Airport from 1947 through 1994. The simulations focused on the operational impacts of the proposed Master Plan Update alternatives.

Representative locations along Miller Creek and Des Moines Creek were selected to evaluate the alternatives. Three locations were evaluated along Miller Creek, including below the Lake Reba Detention facility (Location A in **Exhibit IV.10-1**), at First Avenue S. (Location B), and near the mouth of the creek (Location C). Two locations were evaluated along Des Moines Creek, including below the confluence of the east and west branches (Location D) and at South 208th Street (Location E). Both Miller Creek and Des Moines Creek were simulated for a 47-year period. At each location, hydrologic parameters including flood frequencies, annual flow duration, annual runoff volumes, and flow exceedance characteristics as is listed in **Table IV.10-1** were summarized and evaluated.

A flood frequency analysis for existing conditions was done to characterize the peak flow rates in the creeks, which then served as a basis for determining the adequacy of the prescribed stormwater management facilities in attenuating peak flow rates under Alternative 2, 3, or 4. For the flood frequency analysis, various return periods for the peak flows were considered, including 100-year, 10-year, 2-year, and 1.11-year periods. Peak flows for each of these return periods have a probability of occurring, during any given year, of 1 percent, 10 percent, 50 percent, and 90 percent, respectively. The 100-year and 10-year return periods are conventionally used to evaluate flooding potential, while 2-year and 1.11-year return periods are most commonly used to evaluate stream channel erosion and sedimentation potential. Comparing flow durations and annual runoff volumes of Alternatives 2 through 4 against those of Alternative 1 provided an indication of stream channel erosion potential. Differences in annual runoff volumes among the alternatives also were calculated to evaluate changes in recharge to shallow groundwater.

Determining flow exceedance characteristics for the alternatives allowed a comparison of average flow rates during different seasons of the year when habitat requirements for aquatic species may vary. For purposes of this analysis, low, median, and high flow rates were evaluated during different seasons of the year representing 90, 50, and 10 percent flow exceedance levels, respectively.

Analysis of water resources in the Miller and Des Moines Creek basins was based on review of existing data. Potential impacts of each alternative on surface and groundwater resources were assessed by comparing estimates of pollutant loads in stormwater runoff for each alternative with existing water quality, state water quality standards, and other relevant water quality criteria, and known pollutant characteristics (e.g., fate, transport, and toxicity). In addition, required and practicable mitigation measures are discussed.

(2) <u>EXISTING CONDITIONS</u>

The following paragraphs summarize the existing surface water and ground water quality.

(A) <u>Hydrology</u>

Miller Creek watershed has a total basin area of 5,183 acres as is listed in **Table IV.10-2**. The watershed has about 1,224 acres of effective impervious land area with 60 impervious acres at the Airport. Des Moines Creek watershed has a total basin area of 3,585 acres. Des Moines Creek watershed has about 1,202 acres of effective impervious area with 369 impervious acres at the Airport.

The primary land uses in the watersheds are residential and commercial. Approximately

[5] *South Aviation Support Area Final Environmental Impact Statement*, Port of Seattle, 1994

[6] *TR-20 Model Files for Des Moines Creek Pond C (Tyee Pond)*, King County Surface Water Management Division, 1989.

AR 039072

62 percent of the land use in the Miller Creek basin is residential, 14 percent is commercial (non-Airport), and 4 percent is Airport. Approximately 29 percent of the land use in the Des Moines Creek basin is residential, 23 percent is commercial (non-Airport), and 27 percent is Airport. Both Miller Creek and Des Moines Creek watersheds are urbanized and exhibit "flashy" stream flow characteristics associated with developed basins. Storm flow rates measured in the creeks at the established gage stations, as well as those modeled, generally showed rapid flow rate increases in response to rainfall and rapid decreases at the cessation of storms. Between 1987 and 1991, King County Surface Water Management Division received drainage and flooding complaints in the Miller Creek watershed, some of which were flooding and erosion problems along Miller Creek.[7]

Flood frequencies under existing conditions were computed by using 47 years of hydrologic simulation for Locations A, B, and C along Miller Creek and Locations D and E along Des Moines Creek (as shown in **Exhibit IV.10-1**). The 100-year flow rates in Miller Creek, for instance, ranged from 171 cubic feet per second (cfs) below the Lake Reba Detention facility to 468 cfs at the mouth (**Table IV.10-4**). The 2-year flow rates ranged from 80 cfs below the Lake Reba Detention facility to 173 cfs at the mouth. The 100-year flow rates in Des Moines Creek were estimated to be 232 cfs below the confluences of the east and west branches and 280 cfs at South 208th Street, while the 2-year flow rates at these locations were 103 cfs and 112 cfs, respectively (**Table IV.10-5**).

Average seasonal flow rates were computed for existing conditions to illustrate the range that occurs throughout the year. Low, median, and high flow rates were calculated for Location B along Miller Creek and for Location D along Des Moines Creek (**Exhibits IV.10-2** and **IV.10-3**). Stream flow rates are highest from October through April, coinciding with the wet season. Flows in the streams typically reach their lowest rates between May and September. Similar seasonal flow characteristics were found at Locations A, C, and E and are listed in **Appendix G**.

(B) Surface Water Quality

Surface water resources within the vicinity of the Airport are shown in **Exhibit IV.10-4**. Portions of three drainage basins are within the vicinity of the Airport: the Lower Green River basin, the Miller Creek basin, and the Des Moines Creek basin. Presently, minimal runoff from the Airport drains to the Lower Green River basin. Approximately 19% of the existing Airport surface area is in the Miller Creek basin, and approximately 81% is in the Des Moines Creek basin, with portions from each basin going to the Industrial Wastewater System (IWS).

The Miller and Des Moines Creek basins exhibit similar drainage patterns, topographic characteristics, and land uses. Drainage from both basins flows to Puget Sound. Several tributaries, lakes, and wetlands are associated with each of these drainages. The Seattle-Tacoma International Airport covers an estimated 5 percent of the Miller Creek basin and 30 percent of the Des Moines Creek basin.

Miller Creek and Des Moines Creek and their tributaries are classified by the Washington Department of Ecology as Class AA (extraordinary) waters.[8] Surface waters are classified on the basis of both present and potential water uses. Classes range from Class AA (extraordinary) to Class C (fair). Although Miller and Des Moines Creeks are classified as Class AA (extraordinary) waters, they presently fail to meet some of the state water quality standards listed in **Table IV.10-6**.

Water quality degradation in Miller and Des Moines Creeks and their tributaries is characteristic of pollutants commonly found in urban stormwater runoff. Such pollutants, including nutrients, organics (e.g., oil and grease), metals, fecal coliform bacteria, and suspended solids, have contributed to occasional violations of Class AA water quality standards and federal water quality criteria in these basins. Miller and Des Moines Creek storm flow monitoring data

[7] *Drainage Complaints Information for Miller/Salmon/Seola Basin Planning Area, King County Surface Water Management Division, 1992.*

[8] *Washington Administrative Code - Water Quality Standards for the Surface Waters of the State of Washington.* WAC 173-201A, November 25, 1992.

indicate that state Class AA water quality standards are occasionally violated for pH, dissolved oxygen, and ammonia (as shown in Table IV.10-3). In addition, these data indicate that fecal coliform bacteria numbers frequently exceed state water quality standards. Potential sources of fecal coliform bacteria include failing septic systems in residential areas near Miller and Des Moines Creeks. Total phosphorus levels observed in storm flow samples often exceed the U.S. Environmental Protection Agency total phosphorus criterion of 100 µg/L, which is recommended to prevent nuisance algal growths in streams.[9] Except for occasional contributions of glycol and ammonia following deicing events and elevated copper and zinc, pollutant concentrations observed in airport stormwater runoff are comparable to storm flow monitoring data results collected from locations upstream and downstream of the Airport in both basins. These data appear to indicate that pollutant sources in both basins are widespread and not limited to the Airport. Runoff from portions of state highways 509, 518 and 99 within these drainage basins are likely major contributors to elevated levels of metals and suspended solids in Miller and Des Moines Creeks.[10]

National and local (Bellevue, Washington) studies of urban runoff have shown that copper, lead, and zinc are generally the most common and abundant metals in urban runoff.[11] The U.S. Environmental Protection Agency has determined that most metals in stormwater runoff are associated with or bound to suspended solids and, thus, generally are not available to aquatic life as potential toxicants. Approximately 40 percent or more of the total copper and zinc in stormwater runoff may be in dissolved forms.[12] Therefore they can be taken up by aquatic life through water, plants, and other animals ingested. Copper, zinc, and lead are generally the metals of most concern in urban stormwater runoff.

Urban and Airport stormwater runoff contribute to elevated levels of pollutants in Miller and Des Moines Creeks during storms. Many of these pollutants (e.g., organics and metals) are bound to suspended solids that pass rapidly through the systems and are deposited in the sediments of receiving waters, including Puget Sound. Consequently, concentrations of these solids-bound pollutants in streams quickly diminish as storm events pass and base flow conditions return.[13]

Existing pollutant loading contributions to Miller and Des Moines Creeks have been estimated for the Airport, the remainder of the basins, and the total basin. The relative pollutant contribution from Airport stormwater runoff was compared to total pollutant loading in each basin. Pollutant loadings for seven pollutants (TSS, BOD, TP, copper, lead, zinc, and oil and grease) in Airport stormwater runoff have been estimated based on water quality monitoring data. Pollutant loadings from the Airport may be over-estimated as stormwater samples were collected on the front end of storm events when pollutants concentrations appeared to be higher compared to the remainder of the storm flow event[14].

Annual pollutant loadings were estimated for these pollutants for the remainder of the Miller and Des Moines Creek basins by multiplying a range of established low and high loading rates for different land uses (e.g., open space, commercial, residential) by the appropriate land use areas. Total pollutant loadings were then calculated by adding Airport contributions to the remainder

9/ *Toward a Cleaner Aquatic Environment.* K.M. MacKenthun, U.S. Environmental Protection Agency, Washington, D.C. 1973 (As cited by U.S. EPA 1986)

10/ Personal communication with David Masters, King County Surface Water Management Division, March 22, 1995

11/ *Toxicants in Urban Runoff.* Galvin, D.V. and R.K. Moore, Municipality of Metropolitan Seattle, Seattle, WA. 1982. *Bellevue Urban Runoff Program Summary Report.* Pitt, R. and P Bissonnette, City of Bellevue, Storm and Surface Water Utility, Bellevue, WA. 1984. *Effects of Seattle Area Highway Stormwater Runoff on Aquatic Biota.* Highway Runoff Water Quality Report No. 11. Portele, G.J., B.W. Mar, R.R. Horner, and E.B. Welch, Department of Civil Engineering, University of Washington, Seattle, WA. 1982. *Results of the Nationwide Urban Runoff Program, Volume 1 - final Report.* Water Planning Division, U.S. Environmental Protection Agency, Washington, D.C. 1983.

12/ *Results of the Nationwide Urban Runoff Program, Volume 1 - final Report.* Water Planning Division, U.S. Environmental Protection Agency, Washington, D.C. 1983.

13/ *Toxicants in Urban Runoff.* Galvin, D.V. Pages 176-210 in R. Seabloom and G. Plews, eds. Proceedings of the Northwest Nonpoint Source Pollution Conference. Washington Department of Social and Health Services, Olympia, WA. 1987.

14/ *Seattle Tacoma International Airport Stormwater Pollution Prevention Plan*, Port of Seattle, June,1995.

of these basins (**Table IV.10-7**). All pollutant loading rates used were based on data collected in Pacific Northwest region (i.e., Portland, Seattle, King County) studies. Therefore, it is expected that actual pollutant loading rates would be accurately represented by the estimated loadings and actual loading rates would likely fall somewhere in between the low and high loading estimates. Based on estimated loading rates, the Airport contributes about 2 to 39% of the total TSS, BOD, TP, copper, lead, zinc, and oil and grease pollutant loads in the Des Moines Creek basin and between less than 1 and 4% of the total loading for these pollutants in the Miller Creek basin.

The percent contribution of Airport stormwater runoff to total annual pollutant loading varies for the different parameters, depending on the loading rate used for estimating loadings from the remainder of the Miller and Des Moines Creek basins. Using the lower loading rates for the different land uses, the Airport contributes a higher percentage of the total pollutant loading. Using the higher loading rates, the Airport contributes a lower percentage of the total pollutant loading. The relative contributions of these pollutants to the total pollutant loadings in each basin is generally lower than the percent of each basin that the Airport covers (i.e., 30% of the Des Moines Creek basin and 5% of the Miller Creek basin). The only exception being that the Airport could contribute as much as 39% of the total copper loading in the Des Moines Creek basin based on estimated total copper loadings using the lower loading rate for the appropriate land uses in the remainder of the basin. A majority of the total pollutant loads for these seven pollutants comes from stormwater runoff from other urbanized areas within each basin. Estimated contributions from the Airport to the total pollutant loadings for these pollutants supports the statements that Airport runoff is generally comparable or cleaner than stormwater runoff from other urban areas in these basins for these pollutants and that sources of pollutants to the creeks are widespread in these basins.

The *Annual Stormwater Monitoring Summary Report* [15/] also indicates that Airport stormwater runoff is generally cleaner or comparable to urban runoff for TSS, BOD, TP, total copper, total lead, total zinc, and oil and grease. It should be noted; however, that based on limited Airport stormwater monitoring for dissolved metals (i.e., copper, lead, and zinc), a majority of the copper and zinc appears to be in dissolved ionic forms. Therefore, the Airport may contribute to a higher percentage of the total dissolved copper and zinc pollutant loadings in Miller and Des Moines Creeks. This is important because dissolved metals are more toxic to aquatic biota. The stream monitoring study of Miller and Des Moines Creeks being conducted by the Port of Seattle this winter (1995-1996) at selected locations upstream and downstream of Airport stormwater discharges of the receiving waters is expected to determine toxicity of Airport stormwater runoff and creek water quality.

Other pollutants sometimes found in Airport stormwater runoff include ethylene and propylene glycol, potassium acetate, and ammonia. Ethylene and propylene glycol are presently used in the deicing of aircraft, and urea and potassium acetate are used to de-ice runways and taxiways at Sea-Tac Airport. In general, deicing of large numbers of aircraft occurs infrequently; however, deicing of some aircraft (MD-80) occurs frequently. Anti-icing of runways and taxiways occurs infrequently during snow storms or when water is present on runways and taxiways and temperatures are at or below freezing. As a result, relatively small quantities of these substances are used annually during Airport operations compared to other large airports. In 1991, an estimated 115,000 gallons of deicing fluid were used at Sea-Tac Airport[16/]. *All* of the aircraft deicing areas drain to the Industrial Wastewater System (IWS). Runways and taxiways drain to a separate storm drainage system. Some glycols and ammonia (from degradation of urea) have been observed in stormwater runoff.

Most of the glycols from aircraft deicing are collected and conveyed to the IWS and treated by the IWS treatment plant before being discharged to a sewer line that carries effluent to the Midway Sewer Treatment

15/ *Annual Stormwater Monitoring Summary Report*, Port of Seattle, August 1995.

16/ *Draft Sea-Tac Airport Comprehensive Stormwater and Industrial Wastewater Plan: Task 4 Report- De-icing Fluids Handling Practices*, prepared by KCM, Inc. for the Port of Seattle, 1994.

Plant. Glycols have been observed in four of seven monitored stormwater outfalls. Glycol concentrations monitored in Airport stormwater runoff are generally two orders of magnitude below levels reported to have acute toxic effects on salmonids. Levels of glycols in Airport stormwater runoff samples have ranged from below analytical limits of detection (<5 mg/L) to 479 mg/L[17]. Although unlikely, glycol levels in stormwater runoff, which contribute to biochemical oxygen demand, may contribute to reductions in dissolved oxygen and chronic effects on aquatic biota (e.g., reduced growth or increased susceptibility to disease).

Ammonia (from the degradation of urea used in runway anti-icing) levels observed in Airport stormwater runoff occasionally exceed both Class AA acute and chronic toxicity standards. Ammonia levels (from degradation of urea) in stormwater runoff samples have ranged from below limits of detection (<0.01 mg/L to 13.1 mg/L. Elevated levels of glycols and ammonia in Airport stormwater runoff may contribute to adverse impacts on the biota of receiving waters.

Some heavy metals, particularly copper, lead, and zinc appear to violate both chronic and acute toxicity standards for aquatic life. Because metals data are reported as total metals and state water quality standards are based on dissolved ionic forms, it is uncertain whether or not chronic and acute toxicity standards for these metals are occasionally violated. State water quality standards (not shown in **Table IV.10-2**) govern dissolved metals and vary depending on receiving water hardness.

Water quality data available for Miller and Des Moines Creeks indicate that water quality has been degraded by urbanization and pollutant loading from urban stormwater runoff. Although Miller and Des Moines Creek monitoring data show that pollutants in storm flow and base flow occasionally violate selected Class AA water quality standards, water quality generally appears to be good, as indicated by the presence of resident and anadromous salmonid populations (e.g., trout and salmon). Salmonids, which require cold, clean water, generally are indicators of good water quality. Even though base flow water quality may be considerably better than storm flow water quality, limited base flow data for conventional parameters on Miller Creek indicate that temperature, dissolved oxygen, and pH infrequently violate state water quality standards.[18] These base flow data also indicate that numbers of fecal coliform bacteria frequently exceed the Class AA water quality standard. Violations of these parameters are not necessarily an indication of the presence of toxic concentrations of pollutants or poor water quality. Although no base flow data are available for Des Moines Creek, it appears likely that Des Moines Creek base flow water quality is similar to that of Miller Creek, since no permitted industrial discharges are present and because Des Moines Creek has similar drainage area, watershed, and land use characteristics.

Historically, fuels spills from the Airport have had a significant adverse impact on water quality in Des Moines Creek. Three fuel spills to Des Moines Creek have been reported since 1973. Each of these spills resulted in the mortality of fish and aquatic life in Des Moines Creek.[19] In 1973, an uncertain quantity of fuel was spilled into Des Moines Creek. The cause of this first spill was not reported. The 1985 and 1986 spills, which occurred at the Olympic tank farm and the Northwest tank farm, respectively, were caused by problems with the stormwater drainage and containment systems at those facilities. The spill at the Olympic tank farm occurred when a valve on a stormwater discharge line was inadvertently left open, permitting the spilled fuel to discharge to Des Moines Creek. All stormwater is now retained within the spill containment berms and pumped to the Industrial Wastewater System. Spills at the Northwest tank farm resulted from a mechanical failure. Spill containment systems at the Northwest tank farm have

17/ *Stormwater Pollution Prevention Plan*, Port of Seattle, June, 1995.

18/ Personal communications with Tim Yokers, Process Supervisor, Southwest Suburban Sewer District, on August 11, 1994.

19/ *South Aviation Support Area Final Environmental Impact Statement*. Port of Seattle, Seattle, WA, 1994.

been improved to contain potential future spills.[20]

The IWS is a separate conveyance system that collects and conveys wastewater from airport operations in the cargo, hangar, and gate areas, including deicing wastewater, to three IWS lagoons and a dissolved air flotation treatment facility in the southwest corner of the Airport. Collected wastewater, which includes glycols, is treated at the IWS treatment plant to meet NPDES permit effluent limits before being discharged to an 18-inch line that goes to the Midway Sewer Treatment Plant and then to a deep water outfall in Puget Sound. The Port of Seattle is presently in negotiations to settle a notice of intent to sue for alleged violations of the NPDES permit discharge limits for the IWS effluent.

(C) <u>Groundwater Quality</u>

The Airport lies on the Des Moines Drift Plain, which is the topographic area between Puget Sound and the Duwamish Valley. Three distinct groundwater aquifers (shallow, intermediate, and deep) have been identified in the Des Moines Drift Plain. Shallow, intermediate, and deep groundwater are separated by low-permeability silt and clay layers within the drift plain. In addition, in some locations groundwater is perched in depressions located on top of relatively impervious glacial till material and beneath the thin mantle of Alderwood and Everett gravelly sandy loam soils common in this region (see Chapter IV, Section 19). Perched groundwater is often found within 5 to 15 feet of the ground surface during the wetter months (October through March) but generally recede during drier months. Perched groundwater may appear on the surface as hillslope seeps, but is not likely a significant contributor to base flow conditions in Puget Lowland streams such as Miller and Des Moines Creeks. Perched groundwater zones are discontinuous. Although no comprehensive surveys or mapping of shallow, perched groundwater has been done in the vicinity of the Airport, the presence of Alderwood and Everett series soils and seeps around Miller and Des Moines Creeks and associated wetlands is an indicator of their presence. The availability of perched groundwater is typically too limited for use as a drinking water supply. There is no known use of this groundwater as a source of drinking water in the Airport vicinity, and its quality is unknown though assumed to be generally good. Some specific areas of perched shallow groundwater beneath the Airport is contaminated by aviation fuel.[21]

In addition to perched groundwater, shallow, intermediate, and deeper regional aquifers underlie the Airport. Based on recent geotechnical investigations in potential borrow site areas to the north and south of the Airport, an uppermost aquifer is located about 30-100 feet beneath the surface at an elevation of about 300 feet above sea level. This upper level aquifer (also called advance outwash or shallow aquifer), which has been contaminated in five locations from leaking jet fuel, and rental car fuel distribution systems at the Airport, is not used for domestic water supply. In addition, available site data indicates that impacts on the aquifer tend to be localized and contamination has not moved far or been identified at significant distances away from the sites. Contaminated soil and groundwater at these sites is in various stages of characterization and clean-up by the responsible parties.

There are several stages to management of groundwater contamination: discovery and reporting; identification and characterization of the sources, types, and extent of contamination; evaluation and selection of remedial responses; implementation of remedial responses (i.e., clean-up); and monitoring and sampling to confirm clean-up has been successful[22]. Characterization of some localized groundwater contamination has been completed and clean-up is ongoing. At some locations, contamination is in the process of being characterized and appropriate remediation will be developed as necessary to protect environmental and human health. In some cases, long-term monitoring may be an appropriate management strategy if there is no immediate threat to human or environmental health.

20/ *Stormwater Pollution Prevention Plan*. Port of Seattle, Seattle, WA. June, 1995.

21/ Personal communication with Roger Nye, Toxics Clean-up Program, Washington State Department of Ecology. Personal communication on August 18, 1994.

22/ Letter from Mr. Roger Nye, Washington Department of Ecology Toxics Clean-up Program, dated February 27, 1995 to Mr. Ronald Park, Assistant Planner, City of Des Moines.

Sources of contamination (e.g., leaking underground storage tanks and fuel distribution systems) typically are corrected immediately upon detection.

Management of groundwater contamination at the Airport is being conducted according to all applicable environmental regulations, including the Washington Model Toxics Control Act (MTCA). The Washington Department of Ecology (Ecology) is responsible for implementing MTCA, including listing areas or sites of known contamination and delisting sites as clean-up activities are completed. Ecology's Toxics Clean-up Program has confirmed that some areas of contamination have been cleaned-up. All Ecology Toxics Clean-up Program files, including a list of known areas of groundwater contamination and the status of completed and activities at the Airport (i.e., records) are available to the public by appointment at the Washington Department of Ecology Northwest Regional Office in Bellevue.

The intermediate or, Highline Aquifer (also called the Third Coarse Grained Deposit (Qc(3)) is located at an elevation between about 227 and 108 feet above mean sea level, which is over 100 feet beneath the surface of the Airport. The Seattle Water Department (SWD) has three operating wells in the Highline Aquifer. **Exhibit IV.10-4** shows the locations of these production wells. The Highline Water District (HWD), formally Water District 75, operates two wells in a deep aquifer (also called Fourth Coarse Grained Deposit (Qc(4)), which is located at about sea level. The two HWD wells serve as a source of drinking water for over 39,000 customers[23/]. The Des Moines well and the Angle Lake well (HWD wells) are located about a mile southwest and south of the Airport, respectively. The Des Moines well is located near Borrow Source Area 3 (Chapter IV, Section 19 Earth, includes a discussion of Borrow Source Areas). All three SWD wells are located north of SR 518 and the Airport. Two SWD wells, Riverton Heights Wells #1 and #2, are located near Borrow Source Area 5. The third SWD well, Boulevard Park is located further north.

The three SWD wells are part of a well field in the Highline Aquifer developed as part of an artificial recharge and recovery demonstration program. Treated Cedar River water is injected into the wells from the fall to spring, stored temporarily, and later withdrawn during peak summer demand periods between summer and early fall.

According to well logs, the static surface water level of the Highline Aquifer is approximately 80 to 200 feet beneath the ground surface. Overlying aquitards of glacial till and clay, which have very low and low permeabilities, protect the integrity of the Highline Aquifer by restricting downward movement of contaminants through these layers. For these reasons, the U.S. EPA considers the Highline Aquifer to have a low susceptibility to contamination from contaminants originating from the ground surface.[24/] There is no threat of contamination to SWD wells from existing contamination at the Airport because the wells are located up gradient and/or cross gradient of existing contamination and the direction of groundwater flow. These wells would become more susceptible to contamination if excavation of potential fill source materials at Borrow Source Area 5 remove aquitards (e.g., glacial till) providing a potential pathway for contaminants originating on the ground surface to reach the underlying aquifer. However, even with removal of these material, their up gradient/cross gradient location continue to protect them from contamination associated with the Airport.

Highline Water District wells also are protected from existing contamination by overlying aquitards. As indicated previously, additional studies are being conducted to better determine detailed groundwater movement patterns in the vicinity of the Airport. Both the Des Moines well and the Angle Lake well are over a mile south or southwest of the nearest area of localized contamination near the Alaska Airlines hangar and are considered, given current data, to be up gradient and/ or cross gradient of the Airport.

Most of the contamination at the Airport is jet fuel, which has relatively low water

23/ *Groundwater Contamination Susceptibility Assessment*, Highline Water District, SeaTac, WA, 1994.

24/ *Final Report Highline Well Field Aquifer Storage and Recovery Project*, Seattle Water Department, 1994.

solubility and generally binds to soil particles. Gasoline, which is also present, contains hydrocarbon constituents that while more mobile than jet fuel, also have relatively low water solubilities and a tendency to adsorb to sand, silt, and clay particles. Geologic materials present between existing contamination and Highline Water District wells would restrict movement of contaminated groundwater from perched groundwater and the upper aquifer to the deep Aquifer. In addition, there is no indication from groundwater monitoring well data that contamination is moving toward either of these wells. Migration potential of contaminants is low due to the low hydraulic conductivities, ranging from about 0.3 to 0.00003 feet per day[25], low flow rates and high pollutant adsorption and retention capacity of geologic materials (i.e., till and clay units) between localized areas of contamination and the wells. Therefore, it is unlikely that potable water would become contaminated or be ingested and existing localized areas of groundwater contamination do not represent a potential threat to human or environmental health. In addition, groundwater management activities being conducted in compliance with MTCA regulations are being designed to clean up any potential threats to human or environmental health.

Although neither the Highline Aquifer nor the deep aquifer is a sole-source aquifer, wellhead protection plans are being prepared to protect these wells from pollution within the 10-year time of travel zone, which is the area within about a half-mile radius of each well. Deep Aquifer water quality is excellent. There have been no violations of drinking water standards or detectable volatile organic carbons in these wells.[26] In conjunction with the federal Wellhead Protection Program, Highline Water District and the Seattle Water Department are in the process of preparing wellhead protection plans. The plans include identification and evaluation of potential sources of groundwater pollution adjacent to these wells and specific measures for preventing groundwater contamination. To comply with existing laws, an approved wellhead protection plan must be in place by mid-1996.[27] Groundwater contamination susceptibility assessments have been completed for these wells, the first step in the wellhead protection planning process.

Based on previous geotechnical studies and ongoing groundwater monitoring in the vicinity of groundwater contamination, uppermost groundwater beneath the Airport is located in perched zones that are laterally discontinuous and likely do not discharge to Miller or Des Moines Creeks. Flow of groundwater in the shallow aquifer (advance outwash aquifer) generally appears to be toward the west. The shallow aquifer discharges to Miller and Des Moines Creeks where the creeks intersect advance outwash deposits. Groundwater contamination areas are located near the terminals on the east side of the Airport. Groundwater flow rates are generally slow (a few feet per year). Because localized areas of contaminated groundwater are isolated and small, geologic deposit conductivity rates are low, and contamination is being monitored and cleaned up, it is unlikely that contaminated groundwater would reach Miller or Des Moines Creeks.

A more detailed recent geohydrology study at the Airport completed by the Port of Seattle characterizes subsurface geology, aquifers, and aquitards, groundwater occurrence, movement, and recharge and discharge relationships in the vicinity of the Airport (**Appendix Q-A** of the Final EIS). This study confirms that:

- There are four zones of groundwater occurrence: perched zone; upper or shallow aquifer (Vashon Advance Outwash (QVA)), Intermediate or Highline Aquifer (Third Coarse Grained Deposit (Qc(3)), and Deep Aquifer (Fourth Coarse Grained Deposit (Qc(4));
- Ground water is occasionally perched on top of glacial till, within fill, or in isolated lenses of sand within glacial till deposits.
- Perched groundwaters beneath the Airport are generally seasonal, laterally discontinuous, and likely do not

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25/ *Geology of Seattle Washington*, Bulletin of the Association of Engineering Geologists, 28(3):239-302, 1991.

26/ Personal communication with Jay Gibson, Planning and Construction Manager, Water District No. 75 on November 15, 1994.

27/ Letter from Scott Haskins, Acting Superintendent of Water, Seattle Water Department, December 21, 1994 to Michael Cheyne, Port of Seattle.

discharge to Miller or Des Moines Creeks.

- Perched groundwater is generally separated from the uppermost aquifer (advance outwash) by an aquitard of glacial till (10-50 feet thick); this aquitard restricts the downward movement of contamination from localized areas of perched groundwater to the upper aquifer.
- The upper aquifer is generally located in advance outwash deposits and generally flows west; discharge from this aquifer to Miller and Des Moines Creeks occurs in areas where the creeks intersect these deposits.
- A 50-to-100 foot thick aquitard of very low permeability silt and clay material (Lawton Clay) generally exists between the upper and intermediate or Highline Aquifer; this aquitard restricts the movement of pollutants from isolated areas of contamination in the upper aquifer to the intermediate aquifer; the Lawton Clay aquitard appears to be discontinuous to the south near Borrow Source Area 1.
- Downward movement of contaminants through clay and till aquitards is restricted by the very low hydraulic conductivity and high absorption capacity of the silt and clay particles in these deposits.
- Removal of the glacial till aquitard at borrow source areas would increase the susceptibility of the upper aquifer to contamination from substances originating on the ground surface; in addition, removal of the glacial till aquitard would expose underlying advance outwash deposits and increase upper aquifer recharge area and recharge volumes; these increases could be reduced in the future if new developments create impervious surfaces in these areas.
- Construction of the parallel third runway would reduce the upper aquifer recharge area, but an overall net increase in upper aquifer recharge area and volumes would result from activities in borrow source areas.

(3) FUTURE CONDITIONS

Potential construction and operational impacts are evaluated for five different construction phases scheduled for completion by the years 2000, 2010, and 2020.

(A) Do-Nothing (Alternative 1)

Hydrology in Miller Creek and Des Moines Creek would not change appreciably in future years under Alternative 1 (Do-Nothing). Opportunities for new development in the upper reaches of the basin are limited and would be subject to increasingly more stringent stormwater detention standards. While annual stormwater volumes would increase with additional development, flood frequencies would remain about the same. Efforts such as improving the efficiency of existing regional stormwater detention facilities and constructing new facilities could improve stream flow conditions by further attenuating peak flow rates, thereby reducing flooding, erosion, and sedimentation. These issues would be addressed as part of future basin planning activities jointly conducted by King County Surface Water Management Division, the Port of Seattle, and the cities of Burien, Des Moines, and SeaTac.

Construction would not have the potential to affect surface water and groundwater quality if a proposed new parallel runway and associated terminal options were not constructed. Because of various conditions of the Port of Seattle National Pollutant Discharge Elimination System Permit (NPDES) that would be implemented regardless of whether the proposed Master Plan Update alternatives are completed, the quality of Airport stormwater runoff and water from the Industrial Wastewater System (IWS), which discharges to the Midway Sewage Treatment Plant outfall could improve. Because pollutant sources in both the Miller and Des Moines Creek basins and Puget Sound appear to be widespread and because the Airport likely contributes only a fraction of the total pollutants to these waters, the potential for improvement of these receiving waters is unlikely to be significant.

In the case of SR 509/South Access, the roadway alignment could include at least 3 miles of roadway length in the Des Moines Creek watershed and 0.7 miles in the Miller

Creek watershed.[28] The SR 509 roadway alignment would impact several wetlands and cross Des Moines Creek in up to three different locations. Coordinating mitigation associated with the Master Plan Update improvements with the mitigation for this roadway, in instances where these project areas impact a common resource, would increase the effectiveness of the mitigation and minimize the likelihood of significant cumulative impacts.

(B) <u>**"With Project" Alternatives (Alternative 2, 3 and 4)**</u>

Under the "With Project" alternatives, approximately 97 acres of new impervious surface area and 264 acres of fill area would drain to Miller Creek. Approximately 95 acres of new impervious surface area and 282 acres of fill area would drain to Des Moines Creek.

Stormwater leaving the Airport area would be detained according to Washington State Department of Ecology standards. To meet these standards, preliminary hydrologic modeling indicated that approximately 61 acre-feet of new stormwater detention volume would be needed on-site in the Miller Creek watershed, and 31 acre-feet would be needed on-site in the Des Moines Creek watershed.

A conceptual layout of the stormwater management facilities and discharge locations is shown in **Exhibit IV.10-5**. Hydrologic simulations indicate the peak flow rates in Miller Creek would be slightly lower in comparison to Alternative 1 for the flood frequencies listed in **Table IV.10-4**. At Location B, for instance, the 100-year peak flow rate was predicted to decrease from 293 cfs under Alternative 1 to 292 cfs under Alternatives 2, 3, or 4. Peak flow rates for return periods of 1.11 years and 2 years were estimated to be lower for Alternatives 2, 3, or 4 compared to those of Alternative 1 (shown in **Table IV.10-7A**). In Des Moines Creek, in-stream peak flow rates for Alternative 2, 3, or 4 were predicted to be the same for the 100-year return period compared to those of Alternative 1 (see **Table IV.10-8**). For the 1.11-year, 2-year, and 10-year return periods, flow rates predicted for Alternatives 2, 3, and 4 were less than those for Alternative 1. On-site detention, combined with diverting 66 acres of impervious surface area at SASA from the stormwater system to the industrial waste system,[29] caused the lower peak flow rates in Des Moines Creek for these return periods. Regulating peak flow rates to the 10-year return period rate and more frequently occurring flows would decrease future flooding and erosion potential in Des Moines Creek.

By adding impervious and compacted fill areas to the watersheds, the "With Project" alternatives would increase the annual runoff volumes in Miller Creek and Des Moines Creek. Annual runoff volumes would be increased by 6 to 11 percent at various locations in Miller Creek and 1 to 2 percent in Des Moines Creek (**Table IV.10-9**). However, 91 to 93 percent of the incremental volume in Miller Creek would occur at rates less than the 1.11-year return period flow rate, and 97 percent would occur at rates less than the 2-year return period flow rate. Approximately 92 to 96 percent of the incremental volume in Des Moines Creek would occur at rates less than the 1.11-year return period flow rate, and 97 to 99 percent would occur at rates less than the 2-year return period flow rate. The 1.11-year and 2-year return period flow rates are generally considered to be responsible for defining the shape of stream channels; therefore, most of the additional volume added to the creeks would pass downstream at rates having low erosion potential.

Flow exceedance characteristics were determined for both Miller Creek (**Exhibit IV.10-6**) and Des Moines Creek (**Exhibit IV.10-7**) for different seasons of the year. Low and median flows for both creeks were largely unaffected during the summer months (May-September) and only slightly affected during the winter months (October-April). In Miller Creek, high flows increased on average by 0.2 cfs during the summer months and 1.4 cfs during the winter months when comparing Alternative 1 (Do-Nothing) to the "With Project" (Alternatives 2, 3 and 4). In Des Moines Creek, high flows increased on average by 0.1 cfs during the summer months and increased on average by 0.6 cfs during the winter months when comparing

[28] *SR 509/South Access Road Discipline Draft Report - Water Quality*, Shapiro and Associates, Inc., 1994.

[29] *South Aviation Support Area Final Environmental Impact Statement*, Port of Seattle, 1994.

Alternative 1 to Alternatives 2 through 4. The magnitude of changes in flow was similar at Locations A, C, and E. These relatively small changes in flow rates would not appreciably alter the existing character of these stream channels.

Two variations in the design of Alternatives 2 through 4 include runway lengths of 7,000 feet and 7,500 feet instead of an 8,500-foot length. The 7,000-foot and 7,500-foot runway lengths would create approximately 18 percent and 12 percent less impervious area, respectively, compared to the 8,500-foot runway length. A corresponding reduction in the magnitude of peak runoff rates entering the stormwater management facilities would result. Since flow rates leaving the facilities are limited by stormwater release rate criteria[30] the peak flow rates at the outlets would be about the same for each of Alternatives 2 through 4, regardless of runway length. Smaller amounts of detention volume would be required for the 7,000-foot and 7,500-foot runway lengths to attenuate peak flow rates to Department of Ecology criteria. In comparison to the 8,500-foot length, the 7,000-foot and 7,500-foot runway lengths would result in more infiltration and less annual runoff volume.

Potential construction impacts on surface water quality generally would be primarily related to short-term increases in total suspended solids from erosion and sedimentation. Such impacts would be mitigated by implementation of an approved stormwater pollution prevention plan and erosion and sedimentation control plan, which are required conditions of the Port of Seattle NPDES permit for the Airport. These plans would be required before construction could begin and would include specific performance standards and contingency plans.

Another potential construction impact on water quality involves a range of pollutants used during construction (e.g., fuels, lubricants, and other petroleum products, and construction waste such as concrete wash water). Pollution could result from accidental spills of these substances, from leaking storage containers, from refueling, and from construction equipment maintenance activities. Because spilled petroleum products and other substances generally are bound to soil particles, spilled substances are unlikely to reach or contaminate surface water or groundwater. Potential transport also is related to the distance of a spill site from surface and groundwater resources, the size of the spill, construction site characteristics (e.g., soils and topography), and contractor preparedness. Impacts from potential spills can be mitigated by implementation of best management practices (e.g., construction waste handling plans and fueling and vehicle maintenance plans) and strict contractual requirements of contractors.

Potential increases in suspended solids or other pollutants (e.g., spilled petroleum products) from construction sites are directly related to the size of the construction area, the amount of exposed soil, topography, proximity to water bodies, and the effectiveness of erosion and sediment control plans. Phase 1 construction activities scheduled for completion by the year 2000 have the greatest potential to affect surface and groundwater quality because construction areas total 193 acres (for an 8,500-foot runway). Phase 1 construction activities include construction of the new parallel runway, realignment of South 156th Way and South 154th Street, and construction of other airport infrastructure. Unless mitigated effectively through compliance with grading and drainage design standards, runway construction, which involves clearing, grading, and filling of 249 acres, would contribute significant quantities of sediment to Miller Creek and Des Moines Creek and temporary increases in suspended sediment levels. Without effective mitigation, Phase 1 construction of the 7,500-foot runway or 7,000-foot runway option also would result in temporary increases in suspended solids in Miller and Des Moines Creeks. Because of the smaller areas affected, the 7,500-foot and 7,000-foot runway options would have incrementally lower risks of temporarily increasing the concentration of total suspended solids in these creeks.

Construction activities scheduled for completion by the year 2010 (Phases 2 and 3) are limited to airport infrastructures required to support airport operations, including

[30] *Stormwater Management Manual for the Puget Sound Basin*, Washington State Department of Ecology, 1990.

expansion of existing parking, creation of a new parking garage, and expansion of the north and south satellites. All of these proposed construction activities (involving about 80 acres) are within the Des Moines Creek drainage basin. Increased erosion and sedimentation during construction of landside options would contribute to temporary increases in total suspended solid levels. Potential impacts on water quality are not expected, however, since implementation of erosion and sedimentation control plans (which are required before construction begins) would effectively control erosion through prevention or collection of eroded material in nearby catch basins. If Best Management Practices (BMPs) are not effectively implemented, Phase 2 and 3 construction activities could result in temporary increases in suspended sediment levels in Des Moines Creek.

Activities scheduled for completion by the year 2020 (Phases 4 and 5) involve about 40 acres or about 22% of the total area affected by Phases 1 through 3. Activities include construction of new taxiways, additional expansion of the north and south satellites, additional expansion of existing parking facilities, and new aircraft maintenance facilities within the South Aviation Support Area (SASA). Proposed landside construction activities, which generally would redevelop previously developed areas, are within the Des Moines Creek drainage basin. If erosion and sedimentation control and construction waste management plans are effectively implemented, significant temporary increases in suspended sediment levels or other pollutants in Des Moines Creek from Phases 4 and 5 construction activities are unlikely.

Potential increases in total suspended solids (TSS) in Miller and Des Moines Creeks from sheet and rill erosion of fillslopes and cutslopes have been estimated (Please see Chapter IV, Section 23 for a more detailed discussion on erosion and sedimentation estimates). Sediment yielded from fillslopes and borrow source areas and actual amount of sediment reaching the creeks would be expected to be reduced by removal of suspended solids by stormwater management facilities (i.e., wet vaults, wet ponds, and biofiltration swales). The primary mechanism for delivery of sediment from these sites to Miller and Des Moines creeks is in stormwater runoff as suspended solids. It is assumed that all sediment yielded from fillslopes and cutslopes would be delivered to stormwater management facilities and proposed conceptual stormwater runoff control wet vaults, wet ponds, and biofiltration swales would remove at least 80% of suspended solids in stormwater runoff. Therefore, 20% of the estimated sediment yields would be delivered to Miller and Des Moines Creeks as TSS.

During and up to 1 year after construction, it is estimated there would be an increase in TSS loading of between about 28 to 71 tons per year to Miller Creek and between about 24 to 60 tons per year to Des Moines Creek, depending on the effectiveness of erosion controls. Based on estimated existing sediment loadings (as TSS) for Miller Creek and Des Moines Creek, these represent estimated increases of about 11 to 27% (Miller) and 14 to 36% (Des Moines) during and immediately after construction. As vegetation becomes established the first year after completion of construction, average annual increased sediment loading would be expected to decrease exponentially to about 10 tons per year on Miller Creek and 7 tons per year on Des Moines Creek; these represent an increase of about 4% compared to existing total loading for both creeks. These estimated increased loadings may be higher than actual loadings, as some of the eroded material would be expected to be deposited at the base of slopes and would not be delivered to stormwater runoff facilities or Miller and Des Moines Creeks. Actual increases in sediment loading to the creeks depends on the effectiveness of the erosion and sediment control measures implemented as part of an approved erosion and sediment control plan. Numbers could be higher if untreated stormwater runoff from construction and borrow source areas reaches Miller and Des Moines Creeks.

In addition to potential impacts to surface water, activities at borrow source areas could affect groundwater resources by altering geology and changing groundwater recharge, movement, and discharge patterns. In general, precipitation percolates through shallow mantles of soil to underlying glacial till (except at borrow source area 3 where till is generally absent), contributing to seasonally perched groundwater, groundwater recharge, and groundwater discharge to Miller and Des Moines Creeks (along slopes near the creeks). Removal of glacial till layers at most borrow source areas would expose underlying advance or recessional outwash deposits increasing potential recharge and susceptibility to contamination of the uppermost aquifer, which is located in advance outwash deposits. Removal of glacial till layers and exposure of more permeable advance and recessional outwash could result in proportional reductions in perched groundwater or increases in upper aquifer (advance outwash aquifer) recharge. Potential impacts on perched groundwater and upper aquifer recharge, discharge, and movement patterns depends on the geology at these sites, proposed grading plans and future site development. Please see Chapter IV, Section 23 "Construction Impacts" of the Final EIS for a more detailed discussion of potential impacts to surface and groundwater.

Potential operational impacts on surface and groundwater quality are related primarily to the amount of new impervious surface area and increased stormwater runoff. Airport stormwater outfalls to Miller and Des Moines Creeks are shown in **Exhibit IV.10-8.** About 193 acres of new impervious surface would be created upon completion of Phase 1 (i.e., Year 2000). Drainage from the new runway and taxiways would be detained on-site and then conveyed to both Des Moines Creek and Miller Creek. Although proposed stormwater management facilities would remove some pollutants from airport runoff, Miller and Des Moines Creeks would receive increased loadings of organics, metals, fecal coliform bacteria, and nutrients during storms. Increases in the loadings of these pollutants in these creeks during storms would contribute to violations of Class AA water quality standards for dissolved oxygen, copper, lead, zinc, and ammonia. These increases would adversely affect the beneficial uses of these streams and could result in acute and chronic effects on aquatic biota (i.e., impairment of the propagation of aquatic biota).

Concentrations of glycols detected in Airport stormwater runoff are several orders of magnitude below levels reported to have acute effects on salmonids.[31] Increases in the quantities of glycols or runway anti-icers (i.e., urea and potassium acetate) in stormwater runoff could contribute on adverse effects on aquatic biota in Miller and Des Moines Creeks.

Operational activities related to Phases 2, 3, 4, and 5 would not have significant adverse effects on water quality. Completion of these phases, which consist almost entirely of redevelopment of previously developed areas, would not significantly increase impervious surface areas, stormwater runoff, or pollutant loading to Miller and Des Moines Creeks.

Under Phases 2 through 5, pollution of surface water and groundwater could result from airport operations via the use or leakage of hazardous materials (e.g., fuels and other petroleum products) stored in large quantities at the Airport. Causes of past fuel spills to Des Moines Creek have been remedied through containment and recovery measures now in place. Future spills of fuel and other substances used at the Airport are unlikely to reach Des Moines Creek because tenants are required to prepare and implement spill prevention, control, and countermeasures plans. In addition, the Port of Seattle also is required to prepare a Spill Prevention, Control and Countermeasures Plan as part of the NPDES Permit issued and enforced by the Washington Department of Ecology. The permit contains a series of general and specific conditions designed to prevent and control delivery of pollutants to Miller and Des Moines Creeks and Puget Sound.

Chapter IV, Section 16 "Plants and Animals" includes a discussion of the portions of Miller Creek and Des Moines Creek, and their tributaries which would be directly affected and require relocation as a part of the Master Plan Update improvements.

(C) <u>Preferred Alternative (Alternative 3)</u>

As was described earlier, approximately 97 acres of impervious surface area and 262 acres of fill area would drain to Miller Creek with the Preferred Alternative (Alternative 3). Approximately 95 acres of impervious

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[31] *Seattle-Tacoma International Airport De-Icer/Anti-Icer Study.* Prepared by Woodward-Clyde Consultants for the Port of Seattle 1993.

surface area and 282 acres of fill area would drain to Des Moines Creek. To meet the Washington State Ecology standards, approximately 61 acre-feet of new stormwater detention volume would be needed on-site in the Miller Creek watershed, and 31 acre-feet would be needed on-site in the Des Moines Creek watershed.

Hydrologic simulations indicate the peak flow rates in Miller Creek would be slightly lower in comparison to the Do-Nothing for the flood frequencies assessed. At Location B, for instance, the 100-year peak flow rate would decrease from 293 cfs under Alternative 1 to 292 cfs under with the Preferred Alternative. Peak flow rates for return periods of 1.11 years and 2 years were estimated to be lower compared to those of Alternative 1. In Des Moines Creek, in-stream peak flow rates would be the same for the 100-year return period compared to those of Alternative 1. For the 1.11 year, 2-year, and 10-year return periods, flow rates would be less than those for Alternative 1. On-site detention, combined with diverting 66 acres of impervious surface area at SASA from the stormwater system to the industrial wastewater system,[32] would cause the lower peak flow rates in Des Moines Creek for these return periods. Regulating peak flow rates to the 10-year return period rate and more frequently occurring flows would decrease future flooding and erosion potential in Des Moines Creek.

By adding impervious and compacted fill areas to the watersheds, the annual runoff volumes would increase in Miller Creek and Des Moines Creek. Annual runoff volumes would be increased by 6 to 8 percent at various locations in Miller Creek and 1 to 2 percent in Des Moines Creek. However, 91 to 93 percent of the incremental volume in Miller Creek would occur at rates less than the 1.11-year return period flow rate, and 97 percent would occur at rates less than the 2-year return period flow rate. Approximately 92 to 96 percent of the incremental volume in Des Moines Creek would occur at rates less than the 1.11-year return period flow rate, and 92 to 97 percent would occur at rates less than the 2-year return period flow rate.

Flow exceedance characteristics were determined for both Miller Creek and Des Moines Creek for different seasons of the year. Low and median flows for both creeks would be largely unaffected during the summer months (May-September) and only slightly affected during the winter months (October-April). In Miller Creek, high flows would increase on average by 0.2 cfs during the summer months and 1.4 cfs during the winter months when comparing Alternative 1 (Do-Nothing) to the Preferred Alternative. In Des Moines Creek, high flows would increase on the average by 0.1 cfs during the summer months and increase on average by 0.6 cfs during the winter months when comparing Alternative 1 to the Preferred Alternative. The magnitude of changes in flow would be similar at Locations A, C, and E. These relatively small changes in flow rates would not appreciably alter the existing character of these stream channels.

Potential construction impacts on surface water quality generally would be primarily related to short-term increases in total suspended solids from erosion and sedimentation. Such impacts would be mitigated by implementation of an approved stormwater pollution prevention plan and erosion and sedimentation control plan, which are required conditions of the Port of Seattle NPDES permit for the Airport. These plans would be required before construction could begin and would include specific performance standards and contingency plans.

Another potential construction impact on water quality involves a range of pollutants used during construction (e.g., fuels, lubricants, and other petroleum products, and construction waste such as concrete wash water). Pollution could result from accidental spills of these substances, from leaking storage containers, from refueling, and from construction equipment maintenance activities. Because spilled petroleum products and other substances generally are bound to soil particles, spilled substances are unlikely to reach or contaminate surface water or groundwater. Potential transport also is related to the distance of a spill site from surface and groundwater resources, the size of the spill, construction site characteristics (e.g., soils and topography), and contractor preparedness. Impacts from potential spills can be mitigated by implementation of best management practices (e.g., construction

[32] *South Aviation Support Area Final Environmental Impact Statement*, Port of Seattle, 1994.

waste handling plans and fueling and vehicle maintenance plans) and strict contractual requirements of contractors.

Potential increases in suspended solids or other pollutants (e.g., spilled petroleum products) from construction sites are directly related to the size of the construction area, the amount of exposed soil, topography, proximity to water bodies, and the effectiveness of erosion and sediment control plans.

Operational activities related to Phases 2, 3, 4, and 5 would not have significant adverse effects on water quality. Completion of these phases, which consist almost entirely of redevelopment of previously developed areas, would not significantly increase impervious surface areas, stormwater runoff, or pollutant loading to Miller and Des Moines Creeks.

Under Phases 2 through 5, pollution of surface water and groundwater could result from airport operations via the use or leakage of hazardous materials (e.g., fuels and other petroleum products) stored in large quantities at the Airport. Causes of past fuel spills to Des Moines Creek have been remedied through containment and recovery measures now in place. Future spills of fuel and other substances used at the Airport are unlikely to reach Des Moines Creek because tenants are required to prepare and implement spill prevention, control, and countermeasures plans. In addition, the Port of Seattle also is required to prepare a Spill Prevention, Control and Countermeasures Plan as part of the NPDES Permit issued and enforced by the Washington Department of Ecology. The permit contains a series of general and specific conditions designed to prevent and control delivery of pollutants to Miller and Des Moines Creeks and Puget Sound.

Chapter IV, Section 16 "Plants and Animals" includes a discussion of the portions of Miller Creek and Des Moines Creek, and their tributaries which would be directly affected and require relocation as a part of the Master Plan Update improvements.

(4) CUMULATIVE IMPACTS

Hydrology in Miller Creek and Des Moines Creek could be affected by future development and large-scale projects in the watersheds. In the Des Moines Creek watershed, proposed non-Master Plan Update projects and other urban development would add impervious surface area in the watersheds and reduce infiltration. As with all new development, these projects would be required to provide stormwater management facilities designed to Ecology standards. As currently planned, impacts from each project would be mitigated on a project-by-project basis.

Although it is anticipated that construction and operational impacts on water quality would be mitigated through implementation of NPDES permit requirements, detention requirements, and compliance with state water quality standards, construction and operation of the proposed Master Plan Update alternatives and other projects in the vicinity could contribute to cumulative adverse effects on surface water and groundwater resources. Implementation of an erosion and sedimentation control plan would reduce temporary increases in total suspended solids but may not eliminate them. Similarly, the potential for pollutant loading would be reduced but not eliminated by the required stormwater management facilities (e.g., detention facilities, wet ponds, biofiltration swales). The proposed project in combination with other proposed development in these drainage basins would result in increased pollutant loading to receiving waters and adverse cumulative effects on water quality.

These other projects also could contribute to cumulative effects on groundwater. Conversion of forests and other vegetated areas to impervious surfaces contributes to reduced infiltration and groundwater recharge. Reductions in pervious areas would reduce recharge to perched groundwater and aquifers. Assuming that shallow groundwater discharges are a component of base flows in Miller and Des Moines Creeks, incremental reductions in groundwater discharge could reduce base flows in these creeks.

(5) MITIGATION

The following stormwater management mitigation would be required unless basin plans determine that other criteria would be acceptable:

- Provide stormwater detention for construction and operation of new on-site development. Detention criteria would be based upon Department of Ecology standards limiting 2-year peak flow rates from the developed portions of the site to 50 percent of the existing 2-year rate, limiting the developed 10-year flow rate to the existing 10-year rate, and limiting the developed 100-year flow rate to the existing 100-year rate. Stormwater detention volumes would be provided with either underground storage vaults, as shown in **Exhibit IV.10-5**, or with regional storage ponds. Detention requirements of Ecology's *Stormwater Management Manual for the Puget Sound Basin* are more stringent than those of the *King County Surface Water Design Manual*, the latter of which have been adopted by the City of SeaTac. The *King County Surface Water Design Manual* is presently being revised and the revised version is expected to contain design standards that are comparable to or more stringent than Ecology's manual.

- Stormwater quality treatment would be provided with a combination of wet vaults and biofiltration swales.
- Design stormwater facility outlets to reduce channel scouring, sedimentation and erosion, and improve water quality. Where possible, flow dispersion and outlets compatible with the proposed stream mitigation (Appendix P) should be incorporated into engineering designs.
- To mitigate potential reductions in shallow groundwater recharge and incremental reductions in base flows in these creeks, infiltration facilities would be constructed where feasible. One location has been identified as suitable for shallow infiltration facilities an area in the northeast corner of the Airport.[33]
- Existing and proposed new stormwater facilities should be maintained according to procedures specified in the operations manuals of the facilities.
- The potential for using constructed aquifers within the runway fill, as described in **Appendix Q-C**, should be further investigated.
- Tyee pond would be relocated and enlarged as part of the SASA project. The relocated and enlarged pond would be a three-celled system with 40 to 45-acre feet storage capacity located north of the main SASA footprint. The first two cells would be densely vegetated emergent wetland cells for enhanced biofiltration and water quality improvement and the third cell would be off-line, providing detention for large storm events[34].

Various mitigation requirements, as stipulated by federal, state, and applicable local laws, policies, and design standards, would be applicable to construction and operation of the proposed new parallel runway and landside development at the Airport. These requirements would be components of the proposed design and are expected to reduce potential impacts on surface water and groundwater quality. For example, potential temporary increases in suspended solids levels in Miller and Des Moines Creeks or their tributaries from construction activities would be reduced by implementation of an effective erosion and sedimentation control plan, which is required before construction could begin.

Effective erosion and sedimentation control could be achieved by using a system of erosion controls (e.g., mulching, silt fencing, sediment basins, and check dams) that are properly applied, installed, and maintained. In a study of construction sites in King County between January 1988 and April 1989, the most common reasons for ineffective erosion control plans included failure to install Best Management Practice (BMP) erosion controls, improper installation of erosion controls, and failure to maintain erosion controls.[35] The Port of Seattle may need to include specific provisions in its agreements with contractors to ensure that erosion control measures are properly installed and maintained during construction activities (e.g., performance bonds).

Use of BMPs at construction sites, such as spill containment areas, phasing of construction activities (to minimize the amount of disturbed and exposed areas), and conducting activities during the dry season (April through September), also should prevent or reduce potential impacts on surface water and groundwater quality. According to the NPDES permit (Permit No. WA-002465-1) issued by the Washington State Department of Ecology, the Port of Seattle is

[33] Draft Technical Memorandum dated June 28, 1995 from Dan Cambell, Hong West & Associates, Inc. to Jim Peterson and John Genkshow, HDR Engineering, Inc.

[34] *South Aviation Suppport Area Final Environmental Impact Statement*, Port of Seattle, 1994.

[35] *Erosion and Sediment Control: An Evaluation of Implementation of Best Management Practices on Construction Sites in King County, Washington January 1988-April 1989*. Prepared by C. Tiffany, G. Minton, and R. Friedman-Thomas for the King County Conservation District, Renton, WA. King County. 1990.

responsible for developing and implementing a construction erosion and sedimentation control plan to prevent and control the potential for water quality impacts on surface water from all construction activities at the Airport.

Temporary and permanent terraces are recommended for fillslopes and cutslopes wherever possible because they reduce sheet and rill erosion. Terraces reduce slope length, reducing potential rill development and surface erosion. Terraces also increase deposition, reducing transport of eroded materials from construction sites. Other BMPs and mitigation that could be used to reduce potential increases in TSS from construction activities include graveling of access roads, use of wheel wash facilities, and covering of loads. Prohibiting fuel storage, refueling, or maintenance of construction equipment at borrow source areas or implementing best management practices, such as installing proper temporary fuel storage and spill containment or designated maintenance areas would eliminate or reduce spills and contamination potential.

Several required and numerous optional practices are used to mitigate the potential for operational impacts on surface water and groundwater quality. The Port of Seattle's National Pollutant Discharge Elimination System (NPDES) permit requires the Port to prepare several plans and to carry out several studies to identify pollutants coming from the Airport, and to prevent and control potential operational impacts on surface and groundwater resources from industrial wastewater system (IWS) and storm drainage system (SDS) discharges.

- Specific plans required as part of compliance with the NPDES permit include:
  - a stormwater pollution prevention plan (SWPPP);
  - a spill prevention, control and countermeasures plan (SPCCP);
  - a construction erosion and sediment control plan for each project exposing more than 5 acres of ground;
  - a pond sludge characterization and treatment disposal plan; and
  - a solid waste disposal plan.
- Specific studies required as part of compliance with the NPDES permit include:
  - an engineering and treatability study of the IWS
  - a vehicle washwater study
  - annual stormwater monitoring reports
  - whole effluent (both IWS and stormwater) toxicity studies
  - a marine sediment monitoring study.
- Major elements of the SWPPP include:
  - monitoring of base flow and stormwater runoff from the Airport outfalls;
  - identification and implementation of operational BMPs and applicable source control BMPs that do not require capital improvements (by December 31, 1995);
  - identification and implementation of BMPs requiring capital improvements (by June 30, 1997);
  - development of a list of pollutants that would be present in stormwater and estimation of annual quantities of these pollutants in stormwater discharges;
  - inspection of SDS periodically to ensure they are functioning properly and that there are no illegal discharges (i.e., to the SDS); and
  - modification of the existing plan whenever there is an alteration of airfield facilities or their design, construction, operation or maintenance, which causes the SWPPP to be less effective in controlling pollutants.

In addition, the Port of Seattle is conducting a stream study of Miller and Des Moines Creeks to determine the effects of Airport stormwater discharges on aquatic biota. Implementation of these plans and mitigation measures is expected to identify potential existing water quality problems caused by airport operations and to control and reduce the potential pollutant loading to Miller and Des Moines Creeks and Puget Sound from the Airport.

The Port of Seattle has completed or is in the process of completing a number of operational BMPs and capital improvements that are expected to reduce the amount of pollutants in stormwater runoff. The Port of Seattle has implemented a strategy to reduce anti-icing fluids.[36] This strategy minimizes the amount of potassium acetate and urea required to anti-ice runways and taxiways and the frequency of anti-icer use by:

- Using remote sensors to provide temperature and moisture data on runway and taxiway

[36] *Stormwater Pollution Prevention Plan*, Port of Seattle, June 30, 1995.

surface conditions to determine when chemicals need to be applied;

- Applying chemicals before ice forms, which requires less chemical compared to deicing;
- Applying chemicals at specified rates using applicators with metering systems.

This procedure is expected to reduce the amount of potassium acetate and ammonia in stormwater runoff and in Miller and Des Moines Creeks.

In accordance with the SWPPP, the Port of Seattle has completed or is in the process of completing a number of mitigation actions. Operational, source control, and capital improvement BMPs completed and implemented as part of the SWPPP are expected to reduce the amounts of fecal coliform bacteria, potassium acetate, glycols, ammonia, and other pollutants in stormwater runoff from reaching Airport stormwater outfalls and Miller and Des Moines Creeks. Recent capital improvements correcting specific identified problems include:[37/,38/]

- Installation of an elevated berm to contain washwater from solid waste containers and prevent drainage of fecal coliform bacteria to Outfall 002.
- Connection of areas in the C and D Concourse to the IWS.

The Port of Seattle continues to monitor stormwater quality. The results of ongoing base flow and stormwater runoff water quality monitoring are used to determine the need for additional BMPs and capital improvements to the SDS. The Port of Seattle develops BMPs and structural improvements in coordination with Ecology, as necessary, to mitigate operational impacts on water quality and aquatic biota in Miller and Des Moines Creeks. These are reflected, in part, by periodic revisions to the SWPPP.

A number of capital improvements to the IWS are scheduled to be completed on or before June 30, 1997, including :

- Connecting the Port Maintenance Shop Yard and a portion of the U.S. Postal Service aircraft parking area near the North Satellite, which presently drain to the SDS and Outfall 002, to the IWS;
- Connecting a suspected glycol source: an area north of the South Satellite to the IWS;
- Connecting the aviation industrial activity area now draining to Outfall 007, which is suspected of contributing to elevated ammonia and BOD with stormwater runoff, to the IWS; and
- Connecting snow storage areas, which have been identified as probable sources of glycols, to the IWS.

These improvements are expected to reduce the amounts of anti-icing and deicing chemicals (e.g., potassium acetate, ammonia, and glycols) reaching SDS outfalls and Miller and Des Moines Creeks.

The Stipulated Settlement Agreement and Agreed Order of Dismissal, which dismissed Ms. Brasher's, Normandy Park Community Club's, and the City of Des Moines' appeal of the Port's NPDES permit contained the following provisions:[39/]

- Creating a Monitoring Team, including representatives appointed by the appellants;
- Conducting at least two additional sampling events of permitted stormwater outfalls in 1995;
- Contributing funds to the Des Moines Creek Basin planning and visioning process;
- Developing a short-term monitoring plan in cooperation with the Monitoring Team to sample Miller Creek basin outfalls and the outfall from Lake Reba examining glycol, BOD TSS, flow, ammonia, and turbidity and develop appropriate responses, as necessary, for any identified water-quality problems.

Additional mitigation for potential operational impacts to surface water quality would be considered depending on the results of the stream monitoring study[40/] and the effects of Airport stormwater runoff on Miller and Des Moines Creeks. Monitoring of selected stations upstream and downstream of Airport outfalls to Miller and

37/ *Stormwater Pollution Prevention Plan*, Port of Seattle, June 30, 1995.

38/ *Annual Stormwater Monitoring Report Summary*, Port of Seattle, August 30, 1995.

39/ *Stipulated Settlement Agreement No. 94-157*, Washington Pollution Control Hearings Board, 1995.

40/ *Stormwater Receiving Environment Monitoring Plan*, Port of Seattle, August, 1995.

Des Moines Creeks is planned for this winter (95/96). Potential additional mitigation that would be considered includes use of alternative, FAA-approved runway anti-icing chemicals (e.g., calcium magnesium acetate and sodium formate) or diversion of runway runoff to the IWS during anti-icing events. The latter option is being evaluated as part of ongoing IWS engineering study, which includes capital improvements to increase the treatment efficiency and capacity of the IWS treatment plant.

Basin planning is another method for investigating mitigation of water quality impacts on Miller and Des Moines Creeks and Puget Sound from Airport and urban runoff. Although the Airport affects relatively small proportions of both the Miller and Des Moines Creek drainage basins (approximately 5 and 30 percent, respectively), activities on these areas could significantly affect these drainages. The Port of Seattle is actively participating in basin planning activities in the Miller and Des Moines Creek basins with local jurisdictions, including King County and the cities of Des Moines, Normandy Park, Sea-Tac, and Burien.

(6) WATER CERTIFICATION

49 USC 47106(c)(1)(B) requires that Airport Improvement Program applications for airport projects involving the location of a new runway may not be approved unless the Chief Executive Officer of the state in which the project is located, or the appropriate state official certifies in writing that there is "reasonable assurance" that the project will be located, designed, constructed, and operated in compliance with applicable air and water quality standards. Therefore, certification from Washington State s Governor's Office is required indicating that the proposed project will comply with all applicable water quality standards. Certification is issued in the form of a Governor's Water Quality Certificate.

It is anticipated that the Governor's Certificate will be issued before completion of the Record of Decision.

AR 039090

TABLE IV.10-1

Seattle-Tacoma International Airport
Environmental Impact Statement

SUMMARY OF HYDROLOGIC PARAMETERS EVALUATED

Parameter	Relevance of Parameter
Flood Frequencies	Flood frequencies for Alternative 1 establish baseline conditions and allow evaluation of the performance of stormwater detention facilities under Alternatives 2 through 4. Flood frequencies are useful for evaluating flooding and erosion potential.
Flow Duration	Increases in flow duration may indicate potential for increased stream channel erosion.
Annual Runoff Volume	Increases in runoff volumes relative to Alternative 1 may indicate increased stream channel erosion potential and reductions in shallow groundwater recharge.
Flow Exceedance	Flow exceedance parameter allows seasonal evaluation of low (90 percent exceedance), median (50 percent exceedance), and high flow (10 percent exceedance) conditions, which could be related to aquatic habitat requirements.

TABLE IV.10-2

Seattle-Tacoma International Airport
Environmental Impact Statement

DESCRIPTION OF WATERSHEDS

Category	Watershed	
	Miller Creek[41]	Des Moines Creek[42]
Existing Watershed		
Total Area (Acres)	5,183	3,585
Impervious Area (Acres)	1,224	1,202
Existing Land Uses in the Watershed (Acres)		
Residential	3,238	1,052
Commercial	727	815
Airport	193	983
Open (parks, cemeteries, etc.)	720	735
Forest/Wetland	305	*
Airport - Alternative 1 (Do-Nothing)		
Total Area (Acres)	193	983
Impervious Area Draining to Industrial Waste System (Acres)	50	204
Impervious Area Draining to Storm System (Acres)	60	369
Airport - Alternatives 2, 3, and 4 ("With Project")		
Total Area (Acres)	519	1,187
Impervious Area Draining to Industrial Waste System (Acres)	50	270
Impervious Area Draining to Storm System(Acres)	157	464

* Forested and wetland area for Des Moines Creek are included among the other land use categories.

Source: Northwest Hydraulics, 1990; Shapiro & Associates, Gambrell Urban, 1994.

41/ *Miller Creek Regional Stormwater Detention Facilities Design Hydrologic Modeling*, Northwest Hydraulics Consultants, 1990.

42/ Shapiro and Associates, and Gambrell Urban, 1994.

TABLE IV.10-3
WATER QUALITY PARAMETERS FOR AIRPORT STORMWATER RUNOFF COMPARED WITH STORMFLOW WATER QUALITY DATA FOR MILLER AND DES MOINES CREEKS (AVERAGE (RANGE))

Parameter	TP	SRP	N02+N03 - N	NH3	HARD	FC	pH	FOG	TURB	TSS	Cu	Pb	Zn	DO	T	Source
Upper Miller Cr. (Above SR 518)	0.103 (0.081-0.138)	0.024 (0.006-0.046)	0.319 (0.080-0.959)	ND	18 (8-40)	(640-3400)	ND	1.1 (0.8-1.4)	16 (6-28)	23 (4-51)	0.022 (0.012-0.043)	0.023 (6.006-0.055)	0.054 (0.007 - 0.080)	ND	ND	King County, 1994
Lake Reba Inlet Streams	0.099 (0.030-0.217)	0.020 (0.010-0.029)	0.375 (0.154-0.715)	0.401[a] (0.126-0.675)	38 (23-53)	(420-7200)	6.73[a]	1.1 (1.0-1.6)	11 (6-16)	41 (4-147)	0.019 (0.006-0.097)	0.011 (0.001-0.040)	0.060 (0.036-0.090)	ND	ND	King County, 1994
Downstream from Lake Reba	0.106 (0.083-0.134)	0.033 (0.007-0.059)	0.541 (0.344-0.847)	ND	34 (18-51)	(720-2480)	ND	1.4 (1.0-1.8)	7 (5-12)	22 (10-49)	0.006 (0.004-0.008)	0.004 (0.001-0.007)	0.049 (0.035-0.069)	ND	ND	King County, 1994
Walker Creek	0.132 (0.061-0.200)	0.048 (0.011-0.101)	0.766 (0.469-1.130)	ND	63 (46-90)	(620-1920)	ND	1.2[b]	12 (3-31)	39 (9-108)	0.009 (0.002-0.013)	0.007 (0.002-0.013)	0.034 (0.022-0.053)	ND	ND	King County, 1994
Trib.0354 (Lake Burien)	(0.093 (0.070-0.109)	0.025 (0.017-0.040)	0.192 (0.083-0.265)	ND	12[a] (9-15)	(500-3400)	ND	0.9[b]	20 (19-20)	23 (18-29)	0.008[a] (0.004-0.012)	0.013[a] (0.007-0.020)	0.037[a] (0.021-0.052)	ND	ND	King County, 1994
Lower Miller Cr. (below Marine View Dr.)	0.107 (0.063-0.247)	0.036 (0.006-0.065)	0.852 (0.569-1.240)	ND	64 (33-97)	(320-1240)	ND	1.4 (1.0-1.7)	14 (2-41)	64 (5-291)	0.003 (0.002-0.005)	0.001 (0.001-0.002)	0.017 (0.013-0.023)	ND	ND	King County, 1994
Miller Cr. @ WWTP	ND	ND	ND	ND	ND	(28-3600)	7.4 (6.1-8)	ND	ND	ND	ND	ND	ND	11.1 (8.3-12.2)	12 (6-21)	Yokers, 1994
Sea-Tac Storm water Runoff Discharge to Miller Cr.	0.096[a] (0.091-0.100)	ND	ND	(<0.01-27)	86 (27-158)	(3->4000)	6.66 (6.4-6.85)	2.2 (1.1-3.3)	6.4 (4.1-10)	10 (2-22)	0.040 (0.023-0.064)	0.005 (0.001-0.008)	0.280 (0.022-1.030)	ND	ND	Port of Seattle, 1995
Sea-Tac Storm water Runoff discharge to Des Moines Cr.	0.086[a] (0.078-0.093)	ND	ND	(0.01-8.69)	75 (36-99)	(10-132)	6.77 (5.76-7.14)	3.4 (1.1-8.3)	6 (1-11)	4 (3-6)	0.040 (0.020-0.084)	0.004 (0.001-0.008)	0.100 (0.009-0.234)	ND	ND	Port of Seattle, 1995
Des Moines Cr. at South 192nd Street	0.267	ND	0.317	0.802	ND	31,00[f]	6.7	1.3	22.3	28.55	0.020	0.013	0.157	7.2	8.9	Port of Seattle, 1993
Des Moines Cr. @ Tyee Pond	0.248	ND	2.361	0.319	ND	5,700[f]	7.42	0.67	8.70	8.93	0.017	0.005	0.061	6.54	10.9	Port of Seattle, 1993
Des Moines Cr. @ South 200th St.	0.208	ND	1.123	0.167	ND	4,500[f]	7.52	0.64	5.36	4.54	0.009	0.004	0.045	7.14	10.9	Port of Seattle, 1993

Unbracketed numbers - Applicable water quality standards
(xx-xx) - Range of Actual Data

TP	-	total phosphorus (mg/L)	TURB	-	turbidity (nephalometric turbidity units or NTU)
SRP	-	Soluble reactive phosphorus (mg/L)	TSS	-	total suspended solids (mg/L)
N02+N03-N	-	nitrite plus nitrate nitrogen (mg/L)	Cu	-	total copper (mg/L)
NH3	-	ammonia nitrogen (mg/L)	Pb	-	total lead (mg/L)
HARD	-	Hardness ($CaCO_3$ mg/L)	Zn	-	total zinc (mg/L)
FC	-	fecal coliform bacteria (#/100 mL)	T	-	temperature (_C)
FOG	-	freon extracted oil and grease (mg/L)	DO	-	dissolved oxygen (mg/L)

NOTES:
- a arithmetic mean value of two samples
- b only one sample with FOG above the limits of detection (1.0 mg/L or 0.25)
- c 86% of samples collected between January and July 1994 (25 of 29) contained more than 100 organisms per 100 mL.
- d September and October 1994 stormwater monitoring data for outfalls 006-008 (refer to Exhibit IV.10-8).
- e September and October 1994 stormwater monitoring data for outfalls 002-005 and 009-010 (refer to Exhibit IV.10-8)
- f Geometric mean of 4 samples
- ND No data

Sources: King County, 1994. Unpublished storm flow monitoring data received from Kate Rhoads, King County Surface Water Management. Yokers, Jim, 1994, Southwest Suburban Sewer District. Personal communication, unpublished data. Port of Seattle, 1995. Monthly Stormwater Discharge Monitoring Reports. Port of Seattle, 1993. *Stormwater and Industrial Wastewater Quality at Seattle-Tacoma International Airport.* Port of Seattle. Port of Seattle, 1995, *Annual Stormwater Monitoring Summary Report.*

TABLE IV.10-4

Seattle-Tacoma International Airport
Environmental Impact Statement

EXISTING FLOOD FREQUENCIES FOR LOCATIONS ALONG MILLER CREEK

Return Period (Years)	Probability (%)	Alternative 1 (Do-Nothing) Flow Rates (cfs)		
		Stream Location		
		A	B	C
100	1	171	293	468
10	10	125	185	293
2	50	80	109	173
1.11	90	47	64	104

Location A is below the Lake Reba Detention facility (Exhibit IV.10-1).
Location B is at First Avenue South.
Location C is near the mouth of the creek.
Source: Montgomery Water Group, 1995.

TABLE IV.10-5

Seattle-Tacoma International Airport
Environmental Impact Statement

EXISTING FLOOD FREQUENCIES FOR LOCATIONS ALONG DES MOINES CREEK

Return Period (Years)	Probability (%)	Alternative 1 (Do-Nothing) Flow Rates (cfs)	
		Stream Location	
		D	E
100	1	232	280
10	10	154	178
2	50	103	112
1.11	90	74	76

Location D is below the confluence of the east and west branches (Exhibit IV.10-1).
Location E is at South 208th Street.
Source: Montgomery Water Group, 1995.

TABLE IV.10-6

Seattle-Tacoma International Airport
Environmental Impact Statement

WASHINGTON STATE DEPARTMENT OF ECOLOGY CLASS AA FRESHWATER WATER QUALITY STANDARDS

Parameter	Standard
Fecal coliform bacteria	Shall not exceed a geometric mean of 50 colonies per 100 mL, and shall have not more than 10 percent of the samples used to calculate the geometric mean exceeding 100 colonies per 100 mL.
Dissolved oxygen	Shall exceed 9.5 mg/L.
Total dissolved gas	Shall not exceed 110 percent of saturation at any point of sample collection.
Temperature	Shall not exceed 16°C due to human activities. Temperature increases from point source discharges shall not, at any time, exceed t = 23/(T + 5), where t = the permissive temperature increase measured at the mixing zone boundary and T = highest ambient temperature outside the mixing zone in the vicinity of the discharge. Incremental increases resulting from non-point source activities shall not exceed 2.8°C.
pH	Shall be within the range of 6.5 to 8.5 with a human-caused variation within a range of less than 0.2 units.
Turbidity	Shall not exceed 5 NTU over background when the background turbidity is 50 NTU or less, or have more than 10 percent increase in turbidity when background turbidity is more than 50 NTU.
Toxic, radioactive, or deleterious material concentrations	Shall be below those that may adversely affect characteristic water uses, cause acute or chronic conditions in the most sensitive aquatic biota, or adversely affect public health.
Aesthetic values	Shall not be impaired by the presence of materials or their effects, excluding those of natural origin, which offend the senses of sight, smell, touch, or taste.

Source: WAC 173-201A. November 25, 1992.

TABLE IV.10-7

Seattle-Tacoma International Airport
Environmental Impact Statement

LOW AND HIGH ESTIMATES OF STORMWATER RUNOFF POLLUTANT LOADING CONTRIBUTIONS (pounds/year)

for seven pollutants from the Seattle-Tacoma International Airport to Miller and Des Moines Creeks compared to the total pollutant loads for these basins.

	Airport[1/]	Remainder of Basin[2/]		Total Basin Loading[3/]		% from Airport	
		Low	High	Low	High	Low	High
Des Moines Creek							
Parameter[4/]							
TSS	22,764	311,106	1.221.353	333,870	1,244,117	6.8	1.8
BOD	23,614	73,129	123.558	96,743	147,172	24.4	16.0
TP	212	986	4,187	1,198	4,399	17.7	4.8
Tot. Cu	103	161	285	264	388	39.0	26.6
Tot. Pb	15	413	553	428	568	3.5	2.6
Tot. Zn	232	1,129	1,547	1,361	1,779	17.0	13.0
O&G	5,954	32,363	32,363	38,317	38,317	15.5	15.5
Miller Creek							
Parameter							
TSS	2,995	522,300	2,669,300	525,295	2,672,295	0.6	0.1
BOD	3,058	139,775	209,900	142,833	212,958	2.1	1.4
TP	54	2,052	8,969	2,106	9,023	2.6	0.6
Tot. Cu	11	243	448	254	459	4.3	2.4
Tot. Pb	3	635	857	638	860	0.5	0.3
Tot. Zn	54	2,024	2,638	2,078	2,692	2.6	2.0
O&G	1,179	61,110	61,110	62,289	62,289	1.9	1.9

1/ Annual airport pollutant loads taken from the *Seattle-Tacoma International Airport Stormwater Pollution Prevention Plan*, Port of Seattle, June, 1995.

2/ Pollutant loads for basin, excluding the Airport.

3/ A range of low and high pollutant loading rates for different land uses (e.g., residential, commercial, open space) based on data from the Pacific Northwest was obtained from the literature. Total annual pollutant loadings were calculated by multiplying the loading rates by the appropriate land use areas within each basin (Table IV.10-2)

4/ TSS - total suspended solids; BOD - biochemical oxygen demand; TP - total phosphorus; Tot. Cu - total copper; Tot. Pb - total lead; Tot. Zn - total zinc; O&G - oil and grease.

TABLE IV.10-7A
FLOOD FREQUENCIES AND RATES FOR LOCATIONS ALONG MILLER CREEK FOR ALTERNATIVE 1 AND ALTERNATIVES 2, 3 AND 4.

Return Period (Years)	Probability (%)	Alternative 1 Flow Rates (cfs)			Alternatives 2-4 Flow Rates (cfs)		
		Stream Location			Stream Location		
		A	B	C	A	B	C
100	1	171	293	468	166	292	454
10	10	125	185	293	119	181	285
2	50	80	109	173	76	105	170
1.11	90	47	64	104	46	63	103

Location A is below the Lake Reba Detention facility (Exhibit IV.10-1). Location B is at First Avenue South. Location C is near the mouth of the creek.

TABLE IV.10-8
FLOOD FREQUENCIES AND RATES FOR LOCATIONS ALONG DES MOINES CREEK FOR ALTERNATIVE 1 AND ALTERNATIVES 2,3 AND 4.

Return Period (Years)	Probability (%)	Alternative 1 Flow Rates (cfs)		Alternatives 2-4 Flow Rates (cfs)	
		Stream Location		Stream Location	
		D	E	D	E
100	1	232	280	232	280
10	10	154	178	149	173
2	50	103	112	96	108
1.11	90	74	76	68	74

Location D is below the confluence of the east and west branches (Exhibit IV.10-1).
Location E is at South 208th St.

TABLE IV.10-9
ANNUAL RUNOFF VOLUMES TO MILLER CREEK AND DES MOINES CREEK

	Miller Creek			Des Moines Creek	
	Stream Location			Stream Location	
	A	B	C	D	E
Annual Runoff Volume (acre-feet)					
Alternative 1	1,680	2,880	5,054	3,525	4,184
Alternatives 2-4	1,781	3,124	5,361	3,586	4,223
Change in Annual Runoff Volume					
(acre-feet)	101	244	307	61	39
(%)	6	8	6	2	1
Percent of Volume Increase Flowing at < $Q_{1.11}$ [1]	93	91	92	96	95
Percent of Volume Increase Flowing at < $Q_{2.00}$ [2]	97	97	97	99	98

[1] $Q_{1.11}$ is the in-stream peak flow rate for a 1.11-year return period.
[2] $Q_{2.00}$ is the in-stream peak flow rate for a 2-year return period.
Source: Montgomery Water Group, 1995.

AR 039096

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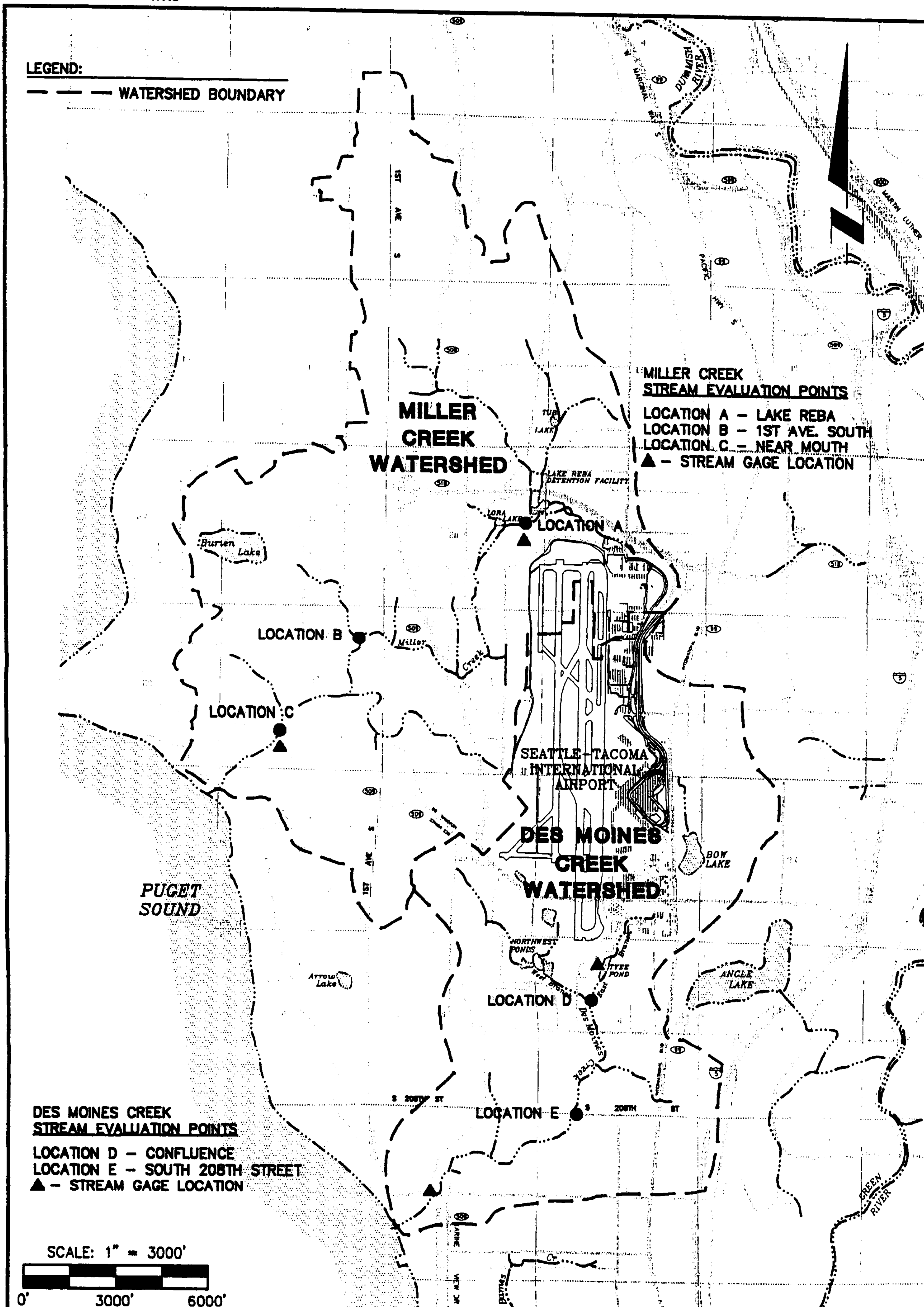
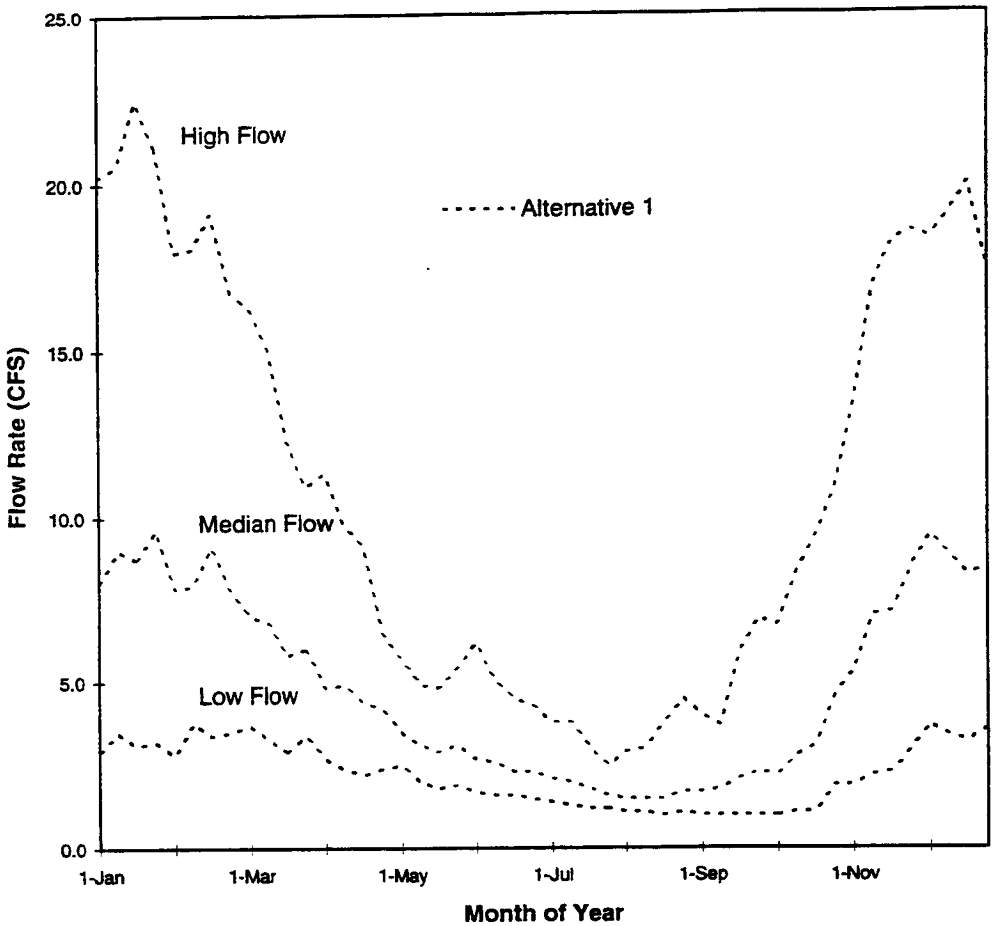


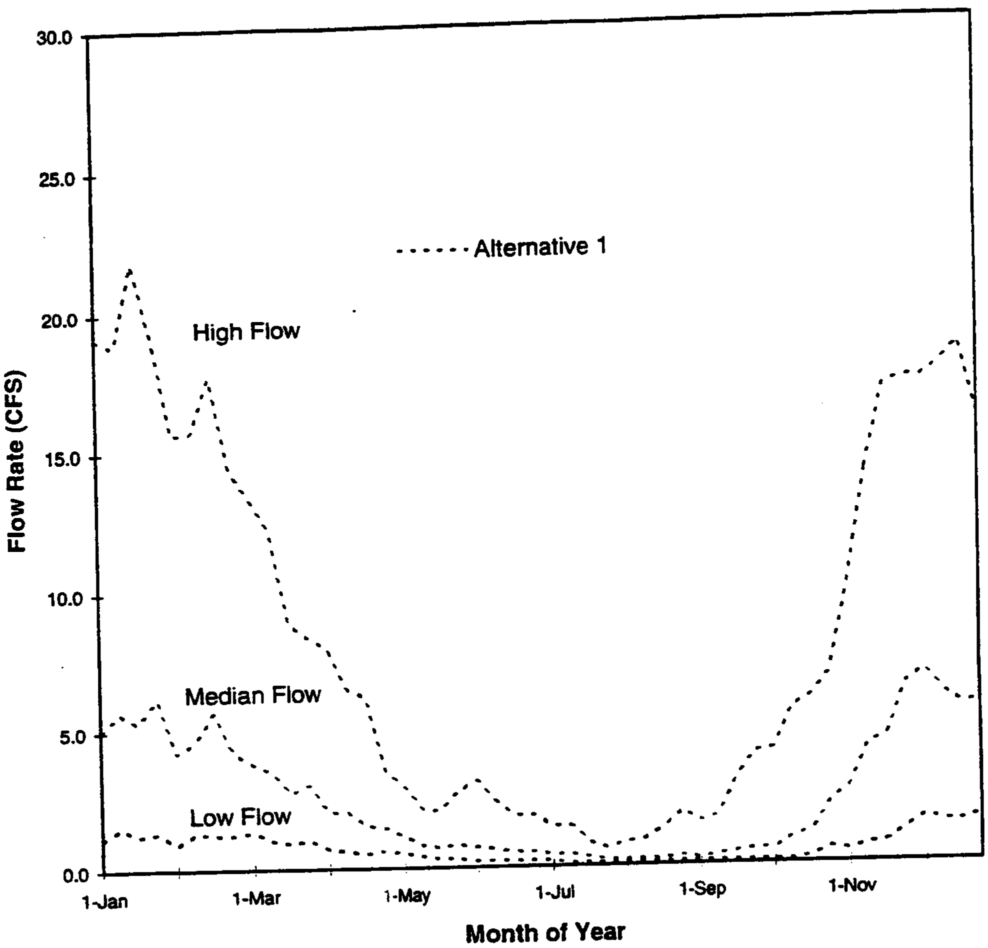
Seattle - Tacoma International Airport	Miller Creek And Des Moines Creek Watersheds	EXHIBIT: IV.10-1

Exhibit IV.10-3. Average low, median, and high flow rates for Alternative 1 at Location D along Des Moines Creek.



Source: Montgomery Water Group, 1995.

Exhibit IV.10-2. Average low, median, and high flow rates for Alternative 1 at Location B along Miller Creek.



Source: Montgomery Water Group, 1995.

Seattle-Tacoma International Airport Environmental Impact Statement for the Master Plan Update

Exhibit IV.10-4

Water Resources: Streams and Lakes

Class 2. Perennial stream with salmonids.

Class 2. Perennial. Salmonids undetermined.

Class 3. Intermittent stream.

Unclassified stream.

Lake

Drinking Water Supply Wells:
Highline Water District (HWD)
Seattle Water Department (SWD)

Source: Gambrell Urban, Inc. and
Shapiro & Associates, 1995
King County Basin Reconnaissance Reports, 1987
King County Sensitive Areas Map Folio, 1990

Scale 1" = 2,500'

0 2500 5000

Scale in Feet

Projection: Lambert Conformal Conic
Coordinate System: State Plane NAD27

November 30, [illegible]

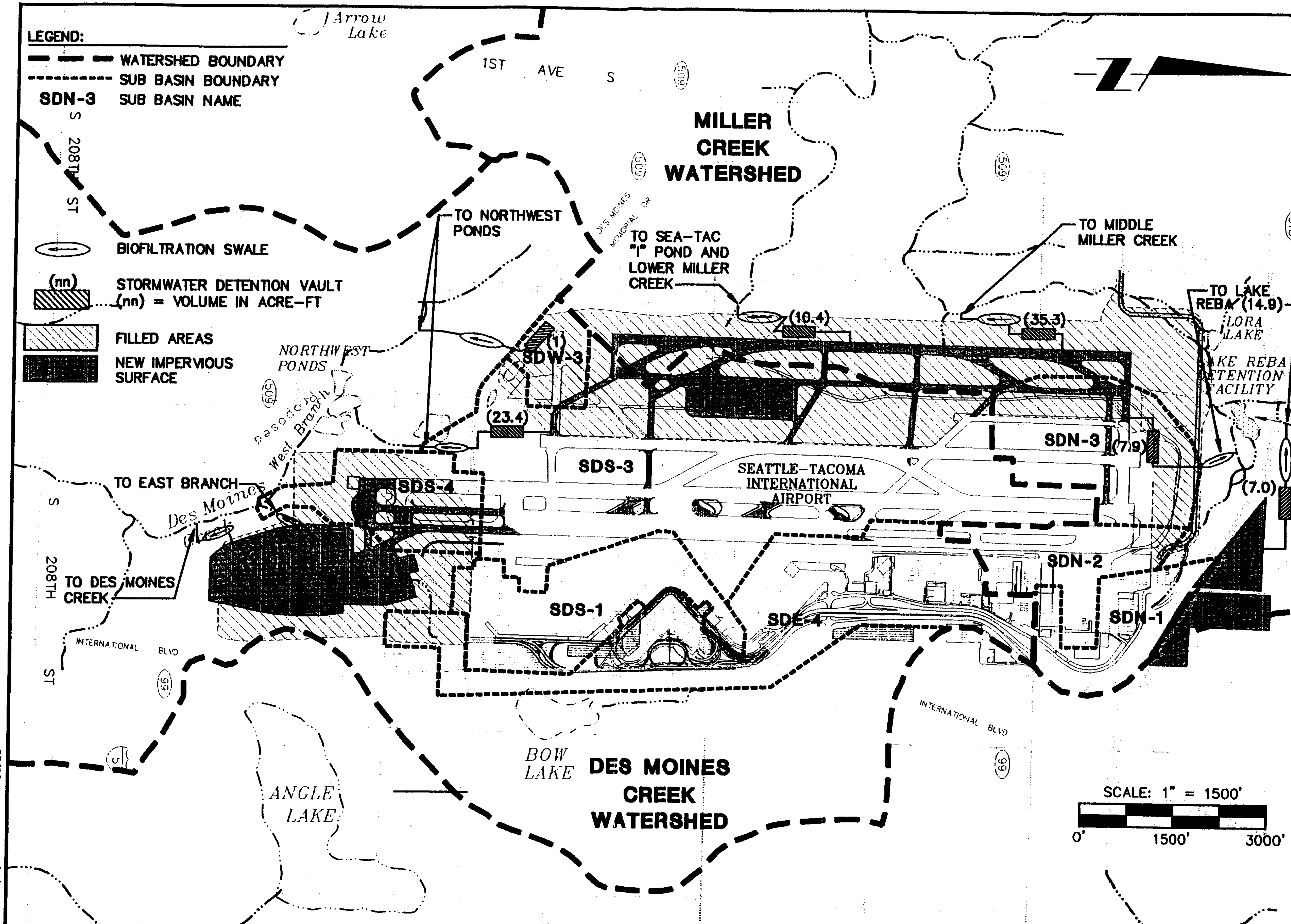


EXHIBIT: IV.10-5

Conceptual Layout of Proposed Stormwater Management System

Seattle - Tacoma International Airport

CAD CONTROL BLOCK REF: EXHIBIT3.DWG
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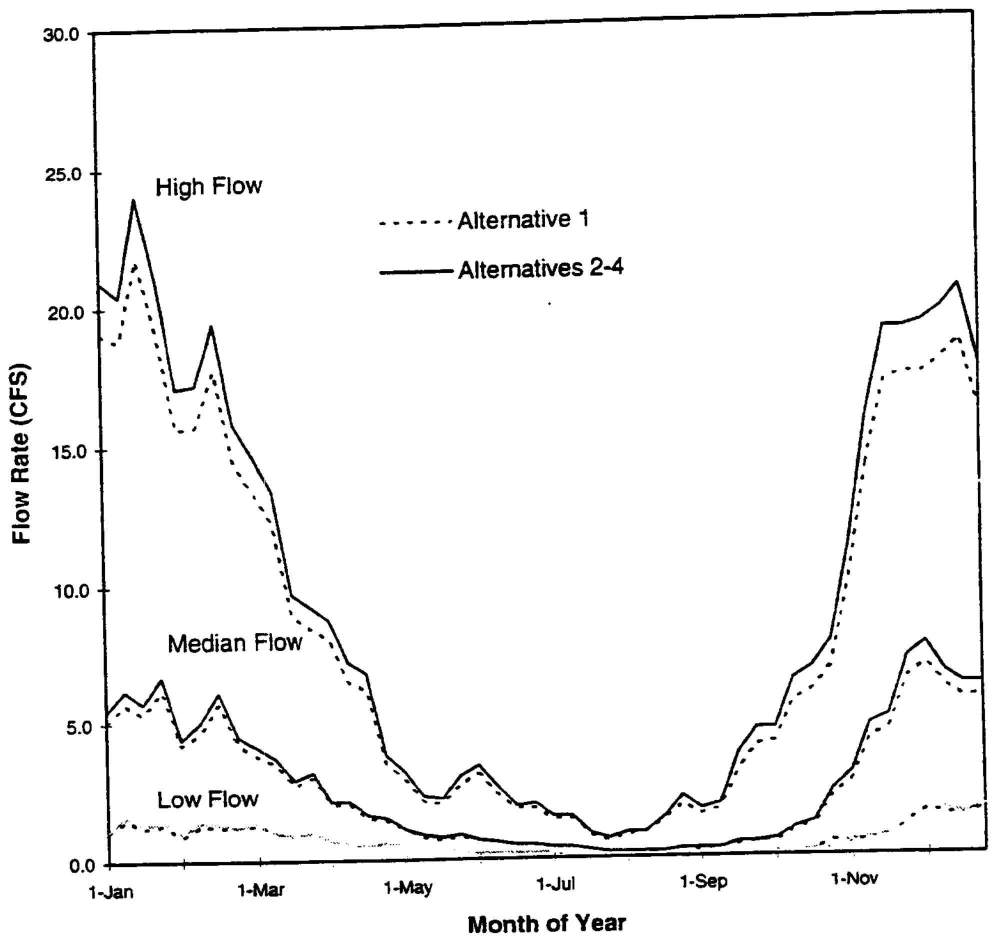
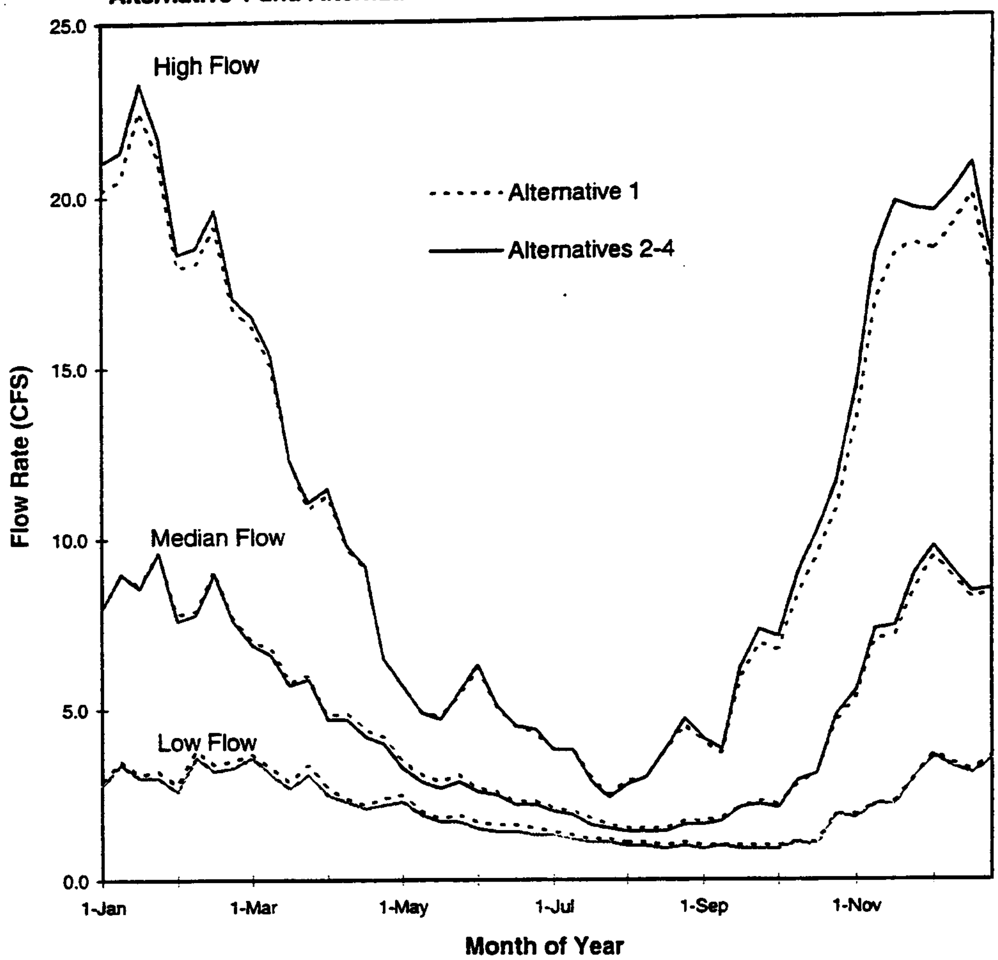
Exhibit IV.10-6. Average low, median, and high flow rates for Alternative 1 and Alternatives 2-4 at Location B along Miller Creek.



Source: Montgomery Water Group, 1995.

Exhibit IV.10-7. Average low, median, and high flow rates for Alternative 1 and Alternative 2-4 at Location D along Des Moines Creek.



Source: Montgomery Water Group, 1995.

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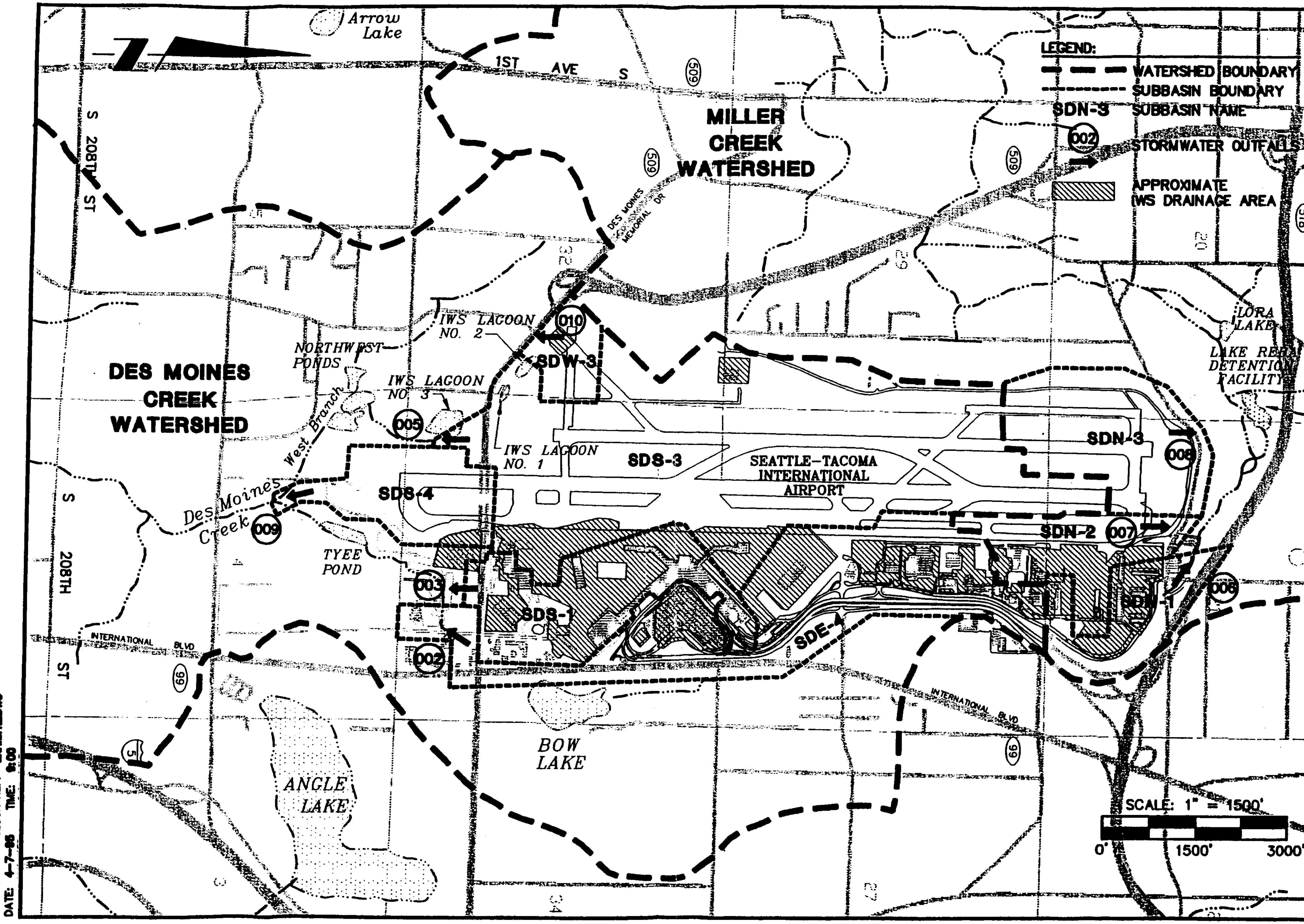
EXHIBIT: IV.10-8

Onsite Basins At SEA-TAC Airport

Seattle - Tacoma International Airport



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AR 039104

CHAPTER IV, SECTION 11

WETLANDS

Proposed Master Plan Update alternatives at Sea-Tac Airport would affect existing wetlands. Impacts on these wetlands would include: placement of fill material, dredging, removal of existing vegetation, and changes in hydrologic regimes as a result of increased impervious surface area and stormwater management system restructuring.

Wetlands that would be affected by each of the "With Project" alternatives are palustrine emergent, scrub-shrub, open water, and forested systems.[1] Wetland investigations of the airport area identified almost 144 acres of wetland. The specific number of wetlands that would be affected by the "With Project" alternatives will be determined by how much earth is excavated from the on-site borrow locations. Utilization of Borrow Area 8 (North Borrow Area) would result in direct impacts occurring to 16-acres of wetland in six different systems. Due to these large impacts, excavation is not proposed to occur in Borrow Area 8.

About 34 individual wetlands could be directly affected by development at the Airport. Including fill for the following:

Alternative	Wetland Impacts
Alt 1 (Do-Nothing)	1.70 acres
Alt 2 (Central Terminal with):	
8,500 ft runway	10.37 acres
7,500 ft runway	9.43 acres
7,000 ft runway	9.62 acres
Alt 3 (North Terminal with):	
8,500 ft	10.37 acres
7,500 ft	9.43 acres
7,000 ft	9.62 acres
Alt 4 (South Terminal with):	
8,500 ft	10.37 acres
7,500 ft	9.43 acres
7,000 ft	9.62 acres

Source: Shapiro & Associates. 1995
Assumes fill is not excavated from On-Site Borrow Area 8.

Adverse impacts on wetlands would require permits or approvals from the following agencies: U.S. Army Corps of Engineers, Washington State Department of Ecology, and Washington Department of Fisheries and Wildlife. In addition to required permits or approvals, compensatory mitigation would be required.

(1) METHODOLOGY

Three different methods were used to identify wetlands, and potential impacts:

- comprehensive and intermediate, on-site wetland determinations[2,3] were conducted to delineate wetlands that could be affected;
- existing wetland delineations of portions of the detailed study area were reviewed and included as part of this document; and
- in those portions of the detailed study area where right-of-entry was not granted, wetlands were identified from aerial photographs, existing inventories, and observations made from adjacent properties.

A detailed description of criteria used to make wetland determinations is contained in **Appendix H-A**.[4] As is noted in Appendix A, the U.S. Army Corps of Engineers is a cooperating agency in the preparation of this EIS.

(2) EXISTING CONDITIONS

A total of 55 individual wetlands were identified within the detailed study area and are shown in **Exhibit IV.11-1**. These wetlands range in size from approximately 0.02 acre to 30 acres with a total area of approximately 144 acres. A total of 20 emergent, 9 scrub-shrub, 4 open water, and 22 forested wetlands were identified. Wetlands may have more than one classification, (i.e., forested/scrub-shrub), in these cases the predominant vegetation class is listed first. **Table IV.11-1** contains a list of wetlands identified, their classification, the approximate area of each wetland, and the degree to which they may be affected by the proposed Master Plan Update alternatives.

1/ *Classification of Wetlands and Deepwater Habitats of the United States*, Cowardin, et al., 1979.

2/ *Corps of Engineers Wetlands Delineation Manual*, Environmental Laboratory, 1987.

3/ *Federal Manual for Identifying and Delineating Jurisdictional Wetlands*, Federal Interagency Committee for Wetland Delineation, 1989.

4/ *Jurisdictional Wetland Determination for the Seattle-Tacoma International Airport Master Plan Update Environmental Impact Statement*, Shapiro and Associates, Inc., 1995.

Wetlands provide hydrologic and biological functions that are considered important to human health, safety, and welfare. Hydrologic functions provided by wetlands include: storage of flood or stormwater; enhancement of water quality by filtering out pollutants; recharge of groundwater aquifers; and dissipation of floodwater energy. Biological functions of wetlands include providing breeding, feeding, nesting, and resting habitat for fish and wildlife species as well as retention and detention of nutrients. Different classifications of wetlands are generally considered to be better suited to provide different wetland functions. Forested and scrub-shrub wetlands are generally considered to provide greater flood energy dissipation and wildlife nesting habitat than that provided by emergent wetlands. Emergent wetlands are generally considered to provide greater water quality improvement functions and wildlife feeding opportunities than other wetland types. Open water wetlands are usually associated with groundwater recharge and fish habitat functions. Additional detail on the biological and hydrologic functions impacted by the proposed Master Plan Update alternatives are presented in the Wetland Mitigation Plan (**Appendix P**).

The following sections briefly describe the location, size, and general characteristics of wetlands in the study area. Wetlands are discussed by region in which they occur, as illustrated in **Exhibit IV.11-2**: North Borrow Source Areas and Warehouse/Parking Area, West Area, South Aviation Support Area, and South Borrow Source Areas. Detailed descriptions of each wetland are provided in **Appendix H-A**.

(A) <u>North Borrow Source Areas (5 & 8) and Warehouse/Parking Area Wetlands</u>

A total of 16 wetlands were identified in the North Borrow Source Areas and the Warehouse/Parking Area. Of these, 14 were delineated (Wetlands 1 through 14), and two (Wetlands 33 and 34) were identified from existing wetland inventories. Wetland numbering follows the labels assigned in the wetland delineation report as provided in **Appendix H-A**. This portion of the study area is bound on the south by S. 154th Street, on the west by 15th Avenue S., on the north by S. 146th Street, and generally on the east by 28th Avenue S. Sizes of wetlands in this area range from 0.07 acres (Wetland 1) to 17.6 acres (Wetland 33). As a result of the quantities of wetland in Borrow Area 8, the excavation will not occur in this area.

(B) <u>West Wetland Area</u>

Thirteen wetlands (Wetlands 15 through 27) were delineated in the area of the proposed new parallel runway during August and September, 1994. Ten additional wetlands (Wetlands 35 through 44) were identified in the west wetland area from either aerial-photograph interpretation or review of existing inventories, delineations were not conducted as right-of-entry was not granted by property owners. The west wetland area is bound on the west by Des Moines Memorial Drive S., on the east by existing runways, on the north by S. 154th Street, and on the south by S. 200th Street. Soils throughout this area consist of fill and are highly compacted. The wetlands in this area range in size from 0.06 acres (Wetland 22) to 30.3 acres (Wetland 43).

(C) <u>South Aviation Support Area Wetlands</u>

Three wetlands were identified within the South Aviation Support Area (SASA). Two wetlands (Wetlands 52 and 53) were identified and delineated as part of the 1994 SASA Final EIS.[5/] A wetland (Wetland 28) was identified and the portion within the potential construction area was delineated. The SASA boundaries are demarked on the north by S. 188th Street, on the east by Pacific Highway S. (Highway 99), on the south by S. 200th Street, and on the west by 18th Avenue S. Wetlands in this area range in size from 0.6 acres (Wetland 53) to 18.1 acres (Wetland 28).

(D) <u>South Borrow Area Wetlands</u>

Four wetlands (Wetlands 29, 30, 31, and 32) were delineated in the south borrow area during November 1994. The South Borrow Area (Borrow Areas 1, 2, and 3) is located between 16th Avenue S., 24th Avenue S., S. 216th Street, and S. 200th Street. Three additional wetlands (Wetlands 48, 49, and 50) were delineated and are described in the Des Moines Creek Technology Campus Draft

5/ *South Aviation Support Area Final EIS*, Port of Seattle, 1991.

EIS.[6] Des Moines Creek traverses this area in a relatively deep ravine. Wetlands in this area are smaller than 0.03 acres.

(E) Other Wetlands

Four wetlands were identified in the general vicinity, outside of any identified impact area. These wetlands were not delineated but rather were identified from the *National Wetland Inventory Map, Des Moines, Washington, Quadrangle*.[7] These wetlands range in size from 0.06 acres (Wetland 46) to 26 acres (Wetland 54).

(3) FUTURE CONDITIONS

Of the 55 individual wetlands identified, 34 could be directly affected by future airport improvements at Sea-Tac. Each of the proposed "With Project" alternatives would affect wetlands. The specific area of wetland that could be affected would depend upon the amount of fill excavated from the on-site borrow locations. This analysis assumes that Borrow Area 8 would not be utilized. Wetland impacts can be avoided or minimized through the use of off-site fill. However, use of off-site material would increase the amount of truck traffic affecting area roads during the construction period, as discussed in Section 23 "Construction Impacts".

Development of an 8,500-ft runway and full utilization of the south borrow source and warehouse/parking areas would directly affect about 10.4 acres of wetland including; 7.07 acres of forested wetlands, 0.39 acres of scrub-shrub wetlands, and 2.88 acres of emergent wetlands. Development of a 7,500-ft runway would directly affect 9.43 acres of wetland including; about 6.6 acres of forested wetland, 0.38 acres of scrub-shrub wetland, and about 2.46 acres of emergent wetland. Development of the 7,000-ft runway option would directly affect about 9.62 acres of wetland including; about 6.58 acres of forested wetland, 0.38 acre of scrub-shrub wetland, and 2.56 acre of emergent wetland.

All impacts on wetlands would be anticipated to occur during the Phase I time period (1996-2001). No wetland impacts would occur as a result of terminal expansion options. **Table IV.11-2** summarizes potential impacts on wetlands by location and alternative.

Construction of the proposed new parallel runway, extension of Runway 34R, grading and filling of the Runway Safety Areas, and utilization of borrow source areas would require removal of existing vegetation, draining, and discharging of fill material to wetland habitats. Existing wetland area and functions would be lost or diminished as a result of these actions. Loss of wetland habitat and function represent a significant adverse environmental impact.

Wetland impacts associated with each of the proposed Master Plan Update alternatives are described below.

(A) Do-Nothing (Alternative 1)

The Do-Nothing alternative would maintain Sea-Tac as it exists today. As the Port of Seattle has received approval from the FAA to initiate development of the South Aviation Support Area, impacts to wetlands could occur to complete that development. As was described in the Final Environmental Impact Statement for the SASA development, approximately 1.7 acres of wetland would be affected (Wetlands 52, 53, and 55). No other wetland impacts would be expected. Proposed extension of SR509 could effect up to 11.1 acres of wetland.[8] However, as a specific alignment as not been identified, these impacts are not included in the Do-Nothing assessment.

(B) "With Project" Alternatives (Alternatives 2, 3, and 4)

Each of the "With Project" alternatives would affect wetlands. No direct wetland impacts would be anticipated as a result of the various landside improvements. However, wetland impacts would vary as a result of the three alternative runway lengths (8,500, 7,500, or 7,000 feet). Wetland impacts associated with each runway length option are listed in **Table IV.11-2**.

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[6] *Des Moines Creek Technology Campus, Draft EIS*, Port of Seattle, February, 1995.

[7] *National Wetland Inventory Map, Des Moines, Washington, Quadrangle*, U.S. Fish and Wildlife Service, 1987.

[8] *SR 509/South Access Draft EIS*, December, 1995.

1. **8,500-ft New Runway**

Construction activities associated with building an 8,500-ft proposed new parallel runway, separated by 2,500 feet from Runway 16L/34R, extending Runway 34R. development of additional warehouse and parking space, and utilizing Borrow Areas 1,2,3 and 5 for structural fill would affect 10.37 acres in 31 different wetland habitats.

Impacts associated with construction of the proposed new runway include filling, grading, or otherwise affecting 7 forested wetlands (Wetlands 11, 14, 18, 19, 21, 37, and 40) with a total area of approximately 2.88 acres. Two scrub-shrub wetlands (Wetlands 20, and 22) totaling 0.07 acre would be impacted. Approximately 2.51 acres of 11 different emergent wetlands would be affected by construction of an 8,500-foot-long third runway. About 5.48 acres of wetland habitat would be impacted as a result of the proposed new parallel runway.

2. **7,500-ft New Runway**

Impacts associated with new runway construction include filling, grading, or otherwise affecting 6 forested wetlands (Wetlands 18, 19, 21, 25, 37, and 40) with a total area of approximately 2.40 acres. Two scrub-shrub wetlands (Wetlands 20 and 22) totaling 0.06 acre would be directly impacted. Approximately 2.09 acres of 9 different emergent wetlands (Wetlands 12, 15, 16, 17, 23, 24, 26, 35, and 41) would be affected by construction of a 7,500-foot-long third runway. Impacts would occur on 4.55 acres of wetland habitat as a result of the 7,500 ft long new parallel runway.

3. **7,000-ft New Runway**

Impacts associated with development of a 7,000 foot-long runway would be similar to those described for the 7,500 foot-long runway option, with the exception of emergent wetland impacts. Direct impacts as a result of this alternative would include filling, grading or otherwise affecting 2.19 acres of 9 different emergent wetlands. Impacts on scrub-shrub wetlands would be the same as those described for the 7,500 foot-long runway option.

* * *

Development in the SASA would affect two forested wetlands (Wetlands 52 and 53), and shrub/scrub wetland (#55) with a total area of 1.7 acres. Proposed extension of Runway 34R would affect Wetland 28 (0.06 acre).

Full development of warehouse/parking facilities north of the existing air-cargo area at the Airport would directly affect two forested wetlands (Wetlands 1 and 2). The total wetland impact as a result of construction in this area would be approximately 0.81 acre.

Utilization of Borrow Areas 1, 2, and 3 for structural fill would result in direct impacts on two forested wetlands (Wetlands 29 and 51), two scrub-shrub wetlands (Wetlands 30 and 49), and three emergent wetlands (Wetlands 31, 32, and 50). Total wetland area affected by utilization of the south borrow source areas would be: 1.62 acres of forested wetland habitat, 0.12 acre of scrub-shrub wetland habitat, and 0.08 acre of emergent wetland habitat. A total of 1.82 acres of wetland habitat would experience impacts as a result of development activities in this area.

(C) **Preferred Alternative**

As is described in Chapter II, the Port of Seattle staff have recommended the implementation of Alternative 3 (North Unit Terminal) with a new parallel runway with a length of 8,500 feet. As the previous paragraphs indicate, all of the alternatives would result in the filling of wetlands. The preferred alternative would result in the filling of 10.37 acres of wetland in 33 different wetland habitats. These impacts include the following:

- 7.07 acres of forested wetlands
- 0.39 acres of shrub-scrub wetlands
- 2.88 acres of emergent wetlands

No wetlands were identified in Borrow Area 5. The Port will not excavate earth from Borrow Area 8 in order to avoid over 16 acres of impact to wetland areas.

* * *

FAA Order 5050.4A "Airport Environmental Handbook" states:

"Federal agencies ... avoid undertaking or providing assistance for new construction located in wetlands unless the head of the agency finds: a) that there are no practicable alternatives to such construction, and b) that the proposed action includes all practicable measures to minimize harm to wetlands which may result from such use." [Chapter 5, Paragraph 47 e (11) (b)]

"The term 'practicable' means feasible. Whether another alternative is practicable depends on its feasibility in terms of safety, meeting transportation objectives, design, engineering, environment, economics, and any other applicable factors." [Chapter 5, paragraph 47e(11)(e)]

In evaluating alternatives, Chapter II considered:

- *Off-site alternatives* to satisfying the existing and future aviation needs - as was shown none of the off-site alternative can satisfy the need for the following reasons:
    1. There is no sponsor, identified source of funds or acceptable site for a new airport;
    2. Extensive study of this issue resulted in the consideration of all alternatives for addressing air transportation capacity issues in this Region. Based on this process, the Puget Sound Regional Council (PSRC) adopted Resolution A-93-03 and EB-94-01 confirming that no feasible sites exist; and
    3. If a new site could be identified, market forces would not enable it to be successful until regional origin and destination air travel demand exceeds 10 million enplanements annually - currently forecast to occur around the year 2010. In addition, all of the sites considered in the Major Supplemental Airport Study were found to affect wetlands.
- *Technology or Activity/Demand Management Alternatives* - no technology or activity/demand management related alternative is capable of addressing the poor weather related constraint at Sea-Tac or to accommodate forecast increases in air travel demand.
- *On-Site Alternatives* - Because of FAA safety related airport design standards, no other on-site alternative exists to avoid the fill of wetlands. Within the on-site alternatives (Alternatives 1 through 4), the Do-Nothing alternative (Alternative 1) will not satisfy the Region's aviation needs. In assessing Alternatives 2, 3 and 4, attempts would be made to minimize adverse impacts to wetlands.

As the Do-Nothing alternative would not satisfy the needs identified by the EIS, it was determined not to be a practicable alternative.

Wetland impacts could be avoided through the acquisition of off-site fill to complete a portion of the "With Project" alternatives. As is noted in the previous sections, about 16 acres of wetland could be affected in on-site Borrow Area 8.

(4) CUMULATIVE IMPACTS

As previously mentioned, a maximum of 10.37 acres of wetland would be filled as a result of the Master Plan Update "With Project" alternatives. Loss of this amount of wetland area, however, should be viewed as one of many contributing to cumulative effects on natural resources in the Puget Sound Region. The result of past wetland filling has been to increase the functional importance of the remaining wetlands in the Region. Removal or alteration of wetlands as a result of the alternative airport development and other projects in the area may limit the ability of remaining wetlands to perform the lost or diminished functions. This may be particularly true of the stormwater storage functions of wetlands in the project vicinity. Increased impervious surfaces associated with development activities at the Airport may increase both the depth and duration of stormwater in remaining wetlands. This could result in increased floodwater elevations for longer periods of time in the watershed.

(4) MITIGATION

Actions that affect wetlands generally require authorization from various federal, state, and applicable local agencies. In the State of Washington, projects with significant adverse wetland impacts require a Section 404 permit from the U.S. Army Corps of Engineers (Corps), and Section 401 Water Quality Certification from the Washington State Department of Ecology (Ecology). In addition to the required permits and approvals, compensatory wetland mitigation may also be required to offset significant adverse impacts on wetlands and their functions.

The Port of Seattle has initiated the wetland permitting process with the Seattle District of the Corps. The Corps is a cooperating agency in the preparation of this EIS. Additional coordination is anticipated with the Washington State Department of Ecology. It is anticipated that permits would be issued after approval of the Final Environmental Impact Statement/Record of Decision for the Master Plan Update actions and that no adverse impacts would occur on wetlands as a result of the Master Plan Update prior to issuance of the appropriate permits.

Significant unavoidable adverse impacts would occur to wetlands; these impacts include filling, grading, changes of hydrology, and removal of vegetation. The Port of Seattle would avoid adverse impacts where possible (e.g., use of off-site fill to avoid approximately 16-acres of wetland impact in Borrow Area 8), and would minimize impact by using Best Management Practices (BMP) during construction and operation of the proposed improvements. Among the BMPs to be utilized are: installation of silt-fences around wetlands not being directly affected, timing of construction activities to avoid impacts during the rainy season, and staging of construction equipment and vehicles away from wetland areas.

In addition to avoidance and minimization as mitigation for direct impacts on wetlands, the Port of Seattle has identified the following wetland compensatory mitigation needs as a result of direct impacts on wetlands. Direct wetland impacts and mitigation area required, presented in **Table IV.11-3**, represents the "worst-case scenario;" that is, the maximum wetland impact that could occur as a result of the proposed action (a new parallel runway with a length of up to 8,500 feet and full utilization of on-site south borrow source areas and warehouse/parking facilities). Wetland mitigation ratios listed assume creation of new wetland area as presented in **Appendix P**.

After extensive study, the Port of Seattle has selected a preferred wetland mitigation site in the lower Green River Valley. Mitigation for impacts on wetlands at the Airport, within the watershed where the impacts may occur, is not feasible for three reasons: (1) the majority of the area surrounding the Airport is developed, and not enough land area exists in the watershed to create compensatory mitigation wetlands, (2) much of the undeveloped land in the watersheds is existing wetland, or land unsuitable for wetland mitigation due to topographic (moderate to steeply sloping) or hydrologic (lack of sufficient water) conditions, and (3) the FAA guidelines strongly recommend[9] that airports do not have "wildlife attractions" within 10,000 feet of the edge of any active jet runway. For these reasons, the Port proposes to conduct wetland mitigation outside of the watershed where these constraints do not exist.

The Port of Seattle is committed to attaining "no net loss" of wetlands through mitigation efforts. After investigating over 100 individual parcels, the Port has selected a site located within the City of Auburn for the development of the compensatory wetland mitigation. This site, located in Section 31, Township 22N, Range 5E, Willamette Meridian in the Green River watershed, is a 69 acre parcel of land slightly south of S. 277th Street and east of Auburn Way. The undeveloped parcel has been farmed in the recent past, and currently supports a mix of upland pasture grasses and forbs that are common to abandoned agricultural land in the Puget Sound Region. Approximately 4.3 acres of reed canarygrass-dominated wetland was delineated at the site. The site is bound by a variety of land uses including agriculture to the north and south; undeveloped land, multi-family housing and a drive-in theater to the west; and the Green River, patches of riparian forest, and undeveloped slopes to the east. A narrow strip of land along the western banks of the Green River is held by King County. In December 1995, the Port of Seattle gained ownership of the property following completion of a bankruptcy proceeding by the previous owners.

The Port of Seattle is coordinating with the Corps of Engineers concerning the proposed mitigation site and the plan included in this Final EIS. **Appendix P** contains a detailed mitigation plan for the proposed wetland mitigation, including:

- Water regime;
- Site grading;
- Landscape plan; and
- Monitoring plan

Initially, the City of Auburn expressed reservations concerning the development of the mitigation site within the City boundaries. However, the final mitigation plan was developed to reflect their concerns regarding land use.

9/ "Wildlife Attractions On or Near Airports," *FAA Draft Advisory Circular 150/5200-*, no date.

TABLE IV.11-1
Page 1 of 2

Seattle-Tacoma International Airport
Environmental Impact Statement

WETLAND CLASSIFICATION AND AREA

Option Wetland Number	Classification	Area[1/] (ac)	(8,500 Foot Runway Impact[1/] (ac)
1	PFO	0.07	0.07
2	PFO/EM	0.74	0.74
3	PFO	0.56	0.56
4	PFO	5.02	0.0
5	PFO/SS	4.58	0.0
6	PSS	0.878	0.0
7	PFO/OW/EM	6.7	0.0
8	PSS/EM	4.95	0.0
9	PEM/FO	2.85	0.13
10	PSS	0.31	0.0
11	PFO/EM	0.50	0.47
12	PEM/FO	0.21	0.21
13	PEM	0.05	0.05
14	PFO	0.19	0.19
15	PEM	0.28	0.28
16	PEM	0.06	0.06
17	PEM	0.03	0.03
18	PFO	0.12	0.12
19	PFO	0.57	0.57
20	PSS/EM	0.06	0.06
21	PFO	0.22	0.22
22	PSS/EM	0.06	0.06
23	PEM	0.78	0.78
24	PEM	0.14	0.14
25	PFO	0.06	0.06
26	PEM	0.02	0.02
27	PEM	0.0	0.0
28	POW/SS	18.1	0.06
29	PFO	0.74	0.74
30	PSS/FO	0.50	0.50
31	PEM	0.05	0.00
32	PEM	0.05	0.05
33	PFO/SS/EM/OW	17.6	0.0
34	POW	1.4	0.0
35	PEM	0.21	0.18
36	PFO/EM	0.3	0.0
37	PFO/SS	2.41	1.68
38	PEM/SS	0.0	0.0
39	PFO	0.07	0.0

TABLE IV.11-1
Page 2 of 2

Seattle-Tacoma International Airport
Environmental Impact Statement

WETLAND CLASSIFICATION AND AREA

Wetland Number	Classification	Area[1/] (ac)	Impacts[1/] (ac)
40	PFO	0.09	0.09
41	PEM	0.08	0.08
42	PEM	0.5	0.0
43	PEM/SS/FO/OW	30.3	0.0
44	PFO/SS	0.7	0.0
45	PEM	5.0	0.0
46	POW	0.06	0.0
47	POW	0.2	0.0
48	PEM	0.02	0.0
49	PSS	0.02	0.02
50	PEM	0.03	0.03
51	PFO	8.1	0.48
52	PFO/SS	1.0	1.0
53	PFO	0.6	0.6
54	PSS/OW	25.7	0.0
55	PSS	0.04	0.04
	TOTALS	143.8	10.37

P - Palusterine
EM - Emergent Marsh
OW - Open Water
FO - Forested
SS - Shrub/Scrub

1/ Source: Parametrix; and Shapiro & Associates, Wetland impact values provided by a GIS operated by Gambrell Urban, 1995. Wetland area values for wetlands 1-31 based on survey conducted by Port of Seattle (1995). Area values for wetlands 32-48 based on GIS output. Area values for wetlands 49-54 based on existing literature.

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TABLE IV.11-2

SUMMARY OF WETLAND IMPACTS BY AREA AND ALTERNATIVE

	Wetland Types Affected (acres) a/			
Runway Length Option	Forested	Shrub/Scrub	Emergent	Total
8,500 ft. New Parallel Runway				
Runway	2.88	0.07	2.51	5.48
SASA	1.50	0.20	0.00	1.70
Warehouse/Parking	0.51	0.00	0.29	0.81
South Borrow Areas	1.62	0.12	0.08	1.82
North Borrow Areas	0.56	0.00	0.00	0.56
TOTAL	7.07	0.39	2.88	10.37
7,500 ft. Parallel Runways				
Runway	2.40	0.06	2.09	4.55
SASA	1.50	0.20	0.00	1.70
Warehouse/Parking	0.51	0.00	0.29	0.81
South Borrow Areas	1.62	0.12	0.08	1.82
North Borrow Areas	0.56	0.00	0.00	0.56
TOTAL	6.59	0.38	2.46	9.43
7,000 ft. Parallel Runways				
Runway	2.49	0.06	2.19	4.74
SASA	1.50	0.20	0.00	1.70
Warehouse/Parking	0.51	0.00	0.29	0.81
South Borrow Areas	1.62	0.12	0.08	1.82
North Borrow Areas	0.56	0.00	0.00	0.56
TOTAL	6.68	0.38	2.56	9.62

a/ All runway lengths assume a 2,500 foot (dependent) separation from Runway 16L/34R. The impacts noted above assume maximum use of south on-site fill for construction, resulting in a worst-case presentation of wetland impacts. Assumes no material is taken from Borrow Area 8.

Source: Parametrix; Shapiro and Associates, and Gambrell Urban, 1995.

TABLE IV.11-3

SUMMARY OF WETLAND IMPACTS AND POTENTIAL MITIGATION AREA

		Wetland Class		
	Total	Forested	Shrub/Scrub	Emergent
Total Wetland in Study Area (ac)	143.8	51.7	50.8	41.3
Wetland Area Directly Impacted (ac)	10.37	7.07	0.39	2.88
Minimum Mitigation Ratio		2:1	2:1	1.5:1
Mitigation Area Required (ac)	19.24	14.14	0.78	4.32

Source: Parametrix; and Shapiro & Associates, 1995.

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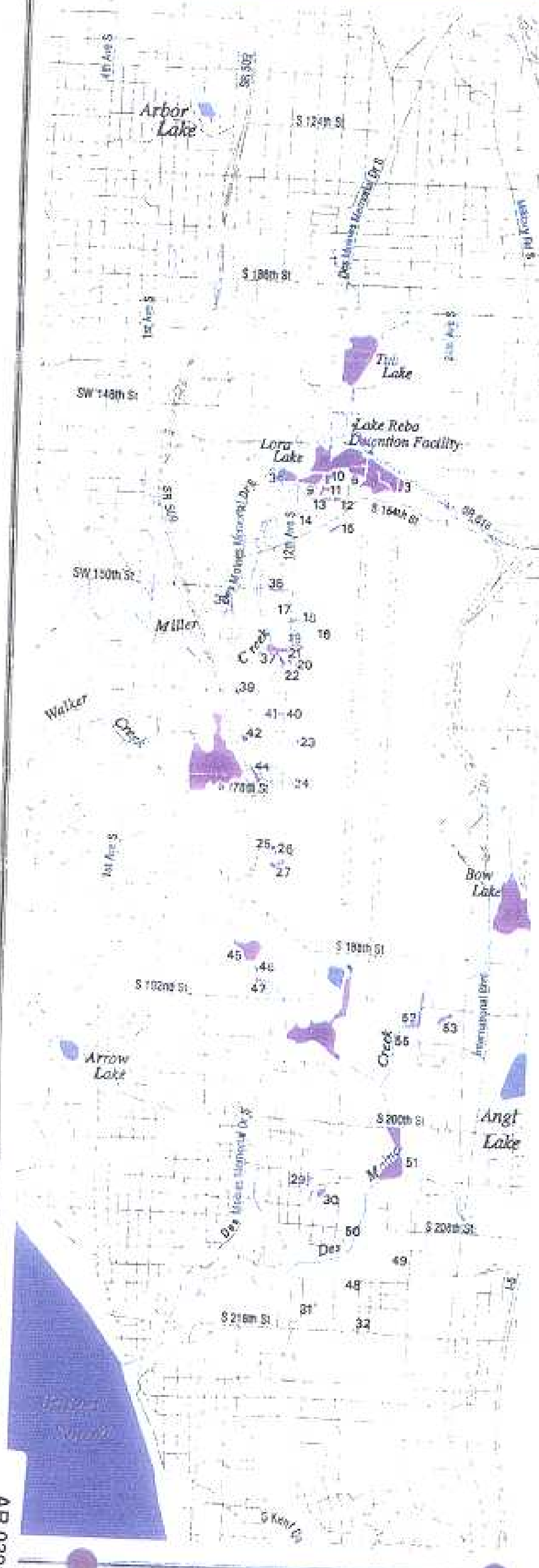
Seattle-Tacoma International Airport
Environmental Impact Statement
for the Master Plan Update

Exhibit IV.11-1

Wetlands in the Study Area



Palustrine Wetland

Source: Gambrell Urban, Inc. and
Shapiro & Associates, 1994
SASA Final EIS, 1994
King County Sensitive Areas Map Folio, 1990
City of SeaTac Wetland and
Stream Classification, 1991
National Wetland Inventory, 1988
Port of Seattle Wetland Management Plan, 1992

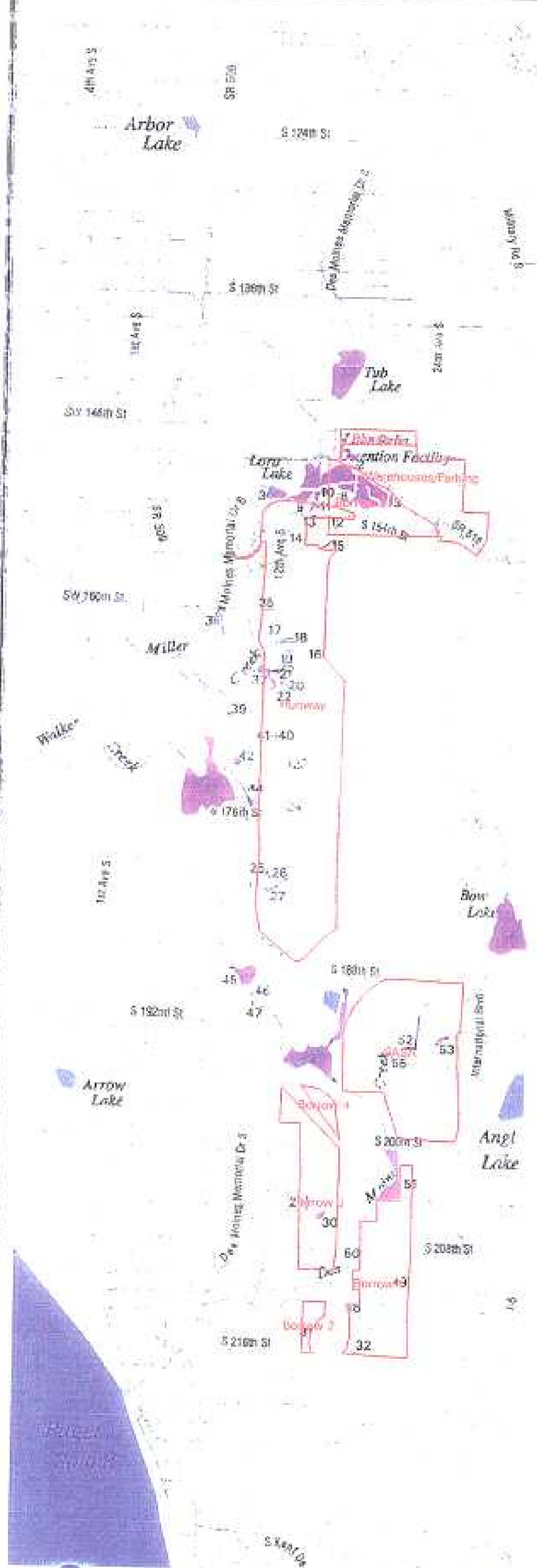
Scale 1" = 2,500'

0 2500 5000
Scale in Feet

Projection: Lambert Conformal Conic
Coordinate System: State Plane NAD27

December 20, 1996

AR 039115



Seattle-Tacoma International Airport Environmental Impact Statement for the Master Plan Update

Exhibit IV.11-2

Wetlands Affected by Construction (8,500 Foot New Runway Option)

Palustrine Wetland

Potential Construction Impact Area

Source: Gambrell Urban, Inc. and Shapiro & Associates, 1994
SASA Final EIS, 1994
King County Sensitive Areas Map Folio, 1990
City of SeaTac Wetland and Stream Classfication, 1991
National Wetland Inventory, 1988
Port of Seattle Wetland Management Plan, 1992

Scale 1" = 2,500'

0 2500 5000
Scale in Feet

Projection: Lambert Conformal Conic
Coordinate System: State Plane NAD27

December 20, 1996

AR 039116

CHAPTER IV, SECTION 12
FLOODPLAINS

Reported flooding and 100-year floodplains in the Sea-Tac area were identified from the most recent Flood Insurance Rate Maps compiled by the Federal Emergency Management Agency, flood insurance studies, and drainage complaints. Potential impacts on floodplains and flooding in Miller and Des Moines Creeks were evaluated by using construction footprints associated with the "With Project" alternatives and by modeling post-construction flows.

Without mitigation, construction, and operation of the proposed Master Plan Update alternatives could result in significant adverse floodplain impacts, including reduction of 100-year floodplain area and flood storage capacity, increased volumes of stormwater runoff and peak flows, and increased flooding potential in downstream areas on both Miller and Des Moines Creeks. Because mitigation would be required to prevent reduction of 100-year floodplain area and flood storage capacity, the proposed Master Plan Update alternatives would be unlikely to result in loss of flood storage or conveyance capacity. In addition, flow modeling results using detention requirements for the new development show that the proposed Master Plan Update alternatives would not increase peak flows or potential flooding in downstream areas of Miller of Des Moines Creek.

(1) METHODOLOGY

The boundaries of 100-year floodplains are determined by the Federal Emergency Management Agency (FEMA) and the U.S. Army Corps of Engineers. Floodplain boundaries are estimated on the basis of hydraulic modeling. Existing 100-year floodplain boundaries discussed in this section are those identified in the most current FEMA flood insurance rate maps and flood insurance studies. The approximate floodplain area affected by each alternative was determined by overlaying the potential construction footprints for each proposed Master Plan Update alternative on the floodplain maps.

Potential flooding impacts of the alternatives were determined by using recent hydrologic modeling results for Miller and Des Moines Creeks. Hydrologic models calibrated with existing stream flow information are used to identify existing and future peak flow rates and flood frequencies. Future peak flow rates and flood frequencies are calculated by using existing detention requirements for the 2-, 10-, and 100-year storm events. Potential flooding and impacts are estimated by comparing existing flow rate return frequencies to future flow rate return frequency.

(2) EXISTING CONDITIONS

Existing floodplains have been significantly altered by modern urbanization in both the Miller and Des Moines Creek basins, contributing to existing floodplain encroachment and reduction in available flood storage capacity. Urban development in two basins also has altered the hydrology of Miller and Des Moines Creeks, causing historic flooding in some areas, generally downstream of the Airport, and increased risk of flooding in naturally floodprone areas (i.e., depressions and low-lying downstream areas adjacent to these creeks).

(A) Present Floodplain Conditions

Urban development within the two basins has altered the existing size and structure of floodplains and contributed to the present floodplain configurations. As is typical of most urbanized drainage basins, streamside development has resulted in channelization of Miller and Des Moines Creeks and has eliminated or reduced linkages between the creeks and floodplain areas. Urban development activities that have contributed to altered floodplain configuration include filling of wetlands and riparian areas, removal of streamside vegetation within stream corridors, and construction of roads, residences, and commercial development. These alterations contribute to flooding by reducing channel capacity and floodplain storage in Miller and Des Moines Creeks.

In the Miller and Des Moines Creek basins, FEMA identifies two types of 100-year floodplain boundaries: Zone A and Zone AE. In Zone A, no base flood elevations have been determined. Base flood elevations have been determined for Zone AE. Existing 100-

year floodplains in each drainage basin are identified in **Exhibit IV.12-1.**[1] The Zone A 100-year floodplain boundary is an estimated boundary. Zone AE includes the 100-year floodplain boundaries from which the base flood elevations have been determined.

The 100-year floodplain widths vary, depending on topography. In the Miller Creek basin, relatively wide 100-year floodplain areas extend southward from the Lake Reba Detention facility and Lake Lora areas. These floodplains are located in depressions and relatively flat areas with little topographic relief, and extend downstream to about First Avenue S. The Lake Reba Detention Facility and Lake Lora provide considerable flood storage because of their associated wetlands and a flow control structure at the outlet of the Lake Reba Detention facility. This flow control structure was constructed recently by the King County Surface Water Management Division as part of the Lake Reba regional detention facility capital improvement project. Below First Avenue S., Miller Creek is more confined by the narrow, steep ravine topography. The average 100-year floodplain width in this area is about 50 feet. As the creek nears Puget Sound and the base of the steep ravine, the channel and floodplain widen to about 300 feet.[1] The areas most susceptible to flooding in the Miller Creek basin are along the lower reaches of Miller Creek and Walker Creek. This flood prone area lies within the northwest portion of the City of Normandy Park, near the Puget Sound shoreline.[2] Only minor flooding problems have been reported in the past few years.

The Des Moines Creek 100-year floodplain has a configuration similar to Miller Creek. From the origins of the two main tributaries at Bow Lake and the Northwest Ponds down to South 200th Street, no 100-year floodplain has been identified. In this gently sloping area around the Tyee Valley Golf Course, there are two manmade detention facilities, Northwest Pond, and Tyee Pond. Both the Northwest Pond and the Tyee Pond, the latter of which was constructed in 1989, [3] provide significant flood storage. **(See Chapter IV, Section 10, "Water Quality and Hydrology")** As the creek begins its descent toward Puget Sound near South 200th Street, the channel becomes more incised and confined, and there is a narrow floodplain. Farther down the ravine, the creek becomes well confined and the floodplain is very narrow, averaging about 30 feet in width. The floodplain widens to about 280 feet near the mouth of the creek and confluence with Puget Sound at Covenant Beach Camp. The area most susceptible to flooding and which has experienced historic flooding is Covenant Beach Camp near the mouth of Des Moines Creek. Flooding has occurred primarily during large storms and unusually high tide conditions.[4]

(B) <u>Historic Flooding</u>

In the Miller Creek basin, historic flooding problems have been reported between Southwest 150th Street and Southwest 152nd Street just west of Des Moines Memorial Drive, upstream of Southwest 160th Street, and elsewhere throughout the basin where yard waste has constrained streamflow.[5] This flooding, caused primarily by undersized or poorly maintained conveyance structures, has been corrected by modification of the Lake Reba regional detention facility, other structural improvements, and maintenance activities (e.g., culvert debris removal).

Historic flooding also has been reported for the Des Moines Creek system.[6] An undersized grassy swale and filling of a wetland near South 216th Street have contributed to flooding problems in this reach of Des Moines Creek. An undersized detention facility and filling of wetland also

1/ *Flood Insurance Rate Maps, King County, Washington, and Incorporated Areas.* Map Number 53033C0319D, 53033C0309D, 53033C0308E, and 53033C0317D Federal Emergency Management Agency. September 29, 1989 and September 30, 1994.

2/ *Flood Insurance Study, City of Normandy Park, Washington, King County.* U.S. Department of Housing and Urgan Development, Federal Insurance Administration. 1980.

3/ *South Aviation Support Final Environment Impact Statement,* Federal Aviation Administration and Port of Seattle, Seattle, WA, 1994.

4/ *Flood Insurance Study, City of Des Moines, Washington, King County.* Federal Emergency Management Agency. 1985.

5/ *Reconnaissance Report No. 12, Miller Creek Basin.* King County Basin Reconnaissance Summary Program. Vol. III. King County Surface Water Management, Seattle, WA. 1987.

6/ *Reconnaissance Report No. 9, Des Moines Creek Basin. King County Basin Reconnaissance Summary Program. Vol. III.* King County Surface Water Management, Seattle, WA 1987.

AR 039118

have contributed to flooding on Tributary 0377A (shown in **Exhibit IV.10-4**). Similarly, wetland filling has contributed to flooding on Tributary 0379 near the outlet of Wetland 53 (as shown in **Exhibit IV.11-1**).

According to conversations with public works personnel in the cities of Normandy Park, Des Moines, and SeaTac, no significant flooding problems were reported during the November 1990 and January 1991 storms. The last major flood events on Miller and Des Moines Creeks were in 1972 and 1977, respectively. According to the flood insurance study, damage has generally been limited to stream erosion and limited flooding of residences in Normandy Park (Miller Creek) and Des Moines (Des Moines Creek). The 1977 flood event on Des Moines Creek, which was associated with a high tide with an approximate recurrence interval of 70 years, caused some property damage to buildings at the Covenant Beach Bible Camp.[7/]

(3) FUTURE CONDITIONS

Without mitigation, the proposed Master Plan Update alternatives could result in significant floodplain encroachment, reduced flood storage capacity, and increased flow rates and flow volumes, and could cause flooding in downstream areas adjacent to Miller and Des Moines Creeks. Development requirements prohibit significant floodplain encroachment and reduction of flood storage capacity. In addition, stormwater runoff detention requirements will prevent significant increases in peak flow rates. Implementation of these mitigation requirements would be expected to prevent significant floodplain or flooding impacts from the proposed Master Plan Update alternatives.

(A) Do-Nothing (Alternative 1)

Under Alternative 1, adverse impacts on floodplains or flooding in the Des Moines basin would potentially result from development of the South Aviation Support Area. The Tyee Pond would be relocated elsewhere on the Tyee Valley Golf Course as part of the SASA mitigation to retain existing storage capacity and flood control on Des Moines Creek. This would maintain existing conditions and prevent flooding as a result of the SASA.

(B) "With Project Alternatives (Alternatives 2,3, and 4)

The proposed airside and landside alternatives would result in floodplain encroachment of varying amounts, depending on the runway length, as shown in **Exhibit IV.12-2**. An 8,500-ft new parallel runway (with a lateral separation of 2,500 feet from existing Runway 16L/34R) would result in the loss of about 7.2 acres of 100-year floodplain adjacent to and downstream of Lake Lora. By contrast, about 1.1 acres of 100-year floodplain would be eliminated with a 7,500-foot staggered, runway alignment. A 7,000-foot runway would displace an estimated 0.03 acre of 100-year floodplain. Encroachment on the floodplain could result in loss of flood storage capacity. Increases in flood heights in downstream areas, particularly in those susceptible to flooding, would depend on the amount of flood storage displaced and on stormwater runoff detention facility flow release rates, volumes, and timing of peak rates relative to other areas of the watershed.

Without mitigation, flooding could occur in receiving areas downstream of Airport stormwater runoff discharges into Miller and Des Moines Creeks. The amount of stormwater runoff and potential flood impacts would be directly related to the amount of new impervious surface area constructed for each alternative. Because the landside options are essentially the same for the different runway lengths, the amount of impervious surface area varies only as a function of the runway alignment options. An 8,500-foot runway could have the greatest potential flood impacts because it would result in the most impervious surface area (an estimated 73 acres). By comparison, the 7,500-foot and 7,000-foot runway alignments could have lower potential flood impacts because they would create an estimated 65 and 60 acres of impervious surfaces, respectively. Because stormwater drainage controls are required for new Airport developments, it is unlikely that the proposed alternatives would have significant flood impacts.

7/ Flood Insurance Study, King County, Washington & Incorporated Areas, Volumes 1-4, FEMA, 1994.

(C) Preferred Alternative (Alternative 3)

As is described in Chapter II, the Port of Seattle staff have recommended the implementation of Alternative 3 (North Unit Terminal) with a new parallel runway with a length up to 8,500 feet. As the previous paragraphs indicate, all of the alternatives would result in the floodplain encroachment. About 7.2 acres of the 100-year floodplain adjacent to and downstream of Lake Lora would be filled. However, as is noted, **Appendix P** contains a proposed mitigation plan for this area that would compensate for the filled floodplain.

(4) CUMULATIVE IMPACTS

Adverse impacts on floodplains or flooding in the Des Moines basin would potentially result from development of other proposed projects in the vicinity, particularly if these encroach on existing floodplains or fail to meet regional detention requirements for stormwater runoff. Enforcement of local floodplain development standards and stormwater runoff detention requirements would prevent floodplain encroachment and mitigate potential flooding impacts from other proposed development.

(5) MITIGATION

Floodplain encroachment and flooding impacts in the Miller and Des Moines Creek basins resulting from the proposed alternatives would be unlikely because of required mitigation. Mitigation would include adherence to floodplain development standards and floodway management requirements of the FAA and Washington State Department of Ecology. Floodplain development standards prohibit any reduction in the 100-year floodplain or base flood storage volume. Compensatory mitigation is required by state law for any proposed filling of 100-year floodplain so as to achieve no net loss in flood storage capacity and to prevent an increased risk of loss of human life or property damage.[8/]

Compensatory mitigation for floodplain impacts near the northwest corner of the proposed new parallel runway has been incorporated into the stream relocation design (**Appendix P**). The stream mitigation design would create an equivalent amount of floodplain storage - so no net loss of flood storage capacity.

Another potential flood storage and flood control mitigation option for the Miller Creek basin that is being considered involves modification of current operating procedures at the Lake Reba Regional Detention facility to provide additional storage. King County Surface Water Management Division, which currently operates the facility, is negotiating transfer of the facility operating responsibilities to the Port of Seattle. According to as-built drawings, the Lake Reba Detention facility has a design storage capacity of about 80-acre feet; however, a dam safety report indicates that it has a maximum storage capacity of about 90-acre feet. Based on the dam safety report, the storage capacity appears to be underused. Before any recommendations can be made on operational procedure modification for maximizing or providing additional capacity, the outlet rating curve for the facility must be verified to accurately determine detention characteristics and available storage capacity.

FAA directives state: "a significant encroachment will require a federal finding as part of any favorable decision on the action that there is no practicable alternative and that the action conforms to applicable state and/or local floodplain protection standards."[9/] Significant encroachment includes the risk of loss of human life, likely property damage, and notable adverse impacts on natural and beneficial floodplain values (e.g., groundwater recharge, wildlife habitat, flood storage and control). FAA directives also state: "The term practicable means feasible. Whether another alternative is practicable depends on its feasibility in terms of safety, meeting transportation objectives, design, engineering, environment, economics and other applicable factors." FAA directives indicate that an alternative is feasible if it can engineered, but an alternative also must be prudent, which is a reference to safety, policy, environmental, social, or economic consequences.[10/] These directives require analysis of all practicable measures to minimize harm, restore and preserve the natural and beneficial floodplain values affected, and provide evidence of conformance with applicable state or local floodplain protection standards.

8/ *Environmentally Sensitive Areas - Flood Hazard Areas, Chapter 15.30210-250, City of SeaTac Municipal Code.*

9/ *FAA Airport Environmental Handbook. 5050.4A* Chapter 5, Paragrph 47e.(12)(F). Federal Aviation Administration, Washington, D.C. October 8, 1985.

10/ 49 USC 47101 and Section 4(f) of the Department of Transportation Act require findings that no "possible" or "feasible" alternative exists.

As this Environmental Impact Statement demonstrates, no other practicable alternative exists other than completion of one of the proposed Master Plan Update alternatives. Significant floodplain encroachment would be unlikely as a result of the "With Project" alternatives due to strict mitigation requirements which would be adhered to under any of the alternatives.

The Washington State Department of Ecology also has specific mitigation requirements to reduce potential flooding impacts from new developments. New projects are required to meet Ecology stormwater drainage detention for the 2-, 10-, and 100-year storm events.[11] Storm flow modeling based on conceptual stormwater detention facilities and using these design storms indicates no increase in peak flow rates and little risk of flooding from the proposed Master Plan Update alternatives. Required mitigation would be expected to prevent significant adverse impacts on floodplains or flooding in the Miller and Des Moines Creek basins. Preliminary compensatory floodplain replacement designs for floodplain encroachment in the Miller Creek basin for the 8,500-ft. runway length, demonstrating no net loss of flood storage capacity, are presented in **Appendix P**.

As shown in the preceding section, the Master Plan Update alternatives are the only practicable alternative to satisfying the needs identified by this EIS. While the displacement would be substantially greater (7.2 acres displaced versus 0.03 acres) with the preferred alternative, potential impacts would be mitigated through creation of an equivalent amount of floodplain so there would be no net loss of flood storage capacity of increased risk of loss of human life or property damage.

[11] *Stormwater Management Manual for the Puget Sount Basin.* Washington State Department of Ecology, 1990.

AR 039122

Seattle-Tacoma International Airport Environmental Impact Statement for the Master Plan Update

Exhibit IV.12-1

Floodplains - Existing

Zone A - Base Elevation Not Determined

Zone AE - Base Elevation Determined

Source: Gambrell Urban, Inc. and Shapiro & Associates, 1994
Federal Emergency Management Agency, 1994, 1989

100-year floodplains based on FEMA maps shown for Miller Creek and Des Moines Creek only.

Scale 1" = 2,500'

Projection: Lambert Conformal Conic
Coordinate System: State Plane NAD27

11, 1996

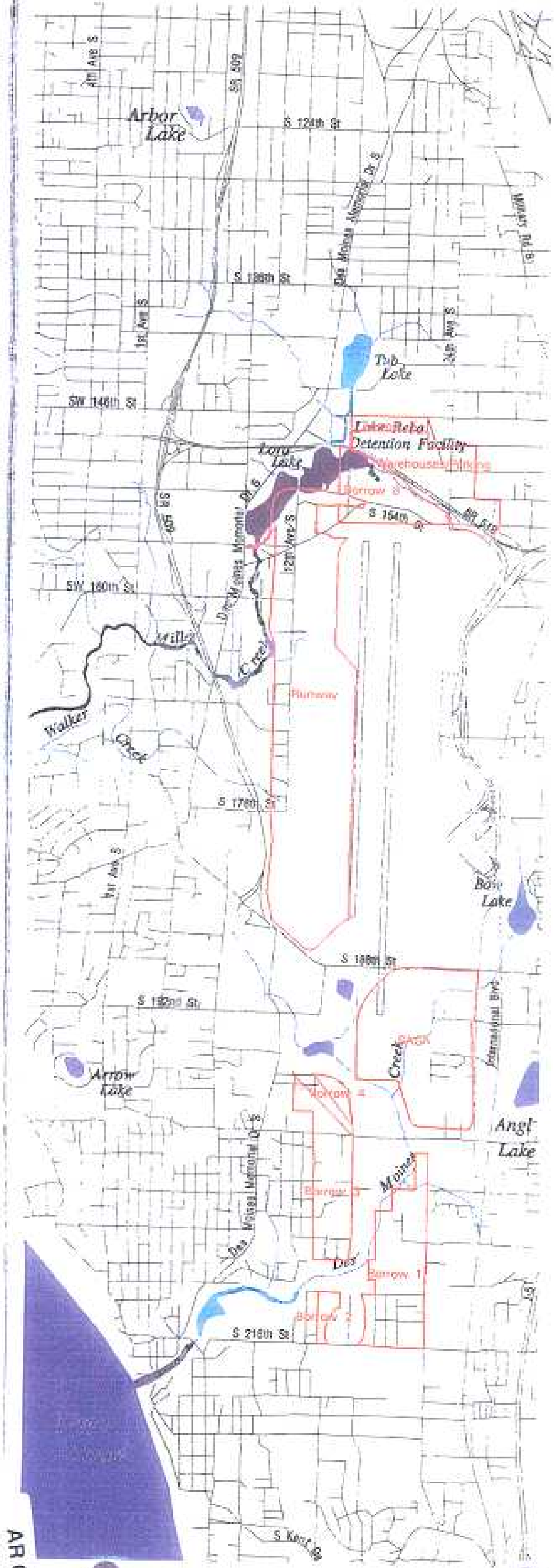
AR 039123

Seattle-Tacoma International Airport
Environmental Impact Statement
for the Master Plan Update

Exhibit IV.12-2

Floodplains Affected by Construction

(8,500 Foot New Runway Option)



Zone A - Base Elevation Not Determined

Zone AE - Base Elevation Determined

Potential Construction Impact Area

Source: Gambrell Urban, Inc. and Shapiro & Associates, 1994
Landrum & Brown, Inc. 1994
Federal Emergency Management Agency, 1994, 1989

100-year floodplains based on FEMA maps shown for Miller Creek and Des Moines Creek only.

Scale 1" = 2,500'

0 2500 5000

SCALE IN FEET

Projection: Lambert Conformal Conic
Coordinate System: State Plane NAD27

- IV.12-5B -

AR 039124

CHAPTER IV, SECTION 13

COASTAL ZONE MANAGEMENT PROGRAM AND COASTAL BARRIERS

The Washington State Department of Ecology (Ecology) determines the consistency of a proposed development with the Coastal Zone Management Act and the Washington Coastal Zone Management Program. Before issuing a Section 10/404 permit, the U.S. Army Corp of Engineers must receive notice that Ecology, following review of the proposed project, concurs with the Port of Seattle certification statement of compliance with the Washington Coastal Zone Management Program.[1]

All coastal counties within the state of Washington are subject to the Coastal Zone Management Program. Local shoreline master programs are enforceable policies of the State's Coastal Zone Management Program. Local shoreline master programs are approved and adopted by the state, which ensures consistency with the Coastal Zone Management Act.

The proposed Airport Master Plan alternatives would result in development located within King County and the Cities of SeaTac and Burien. Within the Airport vicinity, Angle Lake is the only waterbody under the jurisdiction of a local Shoreline Master Program,[2] and it would not be affected by any of the Master Plan Update alternatives. Prior to construction, the Port of Seattle will certify that the proposed Master Plan Update alternatives conform to all applicable local shoreline management program policies and Coastal Zone Management Program policies.

1/ Personal communication, telephone conversation with Bonnie Shorin, Washington State Department of Ecology, Shorelands and Coastal Zone Managment Program, November 3, 1994 and March 4, 1995.

2/ *City of SeaTac Comprehensive Plan*. City of SeaTac Department of Planning & Community Development, 1994.

CHAPTER IV, SECTION 14

WILD AND SCENIC RIVERS

According to the Wild and Scenic Rivers Act, as amended (16 United States Code 1271 et seq.), there are no wild and scenic rivers within the airport area. Therefore, no wild and scenic rivers would be affected by any of the Master Plan Update alternatives.

CHAPTER IV, SECTION 15

SURFACE TRANSPORTATION

The analysis presented in the Draft EIS was updated to reflect the Puget Sound Regional Council's adopted 1995 Metropolitan Transportation Plan.

Continued regional population growth will impact the surface transportation system in the vicinity of Sea-Tac Airport regardless of the improvements undertaken at the Airport. This section of the Environmental Impact Statement presents a summary of the detailed surface transportation analysis provided in **Appendix O**. Chapter IV, Section 23 of the EIS summarizes the construction-related surface transportation impacts.

Two surface transportation analyses were performed:

- an equivalent level of analysis of all Master Plan Update alternatives based on preliminary regional surface travel levels, and;
- a refined analysis of the Preferred Alternative (Alternative 3), reflecting the Region's adopted metropolitan transportation plan regional surface travel levels.

The refined analysis also assesses the impact of the Preferred Master Plan Update Alternative with and without the proposed South Access/SR 509 extension.

The refined analysis of the Preferred Alternative showed the following:

- Total Airport surface traffic is expected to increase from approximately 75,030 vehicles per average day in 1994, to approximately 139,035 vehicles per average day in 2020 for the Do-Nothing Alternative, or to approximately 129,055 vehicles per average day in 2020 for the Preferred Alternative. The differences between the Do-Nothing Alternative traffic volumes and the Preferred Alternative traffic volumes are associated with the off-site parking mode choice assumptions.
- The Preferred Alternative (With State Route 509) impacts the surface transportation system at five intersections and one freeway ramp junction in comparison with the Do-Nothing Alternative. These include:
  - International Boulevard/State Route 99 and South 160th Street;
  - International Boulevard/ State Route 99 and South 170th Street;
  - Air Cargo Road and Southbound Airport Expressway Ramps;
  - Northbound Airport Expressway Ramps and South 170th Street;
  - Air Cargo Road and South 170th Street; and
  - Northbound I-405 on-ramp from Southbound I-5.

  Mitigation measures would reduce these impacts.
- The Preferred Alternative (Without State Route 509) impacts the surface transportation system at ten intersections and one freeway ramp junction in comparison with the Do-Nothing Alternative. These include:
  - International Boulevard/State Route 99 and South 160th Street;
  - International Boulevard/State Route 99 and South 170th Street;
  - International Boulevard/State Route 99 and South 188th Street;
  - International Boulevard/State Route 99 and South 200th Street;
  - 24th/28th Avenue South and South 200th Street;
  - Military Road South and South 200th Street/Southbound Interstate 5 Ramps;
  - Military Road South and Northbound Interstate 5 Ramps;

- Air Cargo Road and Southbound Airport Expressway Ramps;
- Northbound Airport Expressway Ramps and South 170th Street;
- Air Cargo Road and South 170th Street; and
- Northbound I-405 on-ramp from Southbound I-5.

- The transportation improvement project that would have the greatest impact on conditions in the Airport area is the construction of the State Route 509 Extension and South Access. Numerous alternatives have been developed and evaluated that range from building a limited access expressway, to using the proposed 24th/28th Avenue South arterial. Since the land use development assumptions have dramatically changed during the past few years, it is anticipated that the project-specific EIS for the proposed South Access would perform further considerations of cost effective means of reducing congestion on the regional roads south of the Airport.

(1) METHODOLOGY

The surface transportation analysis is based on detailed level of service calculations at relevant intersections and freeway ramp junctions in the Airport vicinity as identified in **Exhibit IV.15-4**. These calculations were performed for existing 1994 conditions and for all future year conditions; including the years 2000, 2010, and 2020 for the Do-Nothing Alternative and all Master Plan Update Alternatives. For each future year the level of service results of the Do-Nothing Alternative were separately compared to the level of service results of the Master Plan Update Alternatives in order to identify the adverse impacts. An adverse impact is defined as a significant degradation in level of service when the Master Plan Alternative is compared to the Do-Nothing Alternative and the level of service is lowered by the proposed improvements. Mitigation is proposed for each adverse impact that would occur with each Master Plan Update Alternative.

(A) Level of Service (LOS)

Level of service (LOS) is used to describe the operating conditions at intersections, freeway ramp junctions, or along roadway segments. The level of service is described by the letters ranging from "A" through "F". The highest or most efficient operation is LOS A, which indicates little or no congestion, while LOS F indicates severely congested traffic flow conditions.

The level of service calculations for the initial analysis were performed according to the methodologies presented in the Transportation Research Board's 1985 Highway Capacity Manual for signalized intersections, unsignalized intersections, freeway ramp junctions, and according to Circular #373 for all-way stop intersections. The refined freeway ramp junction level of service analysis was performed according to the methodologies presented in the Transportation Research Board's 1994 Highway Capacity Manual. LOS calculations were performed for peak hour conditions at all relevant intersections and freeway ramp junctions in the Airport vicinity.

Current flight schedules indicate that the Airport's weekday peak period occurs between 11:00 a.m. and 1:00 p.m.[1] Surface transportation patterns in the vicinity of the Airport peak between 11:00 a.m. and 1:00 p.m., and between 3:00 PM and 6:00 PM.[2] The afternoon peak reflects the heaviest traffic conditions of the day and the period of peak congestion for the surface transportation system. The hour between 5:00 p.m. and 6:00 p.m. represents the hour of peak congestion for the surface transportation system. Therefore, the level of service calculations were performed for peak hour conditions that occurred between 5:00 p.m. and 6:00 p.m.

(B) Future Traffic Volume Forecasts

The Puget Sound Regional Council (PSRC) is the Metropolitan Planning Organization for the Puget Sound area. This past year the PSRC was in the process of updating the 1995 Metropolitan Transportation Plan (MTP) and has adopted it this past Spring. The MTP represents the transportation plan for the entire Puget Sound area.

The initial analysis of all Master Plan Update alternatives was prepared in early

1/ *Technical Report No. 4: Facilities Inventory*, p. 5-4, P&D Aviation, Revised August 12.

2/ *Historical Average Daily Traffic Counts*, City of SeaTac Department of Public Works, 1994.

1995 based on the anticipated preferred Metropolitan Transportation Plan alternative, Package 3 (the Demand Management/ Expansion Focus Package). Base year 1990 and Package 3 future year 2000, 2010, and 2020 traffic volumes were obtained, and were used to forecast future traffic volumes. Annual average growth rates were calculated from the MTP traffic volumes. These calculated annual average growth rates were then used to forecast the future year traffic volumes for each Master Plan Update alternative.

For the Final EIS, the surface transportation analysis was updated for two separate conditions: (1) to reflect the changes associated with the adopted Metropolitan Transportation Plan and (2) to reflect the selection of Alternative 3 (North Unit Terminal) as the preferred Airport Master Plan Update improvements. The adopted Metropolitan Transportation Plan reflects a different forecast scenario than was used in the Draft EIS, and as a result, the traffic volume forecasts are approximately 20 percent higher in the refined analysis of the Final EIS. A more detailed description of the differences between the adopted and initial Metropolitan Transportation Plans is included in **Appendix O-B**. A refined analysis was not prepared for Alternatives 2 and 4, since it would not alter the conclusion of the Draft EIS. In addition, this refined analysis would not alter the selection of the preferred alternative, as the selection was based on other factors. Although the traffic volumes would be greater with the adopted Metropolitan Transportation Plan, the outcome of the analysis would not change; Alternatives 2, 3 and 4 would affect the surface transportation system in a similar manner as described in the Draft EIS.

(C) <u>Airport Trip Generation and Travel Patterns</u>

The Airport is a sizable regional traffic generator with an estimated 75,030 annual average vehicles per day in 1994. Eight categories of Airport traffic were quantified and described as follows:

- Passenger - Traffic on the terminal drive system consisting of short-term and long-term garage parking, passenger drop-offs and pick-ups, courtesy vehicles, shuttles, car rentals, taxis, and transit.
- Passenger Off-Site Parking - Traffic generated by passengers using the off-site parking facilities but not including the courtesy vehicles.
- Airport Employee - Traffic generated by Port of Seattle employees, airline employees, tenants and the remote parking lot shuttle bus.
- Air Cargo - Traffic generated by the air cargo facilities and associated employees.
- Airfield Operations Area (AOA) - Traffic generated by activities within the Airfield Operations Area, including the off-site flight kitchens.
- General Aviation - Traffic generated by general aviation activities and associated employees.
- Maintenance - Traffic generated by the Aircraft Maintenance facilities and associated employees.
- Other - Traffic generated by miscellaneous activities such as deliveries to the Airport (non air cargo related).

The trip characteristics of these eight categories of Airport traffic were used to allocate Airport traffic to the various activity centers on-Airport. **Table IV.15-1** summarizes Airport traffic by each category for each year evaluated. **Table IV.15-2** summarizes the mode choice patterns of passenger related Airport traffic. **Exhibit IV.15-1** summarizes the regional origin-destination patterns of all Airport related traffic. Further discussion of Airport related trip generation and travel patterns can be found in **Appendix O-B**.

(2) <u>EXISTING CONDITIONS</u>

The following sections summarize the existing surface transportation system and the level of service presently afforded by this system.

(A) <u>Surface Transportation System</u>

The surface transportation system is illustrated in **Exhibit IV.15-5** and further defined in **Appendix O-B**. Existing 1994 traffic volumes were provided by the City of SeaTac, Washington State Department of Transportation (WSDOT), and collected by field observations. These traffic volumes were then seasonally adjusted to reflect annual average daily traffic (AADT) conditions. WSDOT seasonal adjustment factors were used to adjust these volumes. The 1994 AADT volumes were then compared to the City of SeaTac 1991-1992 traffic volumes,[3] WSDOT 1992 traffic volumes,[4] and the MTP base 1990 traffic volumes to ensure data conformity. These comparisons determined that the 1994 AADT volumes are an accurate representation of area traffic volumes and are consistent with other transportation planning efforts. The 1994 volumes are shown in **Exhibit IV.15-5.**

(B) Level of Service

Detailed level of service calculations were performed at relevant intersections and freeway ramp junctions in the Airport vicinity. The intersection level of service results are summarized in **Tables IV.15-3 through IV.15-5**, and shown in **Exhibits IV.15-2 and IV.15-4**. The freeway ramp junction level of service results are summarized in **Appendix O**. Five of the 33 evaluated intersections, and 5 of the 23 evaluated freeway ramp junctions operate under LOS E or LOS F conditions.

The surface transportation system has significant peak hour congestion, particularly on the freeway system, mainly due to regional, non-Airport related, traffic.

Appendix O-C contains a summary of the current conditions on the Airport terminal area roadways.

(3) INITIAL ANALYSIS OF FUTURE CONDITIONS

As was noted earlier, two analyses of the surface transportation system were conducted. This section summarizes the initial comparative analysis performed for each Master Plan Update alternative.

[3] *Comprehensive Transportation Plan Summary Report*, City of SeaTac Department of Public Works and the TRANSPO Group, Inc., 1991.

[4] *1992 Annual Traffic Report*, Washington State Department of Transportation.

The proposed new parallel runway will not affect roadway traffic levels and will not notably alter the surface transportation system. Several Transportation Improvement Projects are planned within the Airport vicinity between now and the year 2020. These projects are shown by type in **Exhibits IV.15-6, IV.15-7, and IV.15-8** and are described in **Appendix O-B**. The projects that would significantly improve the operational performance of the surface transportation system include:

- *International Boulevard (State Route 99)* - International Boulevard would be widened to seven lanes (six general purpose lanes, and one two-way left-turn lane) with sidewalks and associated intersection improvements from South 152nd Street to South 216th Street by the year 2000.[5]
- *Interstate 5* - HOV and truck climbing lanes would be constructed from Pierce County to Tukwila by the year 2000.[6] The partial reconstruction of the Interstate 5 and State Route 518/Interstate 405 interchange to construct an HOV bypass would also be included.
- *State Route 509 Extension* - State Route 509 would be extended to connect with Interstate 5 in the vicinity of South 216th Street by the year 2020. The interchange at South 188th Street would be reconstructed, and new interchanges constructed at South 200th Street/16th Avenue South, the Southern Airport Expressway, 24th Avenue South, and Interstate 5.[7]
- *Southern Airport Expressway* - The Southern Airport Expressway would be constructed as part of the State Route 509 extension project, and would connect the Airport terminal drive system to State Route 509 by the year 2020. A partial interchange would be constructed at South 200th Street.
- *Airport Access* - The existing Airport access from International Boulevard/State Route 99

[5] *Comprehensive Transportation Plan Summary Report*, p. 31, City of SeaTac Department of Public Works and the TRANSPO Group, Inc., 1991.

[6] *Washington Statewide Multimodal Transportation Plan*, p. I-F-4, Washington State Department of Transportation, 1993.

[7] *Washington Statewide Multimodal Transportation Plan*, p. I-F-17, Washington State Department of Transportation, 1993.

would be limited to transit type vehicles only.[8]

While the surface transportation system analysis was completed for the interim years (2000 and 2010), the following sections summarize the ultimate year 2020 conditions for each Alternative. A detailed description of all future year conditions for each Alternative is included in **Appendix O-A**.

(A) <u>**Alternative 1 (Do-Nothing)**</u>

Year 2020 Alternative 1 traffic volumes are shown in **Exhibit IV.15-3**. Approximately 70 percent of the Airport terminal traffic would access the terminal drive system via the Northern Airport Expressway, 20 percent via the Southern Airport Expressway, and 10 percent via the International Boulevard access.

Level of service calculations were performed at relevant intersections and freeway ramp junctions in the Airport vicinity. The intersection level of service results are summarized in **Tables IV.15-3** and **IV.15-4**, and shown in **Exhibit IV.15-2**. The freeway ramp junction level of service results are summarized in **Appendix O-A**. Eight of the 33 intersections, and 13 of the 23 evaluated freeway ramp junctions would operate at LOS E or LOS F conditions. The surface transportation system would experience significant peak hour congestion, particularly on the freeway system, mainly due to regional, non-Airport related traffic.

(B) <u>**Alternative 2 (Central Terminal)**</u>

Level of service calculations were performed at relevant intersections and freeway ramp junctions in the Airport vicinity. The intersection level of service results are summarized in **Tables IV.15-3** and **IV.15-4**, and shown in **Exhibit IV.15-2**. The freeway ramp junction level of service results are summarized in **Appendix O-A**. In comparison with the year 2020 Alternative 1 (Do-Nothing), the following impacts were identified:

- The intersection of Air Cargo Road and S. 170th Street remains at LOS F but the average delay more than doubles in length.
- The intersection of Northbound Airport Expressway ramps and S. 170th Street degrades from LOS B to LOS F.
- The intersection of International Boulevard and S. 170th St. remains at LOS F but the average delay more than triples in length.
- The intersection of Southbound Airport Expressway off-ramp and S. 200th Street degrades from LOS A to LOS B.

The planned Airport improvements included in Alternative 2 would alter Airport-related travel patterns and would cause the following operational improvements:

- The intersection of 24th Avenue S. and S. 154th Street improved from LOS D to LOS C.
- The intersection of International Boulevard and S. 160th Street improved from LOS D to LOS C.

(C) <u>**Alternative 3 (North Unit Terminal)**</u>

Level of service calculations were performed at relevant intersections and freeway ramp junctions in the Airport vicinity. The intersection level of service results are summarized in **Tables IV.15-3** and **IV.15-4**, and shown in **Exhibit IV.15-2**. The freeway ramp junction level of service results are summarized in **Appendix O-A**. In comparison with the year 2020 Do-Nothing (Alternative 1), the following adverse impacts were identified:

- The intersection of Southbound Airport Expressway off-ramp and S. 200th Street degrades from LOS A to LOS B. The change in average delay is less than one second in length, and therefore not significant; mitigation is not needed.

The planned Airport improvements included in Alternative 3 would change Airport-related travel patterns and could cause the following operational improvements:

[8] *Comprehensive Transportation Plan Summary Report*, p. 34, City of SeaTac Department of Public Works and the TRANSPO Group, Inc., 1991.

- The intersection of 24th Avenue S. and S. 154th Street improved from LOS D to LOS C.
- The intersection of International Boulevard and S. 160th Street improved from LOS D to LOS C.
- The intersection of Military Road and S. 188th Street improved from LOS D to LOS C.

(D) Alternative 4 (South Unit Terminal)

The planned Airport improvements included in Alternative 4 would change the Airport-related travel patterns and could cause the same operational improvements as described under Alternative 2.

(4) REFINED ANALYSIS OF THE PREFERRED ALTERNATIVE

The refined analysis of the Preferred Alternative (Alternative 3) was prepared based upon the adopted MTP and clarification in the location and operational characteristics associated with the Preferred Alternative. An assessment of the Do-Nothing (Alternative 1) was also prepared and demonstrates how the proposed airport improvements would alter surface transportation conditions.

(A) Do-Nothing (Alternative 1)

Chapter II provides a detailed description of the actions included in the Do-Nothing alternative. The main Do-Nothing actions that would affect area surface transportation patterns would be the State Route 509 Extension/South Access and the South Aviation Support Area improvements.

1. Surface Transportation System

Year 2020 traffic volumes for the Do-Nothing Alternative are shown in **Exhibit IV.15-5**. Level of service calculations were performed at relevant intersections and freeway ramp junctions in the Airport vicinity. The intersection level of service results are summarized in **Table IV.15-5** and shown in **Exhibit IV.15-4**. The freeway ramp junction level of service results are summarized in **Appendix O-B**. Eighteen of the 40 intersections, and 12 of the 24 evaluated freeway ramp junctions would operate at LOS E or LOS F conditions.

Most of the congestion occurs along the International Boulevard/State Route 99, South 188th Street, and South 200th Street corridors. A great deal of the congestion on the South 188th Street and South 200th Street corridors is from the planned development located south of the Airport on the 28th/24th Avenue South corridor. Since the State Route 509 Extension project does not provide direct connections for traffic traveling northbound on Interstate 5, this traffic must use either the South 188th Street or the South 200th Street corridors to access Interstate 5.

2. Terminal Drive System

Approximately 74 percent of the Airport passenger traffic would access the terminal drive system via the Northern Airport Expressway, 25 percent via the Southern Airport Expressway, and 1 percent via the International Boulevard access. **Appendix O-C** contains a detailed description of the on-airport roadway system.

(B) Preferred Alternative (With State Route 509)

The Preferred Alternative was assessed assuming the construction of the State Route 509 Extension and Southern Airport Expressway project, as defined in the PSRC adopted 1995 MTP. This scenario also includes the planned Airport improvements that impact the existing surface transportation patterns as described in Chapter II.

1. Surface Transportation System

Year 2020 traffic volumes for the North Unit Terminal Alternative (With State Route 509) are shown in **Exhibit IV.15-5**. Level of service calculations were performed at relevant intersections and freeway ramp junctions in the Airport vicinity. The intersection level of service results are summarized in **Table IV.15-5** and shown in **Exhibit IV.15-4**. The freeway ramp junction level of service results are summarized in **Appendix O-B**. Sixteen of the 40 evaluated intersections, and 13 of the 27 evaluated freeway ramp junctions would operate at LOS E or LOS F conditions.

2. Terminal Drive System

Approximately 64 percent of the Airport passenger traffic would access the terminal drive system via the Northern Airport Expressway, 15 percent via the Southern Airport Expressway, and 21 percent via the International Boulevard access. Appendix O-C contains a detailed description of the on-airport roadway system.

(C) Preferred Alternative (Without State Route 509)

To contrast the impact of the Preferred Alternative with and without the SR 509 extension, the "without SR 509" scenarios was assessed, as defined in the PSRC adopted 1995 MTP. This Alternative also includes the planned Airport improvements that impact the existing surface transportation patterns as described in Chapter II.

1. Surface Transportation System

Year 2020 traffic volumes for the North Unit Terminal Alternative (Without State Route 509) are shown in **Exhibit IV.15-5**. Level of service calculations were performed at relevant intersections and freeway ramp junctions in the Airport vicinity. The intersection level of service results are summarized in **Table IV.15-5** and shown in **Exhibit IV.15-4**. The freeway ramp junction level of service results are summarized in **Appendix O-B**. Seventeen of the 33 evaluated intersections, and 13 of the 27 evaluated freeway ramp junctions would operate at LOS E or LOS F conditions.

2. Terminal Drive System

Approximately 64 percent of the Airport terminal traffic would access the terminal drive system via the Northern Airport Expressway, 15 percent via the Southern Airport Expressway, and 21 percent via the International Boulevard access. **Appendix O-C** contains a detailed description of the conditions associated with the On-Airport roadway system.

(5) CUMULATIVE IMPACTS

As is identified in Chapter III "Affected Environment" a number of non-Airport related developments are anticipated in the Airport vicinity. These actions are likely to affect surface transportation volumes in the Airport area. As additional surface traffic would occur, increased congestion beyond those forecast by this analysis would result. However, until specific projects are proposed for these developments, the total cumulative impacts can not be identified. The roadway project that is likely to have the greatest impact on conditions in the Airport area is the construction of the State Route 509 Extension and Southern Airport Expressway. The impacts of this roadway, which would not likely be available until the year 2020, have been included in the year 2020 Do-Nothing and Preferred Alternative roadway analysis described in the preceding paragraphs. In addition, other regional and local initiatives are under study to increase vehicle occupancy. These initiatives should assist in reducing roadway congestion.

(6) MITIGATION

Mitigation is proposed for each adverse impact that would occur with each "With Project" alternative (Alternatives 2, 3, and 4). An adverse impact is defined as a significant degradation in level of service (reducing the level of service) compared to the Do-Nothing alternative. In all cases the proposed mitigation measures would be sufficient to alleviate the significant adverse impact caused by proposed Airport improvements.

Because of the uncertainty of the proposed extension of SR 509 and South Access, as well as the public acceptance and use of high and higher occupancy vehicles and the impact of regional traffic on airport area roadways, the Port will continue to participate in cooperative planning with State and local officials to address its respective share of surface transportation impacts. Mitigation actions that are expected to be addressed in continued planning include the following:

(A) <u>Alternative 2 (Central Terminal) & Alternative 4 (South Unit Terminal)</u>

The planned Airport improvements included in Alternative 2 and Alternative 4 would cause adverse impacts to the surface transportation system at three intersections. The following mitigation measures are proposed for each identified adverse impact:

- Significant differences in the operational conditions at the **intersection of Air Cargo Road/S. 170th Street** would not begin until the year 2010. This intersection would operate at LOS F with Alternatives 2 and 4, as well as with the Do-Nothing in 2010 and 2020. However, with these alternatives, the average delay at this intersection is more than doubled in the years 2010 and 2020. This level of service degradation is primarily caused by the construction in 2010 of an employee parking garage at the site of the current Doug Fox lot. If this intersection were signalized, the level of service would improve from LOS F to LOS B in the year 2010, and remain at LOS B through the year 2020.

- Significant differences in the operational conditions at the **intersection of Northbound Airport Expressway ramps/S. 170th Street** do not begin until the year 2010. This intersection degrades from LOS B (Do-Nothing) to LOS D (Alternatives 2 and 4) in the year 2010, and from LOS B (Do-Nothing) to LOS F (Alternatives 2 and 4) in the year 2020. This level of service degradation is primarily caused by the construction in 2010 of the employee garage at the present Doug Fox lot. The secondary cause is the reconstruction of the Airport access from International Boulevard into a transit type vehicle entrance only in the year 2010. Mitigation measures could include improvements to the south leg to provide dual right-turn lanes, and protected phasing for the eastbound lefts. If these improvements are completed, the level of service would improve to LOS B in the year 2010, and LOS D in the year 2020.

- Significant differences in the operational conditions at the **intersection of International Boulevard/S. 170th Street** do not begin until the year 2010. This intersection would operate at LOS F in year 2010 and 2020 with or without airport improvements. However, under Alternatives 2 and 4 conditions the average delay at this intersection is more than doubled in the year 2010, and more than tripled in the year 2020 compared to the Do-Nothing levels. This level of service degradation is primarily caused by the construction of the employee garage at the current Doug Fox lot and the reconstruction of the Airport access from International Boulevard into a transit type vehicle entrance only in the year 2010. The recommended mitigation includes improvements to the south leg to provide dual left-turn lanes, and improvements to the west leg to provide a high-capacity free right-turn lane. If these improvements are completed, the level of service would improve to LOS E in the year 2010, and remain at LOS E through the year 2020.

(B) <u>Alternative 3 (North Unit Terminal) - Preferred Alternative</u>

Because of the uncertainty of the proposed extension of SR 509 and South Access, as well as the public acceptance and use of high and higher occupancy vehicles and the impact of regional traffic on airport area roadways, the Port will continue to participate in cooperative planning with State and local officials to address its respective share of surface transportation impacts. Mitigation actions that are expected to be addressed in continued planning include the following mitigation associated with the Preferred Alternative:

<u>North Unit Terminal Alternative (With State Route 509)</u>

The following possible mitigation has been identified:

- International Boulevard (State Route 99) and South 160th Street - This intersection would degrade from LOS E to LOS F in the year 2010 with the proposed improvements and development of the SR 509 extension.

AR 039134

The construction of the North Unit Terminal will likely shift some regional traffic from South 170th Street to South 160th Street, but the primary cause of the congestion is the regional traffic on International Boulevard (State Route 99). For the year 2010 only minor improvements to the intersection would be necessary (dual southbound left-turn lanes, improvements to the westbound right-turn lane). These improvements would provide a level of service rating of LOS E for the year 2010. However, these improvements would not be sufficient for the year 2020 traffic levels due to the significant amount of regional traffic on International Boulevard (State Route 99). For the year 2020, the International Boulevard (State Route 99) corridor would need to be improved to provide additional capacity (i.e. seven lanes plus HOV treatments). These improvements would provide a level of service rating of LOS D for the year 2020. The Port of Seattle would be responsible for a pro-rata contribution towards the proposed improvements at this intersection.

- International Boulevard (State Route 99) and South 170th Street - This level of service at this intersection would actually improve under this scenario (better LOS F rating), but it would serve as an access point to the Airport terminal area and would need to meet the City of SeaTac's adopted level of service standard. For the year 2010 only minor improvements to the intersection would be necessary (dual northbound left-turn lanes, high-capacity right-turn lanes in the southbound and eastbound directions, westbound right-turn lane). These improvements would provide a level of service rating of LOS E for the year 2010. Again, these improvements would not be sufficient for the year 2020 due to the significant amount of regional traffic on International Boulevard (State Route 99). For the year 2020, the International Boulevard (State Route 99) corridor would need to be improved to provide additional capacity (i.e. seven lanes plus HOV treatments). These improvements would provide a level of service rating of LOS E for the year 2020. The Port of Seattle would be responsible for a pro-rata contribution towards the proposed improvements at this intersection.

- Air Cargo Road and Southbound Airport Expressway Ramps; Air Cargo Road and South 170th Street; Northbound Airport Expressway Ramps and South 170th Street - These three intersections would need signalization by the year 2010 with SR 509 extension. However, the construction of the North Unit Terminal would eliminate these three intersections by the year 2010. Therefore, temporary signals should be installed when the signal warrants are satisfied in order to provide adequate intersection control until the North Unit Terminal is constructed. The Port of Seattle would only be responsible for a pro-rata contribution towards the installation of the temporary signals due to the significant amount of regional pass-through traffic utilizing the Airport Expressway at this interchange area.

- Northbound Interstate 405 On-Ramp from Southbound Interstate 5 - This freeway ramp junction would degrade from LOS C to LOS F in the year 2020 with SR 509. The primary cause would be a shift in Airport traffic patterns that would route more traffic eastbound through the Southcenter interchange. Eastbound State Route 518/Northbound Interstate 405 should be widened to two lanes through the interchange. This additional lane could then be dropped at the State Route 181 Off-Ramp located down-stream. The Port of Seattle would only be responsible for a pro-rata contribution towards the proposed improvements at this interchange.

<u>North Unit Terminal Alternative (Without State Route 509)</u>

- International Boulevard (State Route 99) and South 160th Street - The impacts and possible mitigation measures would be the same as with SR 509. The only exception is that for the year 2020 the improvements would provide a level of service rating of LOS E instead of LOS D. The Port of Seattle would be responsible for a pro-rata contribution towards the proposed improvements at this intersection.

- International Boulevard (State Route 99) and South 170th Street - The impacts and possible mitigation measures would be the same as the with SR 509 extension scenario. The Port of Seattle would be responsible for a pro-rata contribution towards the proposed improvements at this intersection.
- International Boulevard (State Route 99) and South 188th Street - This intersection would degrade deeper into LOS F in the year 2020 without SR 509. This intersection is forecast to have a demand of approximately 6,000 vehicles during the PM Peak Hour and would need the construction of an urban interchange to meet the City of SeaTac's adopted level of service standard. With this type of improvement it would also be possible to incorporate a fly-over ramp design for the Airport South Access. The Port of Seattle would be responsible for a pro-rata contribution towards the proposed improvements at this intersection.
- International Boulevard (State Route 99) and South 200th Street - This intersection would degrade deeper into LOS F in the year 2020 without SR 509. Significant improvements would be needed in order to meet the City of SeaTac's adopted level of service standard. These could include the following: providing additional capacity along the International Boulevard (State Route 99) corridor (i.e. seven lanes plus HOV treatments); providing additional capacity along the South 200th Street corridor (i.e. seven lanes); dual left-turn lanes in the southbound, eastbound, and westbound directions; and a westbound right-turn lane. These improvements would provide a level of service rating of LOS E for the year 2020. The Port of Seattle would be responsible for a pro-rata contribution towards the proposed improvements at this intersection.
- 28th/24th Avenue South and South 200th Street - This intersection would degrade from LOS D to LOS F in the year 2020 without SR 509 extension. Only minor improvements to this intersection would be needed (dual westbound left-turn lanes, eastbound right-turn lane, re-striping the northbound approach to provide one left-turn, one through, and two right-turn lanes). These improvements would provide a level of service rating of LOS E for the year 2020. The Port of Seattle would be responsible for a pro-rata contribution towards the proposed improvements at this intersection.
- Military Road South and South 200th Street/Southbound Interstate 5 Ramps - This intersection would degrade deeper into LOS F in the year 2020 without the SR 509 extension. Only minor improvements to this intersection would be needed (dual northbound left-turn lanes, two eastbound through lanes). These improvements would provide a level of service rating of LOS D for the year 2020. The Port of Seattle would be responsible for a pro-rata contribution towards the proposed improvements at this intersection.
- Military Road South and Northbound Interstate 5 Ramps - This intersection would degrade from LOS E to LOS F in the year 2020 without the SR 509 extension. Only minor improvements to this intersection would be needed (widening the eastbound approach to provide one left-turn and one right-turn lane, and providing a southbound right-turn phase overlap). These improvements would provide a level of service rating of LOS D for the year 2020. The Port of Seattle would be responsible for a pro-rata contribution towards the proposed improvements at this intersection.
- Air Cargo Road and Southbound Airport Expressway Ramps; Air Cargo Road and South 170th Street; Northbound Airport Expressway Ramps and South 170th Street - These three intersections would need signalization by the year 2010 without SR 509. However, the construction of the North Unit Terminal would

remove these three intersections by the year 2010. Therefore, temporary signals should be installed when the signal warrants are satisfied in order to provide adequate intersection control until the North Unit Terminal is constructed. The Port of Seattle would only be responsible for a pro-rata contribution towards the installation of the temporary signals due to the significant amount of regional pass-through traffic utilizing the Airport Expressway at this interchange area.

- Northbound Interstate 405 On-Ramp from Southbound Interstate 5 - The impacts and possible mitigation measures would be the same as the with SR 509 extension scenario. The Port of Seattle would be responsible for a pro-rata contribution towards the proposed improvements at this interchange.

(C) State Route 509 and South Access

Issues surrounding the State Route 509 extension project and an Airport South Access have been discussed among the Port of Seattle and the surrounding southwestern King County communities for quite some time. State Route 509 was originally adopted by the Washington State Transportation Commission in 1957 as a limited-access highway between Seattle and Tacoma. Construction from the northern terminus began in the 1960s in South Seattle, and ended in the 1970s at South 188th Street. WSDOT did not finish the construction of the proposed highway due to rising costs, limited federal and state highway construction funds, and local government opposition to the project.

In 1992 the WSDOT took the lead for several local agencies (Cities of SeaTac, Des Moines, King County, and the Port of Seattle) to begin the State Route 509 Extension/South Access Road Corridor Environmental Impact Study.[9] A technical Steering Committee, composed of representatives from member agencies, was organized to direct the EIS consultant team. An Executive Committee, composed of elected and appointed officials from member agencies, provided direction on policy decisions and will select the preferred corridor alignment. The Federal Highway Association (FHWA) must approve and the Washington Transportation Commission must adopt the preferred corridor alternative before a more in-depth project-level analysis can be completed. The corridor programmatic Draft EIS has been completed and was issued in December, 1995. Each of the "build" alternatives analyzed in the Draft EIS include the extension of State Route 509 to Interstate 5, and the construction of the South Access roadway as a limited access expressway that connects the Airport's terminal drive system with State Route 509.

Over the past few years the Puget Sound Regional Council has been updating the Metropolitan Transportation Plan (MTP).[10] The adopted 1995 MTP includes both the State Route 509 extension and South Access roadway projects to be completed by the year 2020.

All of these plans and studies were based on two general developments assumptions: the forecast passenger activity levels at the Airport; and the proposed urban development south of the Airport along the 28th/24th Avenue South corridor. These development assumptions are summarized by plan or study as follows:

- SeaTac Area Update (1989) - This plan forecast a 190 acre business park along the 28th/26th Avenue South corridor which would generate approximately 30,000 to 50,000 average weekday trips. It was also assumed that 40 percent of Airport traffic would utilize the South Access roadway.

[9] *State Route 509 Extension/South Access Road Corridor Study*, King County, SeaTac, Des Moines, Kent, December 1995.

[10] *1995 Metropolitan Transportation Plan: The Transportation Element of VISION 2020, the Region's Adopted Growth and Transportation Strategy*, , Puget Sound Regional Council, May 25 1995.

- South Access Roadway Study (1990) - This plan forecast a 6 million gross square foot (gsf) business park along the 28th/24th Avenue South corridor which would generate approximately 60,000 to 80,000 average weekday trips. Airport activity levels were also forecast at 38 million annual passengers by the year 2010. According to that report 149,000 average weekday trips, of which approximately 40 percent, or 59,600 average weekday trips, would utilize the South Access roadway.
- City of SeaTac Comprehensive Transportation Plan (1994) - This plan forecast a 2-3 million gsf combined commercial/industrial/retail development along the 28th/24th Avenue South corridor which would generate approximately 34,000 average weekday trips.
- **Seattle-Tacoma International Airport Master Plan Update (1995)** - Current Airport activity forecasts developed for the Master Plan Update[11] indicate that approximately 98,000 annual average weekday trips within the terminal area by the year 2020 would occur, of which only 19,600 annual average weekday trips (20 percent) would utilize the South Access roadway.

Differences between these development assumptions have led to several different proposed alignments and configurations for the South Access roadway. These development assumptions will also continue to evolve with land use decisions concerning the South Aviation Support Area,[12] the Des Moines Creek Technology Campus,[13] and other local development. However, there are two alternate options for the South Access roadway described as follows:

- The construction of two separate roadway facilities: the construction of a principal arterial along the 24th/28th Avenue South corridor to accommodate the forecast urban development; and the construction of a separate limited access expressway for the Airport to accommodate forecast Airport passenger activity.
- The construction of a combined facility along the 24th/28th Avenue South corridor to accommodate both the forecast urban development, and the forecast Airport passenger activity.

Until a preferred corridor alternative is selected from the State Route 509 Extension/South Access Road Corridor EIS, and the project-level analysis is begun, the exact alignment and configuration of both State Route 509 and South Access are unknown.

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11 *Technical Report No.2: Preliminary Forecast Report*, Port of Seattle, 1994.

12 *South Aviation Support Area Final Environmental Impact Statement*, Port of Seattle, March 1994.

13 *Des Moines Creek Technology Campus Final Environmental Impact Statement*, CH2M Hill, May 1995.

TABLE IV.15-1

Seattle-Tacoma International Airport
Environmental Impact Statement

AIRPORT TRAFFIC SUMMARY

Do-Nothing Alternative Conditions				
Airport Traffic Description	**1994 Existing**	**Future Year**		
		2000	**2010**	**2020**
Passenger	58,200	64,200	79,300	95,100
Passenger Off-Site Parking	1,160	2,570	6,740	14,930
Airport Employee	6,410	7,140	8,540	10,270
Air Cargo	4,450	6,000	7,930	10,290
Airfield Operations Area (AOA)	1,460	1,630	1,740	1,900
General Aviation	60	65	70	75
Maintenance	3,190	4,730	6,270	6,270
Other	100	130	160	200
Totals	**75,030**	**86,465**	**110,750**	**139,035**

North Unit Terminal Alternative Conditions				
Airport Traffic Description	**1994 Existing**	**Future Year**		
		2000	**2010**	**2020**
Passenger	58,200	64,200	80,300	98,000
Passenger Off-Site Parking	1,160	1,290	1,670	2,050
Airport Employee	6,410	7,140	8,540	10,270
Air Cargo	4,450	6,000	7,930	10,290
Airfield Operations Area (AOA)	1,460	1,630	1,740	1,900
General Aviation	60	65	70	75
Maintenance	3,190	3,190	4,730	6,270
Other	100	130	160	200
Totals	**75,030**	**83,645**	**105,140**	**129,055**

Source: INCA Engineers, Inc., December, 1995.

TABLE IV.15-2

Seattle-Tacoma International Airport
Environmental Impact Statement

PASSENGER MODE CHOICE PATTERNS

Passenger Mode of Access		1994 Existing	Do-Nothing Alternative			North Unit Terminal Alt.		
			2000	2010	2020	2000	2010	2020
Curb Side (Drop-Off/Pick-Up)	Arriving	16.0%	16.0%	16.0%	16.0%	16.0%	16.0%	16.0%
	Departing	33.0%	33.0%	33.0%	30.0%	33.0%	33.0%	30.8%
Courtesy Buses	Arriving	4.5%	4.5%	4.5%	4.5%	4.5%	4.5%	4.5%
	Departing	4.5%	4.5%	4.5%	4.5%	4.5%	4.5%	4.5%
Taxis	Arriving	4.7%	4.7%	4.7%	4.7%	4.35%	4.35%	4.35%
	Departing	4.7%	4.7%	4.7%	4.7%	4.35%	4.35%	4.35%
For-Hire Vans	Arriving	1.0%	1.0%	1.0%	1.0%	1.0%	1.0%	1.0%
	Departing	1.0%	1.0%	1.0%	1.0%	1.0%	1.0%	1.0%
METRO Transit	Arriving	2.0%	3.0%	3.0%	2.6%	3.0%	3.0%	2.6%
	Departing	2.0%	3.0%	3.0%	2.6%	3.0%	3.0%	2.6%
RTA	Arriving	None	None	None	7.8%	None	None	7.7%
	Departing	None	None	None	7.8%	None	None	7.7%
Scheduled Buses	Arriving	2.6%	2.6%	2.6%	2.6%	2.6%	2.6%	2.6%
	Departing	2.6%	2.6%	2.6%	2.6%	2.6%	2.6%	2.6%
Short-Term Parking	Arriving	26.0%	26.0%	26.0%	21.6%	26.0%	26.0%	21.2%
	Departing	9.0%	9.0%	9.0%	4.6%	9.0%	9.0%	6.4%
Long-Term Parking	Arriving	19.0%	16.0%	14.0%	8.0%	18.35%	18.35%	15.85%
	Departing	19.0%	16.0%	14.0%	8.0%	18.35%	18.35%	15.85%
Car Rentals	Arriving	17.1%	17.1%	15.0%	13.0%	17.1%	17.1%	17.1%
	Departing	17.1%	17.1%	15.0%	13.1%	17.1%	17.1%	17.1%
Off-Site Parking	Arriving	2.0%	4.0%	8.1%	13.1%	2.0%	2.0%	2.0%
	Departing	2.0%	4.0%	8.1%	16.0%	2.0%	2.0%	2.0%
Charter Buses	Arriving	3.6%	3.6%	3.6%	3.6%	3.6%	3.6%	3.6%
	Departing	3.6%	3.6%	3.6%	3.6%	3.6%	3.6%	3.6%
Other Buses	Arriving	1.5%	1.5%	1.5%	1.5%	1.5%	1.5%	1.5%
	Departing	1.5%	1.5%	1.5%	1.5%	1.5%	1.5%	1.5%
Totals	**Arriving**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**
	Departing	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**

Source: P&D Aviation, Inc., 1995.

AR 039140

TABLE IV.15-3

Seattle-Tacoma International Airport
Environmental Impact Statement

INTERSECTION LEVEL OF SERVICE SUMMARY

Intersection Evaluated	1994 Existing	2020 Alt 1	2020 Alt 2	2020 Alt 3	2020 Alt 4
Southbound SR 509 Ramp & SR 518	B	B	B	B	B
Northbound SR 509 Ramp & SR 518	A	A	A	A	A
20th Ave. S. & Eastbound SR 518 Ramps	N/A	N/A	N/A	B	N/A
20th Ave. S. & Westbound SR 518 Ramps	N/A	N/A	N/A	B	N/A
Des Moines Memorial Drive S & South 156th Street	B	C	C	C	C
20th Avenue & South 154th Street	N/A	N/A	N/A	A	N/A
Perimeter Road/24th Ave. S. & South 154th Street	B	D	C	C	C
International Blvd. & South 154th Street	D	E	E	E	E
Southbound SR 509 & South 160th Street	E	F	F	F	F
Northbound SR 509 & South 160th Street	D	F	F	F	F
Des Moines Memorial Drive South & S. 160th Street	B	B	B	B	B
Air Cargo Rd/Perimeter Rd & South 160th Street	A	B	B	B	B
International Blvd. & South 160th Street	B	D	C	C	C
Southbound Airport Exp. Ramps & Air Cargo Rd.	D	B	B	N/A	B
Air Cargo Rd & South 170th Street	C	F	F	N/A	F
Northbound Airport Exp. Ramps & S. 170th Street	D	B	F	N/A	F
International Blvd. & South 170th Street	D	F	F	F	F
International Blvd. & South 176th Street	B	B	B	B	B
International Blvd. & Airport Entrance	B	A	A	A	A
Southbound SR 509 Off-Ramp & South 188th	A	B	B	B	B
Northbound SR 509 Off-Ramp & South 188th	N/A	C	C	C	C
Des Moines Memorial Dr. S. & S. 188th	C	C	C	C	C
28th Ave. South & S. 188th Street	B	B	B	B	B
International Blvd. & South 188th Street	F	F	F	F	F
Military Road & South 188th Street	C	D	D	C	D
Southbound I-5 Ramps & South 188th Street	B	B	B	B	B
Northbound I-5 Ramps & South 188th Street	C	C	C	C	C
28th Ave. South & South 192nd Street	B	B	B	B	B
International Blvd. & South 192nd Street	E	F	F	F	F
Des Moines Memorial Drive S. & South 200th Street	B	C	C	C	C
Southbound SR 509 Ramps/16th Ave. S & S 200th	N/A	B	B	B	B
Northbound SR 509 Ramps/16th Ave. S & S 200th	N/A	B	B	B	B
Southbound Airport Exp. Off-Ramp & S. 200th	N/A	A	B	B	B
Northbound Airport Exp. On-Ramp & S. 200th	N/A	A	A	A	A
28th Ave. South & South 200th Street	C	A	A	A	A
International Blvd. & South 200th Street	C	C	C	C	C
Military Rd & S. 200th St./Southbound I-5 Ramps	B	D	D	D	D
Military Road & Northbound I-5 Ramps	C	C	C	C	C
Southbound SR 509 Ramps & 24th Ave. S.	N/A	B	B	B	B
Northbound SR 509 Ramps & 24th Ave. S.	N/A	C	C	C	C
Des Moines Memorial Dr. S. & Marine View Dr.	B	B	B	B	B
International Blvd. And Kent-Des Moines Memorial	C	D	D	D	D
Southbound I-5 Ramps & Kent -Des Moines Mem.	E	F	F	F	F

N/A = Not Applicable
Source: INCA Engineers, January, 1995

AR 039141

TABLE IV.15-4

Seattle-Tacoma International Airport
Environmental Impact Statement

INTERSECTION AVERAGE DELAY SUMMARY

Intersection Evaluated	1994 Existing	2020 Alt 1	2020 Alt 2	2020 Alt 3	2020 Alt 4
Southbound SR 509 Ramp & SR 518	12.1	7.0	6.9	6.9	7.8
Northbound SR 509 Ramp & SR 518	2.0	2.3	2.3	2.3	2.3
20th Ave. S. & Eastbound SR 518 Ramps	N/A	N/A	N/A	6.6	N/A
20th Ave. S. & Westbound SR 518 Ramps	N/A	N/A	N/A	7.1	N/A
Des Moines Memorial Drive S & South 156th Street	6.4	21.7	16.2	17.9	16.2
20th Avenue & South 154th Street	N/A	N/A	N/A	4.2	N/A
Perimeter Road/24th Ave. S. & South 154th Street	6.8	31.7	19.1	22.5	19.1
International Blvd. & South 154th Street	37.0	55.7	55.4	54.0	55.4
Southbound SR 509 & South 160th Street	N/S	N/S	N/S	N/S	N/S
Northbound SR 509 & South 160th Street	N/S	N/S	N/S	N/S	N/S
Des Moines Memorial Drive South & S. 160th Street	5.7	7.7	5.4	5.4	5.4
Air Cargo Rd/Perimeter Rd & South 160th Street	4.5	5.6	5.0	5.3	5.0
International Blvd. & South 160th Street	11.0	26.1	24.4	21.2	19.7
Southbound Airport Exp. Ramps & Air Cargo Rd.	N/A	7.3	7.3	N/A	7.3
Air Cargo Rd & South 170th Street	16.8	190.6	501.7	N/A	501.7
Northbound Airport Exp. Ramps & S. 170th Street	N/A	12.0	108.4	N/A	108.4
International Blvd. & South 170th Street	39.7	94.0	342.6	80.1	333.2
International Blvd. & South 176th Street	8.1	6.1	6.5	6.3	8.1
International Blvd. & Airport Entrance	9.0	3.5	4.8	4.8	4.8
Southbound SR 509 Off-Ramp & South 188th	N/A	14.1	14.1	14.1	14.0
Northbound SR 509 Off-Ramp & South 188th	N/A	22.1	22.1	22.1	22.1
Des Moines Memorial Dr. S. & S. 188th	21.3	17.7	17.9	16.5	17.8
28th Ave. South & S. 188th Street	12.6	11.0	8.1	8.1	8.6
International Blvd. & South 188th Street	86.4	83.7	71.3	65.7	71.3
Military Road & South 188th Street	16.7	39.2	27.7	20.2	27.2
Southbound I-5 Ramps & South 188th Street	10.7	11.2	10.8	10.3	12.9
Northbound I-5 Ramps & South 188th Street	19.5	18.8	20.9	21.0	20.9
28th Ave. South & South 192nd Street	8.5	6.1	6.0	6.0	6.0
International Blvd. & South 192nd Street	N/S	N/S	N/S	N/S	N/S
Des Moines Memorial Drive S. & South 200th Street	8.2	15.0	15.1	15.1	15.1
Southbound SR 509 Ramps/16th Ave. S & S 200th	N/A	8.3	8.3	8.3	8.3
Northbound SR 509 Ramps/16th Ave. S & S 200th	N/A	6.5	6.5	6.5	6.5
Southbound Airport Exp. Off-Ramp & S. 200th	N/A	4.4	5.2	5.2	5.2
Northbound Airport Exp. On-Ramp & S. 200th	N/A	N/S	N/S	N/S	N/S
28th Ave. South & South 200th Street	N/A	3.8	4.2	4.2	4.2
International Blvd. & South 200th Street	21.6	17.8	20.9	20.6	20.9
Military Rd & S. 200th St./Southbound I-5 Ramps	7.6	31.9	30.8	31.9	30.8
Military Road & Northbound I-5 Ramps	N/A	23.0	18.1	20.3	18.1
Southbound SR 509 Ramps & 24th Ave. S.	N/A	13.0	13.6	13.0	13.6
Northbound SR 509 Ramps & 24th Ave. S.	N/A	18.9	19.7	19.7	19.7
Des Moines Memorial Dr. S. & Marine View Dr.	6.3	7.0	7.0	7.0	7.0
International Blvd. And Kent-Des Moines Memorial	21.1	34.0	34.6	34.6	31.1
Southbound I-5 Ramps & Kent -Des Moines Mem.	41.5	129.5	129.6	129.6	129.6

N/A = Not Applicable N/S - Not signalized. See Appendix O, Table 25 for intersection reserve capacity.
Source: INCA Engineers, January, 1995

TABLE IV.15-5
Page 1 of 3

Seattle-Tacoma International Airport
Environmental Impact Statement

INTERSECTION LEVEL OF SERVICE SUMMARY

Intersection Evaluated	Level of Service (LOS)			
	1994 Existing	2020 Alt 1 Do-Nothing	2020 Alt 3 (W/ SR509)	2020 Alt 3 (W/O SR509)
Southbound SR509 Ramps & SR518	B	C	D	D
Northbound SR509 Ramps & SR518	A	A	A	A
International Blvd. / SR99 & South 154th Street	D	F	E	F
International Blvd. / SR99 & South 160th Street	C	F	F	F
International Blvd. / SR99 & South 170th Street	F	F	F	F
International Blvd. / SR99 & South 176th Street	C	C	D	D
International Blvd. / SR99 & South 180th Street	C	B	B	B
International Blvd. / SR99 & South 188th Street	F	F	F	F
International Blvd. / SR99 & South 192nd Street	F	D	D	D
International Blvd. / SR99 & South 200th Street	D	F	F	F
International Blvd / SR99 & Kent-Des Moines / SR516	E	E	E	F
24th Ave S / Perimeter Rd & S 154th / 156th Street	B	F	F	E
Des Moines Memorial Drive S & S 156th Street	B	C	C	C
Des Moines Memorial Drive S & S 160th Street	B	B	B	B
Northbound SR509 Ramps & S 160th Street	C	F	F	E
Southbound SR509 Ramps & S 160th Street	E	F	F	F
Air Cargo Rd / Perimeter Rd & S 160th Street	B	C	C	C
Air Cargo Road & SB Airport Expressway Ramps	D	C	N/A	N/A
Air Cargo Road & South 170th Street	C	F	N/A	N/A

AR 039143

TABLE IV.15-5
Page 2 of 3

Seattle-Tacoma International Airport
Environmental Impact Statement

INTERSECTION LEVEL OF SERVICE SUMMARY

Intersection Evaluated	Level of Service (LOS)			
	1994 Existing	2020 Alt 1 Do-Nothing	2020 Alt 3 (W/ SR509)	2020 Alt 3 (W/O SR509)
NB Airport Expressway Ramps & S 170th Street	C	F	N/A	N/A
Southbound SR518 Ramps & South 188th Street	A	B	B	D
Northbound SR518 Ramps & South 188th Street	N/A	B	B	N/A
Des Moines Memorial Drive S & S 188th Street	B	B	B	C
28th Avenue South & South 188th Street	B	F	E	F
Military Road South & South 188th Street	D	F	F	F
Southbound Interstate 5 Ramps & South 188th Street	C	F	F	F
Northbound Interstate 5 Ramps & South 188th Street	D	F	F	F
Des Moines Memorial Drive South & South 200th Street	B	B	B	B
Des Moines Memorial Dr S & Marine View Dr / SR509	B	B	B	B
28th Avenue South & South 200th Street	C	D	D	F
Military Rd S / S 200th Street & SB Interstate 5 Ramps	B	F	F	F
Military Road South & Northbound Interstate 5 Ramps	C	E	E	F
28th Avenue South & South 192nd Street	A	B	B	B
SB Interstate 5 Ramps & Kent-Des Moines / SR516	D	F	F	F
SB SR509 Off-Ramp / 16th Ave S & S 200th Street	N/A	B	B	N/A
NB SR509 On-Ramp / 16th Ave S & S 200th Street	N/A	B	B	N/A
Southbound SR509 Ramps & 28th Avenue S	N/A	B	B	N/A
Northbound SR509 Ramps & 28th Avenue S	N/A	C	B	N/A

AR 039144

TABLE IV.15-5
Page 3 of 3

Seattle-Tacoma International Airport
Environmental Impact Statement

INTERSECTION LEVEL OF SERVICE SUMMARY

Intersection Evaluated	Level of Service (LOS)			
	1994 Existing	2020 Alt 1 Do-Nothing	2020 Alt 3 (W/ SR509)	2020 Alt 3 (W/O SR509)
Southbound Airport Expressway Off-Ramp & S 200th Street	N/A	A	A	N/A
Northbound Airport Expressway On-Ramp & S 200th Street	N/A	A	A	N/A
20th Avenue S & Westbound SR518 Ramps	N/A	N/A	B	B
20th Avenue S & Eastbound SR518 Ramps	N/A	N/A	C	B
20th Avenue South & South 154th / 156th Street	N/A	N/A	B	C

N/A - This intersection does not exist for that time period or alternative.
Source: INCA Engineers, December 1995.

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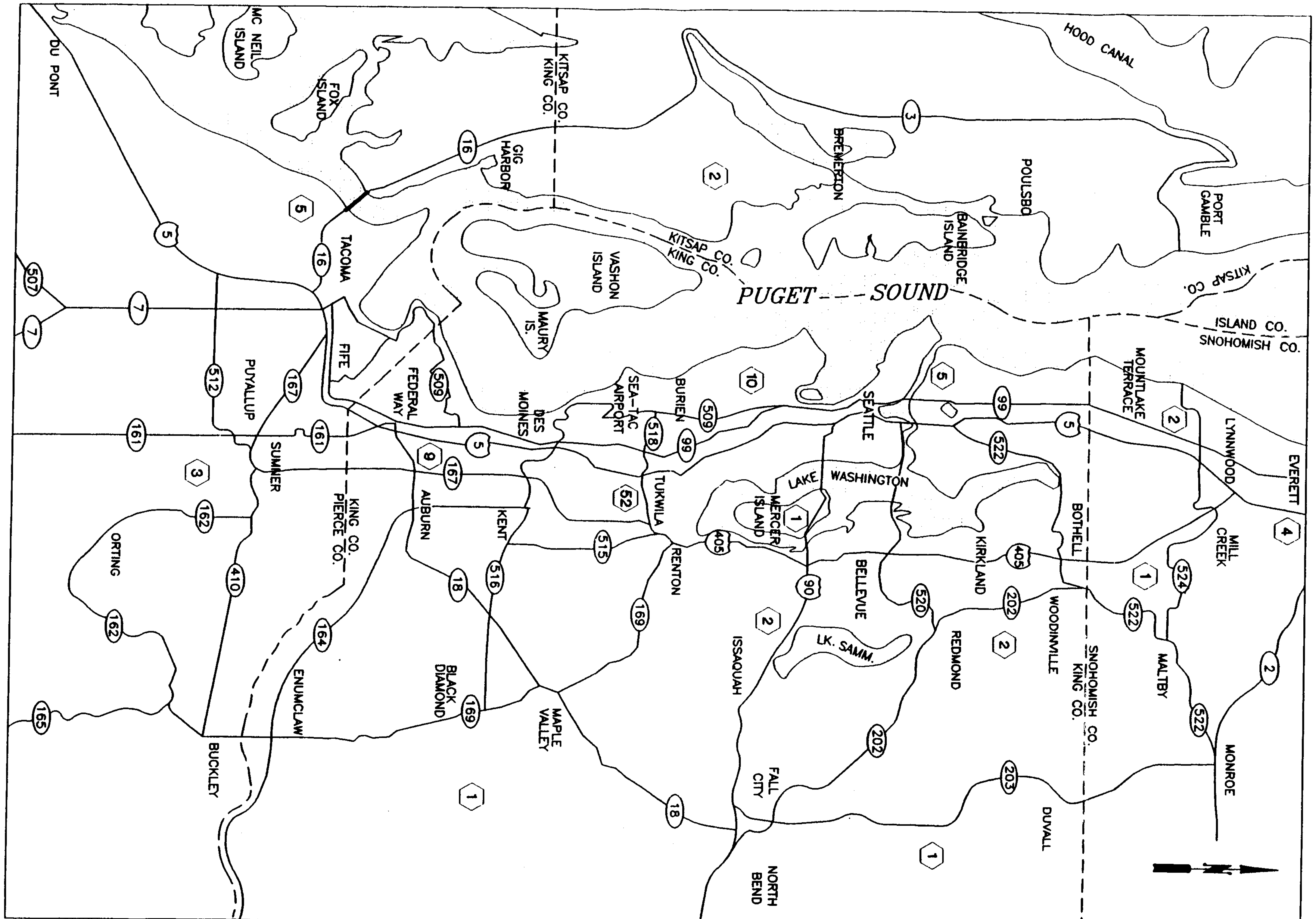


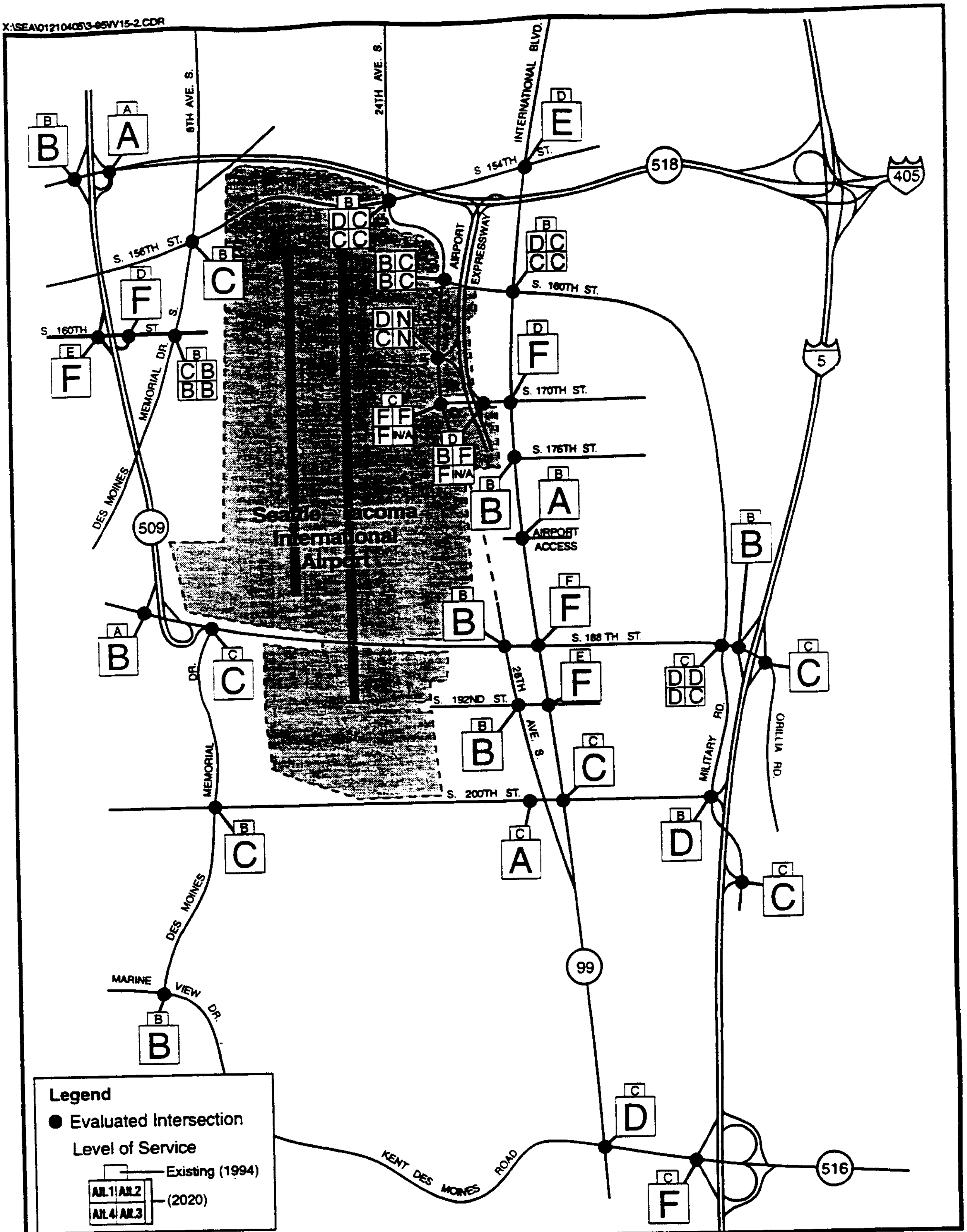
LEGEND

(X) PERCENT DISTRIBUTION OF AIRPORT TRAFFIC

Source: INCA Engineers, Inc.

Seattle - Tacoma International Airport	Regional O-D Patterns	EXHIBIT: IV. 15-1

X:\SEA\01210405\3-95\IV15-2.CDR



Seattle - Tacoma International Airport	Levels of Service	EXHIBIT: IV.15-2

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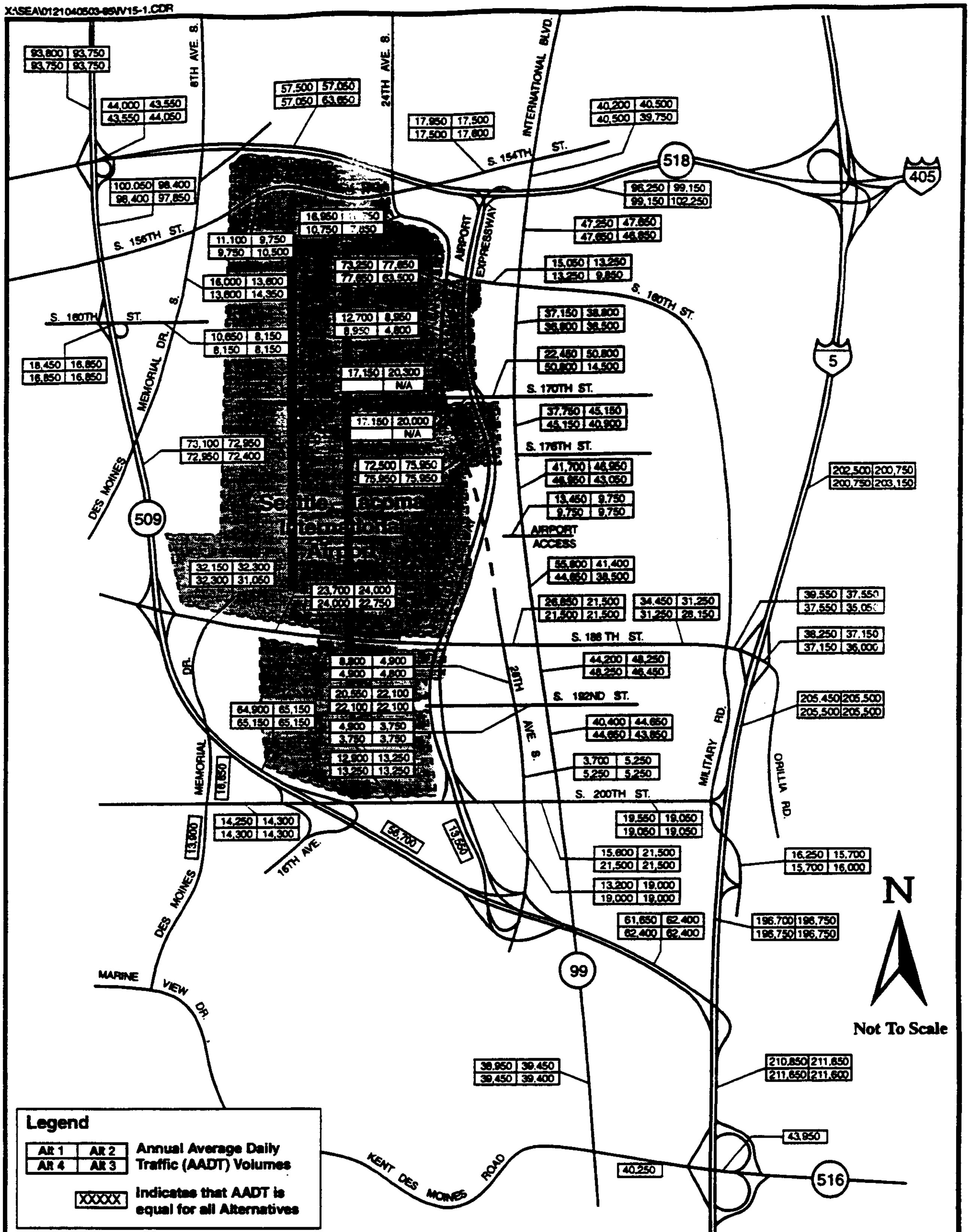
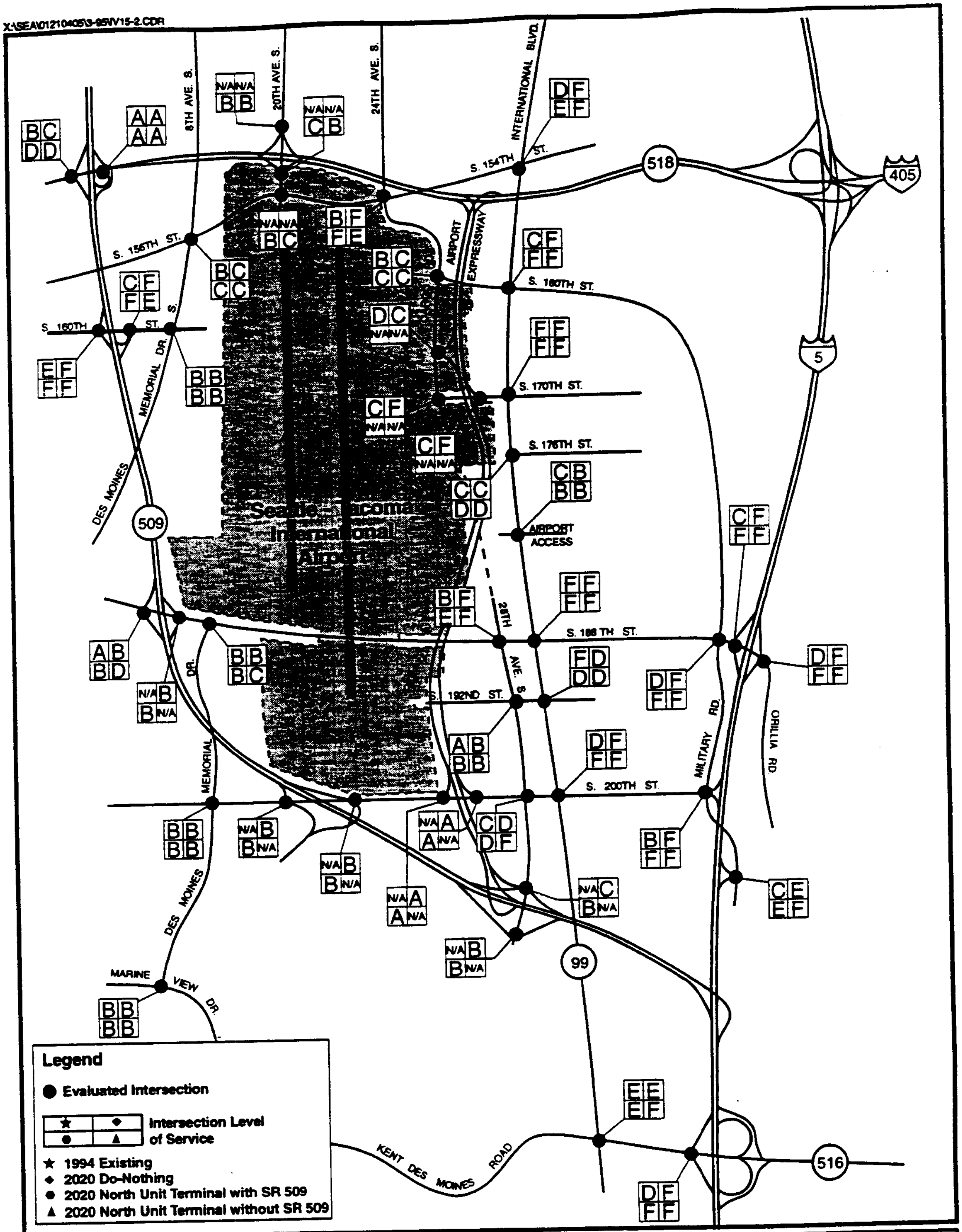


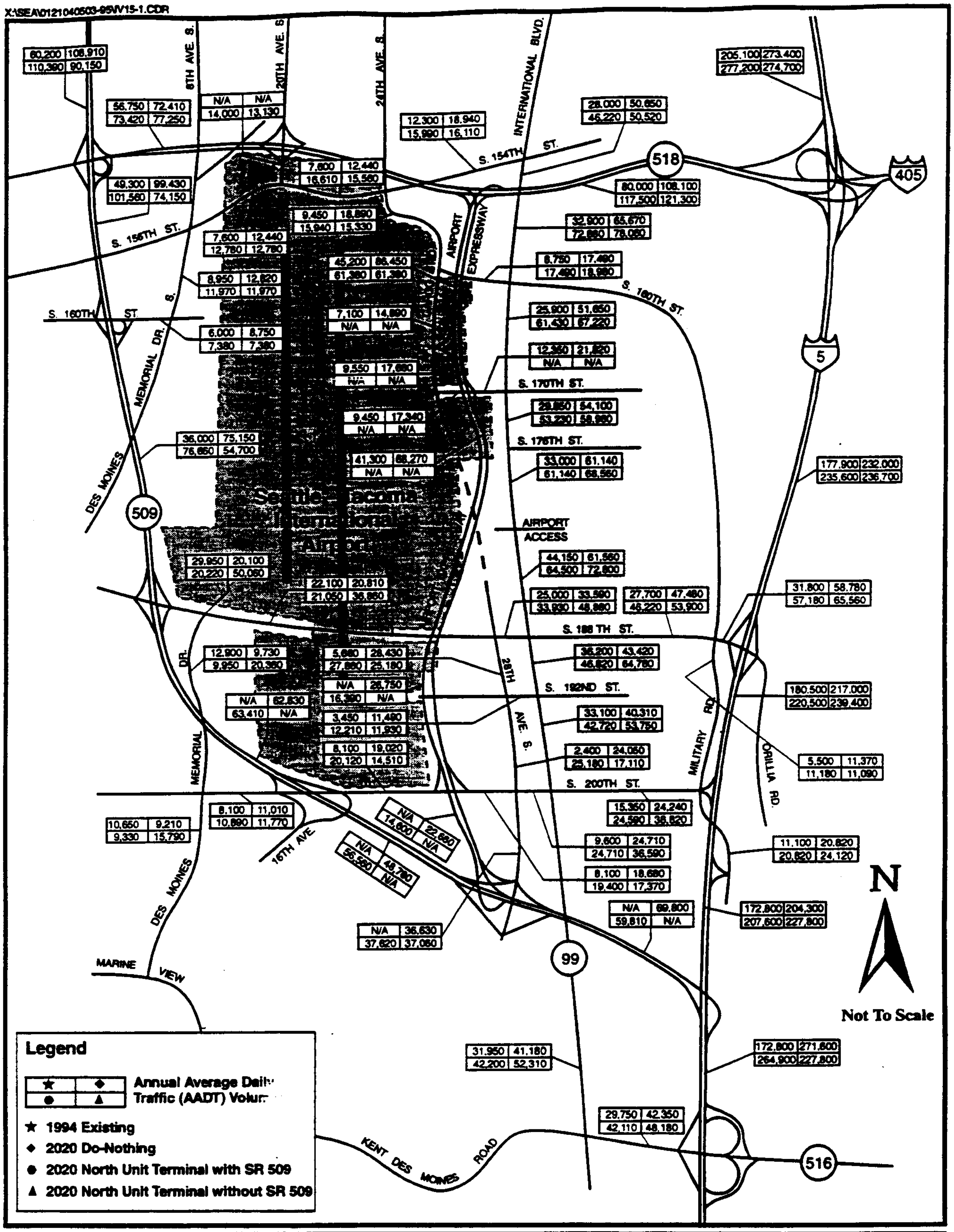
Seattle - Tacoma International Airport

2020 AADT Volumes

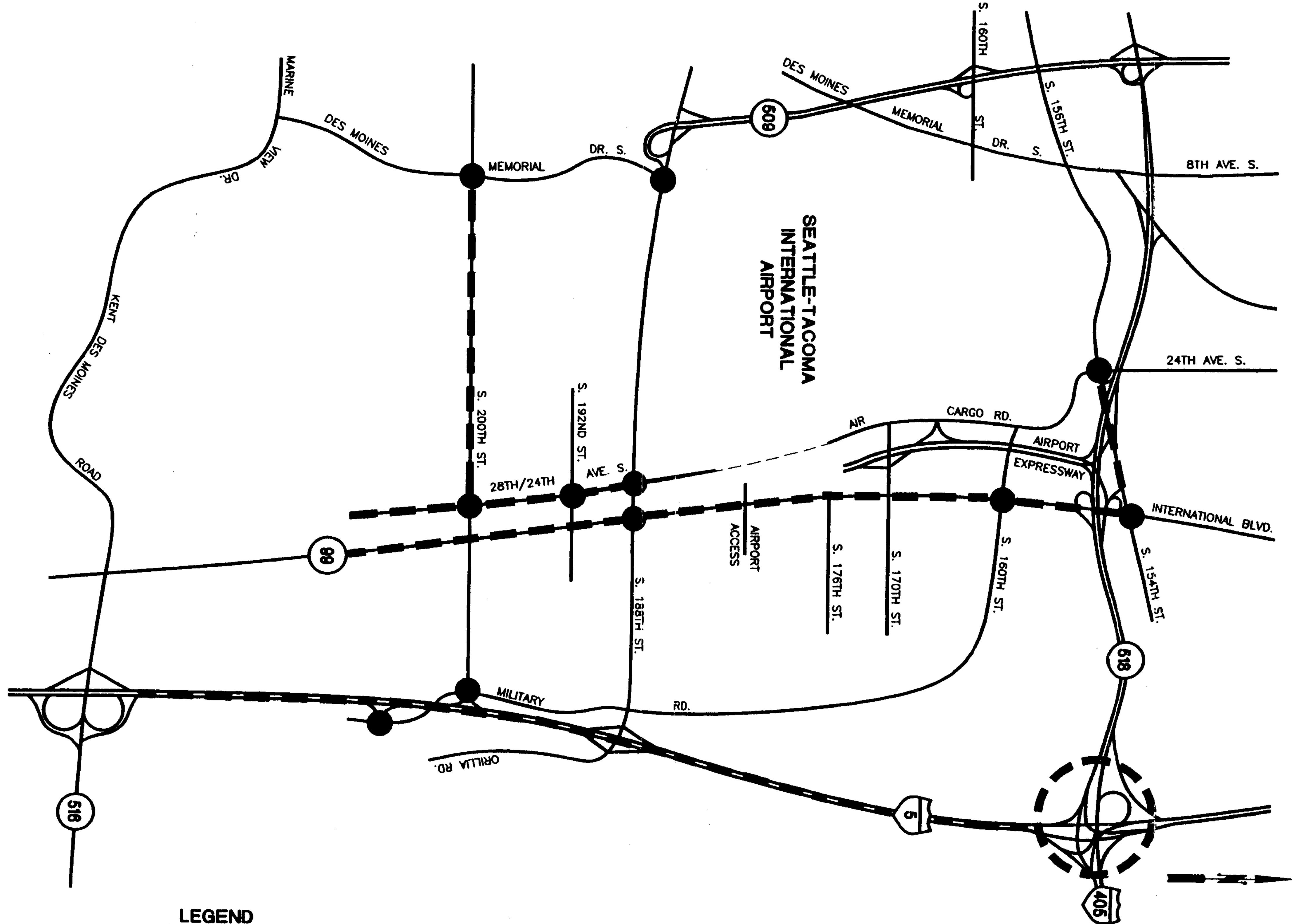
EXHIBIT: IV.15-3



Seattle - Tacoma International Airport	Level of Service	EXHIBIT: IV.15-4

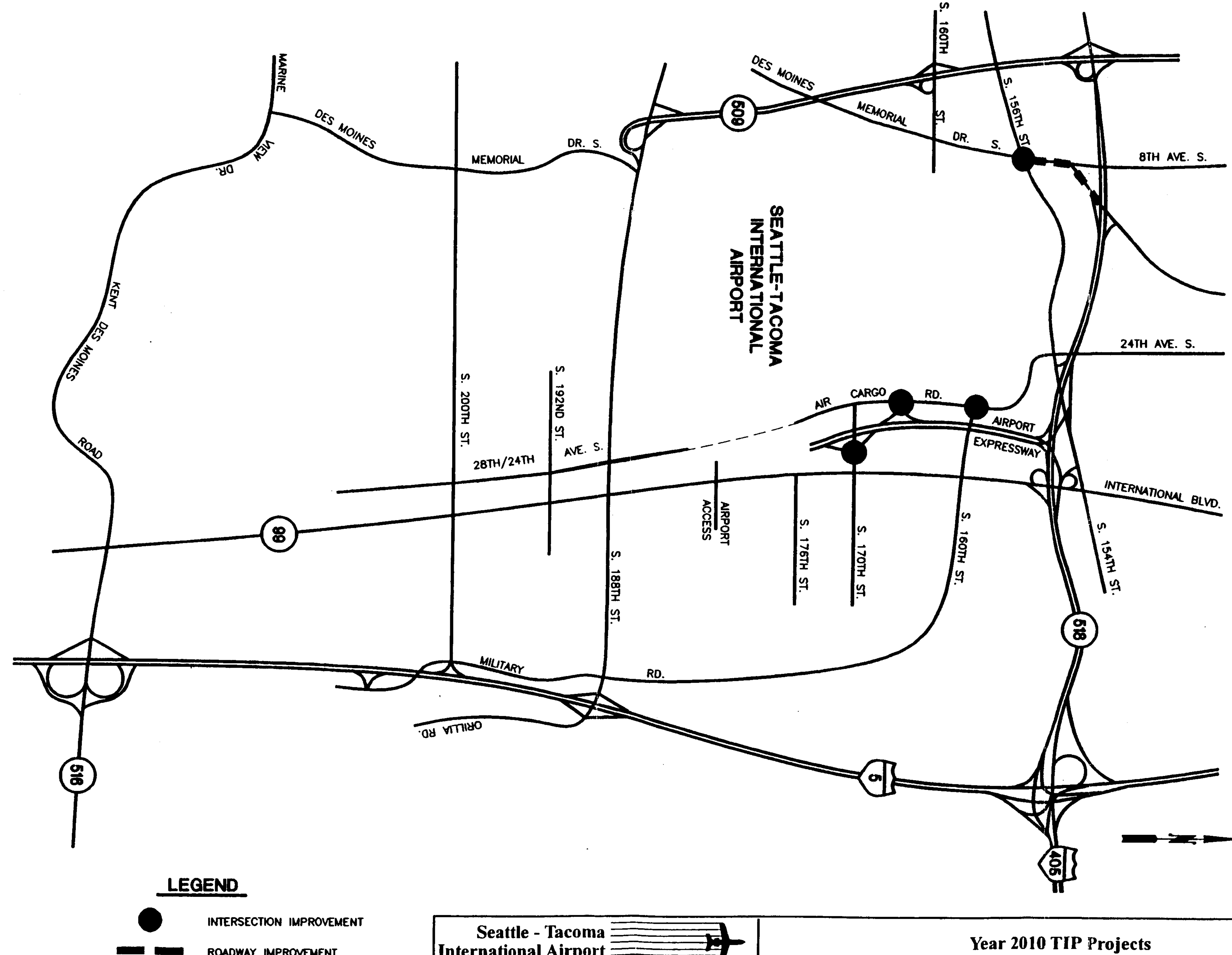


Seattle - Tacoma International Airport	AADT Volumes	EXHIBIT: IV.15-5



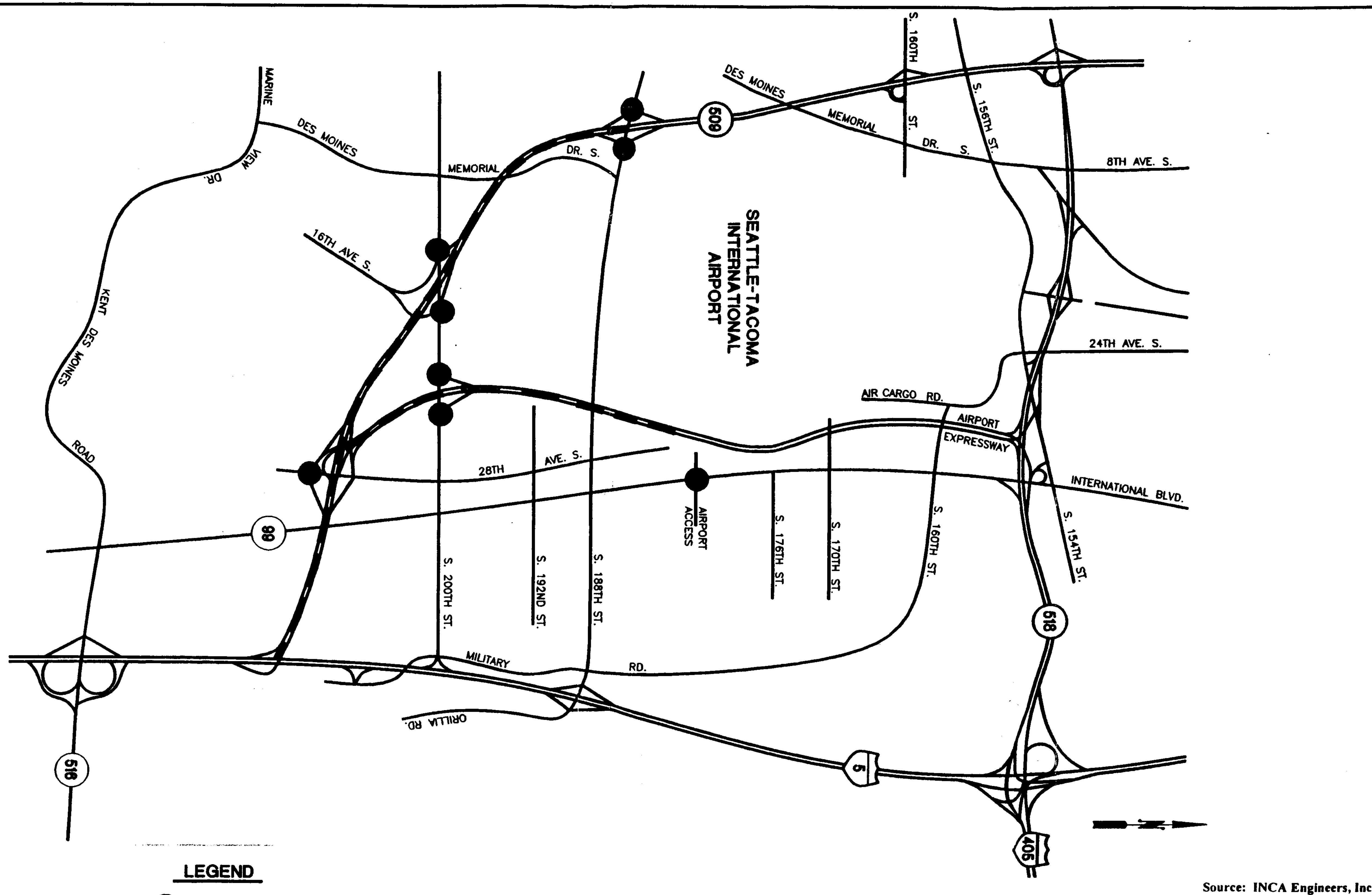
Source: INCA Engineers, Inc.

Seattle - Tacoma International Airport	Year 2000 TIP Projects	EXHIBIT: IV. 15-6



Source: INCA Engineers, Inc.

Seattle - Tacoma International Airport	Year 2010 TIP Projects	EXHIBIT: IV. 15-7



Source: INCA Engineers, Inc.

Seattle - Tacoma International Airport	Year 2020 TIP Projects	EXHIBIT: IV. 15-8

CHAPTER IV, SECTION 16

PLANTS AND ANIMALS (BIOTIC COMMUNITIES)

This report describes vegetation and wildlife communities and evaluates potential impacts of the proposed Master Plan Update alternatives on these communities.

Approximately 40 percent of the detailed study area is occupied by Sea-Tac Airport and is characterized by frequently mowed grassland bisected by service roads and taxiways. This area provides little wildlife habitat value. Wildlife habitat surrounding the airfield consists of fragmented habitat, which is composed of forest, shrub, and grassland with scattered wetlands. These areas are subject to a variety of airport-related disturbances as well as increasing residential, commercial, and industrial development. Each of the "With Project" alternatives would remove approximately the same amounts of vegetation (about 712 acres total). Of that total, the majority is managed grassland (about 303 acres), which provides little wildlife habitat value. In addition, about 269 acres of forest, 78 acres of shrub, 52 acres of unmanaged grassland, and 10 acres of wetlands would be removed under each "With Project" alternative.

Various physical, biological, and chemical factors affect fisheries and aquatic biota. Urbanization in the Miller and Des Moines Creek basins has altered some of these factors with resulting changes in the aquatic ecosystem. Hydrologic regime and channel morphology have been altered, habitat complexity and quality have been reduced, and water quality has been degraded. These alterations have resulted in reduced diversity and abundance of fish and aquatic biota in Miller and Des Moines Creeks.

Construction and operation of the proposed new dependent parallel runway would have some adverse affects on fishery and aquatic resources of Miller and Des Moines Creeks and Puget Sound. About 3,700 feet of Miller Creek and its tributaries would require realignment and relocation to complete the runway. About 200 feet of Des Moines Creek would require relocation due to the 600 ft extension of Runway 34R. About 2,200 feet of open channel on Des Moines Creek would require relocation due to the South Aviation Support Area. The 200-foot section of Des Moines Creek that would be affected by the extension of Runway 34R is within the area that would be realigned as mitigation for SASA. Proposed mitigation would reduce potential impacts on the hydrology, water quality, and aquatic habitat and biota of Miller and Des Moines Creeks and Puget Sound.

(1) METHODOLOGY

For purposes of this analysis, the study area consists of a 4 square mile area that is bound by Highway 99 to the east, S. 140th Street to the north, State Route 509 (SR509) and Des Moines Way S. to the west, and S. 216th Street to the south.[1/] Study area boundaries were determined using preliminary site plans to analyze the proposed Master Plan Update alternatives and their potential impacts. Because of restricted access in the privately-owned, residential areas, studies focused on public property and lands owned by the Port of Seattle.

Information for this report was gathered from a variety of sources. The Washington Department of Fisheries and Wildlife (WDFW) Nongame and Priority Habitats and Species) Programs, and the Washington State Department of Natural Resources Natural Heritage Program were consulted regarding sensitive wildlife and plant species and priority habitats in the study area. In accordance with Section 7(c) of the Endangered Species Act of 1973, the U.S. Fish and Wildlife Service (USFWS) and the National Marine Fisheries Service were consulted regarding federally listed threatened or endangered species possibly occurring in the project area (as described in Chapter IV, Section 17).

Analysis of fishery and aquatic resources within the Miller and Des Moines Creek basins was based on past and recent studies. The *King County Sensitive Areas Map Folio* (1990),[2/]

1/ This area includes portions of Sections 4, 5, 8, and 9, Township 22N, Range 4E, and Sections 16, 17, 20, 21, 28, 29, 32 and 33, Township 23N, Range 4E.

2/ *King County Sensitive Areas Map Folio*. Department of Parks, Planning and Resources, Planning and Community Development Division, King County, Washington, 1990.

National wetlands inventory maps,[3] and the catalog of Washington streams for the Puget Sound Region[4] were reviewed for information on sensitive habitat areas and fisheries resources. Discussions of fish habitat (e.g., substrate composition, pool: riffle ratios, riparian vegetation, in-stream cover, and channel morphology) are based on recent fish habitat surveys performed on Miller Creek (as described in greater detail in **Appendix F**) and Des Moines Creek.[5] Evaluation of potential construction and operation impacts on fisheries in these drainages involved a comparison of existing and future fish population vitality (e.g., abundance and diversity) based on fish habitat requirements and preferences, water quality, and water quantity.

Vegetative cover and wildlife habitat in the study area were assessed by aerial photograph and map interpretation. Habitat classification was determined using a two-tiered system of generally accepted vegetation and wildlife habitat categories: forest, shrub, grassland, and wetland. The secondary levels included three types of forest and two types of grassland: coniferous, deciduous and mixed forest, and managed or unmanaged grassland. Wetlands are classified according to the USFWS Wetland Classification System.[6] The vegetative classification was interpreted from color aerial photographs at a scale of 1:24,000 and a vegetative cover map of the focus area was developed at a scale of 1:2,500. Further consultation was made with the Port of Seattle. Personnel with specific knowledge of the study area provided information on bald eagles and other wildlife.

A review of this information along with information provided in previous technical studies,[7,8] agency reports, natural resource inventories, and topographic and resource maps allowed an inventory and assessment of resources that could be affected by the proposed Master Plan Update alternatives.

Two, one-day site visits were conducted in October and November 1994 to field-verify information collected on vegetation communities within the study area, wildlife habitat, and general wildlife use of the area. Additional field surveys were conducted during December 1994 in conjunction with wetland surveys. Wildlife observations and habitat data were recorded to further augment existing information.

(2) EXISTING CONDITIONS

Both wetland and upland habitats are located within the study area and are shown in **Exhibit IV.16-1.** Several wetland communities and several upland habitat associations were identified. These communities are discussed in the following section. A detailed characterization of vegetation, wildlife species, and fish, and common and scientific names of plant species occurring in the study area are presented in **Appendix M.** Scientific nomenclature follows industry standards.[9]

(A) Vegetation

No rare plants, high-quality native wetlands, or high-quality native plant communities listed by the Washington Department of Natural Heritage Information System are located in the study area.[10]

Upland vegetative communities consist of grassland, shrub, deciduous forest, coniferous forest, and mixed deciduous/coniferous forest. Eight habitat types are distinguished as shown in **Exhibit IV.16-1**: grassland, managed lawn, pasture, row crop, mixed shrub, coniferous forest, deciduous forest, mixed forest, mixed vegetation classes, and wetland. Existing acreages of each habitat type were determined by overlay of the vegetation map and are shown in **Table IV.16-1.** For ease of tabulation; the managed lawn, pasture, and row crop categories were combined into one category (managed grassland), which includes managed

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3/ *National Wetlands Inventory, Maple Valley, Washington Quadrangle.* U.S. Fish and Wildlife Service. 1988.

4/ *A Catalog of Washington Streams and Salmon Utilization; Vol. 1, Puget Sound Region.* Williams, R.W., R.M. Laramie and J.J. Ames, Washington Department of Fisheries, 1975.

5/ *Draft Fish Habitat Survey of Des Moines Creek.* Prepared by Resource Planning Associates, Aquatic Resource Consultants, and Caldwell Associates for the Port of Seattle. May, 1994.

6/ *Classification of Wetlands and Deepwater Habitats of the United States.* U.S. Fish and Wildlife Service, Pub. #FWS/OBS-79/31. Cowardin, L.M., V. Carter, F.C. Golet, and E.T. LaRoe, 1979.

7/ *South Aviation Support Area Final EIS.* Port of Seattle, 1994.

8/ *Des Moines Creek Technology Campus, Preliminary DEIS.* Port of Seattle. 1994.

9/ *Flora of the Pacific Northwest.* Hitchcock, C.L. and A. Cronquist, 1976.

10/ Communication with Sandra Norwood, Washington Natural Heritage Program, Division of Land and Water Conservation. January, 1995.

grassland areas associated with airport operations areas, industrial and commercial development, and agricultural lands. From a wildlife perspective, these areas provide similar habitat value.

Seven streams were identified. Des Moines Creek and Miller Creek are the largest of these streams. The riparian areas associated with streams consist of both upland and wetland communities dominated by an overstory of red alder, black cottonwood, and willow trees with Himalayan blackberry, mixed grasses, lady fern, field horsetail, slough sedge, burreed, reed canarygrass, and creeping buttercup comprising much of the understory.

TABLE IV.16-1
EXISTING WILDLIFE HABITAT

Vegetation Class	(Acres) Existing Area
Managed Grassland	900
Grassland*	142
Shrub	253
Wetland**	
Forested Wetland	52
Scrub-shrub Wetland	51
Emergent Marsh	41
Deciduous Forest	723
Mixed Forest	78
Coniferous Forest	112
Total	**2,352**

* Includes unmanaged grassland such as overgrown fields and grassland areas scattered throughout less developed portions of the site.

** Refer to Wetland Section of this report for detailed information on wetlands

Source: Shapiro and Associates, Inc., 1994

Wooded residential areas characterize parts of the easternmost portion of the study area, between the airport and Highway 99. Field studies were not conducted in this portion of the study area due to restricted access. Existing information shows that these areas are dominated by Douglas fir, big-leaf maple, and red alder. Common understory species include red alder saplings, Himalayan blackberry, hazelnut, and Indian plum. Ornamental trees and shrubs also are common throughout these residential areas.

For descriptive purposes, the study area has been divided into five distinct areas: (1) Airfield Vegetation, (2) South Aviation Support Area (SASA) Vegetation, (3) West SeaTac Vegetation, (4) North Borrow Area, (areas 5 and 8) and (5) South Borrow Area (areas 1-4). **Appendix M** contains a detailed description of the vegetation communities in each of these areas. Vegetation communities in each of these areas are briefly described below.

1. **Airfield Vegetation**

The airfield encompasses the runway area and associated airport facilities and is bound on the east and west by runways, on the north by S. 154th Street, and on the south by S. 192nd Street. This area is characterized almost entirely by managed grassland interrupted by an array of service roads, airport runways, and taxiways. This is the most common vegetative community in this area, totaling approximately 774 acres in the airfield. Upland shrub habitat often borders the runway area and is scattered throughout the site. Several small patches of grass/forb association emergent wetland occur in the airfield area.

2. **South Aviation Support Area (SASA) Vegetation**

The SASA area is located immediately south of the airfield and is bound on the west by Des Moines Way S., on the east by Highway 99, and on the south by S. 200th Street. Much of this area has been previously described in the 1994 SASA Final EIS and is predominately characterized by a former residential area that is now revegetated with grassland and shrubland, two small mixed deciduous/coniferous woodlots, and the Tyee Valley Golf Course.

3. **West SeaTac Vegetation**

Fragmented stands of second-growth mixed deciduous/coniferous forest are prominent components of the vegetative cover along the western portion of the focus area. It is bound on the east by the airfield, on the west by Des Moines Way S. and SR509, on the north by S. 154th Street, and on the south by S. 200th Street.

4. North Borrow Area (On-site Borrow Source Areas 5 and 8)

The North Borrow Area is bound on the south by S. 154th Street, on the north by S. 146th Street, and Lora Lake on the west. Houses that once existed in this area have been removed as part of the Port's Noise Remedy Program. The North Borrow Area is largely forested and contains the Lake Reba Detention facility, a King County regional stormwater detention facility. A gravel storage area is located in the southern portion of this borrow site and is predominately devoid of vegetation. Miller Creek enters the north end of this area, flows past the north end of Lake Reba, and into Lora Lake. Forested wetland is the most common vegetative community in the North Borrow Area.

5. South Borrow Area (On-site Borrow Source Areas 1-4)

The South Borrow Area is bound on the south by S. 216th Street, on the north by S. 200th Street, on the east by 16th Avenue S., and on the west by 24th Avenue S. Des Moines Creek Park is located in the central portion of this area, between Borrow Areas 1 and 2. Both upland and wetland second-growth deciduous forest are prevalent vegetative components of the South Borrow Area. Des Moines Creek flows through a steep forested ravine from the north side of this area to the southwest corner.

(B) Wildlife Species

Wildlife habitat within the Airport vicinity has been highly modified through urbanization and residential development. Much of the study area is protected from human and domestic animal intrusion through restricted access and fencing. When considering habitat value from a regional perspective, the relatively undisturbed vegetation communities in the area offer valuable habitat for wildlife. Vegetation communities provide habitat for several species of terrestrial and aquatic wildlife. Wildlife diversity is generally related to the structure and plant species composition within these vegetative communities. Fragmentation of habitat and significant ongoing noise disturbance caused by airport operations limit wildlife use of the study area.[11/] Wetlands and forested areas with well developed shrub layers are likely to support the greatest number of species and populations of wildlife.[12/] Common and scientific names of wildlife species discussed in the following text are presented in **Appendix M** along with a detailed characterization of the study area.

(C) Fisheries and Aquatic Resources

Although urbanization has significantly altered channel morphology and fish habitat, Miller, Walker, and Des Moines Creeks continue to support populations of resident and anadromous fish, other fishes, and associated aquatic biota. Historically, Miller and Des Moines Creek basins supported large runs of coho salmon (*Oncorhynchus kisutch*) and perhaps small runs of chum salmon (*O. keta*).[13/] Presently, both basins support only small runs of coho salmon, which appear to be maintained by annual releases of hatchery-reared fingerlings raised by the Des Moines Salmon Chapter of Trout Unlimited. WDFW has not conducted any spawner surveys on either Miller or Des Moines Creeks since 1985; no spawning coho were observed in the 1985 survey.[14/] The Des Moines Salmon Chapter of Trout Unlimited reported about 91 fish in a recent coho spawner survey conducted on Miller Creek.[15/] There is no known chum salmon or steelhead use of

11/ *Disturbance to birds by gas compressor noise stimulators, aircraft, and human activity in the Mackenzie Valley and North Slope, 1972.* Arct. Gas Biol. Rep. Ser. 14. Gunn, W.W.H., and J.A. Livingston, eds., 1974.

12/ *Management of Wildlife Habitats in Forests of Western Oregon and Washington, Vols.1 and 2.* Brown, E.R. (ed).,U.S. Forest Service, 1985.

13/ *Catalog of Washington Streams and Salmon Utilization.* Williams, R.W., R.M Laramie. and J.J. Ames. Washington Department of Fisheries. 1975.

14/ Personal communication with Joe Robel, Fisheries Biologist, Washington Department of Fish and Wildlife. August 8, 1994.

15/ Personal communication with Allen Miller, Restoration Coordinator, Des Moines Salmon Chapter of Trout Unlimited. July 18, 1994.

AR 039158

either creek.[16/,17/] Barriers to upstream fish passage limits salmon use of Miller Creek to the area below the culvert at 1st Avenue S. (about 2 miles) and to the below S. 200th Street on Des Moines Creek (about 2.5 miles).

In addition to anadromous fish, both Miller and Des Moines Creeks support resident populations of cutthroat trout (*O. clarki*) and pumpkinseed sunfish (*Lepomis gibbosus*).[18/] Des Moines Creek also supports resident populations of rainbow trout (*Oncorhynchus mykiss*), bluegill(*Lepomis macrochirus*), black bullhead (*Ictalurus melas*), and largemouth bass(*Micropterus salmoides*). In addition, Miller, Walker, and Des Moines Creeks likely support small populations of native nongame fishes, including sculpin (*Cottus* sp.) and other nongame fishes indigenous to the area. Electrofishing conducted on Des Moines Creek in four reaches (one downstream and three upstream of S. 200th Street) captured five rainbow trout, 13 bluegill, 17 black bullhead, and two largemouth bass.[19/] Bluegill, bullhead, and largemouth bass appear to be restricted to the Northwest Ponds, Bow Lake and slower water habitats at the Tyee Valley Golf Course. In a recent (October 1994) electrofishing survey at seven locations on Des Moines Creek between Marine View Drive and S. 200th Street, a total of 50 salmonids were captured, including 48 cutthroat trout ranging from about 3 to 13 inches and two juvenile coho salmon.[20/] Lengths of juvenile coho were not reported. Cutthroat trout were captured at all seven locations, but juvenile coho were captured only at the most downstream station. In addition, 14 pumpkinseed sunfish were captured, ranging from about 1.5 to 2.5 inches. The source of pumpkinseed sunfish, which were caught at six of the seven sampling locations, is likely Bow Lake and the Northwest Ponds upstream of S. 200th Street. Though no comprehensive population studies have been conducted on either creek, recent electrofishing surveys conducted on Des Moines Creek and limited observations made on Miller Creek, suggested that these creeks support relatively small populations of salmonid and nongame fish species.

16/ Personal communication with Joe Robel, Fisheries Biologist, Washington Department of Fish and Wildlife. August 8, 1994.

17/ Personal communication with Phil Schneider, Fisheries Biologist, Washington Department of Fish and Wildlife. August 18, 1994.

18/ Personal communication with Alan Johnson, Aquatic Scientist, Aquatic Resource Consultants, November 12, 1994.

19/ *South Aviation Support Area Final EIS*. Port of Seattle. 1994.

20/ Personal communication with Alan Johnson, Aquatic Scientist, Aquatic Resource Consultant, August 18, 1994.

(3) FUTURE CONDITIONS

Potential impacts on vegetation communities and wildlife habitat are discussed in the following section. Potential construction and operational impacts for each of the "With Project" alternatives are evaluated by the years 2000, 2010, and 2020.

Construction and operation impacts on fish and aquatic biota that could result from the proposed alternatives include effects on water quality, water quantity, and aquatic habitat. It is anticipated that required mitigation would prevent such impacts, however.

(A) Do-Nothing (Alternative 1)

The following paragraphs summarize the impact of Alternative 1 on vegetation, wildlife and fish.

1. Vegetation

The Do-Nothing alternative would result in the Airport area remaining as it exists today, with the exception of minor improvements. Therefore, no impact on vegetation and wildlife habitat would be expected as a result of continued functioning of Airport facilities. Due to the completion of the SASA development approved in the 1994 SASA Final EIS, about 142 acres of land would be affected. The primary vegetation affected (60 percent) would be managed grassland. Construction activities associated with the SR509/South Access Road project would result in the permanent loss of between 28 and 56 acres of vegetation, depending on the selected alternative.

2. Wildlife Species

The Do-Nothing alternative would result in the Airport area remaining as it exists today, with the exception of improvements such as the SASA and the

SR509/South Access road project. Habitat degradation and vegetation removal as a result of construction would result in displacement of wildlife species. Noise disturbance related to construction activities may cause disturbance-sensitive species to avoid potential habitat in an area surrounding the construction zone.

3. Fish and Aquatic Resources

Fish and aquatic biota will continue to be adversely affected by existing degraded water quality, water quantity, and stream habitat conditions that result from various land uses in these basins. About 2,200 feet of open channel of tributary 0377, a Class 3 intermittent segment of Des Moines Creek, would require relocation due to SASA. Water quality of Miller and Des Moines Creeks could improve due to implementation of NPDES permit requirements for the Airport. Several other proposed developments in the basins (e.g., SR509 extension) could adversely affect hydrology, water quality, and aquatic habitat in Miller and Des Moines Creeks and Puget Sound if not adequately mitigated.

Stormwater runoff from the Airport contains pollutants that can be toxic to aquatic biota at levels above acute and chronic toxicity standards. Standards are generally established below levels observed to have toxic effects on the most sensitive test organisms. Toxicants found in stormwater runoff include dissolved copper and zinc, glycols, and ammonia. Acute and chronic toxicity of these pollutants on aquatic biota in Miller and Des Moines Creeks depend on other receiving water qualities, including ;H, hardness, and temperature. The toxicity of metals is inversely proportional to water hardness (toxicity increases as hardness decreases). Ammonia toxicity varies as a function of pH and temperature. Based on existing stormwater monitoring data, levels of copper, zinc, and ammonia occasionally appear to exceed acute and chronic toxicity standards. Glycol levels in stormwater runoff generally appear to be several orders of magnitude lower than those causing acute toxic effects on salmonids but could contribute to chronic effects on aquatic biota.

The actual quantities of these pollutants in receiving waters and corresponding toxicity to aquatic biota depend on concentrations of these pollutants in the creeks and the total pollutant loads for the entire Miller and Des Moines Creek basins. Most of the total estimated annual pollutant loadings for total suspended solids, oil and grease, total copper, total lead, total zinc, biochemical oxygen demand, and total phosphorus comes from other residential, commercial, and light industrial areas in these basins (see Chapter IV, Section 10 "Water Quality and Hydrology" and Appendix M for a more detailed discussion of pollutant loading contributions from the Airport and copper toxicity). However, the Airport may contribute a relatively high proportion of total loadings of the more toxic dissolved forms of copper and zinc. Additional studies are being conducted by the Port of Seattle to evaluate the toxicity of stormwater runoff on the aquatic biota in Miller and Des Moines Creeks.

(B) "With Project" Alternatives (Alternative 2, 3 and 4)

The following paragraphs summarize the impact of "With Project" alternatives on vegetation, wildlife and aquatic resources.

1. Vegetation

The primary effect on vegetation communities from construction is the direct removal of vegetation. This impact is similar among all "With Project" alternatives but varies in severity depending on the type and quantity of vegetation that would be affected. Loss of plant communities that offer limited habitat value, such as managed grassland, result in less of an adverse effect than loss of more complex vegetation associations, such as mature forests, wetlands and riparian zones. **Table IV.16-2** shows the approximate amount of each vegetation community that would be lost as a result of each alternative. All "With Project" alternatives would result in a direct conversion of approximately 10 acres of wetland, 52 acres of unmanaged grassland, 269 acres of upland forest, 78 acres of shrub, and 303 acres of managed grassland to impervious surfaces. Slight differences in impacts between the "With Project" alternatives would occur as a result of the different terminal location.

AR 039160

TABLE IV.16-2

IMPACTS ON VEGETATION AND WILDLIFE HABITAT

		AREA IMPACTED (acres)*			
		Alternatives			
Vegetation Class	Existing Area (ac)	Alt 1	Alt 2	Alt 3	Alt 4
Managed Grassland	900	85	303	283	311
Grassland	142	0	52	57	57
Shrub	253	20	78	83	71
Wetland					
Forested Wetland	52	2	7	7	7
Scrub-shrub Wetland	51	0	1	1	1
Emergent Marsh	41	0.2	2	2	2
Deciduous Forest	723	34	251	255	244
Coniferous Forest	112	1	18	14	14
Mixed Forest	78	0	0	0	0
Total	**2,352**	**142.2**	**711.7**	**701.7**	**706.7**

* Assumes 8,500-foot runway alternative separated by 2,500 feet from 16L/34R.

Source: Shapiro and Associates, Inc. 1994

Phase 1 construction activities scheduled for completion by the year 2000 would affect the greatest amount of vegetation. Construction areas for this phase total over 300 acres (for an 8,500-ft new parallel runway). Phase 1 construction activities would include construction of the new parallel runway, realignment of S. 156th Way and S. 154th Street, and construction of specified airport infrastructures.

Construction of the proposed new runway itself would require the clearing, grading, and filling of over 200 acres of upland forest, shrub, grassland, and wetland communities. Phase 1 construction with either the 7,500-foot runway or 7,000-foot runway options would require the removal of similar vegetation communities in comparison to the 8,500-foot option; however, construction of either of the shorter runway options would result in a correspondingly lower impact on these communities. In addition to the 300 acres of vegetation removed as a result of Phase 1 construction, approximately 221 acres of upland forest, shrub, grassland, and wetland vegetation would be cleared in Borrow Areas 1, 2, 3, 4, and 5. To minimize wetland impacts, Borrow Area 8 would not be used as a fill source. No excavation would occur in this portion of the site. Grading, clearing, and excavation of Borrow Areas 1,2,3,4, and 5 would be expected to occur during Phase 1.

Construction activities that would be scheduled for completion by the year 2010 (Phases 2 and 3) would be limited to airport infrastructures required to support airport operations, including expansion of existing parking areas and creation of a new parking garage, and expansion of the north and south satellite concourses. Construction activities for Phases 2 and 3 would require the clearing, grading, and filling of approximately 100 acres of upland forest, shrub, grassland, and wetland communities.

Construction activities that would be scheduled for completion by the year 2020 (Phases 4 and 5) would include construction of new taxiways, additional expansion of the north and south satellite concourses, additional expansion of existing parking facilities, and new aircraft maintenance facilities within

SASA. Construction activities associated with these efforts would occur predominantly in former residential areas that are part of the Port's Noise Remedy Program. Primary impacts would involve the removal of approximately 90 acres of grassland and shrub communities.

Cumulative impacts on plant communities could occur as a result of concurrent or future construction of several other proposed projects in the Airport vicinity. The primary impacts associated with construction and operation of these projects are habitat degradation and removal of vegetation. These impacts would contribute to additional loss of native vegetation and habitat, thus further reducing the limited natural resources in the vicinity of the Airport. Vegetation communities potentially affected include managed grassland, shrub, mixed deciduous/coniferous forest, and wetland.

No loss of vegetation communities would be anticipated during the operational phase of the proposed Master Plan Update alternatives. Indirect impacts may occur as a result of increased local development associated with increased human use of the area.

Impacts on vegetation communities as a result of Alternative 2, 3 and 4 are similar. Slight differences in impacts would occur as a result of the different terminal locations. These differences would almost entirely involve managed grassland.

2. **Wildlife**

Construction activities associated with development of any of the "With Project" alternatives would result in the displacement of wildlife species. Highly mobile animals such as large mammals and birds are able to move away from disturbances into nearby habitats. It is generally assumed, however, that these habitats are at or near carrying capacity and these animals would be required to compete for already limited resources. Less mobile animals such as small mammals, amphibians, reptiles, young animals, and nesting birds, would most likely perish during construction.

Disturbance caused by construction activities in the study area may have an adverse impact on wildlife by disrupting feeding and nesting activities. Clearing and grading activities in the South Borrow Area, adjacent to the large forested tract that encompasses Des Moines Creek Park could have an impact on breeding wildlife. This habitat is used extensively by neotropical migrant and resident songbirds for breeding. Significant noise disturbance, especially in this relatively undisturbed area of the site, could cause birds to abandon their nests.

Construction activities associated with any of the "With Project" alternatives could have adverse effects on wildlife populations in aquatic habitats. Approximately 10 acres of wetland loss would occur as a result of filling and grading. A variety of small mammals and amphibians would be directly impacted by this loss because they rely on these areas for foraging, breeding, and overwintering habitat. Because of their limited mobility, these taxa would likely perish during construction activities. Many of the aquatic habitats have been previously degraded by activities such as construction, fuel spills, and refuse dumping. Exposing soil and removing vegetation could result in an increase in sediments and other non-point pollutants entering adjacent wetlands, contributing to further degradation of aquatic habitat. Many amphibian species are sensitive to pollutants, and water quality in aquatic habitats on the site may be a limiting factor for some of these species.

The conversion of one habitat type to another, such as forested tracts to managed grassland, can have a profound effect on the complement of wildlife species using an area. Loss of forested parcels in the study area would further stress those species dependent on forested habitats because these species would be displaced to similar habitats elsewhere. Increasing urbanization over the past 15 years has fragmented existing forested tracts and greatly reduced the area of forest habitat available for wildlife.

The effects of habitat fragmentation on wildlife has been well documented for birds, but recent studies have been conducted with other taxa. In general, the number of species using a particular habitat decreases as the distance between patches of habitat increases (i.e., fragmentation of habitats typically results in loss of species). Studies with birds have shown that smaller patches of habitat, with proportionately more edge, may be associated with increased predation and nest parasitism.21/

The long-term effect of conversion of one successional habitat to another is a shift in the local carrying capacity. Populations of species that utilize grasslands and more urbanized habitats such as American robin, European starling, house sparrow, raccoon, opossum, and deer mouse would likely increase after construction of the proposed Master Plan Update alternatives, and species that utilize older, more complex successional stages would experience population decreases due to habitat loss.22/

As is noted in the FAA's *Aviation Noise Effects* "The effects of aviation noise on animals ... have revealed that the effects are highly species-dependent and that the degree of the effect may vary widely." Upon construction of the proposed new parallel runway, aircraft would approach the Airport at varying altitudes and locations in comparison to current approach procedures. The varied approach procedures may cause some wildlife species to avoid the Airport area.

Phase 1 construction activities that would be scheduled for completion by the year 2000 would have the greatest effect on wildlife communities. The construction footprint for this phase covers over 300 acres of upland forest, shrub, grassland, and wetland habitat with a new runway length up to 8,500 feet. This mosaic of habitats is located in the area west of the airfield and wildlife species inhabiting these areas would be directly impacted as described above. Phase 1 construction with 7,500-foot runway or 7,000-foot runway options would require the removal of similar habitat in comparison to the 8,500-foot option; however, construction of either shorter new runway option would result in a correspondingly lower impact on wildlife species and habitat. In addition to the 100 acres of habitat removed as a result of Phase 1 construction, approximately 221 acres of upland forest, shrub, grassland, and wetland habitat would be cleared in Borrow Areas 1,2,3, 4 and 5. Construction of the new runway would require the use of approximately 17 million cubic yards of fill. The north and south borrow source areas have been identified by the Port as potential. fill source areas (with the exception of Borrow Area 8, where no fill excavation will occur). Grading, clearing, and excavation of Borrow Areas 1,2,3,4 and 5 would be expected to occur during Phase 1.

Construction activities that would be scheduled for completion by the year 2010 (Phases 2 and 3) would require the clearing, grading, and filling of an additional 100 acres of upland forest, shrub, grassland, and wetland habitat. Impacts on wildlife communities related to these construction activities would be relatively low, in comparison to Phase 1-related impacts. Of the 100 acres of habitat removed during these phases, approximately 60 acres would be managed grassland. This vegetation community offers little wildlife habitat due to low species diversity and frequent mowing.

Construction activities that would be scheduled for completion by the year 2020 (Phases 4 and 5) would require the removal of approximately 90 acres of grassland and shrub habitat. This would occur mostly in the former residential areas of the site. These open grassland areas currently provide habitat for small mammals, birds, and reptiles which, in turn, provides foraging habitat for raptors and predatory mammals. A relative abundance of these urban grassland areas are available in the Airport vicinity and raptors and coyote likely would move

21/ *Species Richness, Population Dynamics, and Wildlife Conservation in Fragmented Landscapes*. Lehmkuhl, John F. College of Forest Resources, University of Washington, 1985.

22/ *Conservation Biology: The Science and Scarcity of Diversity*. Soulé, Michael E. 1986.

away from disturbed areas on the construction site to these areas.

Cumulative impacts on wildlife communities may occur as a result of other projects proposed in the Airport vicinity. Fragmentation of habitat, wildlife disturbance caused primarily by vehicular traffic and airport operations, and other activities associated with urbanization have diminished wildlife use of the area. Continuing development in the vicinity would contribute to additional loss of wildlife habitat and further reduce the limited wildlife resources in the area.

Cumulative impacts on wildlife associated with increased local development would be related to the loss of wildlife habitat and displacement of wildlife species.

No loss of habitat would be anticipated during the operational phase of the proposed Master Plan Update alternatives. Indirect impacts may occur as a result of increased local development associated with increased human use of the Airport area.

Impacts on wildlife as a result of Alternative 2, 3, or 4 are similar. Slight differences in habitat impacts would occur as a result of the different terminal locations. These differences would almost entirely involve managed grassland.

3. Fish

Potential construction impacts on fish and aquatic biota would be both short and long-term in nature. If not effectively mitigated, erosion of exposed surfaces at construction sites could contribute to temporary increases in total suspended solids and sedimentation in Miller and Des Moines Creeks. **(See Chapter IV, Section 23 "Construction Impacts")**

Potential long-term impacts on fish and aquatic biota would result from planned fill activities under the different new runway options. All new runway options would require the realignment and relocation of portions of Miller Creek resulting in the loss of existing fish habitat. For the 8,500-foot new runway option, about 3,700 feet of Miller Creek and its tributaries would be realigned and relocated, including about 980 feet of Miller Creek and 440 feet of the tributary south of Lora Lake (see **Appendix P**). This entire 980-foot section of Miller Creek is adjacent to the Vacca Farms and has a ditch-like character with a sandy bottom. About 200 feet of Des Moines Creek tributary 0377, a Class 3 intermittent stream, would require relocation to complete the extension of Runway 34R. It is assumed that proposed improvements identified in the South Side Aviation Support Area EIS also would be implemented. This would require relocation of 2,200 feet of open channel of tributary 0377, a Class 3 intermittent segment of Des Moines Creek.[23] A 7,500-foot runway alignment option would require relocation of a total of about 2,700 feet of Miller Creek and its tributaries, including about 400 feet the tributary south of Lora Lake with undetermined salmonid use. A 7,000-foot runway alignment would require realignment and relocation of about 2,300 feet of Miller Creek tributaries. These tributary reaches are intermittent Class 3 streams.

Of the different new runway lengths, the 8,500-foot option would directly affect the greatest amount of stream. The 7,500-foot and 7,000-foot runway alignments would affect about 27 percent and 38 percent less stream channel, respectively, than the 8,500-foot runway option. Stream sections directly affected by runway fill would be replaced by reconstructing new channels with enhanced aquatic habitat at relocated alignments under all new runway options and alternatives .

Potential operational impacts on fishery and aquatic resources would also include adverse effects on water quality and water quantity (i.e., hydrology). Chapter IV, Section 10 summarized the hydrological impacts. Pollutant toxicity and potential water quality impacts are discussed in **Appendix M** and Chapter

[23] *South Aviation Support Area Final Environmental Impact Statement*. U.S. Department of Transportation, Federal Aviation Administration, and Port of Seattle, Seattle, WA. 1994.

IV, Section 10. Reduced groundwater recharge and reduced base flows could occur in Miller and Des Moines Creeks as a result of the proposed Master Plan Update alternatives. All new runway length options would result in increased impervious surface area, contributing to reduced groundwater recharge and possibly reduced base flows in the creeks. Reduced base flows could adversely affect stream temperature and dissolved oxygen levels. Exceedingly high temperatures (above 70°F) and low dissolved oxygen (below 6 mg/L) could be lethal or have other adverse affects (e.g., reduced growth) on salmonids and other aquatic biota. It is unlikely that base flow reductions that would be caused by the "With Project" alternatives would contribute to lethal temperatures or dissolved oxygen levels.

Cumulative Impacts: Even with successful implementation of proposed mitigation, construction and operation of the proposed Master Plan Update alternatives and other planned development in the area could contribute to cumulative impacts on fish and aquatic resources. Although stormwater drainage controls would reduce pollutant loading to Miller and Des Moines Creeks some increased pollutant loads would reach receiving water bodies. Potential cumulative impacts would be greatest for bottom dwelling fish and invertebrates that are exposed to pollutants near the sediment-water interface or in contaminated sediments.

(C) Preferred Alternative

As is described in Chapter II, the Port of Seattle staff have recommended the implementation of Alternative 3 (North Unit Terminal) with a new parallel runway with a length of 8,500 feet. All of the "With Project" alternatives, including the preferred alternative, would affect plants and animals. **Appendix P** contains a proposed mitigation plan for this the creek relocations that would compensate for the segments of the creek affected by the proposed airport improvements.

1. Vegetation

Like all "With Project" alternatives, the preferred alternative would result in a direct conversion of approximately 10 acres of wetland, 52 acres of unmanaged grassland, 269 acres of upland forest, 78 acres of shrub, and 303 acres of managed grassland to impervious surfaces.

Phase 1 construction activities scheduled for completion by the year 2000 would affect the greatest amount of vegetation. Construction areas for this phase total over 300 acres. Construction of the proposed new runway itself would require the clearing, grading, and filling of over 200 acres of upland forest, shrub, grassland, and wetland communities. In addition to the 300 acres of vegetation removed as a result of Phase 1 construction, approximately 221 acres of upland forest, shrub, grassland, and wetland vegetation would be cleared in Borrow Areas 1, 2, 3, 4, and 5. To minimize wetland impacts, Borrow Area 8 would not be used as a fill source. No excavation would occur in this portion of the site.

Construction activities for Phases 2 and 3 would require the clearing, grading, and filling of approximately 100 acres of upland forest, shrub, grassland, and wetland communities. Construction activities scheduled for completion by the year 2020 (Phases 4 and 5) would include construction of new taxiways, additional expansion of the north and south satellite concourses, additional expansion of existing parking facilities, and new aircraft maintenance facilities within SASA. Construction activities associated with these efforts would occur predominantly in former residential areas that are part of the Port's Noise Remedy Program. Primary impacts would involve the removal of approximately 90 acres of grassland and shrub communities.

Cumulative impacts on plant communities could occur as a result of concurrent or future construction of several other proposed projects in the Airport vicinity. These impacts would contribute to additional loss of native vegetation and habitat, thus further reducing the limited natural resources in the vicinity of the Airport. Vegetation communities potentially affected include managed grassland, shrub, mixed deciduous/coniferous forest, and wetland.

2. Wildlife

Construction activities associated with development of any of the preferred alternative would result in the displacement of wildlife species. Highly mobile animals such as large mammals and birds are able to move away from disturbances into nearby habitats. It is generally assumed, however, that these habitats are at or near carrying capacity and these animals would be required to compete for already limited resources. Less mobile animals such as small mammals, amphibians, reptiles, young animals, and nesting birds, would most likely perish during construction.

Disturbance caused by construction activities in the study area may have an adverse impact on wildlife by disrupting feeding and nesting activities. Clearing and grading activities in the South Borrow Area, adjacent to the large forested tract that encompasses Des Moines Creek Park could have an impact on breeding wildlife. This habitat is used extensively by neotropical migrant and resident songbirds for breeding. Significant noise disturbance, especially in this relatively undisturbed area of the site, could cause birds to abandon their nests.

Construction activities could have adverse effects on wildlife populations in aquatic habitats. Approximately 10 acres of wetland loss would occur as a result of filling and grading. A variety of small mammals and amphibians would be directly impacted by this loss because they rely on these areas for foraging, breeding, and overwintering habitat. Because of their limited mobility, these taxa would likely perish during construction activities. Many of the aquatic habitats have been previously degraded by activities such as construction, fuel spills, and refuse dumping. Exposing soil and removing vegetation could result in an increase in sediments and other non-point pollutants entering adjacent wetlands, contributing to further degradation of aquatic habitat. Many amphibian species are sensitive to pollutants, and water quality in aquatic habitats on the site may be a limiting factor for some of these species.

The conversion of one habitat type to another, such as forested tracts to managed grassland, can have a profound effect on the complement of wildlife species using an area. Loss of forested parcels in the study area would further stress those species dependent on forested habitats because these species would be displaced to similar habitats elsewhere.

The long-term effect of conversion of one successional habitat to another is a shift in the local carrying capacity. Populations of species that utilize grasslands and more urbanized habitats such as American robin, European starling, house sparrow, raccoon, opossum, and deer mouse would likely increase after construction of the proposed improvements, and species that utilize older, more complex successional stages would experience population decreases due to habitat loss.[24]

Phase 1 construction activities scheduled for completion by the year 2000 would have the greatest effect on wildlife communities. The construction footprint for this phase covers over 300 acres of upland forest, shrub, grassland, and wetland habitat with a new runway length up to 8,500 feet. This mosaic of habitats is located in the area west of the airfield and wildlife species inhabiting these areas would be directly impacted as described above. In addition to the 100 acres of habitat removed as a result of Phase 1 construction, approximately 221 acres of upland forest, shrub, grassland, and wetland habitat would be cleared in Borrow Areas 1,2,3, 4 and 5.

Construction activities scheduled for completion by the year 2010 (Phases 2 and 3) would require the clearing, grading, and filling of an additional 100 acres of upland forest, shrub, grassland, and wetland habitat. Impacts on wildlife

[24] *Conservation Biology: The Science and Scarcity of Diversity*. Soulé, Michael E. 1986.

communities related to these construction activities would be relatively low, in comparison to Phase 1-related impacts. Of the 100 acres of habitat removed during these phases, approximately 60 acres would be managed grassland. This vegetation community offers little wildlife habitat due to low species diversity and frequent mowing.

Construction activities scheduled for completion by the year 2020 (Phases 4 and 5) would require the removal of approximately 90 acres of grassland and shrub habitat. This would occur mostly in the former residential areas of the site. These open grassland areas currently provide habitat for small mammals, birds, and reptiles which, in turn, provides foraging habitat for raptors and predatory mammals. A relative abundance of these urban grassland areas are available in the Airport vicinity and raptors and coyote likely would move away from disturbed areas on the construction site to these areas.

Cumulative impacts on wildlife communities may occur as a result of other projects proposed in the Airport vicinity. Fragmentation of habitat, wildlife disturbance caused primarily by vehicular traffic and airport operations, and other activities associated with urbanization have diminished wildlife use of the area. Continuing development in the vicinity would contribute to additional loss of wildlife habitat and further reduce the limited wildlife resources in the area.

3. **Fish**

Potential long-term impacts on fish and aquatic biota would result from planned fill activities. The proposed new parallel runway would require the relocation of about 3,700 feet of Miller Creek and its tributaries, including about 980 feet of Miller Creek and 440 feet of Class 2 tributary south of Lora Lake (see **Appendix P**). This entire 980-foot section of Miller Creek is adjacent to the Vacca Farms and has a ditch-like character with a sandy bottom. About 200 feet of Des Moines Creek tributary 0377, a Class 3 intermittent stream, would require relocation to complete the extension of Runway 34R and the development of the South Aviation Support Area.[25] This would require relocation of 2,200 feet of open channel tributary 0377, a Class 3 intermittent segment of Des Moines Creek.

Potential operational impacts on fishery and aquatic resources would also include adverse effects on water quality and water quantity (i.e., hydrology). Chapter IV, Section 10 summarized the hydrological impacts. Reduced groundwater recharge and reduced base flows could occur in Miller and Des Moines Creeks as a result of the proposed Master Plan Update alternatives. All of the "With Project" alternatives, including the preferred alternative, would result in increased impervious surface area, contributing to reduced groundwater recharge and possibly reduced base flows in the creeks. Reduced base flows could adversely affect stream temperature and dissolved oxygen levels. Exceedingly high temperatures (above 70°F) and low dissolved oxygen (below 6 mg/L) could be lethal or have other adverse affects (e.g., reduced growth) on salmonids and other aquatic biota. It is unlikely that base flow reductions would contribute to lethal temperatures or dissolved oxygen levels.

Cumulative Impacts: Even with successful implementation of proposed mitigation, construction and operation of the proposed Master Plan Update and other planned development in the area could contribute to cumulative impacts on fish and aquatic resources. Although stormwater drainage controls would reduce pollutant loading to Miller and Des Moines Creeks some increased pollutant loads would reach receiving water bodies. Potential cumulative impacts would be greatest for bottom dwelling fish and invertebrates that are exposed to pollutants near the sediment-water interface or in contaminated sediments.

[25] *South Aviation Support Area Final Environmental Impact Statement*. U.S. Department of Transportation, Federal Aviation Administration, and Port of Seattle, Seattle, WA. 1994.

(4) MITIGATION

Safety issues concerning wildlife-caused aircraft accidents are a serious concern to both Port and the Federal Aviation Administration (FAA). In accordance with FAA requirements, a *Wildlife Hazard Management Plan* was prepared for Sea-Tac Airport. A wildlife control program was developed as part of this management plan and consists of both long-term and short-term programs for controlling wildlife populations in the immediate vicinity of the Airport. The primary goals of these programs focus on: identifying potential wildlife attractants on-site and altering or eliminating these features to reduce the risk of a wildlife and aircraft collision.

Potential construction and operation impacts on water quality, hydrology (i.e., flow regime), and aquatic habitat would be reduced or avoided by proposed mitigation as discussed in **Appendices G and P**. In addition, several required elements of the Port of Seattle NPDES permit for discharges of stormwater runoff and the Industrial Waste System, including the Stormwater Pollution Prevention Plan and the Spill Prevention Control and Countermeasures Plan, would reduce pollutant loads to Miller and Des Moines Creeks and Puget Sound.

Impacts from Airport stormwater runoff would be mitigated by implementing Washington Department of Ecology detention and treatment requirements for stormwater runoff. Although implementation of detention requirements for the 2-, 10-, and 100-year design storms are expected to control increases in peak flows compared to existing conditions, they would not mitigate increased duration and frequency of higher flows following storms. Because there already is a lack of high flow habitat in both Miller and Des Moines Creeks, additional mitigation could be required to minimize adverse impacts on resident and anadromous salmonids caused by high flow events. Potential changes in flow regime could be mitigated by implementing stormwater releases and drainage controls that emulate existing flow conditions. This could include infiltrating treated stormwater runoff (e.g., roof and sidewalk runoff) to reduce stormwater runoff volumes and rates. This would also increase groundwater recharge and maintain base flows. Potential adverse impacts on high and low flows also could be reduced by constructing emergent wetlands that moderate flood flows and contribute to base flows.

Potential adverse impacts on aquatic habitat from channel realignment and relocation or flow regime modifications could be mitigated through properly reconstructing the stream channels to provide enhanced fish and aquatic biota habitat conditions. It is assumed that no stream realignment mitigation of Des Moines Creek is necessary for extension of Runway 34R because the entire length of tributary 0377 flowing through Tyee Golf Course would be aligned based on mitigation proposed in the SASA Final EIS. The U.S. Army Corps of Engineers (Corps), and WDFW would be consulted to ensure that specific features and design standards are implemented to mitigate direct impacts on stream habitat caused by filling of existing stream channels. Proposed realignment and relocations of Miller and Des Moines Creeks or their tributaries would require various permits, including a Hydraulic Project Approval (HPA) from WDFW and a Section 10/404 permit from the Corps. Design requirements and specific conditions of the HPA and Section 10/404 permits would be complied with in the proposed stream channel relocation designs. HPA regulations specify that such plans must provide comparable or better habitat in realigned and relocated sections of streams, including habitat type and structure, channel gradient, substrate composition, and riparian or streamside vegetation.[26]

In addition, City of SeaTac (SeaTac) Zoning Code contains provisions relating to stream relocations and to protection of streams and aquatic resources. These provisions are summarized as follows. Stream buffers range from between 100 feet (Class 1) and 25 feet (Class 3), depending on stream class and presence of salmonid fishes. A buffer of 50 feet is required for Class 2 streams, which are not used by salmonids. Class 1 streams are those identified as "Shorelines of the State" in adopted shoreline master programs. Class 2 streams are perennially flowing streams, and Class 3 streams have intermittent flow and are not used by salmonids. Stream buffers begin at the ordinary high water mark or top of the bank on either side of the stream and extend perpendicular away from the stream. Stream relocations are permitted subject to the stream alteration and mitigation requirements of the zoning code. Special studies and mitigation plans are required that demonstrate maintenance of base flood

[26] *Washington Administrative Code - Hydraulic Code Regulations*. Washington Department of Fish and Wildlife. 1994.

storage volume and functions, replacement or improvement of water quality and fish habitat, and maintenance or improvement of other biological and hydrological functions of the stream. Relocated streams have the same buffer requirements as the previously unaltered stream.

The cities of SeaTac and Des Moines have adopted measures for protecting streams from potential water quality and water quantity impacts, resulting from increased stormwater runoff. Both local governments have adopted the *King County Surface Water Design Manual* (SWDM), which has specific designs standards for stormwater management facilities (e.g., detention ponds and biofiltration swales). The SWDM is in the process of being revised. The revised version is expected to contain design standards that are .comparable to or more stringent than those of the *Stormwater Management Manual for the Puget Sound Basin*.

As noted in Chapter IV, Section 2 "Land Use", the Port of Seattle is involved in interlocal negotiations with the City of SeaTac concerning jurisdictional authority. This process, which is not expected to be completed until after the Final EIS is issued, is expected to resolve the issue of applicability of City of SeaTac regulations to the Master Plan Update.

Potential adverse impacts of Airport operations on high and low-flow in-stream habitat could be mitigated by constructing high and low flow habitat in the relocated and realigned sections of Miller and Des Moines Creeks. This would be accomplished using in-stream structures, such as large organic debris and other channel roughness features, altering the existing channel geometry, and constructing scour pools. The channel improvements would be based on hydrologic and hydraulic analysis to determine where and how structures should be placed to create optimum benefit. This mitigation plan for the stream relocation and habitat improvement in Miller Creek was developed in cooperation with resource management agencies and others including the Corps of Engineers, the Washington State Department of Fish and Wildlife, King County, and the Des Moines Salmon Chapter of Trout Unlimited.

The Port continues to actively participate in the development of cooperative basin plans that include measures to reduce and control point and non-point pollution throughout the Des Moines Creek basin. Effectively implemented basin plans would result in improved water quality and associated benefits to fish and other aquatic biota.

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Seattle-Tacoma International Airport Environmental Impact Statement for the Master Plan Update

Exhibit IV.16-1

Vegetation Communities in the Study Area

- Grassland, Overgrown Fields
- Lawns, Managed Lawns
- Pastures, Hayfields
- Row Crops
- Mixed Shrub
- Coniferous Forest
- Deciduous Forest
- Mixed Deciduous/Coniferous Forest
- Mixed Vegetation Classes
- Wetland

Source: Gambrell Urban, Inc. and Shapiro & Associates, 1996

Scale 1" = 2,500'

0 2500 5000

SCALE IN FEET

Projection: Lambert Conformal Conic
Coordinate System: State Plane NAD27

1, 1996

CHAPTER IV, SECTION 17

THREATENED AND ENDANGERED SPECIES

Section 7 of the Endangered Species Act of 1973 (as amended) requires an analysis of the effects of any major construction projects on any federally listed or proposed threatened or endangered species that may use a project area. Consultation with the United States Fish and Wildlife Service (USFWS) is necessary if any threatened or endangered species would be affected by a project. Records suggest the potential for use of the area affected by proposed Master Plan Update alternatives by bald eagles, peregrine falcons, marbled murrelets, pileated woodpeckers, and great blue herons, as well as several other candidate species. For the Draft EIS, a Biological Assessment was prepared for all federally listed and proposed species in accordance with Section 7(c) of the Endangered Species Act (**Appendix K**). For the Final EIS, an addendum to that Biological Assessment was prepared and is included in **Appendix K**. No significant impacts on threatened and endangered species are expected as a result of the proposed Master Plan Update Alternatives.

(1) EXISTING CONDITIONS

A review of Washington Department of Fish and Wildlife's (WDFW) Priority Habitats and Species Data System and Nongame Data System revealed that no federal or state-listed sensitive, threatened, or endangered wildlife species regularly use the detailed study area. WDFW has, however, documented the presence of great blue heron and pileated woodpeckers in the vicinity of the detailed study area.[1] The great blue heron is currently considered a State monitor species and the pileated woodpecker is a candidate for State listing as threatened or endangered. Great blue heron use open water areas and wetlands throughout the area for forage and perch sites; however, noise disturbance from aircraft operations limits nesting by this species. On several occasions during field surveys, great blue herons were observed perching in the trees surrounding Lake Reba and the Northwest Ponds. Pileated woodpeckers are typically found in dense, mature forests. Excavated snags provide evidence of foraging activity by pileated woodpeckers in the forested portion of the South Borrow Area, upslope from Des Moines Creek. **Table IV.17-1** lists all species of concern that may occur in the focus area.

USFWS indicated that the bald eagle and peregrine falcon are the only federally listed or proposed threatened or endangered species documented to occur in the detailed study area.[2] Wintering populations of bald eagles and migrant peregrine falcons may use portions of the Airport area and shoreline areas along Puget Sound for foraging and perch sites. Wintering bald eagles may occur near the Airport area from October 31 through March 31.[3] No breeding sites for either species occurs in the detailed study area. Two active bald eagle nest exist within the vicinity of the Airport. The closest eagle nest is located on Angle Lake, approximately 0.75 mile southeast of the Airport. The next closest nest is located near Seahurst Park, approximately 2 miles northwest of the Airport. Information on the local bald eagle nests and bald eagle use of the Airport area is provided in the Biological Assessment and associated Addendum (**Appendix K**).

Candidate species listed by USFWS that could potentially occur in the detailed study area include bull trout, black tern, mountain quail, northern red-legged frog, northwestern pond turtle, and spotted frog.

The northern red-legged frog is common throughout western Washington and likely uses wetlands in the detailed study area for breeding and overwintering. From January through June, red-legged frogs may be found in marshes, swamps, ponds, lakes, and slow-moving streams where breeding takes place. During the non-breeding season, these frogs are more terrestrial and can be found in upland grassland or forest. The red-legged frog is currently listed as a Level II candidate for federal listing as threatened or endangered.

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[1] Communication with Tom Cyra, Washington Department of Wildlife, Priority Habitats and Species Program and Nongame Heritage Database, January, 1994.

[2] David Frederick, U.S. Fish and Wildlife Service, Division of Ecological Services, Endangered Species Program, June, 1994.

[3] David Frederick, U.S. Fish and Wildlife Service, Division of Ecological Services, Endangered Species Program, June, 1994.

Field studies conducted for the Biological Assessment indicate that the occurrence of black tern, marbled murrelet, mountain quail, bull trout, northwestern pond turtle, and spotted frog is unlikely because appropriate habitat for these species does not exist in the focus area. The Biological Assessment for all listed and candidate species is presented in **Appendix K.**

TABLE IV.17-1

SPECIES OF CONCERN LISTED AS POTENTIALLY OCCURRING IN THE DETAILED STUDY AREA[4]

Common Name	Status*
Bald eagle	ST, FT
Peregrine falcon	SE, FE
Great blue heron	SM
Pileated woodpecker	SC
Marbled murrelet	SC, FC
Black tern	FC
Bull trout	FC
Mountain quail	FC
Northern red-legged frog	FC
Northwestern pond turtle	FC
Spotted frog	FC
Coho salmon	FC
Steelhead	FC
Chum salmon	FC

*Status

SC = State candidate for endangered, threatened, or sensitive; SE = State endangered; SM = State monitor; ST = State threatened; FC = Federal candidate for endangered, threatened, or sensitive; FE = Federal endangered, FS = Federal sensitive; FT = Federal threatened

[4] Management Recommendations for Priority Species, Washington State Department of Wildlife 1991.

The National Marine Fisheries Service documents three anadramous fish species that are currently candidates for listing as potentially occurring in, or downstream from, the detailed study area. These species are coho salmon, steelhead, and chum salmon.[4]

No rare plants, high-quality native wetlands, or high-quality native plant communities listed by the Washington Natural Heritage Program information System are located in the detailed study area.[5]

(2) FUTURE CONDITIONS

Potential impacts on threatened and endangered species are discussed in the following section. Potential construction and operational impacts for each of the "With Project" alternatives were evaluated for five construction phases scheduled for completion by the years 2000, 2010, 2020.

(A) Do-Nothing (Alternative 1)

The Do-Nothing alternative would result in the Airport area remaining as it exists today, with the exception of the SASA development, the SR509/South Access Road project, and other improvements. Therefore, no impact on threatened or endangered species is expected.

(B) "With Project" Alternatives (Alternatives 2, 3, and 4)

As a result of the proposed new parallel runway construction, approximately 274 acres of forest, grassland, and wetlands, potentially suitable for bald eagle perch and foraging habitat, would be permanently lost. These areas are located in the North Borrow Area, South Borrow Area, the SASA, and west of the existing airfield.

Bald eagles and peregrine falcons occur as transients in the detailed study area. Airport development related construction activities are not expected to significantly affect nesting or wintering bald eagles. The only nesting pairs in the vicinity of the Airport are located near Seahurst Park, approximately 2 miles west of the Airport and at Angle Lake, located about 0.75 miles southeast of the Airport. Construction activities are not likely to affect these nests because of their distance from the site. Wintering populations of bald

[4] Brian Brown, U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, June, 1994.

[5] Sandra Norwood, Washington Natural Heritage Program, Division of Land and Water Conservation, January, 1995.

eagles and peregrine falcons use shoreline areas along Puget Sound for foraging and perch sites. These species may occasionally forage for birds, small mammals, and fish in grasslands, wetlands, and open water areas of the site. However, the proximity of higher-quality habitat immediately outside the study area decreases use of Airport property by these species. The U.S. Fish and Wildlife service concurred with the FAA's finding that the proposed Airport improvements would "not likely adversely affect" peregrine falcons and bald eagles.[6]

The red-legged frog, a candidate species for federal listing as threatened or endangered, may occur in the detailed study area. Red-legged frogs are common throughout western Washington and use wetlands for breeding and overwintering. Impacts on red-legged frogs resulting from construction of the proposed alternatives would include displacement of individuals or local populations, and loss of breeding and overwintering habitat.

(C) <u>Preferred Alternative (Alternative 3)</u>

As was noted in earlier chapters, the Port of Seattle staff have recommended the development of a runway with a length of 8,500 feet and a north unit terminal concept. As a result of the proposed new parallel runway construction, approximately 274 acres of forest, grassland, and wetlands, potentially suitable for bald eagle perch and foraging habitat, would be permanently lost. These areas are located in the North Borrow Area, South Borrow Area, the SASA, and west of the existing airfield.

Bald eagles and peregrine falcons occur as transients in the detailed study area. Airport development related construction activities are not expected to significantly affect nesting or wintering bald eagles. The only nesting pairs in the vicinity of the Airport are located near Seahurst Park, approximately 2 miles west of the Airport and at Angle Lake, located about 0.75 miles southeast of the Airport. Construction activities are not likely to affect these nests because of their distance from the site. Wintering populations of bald eagles and peregrine falcons use shoreline areas along Puget Sound for foraging and perch sites. These species may occasionally forage for birds, small mammals, and fish in grasslands, wetlands, and open water areas of the site. However, the proximity of higher-quality habitat immediately outside the study area decreases use of Airport property by these species. The U.S. Fish and Wildlife service concurred with the FAA's finding that the proposed Airport improvements would "not likely adversely affect" peregrine falcons and bald eagles.[7]

The red-legged frog, a candidate species for federal listing as threatened or endangered, may occur in the detailed study area. Red-legged frogs are common throughout western Washington and use wetlands for breeding and overwintering. Impacts on red-legged frogs resulting from construction of the proposed alternatives would include displacement of individuals or local populations, and loss of breeding and overwintering habitat.

(3) <u>CUMULATIVE IMPACTS</u>

Cumulative impacts may occur from the concurrent or future construction of several other proposed projects in the Airport vicinity; however, these projects are not expected to have a significant impact on threatened or endangered species. Habitat potentially affected by these projects may include perch sites and foraging habitat; however, such habitat features are uncommon in the area of the potential Master Plan Update alternatives areas because the developed nature of the sites. Bald eagles and peregrine falcons are not likely to use regularly forage or perch in such highly developed areas.

(4) <u>MITIGATION</u>

No significant impacts on threatened or endangered species are expected as a result of the proposed Master Plan Update alternatives. Therefore, no mitigation is required.

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[6] Letter from David Frederick, USFWS, December 6, 1995.

[7] Letter from David Frederick, USFWS, December 6, 1995.

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CHAPTER IV, SECTION 18

PUBLIC SERVICES AND UTILITIES

This section addresses the public services and utilities serving the immediate Sea-Tac International Airport vicinity, both on the Airport and off the Airport, that would be affected by the proposed Master Plan Update alternatives. This area (focus area) roughly corresponds to property owned by the Port of Seattle and service areas within nearby jurisdictions.

Public services and utilities impacts include minor effects on existing services for residences, businesses, and other facilities displaced by alternative Master Plan development. Major utilities that would be relocated or protected in-place are the Southwest Suburban Sewer District, Miller Creek Interceptor, Seattle Water Department trunk line, Puget Power third electrical service metering point, and US West trunk lines entering the Airport at S. 176th Street. A variety of existing utility services, both on the Airport and off the Airport, would be abandoned. The extent of the off-airport abandonments would depend on the area ultimately acquired to complete the Master Plan Update development.

(1) METHODOLOGY

The analysis and information presented in this section included a review of published reports and consultation with the Port of Seattle.[1/2/]

(2) EXISTING CONDITIONS

The following describes existing conditions at Sea-Tac and within adjacent service areas.

(A) Utilities

The following summarize the existing water, wastewater, solid waste, electrical, natural resource, telephone, and cable TV services.

1. Water

The Port serves as its own water district for the majority of the Airport property, with supplies obtained from the City of Seattle water system. No residential uses are connected to the Airport water system. Current water demand at the Airport is 172 million gallons per year. By implementing recommended conservation activities (see Appendix Q-B, Water Conservation Plan), annual water consumption is expected to decline to about 166 million gallons per year by 2000. However, long-term water demand at the Airport is expected to increase with the forecast increase in passenger traffic. Based on air traffic projections presented in this Final EIS and with implementation of recommended conservation activities, annual water consumption is forecast to increase to about 213 million gallons per year by 2010, and 266 million gallons per year by 2020. Projected water demands assume conservation activities will reduce water consumption from the current rate of 8.2 gallons per passenger to 7.0 gallons per passenger.[3/]

Five water utility agencies serve the Airport area. The five agencies are the Seattle Water Department, Water District No. 20, Water District No. 49, Water District No. 75 (Highline), and Water District No. 125. Water lines within the Airport are maintained by the Port using water provided by Seattle Water Department. Most of the water facilities in the detailed focus area consist of small lines serving residential and other local users. There is, however, a major 36-inch-diameter Seattle Water Department trunk line crossing the focus area and significant local fire protection trunk lines within Airport property.

Water Storage - The Port maintains 300,000 gallons of on-site storage in an elevated reservoir at the northeast corner of Airport property. Additional storage is available in the City of Seattle system; their 20-million-gallon Riverton Heights reservoir is located less than one mile north of the Airport.

1/ *Seattle-Tacoma International Airport, Third Dependent Runway, Preliminary Engineering Report*, HNTB, 1994.

2/ *Facilities Inventory, Master Plan Update Technical Report No. 4*, P&D Aviation, 1994.

3/ *Comprehensive Water System Plan*, Horton Dennis & Associates, August, 1991.

Pumping System - The two 24-inch mains that serve the Airport are connected directly to the pump stations and serve as suction headers for the pumps. The pump station is located at the northwest corner of the intersection of Air Cargo Road and S. 161st Street.

The existing domestic pumping system is insufficient in capacity to meet existing and future system demands. Also, the existing configuration (of pumping to the elevated reservoir for subsequent gravity flow to the distribution system) does not provide the pressures desired under normal operating requirements. Elevated areas of the Airport that are near the elevated storage tank cannot be supplied from the tank and a separate pump is required to serve these facilities.

2. Waste Sewerage

Sanitary Waste - Four off-site sanitary sewer utility agencies serve the Airport vicinity. The agencies are the Southwest Suburban Sewer District, the Val Vue Sewer District, the Midway Sewer District, and the Rainier Vista Sewer District. Sanitary waste is conveyed to the Midway and Val Vue Sewer Districts for treatment before final discharge into Puget Sound. The existing system is in good condition and is sized to accept loads anticipated in the SeaTac Comprehensive Plan. Additionally, the Port maintains sanitary sewer lines on Airport property. Two significant sanitary sewer trunk lines also traverse the area west of the existing airfield. One is the 27-inch diameter Miller Creek Interceptor, operated by the Southwest Suburban Sewer District. The other is an 8-inch diameter Port sewer line carrying sewage from the northeast Airport area to the Miller Creek Interceptor.

Industrial Waste - The Airport industrial waste sewage system was designed and constructed to service 135 acres of paved airport land. The system consists of a network of underground trunk sewers and surface gutters designed to collect fuel spills and storm drainage from the taxiways and apron areas for treatment. Waste is held in the retention lagoons (620,000 cubic feet total storage capacity) before being treated in the waste treatment plant. An overflow lagoon (approximately 4 million cubic feet capacity) was also constructed in 1977. Plant effluent is then piped to a point downstream from the Des Moines domestic sewage treatment plant, where it joins that plant's effluent and is conveyed to Puget Sound.

3. Solid Waste

Solid waste collection services are addressed in Chapter IV, Section 20, "Solid Waste", of this report.

4. Electrical Power

Electrical power service to the Airport area is provided by Puget Sound Power and Light and Seattle City Light. Puget Power maintains a trunk distribution line generally overhead along S. 176th Street, 12th Avenue S., and S. 160th Street. This generally delineates the Puget Power service area. From the distribution line, there are also two Puget Power services into the Airport property. One service is the third electrical service metering point for the Airport, located at the intersection of S. 176th Street and 12th Avenue S. The other service is a feeder to the Airport Surface Radar (ASR) and Airport Surface Detection Equipment (ASDE) navigation aids on the west side of the airfield.

Seattle City Light maintains overhead distribution lines along S. 156th Way and 12th Avenue S. to S. 160th Street. There are no connections to on-airport services from the Seattle City Light lines in this area.

The emergency power system is a separate 4.16 kV system served normally through tie-breaker switch 52. This system serves loads through ten emergency transformers in the Passenger Terminal, Parking Terminal, and the North and South Satellites. Its primary function is to provide back-up electrical power to the field lighting vault for all runway and taxiway lighting.

5. Natural Gas

Natural gas service to the area is provided by Washington Natural Gas.

AR 039177

Gas mains exist along 12th Avenue S., providing local residential gas service, and on Airport property area providing service to the Weyerhaeuser hangar. These mains are generally 1.25-inch and 2-inch diameters.

There is a 6-inch gas line along Highway 99 that branches at 188th Street with service west into Des Moines. The Airport is served with branch lines from these mains at seven points with 4-inch and 6-inch lines. Existing on-airport lines can be extended to accommodate expansion. The demand on the mains is dependent on a much larger service area.

6. **Telephone**

Telephone service in the Airport Area is provided by US West Communications. Telephone service to the Airport is provided by US West. AT&T serves the administration, and Collins provides automatic call distribution for Alaska, Republic, Wien, and Western airlines reservations.

Off-Airport services, generally to the residential areas west of the Airport, are furnished by overhead lines. Major telephone service to the Airport is provided from the west. At one location, trunk lines enter Airport property near the intersection of S. 176th Street and 12th Avenue S. These trunk lines consist of four cables (one fiber optic cable, one 1800-pair copper cable, one 1200-pair copper cable, and one 200-pair copper cable). The lines serve the Airport and Airport tenants, and also carry communications for three other US West offices (Cherry, Duwamish, and Des Moines). At a second service location, a US West trunk line enters the Airport at Des Moines Way S. and S. 188th Street and extends to the Main Terminal.

7. **Cable Television**

Cable television service in the Airport area is provided by TCI. Currently, TCI maintains feeder lines along 12th Avenue S., S. 156th Way, S. 160th Street, and S. 176th Street.

(B) **Public Services**

Proposed development could also affect the provision of public services. The following sections summarize the current fire and emergency medical services.

1. **Fire**

The Port Fire Department and the City of SeaTac provide fire protection to the Airport area. In general, the Port is responsible for providing fire protection services on Port-owned properties.

The Port Fire Department maintains one full-time fire station at the Airport. The station is located north of the existing North Satellite Building. The estimated response time to existing runways is under 3 minutes. Port has entered into mutual aid agreements and has back-up arrangements with local fire districts as well. Fire District 24 maintains a full-time fire station at S. 200th Street and 30th Avenue S.

Fire stations serving the area adjacent to the Airport include the City of SeaTac fire stations at Angle Lake (2929 S. 200th Street); McMicken Heights (3521 S. 170th Street); and Riverton Heights (3215 S. 152nd Street).

Airport Rescue and Firefighting (ARFF) facilities include a headquarters building, a rescue and firefighting training area, and several paved areas set aside for maintenance and practice drills. The location of the existing ARFF station is near the middle of the Airport, where it provides adequate response to existing runways and airport facilities. The existing ARFF headquarters building houses all rescue and structural response vehicles for the Airport and is located 700 feet north of the North Satellite concourse and approximately 1,100 feet east of existing Runway 16L/34R.

2. **Emergency Medical Services**

The Port Fire Department, King County Paramedics, and private carriers provide emergency medical services to the Airport area. The Port Fire Department's medical aid unit is the first unit dispatched in a medical emergency at the

Airport. The department aid units are staffed with at least one certified Emergency Medical Technician. The emergency dispatcher (or the Fire Department aid unit in contact with the dispatcher) may request a paramedic unit depending on the degree of the emergency. This determination is made either before or after the Fire Department aid unit arrives at the scene.

Several paramedic units serve the Airport area. These include: Medical Unit No. 4 located at approximately S. 154th Street and Highway 99 (serving the City of SeaTac area); Medic Unit No. 5, located at Valley Medical Center in Renton; and Medic Units No. 6 and No. 8 located in south King County.

Transportation to area hospitals is typically done by medic units, although this depends on the seriousness of the accident. If the accident does not warrant medical unit transportation, then a private carrier is contacted (this enables medical unit vehicles to respond to other calls).

3. Police

Police service for all Airport-owned property is provided by the Port of Seattle Police Department. The Police Department is headquartered at the Main Terminal Building and police facilities are scattered around the Airport and total 40,000 square feet. The current actual staff level is 61.4 full time officers. The Police Department has a response time of 5 minutes to security checkpoints.

The Port of Seattle Police Department has mutual aid agreements with local jurisdictions and shares specialized personnel with local police forces upon request. Currently there is a need for additional police officers due to increased security demands at the Airport.[4]

[4] Wilkinson, Tom, 1996. Port of Seattle Police Department, personal communication, January 5, 1996.

(3) FUTURE CONDITIONS

The following paragraphs discuss future impacts associated with each of the Airport Master Plan Update alternatives. Generally, the demand for public services and utilities is expected to be the same for all alternatives.

(A) Do-Nothing (Alternative 1)

Air travel demand would grow as would the demand on public services and utilities. Because these services would remain as is in the future without the proposed Master Plan Update improvements, the adequacy and safety of those services at Sea-Tac could be compromised.

(B) "With Project" Alternatives (Alternative 2, 3 and 4)

Public services and utilities provided by nearby cities and others would be affected slightly by changing airport demands. Local jurisdictions' Comprehensive Plans are formulated on the premise that local public services and utilities will have the capacity to accommodate future growth and related needs. The City of SeaTac is in the process of drafting concurrent requirements and has established a process for siting major public facilities (see Section 2, "Land Use").

Many of the existing public utilities that serve residences, businesses, and other facilities in the acquisition areas would be slightly impacted. These impacts take two forms: (1) potential impacts to public services off-Airport that could occur if the facility providing the services was displaced or if there were some disruption in the flow of service; and (2) impacts could occur if the demand for certain public services decline as related properties are acquired.

Based on the Master Plan Update alternatives, there would be little impact to off-Airport, jurisdiction-provided services, either from displacement or interruption in public services.

The "With Project" alternatives would contribute to the need for additional Port of Seattle police officers to serve the increased geographical patrol area, including the new airport area added west of 12th Avenue South to Des Moines Memorial Drive S. The Police Department has also noted the difficulty of serving the proposed new parallel runway from its current location and has suggested that a more centralized location would be helpful in reducing this potential impact.[5]

The Port of Seattle Police Department also has responsibility for adjacent roadways and may be affected by potential traffic volume increases which could add to the need for additional staff members (traffic volumes would increase under the Do-Nothing as well as the "With Project" Alternatives). The Master Plan Update has identified an existing need for additional facilities space for police services. Planned improvements in facilities would also be affected by the proposed North Terminal expansion area (Alternative 3) which could result in the need to replace police service facilities planned there.

1. **Utility Relocations**

Major utilities in and through the Master Plan area that are recommended for relocation (or protected in place where possible) include the following:

Sanitary Sewer: Southwest Suburban Sewer District, Miller Creek Interceptor and POS sewer line from northeast airport area

- Water: Seattle Water Department trunk line
- Electrical Power: Puget Power third electrical service metering point
- Telephone: US West trunk lines entering airport at S. 176th Street.

The Southwest Suburban Sewer District, Miller Creek Interceptor would be affected by the embankment for the proposed new parallel runway. Abandoning the line without replacement is not feasible, because of the broad area the line serves.

An existing 8-inch-diameter, gravity sewer line extends across the north Airport area from the intersection of 24th Avenue S. and S. 154th Street to the Miller Creek Interceptor near Lora Lake. Approximately 1,400 linear feet of this line would be under the embankment of the north safety area for the new parallel runway. Construction design and plans would address mechanisms to avoid disruption of services during development.

Water: The existing 36-inch diameter Seattle Water Department trunk line crossing the airfield would be directly impacted by the design for the new parallel runway. The actual length of the water line affected would depend on the embankment slope design and would not vary for any of the runway length concepts.

Electrical System: The existing third service metering point, located near S. 176th Street, would be relocated to continue this service.

Telecommunications: The major US West telephone trunk lines entering the airport near S. 176th Street would be relocated south of the south end of the new parallel runway.

2. **Utility Abandonments**

There are a variety of existing utility services, both on and off-airport, that would likely be impacted. The extent of off-airport abandonments depends on the final acquisition area. Based on preliminary acquisition areas, the anticipated abandonments are summarized below. These abandonments are expected to be the same for the 7,000 foot, 7,500 foot, and 8,500 foot new runway options.

Sanitary Sewer: Approximately 15,000 linear feet of existing 8-inch, 10-inch, and 12-inch diameter sanitary sewers; Port of Seattle sewer for the Weyerhaeuser Corporation hangar.

Water: The following water mains would be impacted: Water District 20 (4,300 linear feet of water mains); Water District 49 (15,300 linear feet of water mains); Water District 125 (2,800 linear feet of water mains).

Electrical Power: Puget Power service to residential areas within property acquisition areas would be impacted. No

[5] Wilkinson, Tom, 1996. Port of Seattle Police Department, personal communication with Jeff Buckland, Shapiro and Associates, January 5, 1996.

service disruptions to properties adjoining acquisition areas or to the service provider would be affected.

Telephone Service: Service west of the Airport is provided by US West overhead lines, and any service restoration or reconfiguration to accommodate remaining users in acquisition areas would be done by US West.

Fire: Because of vehicle response times to the new parallel runway, FAR Part 139 requirements, and because the training area is located within the safety area for the new parallel runway, the existing ARFF facility may have to be relocated and a new building required. These facilities would be replaced in a way which enables the Port of Seattle to contain its high responsiveness to critical situations.

(C) Preferred Alternative (Alternative 3)

The following summarizes the impacts associated with the Preferred Alternative, Alternative 3.

1. Utility Relocations

Major utilities in and through the Master Plan area that are recommended for relocation (or protected in place where possible) include the following:

Sanitary Sewer: Southwest Suburban Sewer District, Miller Creek Interceptor and POS sewer line from northeast airport area

- Water: Seattle Water Department trunk line
- Electrical Power: Puget Power third electrical service metering point
- Telephone: US West trunk lines entering airport at S. 176th Street.

The Southwest Suburban Sewer District, Miller Creek Interceptor would be affected by the embankment for the proposed new parallel runway. Abandoning the line without replacement is not feasible, because of the broad area the line serves.

An existing 8-inch-diameter, gravity sewer line extends across the north Airport area from the intersection of 24th Avenue S. and S. 154th Street to the Miller Creek Interceptor near Lora Lake. Approximately 1,400 linear feet of this line would be under the embankment of the north safety area for the new parallel runway. Construction design and plans would address mechanisms to avoid disruption of services during development.

Water: The existing 36-inch diameter Seattle Water Department trunk line crossing the airfield would be directly impacted by the design for the new parallel runway. The actual length of the water line affected would depend on the embankment slope design and would not vary for any of the runway length concepts. The Port of Seattle would coordinate with Seattle Water for relocation of the 36-inch Bow Lake line. Relocation of the pipeline would comply with Seattle Water design requirements and the Port would reimburse Seattle Water for all reasonable costs associated with the relocation.

Electrical System: The existing third service metering point, located near S. 176th Street, would be relocated to continue this service.

Telecommunications: The major US West telephone trunk lines entering the airport near S. 176th Street would be relocated south of the south end of the new parallel runway.

2. Utility Abandonments

There are a variety of existing utility services, both on and off-airport, that would likely be impacted.

Sanitary Sewer: Approximately 15,000 linear feet of existing 8-inch, 10-inch, and 12-inch diameter sanitary sewers; Port of Seattle sewer for the Weyerhaeuser Corporation hangar.

Water: The following water mains would be impacted: Water District 20 (4,300 linear feet of water mains); Water District 49 (15,300 linear feet of water mains); Water District 125 (2,800 linear feet of water mains).

AR 039181

Electrical Power: Puget Power service to residential areas within property acquisition areas would be impacted. No service disruptions to properties adjoining acquisition areas or to the service provider would be affected.

Telephone Service: Service west of the Airport is provided by US West overhead lines, and any service restoration or reconfiguration to accommodate remaining users in acquisition areas would be done by US West.

Fire: Because of vehicle response times to the new parallel runway, FAR Part 139 requirements, and because the training area is located within the safety area for the new parallel runway, the existing ARFF facility may have to be relocated and a new building required. These facilities would be replaced in a way which enables the Port of Seattle to contain its high responsiveness to critical situations.

(4) CUMULATIVE IMPACTS

As is identified in Chapter III "Affected Environment" a number of non-airport related developments are planned in the airport vicinity. These actions could increase demand for utilities and public services in the airport area. However, until specific project plans are completed for these developments, the total cumulative impacts can not be identified. The development of a SR 509/South Airport Access Road could have a notable effect on utilities and public services. Because a specific alignment for the roadway has not been selected, its cumulative impacts can not be identified.

(5) MITIGATION

Mitigation options for maintaining the water service provided by the trunk line would include protecting the existing pipe in-place with a cap structure, or replacing the pipe with a parallel line.

The Airport water system calls for the correction of current system deficiencies that include: improving the intertie with the Highline Water District; replacing the on-site and Riverton Heights Reservoir connections; installing large capacity domestic pumps, which are sufficient to meet current and projected demand and using a direct connection to the Seattle system to provide adequate flow and pressure; and replacing old steel piping and loop dead-end mains.

If the embankment for the proposed new parallel runway is constructed with a 55-degree slope or retaining walls in locations critical to the Miller Creek interceptor line, relocation of the line as a result of increased vertical loading should not be necessary. The final phases of engineering for the Master Plan Update facilities should determine the optimal design for this line.

Some reconfiguration of the Puget Power distribution system may be needed to continue service to the residential area remaining west of 8th Avenue S. after abandonment of the distribution lines to the east. Reconfiguration of the City Light distribution system should not be required.

Puget Power is proposing the addition of a switching station and substation at the Airport. Additional substation capacity would be required to serve the new commercial and industrial load associated with the Airport on the property south of the Airport.

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CHAPTER IV, SECTION 19

EARTH

This section describes existing topography, geology, soils, and sensitive hazard areas associated with the proposed Airport Master Plan Update alternatives. Potential impacts on earth resources that could result from construction and operation (including clearing, grading, excavation, and fill placement), are evaluated and potential mitigation measures identified. Source of fill materials, depth of fill placement, and methods of placement and compaction also are addressed. Actions that would occur in sensitive hazard areas are identified and described.

The Master Plan alternatives would require the movement of the following quantities of earth:

Alternative	Million Cubic Yards of Fill
Alternative 1 (Do-Nothing)	2.4
Alternative 2	23
Alternative 3 (Preferred Alt)	23
Alternative 4	23

Note: Alternatives 2, 3 and 4 assume a new parallel runway with a length up to 8,500 feet, located 2,500 ft west of Runway 16L/34R.

Approximately 17.25 million cubic yards of fill would be needed for a proposed 8,500-foot new parallel runway. Preliminary investigations indicate that all of the required fill could be obtained from a combination of Port of Seattle-owned property, and off-site borrow sources.

Two seismic hazard areas have been identified by the City of SeaTac on the site of the proposed new parallel runway. They are small areas of shallow, loose sediment that likely would liquefy during a seismic event. During construction this sediment would be removed and replaced with compacted fill.

Erosion of exposed soils in areas of excavation, fill, and stockpile would occur during construction. The amount of erosion would depend on the design and implementation of an Erosion and Sedimentation Control Plan.

(1) METHODOLOGY

Methods used to prepare the discussion on earth impacts included review of existing information regarding geologic and soil conditions and sensitive hazard areas within the detailed study area. Results of geotechnical investigations and preliminary engineering design analyses for projects included in the Master Plan alternatives have been summarized in this document.[1/ 2/]

Substantial amounts of fill would be needed to construct the proposed airside and landside improvements. Potential sources of large amounts of fill have been identified on Port of Seattle-owned properties on and adjacent to the Airport (on-site) as well as off-site properties. Impacts to on-site borrow source areas are included in this section. Because impacts to off-site borrow source areas have already been documented during the permitting process for these facilities, they are not addressed in this document.

(2) EXISTING CONDITIONS

The following paragraphs summarize the existing topography and geology.

(A) Topography

Sea-Tac Airport is located along a north-south trending ridge, with elevations decreasing to the west toward Puget Sound. **Exhibit IV.19-1** shows topography. Elevations east of the Airport range from about 325 to 450 feet above mean sea level (MSL). Elevations just west of the Airport range from about 250 to 400 above MSL, but drop to sea level within approximately two miles. North and south of the Airport, elevations generally range from 125 to 400 feet above MSL. From north to south, elevation at the main runways ranges from about 420 feet 340 above MSL.

Slopes along the east side of the Airport are generally moderate. Slopes north and south of the Airport are slightly steeper, particularly those associated with Des Moines Creek on the south end and Miller Creek on the north end. The steepest slopes

1/ *Seattle-Tacoma International Airport Third Dependent Runway Preliminary Engineering Report*, HNTB, 1994.

2/ *South Aviation Support Area Final EIS*, Port of Seattle, 1994.

AR 039184

in the detailed study area exist west of the Airport and are associated with Miller Creek, before the creek turns westward to drain into Puget Sound, and within two large swales that drain westward toward that creek.

The South Aviation Support Area (SASA) is located on a hillslope that generally slopes westward to Des Moines Creek. That creek is located along the eastern margin of the SASA site, and separates it from the adjacent airport. Elevation ranges from 425 feet to 250 feet above MSL. Slopes from east to west generally are moderately steep. Fill material for the existing runway and taxiways is located in the northwest corner of the site. The fill is at an elevation of 340 feet, and has embankment slopes of 50 percent.

The topography of the Des Moines Creek Technology Campus (DMCTC) site is gently rolling with slopes that range from nearly level to about 6 percent. Des Moines Creek flows just outside the northwest boundary of the site. The creek ravine is about 70 feet deep and has side slopes of 40 to 60 percent. Elevation on the sites ranges from 275 to 350 feet above MSL.

(B) Geology

The existing geology and subsurface conditions are described in the following section.

1. **Regional Geology and Stratigraphy**

The Airport and vicinity are located within the Des Moines Drift Plain of the Puget Lowland subprovince of the Pacific Border physiographic province, a north-south trending structural and topographic depression bordered on the west by the Olympic Mountains and on the east by the Cascade Mountains.

The Puget Lowland physiographic subprovince is underlain by Tertiary volcanic and sedimentary bedrock, which is covered with Quaternary glacial and nonglacial sediments to the existing land surface. Deposits of at least four glaciations have been identified with the Vashon period being the most recent (ending approximately 11,000 years ago).

The area around Sea-Tac occupies the top of a north-south trending ridge, which is comprised of deposits from the Vashon glaciation. This ridge is dissected by several swales and gulleys, which have been partially filled as part of the extensive grading performed during initial construction of the airfield and subsequent expansions. Deposits of the older Salmon Springs glaciation are exposed along the walls of stream and river valleys.

Surface geology typically encountered in the vicinity of the Airport is described below.

- Lacustrine Deposits: These deposits consist of peat, silt, and clay and typically occur in shallow depressions overlying glaciolacustrine sand and recessional outwash. These materials are generally not suitable fill or subgrade material.
- Recessional Outwash: This unit typically overlies Vashon till and partly fills depressions and former glacial channels. The predominant type is a medium sand with localized deposits of coarse sand and gravel.
- Glacial (Vashon) Till: This unit is exposed at the ground surface or underlies a variable thickness of Recessional Outwash. It typically consists of an unsorted mixture of highly compacted sand, silt, and gravel that is often cemented.
- Kame Terrace Deposits: A kame terrace is stratified drift that has been deposited between a glacier and an adjacent valley wall. It is comprised of silty sand and gravel with lenses of glacial till and sand, silt, and clay.
- Advance Outwash: This unit underlies the till and typically consists of dense medium sand with variable amounts of gravel. Advance outwash deposits beneath the Vashon Till comprise the uppermost aquifer in the Airport area.
- Salmon Springs Drift: These sediments range from fine-grained lacustrine silts and volcanic ash to silty sand and gravel. This unit includes glacial and non-glacial sediments.

2. Site Subsurface Conditions

Surface geology of the Airport area has been modified by extensive grading and filling during construction of the original airfield and subsequent expansions. Fill of variable thickness overlies native deposits over most of the Airport.

The site of the proposed new parallel runway is primarily underlain by till, often with a thin covering of recessional outwash.[3] Perched groundwater occurs during the winter wet season at depths of 5 to 15 feet below ground surface, and permanent groundwater occurs in advance outwash at a depth of 27 feet (300 feet above MSL). Fill material ranging from 15 to 42 feet thick overlies the native soils at two locations within this area: one is located south of S. 176th Street, and the second is located west of the airfield and north of S. 168th Street. The fill is of variable quality and consistency and contains variable amounts of asphalt and cement concrete and wood debris. It is not likely to be suitable subgrade material. Isolated lenses of perched groundwater occur within the fill. Soft, wet soil and recessional outwash silt, ranging from 5 to 20 feet thick, occur within swales that extend across the proposed new parallel runway site. These materials have low bearing capacity and compressibility, and are generally not suitable fill or subgrade material. Similar low bearing-capacity soils are expected to occur at the north end of the north safety area embankment.

Surface geology on the higher, east side of the SASA is primarily advance outwash sand that is underlain by a thick stratum of dense gravels.[4] Glacial till overlies the advance outwash in the northeast and southeast corners of the site. About 30 feet of fill has been placed on the Seattle Christian School property, which is located in the southeast corner of the site. The fill is comprised of various materials including glacial till, concrete rubble, and other debris. The lower, west side of the SASA is predominantly recessional outwash that overlies glacial till. In some places, the recessional outwash directly overlies advance outwash. Lacustrine deposits, chiefly silt and clay, occur in the vicinity of Des Moines Creek near the western margin of the site. Fill material associated with the south end of the Airport covers the northwest corner of the site. Shallow (perched) groundwater occurs on the site at depths of 10 to 28 feet below ground surface.

Surface geology on the DMCTC site is primarily glacial till. Recessional outwash overlies the till in the northwest corner of the site. Shallow groundwater occurs in wetland areas and in localized areas of perched groundwater above the till.

(C) Soils

Soils in the portion of the study area south of S. 192nd Street are identified in the 1973 *King County Soil Survey* as belonging to the Alderwood Soil Association.[5] Soils north of S. 192nd Street were not mapped during the 1973 soil survey, but were identified as Alderwood soils in a 1952 soil survey.[6] However, since that survey, much of that area has been excavated and covered with varying thickness of fill.

The Alderwood Soil Association consists of moderately well drained, undulating to hilly soils that have dense, very slowly permeable glacial till at depths ranging from 20 to 40 inches. The association is comprised of about 85 percent Alderwood soils, 8 percent Everett soils, and 7 percent less extensive soils. The Alderwood Association occurs as large tracts on uplands and terraces in both the northern and southern parts of King County. It occupies approximately 52 percent of the soil survey area in King County.

The Alderwood soil series is made up of moderately well drained soils that have a "weakly consolidated" to "strongly consolidated" substratum at a depth of 24 to

3/ *Seattle-Tacoma International Airport Third Dependent Runway Preliminary Engineering Report*, HNTB, 1994.

4/ *Seattle-Tacoma International Airport Third Dependent Runway Preliminary Engineering Report*, HNTB, 1994.

5/ *Soil Survey of King County Area , Washington*, USDA Soil Conservation Service, 1973.

6/ *Soil Survey of King County Area , Washington*, USDA Soil Conservation Service, 1952.

40 inches. These soils have formed under conifers on glacial uplands. Slopes are convex and generally range from 0 to 30 percent, but range as steep as 70 percent. Slopes greater than 15 percent are considered an erosion hazard.

The Everett soil series is made up of somewhat excessively drained soils that are underlain by very gravelly sand at a depth of 18 to 36 inches. These soils formed in very gravelly recessional outwash deposits, under conifers. They exist on terraces and terrace fronts and are gently undulating and moderately steep with slopes ranging from 0 to 30 percent. Slopes greater than 15 percent have a moderate to severe rating for erosion hazard.

The less extensive soils in this association occur in depressions or on terraces along small streams. These soils, mostly the Norma, Bellingham, Orcas, Shalcar, and Seattle soil series, have impeded drainage and are subject to flooding. There are substantial areas of Kitsap soils, which have a silty substratum, in the major valleys.

(D) **Hazard Areas**

The City of SeaTac and King County have ordinances regulating the use and development of environmentally sensitive areas and have developed map folios indicating hazard areas within their jurisdictions.[7/,8/] For Earth resources, hazard areas would include erosion hazard, landslide hazard, and seismic hazard. The extent of these hazard areas in the vicinity of the Airport are shown in **Exhibit IV.19-2.**

1. **Erosion Hazard**

Erosion hazard areas are defined by King County and the City of SeaTac as areas with soil types that have been rated by the Soil Conservation Service (SCS) as having severe to very severe erosion hazard. Because this definition is based on SCS soils classification, the County and City sensitive-areas studies identify erosion hazard areas only in portions of the county that have been covered by the *King County Soil Survey*.[9/] The area located south of S. 192 Street is within the limits of the soil survey. Within this area, King County and the City of SeaTac have identified erosion hazard areas along segments of Des Moines Creek. Because the study area located north of S. 192 Street, including the site of the proposed new parallel runway, is outside the limits of the soil survey, no erosion hazard areas have been identified in this area by King County or the City of SeaTac. The embankments along the west side of the existing airfield could potentially be an erosion hazard area, however.

2. **Landslide Hazard**

In landslide-sensitive areas, unstable or potentially unstable conditions increase the risk of a slope failure. Criteria used for determining landslide sensitivity include slope percentage and gradient, soil type, character of underlying stratigraphic units, presence of springs or seepage, and type of vegetative cover. No landslide hazard areas have been identified in the study area by King County or the City of SeaTac. Fill material on the Seattle Christian School property within the SASA site may be a landslide hazard; the hazard potential of this fill has not been verified.[10/] During a stream survey of Miller Creek (Appendix F of the Draft EIS), a recent slump/landslide scar was identified on the left bank (looking downstream) of Miller Creek, near its confluence with the Burien Lake tributary.

3. **Seismic Hazard**

Seismic hazards include ground shaking and associated ground failure (including landslides), soil liquefaction, and surface fault rupture resulting directly from earthquakes. The Puget Lowland physiographic subprovince is a seismically active region and historically has experienced thousands of earthquakes. This has led to the designation of the subprovince in the

7/ *Sensitive Areas Ordinance*, King County, 1990.

8/ *Environmentally Sensitive Areas Ordinance*, City of SeaTac, 1994.

9/ *Soil Survey of King County Area , Washington*, USDA Soil Conservation Service, 1973.

10/ *South Aviation Support Area Final EIS*, Port of Seattle, 1994.

Uniform Building Code for Puget Sound as a zone 3 for seismic risk on a scale of 1 (lowest) to 4 (highest).[11] No evidence has been reported that shows a fault trace across the project area.[12/13]. Although the Airport is in proximity to the Seattle fault, which is recognized as seismically active, the relationship between the Seattle fault and seismic activity in the vicinity of the Airport remains uncertain.[13]

Seismic hazard areas are defined by King County and the City of SeaTac as areas subject to severe risk of earthquake damage as a result of seismically induced settlement or soil liquefaction. These conditions occur in areas underlain by cohesionless soils of low density usually in association with a shallow groundwater table. Such conditions are found in areas of recent river, lake, or beach deposits, and areas of artificial fill. Several seismic hazard areas have been identified in the study area by the County and the City of SeaTac. These areas occur in lacustrine deposits and along segments of Miller, Walker, and Des Moines Creeks. Two seismic hazard areas occur on the site of the proposed new parallel runway.

(E) Borrow Source Areas

Preliminary evaluation of potential borrow source areas indicates that a substantial portion of the anticipated fill needs could be obtained from six sites on Port-owned properties on and adjacent to the Airport.[14/15] The sites, labeled Areas 1 through 5, and Area 8, total approximately 335 acres. Potential on-site borrow source area locations are shown in **Exhibit IV.19-1**. As is noted in Section 11 "Wetlands", maximum use of these on-site borrow areas would result in 21.3 acres of wetland impacts (about 74% of the total wetland impacts). Four borrow sites are located south of the Airport and two are located to the north. Additionally, some of the required fill could be supplied by the excavation of SASA.

1. Borrow Source Area 1

Area 1 is an approximately 110-acre former residential area within the south-runway protection zone of the existing runways. The area slopes gently to moderately to the northwest, toward Des Moines Creek. Elevation ranges from 250 to 350 feet above MSL. A small portion of the north side of Area 1 is mapped as a seismic hazard area. An erosion hazard area for this area is mapped in the southwest corner of the site (**Exhibit IV.19-2**). No landslide hazards have been identified on the site.

Higher elevations of Area 1 are underlain by glacial till. In places, the till has a thin mantle of silty sand fill and recessional outwash. Lower elevations in the northern and western parts of the site are underlain by recessional outwash. At the extreme northern end of the site, the outwash is overlain by organic silt lacustrine deposits. Advance outwash was encountered beneath the till and recessional outwash. Depth to groundwater ranges from 30 to 49 feet below ground surface (bgs). Seasonally perched groundwater occurs at depths of up to 7 feet in recessional outwash that overlies glacial till, and at a depth of 4 feet in the lacustrine deposits.

2. Borrow Source Area 2

Area 2 is an approximately 20-acre site of mostly undeveloped land situated north of S. 216th Street between 15th and 16th Avenues. Slopes are gentle to moderate to the northwest, becoming steeply sloping in the extreme northwest corner near Des Moines Creek. Elevations range from 175 to 275 feet above MSL, with the majority of the site being at or above 225 feet above MSL. An erosion hazard area associated with the Des Moines Creek Ravine is mapped along the northern margin of the site. No seismic or landslide hazards have been identified on the site.

11/ *Uniform Building Code*, International Congress of Building Officials, 1988.

12/ *Seismotectonic Map of the Puget Sound Region, Washington*, Gower, H. D., J. C. Yount, and R. S. Crosson, 1985. U.S.G.S. Map No. I-1613.

13/ Personal communication with Steve Palmer, U.S. Geological Survey, Olympia Office, September 8, 1995.

14/ *Seattle-Tacoma International Airport Third Dependent Runway Preliminary Engineering Report*, HNTB, 1994.

15/ *Draft Borrow Source Study, Proposed New Roadway, Seattle-Tacoma International Airport*, SeaTac, Washington, AGI, April, 1995.

Surface geology is predominantly glacial till. Till thickness ranges from 17 to 31 feet. Up to 13 feet of recessional outwash overlies the till in the southern portion of the site. Advance outwash underlies the till throughout the site. Depth to groundwater ranges from 34 to 39 feet bgs. No perched groundwater was encountered during drilling performed in December, 1993 and November, 1994.

3. Borrow Source Area 3

Area 3 is an approximately 60-acre former residential area that is within the fenced security portion of the Airport runway protection zone. Des Moines Creek Park is located immediately south of Area 3. Elevations range from 250 to 350 feet above MSL, sloping gently to moderately to the southeast. Moderate to steep slopes occur in the south-central portion of the site, in an area that appears to be a former borrow site. Abandoned playing fields east of the site also appear to have been used as a former borrow source.

Recessional outwash blankets Area 3. It occurs to depths more than of 49 feet in the southern part of the site, but is underlain by glacial till at depths of about 10 feet in the northern part of the site. Permanent groundwater occurs between 34 and 87 feet. No seismic or landslide hazards have been identified on the site.

4. Borrow Source Area 4

Area 4 is an approximately 40-acre area on an undeveloped wooded hill situated west of Tyee Valley Golf Course, which is immediately south of Sea-Tac. The top of the wooded hill is about 395 feet above MSL. The site slopes moderately to steeply down all sides of the hill. No seismic, erosion, or landslide hazard areas are identified by King County or the City of SeaTac.

Till was encountered along the east slope of the hill. Till thickness averages about 20 feet. The hilltop and the west and north slopes appear to be underlain by advance outwash that occurs at depths of 118 feet on the hilltop. Pre-Vashon drift underlies the advance outwash in the northern part of the site. Groundwater conditions on the site are highly variable. Groundwater was encountered in the advance outwash and perched on top of the pre-Vashon drift, ranging in depths from 10 to 100 feet bgs.

5. Borrow Source Area 5

Area 5 is approximately 60 acres of vacant and cleared former residential property situated immediately north of SR-518, south of 146th Street, and west of 24th Avenue S. The site slopes moderately to the southwest, toward SR-518. Elevation ranges from 275 to 475 feet above MSL. A landfill is located in the north part of Area 5. A seismic hazard area is mapped along the southwestern boundary of the site. No landslide or erosion hazard areas are identified by King County or the City of SeaTac.

The site is underlain by glacial till that extends to depths of 57 to 103 feet before contacting the underlying advance outwash. Recessional outwash up to 10 feet thick and fill material overlie the till in places. The landfill material ranges from 7 to 17 feet thick and is comprised of silty sand to sandy silt with asphalt, concrete, and wood construction debris. The landfill also is reported to contain 50,000 to 70,000 cubic yards of petroleum hydrocarbon-contaminated street sweeping material. The fill is underlain by 4 to 17 feet of recessional outwash which, in turn, is underlain by glacial till. Depth to groundwater ranges from 110 to 118 feet bgs. In places, perched groundwater occurs in recessional outwash on top of the till.

6. Borrow Source Area 8

Area 8 is an approximately 55-acre site that has been used in the past for both borrow and fill disposal. It is located between S. 154th Street and SR 518, immediately north of the existing runways. A moderate to steep slope extends northward down from S. 154th Street to the site. The slope becomes gently sloping further to the northwest, toward Lake Reba. Elevations range from 270 to 375 feet above MSL, although most of the site is at or below

325 feet above MSL. An area designated as a seismic hazard is located along the northeastern boundary of the site. No erosion or landslide hazard areas are identified by King County or the City of SeaTac.

A steep slope in the southeast corner of Area 8 appears to be largely comprised of fill. Numerous small piles of debris are located immediately south of Lake Reba. Surface water and shallow groundwater associated with Lake Reba occur in the northern low-lying portions of the site, and about 20.7 acres of the site is wetland. The eastern portion of the site has a substantial thickness of fill that contains large pieces of asphalt and concrete debris. Till occurs in the southwest corner of the site to depths of about 12 feet. Advance outwash underlies the till and fill material. Depth to groundwater varies from about 6 to 35 feet bgs.

7. Other On-Site Sources

It is anticipated that the Port of Seattle will investigate the availability of additional borrow source sites on other current or future Port-owned land. Such sites could include the South Aviation Support Area (SASA), where material could be excavated, and then replaced through a landfill-type operation. Prior to the use of this material, the Port would comply with all requisite environmental analysis.

(3) FUTURE CONDITIONS

The following sections summarize the impacts of the four Master Plan Update alternatives on earth resources.

(A) Do-Nothing (Alternative 1)

As is identified in the Final EIS for the South Aviation Support Area (SASA), approximately 2.38 million cubic yards (mcy) of fill would be excavated from the SASA site to complete the approved preferred alternative.[16] About 2.16 mcy could be used as backfill on the site. About 300,000 cubic yards (cy) of imported fill would be needed for retaining wall construction and about 20,000 cy of material would be needed to complete grading for the 34L runway safety area.

Approximately 192,000 to 529,000 cubic yards of material would be excavated for construction of the Des Moines Creek Technology Campus (DMCTC) site, depending on the grading option selected.[17] Some of this material could be used on-site as backfill. Approximately 11,000 to 518,000 cubic yards of excess material would be generated.

Extensive earthwork would be required to prepare the SR509/South Access roadbeds for construction. Between 3.7 and 7.5 miles of new roadway and impervious surface area could be created, depending on the selected alternative. At its maximum extent, the SR509 corridor would cross erosion and landslide hazard areas associated with Des Moines Creek, Massey Creek, and the north and south forks of McSorley Creeks. Two additional erosion hazard areas, and up to five seismic hazard areas could be located within the proposed alignments.[18] Approximately 3.2 to 4.2 million cubic yards of material would be excavated during construction of the SR 509/South Access road project, depending on the alternative selected. Between 3.2 and 8.6 million cubic yards of fill would be required for embankment and roadbed construction.[19]

(B) Alternative 2 (Central Terminal)

Impacts on earth resources as a result of the "With Project" alternatives would include changes to topography, construction in seismic hazard areas, and soil erosion. Measures to control erosion during construction could be required to comply with state and applicable local regulations. Transportation-system impacts related to transport of fill materials are addressed in the

16/ *Final Environmental Impact Statement, South Aviation Support Area*, Port of Seattle, March, 1994

17/ *Port of Seattle Des Moines Creek Technology Campus Draft EIS*, CH2M HILL, 1995.

18/ *SR-509/South Access Road Corridor EIS Phase II Study Geology Discipline Report*, Shapiro and Associates, Inc., March, 1995.

19/ *Draft Environmental Impact Statement and Section 4(f) Evaluation, SR 509/South Access Road Corridor Project*, U.S. Department of Transportation Federal Highway Administration and Washington State Department of Transportation, December, 1995.

AR 039190

Chapter IV, Section 23 "Construction Impacts" of this report.

1. Borrow Requirements

The most extensive earthwork associated with the Master Plan alternatives would occur from the proposed new parallel runway, the 600-foot extension of Runway 16L/34R, runway safety area improvements, and site preparation of the SASA. These elements of each "With Project" alternative would require a total of approximately 23 million cubic yards of compacted fill (**Table IV.19-1**) with approximately 17.25 million cubic yards for an 8,500-foot new runway; 2.4 million cubic yards for extension of Runway 16/34R; 0.98 million cubic yards for the runway safety area improvements; and 2.38 million cubic yards to level the SASA in preparation for support facility construction. The 7,500-foot and new parallel runway options are estimated to require 13.52 and 16.77 million cubic yards of fill, respectively. Cut and fill estimates for the aircraft apron area, additional taxiways, and relocation of S. 156th Way are not available at this time, but are not expected to be of the magnitude of the other airfield projects.

Preliminary estimates indicate that approximately 3.1 million cubic yards of the required fill could be generated during excavation of the new runway site, and approximately 2.16 million cubic yards of fill could be generated during SASA site excavation.

Approximately 17.73 million cubic yards of additional fill would be needed. Preliminary evaluation of potential on-site borrow source areas indicates that 4 to 8 million cubic yards of the required borrow could be obtained from Port-owned properties on and adjacent to the Airport. Resource verification would be necessary to confirm availability, quantity, and quality of fill materials at each potential on-site borrow source area, however. The borrow potential of additional current or future Port-owned properties also may be evaluated. Additional fill could be excavated from the SASA property for construction of the new parallel runway. This material would have to be replaced, however, to develop the airfield level facilities of the SASA as currently proposed. Sixteen potential off-site borrow sources have been identified that could supply the remaining volumes of required fill.[20]

Construction of terminals, airport support facilities, utilities, and roads would occur in developed areas that previously have been excavated and filled. Relatively minor amounts of fill would be required for their construction and could be supplied by off-site borrow sources.

As described in Section 11 "Wetlands", the disadvantage of using the on-site borrow areas could be the impact of about 2.4 acres of wetland. However, as is discussed in Section 23 "Construction", if these borrow areas are not used, an increase in off-airport truck trips would be required to import fill to Sea-Tac Airport.

2. Excavation and Fill Placement

The following sections summarize the excavation and fill placement associated with each of the major construction sites.

a. New Parallel Runway

The aerial extent of runway excavation and construction is shown on **Exhibit IV.19-1**. The new runway site would first be stripped of all vegetation and topsoil. Subsurface material over most of the site is primarily till and recessional outwash that has moderate to good bearing capacity, low to moderate compressibility, and is suitable subgrade material. Over-excavation of unsuitable subgrade materials beneath the proposed new runway, taxiways, and embankment toes would be required, however. Over-excavation would include 10 to 20 feet of soft soils in swales that cross the new runway and north safety area; two existing fills, ranging from 15 to 42 feet thick; and, potentially, soils in wetland areas (as shown in **Exhibit IV.11-2**). Temporary control of groundwater would be

[20] *Seattle-Tacoma International Airport Third Dependent Runway Preliminary Engineering Report*, HNTB, 1994.

AR 039191

needed in the swale and wetland areas. Over-excavation materials would be either distributed over the infill area or disposed of at approved disposal sites.

Additional site preparation would include keying and benching along the existing embankment to create a stable fill base where the existing grades slope beneath the proposed new runway embankment. Streamflow within the swales that cross the proposed site would need to be intercepted and controlled to protect embankment fill stability. Subdrains should also be installed behind any reinforced earth slopes and walls.

The new runway would require construction of an extensive fill embankment to establish the proposed runway and runway safety area grades. Upon completion, runway grades would range from 410 feet above MSL at the north threshold to 350 feet above MSL at the south threshold. To establish these grades, fill thickness would range up to approximately 160 feet at the maximum depth, with typical depths ranging between 30 and 100 feet. Cuts in existing grade of up to 20 feet would be required.

Unreinforced fill slopes no steeper than 2 horizontal to 1 vertical are recommended for most of the safety area embankment west of the new parallel runway. The fill would be placed in layers using common construction techniques. Reinforced earth embankments, allowing embankment slopes of up to 55 degrees from the horizontal, could be used along portions of the west embankment, where practical, to minimize encroachment onto adjacent areas. Construction of reinforced embankments involves establishing a zone of moderately well-compacted fill with layers of steel or polymer reinforcement. Retaining walls would be used wherever practical to minimize encroachment on SR 509.

Fill zones may be used to maximize use of on-site fill and produce a new runway that would have acceptable strength, compressibility, and long-term fill settlement. Three general zones are proposed:

- Zone A. High strength and low compressibility would be required to a depth of 5 feet below runway and taxiway pavement subgrade. High quality, import select fill should be used in this zone to achieve consistent, high compaction.
- Zone B. Moderate strength and low compressibility would be required at depth beneath the runway and taxiways, and for construction of reinforced earth slopes. Import select fill or on-site fill may be used in these areas to provide consistent, moderate to moderately high compaction.
- Zone C. General compacted fill with moderate strength and compressibility would be acceptable for the infill zone of the embankment between any reinforced earth slopes and the runway and taxiway fill zones. Because more variable, low to moderate compaction is acceptable in Zone C, on-site fill could be used.

Embankment settlement could result from settlement of the underlying native soils, settlement of embankment fill during placement due to self weight, and post-placement settlement of fill due to creep and inundation.

Over the long-term, differential settlement of the new parallel runway and taxiway pavements would occur in proportion to variations in fill thickness along the alignment. Differential settlement criteria for the runway pavement is limited to less than 0.5 inch in 50 feet. Based on currently proposed new runway elevations and corresponding fill thickness, it appears feasible that the proposed fill zones can achieve the required differential settlement criteria over runway alignment and the runway and taxiways. Mitigating measures may be necessary to meet differential settlement criteria in areas where there are large changes in fill thickness over relatively short distances, which could occur in the vicinity of the existing fill slope south of S. 176th Street, and where the proposed parallel taxiway would straddle the existing airfield embankment north of S. 170th Street.

Runway construction is scheduled for completion by the year 2001. To meet this schedule, year-round construction of the embankment may be necessary. Import-select fill has low moisture sensitivity and can generally be used during wet weather. The majority of on-site borrow source materials is moderately to highly moisture-sensitive because of its high fines content. This material would not be suitable for year-round construction in fill zones requiring consistent, moderate to high compaction. Construction sequencing could be established to use all-weather construction material from off-site sources in these areas during the winter months. It should be feasible to achieve low to moderate compaction with on-site borrow material during the wetter winter months.

Four stockpile sites have been identified on Port property near the new runway site. These four sites, identified as Stockpile Sites AB, C, J, and O on **Exhibit IV.19-1**, have a total estimated stockpile capacity of 580,000 cubic yards.[21]

21/ *Sea-Tac International Airport, Design Development for a New Runway, Draft Fill Material Stockpile Site Study*, HNTB, December, 1994

b. <u>Runway Extension and Safety Area</u>

Construction of fill embankments would be needed for the proposed extension of Runway 34R and safety area. Approximately 3.38 million cubic yards of fill would be needed for embankment construction. Upon completion, the elevation of the runway and safety area would be about 340 feet above MSL.

Site preparation, construction requirements, fill placement, fill settlement, and seasonal construction restrictions would be similar to those described for the new runway.

c. <u>SASA Site</u>

The SASA would require extensive earthwork to prepare the site for paving and construction of Airport support facilities. The finished area would be approximately 80 acres with a total paved area of about 56 acres. The excavation and construction area footprint is shown in **Exhibit IV.19-1**. The footprint area would be leveled to grades of about 0.7 percent by excavating the higher eastern side of the site and filling the lower west side of the site. Des Moines Creek would be relocated to the east. Post-construction elevation would be about 450 feet above MSL. Fills up to 70 feet thick and cuts up to 60 feet would be necessary to achieve the proposed grades. Because groundwater has been observed at depths of less than 10 feet below ground surface, dewatering would be required in some areas during excavation.

Approximately 2.38 million cubic yards of material would be excavated, most of which could be used on-site as compacted backfill. About 0.22 million cubic yards of topsoil and other material not suitable for fill would need to be disposed of either on Port property for the runway safety area or off-site at a pre-approved disposal site.

A series of retaining walls would be constructed around the site. A reinforced earth wall is proposed for the west side of the site. The walls would have a maximum height of 90 feet, and would be constructed in tiers about 30 feet in height with a 30-foot setback to the next tier. A permanent tieback pile wall would be necessary on the east side of the site. The tieback walls would have a maximum height of 63 feet and would be nearly vertical. Import fill would be needed to construct the reinforced earth wall as on-site fill is unsuitable for this purpose because of its high moisture sensitivity.

d. **Des Moines Creek Technology Campus**

The technology campus would be constructed on 54 acres of the 90-acre site. This site is a large portion of the Borrow Area 1 already identified. As identified in the Draft EIS for the Des Moines Creek Technology Campus, two grading options are under consideration. Grading Option A would conform to the existing topography as closely as possible. Approximately 192,000 cubic yards of material would be excavated, most of which could be used on-site as compacted backfill. Approximately 10,000 cubic yards of excess material would need to be disposed of either on Port property or at an approved disposal site. Under Grading Option B, the hilly terrain of the site would be leveled and finished grades would more closely match the lower elevations of the northwest corner of the site. Approximately 529,000 cubic yards of material would be excavated; 11,000 cubic yards of this could be used on-site. Approximately 518,000 cubic yards of excess material would be generated. These cut and fill estimates assume that all on-site material is suitable for reuse. Most of the excavated material would be glacial till, however. Till has limited use for general site grading and cannot be used for structural backfill. Imported select fill would be required for backfill around footings, retaining walls, pipe trenches, and other structures.

During excavation, shallow groundwater likely would be encountered in wetland areas and in localized areas of perched groundwater above the till. Trenching and sump pumps could be used to control perched groundwater. Permanent drainage systems may be needed in wetlands and low-lying areas to maintain stability of fill slopes and retaining structures.

e. **Airport Area**

Construction of facilities within the airfield, terminal, and support facility areas would require minor amounts of earthwork relative to construction of other elements included in the "With Project" alternative. Because construction would occur in nearly level, developed areas that have previously been excavated and filled, required amounts of excavation and fill, and consequent changes to existing topography, are expected to be small.

f. **Borrow Source Areas**

On-site borrow source areas likely would be used to the maximum extent possible to minimize off-site borrow source area utilization. Deposits on the sites were divided into soil units, and samples from each unit were analyzed to evaluate their suitability for use as fill material and to develop preliminary design criteria. In general, the majority of potential fill material from on-site borrow source areas would be derived from recessional outwash, till, and advance outwash deposits. Fill derived from advance outwash and recessional outwash deposits would likely be less moisture-sensitive than material derived from till deposits. The maximum borrow soil volume (in place) was estimated for each on-site source area. These estimates are based on a maximum cut of 10 feet above the water table or to the pre-Vashon drift across each area; a minimum 30-foot-wide buffer from adjacent property lines; and cut slopes at 2:1 (horizontal:vertical). Other assumptions specific to individual borrow source areas are discussed below.

The following borrow estimates are based on in-place soil volumes on the borrow sites. Volumes of the in-place material may either increase or decrease after excavation, placement, and compaction. The amount of fluff (increase) or compression (decrease) varies with the soil material type and the degree of compaction after placement. Fluff and compaction factors are expected to range from +12% to -9%, respectively, for material obtained from the on-site borrow source areas.[22]

- *Area 1.* About 2.3 million cubic yards of material could be obtained using a uniform 15-foot cut and no material is removed from the DMCTC site. Deeper cuts of up to 45 feet on portions would result in the removal of up to 4.0 million cubic yards of material. Excavation of the low-lying area at the north end of the site was not included in the estimates because of the likely occurrence of shallow groundwater. The current plans for this site call for the removal of up to 500,000 cubic yards.
- *Areas 2.* About 330,000 cubic yards fill material could be obtained using a uniform 15-foot cut. Deeper cuts appear feasible and could provide up to 650,000 cubic yards of fill material.
- *Area 3.* Excavation depths of 0 to 30 feet at the south end of Area 3, and 0 to 55 feet at the north end could produce up to 2.9 million cubic yards of material.
- *Area 4.* About 300,000 cubic yards fill material could be obtained using a uniform 15-foot cut. Deeper cuts up to 30 feet may be feasible west of the proposed SR509 right-of-way, which could result in the removal of up to 2.2 million cubic yards of material. Both estimates assume no material would be excavated within the SR509 corridor.
- *Area 5.* About 1.1 million cubic yards of fill material could be obtained using a uniform 15-foot cut. Up to 1.75 million cubic yards of material may be excavated using a maximum cut of 35 feet in places. Petroleum hydrocarbon-contaminated fill that occurs on the site is included in these estimates.
- *Area 8.* About 20.7 acres of wetland occur on the site. Additionally, the site is located near the Lake Reba detention facility. To avoid impacts on wetlands and the lake, no material will be excavated from Area 8.

3. Hazard Areas

Under Alternative 2, excavation and construction would occur in areas that have been identified as seismic hazards by the City of SeaTac (**Exhibit IV.19-2**).[23] Soils in seismic hazard areas are prone to liquefaction during an earthquake, which could result in vertical displacement of embankments and pavement. Two of these areas are located on the SASA. Geotechnical analysis of soils in these areas indicates that these soils would not liquefy during a seismic event and these areas, therefore, do not pose a seismic hazard.[24] Two seismic hazard areas occur on the site of the proposed new parallel runway. Geotechnical investigations indicate these seismic hazards are loose, saturated sediment, about 5 to 20 feet deep, that likely would liquefy during a seismic event. During runway construction, the sediment would be removed and replaced with compacted fill. Seismic hazard areas also occur on Borrow Source Areas 1, 5, and 8. Excavated cut slopes in these

[22] *Draft Borrow Source Area Study*, AGI, April, 1995.

[23] *Environmentally Sensitive Areas Map Folio*, City of SeaTac, 1991.

[24] *South Aviation Support Area Final EIS*, Port of Seattle, 1994.

areas would be prone to failure during a seismic event.

No landslide hazards have been identified in the study area, based on existing information sources. Fill material on the Seattle Christian School property within the SASA may be a landslide hazard, however.[25] The types of material and placement method used to construct this fill should be investigated to evaluate its landslide potential.

Erosion hazards are identified in the northwest corner of the DMCTC site, along the western margin of Borrow Source Area 1 and along the northern margin of Borrow Source Area 2 (**Exhibit IV.19-2**). These hazard areas are associated with steep ravines along Des Moines Creek. No development or borrow excavation would occur within these hazard areas and their associated buffer areas.

4. **Erosion**

Erosion of exposed soils in areas of excavation, fill, and stockpile would occur during construction. Erosion and sedimentation estimates for the new parallel runway, runway improvements, and on-site borrow source areas are listed in **Table IV.23-3**, and discussed in Chapter IV, Section 10, "Water Quality and Hydrology", and Section 23, "Construction Impacts", of this Final EIS. An Erosion and Sedimentation Control Plan would be designed and implemented to control erosion, dust, and waste disposal and minimize impacts.

(C) **Alternative 3 (North Unit Terminal)**

Under Alternative 3, impacts associated with development of the new parallel runway and the SASA, airfield improvements, relocation of S. 156th Way, and excavation of on-site borrow source areas would be the same as for Alternative 2.

Similar to Alternative 2, construction within the airfield, terminal, and support facility areas would require minor amounts of earthwork relative to construction of other elements included in Alternative 3. Because construction would occur in nearly level, developed areas that have previously been excavated and filled, required amounts of excavation and fill, and consequent changes to existing topography, are expected to be relatively small.

(D) **Alternative 4 (South Unit Terminal)**

Under Alternative 4, impacts associated with development of the new parallel runway and the SASA, airfield improvements, relocation of S. 156th Way, and excavation of on-site borrow source areas would be the same as for Alternative 2.

Similar to Alternative 2, construction within the airfield, terminal, and support facility areas would require minor amounts of earthwork relative to construction of other elements included in Alternative 4. Because construction would occur in nearly level, developed areas that have previously been excavated and filled, required amounts of excavation and fill, and consequent changes to existing topography, are expected to be relatively small.

(E) **Preferred Alternative (Alternative 3)**

As is described in Chapter II, the Port of Seattle staff have recommended the implementation of Alternative 3 (North Unit Terminal) with a new parallel runway with a length of 8,500 feet. The following summarize the earth impacts of this alternative.

1. **Borrow Requirements**

The most extensive earthwork associated with the Preferred Alternative would occur from the proposed new parallel runway, the 600-foot extension of Runway 16L/34R, runway safety area improvements, and site preparation of the SASA. These elements would require a total of approximately 23 million cubic yards of compacted fill with approximately 17.25 million cubic yards for an 8,500-foot new runway; 2.4 million cubic yards for extension of Runway 16/34R; 0.98 million cubic yards for the runway safety area improvements; and 2.38 million cubic yards to level the SASA in preparation for support facility construction. Cut and

[25] *South Aviation Support Area Final EIS*, Port of Seattle, 1994.

fill estimates for the aircraft apron area, additional taxiways, and relocation of S. 156th Way are not available at this time, but are not expected to be of the magnitude of the other airfield projects.

Preliminary evaluation of potential on-site borrow source areas indicates that 4 to 8 million cubic yards of the required borrow could be obtained from Port-owned properties on and adjacent to the Airport. Resource verification would be necessary to confirm availability, quantity, and quality of fill materials at each potential on-site borrow source area, however. The borrow potential of additional current or future Port-owned properties also may be evaluated. Additional fill could be excavated from the SASA property for construction of the new parallel runway. This material would have to be replaced, however, to develop the airfield level facilities of the SASA as currently proposed. Sixteen potential off-site borrow sources have been identified that could supply the remaining volumes of required fill.

Construction of terminals, airport support facilities, utilities, and roads would occur in developed areas that previously have been excavated and filled. Relatively minor amounts of fill would be required for their construction and could be supplied by off-site borrow sources.

As described in Section 11 "Wetlands", the disadvantage of using the on-site borrow areas could be the impact of about 2.4 acres of wetland. However, as is discussed in Section 23 "Construction", if these borrow areas are not used, an increase in off-airport truck trips would be required to import fill to Sea-Tac Airport.

2. <u>Excavation and Fill Placement</u>

The following sections summarize the excavation and fill placement associated with each of the major construction sites.

a. <u>New Parallel Runway</u>

The aerial extent of proposed runway excavation and construction is shown on **Exhibit IV.19-1**. The proposed new runway site would first be stripped of all vegetation and topsoil. Subsurface material over most of the site is primarily till and recessional outwash that has moderate to good bearing capacity, low to moderate compressibility, and is suitable subgrade material. Over-excavation of unsuitable subgrade materials beneath the proposed new runway, taxiways, and embankment toes would be required, however. Over-excavation would include 10 to 20 feet of soft soils in swales that cross the new runway and north safety area; two existing fills, ranging from 15 to 42 feet thick; and, potentially, soils in wetland areas. Temporary control of groundwater would be needed in the swale and wetland areas. Over-excavation materials would be either distributed over the infill area or disposed of at approved disposal sites.

Additional site preparation would include keying and benching along the existing embankment to create a stable fill base where the existing grades slope beneath the proposed new runway embankment. Streamflow within the swales that cross the proposed site would need to be intercepted and controlled to protect embankment fill stability. Subdrains should also be installed behind any reinforced earth slopes and walls.

The proposed new runway would require construction of an extensive fill embankment to establish the proposed runway and runway safety area grades. Upon completion, runway grades would range from 410 feet above MSL at the north threshold to 350 feet above MSL at the south threshold. To establish these grades, fill thickness would range up to approximately 160 feet at the maximum depth, with typical depths ranging between 30 and 100 feet. Cuts in existing grade of up to 20 feet would be required.

Unreinforced fill slopes no steeper than 2 horizontal to 1 vertical are recommended for most of the safety area embankment west of the

AR 039197

proposed new parallel runway. The fill would be placed in layers using common construction techniques. Reinforced earth embankments, allowing embankment slopes of up to 55 degrees from the horizontal, could be used along portions of the west embankment, where practical, to minimize encroachment onto adjacent areas. Construction of reinforced embankments involves establishing a zone of moderately well-compacted fill with layers of steel or polymer reinforcement. Retaining walls would be used wherever practical to minimize encroachment on SR 509.

Fill zones may be used to maximize use of on-site fill and produce a new runway that would have acceptable strength, compressibility, and long-term fill settlement. Embankment settlement could result from settlement of the underlying native soils, settlement of embankment fill during placement due to self weight, and post-placement settlement of fill due to creep and inundation.

Four stockpile sites have been identified on Port property near the new runway site. These four sites, identified as Stockpile Sites AB, C, J, and O on **Exhibit IV.19-1**, have a total estimated stockpile capacity of 580,000 cubic yards.

b. Runway Extension and Safety Area

Construction of fill embankments would be needed for the proposed extension of Runway 34R and safety area. Approximately 3.38 million cubic yards of fill would be needed for embankment construction. Upon completion, the elevation of the runway and safety area would be about 340 feet above MSL. Site preparation, construction requirements, fill placement, fill settlement, and seasonal construction restrictions would be similar to those described for the new runway.

c. SASA Site

The SASA would require extensive earthwork to prepare the site for paving and construction of Airport support facilities. The finished area would be approximately 80 acres with a total paved area of about 56 acres. The footprint area would be leveled to grades of about 0.7 percent by excavating the higher eastern side of the site and filling the lower west side of the site. Des Moines Creek would be relocated to the east. Post-construction elevation would be about 450 feet above MSL. Fills up to 70 feet thick and cuts up to 60 feet would be necessary to achieve the proposed grades. Because groundwater has been observed at depths of less than 10 feet below ground surface, dewatering would be required in some areas during excavation.

Approximately 2.38 million cubic yards of material would be excavated, most of which could be used on-site as compacted backfill. About 0.22 million cubic yards of topsoil and other material not suitable for fill would need to be disposed of either on Port property for the runway safety area or off-site at a pre-approved disposal site.

A series of retaining walls would be constructed around the site. A reinforced earth wall is proposed for the west side of the site. The walls would have a maximum height of 90 feet, and would be constructed in tiers about 30 feet in height with a 30-foot setback to the next tier. A permanent tieback pile wall would be necessary on the east side of the site. The tieback walls would have a maximum height of 63 feet and would be nearly vertical. Import fill would be needed to construct the reinforced earth wall as on-site fill is unsuitable for this purpose because of its high moisture sensitivity.

d. Des Moines Creek Technology Campus

The technology campus would be constructed on 54 acres of the 90-acre site. This site is a large portion of the Borrow Area 1 already identified. As identified in the Draft EIS for the Des Moines Creek Technology Campus, two grading options are under consideration. Grading Option A would conform to the existing topography as closely as possible. Approximately 192,000 cubic yards of material would be excavated, most of which could be used on-site as compacted backfill. Approximately 10,000 cubic yards of excess material would need to be disposed of either on Port property or at an approved disposal site. Under Grading Option B, the hilly terrain of the site would be leveled and finished grades would more closely match the lower elevations of the northwest corner of the site. Approximately 529,000 cubic yards of material would be excavated; 11,000 cubic yards of this could be used on-site. Approximately 518,000 cubic yards of excess material would be generated. These cut and fill estimates assume that all on-site material is suitabie for reuse. Most of the excavated material would be glacial till, however. Till has limited use for general site grading and cannot be used for structural backfill. Imported select fill would be required for backfill around footings, retaining walls, pipe trenches, and other structures.

During excavation, shallow groundwater likely would be encountered in wetland areas and in localized areas of perched groundwater above the till. Trenching and sump pumps could be used to control perched groundwater. Permanent drainage systems may be needed in wetlands and low-lying areas to maintain stability of fill slopes and retaining structures.

e. Airport Area

Construction of facilities within the airfield, terminal, and support facility areas would require minor amounts of earthwork relative to construction of other elements. Because construction would occur in nearly level, developed areas that have previously been excavated and filled, required amounts of excavation and fill, and consequent changes to existing topography, are expected to be small.

f. Borrow Source Areas

On-site borrow source areas likely would be used to the maximum extent possible to minimize off-site borrow source area utilization. Deposits on the sites were divided into soil units, and samples from each unit were analyzed to evaluate their suitability for use as fill material and to develop preliminary design criteria. In general, the majority of potential fill material from on-site borrow source areas would be derived from recessional outwash, till, and advance outwash deposits. Fill derived from advance outwash and recessional outwash deposits would likely be less moisture-sensitive than material derived from till deposits. The maximum borrow soil volume (in place) was estimated for each on-site source area. These estimates are based on a maximum cut of 10 feet above the water table or to the pre-Vashon drift across each area; a minimum 30-foot-wide buffer from adjacent property lines; and cut slopes at 2:1 (horizontal:vertical). Other assumptions specific to individual borrow source areas are discussed below.

The following borrow estimates are based on in-place soil volumes on the borrow sites. Fluff and compaction factors are expected to range from +12% to -9%, respectively, for material obtained from the on-site borrow source areas.

- *Area 1.* About 2.3 million cubic yards of material could be obtained using a uniform 15-foot cut and no material is removed from the DMCTC site. Deeper cuts of up to 45 feet on portions would result in the removal of up to 4.0 million cubic yards of material. Excavation of the low-lying area at the north end of the site was not included in the estimates because of the likely occurrence of shallow groundwater. The current plans for this site call for the removal of up to 500,000 cubic yards.

- *Areas 2.* About 330,000 cubic yards fill material could be obtained using a uniform 15-foot cut. Deeper cuts appear feasible and could provide up to 650,000 cubic yards of fill material.
- *Area 3.* Excavation depths of 0 to 30 feet at the south end of Area 3, and 0 to 55 feet at the north end could produce up to 2.9 million cubic yards of material.
- *Area 4.* About 300,000 cubic yards fill material could be obtained using a uniform 15-foot cut. Deeper cuts up to 30 feet may be feasible west of the proposed SR 509 right-of-way, which could result in the removal of up to 2.2 million cubic yards of material. Both estimates assume no material would be excavated within the SR 509 corridor.
- *Area 5.* About 1.1 million cubic yards of fill material could be obtained using a uniform 15-foot cut. Up to 1.75 million cubic yards of material may be excavated using a maximum cut of 35 feet in places. Petroleum hydrocarbon-contaminated fill that occurs on the site is included in these estimates.
- *Area 8.* About 20.7 acres of wetland occur on the site. Additionally, the site is located near the Lake Reba detention facility. To avoid impacts on wetlands and the lake, no material will be excavated from Area 8.

3. Hazard Areas

Excavation and construction would occur in areas that have been identified as seismic hazards by the City of SeaTac. Soils in seismic hazard areas are prone to liquefaction during an earthquake, which could result in vertical displacement of embankments and pavement. Two of these areas are located on the SASA. Geotechnical analysis of soils in these areas indicates that these soils would not liquefy during a seismic event and these areas, therefore, do not pose a seismic hazard. Two seismic hazard areas occur on the site of the proposed new parallel runway. Geotechnical investigations indicate these seismic hazards are loose, saturated sediment, about 5 to 20 feet deep, that likely would liquefy during a seismic event. During runway construction, the sediment would be removed and replaced with compacted fill. Seismic hazard areas also occur on Borrow Source Areas 1, 5, and 8. Excavated cut slopes in these areas would be prone to failure during a seismic event.

No landslide hazards have been identified in the study area, based on existing information sources. Fill material on the Seattle Christian School property within the SASA may be a landslide hazard, however. The types of material and placement method used to construct this fill should be investigated to evaluate its landslide potential.

Erosion hazards are identified in the northwest corner of the DMCTC site, along the western margin of Borrow Source Area 1 and along the northern margin of Borrow Source Area 2. These hazard areas are associated with steep ravines along Des Moines Creek. No development or borrow excavation would occur within these hazard areas and their associated buffer areas.

4. Erosion

Erosion of exposed soils in areas of excavation, fill, and stockpile would occur during construction. Erosion and sedimentation estimates for the new parallel runway, runway improvements, and on-site borrow source areas are listed in **Table IV.23-3**, and discussed in Chapter IV, Section 10, "Water Quality and Hydrology", and Section 23, "Construction Impacts", of this Final EIS. An Erosion and Sedimentation Control Plan would be designed and implemented to control erosion, dust, and waste disposal and minimize impacts.

(4) CUMULATIVE IMPACTS

The cumulative impact of the SeaTac Master Plan and other proposed projects within the vicinity would be an increased the amount of excavation, fill, and modification of existing topography within the vicinity of the Airport, and an increased potential for erosion. Many proposed projects, such as the Regional Transit Project, would require use of substantial fill, which, together with the Sea-Tac Master Plan Update airport improvements, would increase the borrow demand within the Region.

(5) MITIGATION

An Erosion and Sedimentation Control Plan, including measures specific to site conditions, would be designed and implemented to minimize erosion and sedimentation levels. The plan would include elements for site stabilization, slope and drainageway protection, sediment retention, and dust control on haul routes and borrow sites. Approval of the plan by the applicable local authority and the Washington State Department of Ecology would be required prior to project construction.

As stated in Chapter IV, Section 2 "Land Use", the application and implementation of City of SeaTac regulatory provisions to the Master Plan Update improvements is currently the subject of negotiation through interlocal processes between the Port and City.

If applicable as determined from the result of the interlocal negotiation process between the Port of Seattle and the City of SeaTac (not expected prior to issuance of the Final EIS), the City of SeaTac Environmentally Sensitive Areas Ordinances allow alterations to seismic hazard areas only if (1) site-specific subsurface investigations show the site is not a seismic hazard or (2) mitigation is implemented that renders the proposed development as safe as if it were not located in a seismic hazard area.[26] Two seismic hazards occur on the site of the new parallel runway in relatively small areas of loose, shallow sediment. During runway construction, this sediment would be removed and replaced with compacted fill. If future subsurface investigations verify the occurrence of seismic hazards on Borrow Source Areas 1, 5, and 8, special measures to maintain cut slope stability during excavation in these areas may be required.

A landscaping plan would be developed for areas of excavation and construction. For the borrow source areas, the landscaping plan could include recontouring, seeding, and planting of trees and shrubs. Potential mitigation measures for aesthetic impacts of the proposed new runway are included in Chapter IV, Section 24 "Aesthetics and Urban Design" of this Final EIS.

26/ *Environmentally Sensitive Areas Ordinance*, City of SeaTac, 1994.

TABLE IV.19-1

Seattle-Tacoma International Airport
Environmental Impact Statement

FILL AND BORROW REQUIREMENTS
(Million Cubic Yards)

Master Plan Update Construction Activity	Total Fill Requirements (Million Cubic Yards) Minimum	Maximum
8,500 Ft. Runway	17.25	19.84
RSA Improvements	0.98	1.13
Relocation of S. 154th Street	0.13	0.14
Sub-Total	18.36	21.11
Runway 34R Extension	2.40	2.76
SASA Facilities	2.20	2.53
Sub-Total	4.60	5.29
Total Fill Required	**22.96**	**26.40**

On-Site Borrow Source	Available On-Site Fill (MCY) Minimum	Maximum
Area 1	0.00	0.50
Area 2	0.00	0.65
Area 3	0.00	2.90
Area 4	0.00	2.20
Area 5	0.00	1.75
Area 8[1/]	0.00	0.00
Sub-Total	0.00	8.00
Common Excavation[2/]	2.90	3.10
Total Available Fill	**2.90**	**11.10**

1/ Material will not be excavated from this on-site borrow source due to the large quantity of wetland.

2/ Grading and excavation in the fill placement area will generate additional fill material.

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Seattle-Tacoma International Airport Environmental Impact Statement for the Master Plan Update

Exhibit IV.19-1

Topography and Master Plan Construction Impact Areas

Potential Construction Impact Area

Stockpile Area

Source: Gambrell Urban, Inc., Landrum & Brown, Inc. and Shapiro & Associates, 1995
P&D Aviation, 1994
HNTB, 1994

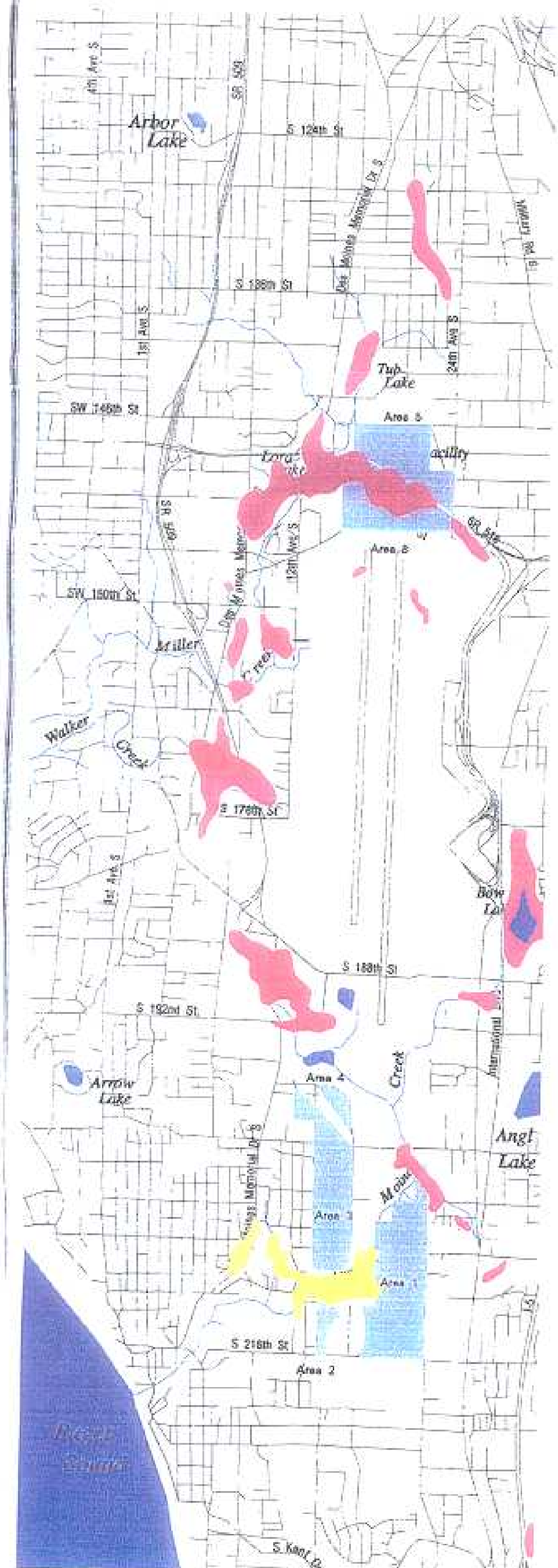
Scale 1" = 2,500'

0 2500 5000

SCALE IN FEET

Projection: Lambert Conformal Conic
Coordinate System: State Plane NAD27

[illegible] 10, 1996



Seattle-Tacoma International Airport Environmental Impact Statement for the Master Plan Update

Exhibit IV.19-2

Earth Hazard Areas

Erosion Hazard Area

Seismic Hazard Area

Potential On-Site Borrow Sources

Source: Gambrell Urban, Inc. and
Shapiro & Associates, 1994
King County Sensitive Areas Map Folio, 1990
City of SeaTac Environ. Sensitive Areas Map, 1991
HNTB, 1994

Scale 1" = 2,500'

0 2500 5000

SCALE IN FEET

Projection: Lambert Conformal Conic
Coordinate System: State Plane NAD27

April 10, 1996

CHAPTER IV, SECTION 20

SOLID WASTE

Solid waste is composed of solid and semi-solid waste, including such things as garbage, rubbish, metal, paper, plastic, and wood, which are generated at Sea-Tac Airport by a wide variety of sources such as:

- Construction activity;
- Airport tenant operations; and
- Airport operations.

Chapter IV, Section 23 "Construction Impacts" summarizes the solid waste impacts of constructing the proposed Sea-Tac Airport Master Plan Update alternatives.

The analysis and information presented in this section are based on a review of published reports, consultation with the Port of Seattle and King County Department of Public Works, Solid Waste Division.

Based on the analysis of solid waste conditions, and the impacts of the Master Plan Update alternatives, no significant impacts on solid waste generation and disposal are expected.

(1) REGIONAL AND LOCAL SITUATION

King County generates over 1.45 million tons of solid waste annually.[1] In 1988, King County adopted a goal of reducing the disposed waste stream by 65% by the year 2000 through waste reduction and recycling (WR/R). In 1993-94, King County reduced and recycled an estimated 45% of total waste generated. With the exception of hazardous waste, all remaining solid waste is disposed in area landfills.

A 1990 study of solid waste in King County (excluding Seattle)[2] indicated that 60 percent of the disposal waste was generated by residential users. The county system includes transfer and disposal of mixed municipal solid waste, special wastes, and recyclables delivered to county-operated transfer stations, landfills, and drop-boxes. Disposal in King County presently occurs in the Cedar Hills Regional Landfill (97 percent of total disposal tonnage) and one rural landfill (3 percent of total disposal tonnage). Hazardous waste is regulated and disposed of according to federal and Washington State rules.

The system of capital facilities owned and operated by the King County Solid Waste Division includes Cedar Hills Regional Landfill, seven transfer stations and two drop-box facilities. In addition, there are eight closed landfills in the Region.

Cedar Hills Regional Landfill has six years of capacity remaining and room to construct additional capacity for the 20-year planning horizon. Its remaining (permitted) capacity is approximately 45 million cubic yards. Modifications to expand the tonnage capacity at Cedar Hills are planned and expected to be completed by 1996. Achieving the King County WR/R goal of 65 percent would extend the useful life of the Cedar Hills Regional Landfill to the year 2020. The King County Solid Waste Division is currently exporting a portion of the County's mixed municipal solid waste to an out-of-County landfill. If waste is exported, the Cedar Hills Landfill would be operated as a back-up facility in the event of an emergency.

Under the existing condition, except for the new Enumclaw Transfer Station, existing King County transfer stations lack capacity for projected Regional waste quantities. The Houghton, Factoria, and Algona stations are near capacity and the First Northeast and Bow Lake stations are projected to reach capacity between 2006 and 2010. The First Northeast, Algona, Factoria, Houghton, and Renton stations have approximate capacities of 350 tons per day (126,700 tons per year), and Bow Lake is 750 tons per day (271,500 tons per year). Enumclaw has a capacity of 200 tons per day (72,400 tons per year). Except for the new Enumclaw Station, existing transfer stations were not designed to be flexible and accept the changing types of recycling services that may be desirable in the future. A transfer/recycling station project is underway to replace the Factoria Station. Siting for stations is being reconsidered by King County and will be determined in their 1997 Plan update.

1/ 1992 *Comprehensive Solid Waste Management Plan*, King County Department of Public Works Solid Waste Division. August, 1993.

2/ *King County Waste Characterization Study*, King County, 1990-91.

The two privately owned and operated transfer/recycling stations are the Regional Landfill Company's (formerly Rabanco) Third and Lander facility and the Waste Management of Seattle (formerly Eastmont) facility.

Federal Aviation Administration guidelines recommend that landfills not be located near airports because of bird strike concerns. However, a waiver can be obtained if it is proven that there is (or will be) no bird strike potential. Waste disposal sites are considered incompatible "if located within 10,000 feet of any runway end used or planned to be used by turbine powered aircraft or located within a 5-mile radius of a runway that attracts or sustains hazardous bird movement into, or across the runways and/or approach and departure patterns of aircraft."[3] There are no landfills located within 5 miles of Sea-Tac Airport. The closest landfill is Cedar Hills, which is approximately 25 miles from the Airport. There are no other landfills being proposed for King County that are inside a 5-mile radius of the Airport.[4]

(2) **EXISTING AIRPORT GENERATED WASTE**

Solid waste collection and disposal services for Sea-Tac Airport are currently provided under contract with Nick Raffo Garbage Company. This company has adequate waste collection and hauling capacity to accommodate existing demands. Construction, demolition, and land clearing waste is forwarded via private venders to either to the Roosevelt Station or to a station located in Arlington, Oregon.

Approximately 2,286 tons of solid waste were directly generated by airport activity in 1993.[5] This represents approximately 0.16 percent of the estimated solid waste generated in King County for that same year. Airport waste composition is shown in **Table IV.20-1**.

TABLE IV.20-1

WASTE COMPOSITION FOR SEA-TAC INTERNATIONAL AIRPORT

Material	Composition (%)	
Organics:	90.2	
Paper		48.2
Plastics		12.4
Wood and Yard Waste		4.0
Other Organics		25.6
Food Wastes		15.1
Inorganics	9.7	
Glass		4.5
Metals		3.8
Miscellaneous Inorganics		1.4

Source: *King County Waste Characterization Study*, King County, 1990-1991.

The Port of Seattle enacted a waste reduction program at Sea-Tac in the early 1990s. A draft plan is scheduled for completion in mid 1995 that will contain future waste reduction/recycling objectives.

There is no information available on the ratios of international and domestic waste at the Airport. International waste is collected from the South Satellite and brought to the Service Tunnel to be processed (autoclaved), then placed in the terminal trash compactor.

All of the waste generated at Sea-Tac Airport is deposited at the Cedar Hills Regional Landfill. The nearest transfer station to the Airport is Bow Lake, located in Tukwila. This station is projected to exceed planned capacity near 2010. The second closest station is the Renton station, 12 miles west of Cedar Hills, is not expected to exceed its 20-year planning horizon.

Construction and demolition-related wastes associated with Sea-Tac Airport are also contracted out with a private firm and these wastes are deposited at Roosevelt Station and at Arlington, Oregon.

(3) **FUTURE CONDITIONS**

This section summarizes the potential solid waste generation in the future with and without airport improvements. The future solid waste impacts are based on present solid waste disposal practices and conditions in King County. Future solid waste generation can be estimated based on the existing annual solid waste generation

[3] *Waste Disposal Sites on or Near Airports, Order 5200.5A*, Federal Aviation Administration.

[4] Personal Communication, King County Solid Waste Division, December 11, 1994.

[5] Personal Communication, K.D. Schmidt, Port of Seattle, Aviation Division, December 12, 1994.

tonnage per enplaned passenger. Based on 1993 waste, each enplaned passenger was found to generate roughly 0.5 pound of waste.

(A) Do-Nothing (Alternative 1)

The Do-Nothing alternative would result in the Airport facilities remaining as they are today. Air travel demand is expected to grow, regardless of the facilities that would be available. Therefore, solid waste generation would be expected to increase.

A forecast of waste generation quantities is derived by using the existing ratio of enplaned passengers to total solid waste generated multiplied by future forecasts of enplaned passengers.[6] Total solid waste generated at Sea-Tac Airport is expected to increase at these following levels:

Do-Nothing (Alternative 1)

Year	Waste Generation
1993	2,286 tons
2000	2,888 tons
2010	3,713 tons
2020	4,635 tons

Source: Port of Seattle, December 1994. Reported in tons per year.

For year 2020, the forecast solid waste generated at Sea-Tac represents a 104% increase over the estimated current Airport-generated solid waste for year 1993. However, the projected increase should not appreciably affect solid waste disposal practices and facilities in King County because current airport-generated wastes comprise only 0.16 percent of the total waste generated. Further, using equivalent forecasts of total waste tonnage levels generated for the entire County, Airport-generated waste would still represent less than 0.2 percent of total waste generated in the county at year 2020. Operating landfills have adequate capacity and useful life to accommodate the projected waste tonnage generated at the Airport. Finally, with the implementation of the Airport's WR/R program, future Airport waste would be that much more diminished.

[6] *1994 Master Plan Update, Technical Report No. 5.* Port of Seattle.

(B) "With Project" Alternatives (Alternatives 2,3 and 4)

As each of the "With Project" alternatives would result in the same level of passengers and aircraft operations as the Do-Nothing, solid waste generation would be expected to be the same. Thus, the projected quantity of waste generated by the Airport would not significantly affect King County solid waste disposal practices and facilities.

	Solid Waste Generation (Tons/yr)	
Year	Alt 1	Alts 2, 3, 4
1993	2,286	NA
2000	2,888	2,888
2010	3,713	3,713
2020	4,635	4,635

Source: Shapiro & Associates, 1994.
NA - Not applicable.

The construction of Alternatives 2, 3 and 4 will result in additional solid waste generation. The construction related solid waste is presented in Chapter IV, Section 23 "Construction Impacts".

(C) Preferred Alternative (Alternative 3)

As the Preferred Alternative would result in the same level of passengers and aircraft operations as the Do-Nothing, solid waste generation would be expected to be the same. Thus, the projected quantity of waste generated by the Airport would not significantly affect King County solid waste disposal practices and facilities.

	Solid Waste Generation (Tons/yr)	
Year	Do-Nothing	Preferred Alternative
1993	2,286	NA
2000	2,888	2,888
2010	3,713	3,713
2020	4,635	4,635

Source: Shapiro & Associates, 1994.
NA - Not applicable.

(4) CUMULATIVE IMPACTS

Additional population growth and urban development in the Region will result in the generation of additional solid waste. Such growth was factored into the preceding analysis. The cumulative impacts of known planned development, in addition to the forecast increase in waste generation at Sea-Tac, is not expected to have a significant impact on the Region's overall waste generation.

(5) MITIGATION

As no significant adverse impacts would result, no mitigation is required.

CHAPTER IV, SECTION 21

HAZARDOUS SUBSTANCES

This section presents a summary of known and potentially existing hazardous materials and waste at Sea-Tac Airport and its vicinity. Also presented is an analysis of potential impacts associated with hazardous substances that might occur through implementation of the Master Plan Update alternatives.

Fifty-one sites are listed in the Vista Environmental Information Agency data base as potential or known hazardous substance sites on the Airport property and in the vicinity of the Sea-Tac Airport. Eleven of those sites are located in the area where a new parallel runway would be completed, and one is located in the proposed SASA Area. Sites located west of the Airport, and those located on Port of Seattle (POS) property, have the potential to be most affected by the Master Plan Update alternatives. Potential sites in the on-site borrow source areas include historic and current businesses in Borrow Source Area 1; a construction debris landfill in Borrow Source Area 5; the abandoned Sunset Park Landfill, located to the north and possibly hydrologically upgradient from Borrow Source Area 5; and the possible presence of residential fuel oil underground storage tanks (USTs) or residual contamination associated with those USTs in all borrow source areas. Operations at the Airport by the Port of Seattle and airport tenants involve the storage and use of hazardous materials and the generation of hazardous wastes.

Potential hazardous substance impacts during construction phases (of all alternatives) could include the exposure of contaminated soils during excavation activities, release of hazardous substances during UST removal and building demolition activities associated with facility relocations, and spills of construction-related hazardous materials (e.g., fuels, lubricants, paints, and asphalt).

Operational impacts associated with hazardous substances, if they were to occur, would be similar under all Master Plan Update alternatives analyzed and would be related to the increase in aircraft operations. Increased aircraft operations would require greater storage and use of fuel and other hazardous materials. With the increase in fuel storage, refueling operations, airport and aircraft operations, and greater use of hazardous materials in the terminal, the potential for accidental releases of these substances increases, resulting in a greater potential for adverse environmental impacts.

Mitigation for potential construction-related hazardous substance impacts would include developing a Spill Prevention, Control, and Countermeasures Plan (SPCCP) outlining procedures for transport, storage, and handling of hazardous materials, and a Hazardous Substances Management and Contingency Plan outlining procedures for removal, storage, transportation, and disposal of hazardous wastes. All federal, state, and local rules and guidelines concerning the handling and disposal of hazardous substances would be followed.

The risk of operational impacts resulting from releases of hazardous substances will be minimized once existing facilities are upgraded to accommodate increased aircraft operations; fuel storage, distribution, and leak protection systems are modernized; and provisions of the SPCCP and the Pollution Prevention Plans (PPP) covering Port and tenant activities are implemented.

(1) METHODOLOGY

Existing conditions are based on various information sources including federal, state, and local data bases. Agency data base searches were conducted by Vista Environmental Information. Information on use and storage of hazardous materials and generation of hazardous waste at the Airport was provided by the Port.1/ Information on airport tenant activities that involve hazardous substances was compiled from interviews with fuel providers, Port personnel, and available reports and studies.2/ Finally,

1/ *Seattle-Tacoma International Airport Spill Prevention Control and Countermeasure Plans,* Draft. Port of Seattle, 1995 and *Port of Seattle Sea-Tac International Airport Pollution Prevention Plan Executive Summary,* Morse Environmental Managers, Inc., 1994.

2/ *Technical Report No. 7B, Other Facilities Requirements and Options, Airport Master Plan Update* P&D Aviation, 1994. *Environmental Site Assessment of the SeaTac Third Runway Project Area*. Shapiro and Associates, Inc. 1995. *South Aviation Support Area Phase I Hazardous Waste Environmental Assessment.* Parametrix, Inc., 1992. *South Aviation Support Area Final Environmental Impact Statement.* Federal Aviation Administration, 1994.

information on historical land use in the potential on-site borrow source areas was gathered from various sources including historical aerial photographs, Polk City Directories, Cole Metropolitan Household Directories, and other regional studies.[3/]

(2) EXISTING CONDITIONS

A review of agency data bases for Sea-Tac Airport and vicinity revealed a variety of sites involving past, current, and potential releases to the environment of hazardous substances. These include 18 listed leaking underground storage tanks (LUST) sites; 7 sites suspected by the Washington State Department of Ecology (Ecology) as being contaminated by hazardous substances (SCL); one site confirmed by Ecology as contaminated by hazardous substances, one site under review by the U.S. Environmental Protection Agency (CERCLIS); one site known to have had a hazardous substance spill (ERNS); one site listed as a Resource Conservation and Recovery Act (RCRA) regulated treatment, storage, and/or disposal facility; 7 sites listed as RCRA small generators (Sm Gen); one site listed as a RCRA large generator (Lg Gen); and 34 sites where underground storage tanks (UST) are listed as being present. The hazardous substance risk sites, their addresses, and agency data bases on which they are listed are presented in **Table IV.21-1** and are shown on **Exhibit IV.21-1. Table IV.21-2** presents those contaminants and compounds confirmed or suspected to be present at each site listed in **Table IV.21-1**. Many sites listed are found on more than one agency data base. It is important to note that a site being reported on one of these lists does not necessarily mean that a release of a hazardous or toxic substance has occurred. In many cases, such materials are routinely used and disposed of safely, and little or no risk is posed to the environment. Sites known or believed to be contaminated, either currently or in the past, are reported in the LUST, SCL, NPL, and ERNS lists.

Contaminants, if present, at the sites west of 12th Avenue South (Risk Sites 1-4, 7, 9, and 10) would not impact current Port property on and around the Airport, as the risk sites are hydrologically downgradient. Sites north of Sea-Tac (Risk Sites 15, 20, 23, 28, and 32) represent little to no risk because of their distance from lands which would be affected by the Master Plan Update alternatives.

Contaminants originating at Site 5 (AFP Partners/Sea-Tac Distribution), if present, could have migrated onto an adjoining area. Risk sites immediately east of the Airport (Risk Sites 13, 14, 16, 24, and 25) present potential risk because of their close proximity and location upgradient from Sea-Tac. Contaminants originating from these sites could migrate or may have migrated onto Port property. Contaminants originating on sites southeast of the Airport (risk sites 19, 29, 30, and 31) may present some risk to the area planned for development as the SASA. The remaining sites (6, 11, 12, 17, 18, 20, 21, 26, 27, 33, and 35-38) are located on and are directly associated with Sea-Tac Airport. Contaminants may be present in nearby soils at these sites.

Additionally, an area immediately north of the IWS was used to landfarm sludge from the IWS lagoons. Up until 1981 lagoon sludge was periodically removed from lagoon 1 and land farmed (i.e., tilled to enhance natural biodegradation of contaminants) in an upland area north of the IWS treatment plant in the vicinity of a proposed snow equipment storage shed. This practice was abandoned in 1981. A 1990 study of the land farmed sludge site found a layer of contaminated soil between 9 and 15 feet thick with total petroleum hydrocarbon concentrations (TPH) varying from 130 to 1,800 parts per million (ppm). The Model Toxics Control Act (MTCA) defines and regulates disposal of hazardous and dangerous wastes and establishes specific cleanup levels, depending on zoning and existing or proposed land uses (e.g., industrial, commercial) in Washington. TPH levels for some of the land farmed sludge layer are well above the MTCA Method A cleanup levels of 200 parts per million (ppm), which is applicable to this site. Samples were tested for benzene, ethylbenzene, toluene, and zylene (BETX) contamination. BETX levels were below MTCA Method A cleanup levels. No TPH levels above MTCA cleanup levels were found in samples collected at the contact between the land farmed sludge layer and underlying fill. Prior to construction of the snow equipment storage shed, some TPH-contaminated soils may require off-site disposal at an approved facility in accordance with applicable regulations. A 1990 study of lagoon sludge sediment indicated that pond sludge was not a dangerous waste according to MTCA standards. ECOLOGY (which implements MTCA) has permitted the sludge to remain in the IWS lagoons pending completion of the IWS Engineering Report, which is required as part of the NPDES permit. Pond sludge will be removed and the pond relined in 1996.

[3/] *Abandoned Landfill Study in King County.* Seattle-King County Department of Health, 1985.

(A) Port of Seattle Operations at Sea-Tac

As part of its day-to-day operations at Sea-Tac Airport, the Port of Seattle stores and uses hazardous materials, and generates and disposes of hazardous waste. Hazardous materials used by the Port are stored in seven underground storage tanks (USTs), 13 above ground storage tanks (ASTs), tanker trucks, drums, and containers at the following locations as shown in **Exhibit IV.21-2**:

- Fire Station - located just north of the North Satellite Terminal Building and west of Air Cargo Road;
- Auto Shop - located in the maintenance building which is north of the Fire Station and south of the United Airlines Maintenance Facility Building;
- Paint Shop - located in the maintenance building;
- Maintenance Building Yard - located immediately south of the maintenance building;
- Supply/Loading Dock Area - located in the main terminal building on the tunnel level;
- Boiler Room and Cooling Towers - the boiler room is locate in the main terminal building on the tunnel level, the cooling towers are located immediately south or parking lot 5 on the south side of the main terminal;
- Conveyor Shops - one shop is located at the main terminal building, another shop is located at the south satellite, and the remaining conveyor shop is located at the north satellite;
- Engineering Yard/Building - located by the water tower just east of 160th Street;
- Contractor Staging Areas - one located southwest of IWS Lagoon 3, one located at Gate E-35 near the northeast corner of the field, two located north of the runways, and one located at the engineering yard;
- IWS Treatment Facility - located in the southwest corner of the Airport; and
- Hazardous Materials Storage Area - located in the southwest portion of the airfield near the IWS treatment facility.

Table IV.21-3 presents a summary of Port of Seattle hazardous materials storage at Sea-Tac. The hazardous materials storage area consists of two small storage buildings used to temporarily store hazardous materials and waste generated by the Port. As of November 1994, materials stored at the hazardous materials storage area include those listed in **Table IV.21-4**.

Until recently, the Port of Seattle Fire Department has conducted annual fire fighter training at the burn pit located near the southwest corner of the Airport. Typically, such training occurred over a three-night period during November. Additionally, fire fighters from King County International Airport (Boeing Field) conducted annual fire fighter training at Sea-Tac. Typically, approximately 79 individual fires, lasting about 5 minutes each, were set and extinguished annually. Each fire consumed approximately 400 gallons of fuel that consisted of roughly 85% Jet A Fuel and 15% unleaded gasoline. Contaminated or waste fuel was not used. Fires were extinguished using 20 to 40 gallons of Aqueous Film Forming Foam (AFFF) that contains glycol foam (3%) and water. Use of the burn pit was suspended during 1995. A facility at Moses Lake, Washington, is planned to be used in 1996, and a permanent fire fighter training facility at North Bend, Washington, is anticipated to be in use in 1997.[4/]

Port of Seattle operations at Sea-Tac generated 17,406 pounds of extremely hazardous waste and 77,098 pounds of dangerous waste in 1993. Extremely hazardous wastes include cleaning solvent, waste oil and freon, oil booms contaminated with toluene, waste gasoline, gas-soaked rags, and polycyclic chlorinated biphenols (PCBs). Dangerous wastes include crushed fluorescent lamp glass (fluorescent light tubes contain mercury), paint-related waste, runway rubber, oil booms contaminated with benzene (<500 parts per million (ppm) benzene), antifreeze and urea, sand blast residue, household hazardous waste (small quantities of various hazardous materials that cannot be combined with other materials for disposal), and ethylene glycol.[5/]

4/ Mike Madella, Port of Seattle Fire Department, September 15, 1995.

5/ *Sea-Tac International Airport Pollution Prevention Plan Executive Summary*, Morse Environmental Managers, Inc., 1994.

B. Airport Tenant Operations

Airport tenant operations also include the use of hazardous substances in their day-to-day operations. Activities that require the use of hazardous materials and the generation of hazardous waste include aircraft fueling operations, aircraft maintenance, and ancillary operations associated with aircraft transportation.

Olympic Pipeline Company supplies all the Jet A fuel stored and used at Sea-Tac Airport. Olympic Pipeline operates an above-ground storage facility with a 24.1-million-gallon capacity at the south end of the Airport (Risk Site 6, Site 9). The aboveground storage tanks are supplied by a pipeline directly from the oil refineries located in Skagit and Whatcom Counties. The pipelines are monitored for leaks by a leak detection system that is monitored on a 24-hour basis. The pipeline is also checked every two to three years by a "smart pig," a device that inspects for corrosion or defects that could lead to future problems. The tanks are periodically inspected by ultrasound, cleaned, and visually inspected every two to three years.[6/] A total of 98 USTs and ASTs are located at Sea-Tac. Seventy-eight (78) of these are maintained and are the responsibility of airport tenants. The remainder are the responsibility of the Port of Seattle. The majority of the storage is controlled by three major carriers. United Airlines maintains 11 USTs with a 420,000-gallon capacity storing Jet A Fuel, two USTs with a 32,000-gallon capacity storing auto gas, and one 20,000-gallon AST storing glycol. Northwest Airlines maintains 14 USTs with a combined capacity of 420,000 gallons storing Jet A Fuel and one 2,000-gallon UST storing heating oil. Delta Airlines maintains three USTs with a combined capacity of 100,000 gallons storing Jet A Fuel, four ASTs with a combined capacity of 14,000 gallons storing glycol, one 2,000-gallon AST storing A/C exterior cleaner, and two ASTs with a combined capacity of 20,000 gallons storing auto gas.[7/] An estimated 1,092,000 gallons of Jet A fuel is used at Sea-Tac Airport daily.[8/]

Sea Port Petroleum supplies all aviation and auto gasoline to airport tenants. It is estimated that 6,000 gallons of aviation gasoline and 7,500 gallons of auto gasoline are used by airport tenants on a monthly basis.[9/] Signature Flight Service distributes aviation and auto gasoline at Sea-Tac Airport. This fuel is distributed via tanker trucks.[10/]

Other hazardous materials used by Airport tenants include various solvents, cleaning fluids, detergents, cleansers, sealants, adhesives, lubricants, antifreeze, and fuels. These materials are typically stored in small quantities and are replaced when stored supplies are exhausted. The quantities stored and used do not likely present a tangible risk to human health and the environment.

C. Environmental Site Assessment Summary

Environmental Site Assessments (ESA) were conducted for the land areas to be affected by alternative airport development to identify environmental issues presented by the potential presence of any toxic or hazardous materials in areas being considered for development.[11/,12/] The complete ESA for the new runway embankment area is included as **Appendix L.** The ESA for the South Aviation Support Area is included in the *South Aviation Support Area Final Environmental Impact Statement*. The following paragraphs summarize the findings of the site assessments.

1. New Runway Development Area

The new parallel runway development area is located west of the north half of Sea-Tac Airport and is bound by State Route (SR-) 518 to the north, SR-509 to the west, and S. 176th Street to the south, and includes the undeveloped northwestern portion of the Airport. The ESA consisted of reviews of aerial photographs, Polk City Directories, Sanborn Fire Insurance and Metsker

6/ David Justice, phone conversation, September 7, 1995. Olympic Pipeline.

7/ STIA Tanks Inventory Database. Port of Seattle, September 12, 1995.

8/ Ron Greene, phone conversation December 28, 1994 with staff at Olympic Pipeline Company.

9/ Phone conversation with Lisa McGhee, Signature Flight Service, January 7, 1995.

10/ Randy Allen, phone conversation December 29, 1994, Signature Flight Service.

11/ *Environmental Site Assessment of the SeaTac New Runway Project Area.* Shapiro and Associates, Inc., 1995.

12/ *South Aviation Support Area Phase I Hazardous Waste Environmental Assessment.* Parametrix, Inc, 1992.

historical maps, regulatory lists, and reports; and site reconnaissance.

The preliminary assessment indicated that there is little potential for contamination associated with activities that have occurred or currently occur on the undeveloped northwestern portion of the airport facility. A review of federal and state agency data bases revealed one site north of SR-518 (Risk Site 5), two sites immediately south of South 176th Street (Risk Sites 9 and 10), three sites on the Airport (Risk Sites 6, 11, and 27), and five sites west of the Airport in the new parallel runway development area (Risk Sites 1, 2, 3, 4, and 7) that are either confirmed or suspected as environmental contamination risk sites. The potential for widespread contamination of the area appears relatively low. Localized contamination, however, is likely.
Potential risks include soil and groundwater contamination by petroleum products associated with underground storage tanks at existing or former residential properties, current or former gas stations, and commercial and industrial facilities, including Sea-Tac Airport. The concrete batch plant currently operating at the north end of this area (Site 7) presents a small risk, as does any site on which machinery that uses petroleum products operates or is serviced.

The large volume of fill underlying the north end of the Sea-Tac runways also presents some risk, primarily because, at the time the fill was placed, monitoring the fill for the presence of hazardous waste generally was not practiced. Some potential exists, therefore, for the presence of zones of contaminated soil within the fill mass.

2. <u>South Aviation Support Area</u>

A Phase I ESA on the proposed South Aviation Support Area (SASA) was prepared in 1992.[13] This study included review of historical records of land use, review of agency records for evidence of past or present (1992) hazardous waste storage and use, and site visits. The complete SASA Phase I ESA is included in the SASA Environmental Impact Statement (EIS) and is available in libraries where this EIS has been placed on file.

One UST site was reported to be located on SASA at the Tyee Golf Course Pro Shop. These tanks were reportedly removed without notifying the Washington State Department of Ecology (Ecology) so they still appear in Ecology's UST data base. Leaks from USTs and spills of petroleum products at the Airport have resulted in contamination of soils at SASA and may have impacted groundwater.

Two buildings, Building 19040 and 19050 were used as a carpentry shop and paint shop, respectively. Activities associated with painting in Building 19050 may have resulted in contaminants (paints and solvents) being introduced to nearby soil and groundwater. This building was serviced by a septic system. Paint disposed of in the building's sinks and drains, and cleaning of paint brushes in the sinks, may have resulted in hazardous materials collecting in the septic tank.

Budget Rent-a-Car maintains four USTs (Risk Site 13, **Exhibit IV.21-1**) at the north SASA.

3. <u>On-site Borrow Source Areas</u>

Six general areas near the Sea-Tac Airport and owned by the Port of Seattle have been targeted as potential on-site borrow sources for construction of a new parallel runway. The areas being considered (numbered 1 - 5, and 8) are shown in **Exhibit IV.19-2**. Each area was assessed to ascertain whether soils in any of the potential borrow source areas may be contaminated with substances that could have adverse effects.

Sources of historical information reviewed for this abbreviated assessment included aerial photographs;[14] Polk City Directories;[15] Cole Metropolitan

[13] *South Aviation Support Area Phase I Hazardous Waste Environmental Assessment*. Parametrix, Inc, 1992.

[14] Walker and Associates, Aerial Photographs dated 1936, 1946, 1960, 1969, 1977, 1985, and 1992. Walker and Associates, Seattle, Washington.

[15] Polk City Directories dated 1954, 1960, 1976, 1981, and 1987. Suzzallo Library, University of Washington, Seattle, Washington.

Household Directories,[16] Kroll Maps, and local reports[17] Information from directories is somewhat limited as the Polk Company did not compile information for the Des Moines area, and the Cole Company did not begin compiling until 1969.

- **Area 1** - Area 1 is a 110-acre site that formerly was a residential area. The area is bound by S. 216th Street; 24th Avenue S.; 20th, 21st and 22nd Avenues S.; and S. 212th, 206th and 202nd Streets. The area once was developed with residences and trailer parks, although most of those buildings were removed between 1985 and 1992. Businesses operated within Area 1 that pose some threat of contamination include the following: Cleaner Carpets, 21420 S. 21st Ave (1969); Import Motor Exchange, 2020 S. 216th St. (1979-89); Nursery, 2031 S. 216th St. (1979); SeaTac Auto, 21306 S. 22nd Ave (1989).[18] Other potential contaminant sources include any underground fuel-oil storage tanks that may have been left in the area when it was cleared of residences.

- **Area 2** - Area 2 comprises approximately 20 acres and is bound by S. 216th Street, S. 212th Street, the eastern property boundaries of properties located on the east side of 15th Avenue S., and 18th Avenue S. The south one-third of the area is pasture, in the center of which is a vacant warehouse/shed structure. In 1979, the property was listed as the Legend Horse Center. A vacated single-family residence is located near the western boundary of Area 2, and an occupied building is near the northeast property boundary.[19] No businesses that pose a potential threat of contamination were identified in Area 2. The vacated residence may have had an underground fuel-oil storage tank that may have leaked, causing localized contamination.

- **Area 3** - Area 3 is an approximately 60-acre site, and is bound by S. 209th Street, S. 200th Street, the eastern property lines of properties on the east side of 16th Avenue S., and 18th Avenue S. Although once residentially developed, most of the residences were removed between 1985 and 1992. An area near S. 204th Street, on the west side of Des Moines Creek, appeared to be an active borrow pit in aerial photographs dated 1977. The pit appeared to have been abandoned in aerial photographs taken in 1985. No businesses that would be potential sources of contamination were identified in the area. The only potential risks identified stem from the possible presence of underground fuel-oil storage tanks that may have been associated with former residential structures.

- **Area 4** - Area 4 comprises approximately 40 acres, and is bound by S. 200th Street, S. 196th Place, 16th Avenue S., and 18th Avenue S. The area is on the north- and east-facing sides of a low, wooded hill and was sparsely developed. No risks were identified for Area 4.

- **Area 5** - Area 5 is an approximately 60-acre site that is bound by S. 146th Street and S. 150th Street, SR 518, 16th Avenue S., and 22nd and 24th Avenues S. The eastern portion of Area 5 was residentially developed until around 1974 when the houses were removed. Currently located on this site are a remote transmitter antenna and equipment building, the North Approach Lighting System, and a landfill containing construction debris comprised of cement and asphalt-concrete. The landfill is also reported to contain 50,000 to 75,000 cubic yards of petroleum-contaminated street sweepings with petroleum hydrocarbon concentrations ranging from 200 to 1,100 ppm.[20] The only business

[16] Cole Metropolitan Household Directories dated 1969, 1979, 1989, 1991. Seattle Public Library, Seattle, Washington.

[17] Seattle-King County Department of Health, 1985. *Abandoned Landfill Study in King County.*

[18] Cole Metropolitan Household Directories dated 1969, 1979, 1989, 1991. Seattle Public Library, Seattle, Washington.

[19] *Preliminary Engineering Study.* HNTB, 1994.

[20] *Preliminary Engineering Study.* HNTB, 1994.

listed in Area 5 is TF Sahli Construction.

A few blocks to the north is the Tub Lake/Sunset Park site, which is listed by the Washington State Department of Ecology as a hazardous waste site. King County Public Works and King County Parks and Recreation both operate facilities at this site. Both facilities had leaking underground storage tanks that were removed. A now abandoned landfill is located on the Tub Lake/Sunset Park site near the southeast corner of the intersection of S. 140th Street and 18th Avenue S. The landfill was used between 1941 and 1945 by the U.S. Navy as a dump site for bilge oil.[21/] At least some of the oil has migrated into Tub Lake; the oil is reported to bubble to the surface of the lake from time to time.[22/] This site is listed as Sunset Park/Tub Lake dump on the by the Washington State Department of Ecology. Contaminants confirmed to be present at this site include priority pollutant metals, PCBs, and petroleum hydrocarbons. According to Ecology, the current status of the site relative to the Model Toxics Control Act is that an independent remedial action is being conducted. This site has been ranked as Risk Level 3 by the Washington Ranking Model, where 1 indicates the greatest risk to human health and the environment and 5 indicates the lowest risk.[23/] If groundwater migrates from the former landfill area toward Area 5, soils at or near the groundwater surface are likely to be contaminated with petroleum hydrocarbons and may not be suitable for use as fill.

- **Area 8** - Area 8 comprises 55 acres and is bound by S. 154th Street, SR-518, 16th Avenue S., and 24th Avenue S. Area 8 has been used as a borrow area and for debris disposal.[24/] This area would not be affected as material will not be excavated from this area.

(3) FUTURE CONDITIONS

The following summarize the future conditions .

(A) Alternative 1 (Do Nothing)

No hazardous substances impacts are expected as long as existing facilities are upgraded to accommodate increased aircraft operations; fuel storage, distribution, and leak protection systems are modernized; and provisions of the Spill Prevention Control and Countermeasures Plans (SPCCP) and the Pollution Prevention Plans (PPP) covering Port and tenant activities are adhered to. Accidental releases, however, may occur even with these measures in place. Should an accidental release occur, it could result in negative environmental impacts. The Port would address any hazardous substances problems (including accidental releases) discovered in a timely and appropriate manner. LUST and suspected and confirmed contaminated sites located on the Airport are currently being evaluated and/or remediated.

Aircraft operations are expected to increase by 30% between 1993 and 2020. It is reasonable to assume that fuel use at the airport will increase by a comparable percentage, as is described in Section 22 "Energy Supply and Natural Resources".

Airport and aircraft maintenance operations and the associated use of hazardous materials are expected to increase at a level comparable to the increase in aircraft operations. Passenger enplanements are expected to increase by 49% by 2020. The use of hazardous materials associated with terminal activities would be expected to incrementally increase related to this increased level of passenger enplanements.

Increased use of fuel and hazardous substances at the Airport will require greater storage capacity for these materials, more transport of hazardous materials to the Airport, and possibly generation of increased levels of hazardous waste requiring disposal. With the increase in fuel storage and refueling operations, airport and aircraft operations, and greater use of hazardous

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21/ Washington State Department of Ecology Files reviewed November 3, 1995

22/ *Abandoned Landfill Study in King County.* Seattle-King County Department of Health, 1985.

23/ Confirmed and Suspected Contaminated Sites Report. Washington State Department of Ecology, 1994.

24/ *Preliminary Engineering Study,* HNTB, 1994.

materials in the terminal, the potential for accidental releases of these substances increases, resulting in greater potential for adverse environmental impacts.

(B) "With Project" Alternatives (Alternative 2, 3 and 4)

Potential hazardous substances impacts during construction phases of all alternatives could include exposure of construction workers to contaminated soils during excavation activities, release of hazardous substances during UST removal and building demolition activities associated with facility relocations, and spills of construction related hazardous materials (e.g., fuels, lubricants, paints, and asphalts).

Activities that may result in hazardous substances impacts related to runway construction would occur during Phase 1 (1996-2000) under all "With Project" alternatives and would include relocation of the Weyerhaeuser Hangar and USTs, the ASR and associated UST, and the ILS Glide Slope Antenna and associated UST; and excavation of existing fill.

Expansion of the main terminal and associated gates during Phase 1 under Alternative 2 would require relocation of the N.W. Airline Hanger to SASA. Expansion and construction during Phase 2 (2001-2005) under Alternative 2 would include relocation of the United Airlines Maintenance Facility and the Port of Seattle's Airport Maintenance Facility both north of the North Satellite, and the Delta Airlines Hangar, the N.W. Airlines USTs, and the Delta Airlines USTs all located south of the main terminal. Expansion and construction during Phase 3 (2006-2010) under Alternative 2 would not occur in areas where hazardous materials are currently being stored or used. During Phase 4 (2011-2015) under Alternative 2, the Alaska Airlines Maintenance Facility would be relocated. During Phase 5 (2016-2020) under Alternative 2, the ARFF would be displaced by North Satellite expansion.

Hazardous substances impacts under Alternatives 3 and 4 would be similar to those that would occur under Alternative 2.

(C) Preferred Alternative (Alternative 3)

Potential hazardous substances impacts during construction phases of the Preferred Alternative could include exposure of construction workers to contaminated soils during excavation activities, release of hazardous substances during UST removal and building demolition activities associated with facility relocation, and spills of construction related hazardous materials (e.g., fuels, lubricants, paint, and asphalt).

Activities that may result in hazardous substances impacts related to runway construction would occur during Phase 1 (1996-2000) and would include relocation of the Weyerhaeuser Hangar and USTs, the ASR and associated UST, and the ILS Glide Slope Antenna and associated UST; and excavation of existing fill. Expansion of the main terminal and associated gates during Phase 1 would require relocation of the Northwest Airlines Hanger to SASA. Expansion and construction during Phase 2 (2001-2005) would include relocation of the United Airlines Maintenance Facility and the Port of Seattle's Airport Maintenance Facility both north of the North Satellite. the Northwest Airlines USTs, and the Delta Airlines USTs all located south of the main terminal. During Phase 3 (2016-2020), the ARFF would be displaced by North Unit Terminal development.

(4) CUMULATIVE IMPACTS

Expected increase in airport use, development of Airport facilities, and urban development within surrounding communities would result in the increased use of hazardous materials and generation of greater amounts of hazardous wastes. Higher use would increase the likelihood of releases of these materials to the environment. Proper storage, use, and disposal procedures would reduce the probability of releases and thus minimize impacts on human health and the environment.

(5) MITIGATION

Construction-related actions involving hazardous substances that require specific management guidelines or mitigation include the transport, storage, and handling of fuels, lubricants, solvents, and paints used during construction; remediation of anticipated and unanticipated hazardous wastes encountered during construction activities; removal and disposal of asbestos-containing materials and PCB-containing electrical equipment from structures that would be demolished; excavation and removal of USTs and associated piping; and relocation of hazardous materials currently stored and used at aircraft maintenance, airport maintenance, airport rescue and fire fighting (ARFF), and other facilities that would be displaced or relocated as a result of airport development.

Construction Best Management Practices (BMPs) would be implemented to control the release of hazardous materials used during the construction phase of the project. The Port of Seattle or their construction contractor would be required to develop procedures for transport, storage, and handling of hazardous materials and prepare a Spill Prevention, Control, and Countermeasures Plan that would outline those procedures. A Construction Hazardous Waste Management and Contingency Plan would be developed to outline procedures for removal, storage, transportation, and disposal of known hazardous wastes such as contaminated soils, asbestos-containing materials, PCB-containing electrical equipment, and used hazardous substances generated during construction. The contingency plan would cover procedures to be followed should a previously undiscovered hazardous waste site be unearthed during construction activities. The contingency plan should include the following elements:

1. Immediately suspend all work in the area.
2. Determine risk to human health and the environment. If material discovered appears to present an immediate risk to human health, or if risk is unknown, the area would be evacuated and cordoned off.
3. Record all circumstances and actions taken.
4. In consultation with appropriate local, state, and federal agencies, develop remedial measure to correct problem.

All federal, state, and applicable local rules and guidelines concerning the removal and disposal of asbestos-containing material and PCB-containing electrical equipment would be followed in conjunction with demolition of any structures as part of the proposed Master Plan Update. Structures to be demolished would be surveyed prior to demolition for hazardous materials including asbestos-containing materials and PCB-containing electrical equipment. The contractor would remove or have removed, by certified asbestos workers, all asbestos-containing products located on the project site. All construction and demolition work in buildings possessing asbestos-containing products is regulated by and would be consistent with the following: Puget Sound Air Pollution Control Agency (Regulation III, Article 4), Washington Industrial Safety and Health Act (WAC 296-62.077 and WAC 296-65), Occupational Safety and Health Administration (29 CFR 1910), and U.S. Environmental Protection Agency (40 CFR 61, Subpart M).

Removal of PCB-containing electrical equipment would be conducted by using proper procedures as outlined in 40 CFR 761 and WAC 173-303. UST removal would be conducted according to proper procedures as outlined in WAC 173-360. Plans and procedures would be developed for the safe relocation of hazardous materials currently stored and used in existing maintenance facilities that would be relocated as part of the project. Obsolete hazardous materials would be disposed of according to prescribed regulations governing the transport and disposal of such substances.

Regular on-site inspections by appropriate regulatory agency personnel during all phases of construction would ensure conformance with all applicable local, state, and federal rules and guidelines.

The risk of operational impacts resulting from releases of hazardous substances would be minimized once existing facilities are upgraded to accommodate increased aircraft operations; fuel storage, distribution, and leak protection systems are modernized; and provisions of the Spill Prevention Control and Countermeasures Plans (SPCCP) and the Pollution Prevention Plans (PPP) covering POS and tenant activities are strictly implemented.

TABLE IV.21-1
SEA-TAC AIRPORT RISK SITES

Map ID	Site	Address	List
1	Furnace Doctors	1037 S. 156th Way	ERNS
2	Chevron USA SS 94312	15804 Des Moines Drive	UST, RCRA-TSD
3	Nick Raffo Garbage	15424 Des Moines Way	UST
4	Willie's Texaco	15939 Des Moines Way	LUST
5	AFP Partners	1900 S. 146th St.	SCL
5	Sea-Tac Distribution Center	1900 S. 146th St.	UST
6	Fuel Farms	Sea-Tac Airport	SCL
7	Lee's Sanitation	849 164th	UST
8	Sea-Tac Airport	Sea-Tac Airport	SCL
9	Highline School District	17810 8th	LUST
10	Unocal Station	18201 Des Moines Way	LUST
11	Weyerhaeuser	West Sea-Tac	UST
12	Airborne Freight Corp.	2580 S. 166th St.	LUST, UST
13	BP 03142	2841 S. 188th	LUST, SmGen
13	Budget Rent-a-Car	2806 S. 188th	LUST, UST
13	Exxon Station #7-3287	2841 S. 188th	LUST, UST
13	Quick Stop Tune Lube	18820 Pacific Highway S.	LUST, UST
13	Sea Tac Gull #263	18812 Pacific Highway S.	UST
13	Thrifty Rent-a-Car	18836 Pacific Highway S.	UST, SmGen
14	Budget Rent-a-Car	17808 Pacific Highway S.	LUST, UST, Sm Gen
15	Burien Fuel	14260 Des Moines Memorial Dr. S.	LUST
16	Chevron 92259	18514 Pacific Highway S.	LUST, UST, SmGen
17	Delta Airlines	18753 28th Ave. S.	LUST, UST
17	Marriott In Flite Services	18850 28th Ave. S.	LUST, UST
18	Sea-Tac Alaska Air Hangar Bldg	18650 Alaska Service Rd.	LUST, UST
19	Highline Water District Equip Yard	19800 28th Ave. S.	LUST
20	Minchew Property	3025 150th S.	SCL
21	Northwest Airlines, Inc.	Sea-Tac International Airport	LUST
22	SAFECO Environmental	2212 S. 144th	CERCLIS, LgGen
23	Sunset Park/Tub Lake	S 136th & 18th Ave S.	SPL
24	Texaco SS 632321419	17010 Pacific Highway S.	LUST, UST, SmGen
25	Dollar Rent-a-Car	17600 Pacific Highway S.	UST
25	The Southland Corp.	3123 S. 176th	UST
25	Unocal Station #4871	17606 Pacific Highway S.	LUST, UST
26	Airport Drayage Co.	16215 Air Cargo Rd.	UST
27	ASRD Sea-Tac International Airport	47° 27' 07" N, 11° 18' 51" W	UST
28	Container Freight Transport	14221 20th Ave. S.	UST
28	Milne Truck Lines	14221 S. 20th	UST
28	Sea-Tac Distribution Center	2201 S. 142nd	UST
29	Federal Aviation Administration	19415 Pacific Highway S.	UST
30	Flt Ops/Admin. Training Center	2651 S. 192nd St.	UST
30	Golf Management, Inc.	2401 S. 192nd St.	UST
31	Budget Rent-a-Car	19030 28th Ave. S.	SmGen, UST
31	Ray's Auto Sales	19059 Pacific Highway S.	UST
32	Scoccolo Construction Inc.	2825 S. 154th	UST
33	U.S. Postal Service	16601 Air Cargo Rd.	UST
34	Seattle Marriott Hotel	3201 South 176th	UST, Sm Gen
35	RTRD Sea-Tac International Airport	47° 27' 07" N, 11° 18' 16" W	UST
36	Sea-Tac/United Fuel Farm	Sea-Tac International Airport	SCL
36	Sea-Tac/Continental Fuel Farm	176th St. Airport Serv. Rd.	SCL
37	Sea-Tac/Pan Am Fuel Farm	Sea-Tac International Airport	SCL

Source: Vista Environmental Information, 1994.

Table IV.21-2 (Page 1 of 2)
SEA-TAC AIRPORT RISK SITES REPORTED CONTAMINANTS AND COMPOUNDS

Map ID	Site	Confirmed Compounds	Suspected Compounds
1	Furnace Doctors	Petroleum Products	
2	Chevron USA SS 94312	Petroleum Products	
3	Nick Raffo Garbage	Petroleum Products	
4	Willies Texaco	Petroleum Products	
5	AFP Partners	Petroleum Products	Halogenated Organic Compounds, EPA Priority Pollutants Metals, Non-Halogenated Solvents
5	Sea-Tac Distribution Center	Petroleum Products	
6	Fuel Farms	Petroleum Products	
7	Lee's Sanitation	Petroleum Products	
8	Sea-Tac Airport	Halogenated Organic Compounds, Petroleum Products, Non-Halogenated Solvents	EPA Priority Pollutants, PCBs
9	Highline School District	Petroleum Products	
10	UNOCAL Station	Petroleum Products	
11	Weyerhaeuser	Petroleum Products	
12	Airborne Express	Petroleum Products	
12	Airborne Freight Corp.	Petroleum Products	
13	BP 03142	Petroleum Products	
13	Budget Rent-a-Car	Petroleum Products	
13	Exxon Station #7-3287	Petroleum Products	
13	Quick Stop Tune Lube	Petroleum Products	
13	Sea Tac Gull #263	Petroleum Products	
13	Thrifty Rent-a-Car	Petroleum Products	
14	Budget Rent-a-Car	Petroleum Products	
15	Burien Fuel	Petroleum Products	
16	Chevron 92259	Petroleum Products	
17	Delta Airlines	Petroleum Products	
17	Marriott In Flite Services	Petroleum Products	
18	Sea-Tac Alaska Air Hangar Bldg.	Petroleum Products	
19	Highline Water District Equip. Yard	Petroleum Products	
20	Minchew Property	Petroleum Products	Halogenated Organic Compounds, EPA Priority Pollutant Metals, Metals-Other, Non-Halogenated Solvents
21	Sea-Tac/NW Airlines Fuel Farm	Petroleum Products, Non-Halogenated Solvents	
22	SAFECO Environmental (SAFECO Solvent Treatment, Inc.)	not reported	
23	Sunset Park/Tub Lake	EPA Priority Pollutant Metals, Petroleum Products, Non-Halogenated Solvents, PAH	Halogenated Organic Compounds
24	Texaco SS 632321419	Petroleum Products	
25	Dollar Rent-a-Car	Petroleum Products	
25	The Southland Corp.	Petroleum Products	
25	UNOCAL Station #4871	Petroleum Products	
26	Airport Drayage Co.	Petroleum Products	
27	ASRD Sea-Tac International Airport	Petroleum Products	

Table IV.21-2 (Page 2 of 2)
SEA-TAC AIRPORT RISK SITES REPORTED CONTAMINANTS AND COMPOUNDS

Map ID	Site	Confirmed Compounds	Suspected Compounds
28	Container Freight Transport	Petroleum Products	
28	Milne Truck Lines	Petroleum Products	
28	Sea-Tac Distribution Center	Petroleum Products	
29	Federal Aviation Administration	Petroleum Products	
30	Flt. Ops./Admin. Training Center	Petroleum Products	
30	Golf Management, Inc.	Petroleum Products	
31	Budget Rent-a-Car	Petroleum Products	
31	Rays Auto Sales	Petroleum Products	
32	Scoccolo Construction, Inc.	Petroleum Products	
33	U.S. Postal Service	Petroleum Products	
34	Seattle Marriott Hotel	Petroleum Products	
·35	RTRD Sea-Tac International Airport	Petroleum Products	
36	Sea-Tac/Continental Fuel Farm	Petroleum Products, Non-Halogenated Solvents	
37	Sea-Tac/Pan Am Fuel Farm	Petroleum Products, Non-Halogenated Solvents	

Contaminants Legend

Petroleum Products - Crude oil and any fraction thereof. Each of these materials may consist of a number of specific chemical compounds. Examples are gasoline, diesel fuel, mineral oil.

Halogenated Organic Compounds - Organic compounds, typically solvents, with one or more of the halogens (e.g., chlorine, bromine, fluorine) incorporated into their structure. Examples are: carbon tetrachloride, chloroform, and vinyl acetate

EPA Priority Pollutants Metals - Metals included in EPA's priority pollutant compounds list. Examples are: antimony, arsenic, beryllium, cadmium, chromium, copper, cyanide, lead, mercury, nickel, selenium, silver, thallium, and zinc.

Non-Halogenated Solvents - Organic solvents, typically volatile and semi-volatile, not containing any halogens. Examples are: acrolein, benzene, toluene, and acetone.

PCBs - Polychlorinated Biphenyls: A specific "family" of aromatic chlorinated organic compounds, often referred to as "AROCLOR."

Metals-Other - Other non-priority pollutant metals. Examples are: aluminum, barium, cobalt, iron, manganese, and tin.

PAH - Polynuclear Aromatic Hydrocarbons: Hydrocarbons composed of two or more benzene rings. Examples are: Benzo-Fluoranthene, Chrysene, Anthracene, and Acenapthene.

Source: Department of Ecology--Toxics Cleanup Program Site Information System Confirmed and Suspected Contaminated Sites. Washington State Department of Ecology, November 13, 1995.

TABLE IV.21-3
PORT OF SEATTLE HAZARDOUS STORAGE

Location (Map ID) [a]	Storage Vessel Type [b]	Capacity	Material
Fire Department (1)	UST	4,000 gallon	Diesel
	UST	4,000 gallon	Gasoline
	AST	4,000 gallon	Diesel
	AST	2,500 gallon	Fuel Oil
	Container	30 - 1 gallon	Antifreeze
	Drum	4 - 55 gallon	Motor Oil - Waste Diesel
	AST	250 gallon	Waste Oil
Auto Shop (2)	UST	2 - 8,000 gallon	Diesel
	UST	4,000 gallon	Gasoline
	AST	250 gallon	Motor Oil
	AST	50 gallon	Waste Antifreeze
	AST	250 gallon	Antifreeze
Paint Shop (2)	Container	300 to 400 - 5 gallon	Oils, Enamels, Solvent
	Container	35 gallons	Spent Paint Thinner
Maintenance Building Yard (2)	AST	20,000 gallon	UCAR Runway Deicing Fluid (ethylene glycol/urea)
	AST	10,000 gallon	Potassium Acetate
	AST	22,000 gallon	Potassium Acetate
	Tanker Trucks	2-2,000 gallon	Liquid Urea (winter only)
	Tanker Truck	4,000 gallon	Liquid Urea (winter only)
	AST	2,000 gallon	Diesel
	Drum	5 to 10 - 55 gallon	Cleaning Solvent, Bulk Oil, Asphalt Emulsion, Waste Gasoline (reused in 2-cycle engines), Waste Antifreeze (to be recycled)
	Container	4 to 8 - 20 gallons	Waste Solvents (to be recycled)
Supply/Loading Dock (3)	AST	3,500 gallon	Urea
	UST	2,000 gallon	Diesel
	UST	2,000 gallon	Diesel
	Drum	3 to 5 - 55 gallon	Hydraulic Fluid
	UST	1,000 gallon	Diesel
Boiler Rm & Cooling Twrs (3)	UST	20,000 gallon	Bunker C
	UST	20,000 gallon	Bunker C
	Drum	4 to 10 - 55 gallon	Sodium Molybdate, Sodium Hydroxide
Conveyor Shop Areas (4)	Drum	2 to 4 - 55 gallon in each area	Gear Box Oil
Engineering Yard/Building (5)	Drum	4 to 6 - 55 gallon	Transformer Fluid (mineral oil)
Contractor Staging Areas (6)	Drum	4 to 6 - 55 gallon	Herbicides, Paints, Concrete Additives
Treatment Plant (7)	AST	250 gallon	Diesel
	AST	300 gallon	Liquid Alum
	AST	15,000 gallon	Recovered Fuel from Lagoons
Hazardous Materials Storage Area (8)	Drums, Containers, and Boxes	various	various

a/ Storage locations shown on **Exhibit IV.21-2.**
b/ UST=underground storage tank, AST=above-ground storage tank

Source: *Seattle-Tacoma International Airport Spill Prevention Control and Countermeasure Plan (Draft)*, Port of Seattle, 1995

TABLE IV.21-4

MATERIALS STORED IN THE HAZARDOUS MATERIALS STORAGE AREA

Description	Quantity	Description	Quantity
Oil and water from an elevator shaft	2 drums	Domino Amjet print ink	1 container
Roof patch compound	1 drum	Freon	1 container
Recovered solvent	4 drums	Electrical insulating compound	1 drum
Contaminated dirt from AOA drains	5 drums	Used/expired Chlorinol	1 container
Absorbal	1 drum	West Bryte wax	1 container
Weathered oil booms from Des Moines Creek	9 drums	Hydro Chem 381L	1 container
		Ice blast waste	1 drum
Transformer oil	1 gallon	Ammonium hydroxide	1 container
Fire foam	1 drum	Nitric acid	1 container
Penetrating seal #207	1 container	Bulk from spray cans	1 drum
Berryman Chem-Dip	1 container	Fire department confiscation (mace, film remover, smoke, etc.)	3 boxes
Kloorkleen Plant Cleaner	1 container	Household hazardous waste	2 drums
Phosphorus pentoxide	1 container	PCB cleanup	1 drum
Filter media	1 drum	Oil & Freon	2 drums

Source: *Port of Seattle's Sea-Tac Airport Fuel and Hazardous Substances Spill Plan* Draft, 11/17/94

Seattle-Tacoma International Airport
Environmental Impact Statement
for the Master Plan Update

Exhibit IV.21-1

Hazardous Substances Risk Sites

Jurisdictional Boundary

LUST Site

SCL, SPL, CERCLIS or ERNS Site

UST Site

Source: Gambrell Urban, Inc. and
Shapiro & Associates, 1995

Scale 1" = 2,500'

0 2500 5000

SCALE IN FEET

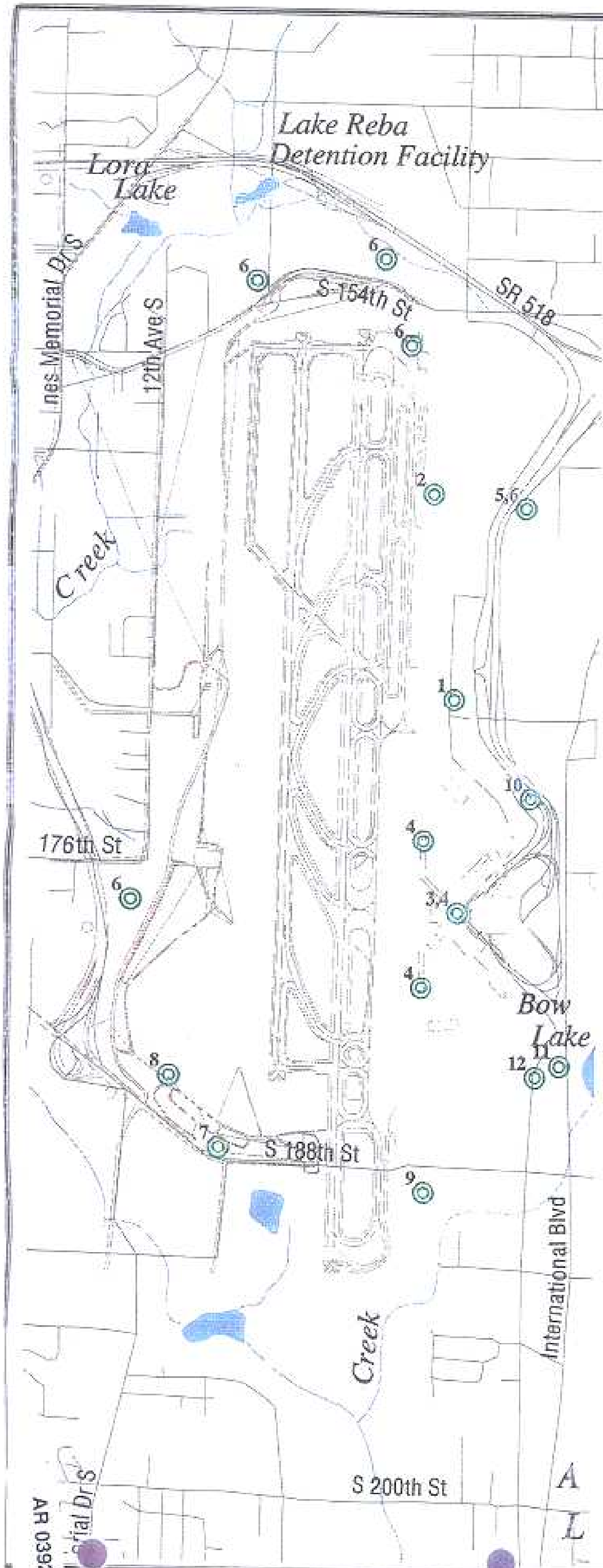
Projection: Lambert Conformal Conic
Coordinate System: State Plane NAD27

April 13, 1995

Seattle-Tacoma International Airport Environmental Impact Statement for the Master Plan Update

Exhibit IV.21-2

Airport Substance Storage Areas



◎ Substance Storage Area

Source: Gambrell Urban, Inc. 1995
Shapiro & Associates, 1995
Port of Seattle, 1994

Scale 1" = 1,250'

0 1000 2000 3000
Scale in Feet

Projection: Lambert Conformal Conic
Coordinate System: State Plane NAD27

De...ber 20, 1996

AR 039225

Seattle-Tacoma International Airport Environmental Impact Statement for the Master Plan Update

Exhibit IV.21-3

On Site Borrow Source Areas

Potential On-Site Borrow Sources

Source: Gambrell Urban, Inc. and Shapiro & Associates, 1994
HNTB, 1994

Scale 1" = 2,500'

0 2500 5000

SCALE IN FEET

Projection: Lambert Conformal Conic
Coordinate System: State Plane NAD27

18, 1996

CHAPTER IV, SECTION 22

ENERGY SUPPLY AND NATURAL RESOURCES

Energy in the form of electricity, natural gas, aviation fuel, diesel fuel, and gasoline is consumed through the operation of the airport facilities, aircraft, and attendant equipment. Increasing demand for the Airports services, as indicated by the increase in the forecast future activity levels, would place an ever increasing demand on the sources of energy at the Airport. The proposed Master Plan Update "With Project" alternatives would increase total energy usage by seven to nine percent in comparison to the Do-Nothing. All suppliers of these natural resources have indicated the capability of serving the increased demand.

The following sections summarize the impacts of alternatives on various energy sources and natural resources.

(1) ENERGY REQUIRED TO OPERATE AIRPORT FACILITIES

Energy demands resulting from the operation of airport facilities are met through the consumption of both electricity and natural gas. Electricity is the primary source of energy used for lighting and cooling of the airport facilities, including the terminal building. On the airfield, electricity is used for runway and taxiway lighting, and to power the various navigational systems.

Natural gas is used primarily to provide heat, steam, and hot water to the airport facilities. The boilers in the Airports main heating plant use natural gas as their primary energy source.[1/] Historically, the alternate energy source has been used less than ten days a year, and in 1993 no fuel oil was used.[2/] Because of the limited use of fuel oil, only electricity and natural gas were analyzed as existing and future sources of energy for Airport facilities.

(A) Existing Usage

Based on utility bills and data provided by suppliers, Airport facilities consumed approximately 604 Billion British Thermal Units (BBTU) of energy in 1993. The energy consumption was distributed as follows:

- Electricity - 119,032,935 Kwh[3/] (406 BBTU)
- Natural Gas - 1,984,915 therms[4/] (198 BBTU)

Electrical service is provided by Puget Sound Power and Light Company to the various portions of the Airport. Sources of electrical consumption include the airfield lighting and navigational aides, the passenger terminal and concourses, Port of Seattle offices, and various airport tenants. According to data received from the Port of Seattle, airfield lighting and navigational aides account for approximately two percent of the Airports annual electrical consumption.[5/] The remainder of the annual electrical consumption can be attributed to the operation of the passenger terminal and concourses, and airport tenant facilities.

Natural gas is supplied by Washington Natural Gas. The Airport's natural gas supply is interruptible, which means that Washington Natural Gas can temporarily suspend delivery of natural gas to Sea-Tac during peak demand periods. These peak

1/ Fuel oil is used as a backup energy source when the natural gas supply is interrupted.

2/ Mr. Gordan Florence, Chief Operating and Maintenance Engineer, Port of Seattle, May and August, 1994.

3/ Mr. Jesse Go, Senior Technical Specialist - Electric, Port of Seattle Department Mr. Gordan Florence, Chief Operating and Maintenance Engineer, Port of Seattle Department of Aviation, May, June, and August, 1994.

4/ Mr. Paul Riley, Supervisor Gas Measurement Division, Washington Natural Gas, May, 1994.

5/ Mr. Jesse Go, Senior Technical Specialist - Electric, Port of Seattle Department of Aviation, Telephone Conversation and Correspondence, June, 1994.

periods typically occur in the winter during extended periods of unusually cold temperatures. During these periods a fuel oil backup system is used to fuel the boilers. As stated previously, this is seldom necessary and in fact did not occur at all in 1993. Historically, the backup system has not been used more than four weeks during a given winter, and no more than ten or twelve days consecutively.[6]

Sea-Tac's electrical usage represents about seven tenths of one percent of the total amount of electricity supplied by Puget Sound Power and Light Co. Airport facilities are, however, one of Puget Sound Power and Light's top ten individual high voltage electricity accounts.[7] The 1.9 million therms of natural gas consumed by Airport facilities in 1993 accounts for a little more than 0.2 percent of the annual therm production of the Washington Natural Gas Company.[8] The Airport's natural gas account is one of the 30 largest single accounts for Washington Natural Gas. However, the usage of electricity and natural gas by airport facilities represent a small percentage of the individual utilities overall production.

(B) **Future Usage**

Energy required to operate airport facilities would increase in the future. Sea-Tac Airport is anticipated to experience increased enplanement levels either with or without development, and the increased enplanement levels would result in an increased energy demand. Airport improvements would increase the amount of building space requiring heating, cooling, and lighting, the provision of which would cause a corresponding increase in energy consumption. The following sections summarize the impacts of both the Do-Nothing and "With Project" alternatives.

[6] Mr. Gordan Florence, Chief Operating and Maintenance Engineer, Port of Seattle Department of Aviation, Telephone Conversation, May and August, 1994.

[7] Ms. Diane Olsen, Account Representative, Puget Sound Power and Light Co., Telephone Conversation, August, 1994. Data based on June, 1994.

[8] Mr. Paul Riley, Supervisor Gas Measurement Division, Washington Natural Gas, Correspondence, May, 1994.

1. **Alternative 1 (Do-Nothing)**

The amount of energy consumed at Sea-Tac would not increase noticeably without development of new facilities to serve the increasing passenger demand. However, the increasing enplanement levels forecast for the Airport are likely to lead to a small increase in the amount of electrical consumption at the Airport. Based on a ratio of existing enplanements to electrical usage, the following future usage was determined.

Alternative 1 (Do-Nothing)

Year	Electrical Consumption (Million Kwh)
1993	119
2000	128
2010	138
2020	147

As shown above, without additional development, electrical consumption levels are expected to reach 147 million Kwh by 2020, a 24 percent increase from current levels.

2. **"With Project" (Alternatives 2 Through 4)**

The Master Plan Update "With Project" alternatives would result in an increased level of energy consumption. Future energy demand levels were developed based on a proportion of existing facility square footage to existing consumption levels. Use of this methodology assumes that a linear relationship exists between facility size (primarily terminal and concourse space) and energy consumption. The increased electrical consumption due to development of the new parallel runway and associated taxiways have been developed based on proportion of existing to future airfield lighting requirements.

Each Master Plan Update "With Project" alternative would result in differing amounts of terminal and concourse space development.

- Alternative 2 - North Unit Terminal - Development of the new dependent parallel runway and taxiways by the year 2020 can be

AR 039228

expected to increase electrical consumption of the airfield by approximately 1.96 million kilowatt hours over the Do-Nothing alternative. Airport terminal, concourse and cargo development under Alternative 2 would increase building space at the Airport by approximately 2.6 million square feet by the year 2020. This additional space would result in an increase in electrical consumption of approximately 93 million kilowatt hours over the Do-Nothing alternative. Total electrical consumption with this alternative would increase approximately 95 million kilowatt hours or 65 percent over the Do-Nothing alternative.

Development of the new parallel runway would not impact natural gas consumption at the Airport. However, heating requirements for the additional building space would increase natural gas consumption by 1.7 million therms over the 2020 Do-Nothing alternative, an increase of approximately 87 percent.

- Alternative 3 - Central Terminal - Development of the new runway would result in the same increase in electrical consumption as Alternative 2. The additional building space would result in increased electrical consumption of approximately 94 million kilowatt hours over the Do-Nothing alternative in 2020. Total electrical consumption in 2020 would increase by approximately 97 million kilowatt hours or approximately 65 percent over the 2020 Do-Nothing alternative.

  The heating requirements for the additional building space would increase natural gas consumption by approximately 1.8 million therms over the 2020 Do-Nothing alternative, an 88 percent increase.

- Alternative 4 - South Unit Terminal - Development of the new runway would result in the same increase in electrical consumption as Alternative 2. This alternative includes the greatest increase in building square footage, terminal and concourse, other expansions would add approximately 3.0 million square feet of building space to the existing facilities. The additional building space would result in an increase in electrical consumption of approximately 110 million kilowatt hours over the Do-Nothing alternative in 2020. Total electrical consumption in 2020 would increase by approximately 112 million kilowatt hours or approximately 76 percent over the 2020 Do-Nothing alternative.

  The additional building space associated with this alternative would increase natural gas consumption by approximately 2.1 million therms over the 2020 Do-Nothing alternative, a 107 percent increase.

3. Preferred Alternative (Alternative 3)

The Preferred Alternative would result in an increased level of energy consumption. Development of the proposed new runway would result in the same increase in electrical consumption by 1.96 million kilowatt hours over the Do-Nothing alternative. The additional building space would result in increased electrical consumption of about 94 million kilowatt hours over the Do-Nothing alternative in 2020. Total electrical consumption in 2020 would increase by approximately 97 million kilowatt hours or approximately 65 percent over the 2020 Do-Nothing alternative. The heating requirements for the additional building space would increase natural gas consumption by approximately 1.8 million therms over the 2020 Do-Nothing alternative, an 88 percent increase.

Sufficient capacity exists in the existing utility supply network to accommodate the increased energy consumption by airport facilities, with or without additional airport development.

(2) ENERGY REQUIRED TO OPERATE AIRCRAFT

The amount of energy consumed by aircraft operating at the Airport is dependent on two operational characteristics:

- The aircraft fleet mix (i.e., the numbers and types of aircraft in use at the Airport.)
- The length of time the aircraft operates in the airport environment.

The time that an aircraft is in operation at an airport is referred to as the landing and takeoff (LTO) cycle. An LTO cycle encompasses the time from which an aircraft descends on final approach to an airport, through the ground taxi and delay time both to and from the terminal, until it climbs out from an airport on departure. The LTO cycle consists of four distinct modes:

- Approach
- Taxi-Idle
- Takeoff
- Climbout

As the consumption of fuel varies substantially according to aircraft operating modes, the average time an aircraft spends in each mode must be identified. In addition, the time in mode for both the approach and climbout phases is dependent on a determination of the mixing altitude for the Seattle Area. The mixing altitude in the Seattle area is 626 meters (2,054 feet) for a winter morning with no precipitation.[9] Thus, the standard LTO cycle time in mode for the approach and climbout phases were adjusted based on a ratio of the Seattle mixing height to the standard mixing height of 914 meters. The time in mode for the takeoff phase was taken directly from AP-42[10] for each aircraft type category. AP-42 also provides an average taxi-idle time for typical airports. However, due to the uniqueness of Sea-Tac's poor weather operating constraints, specific taxi-idle times were calculated.

The amount of fuel consumed at the Airport during each phase of the LTO cycle, for each type of aircraft using the Airport, was estimated using the methodology presented in AP-42. This methodology estimates the amount of aviation fuel consumed by each of the aircraft types during each phase of the LTO cycle. This quantification does not represent total flight consumption. The fuel consumption calculated from the LTO cycles represent the amount of fuel consumed by an aircraft while it is in the airport environs, and does not include the fuel consumed while the aircraft is en-route between the departure airport and Sea-Tac or Sea-Tac and the destination airport.

(A) Existing Usage

In 1994, operations at Sea-Tac resulted in approximately 26.7 million gallons of fuel being consumed during the various phases of the LTO cycle. Approximately 394.2 million gallons of Jet A fuel were dispensed at the Airport in 1993.[11]

The Olympic Pipeline Company is the supplier of Jet A fuel at the Airport and is responsible for the Airports main fuel farm and distribution system. The Airport's fuel farm is composed of eight above ground tanks with a combined capacity of 574,000 barrels (24,108,000 gallons). Four of the tanks have a 55,000 barrel capacity, two have 80,000 barrel capacity, and two have 97,000 barrel capacity. These tanks are refilled via direct connection to the pipeline. Aircraft are fueled in one of two ways, hydrant fueling or by way of a fuel tanker truck. Delta, United, and Northwest Airlines each maintain hydrant fueling systems that provide fuel directly to the aircraft apron via a pipeline. Each of these systems have an intermediate storage area fed from the main tank farm. The remainder of the airlines are fueled directly from a fleet of fuel trucks operated by the individual airlines, Signature Flight Support, or Aircraft Services International Inc.[12] The fuel trucks are all filled at a common truck rack located adjacent to the general aviation apron.

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[9] U.S. Environmental Protection Agency Document AP-101, Mixing Heights, Wind Speeds, and Potential For Urban Air Pollution Throughout the Contiguous United States, Table B-1, Pg. 110.

[10] Compilation of Air Pollutant Emission Factors, Volume II: Mobile Sources, AP-42, U.S. Environmental Protection Agency. September, 1985.

[11] Mr. David Johnson, Accounting Department, Olympic Pipeline Company, Correspondence, June, 1994.

[12] Mr. Tracy Green, Sea-Tac Terminal, Olympic Pipeline Company, Telephone Conversation, April, 1994.

However, the Port of Seattle is currently preparing an Aircraft Fuel System Study,[13] which considers various options in the way aviation fuel is stored and distributed at Sea-Tac. The focus of the current on-going study is to consider eliminating approximately 28 existing underground storage tanks located primarily at three on-airport locations (Delta, United, and Northwest facilities) and centralizing storage and distribution services via the Olympic Pipeline Company. New storage capacity would be added to replace that lost with removal of the underground storage tanks. Such storage capacity would be added within the existing Airport storage area; new added capacity may also be considered within this area. Distribution through a hydrant system is being considered. Overall, the effect of these changes would be to eliminate all of the remote aviation fuel storage facilities, to reduce the number of truck filling/refilling trips, and to provide direct availability through the hydrant system to the aircraft in the terminal area. Upon selection of a final fueling system plan, the Port of Seattle would comply with any necessary NEPA requirements.

(B) **Future Impacts**

The takeoff, climbout, and approach phases of the LTO cycle are not expected to change from existing levels in the future. The taxi-idle phase however would vary in the future for the Do-Nothing, as well as the "With Project" alternatives. Increased activity levels would result in an increase in delay, while the "With Project" alternatives would result in different taxi times as well as a reduction in delay.

1. **Alternative 1 (Do-Nothing)**

Based on forecast aviation demand, aircraft fuel consumption was estimated for the Do-Nothing alternative at each of the future activity levels. Using the LTO cycle methodology previously described, the following future Do-Nothing aircraft fuel consumption levels were calculated:

Year	Alternative 1 (Do-Nothing) Aircraft Fuel Consumption (Million Gallons)
1994	26.7
2000	28.6
2010	35.7
2020	46.0

As shown, aircraft energy consumption is expected to grow from 26.7 million gallons in 1994 to 46 million gallons in 2020, a 72 percent increase over existing levels.

As stated previously, fuel consumption estimated by the LTO cycle methodology does not represent the total amount of fuel dispensed at the airport because it does not account for fuel consumption during the en-route phase of a flight. The Airport's current fuel system has a capacity of 24,108,000 gallons. To estimate the future amount of fuel dispensed, the 397,000,000 gallons of fuel dispensed in 1994 was increased in direct proportion to the increased LTO cycle fuel consumption for each activity level. The annual amount of fuel dispensed and the estimated re-supply period, based on complete discharge of the system, are summarized below:

	Annual Fuel Dispensed (Million Gallons)	Maximum Re-Supply Period (Days)
1994	397.1	22.2
2000	424.6	20.7
2010	529.7	16.6
2020	683.1	12.9

As shown above, increased activity levels would increase the annual amount of fuel dispensed by approximately 286 million gallons from current levels, which reduces the maximum re-supply period by approximately nine days. Generally, the supply of Jet A fuel at the Airport is replenished on a weekly basis. Olympic Pipeline company uses

[13] Working Paper B Draft Report Forecasting Phase: Aircraft Fuel System Study, Seattle-Tacoma International Airport, Prepared for Port of Seattle, and Airline Fuel Committee, Prepared by Argus Engineering, Planning, Management).

historical data to schedule delivery of Jet A fuel to the Airport.[14]

2. "With Project" Alternatives (Alternatives 2, 3 and 4)

Changes in the length of the taxi-idle phase of the LTO cycle account for the changes in fuel consumption between the Do-Nothing and "With Project" alternatives for each of the future activity levels. Each of the proposed alternatives would result in changes in the layout of the aircraft parking positions resulting in variations in the taxi times associated with each alternative.

- Alternative 2 - Central Terminal - By 2020, increasing demand levels would result in greater delay times and an increase in taxi/idle time over 1994 levels. The proposed improvements associated with this alternative are anticipated to reduce aircraft fuel consumption during the LTO cycle by approximately 100,000 gallons, or two tenths of one percent, annually, by the year 2020, as compared to the Do-Nothing alternative.

- Alternative 3 - North Unit Terminal - By 2020, increasing demand levels would result in greater delay times and an increase in taxi/idle time over 1994 levels. The proposed improvements associated with this alternative are anticipated to reduce aircraft fuel consumption during the LTO cycle by approximately 200,000 gallons, or four tenths of one percent, annually, by the year 2020, as compared to the Do-Nothing alternative. **Table IV.22-1** summarizes the annual fuel consumption calculated from the LTO cycles, the corresponding amount of fuel dispensed annually, and the maximum re-supply period for both the Do-Nothing and "With Project" alternatives.

- Alternative 4 - South Unit Terminal - By 2020, increasing demand levels would result in greater delay times and an increase in taxi/idle time over 1994 levels. The proposed improvements associated with this alternative are anticipated to increase aircraft fuel consumption during the LTO cycle by approximately 100,000 gallons, or two tenths of one percent, annually, by the year 2020, as compared to the Do-Nothing alternative.

As can be seen from the previously presented data, for a given activity level, development of the various "With Project" alternatives does not have a significant impact on fuel consumption levels as compared to the "Do-Nothing" alternative. The primary reason that the proposed "With Project" alternatives do not result in a significant change in fuel consumption is that although the development of the new runway causes a reduction in the delay values included in the taxi-idle phase of the LTO cycle, this reduction is offset by the additional taxi times that result from the various facility developments, and the additional time required to taxi to the new runway.

The amount of fuel required by the 2020 activity level, regardless of development option, would result in a reduction of approximately 8 days in the maximum re-supply period of the Airports fuel storage facility. However, the current storage facility would still be capable of maintaining approximately a 13 day supply of fuel.

3. Preferred Alternative (Alternative 3)

Changes in the length of the taxi-idle phase of the LTO cycle account for the changes fuel consumption between the Do-Nothing and Preferred Alternative. The proposed improvements associated with this alternative are anticipated to reduce aircraft fuel consumption during the LTO cycle by approximately 200,000 gallons, or four tenths of one percent, annually, by the year 2020, as compared to the Do-Nothing alternative.

[14] Mr. Tracy Green, Sea-Tac Terminal, Olympic Pipeline Company, Telephone Conversation, April, 1994.

(3) ENERGY REQUIRED TO OPERATE GROUND SERVICE EQUIPMENT

Ground service vehicles (GSE) operate in the terminal gate areas to fuel, tow, load, and unload aircraft and otherwise prepare aircraft for departure. The types of equipment used, and the length of time they are in use, varies by aircraft type. Different tenants and airlines may use different types and quantities of service vehicles to service similar aircraft types. As a general rule however, the larger aircraft types such as the Boeing 747 and MD 11 have longer ground times and service vehicle operation times than do the smaller aircraft such as the Boeing 737.

(A) Existing Usage

To calculate service vehicle fuel consumption, typical aircraft service times and associated service vehicle mix data were used. As defined in several FAA studies,[15] service vehicle fuel consumption is a function of: service time, fuel burn rate, aircraft fleet mix and related service vehicle types. Modifications to the typical service times for each aircraft type were made, as appropriate, to account for more typical operating conditions at the Airport. The various types of service vehicles consume a variety of fuel types including, Jet A, propane, gasoline, and diesel fuel. Because of the wide variety of service vehicle types used by the respective airlines, it is impossible to accurately determine the actual amounts of the various fuel types consumed. Based on existing LTO cycles, approximately 367,500 gallons of fuel was consumed by service vehicles in 1994.

(B) Future Usage

As aircraft activity increases in the future, either with or without the proposed master plan developments, the amount of fuel consumed by service vehicles can be expected to increase also. Because the future activity levels forecast for the Airport are not constrained by lack of airport development, the amount of fuel consumed by the service vehicles for both the Do-Nothing and development alternatives are the same. The amount of fuel consumed by service vehicles at each of the various annual activity levels is shown below:

	Daily Service Vehicle Fuel Consumption Do-Nothing and "With Project" (Gallons)
1994	1,007
2000	1,035
2010	1,156
2020	1,333

As shown above, increases in the annual activity levels result in an increased level of service vehicle fuel consumption. The increased activity level in the year 2020 would result in a 32 percent increase in service vehicle fuel consumption over current levels.

* * *

The consumption levels for each of the energy sources analyzed were converted to one common unit, the British Thermal Unit (BTU), in order to summarize the variations in energy consumption levels between the Do-Nothing and "With Project" alternatives at different annual activity levels.

As shown below, both the proposed development alternatives and the increasing activity levels at the Airport result in an increase in the amount of fuel consumed annually at the Airport. Alternative 4, the South Terminal alternative, results in the greatest increase in annual energy consumption at the Airport, when compared to the Do-Nothing alternative. At the 2020 activity level the South Terminal development alternative results in a 9.4 percent increase in total energy consumption over the Do-Nothing alternative. Alternatives 2 and 3 result in 7.3 and 7.6 percent increases over the Do-Nothing alternative respectively in 2020. All suppliers have indicated sufficient resources are available to meet this increased demand.

(4) CUMULATIVE IMPACTS

The proposed Master Plan Update alternatives would result in additional energy and natural resource consumption. In addition, other regional development would similarly result in the consumption of energy and natural resources. However, none of these additional regional urban plans in combination with the Master Plan Update improvements is likely to

[15] *Airport Vicinity Air Pollution Study*, FAA-RD-74-212, December 1974 and *An Air Pollution Impact Methodology for Airports and Attendant Land Use*, APTD-1470, January, 1973.

exceed the capacity of the region to service the energy and natural resource needs.

(5) MITIGATION MEASURES

As there would be no significant adverse impacts, no mitigation measures are required.

Energy Required to Operate Facilities, Aircraft, and Service Vehicles
(Billion BTU'S)

Year	Alternative 1	Alternative 2	Alternative 3	Alternative 4
1994	3,943.8	N/A	N/A	N/A
2000	4,210.9	4,255.8	4,251.8	4,261.7
2010	5,132.2	5,403.6	5,283.0	5,604.1
2020	6,451.4	6,941.9	6,923.1	7,058.4

N/A = Not Applicable
Source: Landrum & Brown, Inc.

TABLE IV.22-1

Seattle-Tacoma International Airport
Environmental Impact Statement

FUTURE FUEL CONSUMPTION
AIRCRAFT OPERATIONS

Year	Do-Nothing Alternative 1	Central Terminal Alternative 2	North Unit Terminal Alternative 3	South Unit Terminal Alternative 4
Aircraft Fuel Consumption (Million Gallons)				
1994	26.7	N/A	N/A	N/A
2000	28.6	28.7	28.7	28.7
2010	35.7	35.8	35.7	36.0
2020	46.0	45.9	45.8	46.1
Fuel Dispensed (Million Gallons)				
1994	397.1	N/A	N/A	N/A
2000	424.6	425.4	425.8	426.6
2010	529.7	530.9	530.4	533.8
2020	631.1	680.9	680.1	683.8
Maximum Re-Supply Period (Days) **				
1994	22.2	N/A	N/A	N/A
2000	20.7	20.7	20.7	20.6
2010	16.6	16.6	16.6	16.5
2020	12.9	12.9	12.9	12.9

LTO Cycle (Time in Mode) for Taxi-Idle

Year	Do-Nothing Alternative 1	Central Terminal Alternative 2	North Unit Terminal Alternative 3	South Unit Terminal Alternative 4
1994				
Heavy Jet	11.0	N/A	N/A	N/A
Jet	10.7	N/A	N/A	N/A
Propeller	10.3	N/A	N/A	N/A
2000				
Heavy Jet	11.0	11.7	11.6	11.8
Jet	10.9	10.9	11.0	11.0
Propeller	10.2	10.0	10.1	10.1
2010				
Heavy Jet	13.5	13.7	13.6	14.0
Jet	12.9	12.9	12.9	13.1
Propeller	12.3	12.0	12.0	12.0
2020				
Heavy Jet	16.6	16.9	16.9	17.0
Jet	16.0	15.6	15.3	15.7
Propeller	15.3	14.8	15.2	15.3

N/A = Not Applicable
Note: The 397.1 Million gallons of fuel dispensed in 1994 was extrapolated based on data provided by Olympic Pipeline Co. for 1993, and Jan-May 1994.
** Assumes complete discharge of the main tank farm.

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CHAPTER IV, SECTION 23
CONSTRUCTION IMPACTS

Construction impacts are, in general, short-term and temporary in nature. Typical impacts resulting from construction may include air and noise pollution, as well as disruption of surface transportation patterns. Construction impacts considered in this section are: noise, air, surface transportation, social, socio-economic, and water quality. Other construction impacts are discussed in their respective sections of this document.

At this time, detailed design and construction plans have not been prepared. Therefore, it is not possible to identify the specific types of construction equipment and frequency of usage that could occur with construction of the proposed Master Plan Update improvements. This section identifies a range of construction impacts, assuming two alternative scenarios: minimum excavation from on-site sources, and maximum excavation of on-site sources.

To implement the proposed new parallel runway and other Master Plan Update alternatives, one or more permitted material site(s) off of Port owned land may be used to supply the required fill. Permitted material sites have or will be subjected to environmental review as part of the appropriate regulatory process that granted the permits and which established conditions of operations. Several municipalities have recently or are in the process of adopting truck route ordinances that may pose additional conditions on operations from individual material sites. The process of removing fill material at the source and transporting it to the fill site must comply with local permits, operating conditions, legal load limits, and restoration associated with the source site(s) and haul routes. This is standard procedure for construction projects in the Puget Sound Region.

Provisions of FAA Advisory Circular 150/5370-10 "Standards for Specifying Construction of Airports", would be incorporated into construction specifications.

(A) METHODOLOGY

A number of assumptions were made concerning the construction of the Master Plan Update alternatives:

- Schedule:
  1. The largest fill material requirements, associated with the proposed new parallel runway, Runway Safety Improvements, and South Aviation Support Area are expected to occur during the first five years of the Master Plan Update implementation.
  2. Construction activities involving the hauling of embankment fill material for the construction of the proposed new parallel runway, the expansion of Runway Safety Areas, and the haul of fill material for the South Aviation Support area are anticipated to occur over a three year period between 1996 and the year 2000.
  3. Transport of fill material from off-site sources will occur 270 days per year and 16 hours per day. Transport of fill material from on-site sources will occur 210 days per year and 16 hours per day.
- On-Site Borrow:
  1. The EIS addresses both the likely minimum and the likely maximum use of on-site fill.
  2. The Port will explore non-trucking alternatives for material extracted from Port land. Alternatives such as conveyer belts could be used. To present a worst case assessment, this EIS assumes that fill is transported by truck.
- Off-Site Borrow:
  1. At this time, it is not possible to determine the exact off-site material sources that will be used. Several permitted sites exist within 20 miles, sufficient to supply some or all of the material needed for the Master Plan Update Alternatives. Given the fill

AR 039237

requirements of the Master Plan Update, it is also possible that new material sites can be economically developed and permitted. Subject to the appropriate guidelines included in a Construction and Earthwork Management Plan, a selection will be made among the material sites based on availability, costs, mitigation requirements for the use of those material sites, and other considerations.

2. Fill may be transported by rail or barge to locations near to the Airport and then trucked or conveyed by belt systems to the airport construction sites. To present a worst case assessment, this EIS assumes that fill will be most likely transported by truck, but considers a conveyor belt system and rail as potential alternatives that may be considered by construction contractors.

3. Material transported by trucks will use freeway, highway, arterial class roadways, designated truck routes, permitted local streets, or Port properties, until reaching the on-airport haul routes.

The compacted in-place fill requirements were increased by 15 percent to account for shrinkage during placement of transported fill material. **Appendix J** contains an expanded construction impact evaluation.

Table IV.23-1 shows fill requirements that will exist for the Master Plan Update alternatives. Based on an assumed average truck capacity of 22 cubic yards per truck, about 1,200,000 truck loads of fill would be needed to complete all of the improvements included in the Master Plan Update, or about 1,074,500 for the fill requirements between 1996 and the year 2000. The 1996-2000 transport is the worst case scenario and is the analysis event for the EIS.

For the assumed minimum (Option 1) and maximum (Option 2) fill amounts available on-site, the average number of trucks required to haul the required pre-2000 material would be 73 and 44 trucks respectively per hour, per direction. As described in **Appendix J**, for analysis purposes, a factor of 1.5 was assumed to account for peaking of truck traffic, resulting in off-site truck traffic rates of 109 and 66 trucks per hour, per direction. On-site truck traffic necessary to haul the 8.0 MCY of material would average 36 trucks per hour, per direction or adjusted for peaking to 54 trucks per hour, per direction. Construction vehicles, such as scrapers, are anticipated for use in moving the common excavation material, with no trips on public roads.

(B) <u>SURFACE TRANSPORTATION</u>

The following section summarizes the construction related surface transportation impacts. Off airport hauling would affect the level of service on freeways, highways, arterials and permitted local streets used for hauling. The degradation of service levels would be significant if hauling occurs in congested areas during peak travel times. However, these impacts would be temporary and will be mitigated as a part of actions to be included in the Construction and Earthwork Management Plan and similar mitigation measures.

(1) <u>On-Site Source Transportation</u>

Source locations: Due to wetland impacts or cost to excavate, five of the eight on-airport sites identified by the Preliminary Engineering Study would likely be used to extract fill. The range of fill volumes available from these sites is described in Chapter IV, Section 19 "Earth Impacts". The location of those sources and potential haul routes are shown in **Exhibit IV.23-1**.

On-site material Sites #1-4 are located south of South 188th and north of South 216th Streets. All of Site #2 and portions of #1 and #3 lie within the City of Des Moines. Portions of #1 and #3, and all of Sites #4 and #5 lie within the City of SeaTac.

This analysis assumes a constant hourly rate of truck trips, and accounted for the ability to construct during poor weather. A construction haul period of 210 days per year was assumed to account for the water sensitive nature of the on-site material source soils.

Haul conveyance mechanism: As was noted earlier, several means exist for the transport of fill. While trucks are anticipated to be used, contractors may bid use of conveyor systems for the on-site sources. This EIS presents a worst case evaluation by assuming truck modes. Use of conveyors would reduce or eliminate the truck trips.

Haul routes and Service Levels: Transport of the material from the southern on-site material source would most likely use on-site haul routes constructed within or adjacent to the material sites to reach South 200th Street, whereupon the trucks would either access directly into the SASA site or to the on-airport roadway system. South 188th Street would be crossed via the runway bridge. While on-site routes are preferred, construction equipment and trip levels might be found incompatible with safe aircraft operations. In the event that off-site routes are used, this EIS assessed their use.

Construction trucks from Sites #1-4 could use South 200th Street to access Des Moines Memorial Drive and the Airport Perimeter Road at the intersection with South 188th Street. Both South 200th Street and Des Moines Memorial Drive in this area are designated truck routes. As residences exist along both South 200th Street and Des Moines Memorial Drive travel conditions were examined along these routes. This analysis showed that entering sight distance, roadway width, and shoulder conditions are adequate for safe truck traffic along these roadways. Through the year 2000, all intersections along this alternative construction route are expected to operate at LOS C or better. The use of both South 200th Street and Des Moines Memorial Way may require pavement overlays or reconstruction at the end of the construction period.

Site #2 is anticipated to be connected to Site #1 via a constructed east-west haul route, and then use the on-site haul route through Site #1 to South 200th Street. This route would roughly parallel South 216th Street, traversing the proposed SR 509 existing right-of-way. In the event that this haul route could not be constructed, the Port could seek permits from the City of Des Moines for the use of South 216th Street as an alternative route, between Sites #1 and #2.

Transport of the material from the north on-site borrow source, Site #5, would most likely occur on 24th Avenue South and South 154/156th Street, which are both arterials and designated truck routes by the City of SeaTac. Trucks would then enter the northern side of the construction site and use on-Airport haul routes. The north material site could also average 36 trucks per hour, per direction adjusted to 54 trucks per hour for peaking analysis. Construction truck traffic would cause the intersection of 24th Avenue South and South 154th Street to deteriorate from LOS C to LOS E for Option 1 (minimum use on-site material LOS D for Option 2 (maximum on-site material). Mitigation could consist of adding southbound and eastbound right turn lanes. Pavement overlay or reconstruction of 24th Avenue South may be required due to increased truck use.

(2) Off-Site Source Transportation

As noted earlier, the amount of truck trips that would occur would depend on the quantity of soil obtained on-site versus off-site. Minimum (Option 2) versus maximum (Option 1) off-site truck trips necessary to transport required import material ranges from 66 to 109 trucks per hour, per direction, adjusted for peaking conditions.

Source locations: Sixteen (16) off-site material source locations were identified by the Port of Seattle. Two additional sites were identified by this EIS. Potential haul routes to access those sites are depicted in **Exhibit IV.23-2**. Based on a further review of the 18 sites showed that a truck haul will most likely focus on sources 4, 7, 9, 11, 11A, 12, 13, 15, and a potential future site at the Maury Island King County Park (15A) due to the quantity of material these sites can provide, and the condition of the roadway access to these sites. **Table IV.23-2** lists the following haul route characteristics for these off-site locations:

- Roadway jurisdiction
- Roadway classification
- Number of lanes
- Current pavement condition
- Speed limit along route
- Existing average daily traffic volumes

Most of the probable material sites are currently permitted. Sites 11A, 13, and the Maury Island King County Park site could require additional permits.[1] Most likely a combination of sites would be required to comply with hours of operation and future truck route conditions. For these off-site sources, the expected haul routes are categorized as arterial or highway roads, in 'fair' or better pavement conditions. No safety concerns are anticipated due to sight distance or roadway configuration. **Table IV.23-3** summarizes the conditions along the off-site haul routes.

Haul conveyance mechanism: Similar to the on-site source conveyance, trucks are expected to be the likely mode of transport. Other potential ways of providing material to the construction site involve barges to the Duwamish area from sites #15 and the King County Parks site, and/or rail supplied material from site #9 to either the Duwamish or Kent Valley areas. Material barged or rail transported to the Duwamish could be trucked to the Airport via SR 509 during any time of the day. Material transported by rail to the Kent Valley area could be trucked to the site, but due to roadway congestion in this area, trucking may be limited to evening and night periods. Required environmental review would be conducted and compliance with permitting requirements would occur prior to development of a rail station or rail spur for this rail alternative.

An alternative to the import of off-site material by trucks has been suggested. This alternative would use a conveyor belt system to transport material barged or transported by rail to a site in the general vicinity of the Airport. Based on one proponents suggestion, several conveyance routes were reviewed. These include: conveyance south from the Duwamish industrial area along SR 509, conveyance from the Kent valley west along Orilla Road, and conveyance from Puget Sound, along the Des Moines Creek. Based on the transport distances (greater than 2 miles), only the Des Moines Creek route appears financially viable.

The Des Moines Creek route is in the initial stages of development by a private proponent. It is anticipated to require an in-water of Puget Sound off-load and docking station near the Des Moines Beach Park, and installation of an above-ground conveyor belt system approximately two miles along the Des Moines Creek Park via a Midway Sewer District easement to the construction site. The advantages of this proposal is that it has been used effectively on other large scale projects and it would eliminate all off-site material truck transport. Due to the size and quality of the material sites that could barge material, this alternative could also eliminate the need for use of the on-site material sources. The conveyor belt proponent has obtained an agreement with the Sewer District for the use of the easement, but has not obtained other permits or environmental review. Thus, this EIS assumes transport of material by truck. Required environmental review would be conducted and compliance with applicable permitting requirements would occur prior to development of the conveyor system and any associated facilities.

Haul routes and Service Levels: Contractor use of off-site material sites west of I-5 would require the use of I-5 or I-405 to reach SR 518 and SR 509 to access the Airport construction site. Use of material sources located on Maury Island, Port Gamble, or the Dupont area are expected to be barged into the Duwamish and trucked using SR 509 and SR 518 to access the Airport construction site. Level of service analysis throughout the day for year 2000 volumes at key locations with conditions expected to cause congestion impacts due to increased volumes of heavy vehicles were performed. Year 2000 traffic was chosen as a worst case event, even though most construction haul activities are to occur before then.

Results of the level of service analysis are summarized in **Table IV.23-4.** This analysis indicates that I-5 at the SR 518/I-405 interchange area would function at LOS F during the PM peak (3:00 to 7:00 PM) due to regional traffic levels without the truck traffic associated with the Master Plan Update construction activities. Predicted maximum off-site peaking truck volumes of 109 trucks per hour, per direction would worsen somewhat and would also cause deterioration to LOS F during Midday (9:00 AM to 3:00 PM) traffic flows. In addition, I-405 is also expected to be at LOS F without airport construction truck traffic during AM (6:00 to 9:00 AM) and PM peak periods. Increased

[1] Currently, the Maury Island King County Park site is not permitted, although one would be anticipated with the grading associated with the King County project. The other site has been exhausted of fill material under the present permit requirements. Weyerhaeuser is presently working with the owner concerning expansion of the fill capability.

truck traffic would worsen and would also cause Midday peak to deteriorate to LOS F. Predicted maximum off-site truck traffic would cause SR 518 (west of I-5) to deteriorate from LOS D to F during the PM peak. SR 18 which is a potential haul route for truck traffic from the Auburn/Black Diamond area sources is predicted to function under year 2000 traffic without the Airport construction traffic at LOS F during the AM, Midday and PM peaks. Construction traffic would worsen the regional traffic induced level of service. SR 167, which could also serve as a haul route for trucks from the Auburn/Black Diamond area, is predicted to function at LOS F during the PM peak as a result of additional truck traffic. SR 509 which could serve as a haul route for all off-site material sources functions at LOS E or better with both maximum and minimum off-site truck traffic during all periods of the day. All routes considered could accommodate construction truck traffic during evening and night periods.

A Construction and Earthwork Management Plan will be prepared which, based on the selected contractor(s) haul plan, specifies hours of operation, haul routes, and similar controls. It is expected that such a plan would be consistent with normal contracting practices because it is unlikely that a contractor would schedule haul activities during extreme congestion periods. Such scheduling practices radically increase the cost of completing the haul. Contractors would most likely choose to either use material sites that rely solely on SR 509 (which is the least congested major road in the airport area) , or choose to operate very low volumes during the day with most off-site haul activity occurring during the evening (7:00 p.m. to 10:00 p.m.) and night (10:00 p.m. to 6:00 a.m.) periods. Two sites, Sites #9 and #13 are expected to have hours of operation that would support evening and night hauls. Other sites could have additional morning and midday hours of operation permitted through standard environmental and permit review procedures.

Several intersections in the Airport vicinity would be impacted by the construction hauling activity. Thus, it is expected that if during the final construction phasing planning, already severely congested roads are identified by the contractor(s), the Construction and Earthwork Management Plan would include actions such as the following:

- South 170th Street and the Northbound Airport Expressway Ramp. Potential use by off-site truck traffic would change this unsignalized intersection from peak hour LOS D to LOS E for Options 1 and 2. Signalization could raise the intersection to LOS B.
- Air Cargo Road and South 170th Street - Potential use by off-site truck traffic would change this unsignalized intersection from LOS D to LOS E under Options 1 and 2. Signalization would provide LOS B.
- Air Cargo Road and Southbound Airport Expressway Ramp - Potential use by off-site truck traffic would change this unsignalized intersection from LOS E to LOS F under Options 1 and 2. Signalization would provide LOS B.
- South 154th Street and 24th Avenue South - Potential use by both on-site and off-site truck traffic would change this signalized intersection from peak hour LOS C to LOS E (Option 1) or LOS D (Option 2). Additions of Eastbound and Southbound right turn lanes would restore it to LOS C.
- Westbound SR 518 Off-Ramp to Des Moines Memorial Drive - Potential use by off-site truck traffic would keep this unsignalized intersection at a peak hour LOS F with Options 1 and 2. Signalization would improve this intersection to LOS B.
- Des Moines Memorial Drive and 8th Avenue South - Potential use by off-site truck traffic could cause traffic control concerns, Signalization would improve these concerns.
- Southbound SR 509 Ramp at South 160th Street - Potential use by of-site truck traffic would change this intersection during peak hours from LOS E to LOS F under Options 1 and 2. Signalization could restore it to LOS C.
- Northbound SR 509 Ramp at South 160th Street - Potential use by off-site truck traffic could change this unsignalized intersection from peak hour LOS D to LOS F (Option 1) or LOS E (Option 2). Signalization could restore it to LOS B.

AR 039241

(3) Cumulative On-Site and Off-Site

The proposed new Runway embankment and runway safety areas lie along the west side of the existing airfield. Potential direct access from existing roadways include South 154/156th Street, South 160th Street and by way of the Airport Perimeter Road and associated security roads. Haul traffic would reach these roads from SR 518, the Northern Airport Expressway, Air Cargo Road, Des Moines Memorial Drive, SR 509, South 188th Street, and 24th Avenue South. Construction traffic transporting off-site fill material requirements for SASA are anticipated to use SR 509, South 188th Street, and 28th Avenue South. The traffic level of service both with and without construction traffic was calculated at key intersections and freeway locations, and for combinations of on-site and off-site truck volumes.

Appendix J contains a detailed summary of the LOS evaluation which shows that the truck trips associated with the proposed Airport development would result in degradation. This degradation could be significant, particularly where background levels of congestion are at or exceed capacity. However, there are periods and routes which can be used to haul the required material to the site without significant degradation of levels of service.

(C) SOCIAL

Residential and commercial properties requiring acquisition are detailed in Section 6 "Social Impacts" of this document. This section summarizes potential social and neighborhood impacts from truck hauling of fill for the construction of the new parallel runway and runway safety areas.

As is noted in **Table IV.23-3**, residential neighborhoods are located along a portion of the haul routes from the following off-sites borrow sources:

- Site 2 (Des Moines Memorial Drive/SR 509) residents abut Des Moines Memorial Drive,
- Site 6 (Federal Way) residents along Milton Road;
- Site 7 (Auburn) residents along 41st and Ellingson;
- Site 9 residents along Maltby Road.

In addition, residential properties are located along the southern on-site borrow source routes: Des Moines Memorial Drive (the most likely haul route for the southern on-site material) is a minor arterial, with residential development located on the east and west sides of the street. On-site haul routes have been revised to include routes consisting mostly of Port-owned land (see **Exhibit IV.23-1**, which shows potential on-site haul routes). The routes would help to minimize social and neighborhood impacts from truck traffic. South 160th Street, between SR 509 and the airport, could also potentially be used as a haul route. About 15 residential properties face this street.

Temporary construction impacts would include increased noise, dust, vibration, congestion, and truck traffic near residences, businesses, and institutions located along construction routes near on-site contruction areas. Normal vehicular traffic patterns would be disruptive if drivers shose to cut-through neighborhoods to avoid congestion. Neighborhood cohesion could be adversely affected by increased traffic.

Construction traffic using SR 509, SR 518, and Interstate 5 likely would not result in significant impacts to schools because they are limited acces highways with grade separated crossings. The following schools are located in the vicinity of thse limited access haul routes: Dunlap Elem.; Highline High; Woodside Elem. - currently an administrative center; Thorndyke Elem.; Holy Innocents; and Sea-Tac Occupational Skills Center.

The following schools are located near or along haul routes in the immediate airport area (other than SR 509, SR 518) and could be adversely affected: Angle Lake Elementary, Maywood Elementary, Normandy Christian, Sunny Terrace Elementary (currently a mental health facility), and Sunndydale Elementary.

At this time, haul routes have not been finalized; specific routes will depend upon final borrow sources, contractor, and method used to transport fill. Some routes for on-site borrow sources are being investigated that are exclusively on Port property. The potential for social impacts at elementary schools noted previously as well as residential areas would be reduced with the use of these routes. The use of routes on Port property for on-site borrow sources 1 through 4 could result in potential indirected impacts (primarily noise and fugitive dust) on Des Moines Creek Park.

Because of the social disruption that would occur in the general vicinity of the new runway construction program, a construction mitigation acquisition program has been recommended. This acquisition includes about 70 residential and commercial properties located east of Des Moines Memorial Drive between SR 509 and SR 518. If this recommended acquisition program is adopted, only 15 residences would remain in close vicinity to the merge points between on-site and off-site haul traffic. These residences, and those closer to the off-site sources, would experience increased air and noise pollution during the construction period and could, during peak traffic periods experience difficulty in entering and exiting their property.

(D) NOISE

Noise impacts will occur in the vicinity of the construction sites associated with the "With Project" alternatives. Earth work and site preparation activities will result in elevated levels of noise generated by the types of equipment used on most construction sites. Noise from this equipment would vary from model to model, and would change according to the operation (type of construction) involved.

Table IV.23-5 lists an estimate of the typical sound level energy from each basic type of construction equipment. The total sound level energy is essentially a product of the machine's sound level, the number of such machines in service and the average time they operate. Although pile drivers and rock drills produce the greatest sound levels, it is dump trucks, air compressors, and concrete mixers that, due to their greater number or longer operating times, produce the most total sound energy.

Noise levels resulting from operation of construction equipment are generally higher than those generated by normal surface traffic flows. However, with a few exceptions, there would be limited off-airport construction-related noise impacts because of the distances of most residential areas from the sound sources at the various construction sites.

As is discussed in this section, the development of various elements of the Master Plan Update alternatives will result in the movement of earth to develop airport facilities. Based on the maximum hourly number of truck trips, the FHWA's STAMINA .2.0 model was used to quantify the changes in noise exposure to residential areas located along the haul routes.

TABLE IV.23-5

CONSTRUCTION EQUIPMENT NOISE

Type	Typical Sound Level dB(A) at 50'
Dump Truck	88
Portable Air	81
Concrete Mixer	85
Jackhammer	88
Scraper	88
Dozer	87
Paver	89
Generator	76
Pile Driver	101
Rock Drill	98
Pump	76
Pneumatic Tools	85
Backhoe	85

Source: *Handbook of Noise Assessment*,, May, D.N. Page 215. Van Nostrand Reinhold Company, New York, 1978

The following peak hour average sound level changes were identified:

- With maximum use of on-site material, property located along 200th Street, between the on-site borrow sources and Des Moines Memorial Drive could experience construction noise levels of as high as 5.5 dBA over existing roadway-related noise levels if 200th Street is used as a haul route. However, in this area, aircraft noise levels are substantially greater than the peak hour average construction related roadway noise levels;
- Residences facing Des Moines Memorial Drive, between 200th and SR 509 would experience an increase in sound level of about 3.6 dBA;
- Residences facing 24th Street South, near 154th Street would experience an increase in the peak hour average sound level of 6.4 dBA;
- With maximum use of off-site sources, residences facing South 160th Street east of the SR 509 interchange could experience an increased peak hour average roadway-related noise levels of about 7.6 dBA. Because of this increase noise level, much of the area between SR 509 and the new runway embankment is proposed for acquisition.

While construction related noise would increase by 5 dBA or more above existing or Do-Nothing (a substantial increase), according to Washington State Department of Transportation guidelines, these impacts are not permanent changes in noise levels, and are, thus, exempt from the criterion The construction noise impact exemption, however, does not apply during nighttime hours (10 p.m. to 7 a.m.). As a result, the Port will develop the Construction and Earthwork Management Plan to minimize nighttime noise impacts on noise sensitive facilities adjacent to the haul routes. However, even with noise management actions in use during the nighttime hours, residents west of the proposed runway may experience dump truck related construction noise.

(E) <u>AIR QUALITY</u>

Construction will have a short-term impact on local air quality. Air pollution levels during the construction period would be a consequence of one or more of the following activities:

- Vehicular activity in support of construction;
- Wind erosion of soils;
- The movement of construction vehicles along haul routes;
- Excavation; and
- Cement and aggregate handling.

Air pollution impacts would be most pronounced at the individual construction sites and along the construction haul routes.

The air quality impacts associated with the hauling of construction fill material was evaluated through a separate pollutant dispersion modeling analysis. The construction vehicle dispersion analysis was performed using the CAL3QHC air quality computer model, as described in **Appendix D**. CAL3QHC is a USEPA approved model used to predict pollutant concentrations from motor vehicles. Vehicle emission rates for input into the CAL3QHC model were derived from two other USEPA air quality models, MOBILE5A for carbon monoxide emissions and PART5 for particulate matter.

Particulate matter (PM10) is usually the pollutant of greatest concern related to construction activity. To quantify the effects of dispersing the pollutants within the surrounding environs, receptors were modeled at three meters (12 feet) from the edge of the roadways along each of the proposed haul routes.

The construction haul vehicles are expected to rely primarily on use of heavy duty diesel vehicles capable of carrying up to 100,000 tons of fill material. The analysis considers the peak hour of operation by all motor vehicles, including the haul trucks, that would occur "With Project" along each of the routes in comparison to the Do-Nothing condition.

It should be noted that the methodology used in this analysis relies on the use of modeling default values and input assumptions, as determined in consultation with the Department of Ecology and USEPA. Significant coordination was needed, due to the lack of actual data on particulates for the Region. Accordingly, this application represents true worst case analysis characteristics of a much more arid (dry) environment than is typically experienced in the Puget Sound Region.

(1) <u>Carbon Monoxide Concentrations</u>

The use of diesel haul trucks would not be expected to produce substantial carbon monoxide (CO) emissions. As shown in **Table IV.23-6**, the maximum 1-hour and 8-hour CO concentrations along each of the haul routes would be expected to be well below the CO ambient air quality standards. The "With Project" concentrations would be equal to or slightly above the Do-Nothing condition. Nonetheless, CO concentrations at all receptor locations along the proposed routes would be below the standards. Carbon monoxide concentrations along the proposed unpaved, on-airport road south of the airfield would produce negligible CO emissions off-airport.

(2) <u>PM10 Concentrations</u>

The high volume of construction truck activity would be expected to generate considerable fugitive dust emissions, especially during dry conditions. Nearly all of the particulate matter identified would be created by 'stirring' up of the dust particles already on the roads. This 'entrainment' of dust particles would be created by the mixing of turbulent air currents from construction equipment movement. Without mitigation or the use of control measures, the results would be particulate emissions above the ambient air quality standards along each of the proposed construction haul routes.

Table IV.23-7 presents the maximum 24-hour and annual particulate concentrations along each construction route. As shown, the maximum concentrations would be considerably greater than the Do-Nothing concentrations, and exceed the standards along each route.

Along Route 1 (SR 509 to South 160th Street - Routes A & B on **Exhibit IV.23-1**), the maximum 24-hour concentrations of PM10 would be 350 ug/m3 as compared to the 150 ug/m3 standard. The maximum annual concentration along Route 1 or 70 ug/m3 would also exceed the annual 50 ug/m3 annual standard. The PM10 concentrations along all other routes would show similar exceedances.

Use of an on-site, unpaved construction haul route could also result in considerable fugitive dust emissions. As shown in **Table IV.23-7**, (construction route "I"), PM10 emissions with use of an unpaved road would result in concentrations well above the standards without the application of control measures.

Therefore, without mitigation, the PM10 concentrations along each of the haul routes would exceed the standards.

(3) <u>Mitigation Measures</u>

Control measures for paved roads focus on either preventing material from being deposited on the roads (preventive controls), or removal from the travel lanes of any material that has been deposited (mitigative controls). Preventive measures include policies requiring the covering of loads in truck or "wetting" of material being hauled, cleaning vehicles before they leave a construction site, using 'bump strips' or grates to 'shake' dusk from vehicles, or by paving the construction site access roads nearest to the paved roads.

To minimize the stirring or entrainment of fugitive dust already on the roads, mitigation measures include frequent vacuum sweeping, flushing the roadways with water, or a combination of sweeping and flushing. For example, vacuum sweeping along each route would reduce particulate matter by almost 40 percent. Flushing the roadways with water followed by sweeping could reduce particulates by over 90 percent if performed frequently.

Control measures for unpaved roads will include frequently applying water or chemical stabilizers, paving, and traffic control measures limiting vehicle speeds and traffic volumes during dry periods. These measures could achieve up to 80 percent reduction in fugitive dust during dry periods.

Sweeping, watering and paved construction routes are normal Port construction practices used at Sea-Tac Airport. Thus, construction plans will be developed to include these actions. In addition, the Port will develop an overall fugitive dust control program.

* * *

Heavy construction operations at the borrow and construction sites also results in fugitive dust emissions. In general fugitive dust would be generated by two physical occurrences:

- Pulverization and abrasion of surface materials by application of mechanical force.
- Entrainment of dust particles by the action of turbulent air currents. Airborne dust could be generated independently by wind erosion.

The air pollution impact potential of fugitive dust sources would depend on the quantity and drift potential of the dust injected into the atmosphere. While the climate of the Region results in frequent rain, dry spells can result in the generation of fugitive dust.

To estimate the quantity of fugitive dust that could result from heavy construction operations at the fill borrow sites and on-airport construction activity, emissions factors were obtained from the EPA's *"Compilation of Air Pollutant Emission Factors"*. These factors (11.2 lb. per vehicle mile traveled or 1.2 tons per acre disturbed per construction month) were then applied to the area disturbed and estimated construction duration.

The following fugitive dust emissions were estimated:

Alternative	Total Fugitive Dust Emissions (Tons per year)
Do-Nothing/No-Build	2,904
"With Project" Alternatives	
Max. On-Site Use:	55,970
Min. On-Site Use:	69,840

To minimize the fugitive dust transport, unpaved roads and inactive portions of the construction site will be either watered (achieving a 50 percent reduction in dust) or chemically stabilized (achieving an 80 percent reduction) during dry periods. Development of construction plans will include identification of a fugitive dust plan.

(F) INDUCED SOCIO-ECONOMIC IMPACTS

Induced socio-economic effects from construction activities were estimated using input-output model factors. The multipliers used in this analysis are based on data from the Washington State input-output model and were adjusted downward to more accurately reflect the Puget Sound economy. The adjusted multipliers were then applied to estimated capital costs for the construction of the Master Plan Update alternatives to determine employment impacts.

The resulting employment impacts are:

	Construction Related Employment
Do-Nothing (Alternative 1)	
Direct Jobs	3,687
Indirect Jobs	4,465
Total	8,152

	Runway Length Options		
	8,500 ft	7,500 ft	7,000 ft
"With Project" (Alternative 2, 3 and 4)			
Direct Jobs	20,559	19,101	19,231
Indirect Jobs	24,894	23,129	12,286
Total	45,453	42,230	42,517

Revenue effects that would accrue to individual communities in the Region as a result of airport-related construction activity would vary depending on the extent of local purchases of goods and services in these cities. In the State of Washington, materials and labor used in construction are included in the taxable base for retail sales; therefore, one-time sales tax revenues would be generated on the basis of the estimated value of construction spending throughout the construction project period. Construction-activity-generated sales revenues would also accrue to King County and the State of Washington.

(G) WATER QUALITY

Potential construction impacts include temporary increases in suspended sediment concentrations caused by an increase of eroded materials entering/reaching Miller and Des Moines Creeks. Construction activities including clearing, grading, and filling at the runway site (and excavation at borrow source areas) have been estimated using the Revised Universal Soil Loss Equation (RUSLE). RUSLE provides an estimate average sediment production caused by sheet and rill erosion processes, which are the dominant erosion processes at construction sites (i.e., runway fillslopes and borrow source area cutslopes). RUSLE does not account for potential sediment production from gully erosion or mass wasting processes, which are not processes typically encountered at construction sites. It should be noted that estimated sediment yields are estimates of sediment eroded from fillslope and cutslopes. This is not equivalent to the amount of sediment delivered to or received by Miller and Des Moines Creeks. A significant proportion of eroded material would be removed and retained onsite by stormwater management facilities.

A number of assumptions were made to estimate sediment yields from fillslopes and cutslopes at construction (i.e., fillslopes) and borrow source area (i.e., cutslopes) sites. Sheet and rill erosion are the dominant erosional processes at construction sites and therefore sediment yields from construction areas are approximated by the revised universal soil loss equation $A = R*K*L/S*C*P$ where R is the factor for climate erosivity (from R factor map = 40); K is the soil erodibility factor for compacted fillslopes and cutslopes of glacial till, recessional and advance outwash materials, which is approximated by the erodibility factor for Alderwood Series soils (K = 0.15); L/S is the length/slope factor (from published table); slope lengths determined using the Pythagorean Theorem $a^2+b^2=c^2$ where a = horizontal distance from plan view drawings[2/], b = vertical height and c = slope length; all slope lengths for the borrow source area cutslopes use maximum recommended vertical height of 30 feet and 50% slope; fillslopes and cutslopes will be 50% (2H:1V), unreinforced slopes; C is the cover-management factor (C = 0.1 for mulching and 0.03 for established vegetation); P is the support practices factor for conservation planning. Total average annual sediment yield for fillslopes and cutslopes (tons/year) was then determined by multiplying the estimated sediment yield (tons/acre/year) by the appropriate fillslope and cutslope areas determined from plan view drawings. Borrow site sediment yield estimates were determined using the preferred alternatives for each site[3/]. Proposed terminal (i.e., landside) improvements would result in negligible increases in sediment being

2/ *Seattle-Tacoma International Airport Third Dependent Runway Preliminary Engineering Study*, HNTB, 1994.

3/ *Draft Seattle-Tacoma International Airport Investigation of On-Site Borrow Sources*, HNTB, May 1995.

transported to Miller and Des Moines Creeks. Estimated sediment yields using a cover factor of 0.03 and support practices factor of 0.2 represent expected conditions following successful establishment of vegetation. Estimated sediment yields using a cover factor of 0.1 and P factors ranging from 0.5 to 0.2 represent expected conditions during and up to 1 year after construction.

The primary mechanism for delivery of sediment to Miller and Des Moines Creeks from construction and borrow source areas is in stormwater runoff. Without established transport routes or pathways to Miller and Des Moines Creeks (e.g., culverts, ditches, and swales), much of the sediment eroded from fillslope surfaces would be deposited at the base of the fillslopes where there are buffers of established vegetation and lower gradients between potential sediment sources and these creeks. Estimated sediment yields do not account for removal of suspended solids (i.e., water borne sediment) from stormwater runoff. Some fraction of the eroded fillslope materials will reach stormwater collection and conveyance facilities. Proposed conceptual stormwater management facilities (i.e., wet vaults and biofiltration swales), which have suspended solid removal efficiencies ranging from 50 to 100%, Based on treatment efficiencies it is expected that at least 80% of the total suspended solids delivered to stormwater management facilities (e.g., wet vaults, wet ponds, and swales) will be removed. Although unlikely, it is assumed all sediment yields would be delivered to stormwater management facilities.

Therefore, during and up to 1 year after construction, it is estimated there could be an increase in sediment loading of about 28 to 71 tons per year to Miller Creek and about 24 to 60 tons per year to Des Moines Creek. Based on estimated existing sediment loadings (as Total Suspended Solids – TSS) for Miller Creek and Des Moines Creek, these represent estimated increases of about 11 to 27% (Miller Creek) and 14 to 36% (Des Moines Creek) during and immediately after construction. Sediment that is not retained in stormwater management facilities and that reaches Miller and Des Moines Creeks would contribute to temporary increases in TSS concentrations. These potential temporary increases in suspended solids and impacts on water quality could be expected to decrease exponentially as vegetation becomes established, covers exposed soils, reducing soil erodibility and thereby sediment yields and sediment loads. In addition, the Port's erosion control plan, would further reduce potential sedimentation levels.

Actual sediment yields would be expected to be lower than estimates in **Table IV.23-8** for several reasons. Average annual sediment yields for borrow source areas are based on maximum slope gradient of 50%. Based on the preliminary preferred alternative grading plans for the borrow source areas, average slope gradients would be significantly lower than 50% for at least half of the slopes of all borrow source areas. Slope gradient is one of the most important factors affecting erosion. As gradient decreases, potential energy and potential sheet and rill erosion decreases proportionally. Therefore, estimated average sediment yields would be expected to be considerably higher than actual sediment yields from borrow source areas. In addition, several other factors at borrow source areas would be expected to reduce actual sediment yields compared to these estimates:

- Topographic benches or much lower gradient slopes are proposed at the base of all steeper slopes;
- All borrow source area boundaries are separated from Miller and Des Moines Creeks by forested buffers of at least 150 feet;
- A buffer of established vegetation of at least 50 feet would be maintained between clearing and grading limits and borrow source area boundaries;
- Potential sediment delivery pathways (e.g., drainages, culverts, ditches, or swales) to Miller and Des Moines Creeks are absent;
- Only a fraction of the material eroded would eventually reach stormwater management facilities (as TSS) on Miller and Des Moines Creeks; the rest would be retained within the borrow source area boundaries.

For these reasons, actual potential increases in sediment loading to Miller and Des Moines Creeks would be expected to be lower than estimated. Actual sediment yields and temporary increases in TSS from construction activities would depend on the effectiveness of erosion and sediment controls; fillslope and cutslope lengths; widths of existing buffers of forest vegetation (i.e., established vegetation); topographic benches and depressions that act as sinks for eroded materials; and available sediment delivery pathways (e.g., ditches, culverts, and swales).

Potential construction impacts would be reduced by an erosion and sediment control plan. An approved erosion control plan would include a complex and effective system of erosion and stormwater runoff controls. Elements of an erosion and sediment control plan would include a interconnected system of erosion and stormwater runoff controls, including best management practices and structural erosion control methods, such as phased clearing and grading, confining construction to the dry season whenever possible, sediment traps and ponds, interceptor dikes and swales, mulching, filter fabric fence, hydroseeding, and terracing. Terracing and phased clearing and grading and other erosion controls would reduce slope lengths and result in proportional reductions in surface erosion. Similarly, stormwater runoff controls (e.g., interceptor dikes and swales, sediment ponds) would result in proportional reductions in surface erosion by reducing rilling, increasing sediment deposition, and reducing sediment delivery to Miller and Des Moines Creeks. Combined these BMPs or structural erosion controls reduce erosion or sediment delivery and thereby control potential increases in TSS in Miller and Des Moines Creeks. Although implementation of an effective erosion and sediment control plan would not remove all TSS, it is expected to successfully mitigate potential TSS loading and temporary construction impacts on water quality in Miller and Des Moines Creeks.

Erosion control success depends on the timing of application of the control measure(s), the rate of application (for mulches), and types of control measures, soil erodibility, and slope gradient. Erosion controls implemented immediately after or during construction have a much greater potential to appreciably reduce sediment production compared to measures implemented later.[4/] In general, sediment production rates from fillslopes are initially high in unconsolidated material, then decrease exponentially over time as vegetation becomes established. The ability of established vegetation to anchor and hold soils in place is clearly reflected in the lower sediment yield estimates in **Table IV.23-8** for established cover conditions. As vegetation becomes established on these fillslope and cutslope areas following construction, sediment yields are expected to decrease exponentially. Only a fraction of the estimated sediment from fillslope and cutslopes is likely to reach Miller and Des Moines Creeks.

4 *Reduction of Soil Erosion on Forest Roads*, E.R. Burroughs Jr. and J.G. King, General Technical Report INT-264, U.S. Department of Agriculture, Forest Service, Intermountain Research Station, 1989.

Potential construction impacts on surface water quality are generally limited to short-term increases in total suspended solids from erosion and sedimentation. Such impacts would be mitigated by implementation of an approved stormwater pollution prevention plan and erosion and sedimentation control plan, which are required conditions of the Port of Seattle NPDES permit for the Airport. These plans would be required before construction began and would include specific performance standards and contingency plans. Chapter IV, Section 10 "Water Quality and Hydrology" provides additional detail on water quality impacts.

(H) SOLID WASTE

King County contracts with two private firms, Waste Management, Inc. and Regional Disposal Company (Rabanco), to provide receiving facilities for non-recyclable CDL wastes generated in King County. Contracts negotiated with Waste Management, Inc. and Rabanco include an agreement that King County no longer accept CDL wastes, except in incidental quantities. Waste-handling services provided by Waste Management, Inc. and Rabanco include transfer of mixed loads of CDL wastes, removal of recyclable materials, and collection and disposal of CDL wastes. The CDL waste collected at transfer facilities is disposed of in landfills owned and operated by these companies.

Limited recycling of CDL materials is provided at the vendor facilities. King County also offers technical assistance to encourage recycling of CDL wastes. A CDL Material Management Resource Guide, published by the King County Solid Waste Division, lists local CDL recycling facilities.

The amount of construction and demolition waste associated with the four alternatives for the Sea-Tac International Airport Master Plan cannot be quantified at this time, but would be expected to be essentially the same for each build alternative. A substantial amount of demolition and construction waste will be generated. The majority of the waste material will result from off-Airport site building, road, and associated infrastructure demolition, as well as on-site building, road, and taxiway demolition to accommodate new and expanded landside and airside facilities at the Airport.

(I) CUMULATIVE IMPACTS

The completion of the proposed Master Plan Update improvement is not anticipated to have a large impact, in combination with other development in the Airport area. The timing of the proposed new parallel runway embankment construction is not anticipated to coincide with other equally large scale development in the Airport area. Terminal and landside improvements could occur in a timeframe similar to other roadway projects, such as the SR 509 Extension/South Access. The cumulative impacts of the Master Plan Update landside/terminal improvements would likely result in added roadway congestion and impacts due to air, noise, and water pollution.

(J) MITIGATION

Based on the selected hauling plan, the Port of Seattle will develop a Construction and Earthwork Management Plan. If impacts are found, actions such as the following measures will be taken to minimize construction related impacts:

1. The Plan would designate preferred haul routes and specific conditions such as hours of operations, traffic control changes, and route mitigation which should be included in the construction earthwork bid document(s) as contract requirements. If the routes suggested by the contractor(s) include roadways or intersections that are already performing at a LOS D or F, the Plan would include action such as provisions that restrict truck traffic during AM and PM peak periods.

   During dry weather conditions, contract provisions which would require the contractor to cover all loads to reduce debris and dust loss from the transport activities and to provide for street cleaning and pavement repairs during the construction process will be stipulated.

2. Consider acquiring material rights to the Maury Island sites. Use of Site #14 and the Maury Island King County Park (consistent with the development of the park and if permits can be obtained) would limit the affected routes to SR 509, which could handle additional truck traffic throughout the day without significant impacts on levels of service.

Because of the social disruption that would occur in the general vicinity of the proposed new runway construction, a construction mitigation acquisition program will be implemented. This acquisition includes about 70 residential and commercial properties located east of Des Moines Memorial Drive between SR 509 and SR 518.

To minimize the fugitive dust transport, unpaved roads and inactive portions of the construction site will be watered (achieving a 50 percent reduction in dust) or chemically stabilized (achieving an 80 percent reduction) during dry periods.

TABLE IV.23-1

Seattle-Tacoma International Airport
Environmental Impact Statement

CONSTRUCTION FILL REQUIREMENTS

Fill Available

On-Site Borrow Source	Available On-Site Fill (Million Cubic Yards) Minimum	Maximum
Area 1	0.00	0.50
Area 2	0.00	0.65
Area 3	0.00	2.90
Area 4	0.00	2.20
Area 5	0.00	1.75
Area 8	0.00	0.00
Subtotal	0.00	8.00
Common Excavation	2.90	3.10
Total On-Site Fill Available	2.90	11.10

Fill Requirements

Master Plan Update Construction Activity	Total Fill Requirements (Million Cubic Yards) In-Place	Adjusted
8,500 Foot New Parallel Runway	17.25	19.84
RSA Improvements	0.98	1.13
Relocation of S. 154th Street	0.13	0.14
SASA Facilities	2.20	2.53
Subtotal	20.56	23.64
Runway 34R Extension	2.40	2.76
Total Fill Required	22.96	26.40

Exhibit IV.23-1 shows the on-site borrow sources, while Exhibit IV.23-2 shows the possible off-site sources.

Source: INCA Engineers, December 1995.

TABLE IV.23-2
Page 1 of 4

Seattle-Tacoma International Airport
Environmental Impact Statement

SUMMARY OF EXPECTED OFF-SITE BORROW SOURCE HAUL ROUTES

SOURCE #1 - SeaTac, King County

Expected Source Access Route	Jurisdiction/ Agency	Route Classification	Number of Lanes	Pavement Condition	Speed Limit	Existing ADT	Additional Comments
International Boulevard/SR99	WSDOT	Principal Arterial	5 lanes	Very Good	45 mph	33,000	
South 160th Street	City of SeaTac	Minor Arterial	4 lanes	Good	35 mph	9,000	

SOURCE #2 - SeaTac, King County

Expected Source Access Route	Jurisdiction/ Agency	Route Classification	Number of Lanes	Pavement Condition	Speed Limit	Existing ADT	Additional Comments
Des Moines Memorial Drive South	City of SeaTac	Minor Arterial	2 lanes	Good	35 mph	13,000	

SOURCE #3 - SeaTac/Kent/Tukwila, King County

Expected Source Access Route	Jurisdiction/ Agency	Route Classification	Number of Lanes	Pavement Condition	Speed Limit	Existing ADT	Additional Comments
Orillia Road	King County	Principal Arterial	2 lanes	Good	35 mph	27,000	
South 188th Street	City of SeaTac	Principal Arterial	4 lanes	Very Good	40 mph	27,000	

SOURCE #4a, #4b - Dieringer, Pierce County

Expected Source Access Route	Jurisdiction/ Agency	Route Classification	Number of Lanes	Pavement Condition	Speed Limit	Existing ADT	Additional Comments
East Valley Highway	Pierce County	Principal Arterial	2 lanes	Good Poor	35 mph	11,000	North of Forest Canyon Road South of Forest Canyon Road
8th Street East	Pierce County	Principal Arterial	2 lanes	Fair	35 mph	12,000	
State Route 167	WSDOT	Principal Arterial Fwy	4 lanes	Very Good	55 mph	56,500	
West Valley Highway	City of Auburn	Principal Arterial	4 lanes	Good	40 mph		
State Route 18	WSDOT	Principal Freeway	4 lanes	Good	55 mph	68,000	Steep Grades
Interstate 5	WSDOT	Principal Freeway	8 lanes	Fair	55 mph	154,500	

Exhibit IV.23-2 shows the possible off-site sources.

TABLE IV.23-2
Page 2 of 4

Seattle-Tacoma International Airport
Environmental Impact Statement

SUMMARY OF EXPECTED OFF-SITE BORROW SOURCE HAUL ROUTES

SOURCE #5, #8 - Tacoma, Pierce County

Expected Source Access Route	Jurisdiction/ Agency	Route Classification	Number of Lanes	Pavement Condition	Speed Limit	Existing ADT	Additional Comments
Marine View Dr/East - West Road	City of Tacoma	Minor Arterial	2 lanes	Fair/Poor	35 mph	8,300	
Taylor Way/54th Ave East/ Valley Ave	City of Tacoma	Minor Arterial	5 lanes	Good	35 mph	13,500	
Interstate 5	WSDOT	Principal Arterial Fwy	8 lanes	Fair	55 mph	154,500	

SOURCE #6 - Federal Way, King County

Expected Source Access Route	Jurisdiction/ Agency	Route Classification	Number of Lanes	Pavement Condition	Speed Limit	Existing ADT	Additional Comments
Milton Road/16th Ave South	King County	Collector Arterial	2 lanes	Fair/Poor Excellent	35 mph	5,000	South of 375th Street North of South 375th Street
Enchanted Parkway/ State Route 161	WSDOT	Minor Arterial Minor Arterial	2 lanes 5 lanes	Good	35 mph	23,000	South of 351st Street North of South 351st Street
South 348th Street/State Route 18	WSDOT	Principal Arterial	5 lanes	Good	35 mph	51,000	
Interstate 5	WSDOT	Principal Arterial Fwy	8 lanes	Fair	55 mph	154,500	

SOURCE #7 - Auburn, King County

Expected Source Access Route	Jurisdiction/ Agency	Route Classification	Number of Lanes	Pavement Condition	Speed Limit	Existing ADT	Additional Comments
Kersey Way/"R" Street SE	Auburn	Principal Arterial	2 lanes	Good	35 mph	12,200	
Private Truck Route	Private		2 lanes	N/A	N/A	N/A	
Ellingson Road/41st Street SE	Algona/Auburn/ Pacific	Principal Arterial	4 lanes	Good	35 mph	10,800	
State Route 167	WSDOT	Principal Arterial Freeway	4 lanes	Very Good	55 mph	56,500	
West Valley Highway	City of Auburn	Principal Arterial	4 lanes	Good	40 mph		
State Route 18	WSDOT	Principal Arterial Freeway	4 lanes	Good	55 mph	68,000	Steep 6% Grade between I-5 and SR 167 (Westbound Uphill)
Interstate 5	WSDOT	Principal Arterial Fwy	8 lanes	Fair	55 mph	154,500	

Exhibit IV.23-2 shows the possible off-site sources.

TABLE IV.23-2
Page 3 of 4

Seattle-Tacoma International Airport
Environmental Impact Statement

SUMMARY OF EXPECTED OFF-SITE BORROW SOURCE HAUL ROUTES

SOURCE #9 - Maltby, Snohomish County

Expected Source Access Route	Jurisdiction/ Agency	Route Classification	Number of Lanes	Pavement Condition	Speed Limit	Existing ADT	Additional Comments
Maltby Road/Yew Road/Paradise Lake Road/SR 524	WSDOT	Collector Arterial	2 lanes	Good	35 mph	9,300	
State Route 522	WSDOT	Principal Arterial Freeway	2 lanes 4 lanes	Very Good	55 mph	45,500	North of the SR9 Interchange South of the SR9 Interchange
Interstate 405	WSDOT	Principal Arterial Freeway	6 lanes	Good	55 mph	129,000	

SOURCE #10, #11, and 11A - Black Diamond, King County

Expected Source Access Route	Jurisdiction/ Agency	Route Classification	Number of Lanes	Pavement Condition	Speed Limit	Existing ADT	Additional Comments
Black Diamond - Enumclaw Rd/ SR169	WSDOT	Minor Arterial	2 lanes	Good	50 mph 35 mph	9,000	South of Black Diamond Within Black Diamond
Maple Valley - Black Diamond Rd/ SR169	WSDOT	Minor Arterial	2 lanes 4 lanes	Fair	50 mph 35 mph	11,000	North of Black Diamond Within Black Diamond
Auburn - Black Diamond Rd	King County	Principal Arterial	2 lanes	Good	50 mph 40 mph	7,600	East of Kent - Black Diamond West of Kent - Black Diamond
State Route 18	WSDOT	Principal Arterial Freeway	4 lanes	Good	55 mph	68,000	Steep 6% Grade between I-5 and SR167 (Westbound Uphill)
Interstate 5	WSDOT	Principal Arterial Freeway	8 lanes	Fair	55 mph	154,500	

Exhibit IV.23-2 shows the possible off-site sources.

TABLE IV.23-2
Page 4 of 4

Seattle-Tacoma International Airport
Environmental Impact Statement

SUMMARY OF EXPECTED OFF-SITE BORROW SOURCE HAUL ROUTES

SOURCE #12 - Covington/Kent, King County

Expected Source Access Route	Jurisdiction/ Agency	Route Classification	Number of Lanes	Pavement Condition	Speed Limit	Existing ADT	Additional Comments
Covington - Sawyer Rd	King County	Minor Arterial	2 lanes	Good/Fair	35 mph	11,000	
Kent - Kangley Rd/South 272nd Street/SR516	WSDOT	Principal Arterial	5 lanes	Excellent/ Very Good	35 mph	25,000	
State Route 18	WSDOT	Freeway Principal Arterial Fwy	4 lanes 2 lanes	Good	55 mph	49,000	South of Auburn-Black Diamond I/C North of Auburn-Black Diamond I/C Steep 6% Grade between I-5 and SR167 (Westbound Uphill)
Interstate 5	WSDOT	Principal Arterial Fwy	8 lanes	Fair	55 mph	154,500	

SOURCE #13 - North Bend, King County

Expected Source Access Route	Jurisdiction/ Agency	Route Classification	Number of Lanes	Pavement Condition	Speed Limit	Existing ADT	Additional Comments
468th Ave SE	King County	Collector Arterial	2 lanes	Good/Fair	35 mph	11,000	
Interstate 90	WSDOT	Principal Arterial Fwy	6 lanes	Good	55 mph	70,500	West of North Bend
Interstate 405	WSDOT	Principal Arterial Fwy	6 lanes	Good	55 mph	129,000	

SOURCE #14 - Dupont, Pierce County
SOURCE #15 - Maury Island, King County, SOURCE #15A - Maury Island, Future King County Park
SOURCE #16 - Port Gamble, Kitsap County

Expected Source Access Route	Jurisdiction/ Agency	Route Classification	Number of Lanes	Pavement Condition	Speed Limit	Existing ADT	Additional Comments
East Marginal Way South/SR99	WSDOT	Principal Arterial	7 lanes	Good/Fair	45 mph	43,500	The Borrow Source material would be barged into Duwamish Waterway.
State Route 509	WSDOT	Principal Arterial Fwy	4 lanes	Good	55 mph	40,500	

Exhibit IV.23-2 shows the possible off-site sources.

TABLE IV.23-3

Seattle-Tacoma International Airport
Environmental Impact Statement

SUMMARY OF CONSTRUCTION TRAFFIC IMPACTS
REVIEW FOR USE OF OFF-SITE BORROW SOURCES ACCESS ROUTES

Borrow Source	Feasible Site: Quality/ Quantity	Residential Concerns	Safety Concerns	Roadway Classifications	Roadway Condition	Comments
1	Limited Class C		Satisfactory	Satisfactory	Satisfactory	limited quality or quantity. Use not anticipated.
2	Limited Class C May be on SR 509 Alignment	Des Moines Drive	Satisfactory	Satisfactory	Satisfactory	limited quality or quantity. Use not anticipated.
3	B/C	Along Orillia Road and South 188th	Satisfactory	Satisfactory	Satisfactory	limited quality or quantity. Use not anticipated
4A/4B	Yes		Satisfactory	Satisfactory	Satisfactory	
5	Yes		Satisfactory	Satisfactory	Satisfactory	limited quality or quantity. Use not anticipated.
6	Yes	Along Milton Road	Satisfactory	Satisfactory	Satisfactory	Local access route congested throughout the day. Use not anticipated.
7	Yes. Could Supply All	Along 41st/ Ellingson	Satisfactory	Satisfactory	Satisfactory	
8	Yes		Satisfactory	Satisfactory	Satisfactory	limited quality or quantity. Use not anticipated
9	Yes	Along Maltby Road	Satisfactory	Satisfactory	Satisfactory	Potential Rail Source
10	Yes, Could Supply All		Satisfactory	Satisfactory	Satisfactory	limited quality or quantity. Use not anticipated.
11/11A	Yes		Satisfactory	Satisfactory	Satisfactory	
12	Yes		Satisfactory	Satisfactory	Satisfactory	
13	Yes, Could Supply All		Satisfactory	Satisfactory	Satisfactory	
14, 15, 15A	Yes, Could Supply All		Satisfactory	Satisfactory	Satisfactory	
16	Class C		Satisfactory	Satisfactory	Satisfactory	limited quality or quantity. Use not anticipated.

Off-site borrow source construction truck traffic could range from 66 truck trips to 109 truck trips per hour. Exhibit IV.23-2 shows the possible off-site sources.

Source: INCA Engineers, December, 1995.

TABLE IV.23-4

Seattle-Tacoma International Airport
Environmental Impact Statement

LEVELS OF SERVICE SUMMARY SHEET

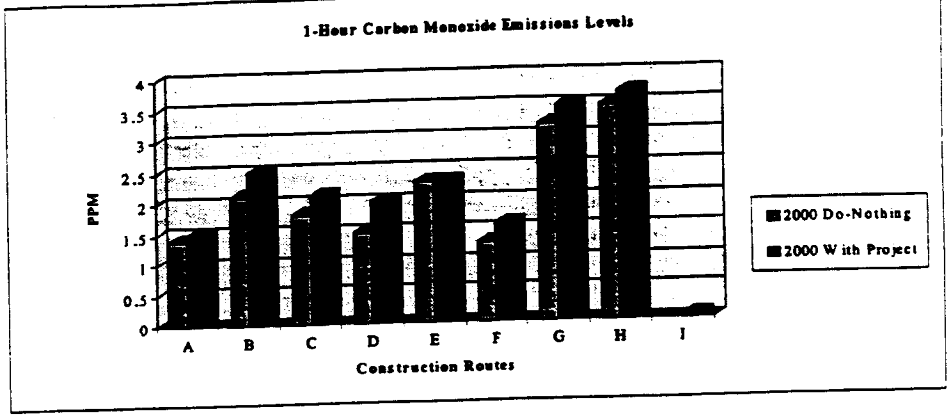
Facility Section		1994 Existing Condition AM	MID.	PM	EVE	NIGHT	Year 2000 Do Nothing Without Const. Trucks AM	MID.	PM	EVE	NIGHT	Minimum On-Site Option #1 AM	MID.	PM	EVE	NIGHT	Maximum On-Site Option #2 AM	MID.	PM	EVE	NIGHT
I-5	NB	E	D	D	B	A	E	D	E	B	A	E	D	E	C	B	E	D	E	C	B
(SR 518 to S 188th St.)	SB	D	E	F	D	A	D	E	F	D	A	D	F	F	E	B	D	E	F	D	B
SR 518	EB	C	C	D	B	A	C	C	E	C	A	D	D	E	C	A	C	D	E	C	A
(I-5 to SR 99)	WB	C	C	D	B	A	C	C	D	B	A	D	D	F	C	B	D	D	E	C	A
SR 518	EB	A	B	B	A	A	A	B	C	A	A	B	C	C	B	A	B	C	C	B	A
(SR 99 to SR 509)	WB	B	B	C	A	A	B	B	C	A	A	D	B	C	A	A	B	B	C	A	A
SR 18	EB	D	C	D	B	A	D	D	D	B	A	E	D	E	C	B	E	D	E	B	B
(I-5 to SR 167)	WB	F	E	F	B	B	F	F	F	C	B	F	F	F	E	E	F	F	F	D	D
SR 509	NB	D	B	C	B	A	E	C	C	B	A	E	C	D	C	B	E	C	C	C	A
(Just north of SR 518)	SB	B	B	C	A	A	B	B	C	A	A	C	C	E	C	B	C	C	D	C	A
SR 509	NB	B	A	B	A	A	C	A	B	A	A	C	B	C	A	B	C	A	C	A	A
(SR 518 to S. 160th St.)	SB	C	C	D	B	C	D	D	D	B	C	D	D	D	C	C	D	D	D	C	C
SR 167	NB	D	D	C	B	A	E	D	D	B	B	E	E	D	C	B	E	D	D	C	B
(I-405 to SW 34th St., Carr St.)	SB	C	D	E	C	A	D	E	E	C	B	E	E	F	D	B	D	E	F	D	B
I-405	NB	F	E	E	C	B	F	E	E	C	B	F	E	F	D	C	F	E	F	C	B
(SR 167 to I-5)	SB	D	E	F	C	A	D	E	F	D	A	E	F	F	E	B	E	F	F	E	B

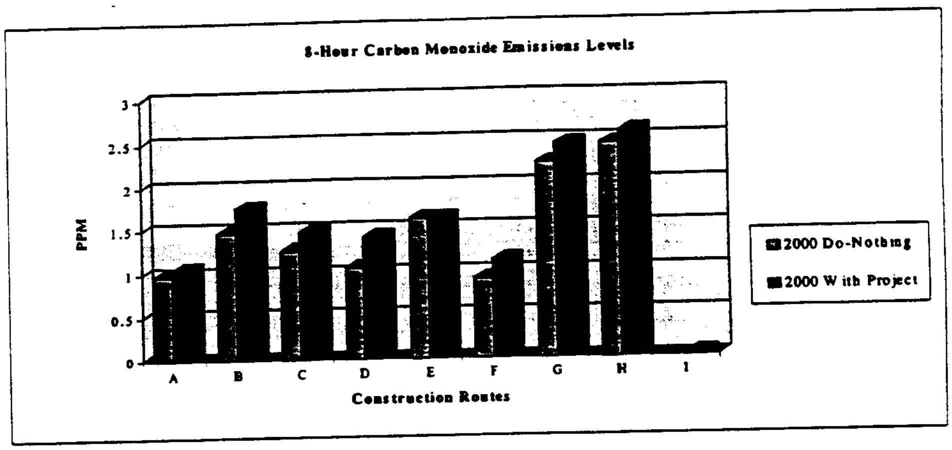
NB = North Bound on segment
SB = South Bound on segment
Source: INCA Engineers, December 1995.

TABLE IV.23-6

Seattle-Tacoma International Airport
Environmental Impact Statement

CONSTRUCTION ROUTE EMISSIONS
1-HOUR & 8-HOUR CARBON MONOXIDE
WITHOUT BACKGROUND LEVEL(ppm)[1/]





Note: A = SR509 from SR518 to So. 160th Street
B = So. 160th Street from SR509 to Des Moines Memorial Drive So.
C = Des Moines Memorial Drive So. from So. 160th Street to 8th Avenue So.
D = Des Moines Memorial Drive So. from 8th Avenue So. to 148th Street
E = 154th Street from 24th Avenue So. to 16th Avenue So.
F = 24th Avenue So. from 154th Street to So. 152nd Street
G = Des Moines Memorial Drive So. from So. 200th Street to 188th Street
H = So. 200th Street from Des Moines Memorial Drive So. to 26th Avenue So.
I = Unpaved on-Airport road south of airfield
[Exhibit IV.23-1 illustrates the construction haul routes]

AAQS: 1-Hour CO = 35 ppm; 8-Hour CO = 9 ppm

1/ Background levels are not included as follows: 1-Hour background=5 ppm; 8-Hour background=3.5 ppm

Source: Landrum & Brown, Inc., CAL3QHC, December, 1995
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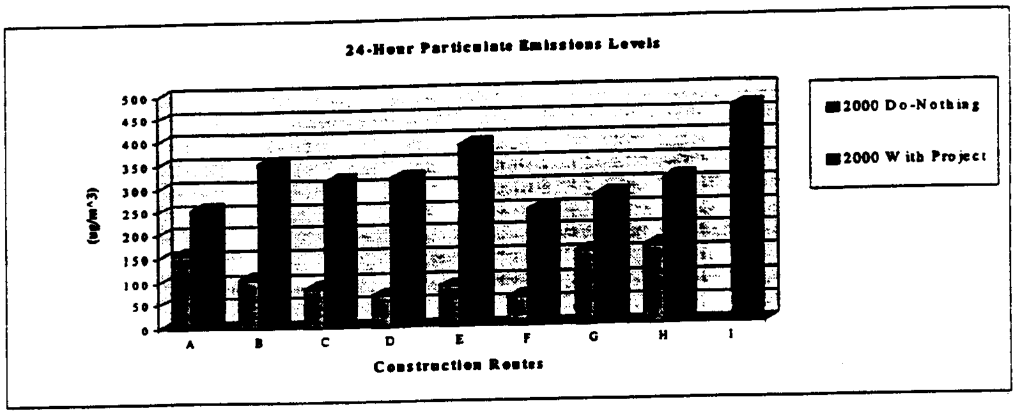
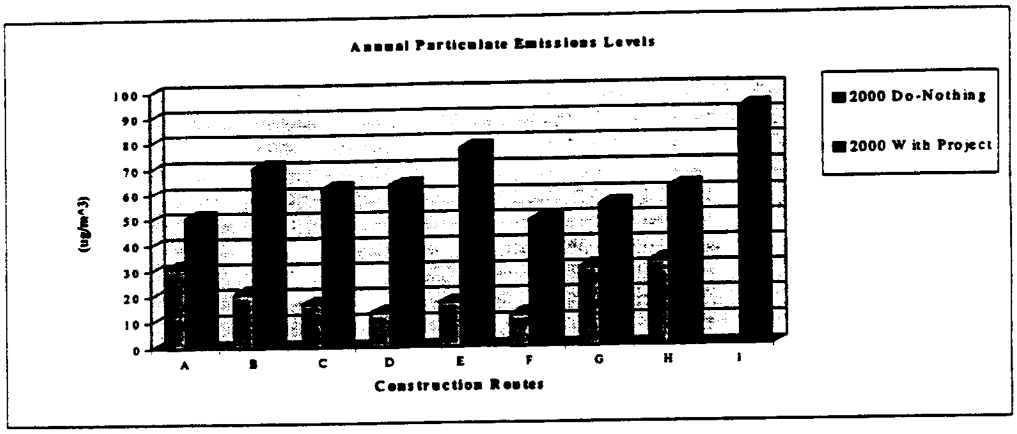
TABLE IV.23-7

Seattle-Tacoma International Airport
Environmental Impact Statement

**CONSTRUCTION ROUTE EMISSIONS
24 HOUR & ANNUAL PARTICULATES
WITHOUT BACKGROUND LEVEL (µg/m^3)**





Note: A = SR509 from SR518 to So. 160th Street
B = So. 160th Street from SR509 to Des Moines Memorial Drive So.
C = Des Moines Memorial Drive So. from So. 160th Street to 8th Avenue So.
D = Des Moines Memorial Drive So. from 8th Avenue So. to 148th Street
E = 154th Street from 24th Avenue So. to 16th Avenue So.
F = 24th Avenue So. from 154th Street to So. 152nd Street
G = Des Moines Memorial Drive So. from So. 200th Street to 188th Street
H = So. 200th Street from Des Moines Memorial Drive So. to 26th Avenue So.
I = Unpaved on-Airport road south of airfield
[Exhibit IV.23-1 illustrates the construction haul routes]

AAQS: 24-Hour Particulates = 150 µg/m^3; Annual Particulates = 50 µg/m^3

1/ Background levels are not included as follows: 24-Hour background=88 µg/m^3; Annual background=33 µg/m^3

Source: Landrum & Brown, Inc., CAL3QHC, December, 1995
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TABLE IV.23-8

ESTIMATED EXISTING AND POTENTIAL SEDIMENT YIELDS (tons/yr)

from sheet and rill erosion at proposed construction sites using the revised Universal Soil Loss Equation.[5/]

	Existing[a]	Mulched/50%[b]	Mulched/20%[b]	Est. Cover/20%[c]
Miller Creek Basin				
West embankment	—	229.8	91.9	27.6
North embankment	—	24.5	9.8	2.9
Runway, etc.[d]	—	18.0	6.9	6.9
North Borrow Sites[e]	—	84.2	33.7	10.1
Total Sediment Yield	—	**356.5**	**142.3**	**47.5**
Total Sediment Load	**263-1,336**	**71.3**	**28.4**	**9.5**
Des Moines Creek Basin				
Runway, etc.[d]	—	22.9	9.1	2.7
South Borrow Sites[e]	—	277.0	110.8	33.2
Total Sediment Yield	—	**299.9**	**119.9**	**35.9**
Total Sediment Load[f]	**167-622**	**60.0**	**24.0**	**7.2**

Assumptions: All embankments and cutslopes are unreinforced 2H:1V slopes; 44% of runway construction area will drain to Miller Creek and 56% will drain to Des Moines Creek; maximum used for borrow source area calculations (slope height 30 feet, slope length 60 feet).

a Range of estimated existing sediment loadings (as TSS) are for the entire basin areas based on established land use loading rates (lbs/acre/year) and land use areas identified in Draft EIS Table IV.10-2.

b All exposed areas would be mulched with straw and 20 to 50% of eroded material delivered to construction site or borrow source area boundaries (i.e., 50 to 80% retained or deposited within these areas).

c All exposed areas would have established grass or shrub vegetation and 20% of eroded material would be delivered to construction site or borrow source area boundaries (80% retained or deposited within these areas).

d Runway, etc. includes the new parallel runway, taxiways, perimeter road, and interrunway areas.

e North Borrow Sites includes only Borrow Source Area 5 (sites 6, 7, and 8 have been dropped and are no longer considered viable options); South Borrow Sites includes Borrow Source Areas 1-4.

f 20% of all sediment delivered (i.e., sediment yield) to stormwater management facilities would be delivered to Miller and Des Moines Creeks.

5/ *Revised Universal Soil Loss Equation,* U.S. Department of Agriculture, Natural Resources Conservation Service, 1995.

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Seattle-Tacoma International Airport
Environmental Impact Statement
for the Master Plan Update

Exhibit IV.23-1

On Site Borrow Source Areas and Airport Vicinity Haul Routes

Jurisdictional Boundary

Potential On-Site Borrow Sources

Off-Site Haul Route

On-Site Haul Route

(X) Air Quality Analysis Haul Routes
Refer to Tables IV.23-6 and IV.23-7.

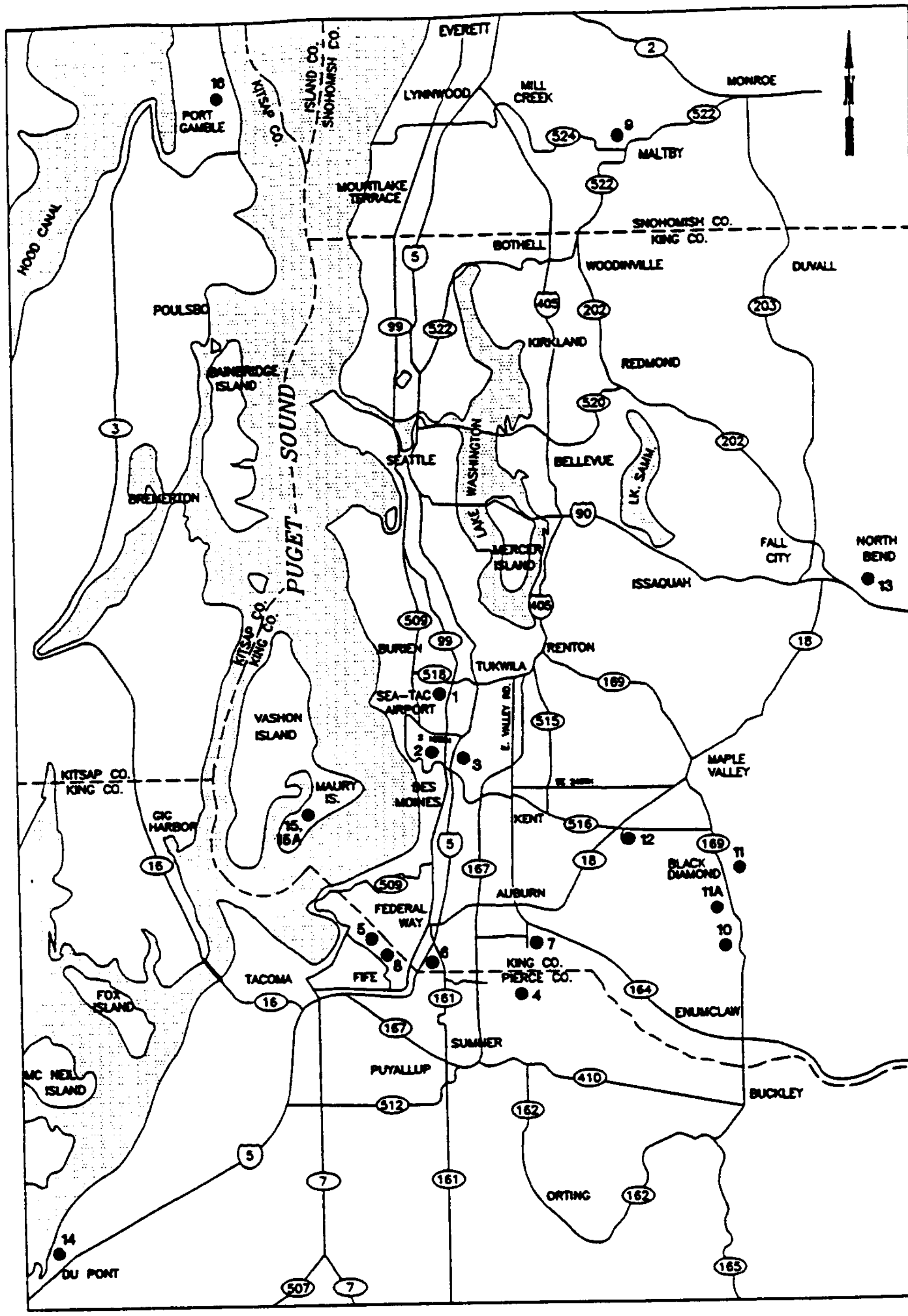
Source: Gambrell Urban, Inc. and
Shapiro & Associates, 1994
HNTB, 1994

Scale 1" = 3,000'

0 2500 5000
Scale in Feet

Projection: Lambert Conformal Conic
Coordinate System: State Plane NAD27

December 18, 1996



LEGEND

● OFF-SITE BORROW SOURCES

INCA INCA ENGINEERS INC.	SEATTLE-TACOMA INTERNATIONAL AIRPORT MASTER PLAN UPDATE ENVIRONMENTAL IMPACT STATEMENT	REGIONAL BORROW SOURCES EXHIBIT IV.23-2

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CHAPTER IV, SECTION 24

AESTHETICS AND URBAN DESIGN

This section includes a general description of the present views and aesthetic characteristics of the Airport. Also presented is an analysis of the aesthetic view impact of Sea-Tac Airport and the proposed Master Plan Update alternatives from specific locations on public rights-of-way around the Airport perimeter. Although the proposed "With Project" alternatives would cause a permanent change in the visual character of the area, adherence to applicable design and landscaping standards would ensure that this impact would not be adverse.

(1) METHODOLOGY

A reconnaissance of Airport perimeter was conducted to establish potential areas which may be affected by the Master Plan Update alternatives. A series of black and white photographs were taken from representative views in which the Airport and/or its facilities could be viewed. These views were located in public rights-of-way in residential and non-residential areas, as well as views from hotels, public recreation facilities, and churches. These photographs formed the basis for preparing a description of views and vistas, amenities, scale, land use character, and massing of development.

The analysis for this section was conducted using digital[1/] airport layout plan illustrations depicting the pre-design concepts of the proposed development and its alternatives, photographs taken during the field reconnaissance depicting existing visual conditions, and imagery produced using a three dimensional computer model[2/] showing the anticipated changes resulting from the alternatives. Also used for this analysis was Digital Elevation Mapping (DEM) data obtained from the U.S. Geological Survey for use in the three dimensional modeling to provide accurate topographic relief and control. Using a combination of AutoCAD© and 3D Studio©, three dimensional representations of each alternative were overlain on the photos of existing conditions to visualize the anticipated changes resulting from each alternative. The resulting views were then used to qualitatively assess the potential aesthetic impact resulting from each alternative.

The following sections describe existing aesthetic conditions and the results of the of the analysis of the proposed Master Plan Update alternatives.

(2) EXISTING CONDITIONS

The present airport site is characterized by somewhat dramatic down-slopes along the northern, western, and southern edges, and a gradual up-slope along the eastern edge. These landforms define a shallow plateau between the Green River to the east and Puget Sound to the west upon which the Airport is situated.

For this analysis, eighteen locations, eight on-Airport and ten off-Airport, were used to describe the existing visual character of the Airport and its immediate environs. These locations are depicted in **Exhibit IV.24-1**. They represent points from which the Airport can be seen unobstructedly or which may be adversely affected by changes in land form as a result of the proposed project and its alternatives. **Table IV.24-1** provides a brief description of each view site.

Combined, the eighteen view sites provide the context in which the Airport is located and provide ample references from which to assess the potential visual and aesthetic impact of airport development alternatives. Photographs from each of the eighteen view sites are provided in **Appendix N**.

The next step of the analysis, the field of eighteen view sites were narrowed to four view sites to perform the 3D overlay analysis of alternatives. These four view site were selected based on the ability to see various aspects of the existing airfield and facilities, as well as the ability to view the result of any proposed changes. The four view sites that were selected for detailed analysis include:

- ***View Site 1*** - Red Lion Hotel Towers. This view site is representative of views which might be seen from commercial and residential areas south and east of the Airport.

1/ Autodesk AutoCAD©, Release 12, Autodesk, Inc., 1992.

2/ Autodesk 3D Studio©, Release 4, Autodesk, Inc., 1994.

- *View Site 5* - Prince of Peace Lutheran Church. This view site is representative of views which might be seen from residential areas south and west of the Airport.

- *View Site 6* - Residential area northwest of Airport. This view site is representative of views which might be seen from residential areas north and west of the Airport.

- *View Site 17* - Holiday Inn Hotel. This view site is representative of views which might be seen from commercial and residential areas east of the Airport.

Exhibits IV.24-2 through **IV.24-5** show the views of the existing Airport as can be seen from each of the four view site analysis locations. In the analysis of future conditions, each of the alternatives will be discussed in terms of these four view site locations.

(3) FUTURE CONDITIONS

This section presents the potential future impacts to the aesthetic character of the area which may result from the implementation each of the three build alternatives. Impacts will be discussed in terms of changes to the existing visual character of the area.

(A) Alternative 1 (Do Nothing)

The Environmental Impact Statements for the SASA, On-Airport Hotel and Des Moines Creek Technology Campus identify the aesthetic and urban design impacts. The SASA development was identified to alter the visual character of the area immediately southeast of Sea-Tac. The On-Airport Hotel, due to its 16 story configuration, would serve as a visual landmark at Sea-Tac. However, it would not block views and it will be designed with anti-reflective surfaces to avoid glare. The Des Moines Creek Technology Campus would alter the character of the site. However, replanting of vegetation will minimize the impacts.

(B) Alternative 2 (Central Terminal)

Alternative 2, Centralized Terminal Concept, calls for the expansion of the existing terminal complex by extending Concourse A to the south along International Blvd South. In addition, this concept includes the expansion of both the north and south satellite concourses, expansion of the existing garage to the south, and construction of a proposed 8,500-foot new parallel runway. The following paragraphs provide an analysis of the potential visual impact at each view site resulting from Alternative 2.

- *View Site 1* - As shown in **Exhibit IV.24-6**, implementation of Alternative 2 would result in additional terminal building frontage and roadway improvements along International Blvd South. Views from this site are currently of mixed low to mid-rise commercial developments including hotels, fast food restaurants, and parking lots. The aesthetic character of this area could be characterized as cluttered and variable. In general, Alternative 2 would improve the street frontage appearance along International Blvd South by providing a maintained landscaped facade similar to that of the existing terminal area. Views from this site would include the facade of the extended Concourse A and new Airport access roads connecting the existing road network to South 188th Street. Existing commercial facilities immediately adjacent to the northwest corner of International Blvd South and South 188th Street would be maintained.

- *View Site 5* - As shown in **Exhibit IV.24-7**, implementation of Alternative 2 would result in no adverse long-term changes to views as seen from this location. Much of the view is and would remain shielded by lines of dense vegetation. However, Alternative 2 would have some limited short-term impacts to views from residential areas south and west of the Airport beyond the construction period while vegetation along the new slopes mature.

- *View Site 6* - Similar to views seen from View Site 5, implementation of Alternative 2 would result in no adverse long-term changes to views as seen from this location. Much of the view is and would remain shielded by lines of dense vegetation as can be seen in **Exhibit IV.24-8**. However, Alternative 2 would have some limited short-term impacts to views from residential areas north and west of the Airport beyond the construction period while vegetation along the new slopes mature.

- *View Site 17* - As shown in **Exhibits IV.24-9a and IV.24-9b**, implementation of Alternative 2 would result in additional terminal building frontage and

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roadway improvements along International Blvd South. Views from this site consist primarily of views of the existing airfield and terminal complex. The aesthetic character of this area could be characterized as maintained and ordered. In general, Alternative 2 would continue to provide a maintained landscaped facade similar to that of the existing terminal area. Views from this site would include the facade of the proposed airport hotel located at the north end of the existing terminal, new Airport access roads, and expansion of the existing north satellite concourse. Existing commercial facilities and cemetery along International Blvd South, north of the existing terminal complex would be maintained.

(C) <u>Alternative 3 (North Unit Terminal)</u>

Alternative 3, North Unit Terminal Concept, calls for a minor expansion of the existing terminal complex by extending Concourse A to the south along International Blvd South, along with the construction of a new unit terminal north of the existing terminal complex. In addition, this concept includes expansion of the existing garage to the south, and construction of a proposed new parallel runway. The following paragraphs provide an analysis of the potential visual impact resulting from the implementation of Alternative 3.

- ***View Site 1*** - As shown in **Exhibit IV.24-10**, implementation of Alternative 3 would result in additional terminal building frontage and roadway improvements along International Blvd. South, both south and north of the existing terminal complex. Views from this site are currently of mixed low to mid-rise commercial developments including hotels, fast food restaurants, and parking lots. The aesthetic character of this area could be characterized as cluttered and variable. Similar to Alternative 2, views resulting from Alternative 3 would generally improve the street frontage appearance along International Blvd South by providing a maintained landscaped facade similar to that of the existing terminal area. Views from this site would include the facade of the extended Concourse A and new Airport access roads connecting the existing road network to South 188th Street. Existing commercial facilities immediately adjacent to the northwest corner of International Blvd South and South 188th Street would be maintained. The proposed north unit terminal would not likely be seen from this site.

- ***View Site 5*** - As shown in **Exhibit IV.24-11**, implementation of Alternative 3 would result in no adverse long-term changes to views as seen from this location. Much of the view is and would remain shielded by lines of dense vegetation. However, Alternative 3 would have some limited short-term impacts to views from residential areas south and west of the Airport beyond the construction period while vegetation along the new slopes mature.

- ***View Site 6*** - Similar to views from View Site 5, implementation of Alternative 3 would result in no adverse long-term changes to views from this location. Much of the view is and would remain shielded by lines of dense vegetation as can be seen in **Exhibit IV.24-12.** However, Alternative 3 would have limited short-term impacts to views from residential areas north and west of the Airport beyond the construction period while vegetation along the new slopes matures.

- ***View Site 17*** - As shown in **Exhibits IV.24-13a and IV.24-13b,** implementation of Alternative 3 would result in additional terminal building frontage and roadway improvements along International Blvd South, both north and south of the existing terminal complex. Views from this site consist primarily of views of the existing airfield and terminal complex. The aesthetic character of this area could be characterized as maintained and ordered. In general, Alternative 3 would continue to provide a maintained landscaped facade similar to that of the existing terminal area. Views from this site would include the facade of the proposed airport hotel located at the north end of the existing terminal, the proposed new north unit terminal and its access roads, and expansion of the existing north satellite concourse. Existing commercial facilities and cemetery along International Blvd South north of the existing terminal complex would be maintained.

(D) Alternative 4 (South Unit Terminal)

Alternative 4, South Unit Terminal Concept, calls for an expansion of the existing terminal complex by extending Concourse A to the south along International Blvd South to connect into a new unit terminal/garage south of the existing terminal complex. In addition, this concept includes the expansion of both the north and south satellite concourses, expansion of the existing garage to the south, and construction of a new parallel runway. The following paragraphs provide an analysis of the potential visual impact resulting from the implementation of this alternative from each view site.

- *View Site 1* - As shown in **Exhibit IV.24-14**, implementation of Alternative 4 would result in additional terminal building frontage and roadway improvements along International Blvd South, south of the existing terminal complex. Views from this site are currently of mixed low to mid-rise commercial developments including hotels, fast food restaurants, and parking lots. The aesthetic character of this area could be characterized as cluttered and variable. Similar to Alternatives 2 and 3, views resulting from Alternative 4 would generally improve the street frontage appearance along International Blvd South by providing a maintained landscaped facade similar to that of the existing terminal area. Views from this site would include the facade of the extended Concourse A and new south unit terminal, as well as new Airport access roads connecting the existing road network to South 188th Street. All of the existing commercial facilities located between the exiting Airport property and International Blvd South to South 188th Street would be eliminated and replaced by the proposed terminal improvements.

- *View Site 5* - As shown in **Exhibit IV.24-15**, implementation of Alternative 4 would result in no adverse long-term changes to views as seen from this location. Much of the view is and would remain shielded by lines of dense vegetation. However, Alternative 4 would have some limited short-term impacts to views from residential areas south and west of the Airport beyond the construction period while vegetation along the new slopes mature.

- *View Site 6* - Similar to views from View Site 5, implementation of Alternative 4 would result in no adverse long-term changes to views from this location. Much of the view is and would remain shielded by lines of dense vegetation, as can be seen in **Exhibit IV.24-16**. However, Alternative 4 would have limited short-term impacts to views from residential areas north and west of the Airport beyond the construction period while vegetation along the new slopes matures.

- *View Site 17* - As shown in **Exhibits IV.24-17a and IV.24-17b**, implementation of Alternative 4 would result in additional terminal building frontage and roadway improvements along International Blvd South, primarily south of the existing terminal complex. Views from this site consist of views of the existing airfield and terminal complex. The aesthetic character of this area could be characterized as maintained and ordered. In general, Alternative 4 would continue to provide a maintained landscaped facade similar to that of the existing terminal area. Views from this site would include the facade of the proposed airport hotel located at the north end of the existing terminal, new Airport access roads, and expansion of the existing north satellite concourse. Also seen from this view would be the facade of the proposed new remote parking garage. Existing commercial facilities and cemetery along International Blvd South north of the existing terminal complex would be maintained.

(E) Preferred Alternative (Alternative 3)

The Master Plan Update study reviewed general aesthetic improvement concepts and guidelines for improving the various areas around the Airport. In general these improvements would respond to:

- The arrival and departure experience being dominated by large scale and high speed experience;
- The improvements should respond to the perspectives of the auto and the aircraft;
- Design priorities should: a) provide clear information to traveling public; b) create a series of spatial rooms; and c) enhance

the Airport's identify and interface with the City of SeaTac; and

- Low or no-maintenance strategies should be applied whenever possible.

Currently, the Airport's entrance is built upon a design concept that emphasizes the arrival sequence in a clear and simple manner that one is arriving in a "green place". This green theme reinforces the natural beauty of Puget Sound. The Master Plan Update suggests that as development undertaken, that the green concept is reinforced in the treatment of open spaces, pedestrian spaces and vehicular areas. It would involve the enhancement of the existing landscape concept, providing gateway elements in support of the entry sequence, maintain options to use the open spaces to the south of the existing main terminal as urban public spaces, and creates special feature areas at pedestrian areas where different modes of movement concentrate. Similarly at the Airport's perimeter, the Master Plan Update recommends blending the Airport's edge with the adjacent off-airport landforms.

The development of the proposed new parallel runway will affect the visual character of the west side of the Airport. The new runway would require construction of an extensive fill embankment to establish the proposed runway and runway safety area grades. Site preparation would include keying and benching along the existing embankment to create a stable fill base where the existing grades slope beneath the proposed new runway embankment. Upon completion, runway grades would range from 410 feet above MSL at the north threshold to 350 feet above MSL at the south threshold. To establish these grades, fill thickness would range up to approximately 160 feet at the maximum depth, with typical depths ranging between 30 and 100 feet. Cuts in existing grade of up to 20 feet would be required.

Unreinforced fill slopes no steeper than 2 horizontal to 1 vertical are recommended for most of the safety area embankment west of the proposed new parallel runway. Reinforced earth embankments, allowing embankment slopes of up to 55 degrees from the horizontal, could be used along portions of the west embankment, where practical, to minimize encroachment onto adjacent areas. Construction of reinforced embankments involves establishing a zone of moderately well-compacted fill with layers of steel or polymer reinforcement. Retaining walls would be used wherever practical to minimize encroachment on SR 509 and natural resources in the area.

The Preferred Alternative calls for a minor expansion of the existing terminal complex by extending Concourse A to the south along International Blvd South, along with the construction of a new unit terminal north of the existing terminal complex. In addition, this concept includes expansion of the existing garage to the south, and construction of a new parallel runway. The following paragraphs provide an analysis of the potential visual impact resulting from the implementation of The Preferred Alternative.

- ***View Site 1*** - As shown in **Exhibit IV.24-10**, implementation of The Preferred Alternative would result in additional terminal building frontage and roadway improvements along International Blvd. South, both south and north of the existing terminal complex. Views from this site are currently of mixed low to mid-rise commercial developments including hotels, fast food restaurants, and parking lots. The aesthetic character of this area could be characterized as cluttered and variable. Similar to Alternative 2, views resulting from The Preferred Alternative would generally improve the street frontage appearance along International Blvd South by providing a maintained landscaped facade similar to that of the existing terminal area. Views from this site would include the facade of the extended Concourse A and new Airport access roads connecting the existing road network to South 188th Street. Existing commercial facilities immediately adjacent to the northwest corner of International Blvd South and South 188th Street would be maintained. The proposed north unit terminal would not likely be seen from this site.

- ***View Site 5*** - As shown in **Exhibit IV.24-11**, implementation of The Preferred Alternative would result in no adverse long-term changes to views as seen from this location. Much of the view is and would remain shielded by lines of dense vegetation. However, The Preferred Alternative would have some limited short-term impacts to views from residential areas south and west of the

Airport beyond the construction period while vegetation along the new slopes mature.

- *View Site 6* - Similar to views from View Site 5, implementation of The Preferred Alternative would result in no adverse long-term changes to views from this location. Much of the view is and would remain shielded by lines of dense vegetation as can be seen in **Exhibit IV.24-12.** However, The Preferred Alternative would have limited short-term impacts to views from residential areas north and west of the Airport beyond the construction period while vegetation along the new slopes matures.

- *View Site 17* - As shown in **Exhibits IV.24-13a and IV.24-13b,** implementation of the Preferred Alternative would result in additional terminal building frontage and roadway improvements along International Blvd South, both north and south of the existing terminal complex. Views from this site consist primarily of views of the existing airfield and terminal complex. The aesthetic character of this area could be characterized as maintained and ordered. In general, the Preferred Alternative would continue to provide a maintained landscaped facade similar to that of the existing terminal area. Views from this site would include the facade of the proposed airport hotel located at the north end of the existing terminal, the proposed new north unit terminal and its access roads, and expansion of the existing north satellite concourse. Existing commercial facilities and cemetery along International Blvd South north of the existing terminal complex would be maintained.

(4) <u>CUMULATIVE IMPACTS</u>

Other development in the airport vicinity, that may occur in the future, in combination with the Master Plan Update improvements, may also affect area aesthetics and design. Specific cumulative impacts could result and would depend on the site design and facility placement.

(5) <u>MITIGATION</u>

Although the proposed "With Project" alternatives would cause a permanent change in the visual character of the area, adherence to applicable design and landscaping codes and standards would help to ensure that this impact would not be adverse. No further mitigation would be needed.

AR 039269

TABLE IV.24-1
Page 1 of 3

Seattle - Tacoma International Airport
Environmental Impact Statement

DESCRIPTION OF VIEW SITES

View Site #	Location	Direction of View	Relative Elevation	Description of View/Land Uses
1	Red Lion Hotel Towers International Blvd South & South 188th Street	West	Above Field Elevation, 13th Floor of Hotel Towers	Provides a view of the south end of the terminal area and airline maintenance facilities. Provides a vantage point in which to observe proposed changes to the south terminal and airfield areas. Land uses along International Blvd include low-rise commercial and retail sales establishments, along with several airport-oriented motels and hotels.
2	Tyee Valley Golf Course parking lot, near the south end of the existing runways	West	Below Field Elevation	From this vantage point can be observed the small valley located at the end of the parallel runways. Situated in this valley is an 18-hole golf course surrounded by wooded areas to the south of South 200th Street and a wooded hillside to the west. Two stream beds cut through the course, one from the northwest corner and the other, the upper reach of Des Moines Creek, flows out of the northeastern corner of the golf course.
3	Along the bend of the road where South 196th Street transitions into 18th Avenue South	North	Below Field Elevation	This site is situated along the west edge of the Tyee Valley Golf Course under the extended centerline of Runway 16R/34L with views to the north. The site overlooks the area previously approved for the SASA development program. Elements of the golf course include undulating terrain below the runway elevation, with a mix of deciduous trees in thin groupings between the fairways and several small impoundments in the northwestern corner of the course.
4	Along the bend of the road where South 196th Street transitions into 18th Avenue South	East	Below Field Elevation	This site is situated along the west edge of the Tyee Valley Golf Course under the extended centerline of Runway 16R/34L with views to the east. The site overlooks the area previously approved for the SASA development program.
5	At the corner of South 192nd Street and 8th Avenue South	East	At Field Elevation	Presents a view of the Airport as seen from the Prince of Peace Lutheran Church. At approximately the same elevation as the Airport, the church grounds afford a view of the south end of the airfield at the easternmost edge of suburban residential areas in the western portion of the city of Sea-Tac. Between the church and the Airport in this view is a small valley along Des Moines Memorial Highway comprised primarily of commercial land uses.

Source: Landrum & Brown, Inc., 1995

TABLE IV.24-1
Page 2 of 3

Seattle - Tacoma International Airport
Environmental Impact Statement

DESCRIPTION OF VIEW SITES

View Site #	Location	Direction of View	Relative Elevation	Description of View/Land Uses
6	In Highline in a residential area along Southwest 146th Street at 5th Avenue South	East / Southeast	Above Field Elevation	This site is representative of views of the Airport and a small valley as seen from residential areas northwest of the Airport. The land uses predominant in this area can be characterized as suburban residential. Des Moines Memorial Highway (hidden from view) runs between this site and the Airport.
7	On Southwest 146th Street as it curves into 12th Place South	South / Southeast	Below Field Elevation	This site affords a view of the westerly side slope of the airfield as seen from a nearby residential area. Between this site and the Airport is a small, tree-lined valley comprised of scattered residential dwellings.
8	At the intersection of 8th Avenue South and Des Moines Memorial Highway	East	Below Field Elevation	This site is among the lowest areas in the vicinity and provides a view of the residences at the bottom of the westerly slope of the Airport. From this vantage point, views are partially blocked by a variety of deciduous trees.
9	Perimeter Road on existing Airport property	South	Below Field Elevation	View of the north end of Runway 16R/34L. View shows the relationship of the Airport to South 154th Street (South Renton - Three Tree Point Road) and depicts the relative change in elevation at the north end of the airfield.
10	On Perimeter Road, adjacent to 12th Avenue South at the intersection of South 158th Street	North / South	Below Field Elevation	Views looking both north and south. Residential land uses are predominant along the west side of 12th Avenue South. Thick areas of deciduous trees and shrubs are located along the rising slope east, between the outer perimeter road and the runways.
11	Along the Perimeter Road, approximately 1/2 mile south of View Site 10	North		From this point, one can look north (towards Site 10) and see the dramatic change in elevation as the terrain slopes down and back up again before reaching View Site 10. Again similar to Site View 10, the west side of 12th Avenue South is residential in nature.
12	Along the inner loop of the Perimeter Road, immediately south of the airport surveillance radar (ASR) antenna	South	At field Elevation	This site provides a southerly view of the airfield as it transitions along the top edge of the western slope.
13	Along the outer loop of the Perimeter Road, near the south end of Runway 16R/34L	North	At Field Elevation	Site provides view of the airfield looking north adjacent to the Weyerhaeuser construction staging area.

Source: Landrum & Brown, Inc., 1995.

TABLE IV.24-1
Page 3 of 3

Seattle - Tacoma International Airport
Environmental Impact Statement

DESCRIPTION OF VIEW SITES

View Site #	Location	Direction of View	Relative Elevation	Description of View/Land Uses
14	Along the outer loop of the Perimeter Road, near the south end of runway 16R/34L	North	At Field Elevation	Site provides view of the airfield looking north adjacent to and immediately east of State Route 509 as it intersects with Des Moines Memorial Highway.
15	Along the Perimeter Road, on the west side of the far south end of Runway 16L/34R (inboard runway)	Northeast	At Field Elevation	This site provides views from the top edge of the slope looking down (south and east) toward the Tyee Valley Golf Course. This site shows the relative change in elevation between the airfield and the surrounding terrain..
16	Along the Perimeter Road, on the east side of the far south end of Runway 16L/34R (inboard runway)	North	At Field Elevation	This site provides views from the top edge of the slope looking down (south and east) toward the Tyee Valley Golf Course. This site shows the relative change in elevation between the airfield and the surrounding terrain.
17	Holiday Inn Hotel, 11th floor. On International Blvd, north of South 176th Street	West	Above Field Elevation	This site provides the best, unobstructed views of the terminal area and north end of the existing airfield from the east side of the Airport area.
18	Marriott Hotel, 5th floor. East of Airport terminal area on 32nd Avenue South	West	Above Field Elevation	Representative of views from residential areas eat of Airport looking toward the terminal area. Views are generally obstructed by dense vegetation.

Source: Landrum & Brown, Inc., 1995.

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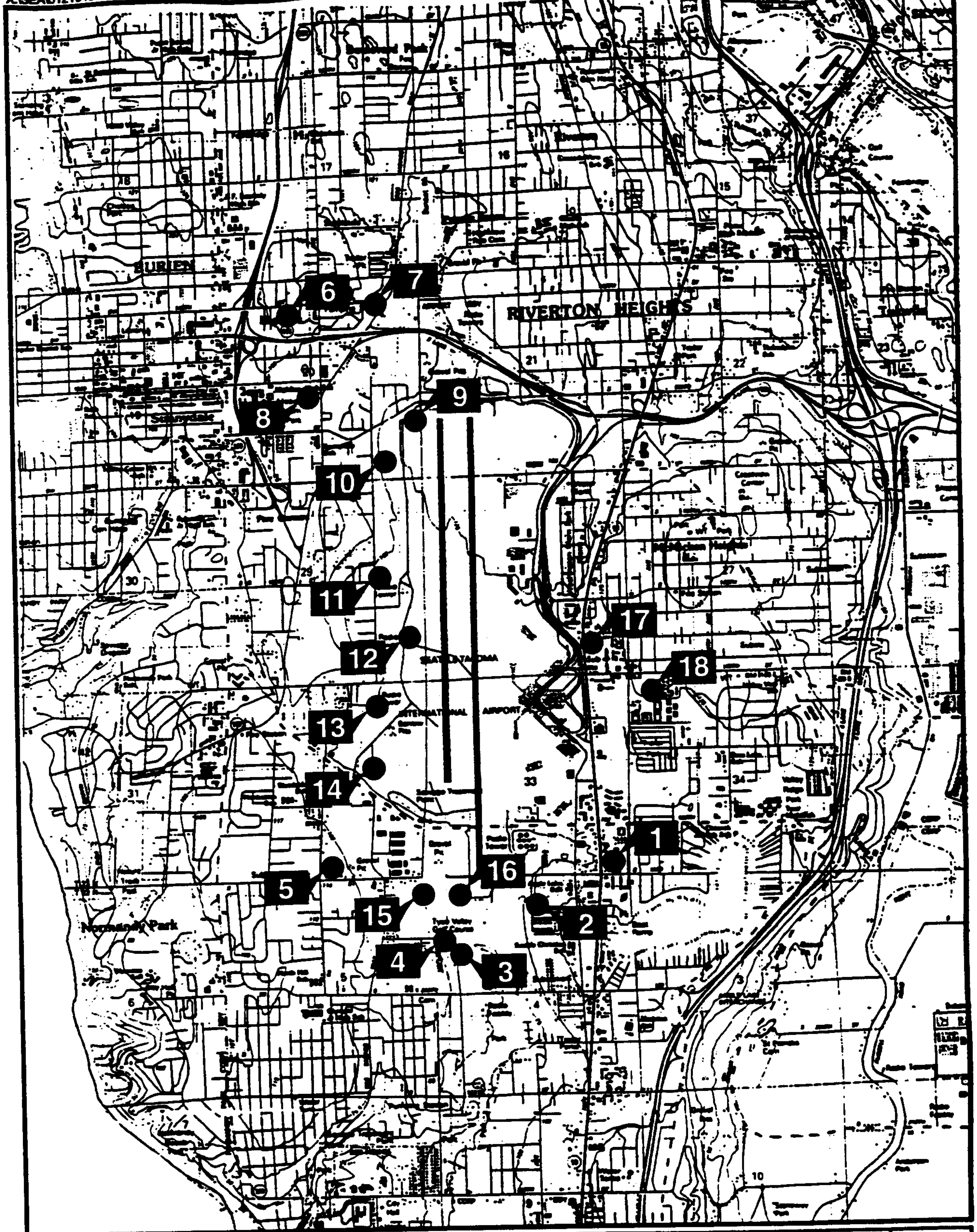

Seattle - Tacoma International Airport	Location of View Sites	EXHIBIT: IV.24-1

AR 039274

Exhibits IV.24-2 through Exhibit IV.24-17b

are provided in Appendix N

CHAPTER V

PROBABLE, UNAVOIDABLE, ADVERSE ENVIRONMENTAL IMPACTS AND MITIGATION MEASURES

This chapter summarizes the probable adverse impacts which would result from implementation of Master Plan Update alternatives at Seattle-Tacoma International Airport and the forms of mitigation possible to reduce these impacts.

1. PROBABLE ADVERSE IMPACTS

As is described in Chapter IV "Environmental Consequences", the "With Project" alternatives would result in adverse impacts on the natural and social environment of the Airport area. The proposed Master Plan Update alternatives would result in impacts to all environmental factors considered, with the exception of:

- Coastal Zone Management and Coastal Barriers;
- Prime and Unique Farmland;
- Wild and Scenic Rivers.

The following section summarizes the mitigation measures that would be implemented to lessen the significant adverse impacts.

2. MITIGATION MEASURES

The following sections summarize the adverse impacts created by the alternatives, and the measures available to reduce these impacts.

(1) Noise, Land Use and Social-Related Impacts (including DOT Section 4(f), Historic sites)

As is described in Chapter IV, Sections 1 and 2, ("Noise" and "Land Use"), the proposed Master Plan Update "With Project" alternatives would increase noise exposed area by 5 to 7 percent over the Do-Nothing action. The additional area exposed to aircraft noise levels in excess of DNL 65 would also increase the population and housing units exposed. Some residential areas affected by DNL 65 and greater sound levels would experience an increase over the Do-Nothing of 1.5 DNL or greater.

The following additional population and housing impact affected by DNL 75 and greater sound levels (severe noise exposure) and DNL 65 and greater sound levels (which include the DNL 75 and greater impacts) are shown in the table to the right.

Increased Noise Exposure over the Do-Nothing (Alternative 1)

65 DNL and greater	Population	Housing
Year 2000		
Alt 2	920	150
Alt 3	920	150
Alt 4	920	150
Year 2010		
Alt 2	420	130
Alt 3	410	130
Alt 4	410	130
Year 2020		
Alt 2	470	180
Alt 3	440	160
Alt 4	470	180

Alternatives with 8,500-ft new runway, located 2,500 feet west of 16L/34R
Source: Shapiro & Associates, 1995

Through the implementation of the Noise Remedy Program, the Port of Seattle has conducted an extensive noise and land use compatibility effort. As a result of this noise and land use compatibility program, a notable portion of the existing and future noise exposed area has been subject to sound insulation and, for the more severely noise affected areas, acquired and relocated. Therefore, the "With Project" alternatives would result in a small number of residents that would be newly affected by noise with the proposed improvements in comparison to the Do-Nothing.

To facilitate continued noise reduction, the following noise and land use mitigation is recommended.

The measures now in effect, that would be continued, include:

- Nighttime Limitations Program - limiting the hours of operation for Stage 2 aircraft.
- Ground Noise Control - reducing the noise of ground events such as powerback operations, run-ups and reduction of reverse thrust on landing.
- Flight Corridorization - maintenance of runway heading flight tracks by departing jets until reaching altitudes above 4,000 feet.
- Flight Track and Noise Monitoring - maintenance of records of noise levels and flight track location information for identification of deviations and communication with public and users.

Several land use mitigation strategies will be undertaken:

Mitigating Significant Noise Impacts: The following five noise sensitive facilities would experience significant increased noise impacts (i.e. an increase of 1.5 DNL or more) in the year 2020 in comparison to the Do-Nothing:

- Sea-Tac Occupational Skills Center (S102) would experience an increase of 3.1 DNL;
- Woodside Elementary (S105) would experience a 1.7 DNL increase:
- Sunny Terrace Elementary (S106) would experience a 2.6 DNL increase;
- Brunelle Residence (A27) would experience an increase of 1.5 DNL;
- Bryan House (A29) would experience an increase of 2.4 DNL.

The Port will coordinate with the owners of these properties and sound insulate the noise sensitive uses subject to FAA sound insulation guidelines.

Provide Directional Soundproofing: Residences that were insulated prior to 1992 may need additional directional soundproofing to mitigate noise generated from new flight paths from the operation of the new runway. Many residences evaluated for noise impacts prior to 1992 were not evaluated to consider the additional noise impacts that the proposed runway would generate. The Port of Seattle estimates that some 60 and 70 houses that were evaluated and/or insulated prior to 1992 would require additional soundproofing at a cost of $6,000 to $10,000 per residence. The Port will audit these facilities, and subject to FAA sound insulation criteria, sound insulate the remaining portions of the home that do not achieve the applicable noise level reduction guidelines.

Acquisition in the Approach Transitional Area - In recognition of the fact that the standard Runway Protection Zone (RPZ) dimensions do not always provide sufficient noise and safety buffer to the satisfaction of nearby residents, the FAA will cost-participate with airport operators to acquire "up to 1,250 feet laterally from the runway centerline, and extending 5,000 feet beyond each end of the primary surface.[1]

The acquisition of properties within the approach and transitional areas north and south of the proposed runway may serve as a feasible and appropriate mitigation measure. This measure would involve the acquisition of all residential uses, and any vacant, residentially zoned properties which cannot be compatibly zoned, within selected areas both to the north and the south of the new runway ends. Commercial land uses, which make up most of the eligible area to the south, need not be acquired and may remain in place on both runway ends.

The FAA Memorandum provides funding eligibility for a box up to 5,000-foot long and 2,500-foot wide, centered on the runway and beginning 200 feet from the physical end of the runway. Based on the configuration of current airport land, local streets, and residential development patterns, the approach and transitional area selected for use as a mitigation area includes the standard Runway Protection Zone and a rectangular extension of the RPZ outward another 2,500 feet. The limit of coverage of the proposed approach and transitional areas are shown in **Exhibit IV.6-3.**

In the northern approach and transitional area, 82 single-family residential parcels, 2 apartment buildings (with 28 units), and 2 mobile home parks, with 96 units, would be

[1] FAA Memorandum, Action: Land Acquisition - eligible Runway Protection, Object Free Area and Approach and Transitional Zones, dated April 30, 1991.

acquired. To the south, 71 single-family residential parcels and 6 apartment buildings (with 32 units) would be acquired. Only residential properties in the approach and transitional area would be acquired -- commercial land uses, which make up most of the area to the south, would not be acquired and would remain in place on both runway ends. Based on the current assessed value of these 309 residential homes and multi-family buildings located in the approach and transitional area, it is estimated that the cost of acquisition and relocation would be approximately $35 million.

As the probable impact of low flying aircraft would not be experienced until the opening of the proposed new parallel runway, this option will receive further consideration during the forthcoming Sea-Tac Airport FAR Part 150 Update, which the Port anticipates undertaking during 1996. It is anticipated that during the Part 150 Update, the Port would further explore this action with the specific residents within the Approach Transition Area, and, if the residents so desire, establish a program including relocation objectives, timing and funding priorities.

(2) <u>**Water Quality**</u>

The following stormwater management mitigation will be undertaken unless basin planning determines that other actions would mitigate the impacts of the proposed improvements:

- Provide stormwater detention for construction and operation of new on-site development. Detention criteria would be based upon Department of Ecology standards limiting 2-year peak flow rates from the developed portions of the site to 50 percent of the existing 2-year rate, limiting the developed 10-year flow rate to the existing 10-year rate, and limiting the developed 100-year flow rate to the existing 100-year rate. Stormwater detention volumes would be provided with either underground storage vaults or with regional storage ponds. Detention requirements of Ecology's *Stormwater Management Manual for the Puget Sound Basin* are more stringent than those of the *King County Surface Water Design Manual*, the latter of which have been adopted by the City of SeaTac. The *King County Surface Water Design Manual* is presently being revised and the revised version is expected to contain design standards that are comparable to or more stringent than Ecology's manual.
- Stormwater quality treatment would be provided with a combination of wet vaults and biofiltration swales.
- Design stormwater facility outlets to reduce channel scouring, sedimentation and erosion, and improve water quality. Where possible, flow dispersion and outlets compatible with stream mitigation should be incorporated into engineering designs.
- To mitigate potential reductions in shallow groundwater recharge and incremental reductions in base flows in the creeks, infiltration facilities would be constructed where feasible.
- Maintain existing and proposed new stormwater facilities. Stormwater management facilities should be maintained according to procedures specified in the operations manuals of the facilities.
- The potential for using constructed aquifers within the runway fill, as described in **Appendix Q-C**, should be further investigated.
- Tyee pond would be relocated and enlarged as part of the SASA.

Various mitigation requirements, as stipulated by federal, state, and applicable local laws, policies, and design standards, would be applicable to construction and operation of the proposed new parallel runway and landside development at the Airport. These requirements would be components of the proposed design and are expected to reduce potential impacts on surface water and groundwater quality. For example, potential temporary increases in suspended solids levels in Miller and Des Moines Creeks or their tributaries from construction activities would be reduced by implementation of an effective erosion and sedimentation control plan, which is required before construction could begin.

Effective erosion and sedimentation control could be achieved by using a system of erosion controls (e.g., mulching, silt fencing, sediment basins, and check dams) that are properly applied, installed, and maintained. In a study of construction sites in King County between January 1988 and April 1989, the most common reasons for ineffective erosion control plans included failure to install Best Management Practice (BMP) erosion controls, improper installation of erosion controls, and failure to maintain erosion controls.[2] The Port of Seattle may need to include specific provisions in its agreements with contractors to ensure that erosion control measures are properly installed and maintained during construction activities (e.g., performance bonds).

Use of BMPs at construction sites, such as spill containment areas, phasing of construction activities (to minimize the amount of disturbed and exposed areas), and conducting activities during the dry season (April through September), also should prevent or reduce potential impacts on surface water and groundwater quality. According to the NPDES permit (Permit No. WA-002465-1) issued by the Washington State Department of Ecology, the Port of Seattle is responsible for developing and implementing a construction erosion and sedimentation control plan to prevent and control the potential for water quality impacts on surface water from all construction activities at the Airport.

Temporary and permanent terraces are recommended for fillslopes and cutslopes wherever possible because they reduce sheet and rill erosion. Terraces reduce slope length, reducing potential rill development and surface erosion. Terraces also increase deposition, reducing transport of eroded materials from construction sites. Other BMPs and mitigation that could be used to reduce potential increases in TSS from construction activities include graveling of access roads, use of wheel wash facilities, and covering of loads. Prohibiting fuel storage, refueling, or maintenance of construction equipment at borrow source areas or implementing best management practices, such as installing proper temporary fuel storage and spill containment or designated maintenance areas would eliminate or reduce spills and contamination potential.

Several required and numerous optional practices are used to mitigate the potential for operational impacts on surface water and groundwater quality. The Port of Seattle's National Pollutant Discharge Elimination System (NPDES) permit requires the Port to prepare several plans and to carry out several studies to identify pollutants coming from the Airport, and to prevent and control potential operational impacts on surface and groundwater resources from industrial wastewater system (IWS) and storm drainage system (SDS) discharges.

- Specific plans required as part of compliance with the NPDES permit include:
    - a stormwater pollution prevention plan (SWPPP);
    - a spill prevention, control and countermeasures plan (SPCCP);
    - a construction erosion and sediment control plan for each project exposing more than 5 acres of ground;
    - a sludge characterization and treatment disposal plan; and
    - a solid waste disposal plan.
- Specific studies required as part of compliance with the NPDES permit include:
    - an engineering and treatability study of the IWS
    - a vehicle washwater study
    - annual stormwater monitoring reports
    - whole effluent (both IWS and stormwater) toxicity studies
    - a marine sediment monitoring study.
- Major elements of the SWPPP include:
    - monitoring of base flow and stormwater runoff from the Airport outfalls;

[2] *Erosion and Sediment Control: An Evaluation of Implementation of Best Management Practices on Construction Sites in King County, Washington January 1988-April 1989.* Prepared by C. Tiffany, G. Minton, and R. Friedman-Thomas for the King County Conservation District, Renton, WA. King County. 1990.

- identification and implementation of operational BMPs and applicable source control BMPs that do not require capital improvements (by December 31, 1995);
- identification and implementation of BMPs requiring capital improvements (by June 30, 1997);
- development of a list of pollutants that would be present in stormwater and estimation of annual quantities of these pollutants in stormwater discharges;
- inspection of SDS periodically to ensure they are functioning properly and that there are no illegal discharges (i.e., to the SDS); and
- modification of the existing plan whenever there is an alteration of airfield facilities or their design, construction, operation or maintenance, which causes the SWPPP to be less effective in controlling pollutants.

In addition, the Port of Seattle is conducting a stream study of Miller and Des Moines Creeks to determine the effects of Airport stormwater discharges on aquatic biota. Implementation of these plans and mitigation measures is expected to identify potential existing water quality problems caused by airport operations and to control and reduce the potential pollutant loading to Miller and Des Moines Creeks and Puget Sound from the Airport.

The Port of Seattle has completed or is in the process of completing a number of operational BMPs and capital improvements that are expected to reduce the amount of pollutants in stormwater runoff. The Port of Seattle has implemented a strategy to reduce anti-icing fluids.[3] This strategy minimizes the amount of potassium acetate and urea required to anti-ice runways and taxiways and the frequency of anti-icer use by:

- Using remote sensors to provide temperature and moisture data on runway and taxiway surface conditions to determine when chemicals need to be applied;
- Applying chemicals before ice forms, which requires less chemical compared to deicing;
- Applying chemicals at specified rates using applicators with metering systems.

This procedure is expected to reduce the amount of potassium acetate and ammonia in stormwater runoff and in Miller and Des Moines Creeks.

In accordance with the SWPPP, the Port of Seattle has completed or is in the process of completing a number of mitigations (i.e., capital improvements to the IWS). In addition, numerous source control and operational BMPs listed in the SWPPP have been or will be implemented by 1997. Operational, source control, and capital improvement BMPs completed and implemented as part of the SWPPP are expected to reduce the amounts of fecal coliform bacteria, potassium acetate, glycols, ammonia, and other pollutants in stormwater runoff from reaching Airport stormwater outfalls and Miller and Des Moines Creeks. Recent capital improvements correcting specific identified problems include:[4,5]

- Installation of an elevated berm to contain washwater from solid waste containers and prevent drainage of fecal coliform bacteria to Outfall 002.
- Connection of areas in the C and D Concourse to the IWS.

The Port of Seattle continues to monitor stormwater quality and the effectiveness of implemented BMPs and capital improvements to both the SDS and IWS. The results of ongoing base flow and stormwater runoff water quality monitoring are used to determine the need for additional BMPs and capital improvements to the SDS and IWS. The Port of Seattle develops BMPs and structural improvements in coordination with Ecology, as necessary, to mitigate operational impacts on water quality and aquatic biota in

[3] *Stormwater Pollution Prevention Plan*, Port of Seattle, June 30, 1995.

[4] *Stormwater Pollution Prevention Plan*, Port of Seattle, June 30, 1995.

[5] *Annual Stormwater Monitoring Report Summary*, Port of Seattle, August 30, 1995.

Miller and Des Moines Creeks. These are reflected, in part, by periodic revisions to the SWPPP.

A number of capital improvements to the IWS are scheduled to be completed on or before June 30, 1997, including :

- Installing a slot drain and diversion to convey captured solid waste container washwater in the tunnel beneath the terminal away from Outfall 002 to the sanitary sewer;
- Connecting the Port Maintenance Shop Yard and a portion of the U.S. Postal Service aircraft parking area near the North Satellite, which presently drain to the SDS and Outfall 002, to the IWS;
- Connecting two suspected glycol sources: Gate C8 and an area north of the South Satellite to the IWS;
- Connecting the aviation industrial activity area now draining to Outfall 007, which is suspected of contributing to elevated ammonia and BOD, to the IWS; and
- Connecting snow storage areas, which have been identified as probable sources of glycols, to the IWS.

These improvements are expected to reduce the amounts of anti-icing and deicing chemicals (e.g., potassium acetate, ammonia, and glycols) reaching SDS outfalls and Miller and Des Moines Creeks.

The Stipulated Settlement Agreement and Agreed Order of Dismissal, which dismissed Ms. Brasher's, Normandy Park Community Club's, and the City of Des Moines' appeal of the Port's NPDES permit contained the following provisions. Components of the stipulated NPDES permit appeal settlement agreement expected to mitigate potential operational impacts on water quality include:[6]

- Creating a Monitoring Team, including representatives appointed by the appellants;
- Conducting at least two additional sampling events of permitted stormwater outfalls in 1995;
- Contributing funds to the Des Moines Creek Basin planning and visioning process;
- Developing a short-term monitoring plan in cooperation with the Monitoring Team to sample Miller Creek basin outfalls and the outfall from Lake Reba examining glycol, BOD TSS, flow, ammonia, and turbidity and develop appropriate responses, as necessary, for any identified water-quality problems.

Additional mitigation for potential operational impacts to surface water quality would be considered depending on the results of the stream monitoring study[7] and the effects of Airport stormwater runoff on Miller and Des Moines Creeks. Monitoring of selected stations upstream and downstream of Airport outfalls to Miller and Des Moines Creeks is planned for this winter (95/96). Potential additional mitigation that would be considered includes use of alternative, FAA-approved runway anti-icing chemicals (e.g., calcium magnesium acetate and sodium formate) or diversion of runway runoff to the IWS during anti-icing events. The latter option is being evaluated as part of ongoing IWS engineering study, which includes capital improvements to increase the treatment efficiency and capacity of the IWS treatment plant.

Basin planning is another method for investigating mitigation of water quality impacts on Miller and Des Moines Creeks and Puget Sound from Airport and urban runoff. Although the Airport affects relatively small proportions of both the Miller and Des Moines Creek drainage basins (approximately 5 and 30 percent, respectively), activities on these areas could significantly affect these drainages. The Port of Seattle is actively participating in basin planning activities in the Miller and Des Moines Creek basins with local jurisdictions, including King County and the cities of Des Moines, Normandy Park, SeaTac, and Burien.

(3) Wetlands and Floodplains

Actions that affect wetlands generally require authorization from various federal, state, and applicable local agencies. In the State of Washington, projects with significant adverse

[6] *Stipulated Settlement Agreement No. 94-157*, Washington Pollution Control Hearings Board, 1995.

[7] *Stormwater Receiving Environment Monitoring Plan*, Port of Seattle, August, 1995.

AR 039281

wetland impacts require a Section 404 permit from the U.S. Army Corps of Engineers (Corps), and Section 401 Water Quality Certification from the Washington State Department of Ecology (Ecology). In addition to the required permits and approvals, compensatory wetland mitigation may also be required to offset significant adverse impacts on wetlands and their functions.

The Port of Seattle has initiated the wetland permitting process with the Seattle District of the Corps. The Corps is a cooperating agency in the preparation of this EIS. Additional coordination is anticipated with the Washington State Department of Ecology. It is anticipated that permits would be issued after approval of the Final Environmental Impact Statement/Record of Decision for the Master Plan Update actions and that no adverse impacts would occur on wetlands as a result of the Master Plan Update prior to issuance of the appropriate permits.

Significant unavoidable adverse impacts will occur to wetlands as a result of the implementation of the proposed improvements. These impacts include filling, grading, changes of hydrology, and removal of vegetation. The Port of Seattle will avoid adverse impacts where possible (e.g., use of off-site fill to avoid wetland impact in Borrow Area 8), will minimize impact by using Best Management Practices (BMP) during construction and operation of the proposed improvements. However, as is noted in Chapter IV, Section 23 "Construction Impacts', the filling of on-site borrow sources could further minimize wetland impacts. However, if the minimum use of on-site material occurs, maximum off-site truck trips will result as well as possible increased cost of construction.

After extensive study, the Port of Seattle has selected a preferred wetland mitigation site in the lower Green River Valley. Mitigation for impacts on wetlands at the Airport, within the watershed where the impacts may occur, is not feasible for three reasons: (1) the majority of the area surrounding the Airport is developed, and not enough land area exists in the watershed to create compensatory mitigation wetlands, (2) much of the undeveloped land in the watersheds is existing wetland, or land unsuitable for wetland mitigation due to topographic (moderate to steeply sloping) or hydrologic (lack of sufficient water) conditions, and (3) the FAA guidelines strongly recommend[1] that airports do not have "wildlife attractions" within 10,000 feet of the edge of any active jet runway. For these reasons, the Port proposes to conduct wetland mitigation outside of the watershed where these constraints do not exist.

After investigating over 100 individual parcels, the Port has selected a site located within the City of Auburn for the development of the compensatory wetland mitigation. This site, located in Section 31, Township 22N, Range 5E, Willamette Meridian in the Green River watershed, is a 69 acre parcel of land slightly south of S. 277th Street and east of Auburn Way. The undeveloped parcel has been farmed in the recent past, and currently supports a mix of upland pasture grasses and forbs that are common to abandoned agricultural land in the Puget Sound Region. Approximately 4.3 acres of reed canarygrass-dominated wetland was delineated at the site. The site is bound by a variety of land uses including agriculture to the north and south; undeveloped land, multi-family housing and a drive-in theater to the west; and the Green River, patches of riparian forest, and undeveloped slopes to the east. A narrow strip of land along the western banks of the Green River is held by King County. In December 1995, the Port of Seattle gained ownership of the property following completion of a bankruptcy proceeding by the previous owners.

The Port of Seattle has coordinated with the Corps of Engineers concerning the proposed mitigation site and the plan included in this Final EIS. **Appendix P** contains a detailed mitigation plan for the wetland mitigation, including:

- Water regime;
- Site grading;
- Landscape plan; and
- Monitoring plan

Initially, the City of Auburn expressed reservations concerning the development of the mitigation site within the City boundaries. However, the final mitigation plan reflects changes that were made to the draft plan to address their concerns.

[1] "Wildlife Attractions On or Near Airports," *FAA Draft Advisory Circular 150/5200-*, no date.

Floodplain encroachment and flooding impacts in the Miller and Des Moines Creek basins resulting from the proposed improvements would be unlikely because of required mitigation. Mitigation will include adherence to floodplain development standards and floodway management requirements of the FAA and Washington State Department of Ecology. Floodplain development standards prohibit any reduction in the 100-year floodplain or base flood storage volume. Compensatory mitigation is required by state law for any proposed filling of 100-year floodplain so as to achieve no net loss in flood storage capacity and to prevent an increased risk of loss of human life or property damage.[9/]

Compensatory mitigation for floodplain impacts near the northwest corner of the proposed new parallel runway has been incorporated into the stream relocation design (**Appendix P**). The stream mitigation design, which was developed in cooperation with several resources agencies, including the U.S. Army Corps of Engineers, would create an equivalent amount of floodplain storage - so no net loss of flood storage capacity or increased risk of loss of human life or property damage would result.

Another potential flood storage and flood control mitigation option for the Miller Creek basin that is being considered involves modification of current operating procedures at the Lake Reba Regional Detention facility to provide additional storage. King County Surface Water Management Division, which currently operates the facility, is negotiating transfer of the facility operating responsibilities to the Port of Seattle. According to as-built drawings, the Lake Reba Detention facility has a design storage capacity of about 80-acre feet; however, a dam safety report indicates that it has a maximum storage capacity of about 90-acre feet. Based on the dam safety report, the storage capacity appears to be underused. Before any recommendations can be made on operational procedure modification for maximizing or providing additional capacity, the outlet rating curve for the facility must be verified to accurately determine detention characteristics and available storage capacity.

FAA directives state: "a significant encroachment will require a federal finding as part of any favorable decision on the action that there is no practicable alternative and that the action conforms to applicable state and/or local floodplain protection standards."[10/] Significant encroachment includes the risk of loss of human life, likely property damage, and notable adverse impacts on natural and beneficial floodplain values (e.g., groundwater recharge, wildlife habitat, flood storage and control). FAA directives also state: "The term practicable means feasible. Whether another alternative is practicable depends on its feasibility in terms of safety, meeting transportation objectives, design, engineering, environment, economics and other applicable factors." FAA directives indicate that an alternative is feasible if it can be engineered, but an alternative also must be prudent, which is a reference to safety, policy, environmental, social, or economic consequences.[11/] These directives require analysis of all practicable measures to minimize harm, restore and preserve the natural and beneficial floodplain values affected, and provide evidence of conformance with applicable state or local floodplain protection standards.

As this Environmental Impact Statement demonstrates, no other practicable alternative exists other than completion of one of the proposed Master Plan Update alternatives. Significant floodplain encroachment would be unlikely as a result of the "With Project" alternatives due to strict mitigation requirements which would be adhered to under any of the alternatives.

The Washington State Department of Ecology also has specific mitigation requirements to reduce potential flooding impacts from new developments. New projects are required to meet Ecology stormwater drainage detention for the 2-, 10-, and 100-year storm events.[12/] Storm flow modeling based on conceptual stormwater detention facilities and using these design storms indicates no increase in peak flow

9/ *Environmentally Sensitive Areas - Flood Hazard Areas, Chapter 15.30210-250, City of SeaTac Municipal Code.*

10/ *FAA Airport Environmental Handbook. 5050.4A.* Federal Aviation Administration, Washington, D.C. October 8, 1985.

11/ 49 USC 47101 and Section 4(f) of the Department of Transportation Act require findings that no "possible" or "feasible" alternative exists.

12/ *Stormwater Management Manual for the Puget Sound Basin.* Washington State Department of Ecology, 1990.

AR 039283

rates and little risk of flooding from the proposed Master Plan Update alternatives. Required mitigation would be expected to prevent significant adverse impacts on floodplains or flooding in the Miller and Des Moines Creek basins. Preliminary compensatory floodplain replacement designs for floodplain encroachment in the Miller Creek basin for the 8,500-ft runway length, demonstrating no net loss of flood storage capacity, are presented in **Appendix P**.

The Master Plan Update alternatives are the only practicable alternative to satisfying the needs identified by this EIS. While the displacement would be substantially greater (7.2 acres displaced versus 0.03 acres) with the preferred alternative relative to other alternatives, potential impacts could be mitigated through creation of an equivalent amount of floodplain so there would be no net loss of flood storage capacity or increased risk of loss of human life or property damage.

(4) Air Quality

The proposed landside improvements included in the "With Project" alternatives–improved terminal facilities and public and employee parking–would result in changing vehicular traffic movement and patterns in the immediate airport area. For the Preferred Alternative, (Alternative 3), the majority of employee parking within the terminal area shifts to a new lot located north of SR 518, reducing congestion and pollutant concentrations.

The intersection "hot spot" analysis for carbon monoxide indicated that potential exceedances of the standards might occur with the Preferred Alternative (North Unit Terminal). The North Unit Terminal alternative would change how motor vehicles access the Airport. Accordingly, these changes would result in increases in motor vehicle traffic, and result in possible exceedances of the AAQS at International Boulevard (SR 99) and South 170th Street, and at South 160th Street. This added Airport-related traffic further contributes to these already heavily congested roadway intersections.

The analysis contained in this document represents a worst case evaluation. Thus, the Port of Seattle will conduct an air monitoring program at two roadway intersections to determine if such exceedances would occur. If such exceedances are found, the Port of Seattle will undertake appropriate action such as those identified below.

(A) Mitigation for International Blvd. and South 170th Street

The Preferred Alternative increases pollutant concentrations over the Do-Nothing alternative at this intersection. This is due primarily to changes in how airport-related traffic would access the Airport in the future.

Because of the high traffic volumes and unacceptable level of vehicle delay, several improvements in this intersection could be undertaken to reduce air pollutant concentrations. The mitigation measures include the addition of an additional northbound left-turn lane (2 total); the construction of high capacity right-turn lanes in the southbound and eastbound directions; and the construction of a westbound right-turn lane. These improvements would occur by 2010 when relief would be needed to substantially decrease the time vehicles idle at this intersection. By 2020, an additional lane along International Boulevard (SR 99) would also be added. These improvements would address the air quality and increased traffic volumes anticipated at this intersection.

(B) Mitigation for International Blvd. and South 160th Street

The Preferred Alternative increases pollutant concentrations over the Do-Nothing alternative at this intersection. Pollutant concentrations at this intersection are only marginally higher by the year 2020.

Mitigation measures proposed would include adding an additional southbound left-turn lane (2 total); and improvements to the westbound right-turn lane. These improvements would occur by 2010. An additional lane along International Boulevard (SR 99) would be needed by 2020 to provide additional relief at this intersection.

(C) Additional Initiatives For Reducing Air Pollutants within the Airport Area

The Port of Seattle continues to support the air quality initiatives which have been

AR 039284

enacted in the Puget Sound Region to improve air quality. These initiatives have included the growth management planning mandated by the Growth Management Act; the wood burning stove curtailment initiative of the 1990's; the seasonal use of oxygenated or reformulated fuels (between November 1 through February 28); and the Inspection/Maintenance program which monitors emissions and compliance with air quality pollution control equipment on motor vehicles. These measures are enforced as part of the USEPA's vehicular emission standards which require progressively more stringent tailpipe emission standards. Restrictions on commercial and residential outdoor burning and mandatory use of oxygenated fuels are measures used to decrease ambient CO concentrations in the Puget Sound Region.

The Port of Seattle is also committed to reducing emissions from various sources at the Airport. On-going considerations have focused on reducing the number of vehicles accessing the airport by providing alternatives to single-occupancy vehicle access to and from the Airport. Other actions have addressed motor vehicle idling along the terminal curbfront. Airport staff rigorously monitor access and idling by taxi's, limousines, and buses within the terminal area.

The Port of Seattle has supported a trip reduction strategy which has several components: employee shuttle bus service to remote public and employee parking to reduce vehicle trips in the terminal area; regional light-rail transit system; limiting passenger drop-off and pickup, and providing short-term parking alternatives.

Additional actions that could further reduce air pollutant concentrations at Sea-Tac:

- Financial disincentives for single occupancy driving to the Airport
  - Raise short-term parking rates
  - Implement toll system on the airport roadway with lower fees for High Occupancy Vehicles (HOV).
- Convenience disincentives/ incentives:
  - Development of remote Park'n'Fly operations
  - Require private autos to use third floor plaza instead of terminal curbfront
  - Require use of alternative fuels by courtesy vehicles
- Improved airport access roads that attract users off the area arterials (i.e., South Access Road).

The Port of Seattle's plans are to continue to explore ways in which to reduce pollutant levels at the Airport.

(5) **Surface Transportation**

Mitigation is proposed for each adverse impact that would occur with each "With Project" alternative (Alternatives 2, 3, and 4). An adverse impact is defined as a significant degradation in level of service (reducing the level of service) compared to the Do-Nothing alternative. In all cases the proposed mitigation measures will be sufficient to alleviate the significant adverse impact caused by proposed Airport improvements.

Because of the uncertainty of the proposed extension of SR 509 and South Access, as well as the public acceptance and use of high and higher occupancy vehicles and the impact of regional traffic on airport area roadways, the Port will continue to participate in cooperative planning with State and local officials to address its respective share of surface transportation impacts. Mitigation actions that are expected to be addressed in continued mitigation planning include the following associated with the Preferred Alternative:

Several mitigation options were identified for the Preferred Alternative. These include options assuming the completion of the South Access/SR 509 Extension and without this Regional roadway improvement. As is noted in Chapter IV, issues surrounding a proposed State Route 509 extension project and an airport south access road have been discussed among the Port of Seattle and surrounding southwestern King County communities. In December 1995, a Draft Programmatic Corridor EIS was released. As a specific alignment has not been identified and funding has not been committed, two

AR 039285

scenarios were examined relative to the proposed airport improvements. Both scenarios identify mitigation associated with the proposed airport improvement with or without a SR 509 extension and south access.

North Unit Terminal Alternative (With State Route 509)

The following mitigation possibilities have been identified:

- International Boulevard (State Route 99) and South 160th Street - This intersection would degrade from LOS E to LOS F in the year 2010 without SR 509. The construction of the North Unit Terminal will shift some regional traffic from South 170th Street to South 160th Street, but the primary cause of the congestion is the regional traffic on International Boulevard (State Route 99). For the year 2010 only minor improvements to the intersection are necessary (dual southbound left-turn lanes, improvements to the westbound right-turn lane). These improvements provide a level of service rating of LOS E for the year 2010. However, these improvements are not sufficient for the year 2020 traffic levels due to the significant amount of regional traffic on International Boulevard (State Route 99). For the year 2020, the International Boulevard (State Route 99) corridor would need to be improved to provide additional capacity (i.e. seven lanes plus HOV treatments). These improvements would provide a level of service rating of LOS D for the year 2020. The Port of Seattle would be responsible for a pro-rata contribution towards the proposed improvements at this intersection.
- International Boulevard (State Route 99) and South 170th Street - This intersection is actually improved under this Alternative (better LOS F rating), but it serves as an access point to the Airport terminal area and would need to meet the City of SeaTac's adopted level of service standard. For the year 2010 only minor improvements to the intersection are necessary (dual northbound left-turn lanes, high-capacity right-turn lanes in the southbound and eastbound directions, westbound right-turn lane). These improvements provide a level of service rating of LOS E for the year 2010. Again, these improvements would not be sufficient for the year 2020 due to the significant amount of regional traffic on International Boulevard (State Route 99). For the year 2020, the International Boulevard (State Route 99) corridor would need to be improved to provide additional capacity (i.e. seven lanes plus HOV treatments). These improvements would provide a level of service rating of LOS E for the year 2020. The Port of Seattle would be responsible for a pro-rata contribution towards the proposed improvements at this intersection.
- Air Cargo Road and Southbound Airport Expressway Ramps; Air Cargo Road and South 170th Street; Northbound Airport Expressway Ramps and South 170th Street - These three intersections would require signalization by the year 2010. However, the construction of the North Unit Terminal would eliminate these three intersections by the year 2010. Therefore, temporary signals should be installed when the signal warrants are satisfied in order to provide adequate intersection control until the North Unit Terminal is constructed. The Port of Seattle would only be responsible for a pro-rata contribution towards the installation of the temporary signals due to the significant amount of regional pass-through traffic utilizing the Airport Expressway at this interchange area.
- Northbound Interstate 405 On-Ramp from Southbound Interstate 5 - This freeway ramp junction would degrade from LOS C to LOS F in the year 2020 with SR 509. The primary cause is a shift in Airport traffic patterns that would route more traffic eastbound through the Southcenter interchange. Eastbound State Route 518/Northbound Interstate 405 should be widened to two lanes through the interchange. This additional lane could then be dropped at the State Route 181 Off-Ramp located down-stream. The Port of Seattle would only be responsible for a pro-rata contribution

towards the proposed improvements at this interchange.

North Unit Terminal Alternative (Without State Route 509)

- International Boulevard (State Route 99) and South 160th Street - The impacts and possible mitigation measures are the same for this scenario as with SR 509. The only exception is that for the year 2020 the improvements provide a level of service rating of LOS E instead of LOS D. The Port of Seattle would be responsible for a pro-rata contribution towards the proposed improvements at this intersection.
- International Boulevard (State Route 99) and South 170th Street - The impacts and possible mitigation measures are the same for this scenario as with SR 509. The Port of Seattle would be responsible for a pro-rata contribution towards the proposed improvements at this intersection.
- International Boulevard (State Route 99) and South 188th Street - This intersection would degrade deeper into LOS F in the year 2020 without SR 509. This intersection is forecast to have a demand of approximately 6,000 vehicles during the PM peak hour and would require the construction of an urban interchange to meet the City of SeaTac's adopted level of service standard. With this type of improvement it would also be possible to incorporate a fly-over ramp design for the Airport South Access. The Port of Seattle would be responsible for a pro-rata contribution towards the proposed improvements at this intersection.
- International Boulevard (State Route 99) and South 200th Street - This intersection would degrade deeper into LOS F in the year 2020 without SR 509. Significant improvements would be required in order to meet the City of SeaTac's adopted level of service standard. These include the following: providing additional capacity along the International Boulevard (State Route 99) corridor (i.e. seven lanes plus HOV treatments); providing additional capacity along the South 200th Street corridor (i.e. seven lanes); dual left-turn lanes in the southbound, eastbound, and westbound directions; and a westbound right-turn lane. These improvements would provide a level of service rating of LOS E for the year 2020. The Port of Seattle would be responsible for a pro-rata contribution towards the proposed improvements at this intersection.
- 28th/24th Avenue South and South 200th Street - This intersection would degrade from LOS D to LOS F in the year 2020 without SR 509. Only minor improvements to this intersection would be required (dual westbound left-turn lanes, eastbound right-turn lane, re-striping the northbound approach to provide one left-turn, one through, and two right-turn lanes). These improvements would provide a level of service rating of LOS E for the year 2020. The Port of Seattle would be responsible for a pro-rata contribution towards the proposed improvements at this intersection.
- Military Road South and South 200th Street/Southbound Interstate 5 Ramps - This intersection would degrade deeper into LOS F in the year 2020 without SR 509. Only minor improvements to this intersection would be required (dual northbound left-turn lanes, two eastbound through lanes). These improvements would provide a level of service rating of LOS D for the year 2020. The Port of Seattle would be responsible for a pro-rata contribution towards the proposed improvements at this intersection.
- Military Road South and Northbound Interstate 5 Ramps - This intersection would degrade from LOS E to LOS F in the year 2020 without SR 509. Only minor improvements to this intersection would be required (widening the eastbound approach to provide one left-turn and one right-turn lane, and providing a southbound right-turn phase overlap). These improvements would provide a level of service rating of LOS D for the year 2020. The Port of Seattle would be responsible for a pro-rata contribution towards the proposed improvements at this intersection.

- Air Cargo Road and Southbound Airport Expressway Ramps; Air Cargo Road and South 170th Street; Northbound Airport Expressway Ramps and South 170th Street - These three intersections would require signalization by the year 2010 without SR 509. However, the construction of the North Unit Terminal would eliminate these three intersections by the year 2010. Therefore, temporary signals should be installed when the signal warrants are satisfied in order to provide adequate intersection control until the North Unit Terminal is constructed. The Port of Seattle would only be responsible for a pro-rata contribution towards the installation of the temporary signals due to the significant amount of regional pass-through traffic utilizing the Airport Expressway at this interchange area.
- Northbound Interstate 405 On-Ramp from Southbound Interstate 5 - The impacts and proposed mitigation measures are the same for this Alternative as with SR 509. The Port of Seattle would be responsible for a pro-rata contribution towards the proposed improvements at this interchange.

(6) <u>Earth</u>

An Erosion and Sedimentation Control Plan, including measures specific to site conditions, will be designed and implemented to minimize erosion and sedimentation levels. The plan would include elements for site stabilization, slope and drainageway protection, sediment retention, and dust control on haul routes and borrow sites.

As stated in Chapter IV, Section 2 "Land Use, the application and implementation of City of SeaTac regulatory provisions to the Master Plan Update improvements is currently the subject of negotiation through interlocal processes between the Port and City. If applicable, as determined from the result of the interlocal negotiation process between the Port of Seattle and the City of SeaTac (not expected prior to issuance of the Final EIS), the City of SeaTac Environmentally Sensitive Areas Ordinances allow alterations to seismic hazard areas only if (1) site-specific subsurface investigations show the site is not a seismic hazard or (2) mitigation is implemented that renders the proposed development as safe as if it were not located in a seismic hazard area.[13] Two seismic hazards occur on the site of the new parallel runway in relatively small areas of loose, shallow sediment. During runway construction, this sediment would be removed and replaced with compacted fill. If future subsurface investigations verify the occurrence of seismic hazards on Borrow Source Areas 1, 5, and 8, special measures to maintain cut slope stability during excavation in these areas may be required.

A landscaping plan will be developed for areas of excavation and construction. For the borrow source areas, the landscaping plan could include recontouring, seeding, and planting of trees and shrubs. Potential mitigation measures for aesthetic impacts of the proposed new runway are included in Chapter IV, Section 24 "Aesthetics and Urban Design" of this Final EIS.

(7) <u>Construction Impacts</u>

Although no surface transportation congestion mitigation is required, the following measures are identified to minimize construction related surface transportation impacts:

1. Develop a Construction and Earthwork Management Plan. The Plan would designate preferred haul routes and specific conditions such as hours of operations, traffic control changes, and route mitigation. Depending upon the selected contractor(s) haul routes, such controls could include:
   - Provisions that restrict truck traffic during AM and PM peak periods.
   - Contract provisions which would require the contractor to cover all loads to reduce debris and dust loss from the transport activities and to provide for street cleaning and pavement repairs during the construction process.
2. Consider acquiring material rights to the Maury Island sites. Use of Site #14 and the Maury Island King County Park (consistent with the development of the park and if permits can be obtained) would limit the affected routes to SR

[13] *Environmentally Sensitive Areas Ordinance*, City of SeaTac, 1994.

AR 039288

509, which could handle additional truck traffic throughout the day without significant impacts on levels of service.

Because of the social disruption that would occur in the general vicinity of the proposed new runway construction, a construction mitigation acquisition will be implemented. This acquisition includes about 70 residential and commercial properties located east of Des Moines Memorial Drive between SR 509 and SR 518.

To minimize the fugitive dust transport, unpaved roads and inactive portions of the construction site will be watered (achieving a 50 percent reduction in dust) or chemically stabilized (achieving an 80 percent reduction) during dry periods.

3. SIGNIFICANT UNAVOIDABLE ADVERSE IMPACTS

Long term unavoidable adverse impacts in the form of displaced residences and businesses would occur under each "With Project" alternative. Between 350 and 390 single-family residences, 26 and 260 apartment and condominium units, and 96 to 117 businesses would be acquired and displaced under Alternatives 2, 3, and 4 depending upon specific runway length and terminal options. All acquisitions would comply with the Uniform Relocation Assistance Act, and would be coordinated by the Port of Seattle.

Impacts on earth resources that could result from construction and operation of the Master Plan Update improvements include clearing, grading, excavation, fill placement, and soil erosion. The "With Project" alternatives would require the movement of approximately 23 million cubic yards of earth. Cuts of 15 to 45 feet would be excavated on Borrow Source Areas 1, 2, 3, 4, and 5. Construction of the new runway would require fills up to 160 feet thick, with typical thicknesses ranging from 30 to 100 feet. Cuts in existing grade would be up to 20 feet. On the SASA site, fills up to 70 feet thick and cuts up to 60 feet deep would be necessary to achieve proposed grades. The size of cuts and fills on the Des Moines Creek Technology Campus site would depend on the selected grading option. Relatively minor amounts of earthwork would be required to construct the remaining elements of the Master Plan Update.

Erosion of exposed soils in areas of excavation, fill, and stockpile, and subsequent sedimentation of adjacent surface waters would occur. The amount of erosion and sedimentation would depend on the design and implementation of an Erosion and Sedimentation Control Plan.

Clearing and grading of upland and wetland habitat represents the principal unavoidable adverse impact on wildlife and wildlife habitat associated with the proposed Airport improvements. Construction of any of the proposed build alternatives would result in the permanent loss of wildlife habitat and native vegetation communities by clearing, grading, and construction of impervious surfaces. Conversion of land uses in the project area following construction would result in an overall reduction in the number of animals and the loss of disturbance-sensitive species. Animals displaced from the site most likely would perish.

4. DEGREE OF CONTROVERSY CONCERNING THE PROJECT

The Master Plan Update alternatives have received support from some local communities and have been the subject of controversy in others. The Port of Seattle worked with local community officials to provide an understanding of the airport master planning process and the identification of options to address existing and future airport needs. In general, jurisdictions furthest from the Airport are supportive of the Master Plan Update, in lieu of the development of a supplemental airport in their locale. A number of the jurisdictions surrounding Sea-Tac oppose the environmental impacts associated with existing airport operation. As they believe that increased aviation traffic would result in additional environmental impacts, they oppose development that would accommodate forecast growth.

To aid public understanding of the Master Plan Update process and recommendations, the Port of Seattle undertook a public information program. This program consisted of:

- *Nine Sea-Tac University Sessions* - public information meetings to brief interested citizens on the Master Plan Update process and status as the planning effort was underway;
- *Community Planners Forum* - two meetings were conducted with the municipal planners of the communities surrounding Sea-Tac. The purpose of the meetings was to ensure an understanding of the status and results of local comprehensive plans, under the Growth

AR 039289

Management Act, and airport master plan; and

- *Technical Advisory Committee* - Five Technical Advisory Committee meetings were coordinated to brief representatives of the local jurisdictions, business community, airport users, and State/Federal agencies of the status of the Master Plan Update

- *Community Elected Officials Briefings* - At the request of a number of communities, staff from the Port of Seattle conducted numerous briefings of elected officials, city councils and special interest groups concerning various facets of the airport and the Master Plan Update.

Controversy over the development at Sea-Tac is primarily focused on noise, land use, water resources and air pollution impacts. In addition, a number of comments from communities immediately adjacent to Sea-Tac concern the need for a supplemental airport.

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CHAPTER VI

LIST OF PREPARERS, ABBREVIATIONS, ACRONYMS, INDEX AND GLOSSARY

Name	Experience/EIS Role	Professional Discipline
FEDERAL AVIATION ADMINISTRATION		
Dennis G. Ossenkop Regional Airports Division	19 years: environmental evaluation and noise control, regional project planning and evaluation and NEPA compliance and processing	Interdisciplinary Science, Business
Sarah P. Dalton Airport Planning & Capacity Officer	11 years: airport capacity, planning, construction, and environmental studies	Civil Engineering, Public Administration
Carolyn T. Read, P.E. Puget Sound Planner	16 years: project coordination within FAA, planning and engineering	Civil Engineering
Karl B. Lewis, Branch Manager Office of Regional Counsel	18 years: regional legal review, project planning and evaluation	Law
Denise Dee Knapp Office of Regional Counsel	11 years: Legal review, environmental law	Law
PORT OF SEATTLE		
Barbara A. Hinkle EIS Project Manager	10 years: environmental management; Natural & built environment; SEPA and NEPA compliance and processing	Environmental Science/ Urban Planning & Design
David Smith Master Plan, Project Manager	11 years: airport/Aviation Planning Master Plan Project Management and Airport Operation	Business Admin/ Aviation Administration
Diane Summerhays	6 years: noise program management and abatement planning	English Literature
Robert A. Wells	14 years: environmental analysis air quality analysis, SEPA/NEPA evaluation	Geography/Biological Oceanography
Michael Feldman	14 years: airport/Aviation Master Planning and Program Management	Urban & Transportation Planning
Troy Brown	4 years: airport Master Planning, SEPA coordination	Geography
Stacey Reisig	1 year: project coordination	Environmental Science

Name	Experience/ EIS Role	Professional Discipline
SYNERGY CONSULTANTS, INC.		
Mary L. Vigilante President	18 years: project management for environmental studies, environmental processing, noise & air impact assessment, socio-economic impact, wetlands, NEPA processing	Mathematics/Computer Science
LANDRUM & BROWN, INC.		
Max A. Wolfe Vice President	27 years: land use planning, noise abatement planning, environmental planning	Urban Geography
Jon M. Woodward Director	24 years: noise modeling and monitoring, noise abatement	Geography/Political Science
Eugene R. Peters Senior Consultant	11 years: environmental planning, air quality assessment and modeling, energy assessment	Community and Environmental Planning
Timothy L. Alexandar Senior Consultant	12 years: air quality assessment and modeling	Environmental Eng./ Meterology
Mark A. Perryman Senior Consultant	10 years: environmental planning, DOT Section 4(f) lands, historic sites, aesthetic and views	Urban and Environmental Planning
Keith B. Wilscheitz Senior Consultant	6 years: surface transportation planning, airport landside planning and design	Aerospace Engineering
Ted J. Woosley Consultant	4 years: noise impact assessment	Aviation Management
Kurt M. Schwager Consultant	3 years: surface transportation planning, surface noise impacts	Civil Engineering
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Michael P. Hanlon Consultant	3 years: airport/aircraft facilities energy usage	Civil Engineering
Dharma Thapa Analyst	1 year: noise/ air quality modeling	Aviation Management
Karen J. Apple Analyst	1 year: air quality impacts, Final EIS coordination and preparation	Urban and Environmental Planning
SHAPIRO AND ASSOCIATES, INC.		
Keith McGowan Vice President	15 years: transportation, land use, socio-economic evaluations, resource recreation and SEPA/NEPA analysis	Urban and Regional Planning

Name	Experience/ EIS Role	Discipline
Steve Kennedy Planner 4	12 years: project management, comprehensive planning, SEPA/NEPA documentation, land use regulation, housing & community development, agency coordination	Urban and Regional Planning
Marc Boule Vice President	20 years: wetland and sensitive natural resource areas, habitat preservation, mitigation planning, biological assessments	Marine Science/Geology
David Roberts Scientist 5	17 years: soil and water resources analysis, hazardous waste management wetland delineation	Soil Science
Edward McCarthy Scientist 5	12 years: watershed planning and evaluation, hydrological modeling, hydrological analysis stormwater design	Water Resources Engineering/Hydrology
Sharon Feldman Scientist 4	7 years: wetland delineation and inventory, soil and water resources water and wastewater treatment	Soil Science
Scott Luchessa Scientist 3	8 years: wetland delineation, water quality, fisheries, and aquatic resource analysis	Aquatic Ecology
Julia Tims Scientist 1	4 years: wildlife biology, avian ecology, threatened & endangered species monitoring, contaminants	Wildlife Biology
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Peter Rowen Planner 2	2 years: transportation planning, land use controls, public finance, SEPA/ NEPA, public involvement	Urban and Regional Planning
Dawn Neeley Planner 4	17 years: urban and regional planning housing and redevelopment, land use archaeology and historic preservation	Urban and Regional Planning and Historic Preservation
Chris Wright Scientist 3	5 years: wetland delineation, and inventory, assessment, soil and water resources, fisheries analysis	Soil Science
Mark Gander Planner 3	7 years: economics, public finance, land use and transportation planning, housing studies, NEPA/SEPA	Urban and Regional Planing
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Name	Experience/ EIS Role	Professional Discipline
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Daniel Patsula, P.E. Principal	25 years: traffic Mitigation, traffic control, construction staging	Transportation Engineering
Ming Wang, P.E. Sr. Engineer	24 years: traffic Signal systems, construction staging, traffic analysis	Transportation Engineering
Heather Waters Traffic Engineer	2 years: transportation impact analysis traffic data collection, construction traffic control, traffic monitoring	Transportation Engineering
METRO COMMUNICATIONS, INC.		
Theresa Greco-Smith President	10 years: air traffic control, public communication	Flight Technology
GAMBRELL URBAN		
Rick Gambrell President	15 years: geographic information systems, land use policy	City Planning
Ivan Gatchik Associate	10 years: geographic information systems	Geography/Bio Resource Engineering
MOLYNEAUX ASSOCIATES, INC.		
Gary Molyneaux, Ph.D. President	20 years: transportation and land use planning, passenger and freight rail planning, public policy coordination	Geography/ Urban Planning
Liza Joffrion Associate	2 years: transportation planning, public policy coordination	Urban Planning
PARAMETRIX, INC.		
Kathleen Stephanik Senior Planner	8 years: natural resource mitigation plan task manager	Geography
Jim Kelley, Ph.D. Senior Wetland Ecologist	15 years: wetland impact assessment and mitigation planning	Plant Ecology/ Aquatic Biology
Paul Fendt Storm Water Engineer	11 years: Miller Creek mitigation design	Civil Engineering
Kittie Ellen Ford Senior Wetland Ecologist	15 years: wetland mitigation design	Urban Planning

LIST OF ABBREVIATIONS AND ACRONYMS

AAIA	Airport & Airway Improvement Act
AADT	Annual Average Daily Traffic
ADP	Airport Development Plan
AF	Airway Facilities Division, FAA
AG	Agricultural Land
AGL	Above Ground Level
AIRTRAC	Air Transportation Commission
ALP	Airport Layout Plan
ALS	Approach Light System
ALSF-2	High Intensity Approach lighting System with Sequenced Flashers
AMF	Airmail Facility
ANCA	Airport Noise and Capacity Act
AP	Airports Division, FAA
APEC	Asian Pacific Economic Cooperation
ARFF	Airport Rescue and Fire Fighting Facility
ARSA	Airport Radar Service Area
ARSR	Air Route Surveillance Radar
ARTCC	Air Route Traffic Control Center
ARTS	Automated Radar Terminal System
ASDA	Accelerate - Stop Distance Available
ASDE	Airport Surface Detection Equipment
ASIL	Acceptable Source Impact Levels
ASR	Airport Surveillance Radar
ASV	Annual Service Volume
AT	Air Traffic Division, FAA
ATC	Air Traffic Control
ATCT	Airport Traffic Control Tower
BBTU	Billion British Thermal Units
BOD	Biological Oxygen Demand
BMP	Best Management Practice
BTU	British Thermal Unit
CAB	Civil Aeronautics Board
CATI	Category I Instrument Landing System (uses MALSR)
CATII	Category II Instrument Landing System (uses ALSF-2)
CATIII	Category III Instrument Landing System (uses ALSF-2)
CBRA	Coastal Barriers Resources Act
CE	Categorical Exclusion
CEQ	Council on Environmental Quality
CEQ Regulations	Council on Environmental Quality Regulations Implementing The National Environment Policy Act
CFR	Code of Federal Regulations
CL	Centerline lights
Class "AA"	Extraordinary (waters)
CMSA	Consolidated Metropolitan Statistical Area

LIST OF ABBREVIATIONS AND ACRONYMS (Continued)

CO	Carbon Monoxide
COE or USCOE	U.S. Army Corps of Engineers
CTI	Cell Therapeutics INC.
cy	cubic yards
CZMA	Coastal Zone Management Act
CZMP	Coastal Zone Management Program
DARC	Direct Access Radar Channel
db	Decibels
dBA	Decibels A-weighted
DEIS	Draft Environmental Impact Statement
DNL or Ldn	Day-Night Average Sound Level
DOE	Washington State Department of Ecology
DOI	U.S. Department of the Interior
DOT	U.S. Department of Transportation
EA	Environmental Assessment
EDMS	Emissions Dispersion Modeling System
EIS	Environmental Impact Statement
EMF	Electromagnetic Fields
EO	Executive Order
EPA	Environmental Protection Agency
F&E	Facilities and Equipment
FAA	Federal Aviation Administration
FAR	Federal Aviation Regulation
FCC	Federal Communication Commission
FEIS	Final Environmental Impact Statement
FEMA	Federal Emergency Management Agency
FHWA	Federal Highway Administration
FIA	Federal Flood Insurance Administration
FICON	Federal Inter-agency Committee on Noise
FICAN	Federal Inter-agency Committee on Aircraft Noise
FIRM	Flood Insurance Rate Map
FIS	Federal Inspection Services
FMS	Flight Management System
FO	Forested Land
FONSI	Finding of No Significant Impact
FPPA	Farmland Protection Policy Act
FR	Federal Register
FS	Flight Standards Division, FAA
ft.	Feet
FTA	Federal Transit Administration, U.S. Department of Transportation
GA	General Aviation
GI	Geographic Information System
GMA	Growth Management Act
GNSS	Global Navigation Satellite System

LIST OF ABBREVIATIONS AND ACRONYMS (Continued)

GPS	Global Positioning System
HC	Hydrocarbons
HCT	High Capacity Transit System
HIRL	High Intensity Runway Lights
HOV	High Occupancy Vehicle
HPA	Hydraulic Project Approval
HSGT	High Speed Ground Transportation Study
HUD	Housing & Urban Development
IFR	Instrument Flight Rules
ILS	Instrument Landing System
INM	Integrated Noise Model
ISTEA	Intermodal Surface Transportation Efficiency Act
IWS	Industrial Waste System
kwh	Kilowatt
LDA	Localizer Directional Aid
LDA	Landing Distance Available
Ldn or DNL	Day-Night Equivalent Sound Level
LdnT	Day-Night Equivalent Sound Level-Total (including non-aircraft related sounds)
Leq	Equivalent Sound Level
LF	Linear Footage
LLWAS	Low Level Wind Shear Alert System
LOS	Level of Service
LTO	Landing and Takeoff Cycle
LUST	Leaking Underground Storage Tank
MALS	Medium Intensity Approach Lighting System
MALSF	Medium Intensity Approach Lighting System with Sequential Flashing Lights
MALSR	Medium Intensity Approach lighting System with Runway Alignment Indicator Lighting System
MCY	Million Cubic Yard
Mgd	Million Gallons per Day
MIRL	Medium Intensity Runway lights
MITL	Medium Intensity Taxiway lights
MLS	Microwave Landing System
MPO	Metropolitan Planning Organization
MSA	Metropolitan Statistic Area
MSL	Mean Sea Level
N/A	Not Applicable
NAAQS	National Ambient Air Quality Standards
NASA	National Aeronautics Space Administration
NAS Plan	National Airports System Plan
NBEG	Narrow Body Equivalent Aircraft Gate
NEPA	National Environmental Policy Act
NLR	Noise Level Reduction

LIST OF ABBREVIATIONS AND ACRONYMS (Continued)

NOAA	National Oceanic and Atmospheric Administration
NPDES	National Pollutant Elimination System
NPIAS	National Plan of Integrated Airport Systems
NPDES	National Pollutant Discharge Elimination System
NTSB	National Transportation Safety Board
N/S	North/ South Corridor
OAG	Official Airline Guide
ODALS	Omnidirectional Airport Lighting System
OFA	Object Free Area
O&D	Origination-Destination
ORDER 1050.1D	Policies and Procedures for Considering Environmental Impacts
ORDER 5050.4A	Airport Environmental Handbook
PAH	Polynuclear Aromatic Hydrocarbons
PAPI	Precision Approach Path Indicator System
Part 150	FAR Part 150 Noise Compatibility Planning Process
PFC	Passenger Facility Charge
PM	Particulate Matter
POS	Port of Seattle
ppm	Parts per million
PPP	Pollution Prevention Plan
PRM	Precision Runway Monitors
PSATC	Puget sound Air Transportation Committee
PSCOG	Puget sound council of Governments
PSRC	Puget Sound Regional Council
PSRCMSA	Puget Sound Regional Council Major Supplemental Airport
R/W	Runway
RAILS	Runway Alignment Indicator Lighting System
RASP	Regional Airport System Plan
REIL	Runway End identifier Lights
ROD	Record of Decision
ROFA	Runway Object Free Area
RPZ	Runway Protection Zone (once called a Clear Zone)
RSA	Runway Safety Area
RTA	Regional Transit Authority
RT/R	Remote Transmitter/Receiver
RVR	Runway Visual Range
SASA	South Aviation Support Area
SCS	U.S. Soil Conservation Service
SEA	Seattle-Tacoma International Airport
SEPA	Washington State Environmental Policy Act
SEL	Sound Exposure Level
SF	Square Feet

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LIST OF ABBREVIATIONS AND ACRONYMS (Continued)

SHPO	State Historic Preservation Officer
SIMMOD	Airspace and Airport Simulation Model
SIP	State Implementation Plan
SMGCS	Surface Management Guidance and control System
SR	State Route
SWPPP	Stormwater Pollution Prevention Plan
TA	Time- Above
TAF	Terminal Area Forecast
TCA	Terminal Control Area
TCAS	Traffic Alert and Collision Avoidance System
TDM	Transportation Demand Management
TDZ	Touchdown Zone
TODA	Takeoff Distance Available
TORA	Takeoff Run Available
TRACON	Terminal Radar Approach Control
µg/m	Micro grams per meter
UAL	United Airlines
UMTA	Urban Mass Transportation Administration
USC	U.S. Code
USCOE or COE	U.S. Army Corps of Engineers
USDA	U.S. Department of Agriculture
USFWS	U.S. Fish and Wildlife Service
VASI	Visual Approach Slope Indicator
VFR	Visual Flight Rules
VOC	Volatile Organic Compound
VOR	Very High Frequency Omnidirectional Range
VORTAC	VHF Omni directional Range with Tactical Air Navigation
WsDOT or WSDOT	Washington State Department of Transportation

INDEX

GLOSSARY OF TERMS

A-Weighted Sound (dBA) - A measurement representing a sound generally as the human ear hears it by filtering out as much as 20 to 40 decibels of sound below 100 hertz (Hz). Used for aircraft noise evaluations.

Airport Elevations - The highest point on an airport's usable runways expressed in feet above mean sea level (MSL).

Airport Improvement Program (AIP) - A Federal funding program for airport improvements. Funds are derived from sources such as airline tickets, aviation fuel, etc.

Airport Layout Plan - An airport plan (ALP) is a scaled drawing of existing and proposed land and facilities necessary for the operation and development of the airport. Any airport will benefit from a carefully developed plan that reflects current FAA design standards and planning criteria. The ALP shows boundaries and proposed additions to all areas owned or controlled by the sponsor for airport purposes, the location and nature of existing and proposed airport facilities and structures, and the location on the airport of existing and proposed non-aviation areas and improvements thereon.

Airport Operations - The total number of movements in landings (arrivals) plus takeoffs (departures) from an airport.

Airport Surveillance Radar (ASR) - A radar system which allows air traffic controllers to identity an arriving or departing aircraft's distance and direction from an Airport.

Annual Service Volume (ASV) - A planning term which describes the number of annual aircraft operations which Is possible at an airport with an acceptable amount of delay. The measure is specific to individual airports because it is derived from their own particular capacity characteristics.

ASIL - Acceptable Source Impact Levels. Values established by the Puget Sound Air Pollution Control Agency which represent incremental ambient air impact concentrations for air emissions sources.

Attainment Area - An area in which the federal or state standards for ambient air quality are being achieved.

Automated Radar Terminal System (ARTS) - Computer-aided radar display subsystems capable of associating alphanumeric data with radar returns.

Base Floodplain - That area subject to a one percent or greater chance of flooding in any given year (i.e., the 100-year floodplain).

Best Management Practices - Methods employed during construction and included in the development for ensuring environmental management to the greatest possible extent.

Biochemical Oxygen Demand - The oxygen used in meeting the metabolic needs of aerobic microorganisms in water rich in organic matter.

Building Restriction Line (BRL) - A line which identifies suitable building area locations on airports. The BRL encompasses the runway protection zones, the runway visibility zone areas required for airport traffic control tower clear line of sight, and all airport areas with less than 35 foot (10.5m) clearance under the FAR Part 77 surfaces.

Capacity - The number of aircraft operations possible at a particular airport. When a continuous demand of activity is assumed, regardless of delay, it is described as ultimate capacity. When a limit on the number of operations is considered based on an acceptable level of delay, it is described as practical capacity.

Commuter Aircraft - Commuters are those carriers that provide regularly scheduled passenger or cargo service or aircraft predominantly seating fewer than 66 passengers or holding cargo with 18,000 pounds of payload or less. A typical commuter flight operates over a trip distance of 100 to 300 miles and is flown at lower altitudes than those operated by the long-haul carriers.

Connecting Passenger - An airline passenger who transfers from an arriving aircraft to a departing aircraft at a hub airport in order to reach their ultimate destination.

Connection Passenger - An airline passenger who transfers from an arriving aircraft to a departing aircraft at a hub airport in order to reach their ultimate destination. Also described as a "through" passenger. The opposite of a connecting passenger.

Constructive Use - Refers to the possible indirect impacts to DOT Section 4(f) properties such as parks. Constructive use is considered to occur when a transportation project does not incorporate land from a Section 4(f) resource but the project's proximity impacts are so severe that the protected activities, features or attributes that qualify a resource for protection under section 4(f) are substantially impaired. Substantial impairment occurs only when the protected activities, features or attributes of the resource are substantially diminished. For example, a substantial increase in noise levels at a park due to transportation project may represent a constructive use, even though the park is not directly affected through acquisition or development.

Day-Night Equivalent Sound Level (DNL)- A noise measure used to describe the average aircraft noise levels over a 24-hour period, typically an average day over the course of a year. Ldn considers aircraft operations that occur between the hours of 10 p.m. and 7 a.m. to be 10 decibels louder than they actually are to account for increased annoyance. Ldn may be determined for individual locations or expressed contours. Ldn is currently the accepted measure for aircraft noise analysis. See Appendix 4.

Decibel (dB) - A unit of noise level representing a relative quantity. This reference value is a sound pressure of 20 micronewtons per square meter.

Delay - The difference, in minutes, between the scheduled time and actual time of an aircraft arrival or departure. For airport planning purposes, it is often expressed as an annual average per aircraft operation (in minutes).

Dewatering - The temporary or permanent lowering of the groundwater table to allow excavation to be carried out in relatively dry conditions above the lowered groundwater table.

Dispersion Analysis - the examination of air pollutant conditions at specific locations. Expressed in parts per million or micro-grams per meter.

Displaced Threshold - A threshold that is located at a point on the runway other than the designated beginning of the runway. The portion of pavement behind a displaced threshold may be available for takeoffs in either direction and landings from the opposite direction.

Enplanements - Domestic, territorial, and international revenue passenger enplanements in scheduled and nonscheduled service of aircraft in intrastate, interstate, and foreign commerce.

Environmental Assessment (EA) - An environmental assessment is a concise document that assesses the environment impacts of a proposed Federal action. This document discusses the need for, and environmental impacts of, the proposed action and alternatives. A listing of agencies and persons consulted is also included. An environmental assessment should provide sufficient evidence and analysis for a Federal determination whether to prepare an Environmental Impact Statement (EIS) or a Finding of No Significant Impact (FONSI).

Environmental Impact Statement (EIS) - An EIS is normally required for a first time airport layout plan approval or airport location approval for a commercial service airport located in a standard metropolitan statistical area and Federal financial participation in or airport layout plan approval of, a new runway capable of handling air carrier aircraft at a commercial service airport in a standard metropolitan statistical area. Even though these actions normally require an environmental impact statement, the preparation of the environmental impact statement will usually be preceded by an environmental assessment. If the environmental assessment demonstrates that there are no significant impacts, the action shall be processed as a FONSI instead of an EIS.

Equivalent Level (Leq) - The equivalent steady noise level which in a stated period of time would contain the same noise energy as the time-varying noise during the same period. The Leq can be for any defined period, unlike the DNL.

Erosion - Wearing away of rock or soils by the gradual detachment of soil or rock fragments by wind, ice, water, and other forces.

Farmland Conversion Impact Rating - A form (form AD-1006) used by the U.S. Soil Conservation Service to evaluate soils which are potentially eligible for protection as Prime or Unique farmland under the Farmland Protection Policy Act of 1981.

FAR - Federal Aviation Regulation.

Federal Aviation Administration - The FAA constructs, operates, and maintains the National Airspace System and the facilities which are a part of the system; allocates and regulates the use of the airspace; ensures adequate separation between aircraft operating in controlled airspace; and through research and development programs, provides new systems and equipment to improve utilization of the nation's airspace.

Federal Aviation Regulation (FAR) Part 150 - Established by Congress under the Aviation Safety and Noise Abatement Act of 1979 for the purpose of developing a balanced and cost effective program to reduce the effects of aircraft noise on local communities.

Finding of No Significant Impact - Following the preparation of an environmental assessment, the Federal Agency determines whether to prepare an EIS or FONSI. If the proposed project is determined not to result in any significant environmental impact, a finding (FONSI) is made by the Federal Agency.

Flight Track Utilization - The use of established routes for arrival and departure by aircraft to and from the existing runways at the airport.

Growth Management Act - The act requires all cities and counties in Washington State to do some planning and calls for the fastest growing counties to plan extensively in accordance with state goals.

Grid Analysis - A type of aircraft noise analysis which evaluates the noise levels at individual points rather than generate noise contours.

Habitat - The specific area or environment in which a particular type of plant or animal lives. An organism's habitat must provide all of the basic requirements for life and should be free of harmful contaminants.

Hub - An airport which serves airlines that have hubbing operations.

Hubbing - A method of airline scheduling that times the arrival and departure of several aircraft in a close period of time in order to allow the transfer of passengers between different flights of the same airline in order to reach their ultimate destination. Several airlines may conduct hubbing operations at an airport.

Hydraulic Project Approval - a permit granted by the Washington Departments of Fisheries and Wildlife for work to be performed on or near a body of water, such as a creek or river.

Instrument Flight Rules (IFR) - Federal Aviation Regulations rules that govern the procedures for conducting instrument flight (FAR Part 91).

Instrument Landing System (ILS) - An electronic system installed at some airports which helps to guide pilots to runways on landing during periods of limited visibility or adverse weather. A pilot must have proper training and his aircraft property equipped to use an ILS. Most major airports have at least one of their runways equipped with an ILS.

Instrument Meteorological Conditions (IMC) - Meteorological conditions expressed in terms of visibility, distance from cloud and ceiling which are less than the minimums specified for visual meteorological conditions.

Integrated Noise Model (INM) - A computer model developed and maintained by the FAA to predict the noise Impacts generated by aircraft operations.

Land Use Compatibility - The ability of land uses surrounding the airport to coexist with airport-related activities with minimum conflict.

Landing and Takeoff (LTO) Cycle - The time that an aircraft is in operation at an airport. An LTO cycle begins when an aircraft starts its final approach (arrival) and ends after the aircraft has made its climb-out (departure).

Level-of-Service (LOS) - A measure of the effect of a number of factors on surface traffic flows. LOS is a function of volume and composition of traffic and speeds attained on any specific roadway, and is defined as LOS "A' through "F" . LOS A is unencumbered free flow, LOS C is stable flow with frequent delay and LOS F is forced flow with extensive backup.

Liquefaction - A temporary condition during which soil behaves more like a viscous liquid than a solid medium. The condition is due to the build-up of water pressure in the spaces (pores) between the soil particles and the inability of the sold to drain quickly, as energy is imparted to the soil mass during an earthquake.

Local Passenger - A passenger who either enters or exits a metropolitan area on flights served by the area's airport The opposite of a connecting passenger.

Location Impact Analysis - An analysis conducted to determine if noise level Increases associated with projected development would approach the FAA threshold of a 1.5 DNL increase within the 65 DNL or greater noise contours over any noise-sensitive land use.

Loudness - The subjective intensity of sound.

Master Plan Update - An update to the long-range airport development requirements. These plans are typically updated every 5-7 years.

Missed Approach - A prescribed procedure to be followed by aircraft that cannot complete an attempted landing at an airport.

Mitigation - The avoidance or minimization of an adverse impact.

Mitigation Measure - An action taken to alleviate adverse impacts.

Modal Split - The distribution of trips among competing travel modes, such as walk, auto, bus, etc.

Mode - A particular form or method of travel, such as walk, auto, bus, etc.

Narrowbody Aircraft - A commercial passenger jet having a single aisle and maximum of three seats on each side of the isle. Narrowbody aircraft include B727, B737, B757, DC9, MD80, MD90 and A320.

Navaid - Any facility used for guiding or controlling flight in the air or during the landing and takeoff of aircraft.

NEPA - The National Environmental Policy Act of 1969 (NEPA) is the original legislation establishing the environmental review process.

Noise - Unwanted Sound.

Noise Abatement - a procedure of the operation of aircraft at an airport which minimizes the impact of noise on the environs of an airport.

Noise Contour Map - A map representing average annual noise levels summarized by lines connecting points of equal noise exposure.

Noise Exposure Map (NEM) - A map of an airport and its environs which identifies the area impacted by various aircraft noise levels. The FAA has specified criteria for presentation of Part 150 Noise Exposure Maps.

Noise Level Reduction (NLR) - The amount of noise level reduction achieved through incorporation of noise attenuation (between outdoor and indoor levels) in the design and construction of a facility.

Non-Attainment Area - an area in which the federal or state standards for ambient air quality are being exceeded.

Operation - An aircraft arrival at or departure from an airport.

Origin and Destination Passengers - Those passengers, whether visitors or residents, that begin or end their trip in the region.

Outer Fix - As point in the destination terminal area from which aircraft are cleared to the approach fix or final approach course.

PAX - Passenger

Precision Approach Procedure/Precision Approach - A standard instrument approach procedure in which an electronic glidescope/glidepath is provided, e.g., ILS and PAR.

Primary Commercial Service Airport - A commercial airport which enplanes 0.01 percent or more of the total annual U.S. enplanements.

Primary Runway - the runway on which the majority of operations take place. At large, busy airports, there may be two or more parallel primary runways.

Public Use Airport - Any public, airport, any privately owned reliever airport, any privately owned airport which is determined to enplane annually 2,500 or more passengers and receive scheduled passenger service of aircraft, and which is used or to be used for public purposes.

Reliever Airport - An airport which, when certain criteria are met, relieves the aeronautical demand on a busier air carrier airport.

Riparian - Relating to, living in, or located on the bank of a natural watercourse, such as a river.

Rotational Runway Use - Variance in the particular runways in use over a specific time period to prevent constant use of one runway.

Run-Up - A routine procedure for testing an aircraft engine at a high power setting. Engine run-ups are normally conducted by airline maintenance personnel checking an engine following the conduct of maintenance.

Runway - A defined rectangular area on an airport prepared for the landing and takeoff run of aircraft along it's length. Runways are normally numbered in relation to their magnetic direction rounded off to the nearest 10 degrees, e.g., Runway 14, Runway 32.

Runway Protection Zone (RPZ) - An area (formally the clear zone) trapezoidal in shape and centered about the extended runway centerline, is used to enhance the safety or aircraft operations. It begins 200 feet (60m) beyond the end of the area usable for takeoff or landing. The RPZ dimensions are functions of the design aircraft, type of operation, and visibility minimums.

Runway Safety Area (RSA) - A defined surface surrounding the runway prepared or suitable for reducing the risk or damage to airplanes in the event of an undershoot, overshoot, or excursion from the runway.

Sediment - Material suspended in or settling to the bottom of liquid.

Sound - Sound is the result of a sound source vibration in the air. The vibration produces alternating bands of relatively dense and sparse particles of air, spreading outward from the source in the same way as ripples do on water after a stone is thrown into it. The result of the movement is fluctuation in the normal atmospheric pressure or sound waves.

Sound Exposure Level (SEL) - The constant sound level which has the same amount of energy in one second as the original sound event.

Stage 2 Aircraft - Aircraft which meet the noise levels prescribed by FAR Part 36 and are less stringent than those established for the quieter designation (Stage 3). The Airport Noise and Capacity Act requires the phase-out of all Stage 2 aircraft by 1999, with case-by-case exceptions through the year 2003.

Stage 3 Aircraft - Aircraft that meet the most stringent noise levels set in FAR Part 36.

Taxiway - A defined path established for the taxiing of aircraft from one part of an airport to another.

Threshold - the beginning of that portion of the runway usable for landing.

Time Above (TA) - Time above indicates the time in minutes that a given dB(A) level is exceeded during a 24-hour period.

Tributary - A stream that flows into another.

Watershed - The geographic region from which water drains into a particular river or body of water. A watershed includes hills, lowlands, and the body of water into which the land drains.

Vehicle-Miles-Traveled (VMT) - a measure of total travel within a study area, usually estimated as the total number of trips multiplied by the average length of a typical trip.

Very High Frequency Omnirange Station - A ground-based radio (electronic) navigation aid transmitting radials in all directions in the VOR frequency spectrum; provides azimuth guidance to pilots by reception of electronic signals.

Visual Approach - An approach by an IFR flight when either part or all of an instrument approach procedure is not completed and the approach is executed in visual reference to terrain.

Visual flight Rules (VFR) - Rules that govern the procedures for conducting flight under visual conditions. In addition, it is used by pilots and controllers to indicate type of flight plan.

Visual Meteorological Conditions (VMC) - Meteorological conditions expressed in terms of visibility, distance from cloud, and ceiling equal to or better than specific minimum. Typically, these conditions occur whenever the cloud ceiling is at least 1,000 feet above ground level, distance to cloud is 1 statue mile, and the visibility is at least 3 statue miles.

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APPENDIX A

SCOPING AND AGENCY COORDINATION

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APPENDIX A

SCOPING AND AGENCY COORDINATION

This appendix contains a summary of the agency coordination that was conducted in preparation of this document. Included are:

- Coordination with agencies
- Scoping
- Public Hearing
- Executive Order 12372 Intergovernmental Review of Federal Programs

1. COORDINATION WITH AGENCIES

A number of Federal , State and local agencies were contacted during the preparation of this Environmental Impact Statement. To facilitate the early consideration of key issues related to airport development, two scoping meetings (as discussed later in this chapter) were conducted to introduce the document preparers to the respective agencies and to begin consideration of the key issues. Following the scoping meetings, formal coordination was conducted with the applicable agencies. Correspondence concerning the Master Plan Update was received from:

- U.S. Department of the Army , Seattle District Corps of Engineers;
- Puget Sound Regional Council;
- Puget Sound Air Pollution Control Agency;
- U.S. Environmental Protection Agency;
- Washington Department of Ecology;
- U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service;
- U.S. Department of Interior, Fish and Wildlife Service;
- Washington State Department of Natural Resources;
- Washington State Department of Community, Trade and Economic Development, Office of Archaeology and Historic Preservation;
- King County, Cultural Resources Division;
- City of SeaTac
- Washington State Department of Community, Trade and Economic Development - Office of Archaeology and Historic Preservation
- King County Surface Water Management Division
- Washington State Department of Fish and Wildlife
- Trout Unlimited
- U.S. Army Corps of Engineers

Copies of the correspondence from each of the above agencies are included in this appendix.

2. PUBLIC AND AGENCY SCOPING

In accordance with CEQ Regulations and SEPA, the FAA and Port of Seattle issued a "Notice of Intent to Prepare and Environmental Impact Statement" (NOI) for the Sea-Tac Airport Master Plan Update. This notice was published in the January 4, 1994 Federal Register. As shown in **Exhibit A-I**, the NOI contained a brief description of the proposed action and the range of alternatives, a description of the scoping process, location of the scoping meetings, and the name and address for the NEPA and SEPA contacts. In addition to publication in the Federal Register, a similar notice was published in the Seattle Times, the Seattle Post Intelligencer, and the Highline Times.

On February 9, 1994 from 3 p.m. until 9 p.m., an open house public scoping meeting was conducted at Tyee High School. This meeting was attended by approximately 100 people. On February 10, 1994 from 9:30 a.m. to 12 p.m. an agency scoping meeting was conducted in the auditorium at Sea-Tac Airport. Approximately 40 individuals from the following groups: Seattle Times, former Congressman Kreidler, University of Washington, City of Normandy Park, Department of Ecology, City of Tukwila, City of Burien, Washington State DOT, Seattle Water, King County Surface Water Management, City of SeaTac, City of Des Moines, Airport Communities Coalition, City of Federal Way, City of Arlington, U.S. EPA, Highline Times, Highline School District, Puget Power, U.S. Department of Housing and Urban Development, Puget Sound Regional Council, the FAA and the Port of Seattle.

Those in attendance at either meeting were provided with a copy of an outline that summarized the Environmental Impact Statement (EIS) process, the contents of an EIS, the range of alternatives to be considered, and environmental factors to be considered.

Scoping was conducted in writing and 114 letters were received. These letters are on file with the Federal Aviation Administration. Issues noted in the scoping letters were:

- A desire for a detailed consideration of noise, air pollution, water resource and human health impacts associated with the current airport operation and how the impacts would change in the future;
- Concerns for impacts on property values from noise and airport expansion;
- Concerns that the expansion at Sea-Tac would be a partial solution to long-term regional aviation demand needs;
- A desire to have a number of alternative modes of travel and alternative airport sites considered.

3. PUBLIC HEARING

The Draft EIS was released in late April, 1995. On June 1, 1995, the FAA and the Port of Seattle conducted a Public Hearing at the Sea-Tac Red Lion Hotel, at South 188th and International Blvd, from 1 p.m. until 10 p.m. The Public Hearing was conducted for the purpose of obtaining comments from the public concerning the materials and methodologies used in the analysis and findings in the Master Plan Update for the Draft EIS. Simultaneous with the Hearing, the FAA and Port of Seattle conducted a public information workshop to aid the public with preparation of the testimony and to answer questions concerning the analysis underlying the Draft EIS and to provide an opportunity for residents to formally submit their comments.

Additionally, as requested by the public, the formal comment period was extended to 90 days, to enable a thorough consideration of the analysis and findings. Therefore, the Hearing record remained open until August 3, 1995. Testimony was provided by 77 individuals and the workshop/hearing was attended by approximately 150 individuals. To further facilitate the general public's understanding of the Master Plan Update development and its resulting environmental impacts, the FAA agreed to conduct a second Public Hearing, which was conducted on June 14, 1995 at the Calvary Lutheran Church in Federal Way, from 6 p.m. until 10 p.m. Testimony was received from 15 individuals and the Public Hearing was attended by approximately 40 individuals.

Comments were mailed to Mr. Dennis Ossenkop, of the Federal Aviation Administration, Regional Airports Office. Approximately 250 comment letters were submitted during the 90 day public and agency comment period. Once all comments submitted during the 90 day comment period were reviewed and the Public Hearing transcript was available, responses were prepared to address all applicable comments. In several instances, the comments resulted in additional analysis that has been included in this document. Copies of the comment letters and official Public Hearing Transcript are included in Appendix T. Likewise, responses to the comment letters and Public Hearing Transcript are included in **Appendix R**.

4. E.O. 12372 INTERGOVERNMENTAL REVIEW OF FEDERAL PROGRAMS

Executive Order 12372 requires the sponsor of actions that will use federal assistance to determine the proposed project's impact or conflict with stateside or areawide comprehensive planning or upon the plans of local governments. In the state of Washington, there is no clearing house for this process. Thus, the public comment process on the Draft EIS, as well as other planning activities in the Region (such as the PSRCs VISION 2020) will be used to determine consistency with regional plans.

Enclosed in this appendix are the following resolutions:

- Puget Sound Regional Council A-93-03
- Port Resolution 3125
- PSRC Executive Board
- Puget Sound Regional Council Executive Board EB - 94-01
- Snohomish County Resolutions

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Questions may be directed to the individual named above under the heading, FOR FURTHER INFORMATION CONTACT.

Issued in Minneapolis, Minnesota on December 10, 1993.

Franklin D. Benson,

Manager, Minneapolis Airports District Office, FAA Great Lakes Region.

[FR Doc. 94-139 Filed 1-4-94; 8:45 am]

BILLING CODE 4910-13-M

Determination of Significance and Notice of Intent To Prepare an Environmental Impact Statement and To Conduct Scoping for Seattle-Tacoma International Airport, Seattle, WA

AGENCY: Federal Aviation Administration (FAA), DOT.

ACTION: Notice of intent.

SUMMARY: The Northwest Mountain Region of the Federal Aviation Administration ("FAA") and the Port of Seattle ("Port") announce that the FAA and the Port, acting as joint lead agencies, intend to prepare an Environmental Impact Statement (EIS) for a proposal by the Port to develop a new parallel runway and other airport facility improvements to be examined in an update to the Seattle-Tacoma International Airport (Sea-Tac Airport) Master Plan. To ensure that all significant issues related to the proposed action are identified, scoping comments are requested.

DATES AND ADDRESSES FOR COMMENTS: To facilitate the receipt of written comments, two scoping meetings will be conducted. The first meeting, in a workshop format, will be conducted for the public on February 9, 1994. A meeting for Federal, state and local agencies will be conducted on February 10, 1994. Send comments to, or seek additional information from the responsible Federal official: Mr. Dennis Ossenkop, Airports Division, Federal Aviation Administration, 1601 Lind Avenue SW., suite 540, Renton, Washington 98055-4056. To be considered, written comments must be received on or before February 25, 1994.

SUPPLEMENTARY INFORMATION: Recent planning studies have indicated both an existing and long-term need for additional airfield capacity at Sea-Tac Airport. Under current demand levels, the Airport experiences reduced operating capability and delay during bad weather conditions due to the close-spacing of the existing parallel runways. During busy hours, arrival demand exceeds the bad weather arrival capacity and aircraft and passenger delays result. In addition to increasing the severity of delays caused by bad weather, continued growth in aircraft operational demand is projected to exceed Sea-Tac's annual airfield capacity within the next ten years. The objective of the Master Plan Update, and accompanying EIS, is to address the bad weather capacity problem and to meet long-term regional air travel needs spurred by a growing regional economy.

An Environmental Impact Statement (EIS) will be prepared for the Master Plan Update, which is expected to include numerous projects including, but not be limited to: A new parallel runway and improvements to the passenger terminal, ground access system, and other support facilities. The range of new parallel runway options that may be considered in the EIS are anticipated to be in the immediate vicinity of the existing airfield at Sea-Tac Airport. Based on the Master Plan Update, other airport developments that may be considered in the EIS would be located on or in the immediate vicinity of the existing Sea-Tac Airport property. Mitigation measures will be proposed, as necessary, for the significant adverse impacts created by development. Major actions or concepts to be discussed in the draft EIS include the no action alternative and other reasonable alternatives meeting the purpose and need. Such alternatives are expected to include several options related to runway lengths, separations and threshold stagger.

The FAA and Port of Seattle have determined that the new parallel runway is likely to have a significant adverse impact on the environment. An Environmental Impact Statement (EIS) is required under the National Environmental Policy Act and the Washington State Environmental Policy Act (SEPA), RCW 43.21C.030(2)(c) and will be prepared. The FAA and Port of Seattle have identified the following key areas for discussion in the EIS including, but not limited to: Alternatives, noise and land use, social and socio-economic impacts, human health, water resources, biotic communities, construction, earth, transportation and air quality.

Scoping is the initial step in the preparation of the EIS. The scoping process is "an early and open process for determining the scope of issues to be addressed and for identifying the significant issues related to the proposed action." Agencies, affected tribes, and members of the public are invited to comment on the scope of the EIS. You may comment on alternatives, mitigation measures, probable significant adverse impacts, and licenses or other approvals that may be required. Comments and suggestions are invited from Federal, State and local agencies, and other interested parties and individuals to ensure that the full range of issues related to a Master Plan Update EIS are addressed and all significant issues identified.

To facilitate the receipt of comments, two scoping meetings will be conducted. A public workshop will be conducted to receive written comments on February 9, 1994 from 4 p.m. until 8 p.m. at Tyee Senior High School, 4424 South 188th Street, City of SeaTac. The second meeting will be held on February 10, 1994 between 9:30 a.m. and 11 a.m. for Federal, state and local agencies in the Sea-Tac Auditorium, Mezzanine Level Main Terminal Building, Seattle-Tacoma International Airport.

Issued in Renton, Washington on December 20, 1993.

Edward G. Tatum,

Manager, Airports Division, Federal Aviation Administration, Northwest Mountain Region, Renton, Washington.

William E. Broegher,

SEPA Responsible Official, Port of Seattle.

[FR Doc. 94-137 Filed 1-4-94; 8:45 am]

BILLING CODE 4910-13-M

PUBLIC AGENCY SCOPING MEETING

SEATTLE TACOMA INTERNATIONAL AIRPORT ENVIRONMENTAL IMPACT STATEMENT

DRAFT MINUTES

FEBRUARY 10, 1994

The Mr. Ossenkop opened the Public Agency Scoping Meeting at 9:30 a.m. and noted that the meeting would be conducted generally following the material distributed in advance of the meeting. Ms. Hinkle reviewed the Environmental Impact Statement (EIS) process and Master Plan Update process. The consulting team conducting the EIS was introduced. Ms. Vigilante provided a summary of the contents of the EIS and the issues to be addressed. The meeting was opened for agency comments and questions. Mr. Ossenkop noted that official comments must be submitted in writing by February 25, 1994. He then asked those in attendance if they had any questions or issues that they would like to see addressed in the EIS.

Washington State Department of Transportation, Office of Urban Mobility, focused on the landside issues related to the local transportation network and its ability to accommodate growth in traffic. He noted that State and local jurisdictions are adding landside capacity through the completion of SR 509, transit improvements, high occupancy vehicle facilities, and TDM programs. The doubling of passenger activity, time of day (peaking), and mode split is of concern and should be reviewed. The WDOT also requested that the parking supply should also be evaluated. The WDOT questioned what assumptions will the EIS make concerning the potential regional transit project. Freight and inter modal connections should be part of the transportation analysis. The land use assumptions should also be closely evaluated. Airside issues include the need to incorporate the Master Plan into the Statewide Multi-Modal Plan process.

Mayor Jhaveri, City of Burien, expressed concern that the EIS scoping process is flawed. He suggested that the Notice of Intent should define the specific alternatives and provide a statement of Need. He asked the FAA to withdraw the Notice of Intent. Mr. Ossenkop responded that the FAA will not withdraw the Notice of Intent as it correctly defines the planning effort. He noted that the public will have multiple opportunities to comment on the EIS and that a Public Hearing will be held. The Master Plan Update and the EIS process are intended to illuminate the issues and alternatives. In addition, Mayor Jhaveri requested that historic sites be assessed in the EIS study process.

Mr. Stooder, City Manager, City of Burien, identified requested that the EIS address the potential impact of telecommuting on the transportation analysis. In addition, he requested that the study include a section that defines "what people want."

Bob Davis, Mayor of Normandy Park, stated that the FAA needs to re-assess the aviation demand at the airport and for the region. He stated that air traffic demand forecasts should be updated, including current population and employment projections, as air traffic has leveled off in recent years. Mr. Ossenkop responded that the Master Plan Update will be re-assessing the aviation demand forecasts. In addition, Mr. Davis suggested that an analysis of "unresolved issues" needs to be included as part of the NEPA process. He stated that a detailed EIS should be prepared on each alternative. He asked if the FAA will amend the Scope of Work based on the scoping comments. FAA responded that the Scope of Work has not been finalized and that the scoping meetings were helping determine the scope of the consultants work.

Kitty Millne, Vice-Mayor, City of Burien, asked in the scope will include the Washington State Air Transportation Commissions recommendations and if it would include issues related to the supplemental airport study. She stated that the EIS should wait until the PSRC work is completed. She also requested that the air and noise analysis reflect monitors in the impacted communities.

Dorothy De Rodas, Tukwila City Council, requested that the study evaluate cumulative impacts of airport activities and local actions on traffic, air pollution, and public services. She noted that the City of SeaTac is a major urban center under the Vision 2020 and will increase densities. Increased air traffic will place more people in the impact area. She questioned if the EIS would include these impacts. Mr. Ossenkop responded that this type of analysis will be included the process.

Richard Kennedy, Mayor, Des Moines, asked if the EIS would address growth management and social and economic issues. He also asked how will mitigation be handled in the study process. He also questioned if the EIS will address the GMA and would it perform a consistency evaluation. Mr. Ossenkop noted that the EIS will address these issues where possible when policies are clearly formulated and adopted. The Mayor continued by asking if the EIS would address impacts on public/private activities and services. Mr. Ossenkop noted that the EIS will address these concerns and are already part of the scope as required.

Mr. Loch, City Manager - Des Moines, stated that citizen input has been limited to the last critical weeks of the EIS process. He commented that this is a disservice to the public involvement process and that the public needs adequate time to review documents and data. He requested that the FAA note that no public testimony is being accepted during the agency scoping exercise. Mr. Loch requested that draft materials be available for public review and that the scoping period be extended. The FAA responded that the issues of draft materials will be reviewed and that the scoping exercise will not be extended.

Mr. Pina, Highline School representative, stated that schools affected by noise have lower test scores than other schools. He requested that noise be measured using the "C" Scale in the same fashion has a study conducted by the School District. Mr. Ossenkop requested a copy of the "C" Scale Study. Mr. Pina responded that they would provide the study. He noted that the district continues to be concerned about noise related issues as it builds new facilities in the area.

Vivian Mathews, Burien City Council, indicated concern that the scoping process does not have an "open mike" for testimony. She stated that the public scoping meeting should not have been an open house and requested that a public meeting be held such that all residents could hear one-another's comments. Ms. Vigilante responded that the scoping process is based upon national experience that preserves the ability of citizens and agencies to submit written comments for a record of concern. Ms. Mathews asked how citizens will know that comments have been received a response. Mr. Ossenkop noted that there will not be any individual responses to comments. However, the issues will be addressed in the EIS.

Mr. Brown, Department of Ecology, stated that DOE requests strong baseline definition of current conditions. This includes air quality and traffic and air operations information, as well as water quality data. He noted that water quality, storm water, and sewage for all off-site watershed alternatives should be addressed.

Mr. Fenins, City of Federal Way, stated that the city will provide written comments and specific analysis requests. He requested that the DEIS comment period be extended from 45 days to 120 days. He also noted that the EIS should update the Part 150 Study.

John Bregar, EPA, will prove written comments on air, noise, etc. issues.

David Masters, King County Surface Water Management, will provide written comments for the scoping process. He noted that cumulative impacts are of concern, as well as operational issues related to de-icing, drainage systems, hydrology, fishery, and monitoring systems.

Diana Shavey, Department of Houing and Urban Development, raised issues related to the impact of the airport on low to moderate income housing. She noted that the EIS should address the impact on housing stock and tenants for both multi- and single family housing. The study should also assess the market impact on housing and its potential for effecting mortgage insurance programs operated by HUD.

Jack Dodge, City of SeaTac, requested that water quality issues concerning Miller Creek and other streams should be assessed. He suggested that new noise impacts on adjacent development and jurisdictions should also be addressed in addition to health impacts, traffic impacts, and construction impacts. He requested that the EIS analysis be coordinated with the City of SeaTac plans and identify how local regulations will be impacted by airport development.

A representative from Puget Power noted that they will provide written comments. Of special concern to Puget Power are electrical requirements and the compatibility between local communities. He noted that relocation of existing facilities serving residential and commercial users is difficult. He noted a desire to cooperate and coordinate on these issues.

Mr. Olander, City Manager - Des Moines, indicated that the EIS process requires good baseline data on water quality. He stated that the analysis should include low to high water periods. He noted similar concerns about the noise analysis.

All agencies attending were provided an opportunity to present issues of concern. The meeting was adjourned at approximately 11:50 a.m.

C:\SEATTLE\SCOPING\SCOPAG.MIN

Mary V.

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REPLY TO ATTENTION OF

FEB - 1 1995

Regulatory Branch

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Federal Aviation Administration
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Renton, Washington 98055-4056

RECEIVED FEB - 9 1995

Dear Mr. Ossenkop:

The Seattle District, U.S. Army Corps of Engineers (Corps) accepts the Federal Aviation Administration's request to be a cooperating agency in the preparation of a National Environmental Policy Act (NEPA) Environmental Impact Statement (EIS) for the proposed expansion of the Seattle-Tacoma International Airport.

The Corps participation as a cooperating agency will be limited to reviewing and commenting on the preliminary draft sections of the EIS that relate to project alternatives and wetland/mitigation issues. We will make every attempt to provide comments on these sections of the preliminary draft EIS within 15 working days of receipt of the information.

As you are aware, the Corps will require a Section 404 permit for the filling of wetlands onsite. As such, the portion of the project requiring Section 404 authorization will be subject to the Corps' own environmental review under NEPA. As a cooperating agency, the Corps can adopt the final EIS in order to satisfy our NEPA compliance obligations associated with issuance of a Section 404 permit.

I agree that cooperation between our agencies is the most effective way to achieve our mutual goal of a draft EIS which satisfies both our agency's needs before being circulated to the public. We look forward to working with you on this project.

Mr. Jonathan Smith has been assigned as the point of contact for the Corps on this project. If you have any questions, please contact Mr. Smith at telephone (206) 764-6910.

Sincerely,

Robert H. Martin

for Thomas F. Mueller
Chief, Regulatory Branch

file

Puget Sound Regional Council

PSRC

Post-it™ brand fax transmittal memo 7671	# of pages ▸ 1
To Gene Peters	From Larry Blain
Co. Landrum + Brown	Co. PSRC
Dept.	Phone # 206-464-5402
Fax # 312-421-6171	Fax #

December 22, 1994

Ms. Barbara Hinkle
Enviromental Management Specialist II
Port of Seattle
Seattle-Tacoma International Airport
P.O. Box 68727
Seattle, WA 98168

Dear Ms. Hinkle:

Thank you for the opportunity to review the Proposed Air Quality Modeling Protocol. I have enjoyed working with Gene Peters of Landrum & Brown, and I trust he has found my suggestions useful.

The scope and level of detail of this modeling exercise are outside the purview of the Puget Sound Regional Council, so no concurrence on our part is necessary. We defer to the other agencies more directly concerned with the subject of this exercise.

Please feel free to call me (464-5402) if you have any questions.

Sincerely,

Lawrence W. Blain
Senior Planner

cc: Gene Peters

PUGET SOUND AIR POLLUTION CONTROL AGENCY
KING COUNTY ▲ KITSAP COUNTY ▲ PIERCE COUNTY ▲ SNOHOMISH COUNTY

November 29, 1994

Barbara Hinkle
Port of Seattle
PO Box 68727
Seattle, WA 98168

Dear Ms. Hinkle:

Comments on Proposed Air Quality Modeling Protocol for Seattle-Tacoma International Airport

Thank you for the opportunity to comment on the proposed air quality modeling procedures for use in the air quality analysis in the Environmental Impact Statement for the Master Plan Update at Seattle-Tacoma International (Sea-Tac) Airport. Mr. Gene Peters of Landrum & Brown has been working with our staff for some time to obtain our formal recommendations on this protocol. We would like the Port to consider the following comments on the protocol dated October 12, 1994.

- **Background Concentration for Carbon Monoxide:** The proposed background concentration for carbon monoxide is acceptable since this is the recommended default in EPA's "Guidelines for Modeling Carbon Monoxide from Roadway Intersections" (1994). However, the equation derived by Larson et al. in a recent technical report entitled "Local Background Levels of Carbon Monoxide in Urban Areas" would also be acceptable. This equation:

$$CO_{8\text{-}hr} = 1.85(V_{traf})^{0.048}$$

is appropriate for high traffic areas where $CO_{8\text{-}hr}$ is the eight-hour average background concentration in ppm and V_{traf} is the highest average weekday traffic volume within 200 meters of the receptor site.

- **Background Concentration for Oxides of Nitrogen:** Although the recommended value of 0.02 ppm (annual) is based on old monitoring data, a recent study by Larson et al. entitled "Atmospheric Observation of Nitrogen Dioxide in Seattle, Washington" (1994) monitored biweekly average concentrations ranging from 0.02 to 0.03 ppm of NO_2 at several locations in the Puget Sound region. Therefore 0.02 ppm is appropriate.

- **Background Concentrations for Particulate Matter and Sulfur Dioxide:** The use of the South Park data for PM_{10} and the Duwamish data for SO_2 is acceptably conservative. However, using 1990-1993 data only is appropriate since this data more closely reflects current background levels.

- **Modeling Techniques:** The air quality modeling protocol should include a description of the methods used to estimate and model emissions from the parking lots, fuel tanks, maintenance activities, and engine testing.

110 Union Street, Suite 500, Seattle, Washington 98101-2038 ▲ (206) 343-8800 ▲ (800) 552-3565 ▲ FAX:(206) 343-752.

- Temperature: The use of 40 degrees F as the average winter annual temperature is a good assumption and probably representative of actual conditions during exceedances. However, note that Ecology used a temperature of 46 degrees F in the CO SIP. Either of these values is acceptable.

- Cold Starts: The use of the percent vehicle cold starts default in Mobile5A of 20.6% for roadways is acceptable. However, assuming 100% vehicle cold starts for cars in the parking lot is overly conservative since many of the cars in the metered parking area remain at the airport only for a short time period. More realistic assumptions would be acceptable to the Agency for determining percent vehicle cold starts in the parking lot.

- Toxic Air Contaminant Emissions/Sensitive Receptors: The evaluation of toxic air contaminants appears to have been dropped from the protocol. The outline presented in the preliminary scoping meeting stated that toxic compounds would be estimated based on their known proportion to pollutant levels identified during the inventory analysis. Landrum & Brown also sent us a study which estimated and evaluated cancer risks near Midway Airport in Chicago which could be used as a model for estimating impacts at Sea-Tac Airport. Since toxic air contaminants are of significant concern to citizens in the vicinity of the airport, we strongly recommend including this analysis. The monitoring data collected in 1993 should be used to verify the modeling data and additional monitoring should be performed if necessary to accurately characterize impacts of toxic air contaminants.

  It is also important to focus on potentially sensitive locations such as hospitals and schools and locations which local community groups are concerned about. Additional receptors should be added at these locations.

- Residue Testing: Although we understand that Mr. Peters was unable to get much interest in residue testing from citizens living in the vicinity of the airport, we would recommend that Landrum & Brown contact at least one of the citizen groups in the area to ensure that this is not a continued issue. If this issue is not of concern, Landrum & Brown should describe the efforts made towards sampling residue (i.e. citizen groups contacted and their response) and the reason this issue was not included in the analysis.

In addition to our comments on the Sea-Tac Airport Master Plan Update, we would recommend using any relevant data from the air quality study in the Environmental Impact Statement being prepared for the proposed hotel to be located adjacent to the north end of the main terminal at the airport.

We are available to provide further technical guidance to the Port and their consultant, Landrum & Brown, on the air quality analysis at Seattle-Tacoma International Airport. If you have further questions and comments, feel free to contact Maggie Corbin at (206) 689-4057.

Sincerely,

David D. Kircher

David S. Kircher
Manager – Engineering

DSK:ls

cc: Brian O'Sullivan, Gerry Pade, Maggie Corbin PSAPCA
Gene Peters, Landrum & Brown
Representative Greg Fisher

PUGET SOUND AIR POLLUTION CONTROL AGENCY
KING COUNTY ▲ KITSAP COUNTY ▲ PIERCE COUNTY ▲ SNOHOMISH COUNTY

May 6, 1994

Eugene Peters
Landrum & Brown
1021 West Adams Street
Chicago, IL 60607

Dear Mr. Peters:

Airport Emissions in PSAPCA's Jurisdiction

I have enclosed the chapter on airport emissions. I hope it will answer all your questions. Since the State Implementation Plan (SIP) did not require SO2 and PM10 emissions estimates, they are not included. I would advise you to get copies of AP-42, Vol. II and Procedure for Emission Inventory Preparation: Volume IV, Mobile Sources, EPA-450/4-81-021d (Revised), 1992. These documents will fill in any other information that you may find missing in my write-up.

I did obtain a full fleet mix data and flight data from Seattle - Tacoma International Airport (SeaTac), and summarized the data into a presentable form. For your purpose you may need to use the raw data. You can obtain that from the Operations Department of the Port of Seattle and also from the FAA publication Airport Activity Statistics. I recommend obtaining it from the Port of Seattle directly since it also gives monthly breakdown.

There are no engine tests at SeaTac. Planes being tested get logged as flights.

I wish to add that I did not follow protocol because Doug referred you. Normally we charge a token fee for information we give to consultants. If you want me to do anything further that might take more than one hour of my time you will have to pass it through my manager, Dave Kircher (206-689-4050), so that he may decide if we should charge a fee or release data that has not been officially published.

You can contact me at 206-689-4054 or fax 206-343-7522

Sincerely,

Kwame Agyei
Assistant Air Pollution Engineer

KA:ls

110 Union Street, Suite 500, Seattle, Washington 98101-2038 ▲ (206) 343-8800 ▲ (800) 552-3565 ▲ FAX:(206) 343-7522

PUGET SOUND AIR POLLUTION CONTROL AGENCY
KING COUNTY • KITSAP COUNTY • PIERCE COUNTY • SNOHOMISH COUNTY

June 16, 1994

Gene Peters
Landrum and Brown
1021 W. Adams Street
Chicago, Illinois 60607

Dear Mr. Peters:

Comments on "Estimation and Evaluation of Cancer Risks Attributed to Air Pollution in Southwest Chicago" in Regard to Sea-Tac Airport

Thank you for the opportunity to review the study performed in Southwest Chicago. In general, the procedures used in this evaluation of existing air quality will be appropriate for your evaluation of air quality in the vicinity of Sea-Tac Airport. However, I would like to make the following comments and suggestions:

1. As I'm sure you know, many of the assumptions made in the Chicago report will have to be refined significantly for Sea-Tac Airport since Midway is a very different type of airport. For example, in the Appendix A letter from John Summerhays, he states that tests of exhaust composition for a CFM-56 engines were considered most representative of jets used Midway Airport. This would not be appropriate for Sea-Tac Airport since there is a more varied mix of engines used at Sea-Tac. Another example on Page B-4, the data should be available for the fleet make-up of air taxis. There is very little General Aviation at Sea-Tac (Page B-5), probably more turbine then piston, and there is an insignificant amount of military activity.

2. The Chicago study only addressed a limited number of toxic air contaminants, only 30 carcinogens. Please address all toxic air contaminants for which information is reasonably available.

3. I was surprised at the high estimates of formaldehyde, 1,3-butadiene and polynuclear aromatic hydrocarbons that were emitted from Midway Airport. These chemicals have a higher toxicity than benzene and would be of particular concern to our Agency.

4. In Appendix B, Page B-4, the report states that mixing height is mainly important for NOx emissions and that a default mixing height will be used since NOx will not be

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calculated. I assume that NOx will be calculated in your study so a default mixing height would not be appropriate.

5. On Page B-24, it is assumed that the approach phase to be considered for dispersion modeling will include only the distance from the edge of the airport to a respective runway. Please evaluate whether significant emissions would occur if you modeled beyond airport boundaries and include if significant.

6. Finally, I was unclear as to whether you were planning on evaluating all sources of air contaminants within a certain distance from the boundary of the airport (as was done in the Chicago study) or just using the procedures pertaining to emissions from Midway Airport. Please clarify.

Please keep me informed of your progress since our Agency is very interested in keeping up to date with the Sea-Tac project. Feel free to contact me at (206) 689-4057 if you have further questions or comments.

Sincerely,

Margaret L. Corbin
Air Pollution Engineer

jrs

cc: Brian O'Sullivan

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 10
1200 Sixth Avenue
Seattle, Washington 98101

REPLY TO ATTN OF: WD-126

Barbara Hinkle
Port of Seattle
Seattle-Tacoma International Airport
P.O. Box 68727
Seattle, WA 98168

Re: Proposed Air Quality Modeling Protocol for Seattle-Tacoma International Airport

Dear Ms. Hinkle

In response to your November 16, 1994 letter to Jon Schweiss in our Environmental Services Division, we have provided the following comments on the proposed air quality modeling protocol for the Master Plan Update at Seattle-Tacoma International Airport.

Our contact for this air quality analysis has been Mr. Gene Peters of Landrum & Brown. We met with him in October to discuss the modeling protocol and he subsequently sent us a written memorandum for our review which was enclosed with your November 16th letter.

Our comments are as follows:

1) The protocol seems to suggest that both a screening-level and a refined-level analyses will be undertaken. It is not clear why both would need to undertaken. Normally, if problems are identified in a screening assessment, the situation is evaluated further using more refined techniques. EPA recommends that the protocol include a list of criteria which would signify if and when a refined analysis is warranted.

2) EPA disagrees with the approach proposed for defining receptors to be evaluated in a refined analysis. Because the screening procedure proposed is independent of local meteorological conditions, locations of concern identified using this technique may not (probably will not) coincide with areas of maximum concentrations identified using a more refined technique with local meteorology. We recommend that the screening approach be used to indicate whether the potential for air quality problems exists. If it does, this would trigger the need to conduct a refined analysis. Receptors used in the refined analysis should be selected to divulge maximum air quality impacts in ambient air (independent of locations indicated in the screening assessment) to evaluate compliance with applicable NAAQS. The

evaluation of impacts at additional specific "sensitive" receptor locations may also be warranted.

3) The November 8, 1994 memo from Gene Peters of Landrum and Brown indicates that dispersion modeling in the vicinity of selected roadway intersections will be conducted using the CAL3QHC model. We recommend that a description of this component of the work be incorporated into the modeling protocol.

4) Phone discussions with Gene Peters have revealed that the Port is currently evaluating other projects that could have impacts that should be included as part of the analyses related to the 3rd runway project. We recommend that the protocol identify these projects and how they will be integrated into the analyses for the 3rd Runway EIS.

Thank you for the opportunity to review this proposal. If you have any questions about these comments, please contact either John Bregar in our Environmental Review Section at (206) 225-1984, or Bill Ryan in our Environmental Services Division at (206) 553-8561.

Sincerely,

Joan Cabreza, Chief
Environmental Review Section

cc: Gene Peters, Landrum & Brown

STATE OF WASHINGTON
DEPARTMENT OF ECOLOGY
Mail Stop PV-11 • Olympia, Washington 98504-8711 • (206) 459-6000

December 6, 1994

Ms. Barbara Hinkle
Port of Seattle
Seattle-Tacoma International Airport
PO Box 68727
Seattle, WA 98168

Dear Ms. Hinkle:

Thank you for your letter of November 16, 1994. Mr. Williams has asked me to respond to you directly. As you noted in your letter, the EIS consultant, Landrum & Brown, has been in contact with Air Quality Program staff regarding the modeling of impacts from the Master Plan Update for Seattle-Tacoma International Airport. We have already notified Mr. Gene Peters of Landrum & Brown that the final protocol, as described in his memorandum of November 8, 1994, is satisfactory.

Please refer any further questions to either Ms. Cris Figueroa (206) 407-6807 or me at (206) 407-6815.

Sincerely,

Clinton R. Bowman, Jr.
Air Quality Modeler

CB:rr

cc: Joseph R. Williams, Ecology
Cris Figueroa, Ecology

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
ENVIRONMENTAL & TECHNICAL SERVICES DIVISION
911 NE 11th Avenue - Room 620
PORTLAND, OREGON 97232
503/230-5400 FAX 503/230-5435

F/NWO3

JUN 30 1994

Ms. Julia Tims, Wildlife Ecologist
Shapiro and Associates Inc.
1201 Third Avenue - Suite 1700
Seattle, Washington 98101

Re: Species List Request for Sea-Tac International Airport
Master Plan

Dear Ms. Tims:

The National Marine Fisheries Service (NMFS) has reviewed your May 16, 1994, letter to Brian Brown requesting a list of threatened or endangered species to aid in your preparation of an environmental impact statement for the Sea-Tac International Airport Master Plan. It is our understanding that this project will entail the construction of a new runway at the airport.

We have enclosed a list the anadromous fish species that are listed as endangered or threatened under the Endangered Species Act (ESA) and those that are candidates for listing. This list includes only anadromous species (salmon and steelhead) under NMFS jurisdiction that occur in the Pacific Northwest. The U.S. Fish and Wildlife Service should be contacted regarding the presence of species falling under its jurisdiction.

Available information indicates that no listed Snake River salmon are in the project area or immediately downstream from it. The final critical habitat designated for the listed salmon (December 28, 1993, 58 FR 68453) does not include the proposed project area.

However, some of the anadromous fish species that are presently *candidates* for listing under the ESA may be present in, or downstream from, the proposed action area. The candidates for listing that may be present are coho salmon (*Oncorhynchus kisutch*), steelhead (*Oncorhynchus mykiss*), and chum salmon (*Oncorhynchus keta*). Candidates for listing have no status under the ESA. Once a candidate species is proposed for listing, or is listed, a conference or consultation may be required.

Please refer to the ESA section 7 implementing regulations, 50 CFR Part 402, for information on the conference and consultation process.

If you have further questions, please contact Steve Stone, of my staff, at (503) 231-2317.

Sincerely,

Brian J. Brown
Acting Division Chief

Enclosure

ENDANGERED AND/OR THREATENED SPECIES UNDER NATIONAL MARINE FISHERIES SERVICE JURISDICTION THAT OCCUR IN THE PACIFIC NORTHWEST

Listed Species

Sacramento River Winter-Run Chinook Salmon	*Oncorhynchus tshawytscha*
Snake River Sockeye Salmon	*Oncorhynchus nerka*
Snake River Fall Chinook Salmon	*Oncorhynchus tshawytscha*
Snake River Spring/Summer Chinook Salmon	*Oncorhynchus tshawytscha*

CANDIDATES FOR LISTING

Mid-Columbia River Summer Chinook Salmon	*Oncorhynchus tshawytscha*
Coho Salmon	*Oncorhynchus kisutch*
Steelhead	*Oncorhynchus mykiss*
North Umpqua River Cutthroat Trout	*Oncorhynchus clarki clarki*

SPECIES FOR WHICH NMFS HAS RECEIVED LISTING PETITIONS

Baker River sockeye salmon	*Oncorhynchus nerka*
Hood Canal/Discovery Bay/Mud bay/ Eld Inlet chum salmon	*Oncorhynchus keta*
Elwha/Lower Dungeness River pink salmon	*Oncorhynchus gorbuscha*
White/Dungeness/North and South Fork Nooksack River spring chinook salmon	*Oncorhynchus tshawytscha*

United States Department of the Interior

FISH AND WILDLIFE SERVICE
Ecological Services
3704 Griffin Lane SE. Suite 102
Olympia. Washington 98501-2192
(206) 753-9440 FAX: (206) 753-9008

June 17, 1994

Julia Lisa Tims
Wildlife Ecologist
Shapiro & Associates
1201 Third Ave., Suite 1700
Seattle, Washington 98101

FWS Reference: 1-3-94-SP-530

Dear Ms. Tims:

This is in response to your letter dated May 5, 1994, and received in this office on May 6. Enclosed is a list of listed threatened and endangered species, and candidate species (Attachment A), that may be present within the area of the proposed Sea-Tac International Airport Master Plan update and new runway. The list fulfills the requirements of the Fish and Wildlife Service (Service) under Section 7(c) of the Endangered Species Act of 1973, as amended (Act). We have also enclosed a copy of the requirements for the Federal Aviation Administration (FAA) compliance under the Act (Attachment B).

Should the biological assessment determine that a listed species is likely to be affected (adversely or beneficially) by the project, the FAA should request Section 7 consultation through this office. If the biological assessment determines that the proposed action is "not likely to adversely affect" a listed species, the FAA should request Service concurrence with that determination through the informal consultation process. Even if the biological assessment shows a "no effect" situation, we would appreciate receiving a copy for our information.

Candidate species are included simply as advance notice to federal agencies of species which may be proposed and listed in the future. However, protection provided to candidate species now may preclude possible listing in the future. If early evaluation of your project indicates that it is likely to adversely impact a candidate species, the FAA may wish to request technical assistance from this office.

In addition, please be advised that federal and state regulations may require permits in areas where wetlands are identified. You should contact the Seattle District of the U.S. Army Corps of Engineers for federal permit requirements and the Washington State Department of Ecology for state permit requirements.

Your interest in endangered species is appreciated. If you have additional questions regarding your responsibilities under the Act, please contact Jim Michaels or Jodi Bush of this office at the letterhead phone/address.

Sincerely,

Carl V. Menk[?]

For David C. Frederick
State Supervisor

jb/ac
SE/FAA/1-3-94-SP-530/King
Enclosures

c: WDFW, Region 4
WNHP, Olympia

ATTACHMENT A

LISTED AND PROPOSED ENDANGERED AND THREATENED SPECIES AND CANDIDATE SPECIES WHICH MAY OCCUR WITHIN THE VICINITY OF THE PROPOSED SEA-TAC INTERNATIONAL AIRPORT MASTER PLAN UPDATE AND NEW RUNWAY PROJECT IN KING COUNTY, WASHINGTON
(T22N R04E S4-5; T23N R04E S16-17/20-21/28-29/32-33)

FWS REFERENCE: 1-3-94-SP-530

LISTED

Bald eagle *(Haliaeetus leucocephalus)* - wintering bald eagles may occur in the vicinity of the project from about October 31 through March 31.

Peregrine falcon *(Falco peregrinus)* - spring and fall migrant falcons may occur in the vicinity of the project.

Major concerns that should be addressed in your biological assessment of project impacts to bald eagles and peregrine falcons are:

1. Level of use of the project area by bald eagles and peregrine falcons.
2. Effect of the project on eagles' and falcons' primary food stocks and foraging areas in all areas influenced by the project.
3. Impacts from project construction and implementation (e.g., increased noise levels, increased human activity and/or access, loss or degradation of habitat) which may result in disturbance to eagles and falcons and/or their avoidance of the project area.

PROPOSED

None

CANDIDATE

The following candidate species may occur in the vicinity of the project:

Black tern *(Chlidonias niger)*
Bull trout *(Salvelinus confluentus)*
Mountain quail *(Oreortyx pictus)*
Northern red-legged frog *(Rana aurora)*
Northwestern pond turtle *(Clemmys marmorata)*
Spotted frog *(Rana pretiosa)*

ATTACHMENT B

FEDERAL AGENCIES' RESPONSIBILITIES UNDER SECTIONS 7(a) AND 7(c) OF THE ENDANGERED SPECIES ACT OF 1973, AS AMENDED

SECTION 7(a) - Consultation/Conference

Requires:

1. Federal agencies to utilize their authorities to carry out programs to conserve endangered and threatened species:

2. Consultation with FWS when a federal action may affect a listed endangered or threatened species to ensure that any action authorized, funded, or carried out by a federal agency is not likely to jeopardize the continued existence of listed species or result in the destruction or adverse modification of critical habitat. The process is initiated by the federal agency after it has determined if its action may affect (adversely or beneficially) a listed species; and

3. Conference with FWS when a federal action is likely to jeopardize the continued existence of a proposed species or result in destruction or an adverse modification of proposed critical habitat.

SECTION 7(c) - Biological Assessment for Construction Projects *

Requires federal agencies or their designees to prepare a Biological Assessment (BA) for construction projects only. The purpose of the BA is to identify any proposed and/or listed species which is/are likely to be affected by a construction project. The process is initiated by a federal agency in requesting a list of proposed and listed threatened and endangered species (list attached). The BA should be completed within 180 days after its initiation (or within such a time period as is mutually agreeable). If the BA is not initiated within 90 days of receipt of the species list, please verify the accuracy of the list with our Service. No irreversible commitment of resources is to be made during the BA process which would result in violation of the requirements under Section 7(a) of the Act. Planning, design, and administrative actions may be taken; however, no construction may begin.

To complete the BA, your agency or its designee should: (1) conduct an on-site inspection of the area to be affected by the proposal, which may include a detailed survey of the area to determine if the species is present and whether suitable habitat exists for either expanding the existing population or potential reintroduction of the species; (2) review literature and scientific data to determine species distribution, habitat needs, and other biological requirements; (3) interview experts including those within the FWS, National Marine Fisheries Service, state conservation department, universities, and others who may have data not yet published in scientific literature; (4) review and analyze the effects of the proposal on the species in terms of individuals and populations, including consideration of cumulative effects of the proposal on the species and its habitat; (5) analyze alternative actions that may provide conservation measures; and (6) prepare a report documenting the results, including a discussion of study methods used, any problems encountered, and other relevant information. Upon completion, the report should be forwarded to our Endangered Species Division, 3704 Griffin Lane SE, Suite 102, Olympia, WA 98501-2192.

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* "Construction project" means any major federal action which significantly affects the quality of the human environment (requiring an EIS), designed primarily to result in the building or erection of human-made structures such as dams, buildings, roads, pipelines, channels, and the like. This includes federal action such as permits, grants, licenses, or other forms of federal authorization or approval which may result in construction.

June 8, 1994

Julia Lisa Tims
Shapiro & Associates
1201 Third Ave - Suite 1700
Seattle WA 98101

SUBJECT: Sea-Tac International Airport Master Plan Update and New Runway (T22N R04E S04 &05 and T23N R04E S16,17,20,21,28,29,32, &33)

We've searched the Natural Heritage Information System for information on significant natural features in your study area. Currently, we have no records for rare plants, high quality native wetlands or high quality native plant communities in the vicinity of your project.

The Washington Natural Heritage Program is responsible for information on the state's endangered, threatened, and sensitive plants as well as high quality native plant communities and wetlands. The Department of Fish and Wildlife manages and interprets data on wildlife species of concern in the state. For information on animals of concern in the state, please contact the Priority Habitats and Species Program, Washington Department of Fish and Wildlife, 600 Capitol Way North, Olympia, WA 98501-1091, or by phone (206) 753-3318.

The Natural Heritage Information System is not a complete inventory of Washington's natural features. Many areas of the state have never been thoroughly surveyed. There may be significant natural features in your study area that we don't yet know about. This response should not be regarded as a final statement on the natural features of the areas being considered and doesn't eliminate the need or responsibility for detailed on-site surveys.

I hope you'll find this information helpful.

Sincerely,

Sandy Norwood

Sandy Norwood, Environmental Review Coordinator
Washington Natural Heritage Program
Division of Forest Resources
PO Box 47047
Olympia WA 98504-7047
(206) 902-1667

Mayor
Joe Brennan
Deputy Mayor
Terry Anderson
Councilmembers
Roger Anderson
Shirley Thompson
Frank Hansen
Kathy Gehring
Don DeHan

CITY OF SEATAC

City of SeaTac
17900 International Blvd., Suite 401 · SeaTac, Washington 98188-4236
City Hall: (206)241-9100 · Fax: (206)241-3999 · TDD: (206)241-0091

City Manager
D. Scott Rohlfs
Assistant City Manager
Thomas J. Fus
City Attorney
Daniel B. Heid

December 12, 1994

Shapiro & Associates
ATTN: P. Rowen
1201 Third Avenue - Suite 1700
Seattle, WA 98101

Re: Vacca Farm Property

Dear Mr. Rowen,

The City of SeaTac rezoned the Vacca farm property to RM-900 in 1991 and changed the comprehensive plan in 1992 to reflect that change. The farm use has continued, but it is not zoned for farm use or agricultural. The farm use is considered a legal non-conforming use. If you wish further information on the rezone action/conditions, you may review the file (REZ0001-91) at the City of SeaTac City Hall during regular business hours.

In regard to other farmland, the City has an Urban Reserve Zone, which would permit Agricultural Crop Sales (Farm Only) on the eastern hillside of the City. At this time, the City does not have an "active" farm, other than the continued activity at the Vacca farm site. Also, the City has not purchased the Vacca farm or any of the surrounding area and does not have any plans to do so in the future.

If you need further assistance, please call me at (206) 241-1893.

Sincerely,

Michael Booth
Senior Planner

G:\group\planning\letters\Vcca.ltr

STATE OF WASHINGTON

DEPARTMENT OF COMMUNITY, TRADE AND ECONOMIC DEVELOPMENT

OFFICE OF ARCHAEOLOGY AND HISTORIC PRESERVATION

111 21st Avenue S.W. • P.O. Box 48343 • Olympia, Washington 98504-8343 • (206) 753-4011 • SCAN 234-4011

June 9, 1994

Mr. Peter J. Rowen
Transportation Planner
Shapiro and Associates
Incorporated
1201 Third Avenue Suite 1700
Seattle, WA 98101

Dear Mr. Rowen:

This is to confirm your visit to the Office of Archaeology and Historic Preservation on June 1, 1994. As part of the environmental check-list, the following townships involved in the Sea-Tac Airport Master Plan Update project were checked for cultural resources:

T23N R4E
T24N R4E
T22N R4E
T21N R4E

The inventories of historic resources, archaeological sites and State and National Register sites were reviewed for this study area.

We appreciate your consideration of the cultural resources during this project.

Sincerely,

Sara Steel
Sara Steel
Inventory Records Specialist

SS:lsw

King County
Cultural Resources Division
Parks. Planning and
Resources Department
Arts Commission
Landmarks Commission
Smith Tower Building
506 Second Avenue. Room 1115
Seattle, Washington 98104
(206) 296-7580 V/TDD 296-7580

June 3, 1994

Mr. Peter Rowen
Shapiro and Associates
1201 Third Avenue Suite 1700
Seattle, Washington 98101

Dear Mr. Rowen:

In response to your recent inquiry about historic resources in the vicinity of Sea-Tac Airport, I have searched our files for properties listed in the King County Historic Resource Inventory (HRI) and on the State Archaeological Site Inventory. The material left for pickup yesterday summarized the information available in our files.

Please note that both the HRI and the State Archaeological Site Inventory are incomplete and that listed properties may have lost their integrity since being surveyed. Heretofore unidentified cultural resources may also exist above or below ground in the drainage. Should you uncover information on unlisted historic or archaeological properties which lie in the planning area but are outside city boundaries, please inform this office.

If you need further information or have questions about the material already provided, please call me at 296-8673.

Sincerely,

Kent Sundberg
Preservation Planner

Enclosure

cc: Julie Koler, Historic Preservation Officer

STATE OF WASHINGTON
DEPARTMENT OF COMMUNITY, TRADE AND ECONOMIC DEVELOPMENT
OFFICE OF ARCHAEOLOGY AND HISTORIC PRESERVATION
111 21st Avenue S.W. • P.O. Box 48343 • Olympia, Washington 98504-8343 • (206) 753-4011 • SCAN 234-4011

March 8, 1995

Ms. Dawn Neeley
Shapiro & Associates
1201 Third Avenue, Suite 1700
Seattle, Washington 98101

Log: 012595-16-FAA
Re: SeaTac Airport Master Plan Update EIS

Dear Ms. Neeley:

Thank you for contacting the Washington State Office of Archaeology and Historic Preservation (OAHP) regarding the above referenced action. From your letter, I understand that an Environmental Impact Statement (EIS) is being prepared in anticipation of expansion at SeaTac International Airport.

In response, I have reviewed the material submitted identifying historic properties within the area of project effect. This material addresses sixty seven buildings (predominantly residences) west of the existing airport property. Based upon the information submitted, it is my opinion that none of the properties are eligible for listing in the National Register of Historic Places. Although a few of the properties are intact examples of early to mid twentieth century residential architecture, none appear to be significant examples of a style, design, or craftsmanship nor exhibit significant historical associations which meet criteria for listing in the National Register.

Thank you for the opportunity to review this material. Should you have any questions, or if additional information comes to light which would cause us to reassess our opinion, please feel free to contact me at (360) 753-9116.

Sincerely,

Greg Griffith

Gregory A. Griffith
Comprehensive Planning Specialist

GAG:tjt

King County
Surface Water Management Division
Department of Public Works
700 Fifth Avenue Suite 2200
Seattle, WA 98104
(206) 296-6519
(206) 296-0192 FAX

October 25, 1994

Edward McCarthy
Shapiro & Associates
1201 Third Avenue
Suite 1700
Seattle, WA 98101

RE: Miller and Des Moines Creek Hydrologic Models, Reports and Data

Dear Mr. McCarthy:

We have provided Senior Water Resources Engineer Kerry Ritland, P.E., of Montgomery Water Group, Inc., the following hydrologic models, reports and data for the Miller and Des Moines Creek basins. This was requested in the letter dated September 19, 1994 from Barbara Hinkle, Senior Environmental Management Specialist, Seattle-Tacoma International Airport (SeaTac), and acknowledged in the letter dated September 19, 1994 from Jim Kramer, Manager, King County Surface Water Management (SWM) Division.

On 120-Megabyte Mini-Data Cartridge

Miller Creek Basin:

1. Ambaum Regional Pond Soil Conservation Service TR-20 hydrologic model
2. HSPF model completed in 1991 for Miller Creek Basin (WDM file)
3. All Miller Creek stream and rainfall gage information collected by the SWM Division
4. HSPF UCI files for current, future and calibrated runs for Miller Creek

Des Moines Creek Basin:

1. All Des Moines Creek stream and rainfall gage information collected by the SWM Division
2. SeaTac Business Park Master Drainage Plan Soil Conservation Service TR-20 hydrologic models and alternatives
3. Des Moines Creek Soil Conservation Service TR-20 hydrologic model and alternatives for Tyee Regional Pond

Studies, Reports, Maps and Construction Plans

Miller Creek Basin:

1. "Brief Design Report of Ambaum Regional Water Quality Detention Pond," Project Management and Design (PM&D) Unit, SWM Division (9/26/89)
2. As-built construction plans for Ambaum Regional Pond, PM&D (11/5/91)

3. "Miller Creek Regional Stormwater Detention Facilities Design Hydrologic Modeling," Northwest Hydraulic Consultants, Inc. (11/13/90 and 4/2/91 supplement)
4. As-built construction plans for Lake Reba Regional Pond, PM&D (4/1/92)
5. "Flood Control Management Plan, City of Normandy Park," R.W. Beck and Associates, preliminary draft report (6/92)

Des Moines Creek Basin:

1. Des Moines Creek - Schematic Diagrams for Soil Conservation Service TR-20 hydrologic model, PM&D (10/16/86)
2. As-built construction plans for Des Moines Creek Regional (Tyee Golf Course) Pond, PM&D (4/4/88)
3. "SeaTac Business Park Master Drainage Plan," R.W. Beck and Associates (2/90)

Miscellaneous

1. "List of Gage Locations and Station Numbers, Miller and Des Moines Creeks" (10/20/94)
2. Description of gage data file and formats, e-mail Funke to Parsons (10/14/94)
3. Windows screen prints of data and modeling file directories and sub-directories

Enclosed is your receipt for the $208.00 reproduction and computer media fee.

Please contact me at 296-8016 if you have any questions regarding these materials or if you would like to arrange a time to meet to discuss them. We look forward to working with you and Mr. Ritland as you develop the HSPF models for Des Moines and Miller Creeks and evaluate the impacts and mitigations for the alternative runway scenarios.

Sincerely,

Randall Parsons, P.E.
Basin Plan/CIP Unit Manager

RP:dsc14

Enclosures

cc: Barbara Hinkle, Senior Environmental Management Specialist, SeaTac International Airport
Kerry Ritland, P.E., Senior Water Resources Engineer, Montgomery Water Group, Inc.
Jim Kramer, Manager, King County Surface Water Management Division

STATE OF WASHINGTON
DEPARTMENT OF FISH AND WILDLIFE
16018 Mill Creek Boulevard • Mill Creek, Washington 98012 • (206) 775-1311 FAX (206) 338-1066

March 27, 1995

Mr. Ed McCarthy
Shapiro and Associates, Inc.
1201 Third Avenue, Suite 1700
Seattle, Washington 98101

RE: **COMMENTS ON THE CONCEPTUAL STREAM MITIGATION OPPORTUNITIES AND CONSTRAINTS REPORT FOR THE SEATTLE- TACOMA INTERNATIONAL AIRPORT MASTER PLAN UPDATE**

Dear Mr. McCarthy:

The following are my comments for this proposal:

1. The mitigation plan should incorporate restoration of fish passage through the culverts on Miller Creek. This could be in the form design work, construction, or bringing together the various agencies, governments to facilitate passage restoration. Perhaps some of the impacts to Miller Creek from SR 518 from a water quality standpoint can be corrected. This would be in line with your holistic approach to your mitigation plan.

2. The proposed realignment of Miller Creek looks good and it seems like it's an opportunity to improve fish habitat in this area. We recommend woody debris for cover and bank stabilization where needed.

3. The streams that are tributary to Miller Creek and are impacted by the runway fill should be mitigated. Opportunities to create spawning areas in these streams should be pursued and appropriate riparian trees or shrubs should be planted along these streams.

4. I would like to see an excellent plan be developed to curtail erosion from both the borrow and fill area. Someone should specifically be hired to monitor and be able to initiate erosion control measures.

I would like to thank you for the opportunity to provide some early comments on this plan. If you have any questions, please call me at (206) 775-1311, ext. 107.

Sincerely,
Philip Schneider
Habitat Biologist

March 24, 1995

Ed McCarthy
Shapiro & Associates, Inc.
1201 Third Ave., Suite 1700
Seattle, WA 98101

Subject: Comments on Preliminary Draft of Environmental Impact Statement (EIS) for Miller Creek "Stream Mitigation Plan".

Reference: Meeting on March 22, 1995 on subject "Stream Mitigation Plan".

Dear Ed,
My comments, resulting from the reference meeting, and assessment of discussions in the meeting, are of a general nature.

As a matter of background, the streams in the vicinity of the Sea-Tac Airport were all, at one time, producers of wild anadromous fish, Miller Creek included. This was true at the time the airport was first built in the mid 1940's. Due to all the development in the area, including expansion of Sea-Tac Airport, the stream has experienced continuous deterioration by pollution and siltation, and has for some time been void of much aquatic life.

The draft EIS discounts the concerned area of Miller Creek as being viable for anadromous fish species due to down stream barriers. This is currently true, and these barriers have all been created by mankind through "development". The proposal as presented would only move the stream bed from one location to another and provide streamside vegetation. Other actions of acquisition in the watershed would help improve water quality over the current situation.

At the present time, there is considerable effort beign expended by concerned citizens, organizations, municipalities, and government agencies to restore streams in the area, Miller Creek being the first as a pilot program. The restoration is planned from stream mouth to source in an effort to provide clean water and to re-instate anadromous fish runs. The barriers referred to in the draft EIS will be removed to permit fish migration.

In the reference meeting, I recommended that the concerned area of Miller Creek be provided with the capability for spawning of anadromous fish. The discussion pointed out that gradient may not be satisfactory for this purpose. Upon further consideration of this matter, it appears the property involved would all be within the control of the Sea-Tac Airport. Establishing the adequate gradient for spawning purposes would be a relatively simple matter, as compared to the extensive movement ofearth fill involved with the cause for the mitigation procedure.

The DesMoines Salmon Chapter of Trout Unlimited feels this to be a minimum of mitigation to be expected to meet our goals.

Sincerely,

Jack A. Danner

Jack A. Danner
Trout Unlimited
16045 25th Ave. S.W.
Burien, WA 98166

King County
Surface Water Management Division
Department of Public Works
700 Fifth Avenue Suite 2200
Seattle, WA 98104
(206) 296-6519
(206) 296-0192 FAX

March 27, 1995

Ed McCarthy, Senior Hydrologist
Shapiro and Associates
1201 Third Avenue
Seattle, WA 98101

RE: Miller Creek and SeaTac Third Runway Fill Project

Dear Dr. McCarthy:

Thank you for the interesting and informative presentation on March 22, 1995 regarding preliminary proposals for mitigating impacts to Miller Creek that could result from filling associated with the third runway proposal at SeaTac Airport. I commend you for getting affected agencies and citizen groups together to discuss this proposal while it is still in the formative stages. I found the discussion to be very useful as a forum for sharing ideas on how to make use of this opportunity to improve the overall function of the Miller Creek stream system.

The biggest concern I have over the proposed fill project, as I mentioned at our meeting, is construction impacts. The proposed fill and associated stream relocation efforts will result in large areas of exposed soil, and very large quantities of fill material being transported and placed, in close proximity to Miller Creek. The opportunity for erosion and resulting sedimentation impacts to Miller Creek during the critical construction window is quite substantial and could easily overwhelm the benefits of even the best mitigation plan in a single, ill-timed, rainfall event. Be that as it may, I understand your responsibility is for the design of mitigation for the stream relocations, and not the construction impacts, so the rest of my remarks will be confined to that subject.

Area 1 Comments:

As I understand the Area 1 proposal, it would involve creation of approximately 1,480 feet of new channel, and the filling of 980 feet of Miller Creek and 440 feet of an unclassified tributary. The proposed mitigation discussed at our meeting involved creating a new meandering channel with in-stream habitat structures and a substantial replanting of the flood plain and riparian area.

If implemented as we discussed, this mitigation would result in substantial improvements to this reach of Miller Creek with resulting benefits to the downstream portions of the basin.

Area 1 is known as a significant source of water quality and sedimentation problems and has a very degraded riparian zone which contributes to elevated water temperatures. The proposed mitigation effort has the potential to reduce or eliminate all of these problems. A successful Area 1 mitigation effort, as proposed, would be a substantial improvement to water quality, habitat and aesthetics in this portion of the Miller Creek drainage.

Area 2 Comments:

My understanding of the Area 2 proposal is that two tributaries would have a total of 2,080 feet impacted through filling, and approximately 1,200 feet of stream and 900 feet of grass-lined swale would be created as mitigation.

The creation of 900 feet of grass-lined swales instead of standard roadside ditches is a good idea and one which I support for its obvious water quality benefits. Swales do not, however, fully replace the functions of existing stream channels that will be lost in this area. I would encourage you to examine opportunities to lengthen the proposed channel relocations to more fully replace the values being lost.

Ongoing restoration and rehabilitation efforts in Miller Creek have, as one goal, expansion of the area utilized by salmonids. Streams coming off of the vegetated fill slope on this portion of the airport could, with minor attention to vegetation management practices on the airport property, have some of the best water quality in the stream basin. I encourage you to examine ways to lengthen the small streams in this area rather than shortening them. You might also consider ways to collect additional high-quality water from the western fill slope in order to supplement flows in these small tributaries.

These small tributaries also present an opportunity to establish potentially stable, high value habitat such as salmonid spawning area, which is currently in short supply in the system. While spawning habitat would not be of use immediately due to downstream blockages, it is important that the design of proposed mitigation efforts not foreclose future opportunities to accomplish this type of restoration. These small streams are some of the only areas in the Miller Creek system with control over upstream land-use, sufficient gradient, and soils appropriate for establishing spawning area.

Area 3 Comments:

I understand the proposal in this area is to create 200 feet of grass lined swale to mitigate for the fill of 200 feet of small stream channel. While grass-lined swale is not a full replacement for stream channel, it does not appear feasible to add additional stream channel or gain additional fisheries habitat in this area. Any imbalance between values lost and values replaced in Area 3 would likely be most effectively made up in the stream relocations occurring in Area 2.

Thank you for this opportunity to comment on your preliminary mitigation proposals. I enjoyed the presentation and the free flow of ideas that occurred in the subsequent discussion. I look forward to additional discussions with you on these and related topics.

Sincerely,

David Masters

David Masters
Project Manager

DM:gmc37

cc: Ken Guy, Assistant Manager, Surface Water Management Division
Keith Hinman, Manager, Basin Planning Program

COMMENTS
SEATTLE-TACOMA AIRPORT MASTER PLAN UPDATE
CONCEPTUAL STREAM MITIGATION PLAN
30 MAR 1995

1. Probably good idea to have Natural Resource Conservation Service confirm that Vacca Farms are in fact prior converted cropland and not farmed wetland. Additional mitigation for wetlands displaced by relocated stream would be required if they are wetlands.

2. Your overall approach appears appropriate. The focus is and should be on replacing lost functions and values. The approximately 1:1 stream length replacement ratio with the reduced sedimentation, septic and water withdrawal improvements appear appropriate. My opinions have not been reviewed by my colleagues, so this statement is not an agency position.

3. The overall design appears satisfactory. It seems that you are ready to begin the more detailed design of the habitat conducive for fish, and aquatic and stream bank plants, insects and other organisms.

4. Need to keep checking that stormwater attenuation, retention, pre-treatment designs will work as planned under actual operating conditions given potential contaminants, sediment loads, infiltration rates, etc.

Jonathan Smith

Jonathan Smith
Project Manager
Regulatory Branch
U.S. Army Corps of Engineers
Seattle District

OPTIONAL FORM 99 (7-90)

FAX TRANSMITTAL	# of pages ▶ 1
To Aaron Simmons	From Jonathan Smith
Dept./Agency Shapiro	Phone # 764-6910
Fax # 624-1901	Fax # 764-6602
NSN 7540-01-317-7368 5099-101	GENERAL SERVICES ADMINISTRATION

SEP 21 '94 09:01AM POS AV/ENG

Post-it™ brand fax transmittal memo 7671	# of pages ▸ 2
To Ed McCarthy	From Barbara Hinkle
Co.	Co.
Dept.	Phone # 439-6606
Fax # (206) 624-1801	Fax #

King County
Surface Water Management Division
Department of Public Works
700 Fifth Avenue Suite 2200
Seattle, WA 98104
(206) 296-6519
(206) 296-0192 FAX

September 19, 1994

Barbara Hinkle
Senior Environmental Management Specialist
Seattle-Tacoma International Airport
Post Office Box 68727
Seattle, WA 98168

RE: Information Request

Dear Ms. Hinkle:

Thank you for your August 24, 1994 letter alerting me to your desire to obtain information on past studies and hydrologic data for the Miller and Des Moines Creek basins. I have directed the Surface Water Management (SWM) Division staff to make copies of any published reports or studies available to you and your staff for our customary copying charges.

Your request for a copy of the "HSP-F model previously prepared for Miller Creek, regional stormwater facility studies and operation criteria that would be needed to model the facilities in the basins" is somewhat difficult for us to respond to. Worded in this way, it asks the SWM Division to decide what information is relevant to modeling the facilities, with little knowledge of what degree of accuracy your modeling effort will undertake to achieve or what level of technical expertise your modeling crew will have. I hope you understand that with no technical analysis role in the process, the SWM Division cannot be expected to decide what information you must have in order to produce meaningful results.

Our experience with HSP-F modeling is that the accuracy of the results can be greatly affected by the quality of the data used in calibration, and by the skill of the modelers in setting up and running the simulation. Our previous efforts in modeling portions of Miller Creek were sufficient for design of the existing facilities, but we recognize some shortcomings in the accuracy of the current calibration. We will be happy to make available the existing model and additional stream gauging data that we have collected in this area since the model was last run. I am also directing our staff to spend up to five hours preparing write-ups of operational criteria and other information that we believe may be relevant to your effort, as well as discussing this information with your staff. Under the present circumstances, the responsibility for determining whether you have sufficient information to produce meaningful results will have to remain with your staff.

I believe your modeling effort could potentially benefit from the assistance of members of our engineering and modeling staff, and I would be happy to discuss arrangements whereby you could utilize our staff to assist in your efforts. The SWM Division staff is available to discuss the hourly rate for supporting your efforts and would be happy to work with you to prepare the appropriate cooperative working agreements.

Thank you again for your letter. Should you be interested in pursuing this matter, please call Susan Thomas, Intergovernmental Relations Coordinator, at 296-8304.

Sincerely,

Jim Kramer
Manager

JK:tvPJ1

Port of Seattle

August 24, 1994

Mr. Jim Kramer
King County Surface Water Management Division
700 Fifth Avenue, Suite 2200
Seattle, WA 98104

Dear Mr. Kramer:

To adequately address scoping comments received from KCSWM and others for the Sea-Tac Airport Master Plan Update EIS, the Port of Seattle submits this request for information from your division. We have recently talked to Randall Parsons who is looking into the availability of hydrologic data and past studies for both Miller Creek and Des Moines Creek. Data which Randall suggested is available and which we would find useful in the analysis of surface water include gage data for Des Moines Creek and Miller Creek, diskette copy of the HSP-F model previously prepared for Miller Creek, regional stormwater facility studies and operation criteria that would be needed to model the facilities in the basins, and a copy of the Sea-Tac Master Drainage Plan.

We hope to work in cooperation with you over the next several weeks in evaluating the concerns that have been identified through the scoping process. Ed McCarthy, from Shapiro and Associates, will be in contact with Randall to coordinate transfer of the above items.

Sincerely,

Barbara Hinkle
Senior Environmental Management Specialist

Seattle-Tacoma International Airport
P.O. Box 68727
Seattle, WA 98168 U.S.A.
TELEX 703433
FAX (206) 431-5912

SHAPIRO

November 22, 1995

Mr. Jeff Haas
U.S. Fish and Wildlife Service
3704 Griffin Lane S.E., Suite 102
Olympia, WA 98501-2192

Dear Mr. Haas:

As per our telephone conversation on November 14, 1995, please find enclosed the addendum to the Biological Assessment for Bald Eagles and Peregrine Falcons prepared for the Sea-Tac Airport Master Plan Update Draft EIS. The Draft EIS was issued in April 1995. The addendum provides additional information on a new bald eagle nest located in the vicinity of the Airport that was discovered after the completion of the draft Biological Assessment.

The purpose of this letter is to request inclusion of the addendum in the consultation process between the Port of Seattle and your office in coordination with Section 7(c) of the Endangered Species Act of 1973, as amended. Based on information provided in both the Biological Assessment and the addendum, the Port of Seattle, in cooperation with the Federal Aviation Administration, has determined that the proposed action is "not likely to adversely affect" bald eagles and peregrine falcons, and we request your concurrence with this determination.

Due to project time constraints, we would appreciate notification of concurrence with our determination by December 15, 1995. The Final EIS for the Master Plan Update is scheduled for completion and distribution in January 1996.

Thank you for your time and consideration. If you have any questions regarding this matter, please do not hesitate to contact me at (206) 624-9190.

Sincerely,

SHAPIRO AND ASSOCIATES, INC.

Jim Keany for JT

Julia Lisa Tims
Wildlife Ecologist

c: Barbara Hinkle, Port of Seattle
Dennis Ossenkop, FAA
Mary Vigilante, Synergy Consultants, Inc.

enclosure

201 Third Ave.
Suite 1700
Seattle
WA 98101
Telephone:
206.624.9190
Facsimile:
206.624.1901

United States Department of the Interior

FISH AND WILDLIFE SERVICE
North Pacific Coast Ecoregion
Western Washington Office
3704 Griffin Lane SE, Suite 102
Olympia, Washington 98501-2192
(360) 753-9440 FAX: (360) 753-9008

December 6, 1995

Julia Lisa Tims,
Wildlife Ecologist
Shapiro and Associates, Inc.
1201 Third Avenue, Suite 1700
Seattle, Washington 98101

FWS Reference: 1-3-96-I-29

Dear Ms. Tims:

This letter is in response to letters dated October 19, 1995, and November 22, 1995, transmitting the Biological Assessment in regard to the proposed construction of a new parallel runway and associated facilities at the Seattle-Tacoma International Airport as part of its Master Plan Update. The proposed new parallel runway site is located within the City of SeaTac, in King County, Washington.

Sufficient information was provided to determine the effects of this project and to conclude whether this project is likely to adversely affect the peregrine falcon and bald eagle. However, regulations implementing 50 CFR§ 402.13 of the Endangered Species Act of 1973, as amended (Act), stipulate that the U.S. Fish and Wildlife Service (Service) concurrence may be provided only to the involved federal agency which, in this case, is the Federal Aviation Administration (FAA).

To expedite the environmental review process, you may consider this project to be in compliance with the requirement of Section 7(a)(2) of the Act if the FAA agrees with your finding of "not likely to adversely affect" the peregrine falcon and bald eagle. To conclude the consultation process, we request a copy of the FAA Determination of Effect for our records. Please use the Service's reference number (1-3-96-I-29) when transmitting the correspondence requested.

This project should be reanalyzed if new information reveals that the action may affect listed species or critical habitat in a manner or to an extent not considered in this consultation; if the action is subsequently modified in a manner that causes an effect to the listed species or critical habitat that was not considered in this consultation; and/or if a new species is listed or critical habitat is designated that may be affected by this project.

Your interest in endangered species is appreciated. If you have further questions about this letter or your responsibilities under the Act, please contact Jeff Haas at (360) 753-6045 or Jim Michaels of my staff at the letterhead phone/address.

Sincerely,

David C. Frederick
Supervisor

jh/jkp
SE/FAA/1-3-96-I-29

c: WDFW (Region 4) Thompson

December 14, 1995

Mr. David Frederick
U.S. Fish and Wildlife Service
North Pacific Coast Ecoregion
Western Washington Office
3704 Griffin Lane S.E., Suite 102
Olympia, WA 98501-2192

(Reference Number 1-3-96-I-29)

Dear Mr. Frederick:

This is in response to your letter of December 6, 1995, to Shapiro and Associates, requesting a copy of our Determination of Effect regarding the recently identified bald eagle nest near Angle Lake.

Enclosed is a copy of the Addendum to the Biological Assessment for Bald Eagles and Peregrine Falcons prepared for the Sea-Tac Airport Master Plan Update. The FAA, in cooperation with the Port of Seattle, has determined that the proposed action is "not likely to adversely affect" the recently identified bald eagle nest near Angle Lake.

Thank you for your expeditious review and concurrence with this determination.

Sincerely,

ORIGINAL SIGNED BY DENNIS OSSENKOP

Dennis Ossenkop
Environmental Protection Specialist

cc: Barbara Hinkle, Port of Seattle
Mary Vigilante, Synergy Consultants, Inc.
Julia Tims, Shapiro and Associates, Inc.

ANM611:DGOssenkop:x2611:bls:12/15/95:USFWS2.DOC
FILE: SEATAC

STATE OF WASHINGTON
DEPARTMENT OF COMMUNITY, TRADE AND ECONOMIC DEVELOPMENT
OFFICE OF ARCHAEOLOGY AND HISTORIC PRESERVATION
111 21st Avenue S.W. • P.O. Box 48343 • Olympia, Washington 98504-8343 • (360) 753-4011

November 22, 1995

Ms. Dawn Neeley, Senior Planner
Shapiro & Associates, Inc.
1201 Third Avenue
Suite 1700
Seattle, Washington 98101

Log: 012595-16-FAA
Re: Sea-Tac Airport Master Plan Update Final Environmental Impact Statement

Dear Ms. Neeley:

Thank you for your letter and supporting material regarding the above referenced project. I understand that this information is being compiled in conjunction with preparation of the update of the Final Environmental Impact Statement addressing expansion plans for Sea-Tac International Airport.

In response to your letter, it is my opinion that the Bryan House (1029 South 146th Street) and the Brunelle House (1243 South 104th Street) both in Burien, are not eligible for listing in the National Register of Historic Places. This opinion is based on substantial alteration of historic building fabric (and apparent removal in the instance of the Brunelle House) at these properties.

In arriving at opinions of eligibility for these properties, Office of Archaeology and Historic Preservation (OAHP) staff use the criteria for listing properties in the National Register of Historic Places. The National Register criteria acknowledges properties with "local significance" which, indeed, is the level at which most National Register listed properties are evaluated. It is likely that properties in the Sea-Tac Airport vicinity would be evaluated at the level of "local significance" rather than at "state" or "national" levels of significance. Another tool used for assessing National Register eligibility is the minimum 50 year age threshold for listing properties. Properties which are less than 50 years in age must demonstrate "exceptional significance" in order to be listed. The 50 year age threshold is also often applied during the survey and inventory process of identifying historic properties. However, the 50 year rule is less stringently applied during a survey and inventory process and indeed, OAHP recommends that surveyors identify properties less than 50 years in age during an inventory project. Application of a lesser age threshold facilitates long range historic preservation planning.

I have also taken the opportunity to review the sixty properties you submitted from the Burien and Des Moines historic property survey process. Several of these properties appear to be of historical and/or architectural interest. However, in order to arrive at an informed decision about National Register eligibility of these properties, additional photographs and substantial additional information is needed. Please see the enclosed list of eleven properties which appear to merit further evaluation.

Again, thank you for the opportunity to review and comment on these properties. Should you have any questions, please feel free to contact me at (360) 753-9116.

Sincerely,

Greg Griffith

Gregory Griffith
Comprehensive Planning Specialist

Enclosure

GAG:tjt

Ms. Dawn Neeley
November 22, 1995
ENCLOSURE

FEIS Number	Name	Location
N-2	Pacific Telephone Bldg.	14605 8th Avenue South, Burien
N-3	Pollock House	654 152nd Street South, Burien
N-6	Sunnydale School	15631 8th Avenue South, Burien
N-7	YMCA	17874 Des Moines Way South, Burien
N-8	Dodd Homestead	606 140th Street, Burien
N-10	1944 Subdivision	128th to 132nd Street, Burien
N-18	Wesley Homes-The Terra	816 216th Street South, Des Moines
N-46	Pacific Telephone Bldg.	22600 28th Avenue South, Des Moines
N-51	Walsworth House	1104 223rd Street South, Des Moines
N-56	Nunner House	1917 240th Avenue South, Des Moines
N-59	Gould House	1242 Kent-Des Moines Road, Des Moines

Puget Sound Regional Council

PSRC

RESOLUTION NO. EB-94-01

A RESOLUTION of the Executive Board of the Puget Sound Regional Council, Seattle, Washington,

WHEREAS, regional studies completed by the Puget Sound Air Transportation Committee, the Washington State Air Transportation Committee, and the Puget Sound Regional Council (PSRC) have clearly identified a near-term air transportation capacity problem at Sea-Tac International Airport, and concluded that the addition of a third all-weather runway at Sea-Tac would provide adequate capacity for the region through the year 2030; and

WHEREAS, the PSRC General Assembly adopted Resolution A-93-03 approving the addition of a third Sea-Tac runway subject to certain conditions, including studying the feasibility of siting a major supplemental airport in the four-county region, and delegating implementation of the resolution to the PSRC Executive Board; and

WHEREAS, the PSRC Executive Board established Implementation Steps and has responsibility for the Regional Council's work program, budget and contracts; and

WHEREAS, the Executive Board concludes that there are no feasible sites for a major supplemental airport within the four-county region and that continued examination of any local sites will prolong community anxiety while eroding the credibility of regional governance; and

WHEREAS, the need for a major supplemental airport continues to be questioned, especially in light of emerging long-term transportation initiatives, including high speed rail and demand/system management programs which may reduce long-range air travel demand; and

WHEREAS, State law fails to address the issue of incentives and compensation beyond normal mitigation for those communities which are recipients of essential public facilities; and

WHEREAS, the cost of building a major supplemental airport would impose a substantial new financial encumbrance which would conflict with other important regional obligations, while the cost of building a third Sea-Tac runway would be met with already identified revenues; and

WHEREAS, air carriers have stated their opposition to the concept of supplemental airports, citing the market-driven economic realities of their industry; and

WHEREAS, a broad spectrum of labor, business, and community groups support the addition of a third Sea-Tac runway to meet the near-term air transportation capacity needs of the region.

1011 Western Avenue, Suite 500 • Seattle, Washington 98104-1035 • (206) 464-7090 • FAX [illegible]

NOW, THEREFORE, BE IT RESOLVED, that the Executive Board further clarifies that the "Resolution A-93-03: Implementation Steps" adopted by the Executive Board allow the Executive Board to determine whether the Regional Council should go forward with additional supplemental airport studies and pursuant to that authority, the Executive Board determines that further studies should not be undertaken.

BE IT FURTHER RESOLVED, that the decision of the Executive Board of the Puget Sound Regional Council is to affirm the General Assembly's approval of a third runway for Sea-Tac, provided the project meets the independent evaluation of the noise and demand management conditions set out in Resolution A-93-03, and satisfies the environmental impact review process.

FURTHER, the Executive Board recommends that the region work with the State to enact legislation allowing for substantial and equitable incentives and compensation for communities impacted by the proximity of essential public facilities.

FURTHER, the Executive Board recommends that the State, in cooperation with appropriate local jurisdictions and regional transportation planning organizations, implement a comprehensive process for evaluating all options to meet the State of Washington's long-term air travel and inter-regional ground transportation needs, including high speed rail.

ADOPTED by the Executive Board this 27th day of October, 1994.

Richard Mitchusson

Mayor Richard Mitchusson
City of Poulsbo
President
Puget Sound Regional Council

Attest: Mary McCumber
Mary McCumber, Executive Director

Puget Sound Regional Council

PSRC

RESOLUTION A-93-03

A RESOLUTION of the General Assembly of the Puget Sound Regional Council Amending the 1988 Interim Regional Airport System Plan (RASP) for Long-Term Commercial Air Transportation Capacity Needs of the Region

WHEREAS, the Puget Sound Regional Council, designated under federal and state laws as the Metropolitan Planning Organization and Regional Transportation Planning Organization for the central Puget Sound region, is responsible for adopting and maintaining regional growth management and transportation strategies for the region; and

WHEREAS, the Regional Council has adopted VISION 2020: Growth and Transportation Strategy for the Central Puget Sound Region, to guide growth management and transportation decisions and actions in King, Kitsap, Pierce and Snohomish counties; and

WHEREAS, VISION 2020 seeks to assure that the people of this region continue to enjoy an outstanding and improving quality of life that includes a vibrant economy, a healthy environment, and livable communities connected by a multimodal, transit-oriented transportation system that emphasizes accessibility and enables the efficient movement of people, goods and freight; and

WHEREAS, with respect to assessments of commercial air transportation needs, the Regional Council acknowledges long term forecasting uncertainties, and the reduction on a day-to-day basis of current airport capacity at Sea-Tac Airport during bad weather conditions; and

WHEREAS, VISION 2020, as the Regional Transportation Plan for the region, includes the 1988 interim Regional Airport System Plan with language that called upon the region to "proceed expeditiously with the detailed evaluation and selection of a preferred regional air carrier system alternative," and which now needs to be amended to reflect the Regional Council's recent planning and deliberations regarding the long-term commercial air transportation capacity needs of the region; and

WHEREAS, jurisdictions in the region agree to site regional transportation facilities in a manner that reduces adverse societal, environmental and economic impacts; seeks equity and balance in siting and improving the region's transportation system; and addresses regional growth planning objectives; and

WHEREAS, the Regional Council, through the Flight Plan Project, has sought to address policy, environmental, and procedural concerns through a variety of products and processes, including the following:

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(a) The Regional Council, acting jointly with the Port of Seattle, completed a non-project Final Environmental Impact Statement evaluating various system alternatives for meeting projected demands and their noise and other environmental impacts, and

(b) The Regional Council conducted a series of workshops, decision meetings, open houses, and a public hearing, to listen to the concerns and suggestions of community groups, individuals and interests that could be affected by a regional commercial air transportation capacity decision; and

WHEREAS, as a part of this effort, the Regional Council finds that commercial air transportation is important to the region's economy, and that additional commercial air transportation capacity needs to be identified and preserved, and implemented when needed at some point in the future; and

WHEREAS, the Regional Council finds that there is no perfect air transportation capacity solution, but that whatever solution is adopted must be part of an integrated transportation system that includes air and marine transportation as well as roadways and rail, that demand management and system management should be utilized to make the most efficient use of the existing system, and that any solution must not result in a decrease in safety and must address noise; and

WHEREAS, the Regional Council further finds that the adopted solution should be flexible, must be consistent with the growth management planning that is occurring in the region, and should be financially feasible; and

WHEREAS, the Regional Council Transportation Policy Board and Executive Board have developed and refined this recommendation to the Regional Council General Assembly; and

WHEREAS, this amendment to the interim Regional Airport System Plan is consistent with the VISION 2020 Final Environmental Impact Statement:

NOW, THEREFORE, BE IT RESOLVED that the Regional Council Executive Board recommends that the General Assembly adopt the following elements of a Regional Airport System Plan amendment:

That the region should pursue vigorously, as the preferred alternative, a major supplemental airport and a third runway at Sea-Tac.

1. **The major supplemental airport should be located in the four-county area within a reasonable travel time from significant markets in the region.**
2. **The third runway shall be authorized by April 1, 1996:**
   a. **Unless shown through an environmental assessment, which will include financial and market feasibility studies, that a supplemental site is feasible and can eliminate the need for the third runway; and**

b. After demand management and system management programs are pursued and achieved, or determined to be infeasible, based on independent evaluation; and

c. When noise reduction performance objectives are scheduled, pursued and achieved based on independent evaluation, and based on measurement of real noise impacts.

3. The Regional Council requests consideration by the Federal Aviation Administration of modifying the Four-Post Plan to reduce noise impacts, and the related impacts on regional military air traffic.
4. Evaluation of the major supplemental airport shall be accomplished in cooperation with the state of Washington.
5. Proceed immediately to conduct site-specific studies, including an environmental impact statement, on a Sea-Tac third runway;
6. Eliminate small supplemental airports, including Paine Field, as a preferred alternative.

BE IT FURTHER RESOLVED that the Board is directed to:

1. Take all necessary steps to assure efficient, effective and economical implementation of this resolution.
2. Negotiate with the Port of Seattle, the Washington State Department of Transportation and other responsible agencies, as necessary, to assure the implementation of this resolution.
3. Assure that implementation of this resolution is at all times in compliance with the requirements of all applicable federal, state and local laws and regulations.
4. Report to the General Assembly on the results of its actions at the next regularly scheduled Assembly meeting or at such special meeting of the Assembly as the Board may call.

ADOPTED by the General Assembly this 29th day of April, 1993.

Bill Brubaker

Bill Brubaker, Councilmember
Snohomish County
President, Puget Sound Regional Council

Attest: Mary McCumber

Mary McCumber, Executive Director

RESOLUTION NO. 3125, As Amended

A RESOLUTION of the Port Commission of the Port of Seattle directing Port staff, in cooperation with the Federal Aviation Administration, to conduct certain studies, prepare certain plans, prepare a site specific environmental impact statement and take certain other actions preparatory to authorization of construction of a third runway at Seattle-Tacoma International Airport.

WHEREAS, studies indicate that the number of aircraft operations at Seattle-Tacoma International Airport (STIA) is continuing to increase and STIA ability to accommodate increasing air traffic is nearing capacity particularly in poor visibility conditions; and

WHEREAS, in 1989, the Port of Seattle and the Puget Sound Regional Council (PSRC) appointed the Puget Sound Air Transportation Committee (PSATC) and initiated the Flight Plan Project to study long-term alternatives for resolving air traffic capacity problems in the Puget Sound area; and

WHEREAS, the PSATC was a broadly based committee, with membership as shown at Attachment A, including citizens, environmental interests, local and state elected officials, and representatives of the airlines and business community, with membership from King, Kitsap, Pierce, Snohomish and Thurston counties; and

WHEREAS, the PSATC, with staff support from the Port and the PSRC, retained independent consultants to assist in its air traffic forecasts and related studies and adopted major findings including the following:

- Hourly capacity at STIA is greatly reduced during inclement weather, which occurs about 45 percent of the year.
- Air travel demand in the Puget Sound region is projected to continue growing strongly well into the next century based on regional population and economic growth estimates.
- Efficient airfield capacity will be exceeded when aircraft operations reach 380,000 per year, which is forecast to occur close to the year 2000. STIA handled 338,000 operations in 1991 and is projected to handle 350,000 in 1992; and

WHEREAS, during its two-year study, the PSATC examined a wide range of system alternatives for meeting the forecasted air travel demand and developed a list of 34 alternatives for further studies of cost, feasibility and environmental impact; and

WHEREAS, in January 1992, the PSATC issued its draft report and a non-project draft environmental impact statement (DEIS) prepared pursuant to the State Environmental Policy Act, evaluating the potential noise, air quality, traffic, land use, and other potential environmental impacts of a number of alternatives including a "no action" alternative; and

WHEREAS, the PSATC conducted 11 public hearings at which verbal testimony was received from approximately 650 people, and the PSATC has reviewed over 5,000 pages of written comments on its draft report and DEIS, leading in June 1992 to issuance of its final report and recommendations, and issuance of a final EIS in September 1992; and

WHEREAS, the PSATC recommended phased implementation of a multiple airport system including: the addition of a dependent air carrier runway at STIA 2,500 feet west of the centerline of existing runway 16L before the year 2000; the introduction of scheduled air carrier service at Paine Field before the year 2000; and identification of a two-runway airport site in Pierce County for development by the year 2010 in collaboration with the military, and failing that, the identification of a suitable location in Thurston County; and

WHEREAS, the PSATC voted 29 to six in favor of its multiple airport system recommendation. Kitsap, Pierce and Thurston county members were unanimous in their support, and Snohomish county members supported the recommendation three to two. Twelve of the fourteen members representing King County government and private interests voted, with eight supporting and four opposing. Members representing the Governor's office, state agencies, the airline industry and the FAA were unanimous in their support.

WHEREAS, preconstruction planning, permitting and construction activities necessary to accomplish the addition of a dependent air carrier runway at STIA as recommended by the PSATC may require five to seven years to complete, it is appropriate to commence study of site-specific environmental impacts and other pre-construction planning at this time in order to meet the PSATC's recommended implementation schedule; and

WHEREAS, the state Growth Management Act requires the PSRC to prepare a new Regional Transportation Plan and requires Puget Sound counties and cities to prepare new comprehensive land use plans; and

WHEREAS, state law authorizes the Washington State Air Transportation Commission to conduct certain studies and issue certain reports regarding air transportation, and prohibits construction of a new runway at STIA prior to the Commission's submittal of a final report, findings and recommendations to the Washington Legislative Transportation Committee by December 1, 1994, but permits planning activities, including studies or preparation of an EIS;

NOW, THEREFORE, BE IT RESOLVED by the Port of Seattle Commission as follows:

SECTION 1:

(a) Subject to the conditions of Section 2, the Port of Seattle adopts the portions of the PSATC recommendations, dated June 17, 1992, that directly pertain to adding a dependent runway at Sea-Tac International Airport to improve the all-weather capacity and safety of the airfield. In addition, the Port of Seattle Commission calls for the remainder of the regional solution to include a reconsideration of a fast rail system linking Portland, OR and Vancouver, B.C. airports and central business districts together with the diversion of all cargo only carriers to an alternative airport site as well as the multiple airport system recommended by the PSATC.

(b) Port Staff is directed, in cooperation with the Federal Aviation Administration (FAA), to: (i) conduct necessary studies and prepare plans for constructing a dependent air carrier runway at Seattle-Tacoma International Airport; (ii) prepare a site-specific environmental impact statement pursuant to the National and State Environmental Policy Acts to consider the potential environmental impacts of such runway development; (iii) work cooperatively with the PSRC and state and local jurisdictions in an effort to arrive at a facility plan that is consistent with other relevant regional and local plans, in accordance with the Growth Management Act; and (iv) issue a Notice of Action pursuant to RCW 43.21C.080 requiring that any lawsuit to challenge this Commission action on the basis of SEPA be filed within 90 days of publication of the Notice of Action or be forever barred.

(c) Port staff is also directed to develop and implement a plan to insulate up to 5,000 eligible single family residences in the existing noise remedy program included on the waiting list as of December 31, 1993, before commencing construction of the proposed runway. The remaining eligible single family residences on the waiting list are to be insulated prior to operation of the proposed runway.

In addition, the Port commits to complete insulation of all single-family residences that become eligible for insulation as a result of actions taken based on the site-specific EIS and are on the waiting list as of December 31, 1997, prior to commencing operation of said runway.

Staff is further instructed to develop and implement amendments to the acoustical insulation program to include multi-family, schools, and other institutional uses.

(d) The Executive Director and the Managing Director, Aviation Division, are each authorized to select and retain outside professional services necessary to carry out these directives within authorized budget limits, and to make application to and accept federal and state grant monies or such other funding assistance as may be available therefore.

ATTACHMENT B TO RESOLUTION NO. 3125, AS AMENDED

Potential Mitigation Strategy Enhancements for Seattle-Tacoma International Airport

INTRODUCTION

Seattle-Tacoma International Airport is in the forefront of the industry-wide effort to mitigate negative impacts generated by commercial air transport. The Port of Seattle in cooperation with the airlines, Federal, State and local governments and private citizens has been both innovative and effective in reducing impacts. The Flight Plan project has put additional focus on these mitigation programs and what might be done to further enhance their effectiveness.

The technical and environmental analysis conducted as part of Flight Plan concluded that taking no action in response to the projected increase in demand for air transportation was not a viable solution. The impacts associated with doing nothing are worse than those associated with taking action. The recommended dependent runway at Sea-Tac will reduce both noise and air quality related impacts below the levels expected if airfield efficiency is not improved. This fact coupled with the conversion of the aircraft fleet serving Sea-Tac to Stage III by the year 2000 and the phased implementation of a regional multiple airport system produces the lowest future impact levels.

There is a continuing commitment and responsibility to reduce impacts to the maximum extent that is reasonable and technically feasible. Such efforts should be focused not only on specific projects but on the entire airport operation. The mitigation programs currently in place need to be reviewed to explore both enhancement and acceleration. There are areas of impact such as surface transportation and air quality that need to be further addressed. There is also a range of community compatibility actions to be considered as part of the Port's continued interest in being a good neighbor and part of the greater South King County community. Some of the potential mitigation actions which could be evaluated during the site specific analysis are described below:

Noise

1. Explore development of a regulatory mechanism to cap aircraft operational noise at the 1992 levels.
2. Fully explore the impacts of peak period pricing and other demand management techniques.
3. Acceleration of the existing Noise Remedy Program with expansion to include public buildings and other institutional uses.
4. Acquisition and redevelopment to compatible uses.
5. Attenuation of airport noise through use of berms and barriers.

6. On-airport noise control measures reducing nighttime sources of aircraft related ground noise.

7. Development and strict application of construction noise reduction techniques and practices.

Air Quality/Transportation

8. Quantify baseline air quality conditions in vicinity of the airport using both sampling and modeling techniques.

9. Design and implement an aggressive on-airport emission reduction program for both aircraft and surface vehicles.

10. Implement aggressive off-airport emission reduction program related to ground access and congestion relief. Become an aggressive advocate at the Regional Transit Plan and Puget Sound Regional Council levels for transit connections designed to reduce the use of automobiles accessing Seattle-Tacoma International Airport.

Land Use/Community Compatibility

11. Utilize FAR Part 150 process to promote increased compatibility of adjacent development.

12. Improve aesthetic appearance of airport boundary.

13. Design a mechanism and process to promote mutual airport/community land use compatibility through improved coordination, communication and involvement of elected officials and staffs of affected local and special purpose governments.

Natural Environment/Water Resources

14. Design and implement protection of local surface and ground water resources.

15. Develop comprehensive stormwater management plan in cooperation with the local surface water agencies.

Public Health and Safety

16. Conduct an examination of educational and health related effects of the incremental additional impacts of aircraft operations on residences, schools and other institutional uses and identify appropriate mitigation measures.

PUGET SOUND AIR TRANSPORTATION COMMITTEE

CHAIRMAN
ROBERT WALLACE
Pacific Group Properties

Membership Roster

PAUL BARDEN
King County Council

M. R. DINSMORE
Port of Seattle

RAY DINSMORE
Port of Olympia

ROY FERGUSON
State Representative

DAVID FIELD
Federal Aviation Administration

BERNARD FRIEDMAN
Snohomish County Citizen

WILLIAM HAMILTON
State Department of Transportation

FRANK HANSEN
Mayor of SeaTac

GWIN HICKS
Thurston County Citizen

RICHARD KENNEDY
Des Moines City Council

ROBERT LARSON
Mayor of Stanwood

HARRY LEHR
Alaska Airlines

DARLENE MADENWALD
Washington Environmental Council

JOHN MCCARTHY
Commissioner, Port of Tacoma

LIZ MCLAUGHLIN
Snohomish County Council

JOHN MCNAMARA
Air Transport Association

PAIGE MILLER
Commissioner, Port of Seattle

RENEE MONTGELAS
Office of the Governor

GREG MYKLAND
Tacoma City Council

KIT NARODICK
Representing King County Business

MARTIN NEEB
Pierce County Citizen

ROBERT NEIR
Kirkland City Council

GREG NICKELS
King County Council

ED NIELSON
United Airlines

DON PADELFORD
King County Citizen

FRANK PARTIN
Representing Snohomish County Business

ANDREA RINIKER
Port of Seattle

FRED SCHONEMAN
Commissioner, Port of Bremerton

ROGER SCHAEFFER
Clyde Hill Council

EARLE SMITH
Kitsap County Citizen

SVERRE STAURSET
Representing Pierce County Business

BILL STONER
Pierce County Council

LEO THORSNESS
State Senator

TOM TIERNEY
Office of the Mayor, City of Seattle

LARRY VOGNILD
State Senator

RAY WHITE
Representing Kitsap County Business

NEIL E. WOODY
Representing Thurston County Business

PAUL ZELLINSKY
State Representative

ATTACHMENT A
RESOLUTION 3125, as amended

SNOHOMISH COUNTY EXECUTIVE

SNOHOMISH COUNTY COUNCIL

SNOHOMISH COUNTY, WASHINGTON

JOINT RESOLUTION NO. 92-010

A JOINT RESOLUTION TO OPPOSE THE RECOMMENDATIONS OF THE FLIGHT PLAN STUDY

WHEREAS on April 11, 1978, the Snohomish County Commissioners adopted by resolution the "Role for Development of Paine Field", and in 1979, the Commissioners further adopted by resolution the recommendation of the Paine Field Mediation Panel in accordance with the established "General Aviation" role; and

WHEREAS this role was reaffirmed by Snohomish County in 1989.

WHEREAS based on the 1978-79 Mediated Role determination, Snohomish County allowed Industrial Zoning around Paine Field to be changed to Single and Multiple Family Housing; and

WHEREAS the Mediated Role determination stipulated that "development of Paine Field will be predicated on the recognition that it resides within an established community and will be sensitive to the quality of life of the surrounding community"; and

WHEREAS development of Paine Field as a major commercial airport would have significant negative impacts upon the surrounding community; and

WHEREAS there are significant flaws and errors in the Flight Plan Project Draft Final Report identified in the Snohomish County response to the Draft Final Report. These flaws and errors are of such a magnitude so to invalidate the conclusions reached.

NOW, THEREFORE, BE IT RESOLVED, the Snohomish County Executive and Snohomish County Council adopts the following:

1. The County opposes, and will continue to oppose, the recommendation of the Flight Plan Project Draft Final Report to begin major commercial airline service at Paine Field or Arlington.

2. The County urges the rejection of the report based on the significant flaws and errors contained within it.

Post-it® Fax Note 7671	Date 1/31/95	# of pages ▶ 4
To MARY VIGILANTE	From DAVE GOSSETT	
Co./Dept. PORT OF SEATTLE	Co. SNOHOMISH CO	
Phone #	Phone # 388-3494	
Fax # 431-4458	Fax #	

3. The County reaffirms its commitment to the 1978-79 Mediated Role determination.

PASSED this 18th day of March, 1992.

Snohomish County Executive
Snohomish County Council
Snohomish County, Washington

Liz McLaughlin
COUNCIL CHAIR

COUNTY EXECUTIVE

ATTEST:

Sheila McCallister
Clerk of the Council

SNOHOMISH COUNTY EXECUTIVE
SNOHOMISH COUNTY COUNCIL

Joint Resolution No. 94-013

A Joint Resolution Reaffirming Snohomish County's Commitment To Preserving Paine Field's Existing Aviation Role

WHEREAS, the Puget Sound Regional Council (PSRC) has previously determined that Paine Field is not an appropriate site for the location of a major commercial airport for a variety of physical and environmental reasons, and

WHEREAS, the PSRC is being prompted to reconsider its previous decision on the status of Paine Field, and

WHEREAS, on April 11, 1978, the Snohomish County Commissioners adopted by resolution the "Role for Development of Paine Field," and in 1979, further adopted by resolution the recommendation of the Paine Field Mediation Panel in accordance with the "General Aviation" role for that public facility, a role which was subsequently reaffirmed by Snohomish County in 1989, and again in 1992, and

WHEREAS, based on the 1978-79 Mediated Role determination, and the subsequent reaffirmations, Snohomish County allowed and has continued to allow the original industrial zoning around Paine Field to be changed to single and multiple family zoning, with the result that a substantial residential community has developed in the area based on the County's promise to protect the community from adverse airport impacts, specifically the use of Paine Field as a major commercial airport, and

WHEREAS, the Paine Field area, based on the 1978-79 Mediated Role determination, has also developed as a major American industrial center, the manufacturing headquarters to our nation's largest exporter, the Boeing Company, as well as numerous other related aviation industries, all providing regional employment to over 40,000 men and women, and

WHEREAS, the integrity of a democratically-elected government's commitment to the constituency it serves is the absolute foundation for a free and just society, and that any abridgment of the promises made by

government to citizens threatens the very substance of a civilized society, and

WHEREAS, the planning and financing of all regional facilities are contingent upon the credibility of long-term government decision making.

NOW, THEREFORE, BE IT RESOLVED that the Snohomish County Executive and Council do jointly reaffirm our county's commitment to preserving the existing aviation role of Paine Field, and urge the PSRC to stand by its previous and valid decision to exclude Paine Field from among potential commercial airport sites.

APPROVED THIS 21ST DAY OF SEPTEMBER, 1994

Bob Drewel

Bob Drewel
County Executive

Karen Miller

Karen Miller
County Council Chair

John Garner

John Garner
County Council

Richard C Johnson

Richard Johnson
County Council

Liz McLaughlin

Liz McLaughlin
County Council

Al Schweppe

Al Schweppe
County Council

Barbara Ditonti

ATTEST: Clerk of the Council, Asst.

D-1

RESOLUTION 92-001

A RESOLUTION OF THE CITY COUNCIL OF THE CITY OF BURIEN DECLARING ITS OPPOSITION TO THE THIRD SEATAC AIRPORT RUNWAY

WHEREAS, the Port of Seattle is currently planning and lobbying for the construction of a third runway at the SeaTac Airport to facilitate the handling of increased commercial airplane and jet traffic; and

WHEREAS, according to certain studies such a runway, even if constructed, would only have a useful life (useful life is defined as that period of time from start of operations until demand traffic equals capacity) of approximately seven years from anticipated completion in the year 2000, until it reaches its fullest traffic capacity in approximately the year 2007; and

WHEREAS, there is no room for further expansion of the SeaTac Airport beyond that proposed with the third runway, which would only mitigate adverse air traffic congestion for approximately seven years; and

WHEREAS, projected growth rates for the year 2000 in Washington State justify the creation and/or expansion of supplemental airports in the Snohomish, Thurston or Pierce counties; and

WHEREAS, factual data supports the proposition that congestion caused delay times at the SeaTac Airport can be reduced through the use of supplemental airports, without further adversely affecting the health and well being of Burien residents living in proximity to SeaTac, some of whom would be displaced from their homes and residences, by the construction of a third runway.

NOW, THEREFORE, BE IT RESOLVED by the City Council of the City of Burien, King County, Washington, that the City of Burien formally expresses its opposition to the construction of a third runway at the SeaTac Airport.

UNANIMOUSLY ADOPTED by the Burien City Council, King County, Washington, at a regular meeting thereof held on this 29th day of September, 1992.

Acting City Clerk

Dottie Harper
Burien City Councilwoman

Arun Jhaveri
Burien City Councilman

Catherine "Kitty" Milne
Burien City Councilwoman

John Kennelly
Burien City Councilman

Vivian Matthews
Burien City Councilwoman

Bert Lysen
Burien City Councilman

Sally Nelson
Burien City Councilwoman

RESOLUTION NO. 674

A RESOLUTION OF THE CITY COUNCIL OF THE CITY OF DES MOINES, WASHINGTON reaffirming its opposition to development of a third runway at Seattle-Tacoma International Airport, calling for the creation of a coalition of interested jurisdictions, organizations, and parties to oppose such development, and authorizing the City Manager to take such action as is necessary to effect the policies stated herein.

WHEREAS, the Port of Seattle has announced the development of a third runway inside the current boundaries of Seattle-Tacoma International Airport, and

WHEREAS, the Port of Seattle may also consider other improvements such as high-speed taxi-ways, use of taxi-ways for aircraft landings and takeoffs and other system improvements leading to increased air traffic, and

WHEREAS, the City of Des Moines and other cities and unincorporated communities now surrounding Seattle-Tacoma International Airport are experiencing severe noise-related impacts from the current runway configuration which adversely affect the quality of life, and

WHEREAS, Des Moines residents are taxed by the Port of Seattle with such taxes being used to construct airport facilities that adversely impact Des Moines residents with increased noise, and

WHEREAS, this expansion of Seattle-Tacoma International Airport will have additional serious negative effects on the City of Des Moines and surrounding cities and unincorporated areas by reducing property values, increasing community uncertainty, disrupting community planning, and reducing private investment, severely degrading the quality of life, and

WHEREAS, the decision to add a third runway at Seattle-Tacoma International Airport ignores significant adverse impacts on surrounding property owners and jurisdictions; now, therefore:

THE CITY COUNCIL OF THE CITY OF DES MOINES RESOLVES AS FOLLOWS:

Section 1. The City of Des Moines reaffirms the position taken in Resolution No. 507 (1988) and in Resolution No. 527 (1988) in opposition to the development of a third runway at Seattle-Tacoma International Airport.

Section 2. The City of Des Moines supports the creation of a coalition of interested jurisdictions and parties to oppose the development of a third runway at Seattle-Tacoma International Airport, and directs and authorizes the City Manager to engage in any and all activities in opposition to development of such third runway, including, but not limited to, research and challenge to the adequacy of any environmental impact statement, research and challenge to noise contour updates, engaging in persuasive activities directed to the Port of Seattle, Washington State Legislature, King County Council, and Puget Sound Regional Council, and taking a leadership role in a coalition formed for the purpose of opposing the development of a third runway at Seattle-Tacoma International Airport.

Section 3. Initiation of litigation in any court of competent jurisdiction shall require further action of the City Council.

ADOPTED BY the City Council of the City of Des Moines, Washington this 9th day of January, 1992 and signed in authentication thereof this 9th day of January, 1992.

MAYOR

APPROVED AS TO FORM:

City Attorney, Assistant

ATTEST:

City Clerk

Resolution No. 594

A RESOLUTION OF THE CITY OF NORMANDY PARK RELATING TO SEATTLE TACOMA INTERNATIONAL AIRPORT EXPANSION AND FLIGHT PLANS.

WHEREAS, the City of Normandy Park lies adjacent to the Seattle Tacoma International Airport, and

WHEREAS, the Citizens of Normandy Park are directly impacted by air traffic overflights, ground access, storm water runoff and other consequences flowing from the operation of said airport, and

WHEREAS, these impacts directly effect the health, safety and welfare, as well as the quality of life within the City of Normandy Park,

NOW, THEREFORE, BE IT RESOLVED BY THE CITY COUNCIL OF THE CITY OF NORMANDY PARK AS FOLLOWS:

Section 1. The City of Normandy Park is adamantly opposed to any expansion of Sea-Tac Airport, installation of a third runway or any expansion West of the existing airport boundary.

Section 2. The City will actively participate in and support other Community and/or Citizen action directed toward the rejection of Sea-Tac Airport expansion as a solution for accommodating increasing air traffic.

Further, to preclude the necessity of Normandy Park's living under the continued threat of Sea-Tac Airport expansion to the West, this correspondence is to strongly insist that the agencies involved immediately adopt binding policy statements ruling out any further consideration of expansion of Sea-Tac Airport to the West.

PASSED BY THE CITY COUNCIL OF THE CITY OF NORMANDY PARK THIS 9 DAY OF April, 1991; AND SIGNED IN AUTHENTICATION OF ITS PASSAGE THIS 9 DAY OF April, 1991.

Kathleen Vermeire

Kathleen Vermeire, Mayor

Attested by:

Shirley Smith

Shirley Smith, Clerk/Treasurer

U.S. Department of Transportation
Federal Aviation Administration

Northwest Mountain Region
Colorado, Idaho, Montana
Oregon, Utah, Washington
Wyoming

1601 Lind Avenue, S. W.
Renton, Washington 98055-4056

FEDERAL AVIATION ADMINISTRATION/PORT OF SEATTLE
DISCLOSURE STATEMENT

We Landrum & Brown, Incorporated. do hearby certify that we have no financial or other interests in the execution or outcome of the proposed Master Plan Update development located at Seattle-Tacoma International Airport. We further understand that this certification is required under Federal Aviation Order 5050.4A and Council on Environmental Quality Regulations Section 1506.5 and that we must remain in compliance there with throughout our participation in the preparation of the NEPA Environmental Impact Statement related to the proposed Master Plan Update development.

The undersigned further certifies that he/she has read the foregoing and is authorized to execute this Disclosure Statement for the above named firm.

Signed: [signature] Date: 4-10-94

Title: Vice President

"Expect Excellence"

U.S. Department
of Transportation
Federal Aviation Administration

Northwest Mountain Region
Colorado, Idaho, Montana
Oregon, Utah, Washington
Wyoming

1601 Lind Avenue, S. W.
Renton, Washington 98055-4056

FEDERAL AVIATION ADMINISTRATION/PORT OF SEATTLE DISCLOSURE STATEMENT

We Shapiro and Associates, Inc. do hearby certify that we have no financial or other interests in the execution or outcome of the proposed Master Plan Update development located at Seattle-Tacoma International Airport. We further understand that this certification is required under Federal Aviation Order 5050.4A and Council on Environmental Quality Regulations Section 1506.5 and that we must remain in compliance there with throughout our participation in the preparation of the NEPA Environmental Impact Statement related to the proposed Master Plan Update development.

The undersigned further certifies that he/she has read the foregoing and is authorized to execute this Disclosure Statement for the above named firm.

Signed: [signature] Date: May 12, 1994

Title: Vice President

"Expect Excellence"

U.S. Department of Transportation
Federal Aviation Administration

Northwest Mountain Region
Colorado, Idaho, Montana
Oregon, Utah, Washington
Wyoming

1601 Lind Avenue, S. W.
Renton, Washington 98055-4056

FEDERAL AVIATION ADMINISTRATION/PORT OF SEATTLE
DISCLOSURE STATEMENT

We ___INCA Engineers Inc.___ do hearby certify that we have no financial or other interests in the execution or outcome of the proposed Master Plan Update development located at Seattle-Tacoma International Airport. We further understand that this certification is required under Federal Aviation Order 5050.4A and Council on Environmental Quality Regulations Section 1506.5 and that we must remain in compliance there with throughout our participation in the preparation of the NEPA Environmental Impact Statement related to the proposed Master Plan Update development.

The undersigned further certifies that he/she has read the foregoing and is authorized to execute this Disclosure Statement for the above named firm.

Signed: [signature] Date: 05·16·94

Title: VP.

"Expect Excellence"

U.S. Department
of Transportation
**Federal Aviation
Administration**

Northwest Mountain Region
Colorado, Idaho, Montana
Oregon, Utah, Washington
Wyoming

1601 Lind Avenue, S. W.
Renton, Washington 98055-4056

**FEDERAL AVIATION ADMINISTRATION/PORT OF SEATTLE
DISCLOSURE STATEMENT**

We _Metro Communications, Inc._ do hearby certify that we have no financial or other interests in the execution or outcome of the proposed Master Plan Update development located at Seattle-Tacoma International Airport. We further understand that this certification is required under Federal Aviation Order 5050.4A and Council on Environmental Quality Regulations Section 1506.5 and that we must remain in compliance there with throughout our participation in the preparation of the NEPA Environmental Impact Statement related to the proposed Master Plan Update development.

The undersigned further certifies that he/she has read the foregoing and is authorized to execute this Disclosure Statement for the above named firm.

Signed: Theresa Greco Smith Date: 4/7/94

Title: President

"Expect Excellence"

U.S. Department
of Transportation
Federal Aviation Administration

Northwest Mountain Region
Colorado, Idaho, Montana
Oregon, Utah, Washington
Wyoming

1601 Lind Avenue, S. W.
Renton, Washington 98055-4056

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Signed: [signature] Date: 5/11/94

Title: President

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APPENDIX B

STUDIES OF ALTERNATIVES

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APPENDIX B

STUDIES OF ALTERNATIVES

This appendix summarizes or identifies the availability of the following:

- History of Seattle Tacoma International Airport
- Flight Plan Study
- Alternative Airport Sites
- Rail Planning
- Master Plan Update Documents

As introduced in the background section of Chapter I "Project Purpose and Need," airport planning and development is governed by federal, state, regional, and local policies. The planning framework is also guided by specific airport study processes, methodologies, and environmental impact assessment procedures as defined in various federal and state statutes and regulatory agency documents. The overall transportation planning process within Central Puget Sound including, jurisdiction roles, responsibilities, and relationships is reviewed in **Appendix S**.

1. HISTORY OF SEATTLE-TACOMA INTERNATIONAL AIRPORT

Seattle-Tacoma International Airport (Sea-Tac Airport) is the primary air transportation hub of Washington State and the Northwestern United States. The Airport is located within the King County and the City of SeaTac, about 12 miles south of downtown Seattle and about 20 miles north of Tacoma. Airport property consists of about 2,500 acres of land. Exhibit I-1 illustrates the location of Sea-Tac Airport relative to the Puget Sound Region (Region).

Sea-Tac Airport is the primary commercial service airport for the Pacific Northwest and is the only airport which provides primary scheduled commercial air carrier service in the four-county Central Puget Sound area, which consists of King, Kitsap, Pierce, and Snohomish Counties. Scheduled passenger service is provided at Sea-Tac by 10 major airlines and 14 all-cargo carriers have scheduled service. Non-stop air service is provided to 44 cities nationwide and to the international cities of Copenhagen, London, Seoul, Tokyo, Hong Kong, Taipei, Shanghai, Osaka, Vancouver, and Victoria. Sea-Tac Airport is the 21st busiest airport in the country, as measured by total passengers. It is also the 8th largest international air gateway to Europe and Asia, and the 17th busiest cargo airport.

(1) Airport Management and Programs

Seattle-Tacoma International Airport is operated by the Port of Seattle (Port), a municipal corporation of the State of Washington. The Port is governed by a five member Commission, elected at-large by the voters of King County. Port Commissioners serve four-year terms of office. The policies enacted by the Commission are implemented by the Port's Executive Officer and administrative and operations staff. Port district and taxation boundaries coincide with the boundaries of King County, Washington.

The Port is responsible for developing and managing commerce though two key operating divisions: the Aviation Division, which operates Sea-Tac Airport and the Marine Division. To accomplish its responsibilities, the Port provides freight and passenger terminals, storage and transfer facilities for air/water/surface transportation modes, acquires and improves lands for sale or lease for industrial or commercial purposes, and creates industrial development districts.

The Port finances its operations and capital improvements at Sea-Tac Airport through the collection of revenue from leases, rentals and other charges to airlines, as well as other users of Port facilities and services. In addition, the Port receives federal grants from the Aviation Trust Fund for specific improvements. The Port levies real property taxes but, no property tax revenue has been used for Sea-Tac Airport operations and capital improvements in over 20 years.

(2) <u>Regional and State Economic Development</u>

The Port of Seattle provides services to facilitate and support the economic vitality of the Region and Washington State. Two primary services include the Sea-Air Cargo Program and Intermodal Connections

- Sea-Air Cargo Program - The Port of Seattle programs have resulted in the world's busiest sea-air facilities, due to shorter sailing times to Asia and flying times to Europe than from any other West Coast port. Seattle's equidistant location between Tokyo and London affords shippers an economic advantage over air-only transportation and a faster alternative to water-only movements. The Pacific Ocean transit time from port cities in Asia to Seattle is 8 days. This is 30 hours less than travel time to Southern California ports. An average of 500 tons of cargo per week (26,000 tons annually) is flown from Seattle to Europe by all-cargo airlines and wide-body passenger aircraft. Currently, 2 all-cargo carriers and 6 passenger service carriers participate in the Sea-Air program, along with six ocean shipping lines and 17 freight forwarders.

- Intermodal Connections - The Port supports intermodal transportation facilities to assist in the transfer of goods between air, sea, and land modes. Two major transcontinental railroads and more than 100 trucking companies link Port facilities to major markets throughout North America. The Seattle Rail Program offers customers a complete package of inland rail services for container and load quantities; and the Seattle Truck Contract Program provides shippers with a low-cost, efficient method of moving less-than-truck-and container-load of imported cargo throughout the continental United States. As a result, the Port of Seattle is the fourth largest container-load center in the U.S. and among the world's top twenty. Containerization has enabled ports traditionally serving relatively small primary markets, such as Seattle, to attain container gateway status.

Two-way trade through the Port of Seattle facilities is conducted between more than 100 countries. On a per-capita basis, Washington State conducts more international trade than any other state. Washington State is the fourth largest exporter in the nation, following California, Texas, and New York. Top air exports include automatic data processing equipment, measuring instruments, aircraft parts, and engines.

The Port of Seattle officials have been active participants, along with numerous other state and national elected officials, business leaders, and trade groups, to support enhanced trade with Asian and Pacific countries. The Puget Sound Region hosted the Asian Pacific Economic Cooperation (APEC) conference in 1993. In June 1994, the National Center for APEC was established in Seattle through the active support of the business community, including the Port of Seattle. As a result, the Port of Seattle has initiated marketing efforts with Asian, Pacific, and European cities to encourage foreign flag and domestic carriers to provide regular service between their respective trade centers.

2. AIRPORT HISTORY

The Puget Sound Region has been a focal point for aviation since the first Boeing aircraft was built in 1916. In 1928, King County built the area's first commercial airport (Boeing Field - now known as King County International Airport) on drained land, prone to fog, near the mouth of the Duwamish River where it flows into Puget Sound. During the late 1930s and early 1940s, the adjacent Boeing Aircraft Factory was expanding rapidly and needed the adjoining air field facilities for its own use. The Army Air Corps required additional facilities for their experimental and technical programs.

In January 1941, Boeing Field was overcrowded and a growing need was identified for additional commercial and military aviation facilities. The Aviation Committee of the Seattle Chamber of Commerce immediately started considering possible sites for locating a new major airport facility. A year later, the Committee was informed by the Civil Aeronautics Administration that $1.0 million had been allocated for a new Seattle airport, subject to finding a suitable site and sponsor. By mid-February 1942, two suitable sites had been found (Bow Lake and Lake Sammamish). The City of Seattle and King County were unable to commit the necessary resources to the project and the Chamber requested that the Port of Seattle serve as the airport sponsor.

During the early years of commercial aviation, airports represented a financial drain to those operating the facilities. Boeing Field was no exception. It cost King County residents $2.5 million between 1928-1942. Thus, when the Chamber approached the Port concerning sponsorship of the airport, they initially rejected the opportunity. However, based on the desires of more than 100 trade, labor and service organizations in the Region, the Seattle Chamber passed a resolution requesting the Port operate and manage the new airport. These groups called for "immediate sponsorship of a new commercial airport ... as a present and future need to the defensive and economic welfare of Seattle". As described at the time, the "Port of Seattle Commissioners performed an unusual wedding ceremony. They united the sea and air by taking upon themselves the added task of providing the Pacific Northwest with an international airport of first magnitude."

The Port, in 1942, acquired 906 acres of land for the development of the new airport at Bow Lake. The site is located within the King County, about 12 miles south of downtown Seattle and about 20 miles north of the City of Tacoma. The land originally contained a horse riding academy, two rabbitries, a frog farm, a mushroom farm, a dog kennel, and 50 homes. To ensure that the Airport was named Seattle-Tacoma Airport, the City of Tacoma contributed $100,000 to the project. Today, the airport is located within the boundaries of the City of SeaTac.

In 1943, the Port officially broke ground on the new airport. To level the terrain and prepare for the runways, terminal, and other facilities, approximately 4 million cubic yards of earth were moved. At its opening, the Airport consisted of 4 runways. These included: a main runway (6,100 feet long) and was oriented north/south and crosswind runways located in the east/west, southeast/northwest, and southwest/northeast directions. Exhibit I-2 illustrates the current layout of the Airport.

In October, 1944, a United Airlines DC-3 departed from Boeing Field and made the first official landing at Sea-Tac Airport. By 1948, Northwest Orient and Western Airlines offered regular scheduled commercial passenger service through a temporary administration facility. In 1949, the Port dedicated a permanent administration terminal at the airport signaling Seattle's bid for dominance in the Pacific Northwest as a major international and domestic air travel center. At the same time, the Airport was re-named the Seattle-Tacoma International Airport. The new administration building withstood an earthquake three months before its dedication on July 9, 1949.

As early as June, 1956, the Port of Seattle began preparing for the jet age by extending the main runway. During the 1960s and 1970s, extensive additions and improvements were made to the passenger terminal to accommodate increased passengers levels and improve service. From 1967 to 1973, Sea-Tac Airport underwent notable change with the completion of the second parallel runway, north and south satellite terminals, passenger subway, the north airport access freeway, and an eight story parking garage. During this time, the Airport roadways were separated into upper and lower levels for departing and arriving passengers.

In 1976, the Port of Seattle and King County adopted the Sea-Tac Communities Plan to guide development of the Airport and surrounding unincorporated King County residential and commercial neighborhoods. The plan included the first major off-airport land acquisition program in the United States designed to reduce the impact of jet aircraft noise on the surrounding community. The plan was updated in 1985, including the adoption by the Port of a Noise Remedy Program. This program included a $140 million allocation to expand airport land acquisition, noise insulation of homes, and provided home-selling assistance to those individuals most affected by aircraft noise.

During the early 1980s, the Port's economic development efforts focused on international service and marine/air interfaces. In 1983, "Sea-Air" cargo service started -- when Asian cargo transported by ship through the Port of Seattle's marine terminals was then flown to Europe from Sea-Tac Airport. The Port hosted the first international familiarization tours to introduce key members of the Japanese travel industry and Japanese journalists to many of the Region's tourist attractions. In addition, Japanese-language tourism information booths were opened to aid Japanese travelers. By 1984, 26 carriers served Sea-Tac Airport, an increase from 12 carriers prior to airline industry deregulation in 1979.

3. AIRPORT PLANNING AND DEVELOPMENT

In 1984, the Port began what has become a significant period of airport planning activity. To help guide the planning , the Port directed that the underlying premise for the activity was that the "...primary role of the Airport is to serve the traveling public and to promote trade by accommodating the air transportation needs of the region." The Sea-Tac Airport Master Plan update was completed in 1985 and many of the plan's recommendations were implemented through the 1980s and early 1990s. In 1989, the Port Commission adopted a missions and goals statement drafted in partnership with customers, labor unions, government officials, and community and business groups. The statement reaffirms the Port's primary mission continues to emphasize its role as, "...a leader in providing services and facilities to accommodate the transportation of cargo and passengers by air, water and land, to provide a home for the fishing industry; and to foster the economic vitality and a quality of life for King County citizens." The missions and goals statement serves as a guide for Port policy, plan, service, and facilities development.

(1) Sea-Tac Airport Planning

The Port completed the Comprehensive Planning Review & Airspace Update Study in the mid-1980s. The purpose of the Study was to assess the validity of previous plans developed for Sea-Tac Airport in light of air travel growth and other changing conditions at the Airport. A major finding of the study identified that previous plans had not indicated a need for new runway capacity, although the review demonstrated that the existing runway system would not be capable of serving the increased airport demand past the year 2000.

This Planning Review & Airspace Update was followed in 1989 by an Airport Capacity Enhancement Study initiated by the Federal Aviation Administration (FAA). The purpose of this effort was to address aircraft delay conditions. The FAA's Study found that in 1989 with 335,259 operations, 48,000 hours of aircraft delay were incurred, while determining that when aircraft operations reach 390,000 annually, delay would reach 168,000 hours. This delay was estimated to cost aircraft operators $69 million annually.

The three year study effort identified the primary cause of delay to be poor weather conditions that reduces operational capacity from 98 to 55 operations per hour. It was also determined that the reduction in capacity is directly related to the close spacing between the existing two parallel runways which cannot support poor weather operations. The Study also examined the impact of numerous capacity improvements and identified 21 possible actions as having the potential means of reducing delays and increasing capacity. Other delay reduction methods implemented at Sea-Tac are described in Chapter II Alternatives.

(2) <u>Central Puget Sound Regional Airport Planning</u>

The Regional Airport System Plan (RASP) was initiated in the late 1980's as part of the Central Puget Sound regional transportation planning process. The RASP is an element of the Metropolitan Transportation Plan. The study was sponsored by the Puget Sound Council of Governments (now the Puget Sound Regional Council or PSRC). This plan evaluated of the Region's airport system, including Sea-Tac International Airport. The RASP concluded that the existing two runways at Sea-Tac would not be adequate to meet regional air travel needs beyond the year 2000. This conclusion confirmed the 1988 findings of the comprehensive Planning Review & Airspace Update.

As a result of the comprehensive Planning Review & Airspace Update, Airport Capacity Enhancement Study, and RASP, the Port of Seattle and the PSRC entered into an interlocal agreement to co-sponsor a process to identify a long-term solution to the Puget Sound Region's air transportation needs. A 39 member blue-ribbon panel, known as the Puget Sound Air Transportation Committee (PSATC) conducted the three year effort known as the Flight Plan Study. The purpose of this study was to "...develop a regional airport system, that would meet the aeronautical needs of the region to the year 2020 and beyond." This effort found that passenger demand would reach 45 million annual passengers by the year 2020 (a 168 percent increase over 1988 levels). Based on the study findings which examined ways to accommodate demand, the Flight Plan Study recommended a multiple airport system that included a new runway at Sea-Tac Airport as the preferred alternative. Two supplemental airports were recommended: Paine Field in Snohomish County (located north of the Airport), and another airport to be located somewhere in Pierce County (south of King County).

An environmental impact statement (EIS) was prepared to assess the Flight Plan Study and recommendations. The EIS was completed in accordance with the Washington State Environmental Policy Act (SEPA) requirements. Following publication of the Flight Plan EIS and related materials, the PSRC and Port chose to narrow the focus of additional studies and environmental review to development of a new runway and associated facilities at Sea-Tac Airport. The Flight Plan EIS and related materials are listed and described in later in this appendix.

In November 1992, based on the Flight Plan Study and EIS, the Port of Seattle passed Port Resolution (No. 3125) mandating:

> "SECTION 1: (a) ... the Port of Seattle adopts the portions of the PSATC (Puget Sound Air Transportation Committee) recommendations, dated June 17, 1992, that directly pertain to adding a dependent runway at Sea-Tac International Airport to improve the all-weather capacity and safety of the airfield. In addition, the Port of Seattle Commission calls for the remainder of the regional solution to include a reconsideration of a fast rail system linking Portland, OR and Vancouver, B.C. airports and central business districts together with the diversion of all cargo only carriers to an alternative airport site as well as the multiple airport system recommended by the PSATC."

Also in response to the Flight Plan Study EIS, and other studies, the PSRC General Assembly adopted Resolution No. A-93-03 in April 1993 to amend the RASP. The PSRC resolution states:

" ... That the region should pursue vigorously, as the preferred alternative, a major supplemental airport and a third runway at Sea-Tac.

1. The major supplemental airport should be located in the four-county area within a reasonable travel time from significant markets in the region.
2. The third runway shall be authorized by April 1, 1996:
   a. Unless shown through an environmental assessment, which will include financial and market feasibility studies, that a supplemental site is feasible and can eliminate the need for the third runway; and
   b. After demand management and system management programs are pursued and achieved or determined not to be feasible, based on independent evaluation; and
   c. When noise reduction performance objectives are scheduled, pursued and achieved based on independent evaluation and based on measurement of real noise impacts.
3. The Regional Council requests consideration by the Federal Aviation Administration of modifying the Four-Post Plan to reduce noise impacts, and the related impacts on regional military air traffic.
4. Evaluation of the major supplemental airport shall be accomplished in cooperation with the state of Washington.
5. Proceed immediately to conduct site-specific studies, including an environmental impact statement on a Sea-Tac third runway.
6. Eliminate small supplemental airports, including Paine Field, as a preferred alternative."

Copies of these resolutions are located in Appendix A.

To implement the recommendations of the Flight Plan, the PSRC passed Resolution A-93-03. The PSRC undertook a study of the feasibility of a major supplemental airport – known as the Major Supplemental Airport (MSA) study and the Port proceeded to conduct an update of the Airport Master Plan, including an environmental impact statement on a third runway at Sea-Tac. The PSRC MSA was envisioned to be conducted in two phases: MSA Phase I-identify feasible sites and MSA Phase II-prepare a site plan for the feasible sites.

MSA Phase I consisted of an exhaustive examination of potential new airport sites. This included review of 14 operating airports and five geographic subareas. These subareas included:

- Arlington/Stanwood Area (Snohomish County)
- Enumclaw/Buckley Area (King/Pierce Counties)
- Fort Lewis/Spanaway Area (Pierce County)
- Olympia/Black Lake Area (Thurston County)
- Napavine Prairie Area (Lewis County).

The evaluation process narrowed the list of prospective sites to three locations: Arlington and Marysville located in Snohomish County and Tanwax Lake in Pierce County.

The PSRC Executive Board reviewed the study findings and concluded that these and the other sites were not acceptable for locating a major supplemental airport within the four county Region. They also concluded that the addition of a third all-weather runway at Sea-Tac would provide adequate capacity for the region through the year 2030.

The Executive Board determined not to proceed with the MSA Phase II site planning process and passed Resolution EB-94-01: This resolution states:

"...Whereas, the Executive Board concludes that there are no feasible sites for a major supplemental airport within the four-county region and that continued examination of any local site will prolong

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> community anxiety while eroding the credibility of regional governance; and...Now, therefore be it resolved, that the Executive Board further clarifies that the Resolution A-93-03: Implementation Steps adopted by the Executive Board allow the Executive Board to determine whether the Regional Council should go forward with additional supplemental airport studies and pursuant to that authority, the Executive Board determines that further studies should not be undertaken."

This resolution ended the feasibility study process.

(3) <u>Washington State Air Transportation Policy Planning</u>

The State involvement in aviation planning is established in legislative statutes. Primary State interest is found in the transportation and environmental statutes. The Washington State Department of Transportation guides development of the State Transportation Policy Plan and MultiModal Transportation Plan, while the Washington State Environmental Policy Act (SEPA) guides environmental evolution. In addition, the Legislature has established commissions to study and make recommendations regarding various transportation modes. Since 1989, the Legislature has created the Rail Development Commission and Air Transportation Commission. Both commissions have completed their assignments and are no longer in operation.

In 1990, the Washington State Legislature created the Air Transportation Commission (AIRTRAC) to recommend statewide air transportation policies. The Commission's mandate was to :

> "...recommend ways to promote a statewide multi-modal transportation system that includes air, stimulate economic development through air transportation, mitigate negative impacts of aviation activities on communities, and to advance the State's competitive position in national and international trade through air transportation."

The Commission's recommendations noted that Sea-Tac Airport is approaching its airfield capacity and found the demand forecasts developed for the Flight Plan Project to be valid. The recommended policies called for:

> "...ensuring that existing capacity is preserved and that new capacity needs are addressed; pursuing modal alternatives and demand management; reducing future noise impacts and ensuring mitigation of noise impacts; improving the performance of the air transportation infrastructure to support economic development goals; and improving surface access to airports."

II. <u>FLIGHT PLAN STUDY</u>

As is described in Chapters I "Background" and II "Project Purpose and Need and Alternatives for Satisfying the Needs", a number of studies were conducted recently concerning identifying sites for a possible new airport to serve air travel needs of the Puget Sound Region. The following resources were developed by the Flight Plan and Major Supplemental Airport Study efforts:

- <u>*Phase I Forecasts*, Flight Plan Study, Puget Sound Region, July 1990</u>: This study found that if current trends continue, activity at Seattle Tacoma International Airport would exceed capacity by the year 2000. The main factors for this facility saturation are passenger growth and increased aircraft operations due to the region's economic and population growth. Passenger growth was forecast to increase from 14,500,000 in 1988, to 25,400,000 in 2000, to 34 million in 2010, to 45 million by 2020. Total airport operations in 1988 were 316,000 and were estimated to grow to 427,000 in 2000, to and to reach 575,000 by the year 2020. With increased operations, aircraft delays would be anywhere from 10 minutes to an hour with poor weather conditions.

- *Phase II: Development of Alternatives Final Report*: Flight Plan Study, Puget Sound Air Transportation Committee, June 1991: Phase II forecast a more conservative growth rate for aircraft operations over the Phase I effort. The forecast was changed slightly downward: the year 2000 with 411,000 operations, and the year 2020 with 524,000 operations. The changes reflected a more reasonable forecast of operations in the largest regional markets served by Sea-Tac. In Phase II it is also recommended that passenger growth be re-evaluated during Phase III.
- *Phase II Development of Alternatives, Appendix*, Flight Plan Study, Puget Sound Air Transportation Committee, June 1991: This appendix to the preceding report contains several summaries concerning airport search areas, the evaluation of existing airports, and hypothetical noise contour maps. It also contains a review of land use plans, and airspace analysis, and aircraft delay analysis.
- *Draft Final Report and Technical Appendices (Including Draft Programmatic Environmental Impact Statement), Flight Plan Project*, Puget Sound Air Transportation Committee, January 1992: This study summarizes the efforts associated with Phase III of the Flight Plan. The revised passenger forecast found that in the year 2000, 25.4 million passengers would occur. Saturation of Sea-Tac would begin when aircraft operations reach 380,000 per year (estimated to be 2000). Delays were found to increase dramatically during bad weather. This study also identified and present the environmental impacts of regional solutions.
- *Final Environmental Impact Statement, Flight Plan Study*, Puget Sound Regional Council and Port of Seattle, October 1992: The Final Environmental Impact Statement is divided into four major sections. These are: the Summary and Decision context; the Problem Statement: Air Capacity Issues, System-level Alternatives; and Affected Environment, Significant Impacts and Mitigation. This FEIS also encompasses the three main options related to improvements at Sea-Tac: broad system management, dependent third runway, and a remote airport.

These resources are available at the following locations:

- Puget Sound Regional Council, Information Center, 216 - 1st Avenue South, Seattle
- Federal Aviation Administration, Airports District Office, 1601 Lind Avenue, Renton

Phases I and II

The PSRC's *Flight Plan Project* was a system-level study of commercial air transportation alternatives jointly sponsored by the PSRC, the Port of Seattle, and the FAA. The Puget Sound Air Transportation Committee (PSATC) was established by the three sponsoring agencies and directed to oversee the project. Phase I of the *Flight Plan Project* developed preliminary forecasts of air transportation demand through the year 2020. Phase I did not include any site level analysis of alternate airport sites. Phase II of the *Flight Plan Project* consisted of preliminary screening of alternatives. The methodology involved forecast adjustments, identification of system alternatives, and evaluation of system alternatives based on their technical feasibility, their ability to meet the standards of PSATC's "Vision: Air Transportation 2020," and public involvement.[1/] Public involvement consisted of stakeholder participation on the PSATC, open comment periods at PSATC meetings, and public hearings on system alternatives. Nine system alternatives were explored, including:

- no action;
- limited short-term capital projects and policies to be implemented at Seattle-Tacoma International Airport (Sea-Tac) before 2000;
- expansion of Sea-Tac;
- closure of Sea-Tac and development of a replacement airport;

[1/] See Puget Sound Regional Council and Port of Seattle's June, 1991 *Phase II: Development of Alternatives* for additional information about methodology.

- the establishment of a multiple airport system involving Sea-Tac and one or more smaller supplemental airports;
- the development of a single remote airport to be functionally linked to Sea-Tac;
- the use of demand management;
- the use of new technologies;
- and the development of a high speed ground transportation system.

The nine system alternatives identified in Phase II of the *Flight Plan Project* were screened for feasibility. Since the availability of sites for each system alternative was critical to feasibility, the feasibility assessment identified specific sites for potential supplemental airports. Both existing airport sites and potential new airports were identified. Existing airport sites considered are listed below.[2]

Arlington Municipal Airport
Bellingham International
Bremerton National
Moses Lake Airport (Grant Co.)
Paine Field (Sno. Co. Airport)
Renton Municipal Airport
Skagit/Bayview Airport
Auburn Municipal Airport
Boeing Field (King Co. Airport)
McChord Air Force Base
Olympia Airport
Port Angeles Apt. (Fairchild Int.)
Seattle-Tacoma Int. Airport
Tacoma Narrows Airport

Several of these existing airports were eliminated from the technical analysis due to size constraints, topography, or urban development (Auburn, Port Angeles, Renton, and Tacoma.) The feasibility assessment also involved a preliminary search for new airport sites. The analysis did not identify specific sites, but general areas where a new airport could be located. The effort identified five "search areas," including:

- Arlington/Stanwood Area (Snohomish County)
- Enumclaw/Buckley Area (King/Pierce Counties)
- Fort Lewis/Spanaway Area (Pierce County)
- Olympia/Black Lake Area (Thurston County)
- Napavine Prairie Area (Lewis County).[3]

The various system alternatives were evaluated based on a series of criteria. These included (1) airspace and the presence of conflicts with other airports or terrain; (2) capacity; (3) ground access for residents of the Puget Sound region; (3) investment requirements; (4) economic impact on the region; and (5) implementation feasibility. The screening process resulted in a recommendation for a multiple airport system as the preferred alternative. The study recommended the expansion of Sea-Tac and the development of one supplementary airport with one or two runways. The study cited the following as potential supplementary airports.[4]

<u>Existing Airports</u>
Arlington
McChord Air Force Base
Paine Field

<u>Potential New Airports</u>
Arlington/Stanwood
Fort Lewis/Spanaway
Olympia/Black Lake

Other system alternatives recommended for further study included the closure of Sea-Tac and construction of a replacement airport; the use of Boeing Field as a close-in remote airport; and continued

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[2] Puget Sound Regional Council and Port of Seattle (1992) *Puget Sound Air Transportation Committee. The Flight Plan Project. Draft Final Report and Technical Appendices*. p. 20.

[3] *Ibid.*, p. 20.

[4] *Ibid.*, p. 22.

use of Sea-Tac in conjunction with demand management techniques, new technology, and alternate modes of transportation. The remaining system alternatives were not recommended.

Phase III

Phase III of the *Flight Plan Project* consisted of a technical/operational, economic/financial, institutional, and environmental analysis of the alternatives recommended for further study.[5] The methodology consisted of refinement of system alternatives, evaluation of system alternatives based on a series of criteria, and public hearings on draft recommendations and a Draft Programmatic EIS. With regard to the multiple airport system, several scenarios were evaluated, based upon whether Sea-Tac would have two or three runways and whether the supplemental airport would have one or two runways. The feasibility of a three-airport system was also evaluated, with one supplemental airport to the north and another to the south, both of which would serve regional markets. The analysis included detailed site layouts for each of the supplemental airport sites under consideration. The following sites and configurations were assessed.[6]

- Existing Arlington Airport with runway extension
- Arlington Airport with a new runway
- Existing Paine Field
- Paine Field with a new runway
- Existing McChord AFB used jointly with military
- McChord AFB with a new runway used jointly with military
- Fort Lewis/Spanaway with one runway (including use of land east of Fort Lewis)
- Fort Lewis site with two runways (including land east of Fort Lewis)
- Olympia/Black Lake site with one runway
- Olympia/Black Lake site with two runways

A total of thirty-three options for five system alternatives were evaluated. These system alternatives and site specific options are outlined in Table B-1. Twenty-eight of the options pertain to the two or three airport multiple airport system alternatives. Other system alternatives in the evaluation included Sea-Tac options, the development of a replacement airport, and a Do-Nothing option.

The various options were evaluated based on the following considerations: operational/technical, economic/financial, institutional, and environmental. Operational and technical factors included runway capacity, airspace, and accessibility. Economic and financial considerations included capital costs, aircraft delay costs, funding, and economic impacts. Institutional considerations related to socio-political factors and the use of existing or new legislation to implement the recommendations. Finally, the environmental assessment considered noise impacts, air quality, wetlands impacts, and salmon stream impacts. It is important to note that while these assessments did involve site level data, the intent of the study was the evaluate *system level* alternatives, each of which included a number of site level options. Given this purpose, data collected at the site level was aggregated for each of the system level alternatives.[7]

Following the technical analysis, the PSATC developed a programmatic, non-project EIS. The EIS was directed toward *system* alternatives and deferred evaluation of specific sites to later work. The analyses,

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[5] Detailed information about each of the analyses is available in working papers of the Flight Plan Project: Working Paper #7, Airspace, Capacity, and Delay; Working Paper #9, Accessibility/Interaction with Other Modes; Working Paper #11, Capital Costs and Funding; Working Paper #8, Economic Benefits and Strategic Economic Issues; Working Paper #12A, Noise Assessment Study; Working Paper #12B, Air Quality Assessment; and Working Paper #12C, Wetlands Impacts and Salmon Stream Impacts.

[6] *Ibid.*, p. 26.

[7] Puget Sound Regional Council and Port of Seattle (1992) *Puget Sound Air Transportation Committee. The Flight Plan Project. Draft Final Report and Technical Appendices.*, p. 31.

public hearings, and Draft Programmatic EIS led to the PSATC's June, 1992 recommendation to PSRC and the Port of Seattle to develop a multiple airport system involving an expanded Sea-Tac and two supplemental airports. The PSRC received PSATC's recommendations but, based on other considerations, chose to endorse a third runway at Sea-Tac and a *single*, larger, supplemental airport as its preferred alternative. This decision and the *Feasibility Study of a New Major Supplemental Airport* (MSA Study) that resulted are discussed in the section to follow.

III. Major Supplemental Airport Study

The Puget Sound Regional Council's (PSRC) *Feasibility Study of a New Major Supplemental Airport* (MSA Study) is one of several study efforts that resulted from the outcome of the PSATC's 1991 *Flight Plan Project*. As discussed above, the PSATC identified the need for two small, supplemental airports and a third runway at Sea-Tac International Airport (Sea-Tac) as the preferred alternative for meeting the region's future commercial air transportation demands. After considering this recommendation, the PSRC adopted Resolution A-93-03 on April 29, 1993, endorsing a third runway at Sea-Tac and a single, larger supplemental airport. The resolution directed the Port of Seattle to study the addition of a third or new runway at Sea-Tac, and directed the PSRC staff to initiate the MSA Study. The MSA Study was to address the environmental, market, and economic factors relating to the feasibility of a major supplemental airport, building upon the work completed during the development of the 1991 *Flight Plan Project*. While the MSA Study did address specific sites, it was intended to be a feasibility analysis, not a site selection process.

The MSA Study commenced in 1994 with the establishment of the MSA Working Group, composed of representatives from the counties, the FAA, the Port of Seattle, the PSRC, professional associations, community interest groups, and other public and private entities. Phase One of the MSA Study consisted of site identification, development of site evaluation criteria, site evaluations, public and policy review of sites, and decision framework on acceptable sites.[8] Public involvement included stakeholder participation on the MSA Working Group, open meetings, the distribution of a public review information packet, public hearings, and a 24-hour hotline for questions and comments related to the supplemental airport site search.

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[8] See PSRC's *Working Paper 1: Site Screening Criteria*, *Working Paper 2*, and *Working Paper 3: Preliminary Airport Site Evaluation Summary* for more information concerning methodology.

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Table B-1

System Alternatives and Site-Specific Options Considered in Phase III of the Flight Plan Project

SYSTEM ALTERNATIVE	AIRPORT OPTIONS	
Sea-Tac Solutions	1	Sea-Tac without commuter runway
	2	Sea-Tac with commuter runway
Multiple Airport System with Two Airports	3	Option 1 & Arlington 1 RW
	4	Option 1 & Paine 1 RW
	5	Option 1 & McChord 1 RW
	6	Option 1 and Central Pierce (Ft. Lewis) 1 RW
	7	Option 1 & Olympia/Black lake 1 RW
	8	Option 1 & Arlington 2 RW
	9	Option 1 & Paine 2 RW
	10	Option 1 & McChord 2 RW
	11	Option 1 and Central Pierce (Ft. Lewis) 2 RW
	12	Option 1 & Olympia/Black Lake 2 RW
	13	Sea-Tac w/ Dependent RW & Arlington 1 RW
	14	Sea-Tac w/ Dependent RW & Paine 1 RW
	15	Sea-Tac w/ Dependent RW & McChord 1 RW
	16	Sea-Tac w/ Dependent RW and Central Pierce 1 RW
	17	Sea-Tac w/ Dependent RW & Oly/Black Lake 1 RW
	18	Sea-Tac w/ Dependent RW & Arlington 2 RW
	19	Sea-Tac w/ Dependent RW & Paine 2 RW
	20	Sea-Tac w/ Dependent RW & McChord 2 RW
	21	Sea-Tac w/ Dependent RW and Central Pierce 2 RW
	22	Sea-Tac w/ Dependent RW & Oly/Black Lake 2 RW
Multiple Airport System with Three Airports	23	Option 1 & Arlington 1 RW & C. Pierce 1 RW
	24	Option 1 & Paine 1 RW & C. Pierce 1 RW
	25	Option 1 & Arlington 1 RW & Oly/Blk Lake 1 RW
	26	Option 1 & Paine 1 RW & Oly/Blk Lake 1 RW
	27	Option 13 & Central Pierce 1 RW
	28	Option 14 & Central Pierce 1 RW
	29	Option 13 & Olympia/Black Lake 1 RW
	30	Option 14 & Olympia/Black Lake 1 RW
Replacement Airport	31	Central Pierce w/ 3 RW
	32	Olympia/Black Lake w/ 3 RW
	33	Fort Lewis w/ 3 RW
Do Nothing	34	Option 1 & Demand Management

With regard to site identification, the MSA Study considered a broader range of alternatives than the previous Flight Plan Project. Forty sites, listed below, were subject to initial site screening. Some of these were existing airports, while others were potential sites for the development of a new airport.

Samish Bay
Skagit Regional Bay Airport
Stanwood/Conway
Arlington Airport
Marysville West
Marysville East
First Air Airport
Campbell Airfield
Harvey Field
Bothell
Martha Lake Airport
Duvall
Redmond
Boeing Field
Renton (Boeing) Airport
Port Orchard Airport
Lake Sawyer
Enumclaw
Auburn Municipal Airport
Lake Tapps
Buckley
Thun Field
Shady Acres Airport
Spanaway
Bremerton National Airport
Gig Harbor
Tacoma Narrows Air
McChord AFB
Fort Lewis Gray Field
Kapowsin Airport
Frederickson
Harts Lake
Tanwax Lake
Vashon Island
Lacey
Olympia Airport
Tenalquot
Sunnydale

The initial screening criteria included the ability to accommodate a supplemental airport with a footprint of 2,140 acres; a maximum slope difference of 2% from one side of the site to the other; and the absence of physical obstructions such as hills, cliffs, or bodies of water.[9] Of the forty sites that underwent preliminary screening, fifteen were eliminated from further evaluation because they did not satisfy these requirements. Twenty-five sites were carried through to the next level of assessment. Again, some of the sites were existing airports, while others were potential sites for a new airport. These twenty-five sites are identified below:

Samish Bay
Stanwood
Marysville West
Bothell/Mill Creek
Redmond
Gig Harbor
Lake Tapps
McChord
Lacey
Spanaway
Harts Lake
Olympia
Sunnydale
Mount Vernon
Arlington
Marysville East
Duvall
Lake Sawyer
Enumclaw
Buckley
Thun
Fort Lewis
Frederickson
Tanwax Lake
Tenalquot

The next level of screening involved evaluation based on eight criteria: (1) market analysis; (2) instrument approach capability; (3) local airspace; (4) construction cost; (5) expansion potential; (6) noise impact; (7) predominant land cover; and (8) natural environment. Six of the twenty-five sites were eliminated from this stage of the analysis because they were located outside the four county jurisdiction of PSRC: Samish Bay, Mt. Vernon, Lacey, Olympia, Tenalquot, and Sunnydale.

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[9] Puget Sound Regional Council. *Major Supplemental Airport Feasibility Study. Working Paper Three: Preliminary Airport Site Evaluation Summary.* p.1.

Based on the evaluation of the remaining nineteen locations, a number of sites were eliminated from further consideration. Lake Tapps, Buckley, and Thun Field were eliminated due to instrument approach capability. Fort Lewis, Harts Lake, and Spanaway were removed due to airspace considerations. Finally, Gig Harbor was dropped due to construction costs.

Following this phase of the evaluation process, twelve sites remained as possible locations for a supplementary airport. Two of these were existing airports, while ten were sites for potential new airports:

Existing Airports
- Arlington
- McChord AFB

Potential New Airports
- Bothell/Mill Creek
- Duvall
- Enumclaw
- Frederickson
- Lake Sawyer
- Marysville East
- Marysville West
- Redmond
- Stanwood
- Tanwax Lake

The MSA Study's Working Paper Three, Preliminary Airport Site Evaluation Summary, provides an overview of PSRC's evaluation process, summary data for each of the twelve sites, and detailed data about each component of the analysis. An appendix to the working paper offers the FAA's perspective on airspace acceptability of the sites under consideration. The following site level summaries are drawn from PSRC's Working Paper Three and its appendices.

Working papers and other documents from the MSA are available through the Puget Sound Regional Council.

EXISTING AREA AIRPORTS

Arlington

Evaluation Summary[10/]

Site Area Access Analysis[11/]	16% of the Puget Sound Population
Instrument Approach Capability	Poor: *East Horizontal Surface Violated by 300'*
Airspace Acceptability	Fair: *Some Conflicts with Paine Field*
Construction Cost	+0%
Expansion Potential	Excellent: Up *to 14,000' for each runway, up to 6,000' runway separation*
Noise Impact	700 People in 65 Ldn Contour
Site Impacts: People, Schools, Hospitals on Site	1,800 People on Site
Natural Environment Impacts	
Acres of Wetlands	45
Miles of Fish Habitat Streams	2.3
Acres of Priority Habitat, Listed Species	124

10/ Puget Sound Regional Council (1994) *Public Review Packet: Major Supplemental Airport Feasibility Study Phase One -- Preliminary Site Screening Evaluation.*

11/ Percentage of Puget Sound population 10 minutes closer to the site than to Sea-Tac.

PSRC Findings:
"The Arlington site is located at the existing Arlington Municipal Airport. Use of the existing airport, relatively good access to I-5, and the generally flat nature of the site combine to make this the least expensive airport to construct. Arlington is also located in an area that provides excellent expansion potential, allowing for both a 14,000 foot runway and 6000 foot separation between runways. Preliminary evaluation of local airspace indicates that the Arlington site has good potential. The Arlington site...has limitations in access potential."[12]

FAA Findings:
The FAA's airspace evaluation indicated that Arlington had the potential to affect Whidbey. It is also possible that there would be an impact on Paine Field and Sea-Tac traffic. The FAA noted that traffic departing to the south and intending to proceed south might have to reverse course to the north until it is above Sea-Tac traffic. Finally, the terrain to the east of Arlington could prove to be a difficulty for the airport's traffic patterns.[13]

<u>McChord</u>

Evaluation Summary[14]

Site Area Access Analysis[15]	22% of the Puget Sound Population
Instrument Approach Capability	Excellent
Airspace Acceptability	Poor: Conflicts with Gray Airfield, Ft. Lewis MOA
Construction Cost	0%
Expansion Potential	Poor: Only Expansion is to the South
Noise Impact	4,600 People in 65 Ldn Contour
Site Impacts: People, Schools, Hospitals on Site	5,600 People, 1 School on Site
Natural Environment Impacts	
Acres of Wetlands	166
Miles of Fish Habitat Streams	4.1
Acres of Priority Habitat, Listed Species	196

PSRC Findings:
"This site is located in such a way as to use the existing McChord Air Force Base runway as the western of the two runways required for a Major Supplemental Airport. McChord has "Excellent" instrument approach capability and the second lowest construction cost increase due mostly to the presence of an existing runway that could be utilized. The proximity to Fort Lewis causes local airspace concerns due to both Gray Field and the Fort Lewis Military Operational Area. McChord has good access potential with approximately 22% of the Puget Sound population 10 minutes closer than to Sea-Tac. The location of McChord relative to the Tacoma population would impact approximately 10,200 people within the Ldn contour, and almost 5,600 people on the airport site itself."[16]

12/ Puget Sound Regional Council. *Major Supplemental Airport Feasibility Study. Working Paper Three: Preliminary Airport Site Evaluation Summary.* p.12.

13/ Puget Sound Regional Council. *Major Supplemental Airport Feasibility Study. Working Paper Three: Preliminary Airport Site Evaluation Summary. Appendix A: FAA Airspace Evaluation Comments.*

14/ Puget Sound Regional Council (1994) *Public Review Packet: Major Supplemental Airport Feasibility Study Phase One -- Preliminary Site Screening Evaluation.*

15/ Percentage of Puget Sound population 10 minutes closer to the site than to Sea-Tac.

16/ *Ibid.*, p.14-15.

FAA Findings:
According to the FAA, the McChord site does have potential airspace conflicts with Fort Lewis and possibly Sea-Tac. Further analysis would be required to determine how much additional capacity McChord could provide.[17]

POTENTIAL NEW AIRPORT SITES

Bothell/Mill Creek

Evaluation Summary[18]

Site Area Access Analysis[19]	31% of the Puget Sound Population
Instrument Approach Capability	Poor: East Horizontal Surface Violated by 100'
Airspace Acceptability	Poor: Conflicts with Paine Field, Some Conflicts with Sea-Tac
Construction Cost	+10%
Expansion Potential	Poor: East Runway May Be Expanded to 12,000'
Noise Impact	2,800 People, 3 Schools in 65 Ldn Contour
Site Impacts: People, Schools, Hospitals on Site	3,400 People on Site, 2 Schools on Site
Natural Environment Impacts	
Acres of Wetlands	92
Miles of Fish Habitat Streams	None
Acres of Priority Habitat, Listed Species	170 Acres, 1 Listed Species

PSRC Findings:
"The Bothell/Mill Creek site is located north of Bothell and immediately west of Mill Creek. This location is within the site search area that produced the highest market potential values of all the site search areas evaluated. This site is ten minutes closer than Sea-Tac to 31% of the Puget Sound population. This airport site is in the second most populated area studied, with more than 3,400 people currently living on the airport site alone. Other negatives of this site include "poor" instrument approach, local airspace acceptability, and expansion potential. Preliminary environmental analysis of the Bothell/Mill Creek site indicate the site apparently contains no fish habitat streams but contains a reported state 'candidate' wildlife species."[20]

FAA Findings:
The FAA confirmed PSRC's observation that airspace acceptability was a problem for this site, identifying conflicts with Sea-Tac, Paine Field, and the presence of high terrain east of the site.[21]

17/ Puget Sound Regional Council. *Major Supplemental Airport Feasibility Study. Working Paper Three: Preliminary Airport Site Evaluation Summary. Appendix A: FAA Airspace Evaluation Comments.*

18/ Puget Sound Regional Council (1994) *Public Review Packet: Major Supplemental Airport Feasibility Study Phase One -- Preliminary Site Screening Evaluation.*

19/ Percentage of Puget Sound population 10 minutes closer to the site than to Sea-Tac.

20/ Puget Sound Regional Council. *Major Supplemental Airport Feasibility Study. Working Paper Three: Preliminary Airport Site Evaluation Summary*, p. 13.

21/ Puget Sound Regional Council. *Major Supplemental Airport Feasibility Study. Working Paper Three: Preliminary Airport Site Evaluation Summary. Appendix A: FAA Airspace Evaluation Comments.*

Duvall

Evaluation Summary[22]

Site Area Access Analysis[23]	29% of the Puget Sound Population
Instrument Approach Capability	Fair: Area Hills, No Surface Violations
Airspace Acceptability	Good: Access to Site Restricted by Mountains
Construction Cost	+20%
Expansion Potential	None
Noise Impact	400 People in 65 Ldn Contour
Site Impacts: People, Schools, Hospitals on Site	900 People on Site
Natural Environment Impacts	
Acres of Wetlands	104
Miles of Fish Habitat Streams	0.2
Acres of Priority Habitat, Listed Species	121

PSRC Findings:
"The Duvall site is located Northwest of Duvall on a ridge above the Snoqualmie River valley. The Duvall site, like the Bothell/Mill Creek site, is located in a site search area with good access potential indicating 29% of the Puget Sound population is 10 minutes closer to this site than to Sea-Tac. The Duvall site does not impact as many people with only 900 people living on the site. Preliminary evaluation of the local airspace indicates the site would have only small potential for interfering with existing airports. Location on a ridge prohibits any expansion potential and increases construction costs significantly due to the amount of earthwork, rockwork, and access improvements which would be required. Duvall is potentially the most expensive site to construct indicating an approximately 20% increase in base construction costs."[24]

FAA Findings:
In contrast to PSRC's evaluation of local airspace at Duvall, the FAA held that the location was impractical from an airspace perspective, given conflicts with Paine Field and Sea-Tac, as well as the presence of high terrain east of the site.[25]

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[22] Puget Sound Regional Council (1994) *Public Review Packet: Major Supplemental Airport Feasibility Study Phase One -- Preliminary Site Screening Evaluation.*

[23] Percentage of Puget Sound population 10 minutes closer to the site than to Sea-Tac.

[24] Puget Sound Regional Council. *Major Supplemental Airport Feasibility Study. Working Paper Three: Preliminary Airport Site Evaluation Summary* .., p.13.

[25] Puget Sound Regional Council. *Major Supplemental Airport Feasibility Study. Working Paper Three: Preliminary Airport Site Evaluation Summary. Appendix A: FAA Airspace Evaluation Comments.*

Enumclaw

Evaluation Summary[26]

Site Area Access Analysis[27]	10% of the Puget Sound Population
Instrument Approach Capability	Fair: Mountains to the South and East
Airspace Acceptability	Fair: Access Limited by Mountains
Construction Cost	+10%
Expansion Potential	Good: Can be Expanded to North, West, and East
Noise Impact	300 People in 65 Ldn Contour
Site Impacts: People, Schools, Hospitals on Site	900 People, 1 School on Site
Natural Environment Impacts	
Acres of Wetlands	83
Miles of Fish Habitat Streams	None
Acres of Priority Habitat, Listed Species	92

PSRC Findings:
The Enumclaw site is located just east of Enumclaw and southeast of Auburn. This site has 'Good' expansion potential and relatively small noise impacts. The instrument approach and local airspace concerns are both 'Fair.' This site would have a 10% construction cost increase due almost entirely to the need to upgrade access for almost 17 miles. The site contains no identified fish habitat streams."[28]

FAA Findings:
The FAA had serious concerns about the airspace acceptability of this site, citing conflicts with Sea-Tac and high terrain.[29]

Frederickson

Evaluation Summary[30]

Site Area Access Analysis[31]	18% of the Puget Sound Population
Instrument Approach Capability	Poor: East Horizontal Surface Violated by 125'
Airspace Acceptability	Poor: Conflicts with Sea-Tac and McChord
Construction Cost	+5%
Expansion Potential	Good: Expandable North, East, and West
Noise Impact	600 People, 2 Schools in 65 Ldn Contour
Site Impacts: People, Schools, Hospitals on Site	2,300 People, 2 Schools on Site
Natural Environment Impacts	
Acres of Wetlands	29
Miles of Fish Habitat Streams	None
Acres of Priority Habitat, Listed Species	33

26/ Puget Sound Regional Council (1994) *Public Review Packet: Major Supplemental Airport Feasibility Study Phase One -- Preliminary Site Screening Evaluation.*

27/ Percentage of Puget Sound population 10 minutes closer to the site than to Sea-Tac.

28/ *Ibid.*, p. 14.

29/ Puget Sound Regional Council. *Major Supplemental Airport Feasibility Study. Working Paper Three: Preliminary Airport Site Evaluation Summary. Appendix A: FAA Airspace Evaluation Comments.*

30/ Puget Sound Regional Council (1994) *Public Review Packet: Major Supplemental Airport Feasibility Study Phase One -- Preliminary Site Screening Evaluation.*

31/ Percentage of Puget Sound population 10 minutes closer to the site than to Sea-Tac.

PSRC Findings:
"This site is located southeast of Spanaway adjacent to State Highway 7. The Frederickson site has good expansion potential and only a 5% increase over base construction costs. The access potential is also relatively good with 18% of the Puget Sound population 10 minutes closer to the site than to Sea-Tac. The local airspace acceptability is 'Poor' due to significant interference potential with both Sea-Tac and McChord. The site contains no fish habitat streams and is the lowest of all sites for acres of potential priority habitats and wetlands."[32]

FAA Findings:
The FAA concurred with PSRC that the Frederickson site had airspace acceptability problems. FAA noted conflict with Sea-Tac, McChord, the Fort Lewis Restricted Area, Mt. Rainier, and possibly the Kapowsin jump area.[33]

<u>Lake Sawyer</u>

Evaluation Summary[34]

Site Area Access Analysis[35]	5% of the Puget Sound Population
Instrument Approach Capability	Fair: Mountains North and South
Airspace Acceptability	Good: Access to Area Restricted by Mountains
Construction Cost	+10%
Expansion Potential	Fair: Can Extend Runways to 12,000', Increase Separation to 5,000'
Noise Impact	800 People and 1 School in 65 Ldn Contour
Site Impacts: People, Schools, Hospitals on Site	1,800 People on Site, 1 School on Site
Natural Environment Impacts	
Acres of Wetlands	39
Miles of Fish Habitat Streams	4.2
Acres of Priority Habitat, Listed Species	179

PSRC Findings:
"The Lake Sawyer site is located immediately west of Lake Sawyer near Black Diamond. This site provides some expansion potential and has good airspace acceptability. Mountains to the north, east, and south do not intrude into the minimum instrument approach slope, but are large enough to be of concern. This site ranks the lowest in access potential with only 5% of the Puget Sound population 10 minutes closer to this site than to Sea-Tac. Construction costs at this site are increased by the presence of two power lines that would need to be relocated, poor access, and significant earthwork requirements. The site contains a relatively low number of wetland acres, but is among the sites with the most miles of fish habitat streams."[36]

32/ Puget Sound Regional Council. *Major Supplemental Airport Feasibility Study. Working Paper Three: Preliminary Airport Site Evaluation Summary*, p. 14.

33/ Puget Sound Regional Council. *Major Supplemental Airport Feasibility Study. Working Paper Three: Preliminary Airport Site Evaluation Summary. Appendix A: FAA Airspace Evaluation Comments.*

34/ Puget Sound Regional Council (1994) *Public Review Packet: Major Supplemental Airport Feasibility Study Phase One -- Preliminary Site Screening Evaluation.*

35/ Percentage of Puget Sound population 10 minutes closer to the site than to Sea-Tac.

36/ Puget Sound Regional Council. *Major Supplemental Airport Feasibility Study. Working Paper Three: Preliminary Airport Site Evaluation Summary*, p. 14.

FAA Findings:
PSRC and the FAA had different perspectives on the airspace acceptability of this site. The FAA had serious concerns about Lake Sawyer's airspace acceptability, citing conflicts with Sea-Tac and high terrain.[37]

Marysville East

Evaluation Summary[38]

Site Area Access Analysis[39]	16% of the Puget Sound Population
Instrument Approach Capability	Fair: High Hills to North and East
Airspace Acceptability	Fair: Conflicts with Arlington and Paine Field
Construction Cost	+5%
Expansion Potential	Fair: Runways Can Be Extended to South, Separation Up to 6,000'
Noise Impact	300 People in 65 Ldn Contour
Site Impacts: People, Schools, Hospitals on Site	700 People on Site
Natural Environment Impacts	
Acres of Wetlands	185
Miles of Fish Habitat Streams	0.1
Acres of Priority Habitat, Listed Species	310

PSRC Findings:
"The Marysville East site is located east of Marysville and due north of Lake Stevens. The Marysville East site is unique to this study as it has no significantly positive points and no significantly negative points. This location has relatively minor construction cost increases due mostly to the need to construct additional roadway capacity from the site to I-5. Some expansion potential exits to allow increased runway separation, however, little room exists to lengthen runways due to the presence of mountains to the north which also limit the instrument approach capability of the site. Again, this site has limited access potential with...16% of the Puget Sound population 10 minutes closer to the site than to Sea-Tac. The site has a relatively high number of wetlands acres and potential priority habitats."[40]

FAA Findings:
The FAA indicated that the Marysville East site would have some impact on Whidbey, Paine Field, and Sea-Tac. Its airspace conditions are similar to those of Arlington.[41]

37/ Puget Sound Regional Council. *Major Supplemental Airport Feasibility Study. Working Paper Three: Preliminary Airport Site Evaluation Summary. Appendix A: FAA Airspace Evaluation Comments.*

38/ Puget Sound Regional Council (1994) *Public Review Packet: Major Supplemental Airport Feasibility Study Phase One -- Preliminary Site Screening Evaluation.*

39/ Percentage of Puget Sound population 10 minutes closer to the site than to Sea-Tac.

40/ Puget Sound Regional Council. *Major Supplemental Airport Feasibility Study. Working Paper Three: Preliminary Airport Site Evaluation Summary*, p. 13.

41/ Puget Sound Regional Council. *Major Supplemental Airport Feasibility Study. Working Paper Three: Preliminary Airport Site Evaluation Summary. Appendix A: FAA Airspace Evaluation Comments.*

Marysville West

Evaluation Summary[42]

Site Area Access Analysis[43]	16% of the Puget Sound Population
Instrument Approach Capability	Poor: West Horizontal Surface Violated by 400'
Airspace Acceptability	Fair: Conflicts with Arlington Municipal and Paine Field
Construction Cost	+5%
Expansion Potential	None
Noise Impact	800 People, 2 schools in 65 Ldn Contour
Site Impacts: People, Schools, Hospitals on Site	800 People on Site
Natural Environment Impacts	
Acres of Wetlands	75
Miles of Fish Habitat Streams	6.2
Acres of Priority Habitat, Listed Species	232

PSRC Findings:
"The Marysville West site is located just North and to the West of Marysville on the Tulalip Indian Reservation. The preliminary local airspace valuation indicates potential conflicts with Paine Field and Arlington Municipal. The proximity of Arlington Municipal would require the transfer of Arlington General Aviation operations to this site. The presence of hills immediately West of this site and the town of Marysville immediately East, limit the instrument approach capability and prohibit any potential expansion of this site. The access potential of the site is [limited, similar to Arlington and Stanwood]. The site is among the sites with the most miles of fish habitat."[44]

FAA Findings:
The FAA also recognized potential airspace difficulties at the Marysville West site, noting potential conflict with Whidbey and Paine Field.[45]

42/ Puget Sound Regional Council (1994) *Public Review Packet: Major Supplemental Airport Feasibility Study Phase One -- Preliminary Site Screening Evaluation.*

43/ Percentage of Puget Sound population 10 minutes closer to the site than to Sea-Tac.

44/ Puget Sound Regional Council. *Major Supplemental Airport Feasibility Study. Working Paper Three: Preliminary Airport Site Evaluation Summary*, p. 12.

45/ Puget Sound Regional Council. *Major Supplemental Airport Feasibility Study. Working Paper Three: Preliminary Airport Site Evaluation Summary. Appendix A: FAA Airspace Evaluation Comments.*

Redmond

Evaluation Summary[46]

Site Area Access Analysis[47]	29% of the Puget Sound Population
Instrument Approach Capability	Fair: Mountains and Radio Towers to South and West
Airspace Acceptability	Good: No Apparent Conflicts, Mountains Restrict Access
Construction Cost	+10%
Expansion Potential	Poor: Can Extend East Runway North to 12,000'
Noise Impact	500 People in 65 Ldn Contour
Site Impacts: People, Schools, Hospitals on Site	1,000 People on Site
Natural Environment Impacts	
Acres of Wetlands	187
Miles of Fish Habitat Streams	1
Acres of Priority Habitat, Listed Species	335

PSRC Findings:
"The Redmond site is located on the plateau east of Redmond. This site is within the same site search area as Duvall and has a good access potential. The Redmond site ranks as 'Good' in local airspace acceptability and has approximately 1,000 people on the site which is relatively low. As with Duvall, the expansion potential of this site is limited by the Snoqualmie River valley and the surrounding topography. Construction costs of this site would be relatively high due to access, drainage concerns, and earthwork. Mountains to the east and south of this site do not intrude on the minimum instrument approach slopes, but are significant enough to be of concern during inclement weather. The site apparently contains the highest number of wetland and potential priority habitat acres of all sites."[48]

FAA Findings:
As in the case of Duvall, the PSRC and the FAA came to different conclusions regarding local airspace at this site. The PSRC concluded that Redmond had "Good" airspace acceptability, as mentioned above, while the FAA deemed the site "impractical" given conflicts with Sea-Tac and Paine Field, as well as the presence of high terrain to the east.

46/ Puget Sound Regional Council (1994) *Public Review Packet: Major Supplemental Airport Feasibility Study Phase One -- Preliminary Site Screening Evaluation.*

47/ Percentage of Puget Sound population 10 minutes closer to the site than to Sea-Tac.

48/ Puget Sound Regional Council. *Major Supplemental Airport Feasibility Study. Working Paper Three: Preliminary Airport Site Evaluation Summary*, p. 14.

Stanwood

Evaluation Summary[49]

Site Area Access Analysis[50]	16% of the Puget Sound Population
Instrument Approach Capability	Poor: NE Horizontal Surface Violated by 350-750'
Airspace Acceptability	Poor: Conflicts with NAS Whidbey, Bayview Airport
Construction Cost	+5%
Expansion Potential	Good: Only Limit to Expansion is I-5 to the East
Noise Impact	100 People in 65 Ldn Contour
Site Impacts: People, Schools, Hospitals on Site	500 People on Site
Natural Environment Impacts	
Acres of Wetlands	182
Miles of Fish Habitat Streams	4.5
Acres of Priority Habitat, Listed Species	233 Acres, 1 Listed Species

PSRC Findings:
"The Stanwood site is located on the Northern border of Snohomish County adjacent to Interstate 5. This remote location results in several positive aspects to this site including low construction costs, good expansion potential, limited noise impact, and a small number of people living on the site at this time. The remote location does, however, significantly lower the access potential of the site with only 16% of the Puget Sound population more than 10 minutes closer to this site than Sea-Tac. Mountains to the east and Whidbey Island Naval Station to the Northwest limit the viability of this site by both instrument approach and airspace concerns. Preliminary environmental analysis of the Stanwood site indicate that it has among the highest numbers of wetland acres, miles of fish habitat streams, and potential priority habitats. These is a state and federal 'threatened' species reported on the site."[51]

FAA Findings:
FAA's evaluation of local airspace indicated that Stanwood could have a serious impact on NAS Whidbey operations, and some conflict with Bellingham and Canadian air traffic.[52]

[49] Puget Sound Regional Council (1994) *Public Review Packet: Major Supplemental Airport Feasibility Study Phase One -- Preliminary Site Screening Evaluation.*

[50] Percentage of Puget Sound population 10 minutes closer to the site than to Sea-Tac.

[51] Puget Sound Regional Council. *Major Supplemental Airport Feasibility Study. Working Paper Three: Preliminary Airport Site Evaluation Summary*, ; p. 12.

[52] Puget Sound Regional Council. *Major Supplemental Airport Feasibility Study. Working Paper Three: Preliminary Airport Site Evaluation Summary. Appendix A: FAA Airspace Evaluation Comments.*

Tanwax Lake

Evaluation Summary[53]

Site Area Access Analysis[54]	17% of the Puget Sound Population
Instrument Approach Capability	Fair: Mountains to South and West
Airspace Acceptability	Fair: Conflict with McChord AFB
Construction Cost	+10%
Expansion Potential	Good: No Site Limitations, Mountains Limit Runway Extension to South
Noise Impact	50 People in 65 Ldn Contour
Site Impacts: People, Schools, Hospitals on Site	250 People on Site
Natural Environment Impacts	
Acres of Wetlands	78
Miles of Fish Habitat Streams	None
Acres of Priority Habitat, Listed Species	77

PSRC Findings:
"This site is located south of Spanaway, northwest of the junction of State Route 702 and State Route 7. The access potential is similar to Frederickson with a value of 17%. This site impacts the fewest people with only approximately 300 people within the Ldn contour. The base construction cost would increase by approximately 10% due entirely to the remote location and the need to construct new access. Preliminary local airspace evaluation indicates some potential for interference with McChord and Sea-Tac. The site contains no fish habitat streams."[55]

FAA Findings:
FAA concurred that Tanwax Lake had a potential airspace conflict with Sea-Tac and McChord, as well as the Fort Lewis Restricted Area, Mt. Rainier, and possibly the Kapowsin jump area.[56]

On July 29, 1994 the Working Group characterized six sites as favorable and six as less favorable. These are identified below.

Favorable Sites
- Arlington
- Marysville East
- Duvall
- Redmond
- McChord
- Tanwax Lake

Less Favorable Sites
- Stanwood
- Marysville West
- Bothell/Mill Creek
- Lake Sawyer
- Enumclaw
- Frederickson

53/ Puget Sound Regional Council (1994) *Public Review Packet: Major Supplemental Airport Feasibility Study Phase One -- Preliminary Site Screening Evaluation.*

54/ Percentage of Puget Sound population 10 minutes closer to the site than to Sea-Tac.

55/ Puget Sound Regional Council. *Major Supplemental Airport Feasibility Study. Working Paper Three: Preliminary Airport Site Evaluation Summary*, p. 15.

56/ Puget Sound Regional Council. *Major Supplemental Airport Feasibility Study. Working Paper Three: Preliminary Airport Site Evaluation Summary. Appendix A: FAA Airspace Evaluation Comments.*

CONCLUSIONS

The recommendations of the Working Group were presented to the PSRC Policy Board, that determined only three sites be forwarded to the PSRC's Executive Board. These sites included:

- **Arlington**
- **Marysville East**
- **Tanwax.**

The Executive Board, in response to the evaluation process, policy alternatives, and public opposition, issued Resolution EB-94-01 on October 27, 1994, concluding there were no feasible sites for a major supplemental airport in the Central Puget Sound Region and directed the PSRC staff to discontinue further study. Consequently, the PSRC did not proceed with the Phase Two, MSA Study, which would have involved detailed planning and assessment of the identified sites.

Working papers from the MSA are available throughout the Puget Sound Regional Council.

IV. RAIL PLANNING

The following summarizes the efforts that have been conducted to evaluate alternative use of rail to satisfy transportation demands in Washington State.

1. Intercity Rail Passenger Program

This program was established by the State in 1990 with the authorization of $41 million in funds to conduct passenger rail studies and provide for improved conventional rail passenger services. The studies included an evaluation of true high speed rail service (speeds above 150 mph) in the I-5 corridor between Portland, Oregon and Vancouver, British Columbia and a possible link to eastern Washington. A second study was authorized, called the "Gap Study,"[57] to evaluate train service between Portland, Oregon and Vancouver, British Columbia utilizing new train technology that can achieve speeds between 79 mph and 150 mph. Program funding for new conventional services has supported improving rail station facilities, additional train frequency, safety improvements, and re-establishment of service to Vancouver, B. C.

2. High Speed Ground Transportation, Train Speeds Above 150 mph

Between 1991 and 1992, the WSDOT and the High Speed Ground Transportation Steering Committee completed a comprehensive feasibility assessment of high speed rail service. This assessment was undertaken because of the growing congestion levels within the state's main highway travel corridors and air transportation system. The High Speed Ground Transportation Study (HSGT)[58] focused on economic, environmental, and institutional issues. Selection of an advanced train technology was not a focus of the study, although such technologies were reviewed by the Steering Committee.

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[57] *Statewide Rail Passenger Program, Passenger Train Speed Increases to Maximums Higher then 79 MPH, Working Paper Number 1 through 3*, Washington State Department of Transportation, Wilbur Smith Associates, 1992. These studies are incorporated by reference and are available through WsDOT.

[58] *High Speed Ground Transportation Study*, Washington State Department of Transportation, Gannett Fleming, Inc., 1992. This study is incorporated by reference and is available through the WsDOT.

The Steering Committee identified several study findings of importance to Sea-Tac Airport, including:

- Existing air and highway modes are facing growing congestion;
- HSGT must be integrated with other transportation modes, including transit;
- The North-South (N-S) corridor between Everett, WA and Portland, OR offers the best near-term opportunity for HSGT;
- The East-West corridor between Seattle and Spokane offers the best long-term opportunity to utilize the speed advantages of new technology;
- Ridership potential exists in the N-S corridor for true high speed service, based on travel surveys, general travel demand model, and socio-economic market data;
- The 334 mile N-S corridor is estimated to cost between $9.03 and $11.95 billion, while the 256 mile East-West corridor is estimated to cost between $5.5 and $7.3 billion; and
- Most ridership came from attracting travelers who would otherwise travel by auto or bus.

Cost estimates were based upon a high speed corridor located east of the I-5 corridor and entering Central Puget Sound east of Lake Washington and the city of Bellevue. Estimates would be higher if rights-of-way and supporting facilities would traverse the urbanized core of the region.

The committee identified seven conclusions affecting airports and intermodal connections:

- HSGT <u>does not</u> obviate the need for continued improvements and expansion of the airport system;
- HSGT has the potential for reducing short-haul air commuter trips, but the greatest impacts are beyond the current year 2020 planning horizon;
- HSGT will not have a significant impact on out-of-state air travel in the foreseeable future;
- Speed, travel time, and topography present serious concerns about the ability of the Moses Lake Airport connection to serve out-of-state passenger travel to and from Central Puget Sound;
- Implementation of a regional multiple airport system in the N-S corridor could impact HSGT ridership raising operational issues for future study;
- HSGT planning should examine the need to serve any supplemental airport; and
- HSGT is currently not envisioned to serve the existing regional airport facility.

Two general study conclusions were drawn by the Oversight Committee:

- The development of a competitive third mode of intercity travel is a must if the economic growth and quality of life in the state are to be maintained and
- Implementation of such a system will require a long lead time to develop and fund.

A phased approach to implementation was recommended to occur between 1993 and the 2020. This approach is to include further study of the HSGT opportunities, a coordinated planning approach with Oregon and British Columbia, improvements to existing rail rights-of-way for existing rail service, introduction of new higher speed conventional technologies to improve existing train speeds, cooperative work arrangements with the railroads to improve freight and passenger movements, and designation of the Northwest Rail Corridor as a federal high speed rail demonstration area.

3. "Gap Study", Train Speeds Between 79 mph and 150 mph

This study was authorized to evaluate train operations, track conditions, and ridership potential in the N-S corridor for trains operating at speeds of 79 mph and 150 mph. The study was completed in conjunction with the Burlington Northern Railroad, Amtrak, and the Departments of Transportation for Washington and Oregon.

The study defined the engineering standards for higher speed rail service within the N-S corridor. It also described the potential rolling stock that could be used with the existing track geometry and right-of-way. The analysis also provided for a segment-specific track speed evaluation to determine locations for improvements and regulatory changes. In addition, rights-of-way relocation was examined, such as the Tacoma Bypass and Nisqually connection, was examined in the urbanized areas. The Gap Study analysis determined that train speeds above 125 mph would require significant changes in track geometry and extensive new rights-of-way and should not be pursued as an alternative. Train service speed goals above 125 mph should be part of any future true high speed rail program.

The introduction of higher speed train service on the existing mainline railroads will produce some inherent constraints due to the mix of freight and passenger service operations requirements. Freight trains operate at significantly slower speeds, with top speeds currently at 60 mph. Because freight trains are heavier than passenger trains, they place additional weight on the inside rail, creating significant wear and increased maintenance costs. The difference in train speeds also creates a greater need for track capacity and sidings than if all trains operated at approximately the same speed. In addition, the lack of existing parallel rail lines in this corridor restricts the potential for transferring freight trains to other rail lines. The study concluded that little can be done to alter freight train schedules within current system capacity and regulatory limitations.

Trip-time calculations within the N-S corridor were based upon the industry train performance model. The schedule assumed a 2.5 hour average trip between Seattle and Portland and a trip of under 3.0 hours from Seattle to Vancouver, B.C., including time to clear U.S. and Canadian customs. The performance model indicated that nearly 68 percent or 126 miles of track of the N-S route would accommodate speeds in excess of 90 mph. Using diesel tilt train technology, this would permit a travel time of approximately 2 hours and 21 minutes. Based upon improved travel times and service frequency there was found to be a potential for higher rail ridership. This ridership would come primarily from highway diversions and pleasure travelers. These findings reflect the conclusions for true high speed service.

The Seattle-Portland corridor would require an estimated investment of $356.6 million in right-of-way and facilities for higher speed service, including $119.4 million for third main line development. The Seattle-Vancouver segment would require an estimated $113.9 million for improvements. These costs are significantly less than the estimates for true high speed operations because extensive new rights-of-way, grade separation, and electrification are not required.

4. Current Intercity Rail Passenger Program

Current intercity rail passenger service is operated through the State of Washington by Amtrak. The Empire Builder, operates one train per day, providing service between Seattle and Spokane. The Coast Starlight and Mount Rainier trains operate one train each between Seattle and Portland daily. Three times per week the Pioneer runs between Portland and Seattle. Between April and September 1994, an additional train demonstrating the new Talgo 200 train technology was added to the Seattle and Portland schedule. This Talgo Project is described below.

Ridership on the existing service has held steady over the past several years. During the federal fiscal year of October 1992 to September 1993, over 569,200 boardings occurred in the Seattle to Portland segment of the corridor. Seattle accounted for 258,911 boardings, while Portland had 140,981 boardings for the period. The corridor has been averaging over 500,000 boardings a year for the total period.

The introduction of new service frequencies and equipment will provide additional opportunities for ridership growth. This growth will require the continued involvement of the State in providing additional support for rail service. Federal policy support for Amtrak service is stronger now than any time over the last 12 years, but financial constraints will hamper development of any new service. The present Amtrak two year budget authorization proposal contains less operating funds and is described as a "bare bones" budget for 1995. Amtrak's $400 million capital and $337 million operating budget requests are currently proposed to be funded at $32 million less than the requested amount. The $270 million budget request for improvements to the Northeast Corridor were eliminated from the budget proposal.

The State determined that an incremental approach to improving rail service for intercity travel was appropriate and cost effective. WSDOT was directed by the Legislature to identify a passenger rail program, including funding requirements, that would fulfill the State's commitment to providing a reliable third mode of travel. To support this effort, $240 million was authorized to improve service speeds and frequency, re-establish service to Vancouver, B. C., improve safety, and introduce new technology to the corridor. Working cooperatively with Amtrak and the Burlington Northern, the State has proceeded with this program.

WSDOT has identified a ten-year investment program for statewide rail passenger service. This program is being funded within the legislative biennial appropriations process and the six-year Transportation Commission funding plan. Total estimated cost for the program is $638.6 million.

A long-term passenger rail program is being developed as an element of the Statewide Multi-Modal Transportation Plan. This element establishes passenger program service objectives and a 20 year investment strategy. To implement this strategy, it is estimated that $802 million will be needed to meet intercity rail passenger service objectives for the period. The service objectives include: improvements to 14 intermodal facilities statewide, 7 daily round trips from Seattle to Vancouver, B. C., and 14 daily round trips between Seattle and Portland.

5. Talgo 200 Demonstration Project

As part of the State's program to improve intercity rail passenger service and provide for a viable third mode of travel in the N-S corridor, the WSDOT established a demonstration project to introduce new train technology. The Talgo 200 demonstration project added new train service to the Seattle-Portland corridor and provided for an evaluation of the state's role in sponsoring train service.

The trainset is a passive tilt system that adjusts to maintain passenger comfort through curves at increased operating speeds of up to 125 mph. Because of track and speed limitations in the N-S corridor, the train did not operate above 79 mph. The trainset consist of two power cars, one dining car, one bistro car, and eight coach cars. Train capacity is 198 passengers and meets American with Disabilities Act standards. The Talgo schedule offered round trip daily service leaving Seattle at 11:30 a.m. and arrived in Portland at 3:25 p.m. The northbound train departed Portland at 6:00 p.m. and arrived in Seattle at 9:55 p.m. Upon expiration of the lease, regular Amtrak equipment replaced the Talgo 200.

The WSDOT leased a Spanish Pendular Talgo 200 trainset for operation between Seattle and Portland during a 6 month period in 1994 at a cost of $527,000.00. During the lease period, train revenues exceeded projected costs of $810,000 as ridership exceeded expectations. Over 33,000 passengers traveled on the Talgo train during the four months, April to July 1994, period. The train served the communities of Seattle, Tacoma, Olympia/Lacey, Centralia, Kelso, Vancouver, and Portland. The 198-seat train operated at 82 and 72 per cent of capacity during April and May, respectively. The Talgo's weekend runs were nearly sold out, but the Monday, Tuesday, and Wednesday runs had available space.

Ridership is up for the whole Northwest corridor. The added frequency of the Talgo service increased overall corridor rail ridership.

V. MASTER PLAN UPDATE DOCUMENTS

The following Master Plan Update reports were prepared by the Port of Seattle:

1. Technical Report Number 1 Final Work Scope
2. Technical Report No. 2 Market Research Results
3. Technical Report No. 3 Planning History and Study Relationships
4. Technical Report No. 4 Facilities Inventory
5. Technical Report No. 5 Preliminary Forecast Report
6. Technical Report No. 6 Airside Options Report
7. Technical Report No. 7A Terminal Options Report
8. Technical Report No. 7B Landside Options Report

All of these documents have been placed on file at the following locations:

Port of Seattle, Project Office, Room MT 6434, Terminal Building Mezzanine Level, Sea-Tac Airport
Puget Sound Regional Council, Information Center, 216-1st Avenue, Seattle
Boulevard Park Library, 12015 Roseberg South, Seattle
Burien Library, 14700-6th SW, Burien
Des Moines Library, 21620-11th South, Des Moines
Federal Way Library, 34200-1st South, Federal Way
Foster Library, 4205 South 142nd, Tukwila
University of Washington, Suzallo Library, Government Publications, Seattle
Valley View Library, 17850 Military Road South, SeaTac

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APPENDIX F

STREAM SURVEY REPORT FOR MILLER CREEK

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Appendix F
SEA-TAC AIRPORT MASTER PLAN UPDATE FINAL EIS

STREAM SURVEY REPORT FOR MILLER CREEK

Prepared for:

Port of Seattle

Prepared by:

Scott Luchessa
Shapiro and Associates, Inc.
1201 Third Avenue, Suite 1700
Seattle, Washington 98101

April 1995

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TABLE OF CONTENTS

List of Tables

List of Figures

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SUMMARY

Shapiro and Associates, Inc. (SHAPIRO) field verified a level I stream survey for Miller Creek (Figure 1) that was conducted by the Des Moines Salmon Chapter of Trout Unlimited (Trout Unlimited). The purpose of this study was to verify the Trout Unlimited information within the study reach (about river mile 2 to river mile 3.3) and supplement this information to document existing fish habitat conditions for the Seattle-Tacoma International Airport Master Plan Update Draft EIS. The study reach is in a third order section of Miller Creek. In general, Trout Unlimited accurately classified existing habitat conditions; however, SHAPIRO's assessment was inconsistent with some of the habitat classifications and pool quality index ratings assigned by Trout Unlimited.

The structural diversity, complexity, and quality of resident and anadromous fish habitat in Miller Creek has been degraded by urbanization. Stream habitat is primarily composed of fast-water habitats including runs, glides, and low-gradient riffles. Although some suitable salmonid spawning gravels exist, these areas are limited within the study reach. There are few high quality pools, which are important over-wintering habitats that provide refuge for fish during high-flow events. Residential development has encroached on Miller Creek; removing native, streamside vegetation and reducing large organic debris recruitment and formation of debris jams. For these reasons, there is generally a lack of (1) instream and overhead cover, (2) available low- and high-flow habitat, and (3) available spawning habitat. These conditions appear to limit the ability of Miller Creek to support substantial populations of anadromous and resident salmonids or nongame fishes native to the region.

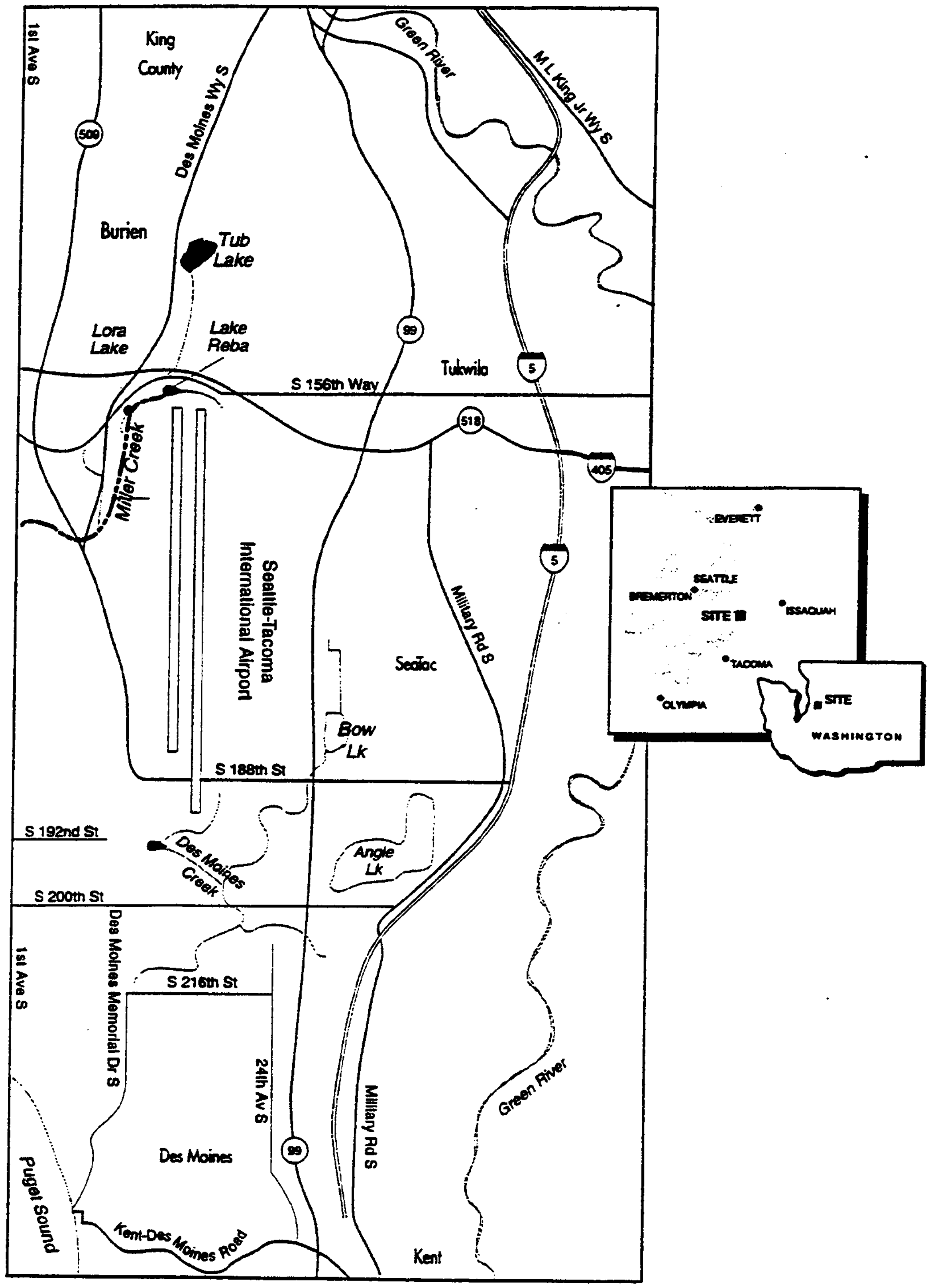
Several corrugated metal pipes (cmp) and concrete box culverts within the study reach appear to be potential barriers to upstream passage of anadromous and resident salmonids. Some of these are seasonal barriers during high or low flow conditions whereas others appear to be impassable under all conditions. Potential barriers to anadromous and resident fish include cmp and box culverts at First Avenue S., S. 160th Street, and SR 509. In addition, there is an 8-foot waterfall about 0.2 mile upstream of S. 160th Street, which is expected to be impassable. Seasonal and year around barriers to upstream fish passage limit the availability of upstream habitat to anadromous and resident salmonids.

There are few prominent morphological features, such as eroding banks, landslides, slumps, or debris jams in the study reach. Seven notable landslides or eroding banks were observed during the verification survey. Of these, two appeared to be recent and unstable. The other five were older and appeared to be stabilized by streamside vegetation. These eroding areas do not appear to be significant sources of sediment to the creek.

Few large, woody debris jams and little, woody debris exists within the study area. The absence of these important structural elements appears to limit the availability of high-quality pools and suitable low- and high-flow fish habitat.

Resident salmonids and other fish were observed throughout much of the reach. Salmonids, probably resident cutthroat (*Oncorhynynchus clarki*), were observed below First Avenue S. and up to the waterfall about 0.2 mile upstream of S. 160th Street. Other fish , possibly pumpkinseed sunfish (*Lepomis gibbosus*), were observed in glides and runs dominated by silt and sand substrate, upstream of 8th Avenue S. and up to Lake Reba.

Observations of aquatic invertebrates were limited to areas with coarse-textured gravels and cobble. A few species of mayflies, caddis flies, and black flies were relatively abundant in such substrate found in riffles and runs below First Avenue S. Upstream of First Avenue S. finer silts and sands were predominant in the streambed. Invertebrate community structure in these finer substrates appeared to consist primarily of midges and worms.



N

0 2000 4000
Scale in Feet
(approximate)

SHAPIRO & ASSOCIATES INC

LEGEND:

- Lakes
- Streams
- Study Reach

FIGURE 1

SITE LOCATION

SEA-TAC AIRPORT MILLER CREEK
STREAM STUDY

4/95

The study reach could benefit from enhancing or creating low- and high-flow habitat. Hydraulic analysis would be required to determine appropriate locations for creation of scour pools and placement of instream structures, including large woody debris. Enhancing existing and creating new low- and high-flow refugia would improve the availability and quality of these habitats.

METHODS

A level I King County stream survey was conducted from the mouth of Miller Creek upstream past SR 518 in 1993 by members of Trout Unlimited. The results of this survey (i.e., within the study reach) are presented in Attachment A. Approximately 4.5 miles of Miller Creek were evaluated in the survey. Trout Unlimited surveyed the study reach segment between March and June 1993. In late June and early July 1994, SHAPIRO conducted a survey of a segment of Miller Creek to verify the analysis of Trout Unlimited. A fish habitat relationship (FHR) methodology developed by the U.S. Forest Service[1] and modified by King County Surface Water Management was used in the SHAPIRO survey.[2]

SHAPIRO personnel verified Trout Unlimited habitat classifications from the confluence of the Lake Burien tributary (WRIA 0354) at about river mile (RM) 2 to Lake Reba (about RM 3.3), a total length of about 1.3 miles. SHAPIRO staff identified the habitat units and compared their classifications with those of Trout Unlimited. Areas in which there were inconsistencies between SHAPIRO and the Trout Unlimited habitat classifications are summarized and cross referenced to Trout Unlimited data sheets (Attachment A). Habitat types and characteristics of these habitat units within the study reach are summarized in this report.

In addition to verifying the Trout Unlimited survey data over an approximately 1.3-mile length of Miller Creek, SHAPIRO supplemented the habitat survey by:

- Creating a photographic record of existing conditions and distinguishing features including landslides, slumps, prominent debris jams, and potential barriers to fish passage (Attachment B);
- Documenting the locations of photographs and distinguishing features by cross-referencing them to habitat unit references in the Trout Unlimited survey (Attachment A);
- Estimating the areal extent of sediment sources, such as eroding streambanks;
- Identifying potential limitations and significant habitat, which are not clearly distinguishable from the Trout Unlimited survey;
- Recording observations of fish and aquatic invertebrates; and
- Identifying potential mitigation opportunities.

The results of the habitat survey verification and supplementary study performed by SHAPIRO is summarized in the following paragraphs.

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[1] *Stream Habitat Classification and Inventory Procedures for Northern California.* McCain, M., D. Fuller, L. Decker, and K. Overton. U.S. Department of Agriculture, Forest Service, Pacific Southwest Region, 1990.
[2] *Stream Survey Report Criteria.* King County Building and Land Development Division (now Department of Development and Environmental Services), 1991.

RESULTS AND DISCUSSION

In general, Trout Unlimited accurately identified stream and riparian habitat in the 1.3-mile study reach. There were a few areas; however, in which there were inconsistencies between Trout Unlimited and SHAPIRO classifications. These areas, identified in Table 1, and the potential sources of inconsistency are described as follows.

Table 1: INCONSISTENCIES BETWEEN TROUT UNLIMITED AND SHAPIRO HABITAT TYPE CLASSIFICATIONS

Reference No.*	Date	Trout Unlimited Classification	SHAPIRO Classification
23	4/24/93	trench/chute	low gradient riffle
27	4/24/93	cascade	plunge and dammed pools
32	4/24/93	run	low gradient riffle
8	5/15/93	glide	run
16	5/15/93	corner pool	channel confluence pool
19-23	5/15/93	plunge pool	dammed pool
37	5/15/93	pocket water	glide or run
47-49	5/15/93	corner and mid-channel pools	plunge pools
54-56	5/15/93	glide	run
32	5/29/93	mid-channel pool	glide or trench chute
4	6/20/93	dammed pool	glide
6	6/20/93	mid-channel pool	glide
8	6/20/93	mid-channel pool	glide

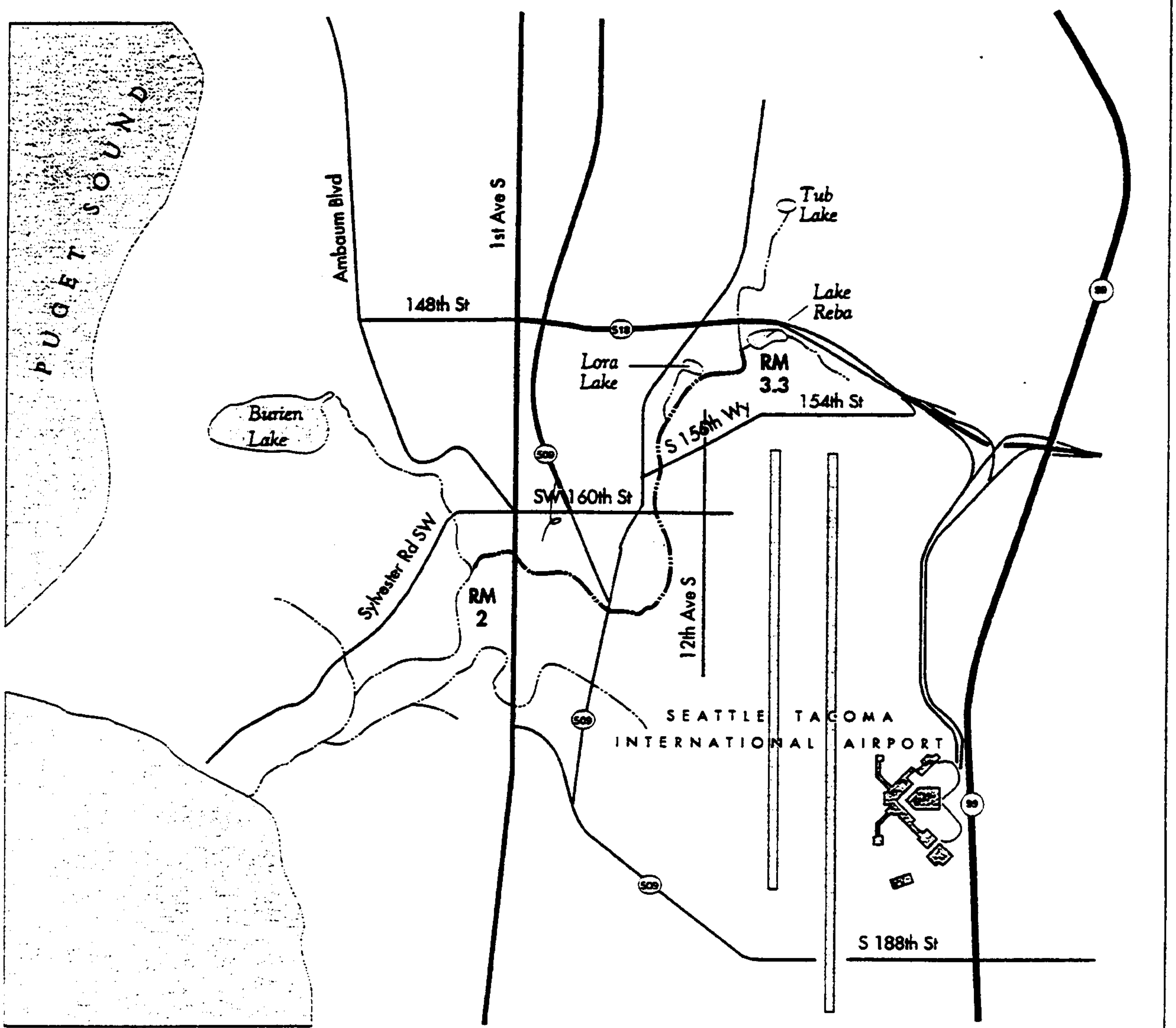
*Reference numbers and dates are those identified on the Trout Unlimited inventory data forms (Attachment A).

Source: Shapiro and Associates, Inc. 1995

Habitat classification is a somewhat subjective and occasionally imprecise practice. Classification can vary depending on flow conditions at the time of an inventory and experience of inventory personnel. A recent study of observer variation in the classification of primary and secondary habitat types concluded that consistency decreases among observers when using a complex classification system.[3] Some of the inconsistency between the Trout Unlimited and SHAPIRO habitat classifications are due to differences in flow conditions at the time of these surveys. Some of Trout Unlimited's survey was conducted following storm events. Other differences may involve the application of the FHR method by Trout Unlimited inventory personnel. Another potential explanation for such inconsistency is that habitat conditions have changed in some areas between the time the Trout Unlimited inventory was conducted and this field verification. The last two cases in Table 1, for example, may be a result of changing substrate conditions. At the time of the verification, there was no evidence of scouring in the middle of the channel. Other than those exceptions noted above, Trout Unlimited habitat classifications were generally consistent with those determined in the 1994 survey.

The Trout Unlimited survey indicates that habitat in the study reach between the Burien Lake tributary and Lake Reba (Figure 2) is primarily composed of fast-water habitats (Table 2) that provide some feeding and rearing opportunities for fish. There are seven fast-water habitat types

[3]Observer variability in classifying habitat types in stream surveys. Roper, B.R. and D.L. Scarnecchia. *North American J. of Fisheries Management.* 15: 49-53, 1995.



LEGEND
Study Reach
RM River Mile

0 .5 1 Mile
0 .5 1 Kilometer

SHAPIRO & ASSOCIATES INC.

FIGURE 2

MILLER CREEK FISH HABITAT SURVEY

SEA-TAC AIRPORT MPU
ENVIRONMENTAL IMPACT STATEMENT

4/95

in the study reach, including low-gradient riffles, runs, step runs, glides, pocket water, trench chute, and cascade (Table 3). Although one unit each was classified as pocket water and cascade, respectively, these were not confirmed during SHAPIRO's verification; these units were classified as glide and a series of dammed and plunge pools, respectively. In general, fast-water habitat is composed of long, relatively shallow riffles, glides, and runs that are separated by small, shallow pools. Many riffles, runs, and glides have substrates of silt and sand (Attachment A) that are unsuitable for spawning by resident or anadromous salmonids. In addition, silt and sand particles provide no instream cover for juvenile or adult fishes. Gravels suitable for coho salmon spawning are limited to riffles below First Avenue S. Areas suitable for cutthroat trout spawning are scattered in small patches between S. 156th Way and First Avenue S. (see Figure 2). Fast-water habitat units, which are generally less than a foot deep, are most suited to feeding and rearing activities.

Table 2: GENERAL HABITAT CATEGORIES IN MILLER CREEK STUDY REACH (RM 2.0-3.3) AND PERCENT OF TOTAL STREAM AREAS AND VOLUME

General Habitat Type	Percent of Total Stream Area	Percent of Total Stream Volume
Fast-water Habitats		
Riffles, Runs, Glides	72%	56%
Slow-water Habitats		
Pools	28%	44%

Source: Des Moines Salmon Chapter of Trout Unlimited, 1993.

Table 3: SUMMARY OF HABITAT TYPES INVENTORIED ALONG MILLER CREEK STUDY REACH (Tributary 0354 to Lake Reba)

Habitat Type	Number Observed	Mean Habitat Length (ft)	Range Habitat Length (ft)	Mean Habitat Width(1) (ft)	Range Habitat Width(1) (ft)	Mean Habitat Depth (ft)	Range Habitat Depth (ft)	Mean Habitat Surface Area (ft^2)
Riffles								
Low-gradient Riffles	67	49.5	10 - 200	10.1	4.3 - 21.0	0.4	0.1 - 0.7	529
Runs	27	55.5	24 - 143	8.8	4.0 - 16.5	0.8	0.5 - 1.4	466
Step Runs	6	70.2	28.4 - 165	11.8	6.0 - 17.0	0.6	0.5 - 0.7	743
Glides	61	69.1	1.3 - 590	9.6	4.5 - 20.0	0.9	0.5 - 2.0	658
Pocket Water	1	35.0	NA	9.7	NA	0.9	NA	340
Trench Chute	1	74.0	NA	12.0	NA	1.4	NA	888
Cascade	1	86.0	NA	17.0	NA	1.5	NA	1,462
Pools								
Corner	20	37.7	9 - 194	19.0	6.0 - 18.3	1.4	0.5 - 1.8	453
Backwater	1	33	NA	19.0	NA	1.4	NA	627
Lateral Scour	9	27.2	19 - 42	7.5	4.0 - 11.6	1.4	0.9 - 2.5	451
Mid-channel	9	36.3	12 - 107	10.6	8.0 - 14.0	1.6	1.4 - 2.0	417
Plunge	13	41.0	10 - 99.5	16.4	7.0 - 25.0	1.5	0.9 - 5.0	676
Dammed	9	78.4	1.8 - 300	16.0	10.0 - 25.0	1.3	0.7 - 2.0	1,397

[1]Width is of wetted perimeter of stream.

Source: Des Moines Salmon Chapter of Trout Unlimited, 1993.

In addition to fast-water habitats, there are six types of pools that provide slow-water habitats. Five of these; corner, backwater, lateral scour, plunge, and dammed pools were observed in the study reach. Corner, lateral scour, plunge and dammed pools are the most common pool habitat types (Table 4). Nine pool habitat units were identified by Trout Unlimited as mid-channel pools. During the verification, SHAPIRO classified all of these units as glides or runs based on the absence of scouring associated with mid-channel pools. With a few exceptions, pool habitats are relatively shallow, filled with sand and silt, and lack instream cover. Maximum water depths are infrequently greater than 3 feet.

Table 4: SUMMARY OF POOL HABITAT QUALITY IN MILLER CREEK STUDY REACH (RM 2.0 - 3.3)

Pool Type	Number of Pools with a PQI[1] Rating of:					Total Number	Number of Pools Formed By:	
	1	2	3	4	5	of Pools[2]	LWD	Debris Jam
Lateral Scour	0	3	1	0	0	8	7	0
Mid-channel[4]	0	3	1	3	1	8	0	0
Corner	0	11	3	4	0	20	0	0
Backwater	0	0	1	0	0	1	0	0
Plunge	0	3	2	4	2	13	0	0
Dammed	0	1	1	4	1	9	2	0
Total	0	21	10	13	4	48	9	0
Percent of Total[3]	0	44	21	27	8	100	19	0

[1]Pool Quality Index (PQI) Source: Platts, et al., 1987.

[2]In some cases, not all pools that were classified received a rating (i.e., PQI). For example, eight lateral scour pools were observed; four were rated, and four were not rated.

[3]Percent of the total number of pools that were rated.

[4]SHAPIRO classified all these habitat units as glides or runs.

Source: Des Moines Salmon Chapter of Trout Unlimited, 1993.

Pool habitat quality is relatively poor. Habitat quality and pool quality index values (Table 3) are a function of water depth, habitat area, and instream cover. Most pools (65%) have pool quality index ratings of two and three. Although 27% and 8% of the rated pools in the study reach had PQIs of 4 and 5, respectively, SHAPIRO could not confirm many of these higher ratings. In general, pools were relatively shallow, small, and provided marginal cover. Only 19% of the rated pools were formed by large woody debris (LWD).

LWD is an important structural element in Pacific Northwest streams, particularly smaller streams like Miller Creek. Logs form deep scour pools, capture organic matter that is a fundamental energy source for aquatic organisms (including fish), sort substrate, and dissipate energy. Pools formed by large organic debris jams can be stable structural components of stream systems and are often important refuges for fish during high flow events. The lack of high-quality pools formed by large organic debris appears to limit the amount of high-flow habitat available to resident and anadromous fish. Lack of high-flow refugia, combined with other factors, may limit the sizes of resident and anadromous fish populations that Miller Creek can support.

Several potential barriers to upstream fish passage, of manmade and natural origin, were observed in the study reach. Some of these affect both anadromous and resident salmonids and others may act as potential barriers only to resident salmonids. In addition, some of these may only pose seasonal barriers and appear to be passable under favorable flow conditions. Concrete box culverts or cmp at First Avenue S., SR 509, and S. 160th Street appear to be barriers to upstream fish passage. A beaver has dammed two-thirds of the 9-foot diameter cmp at First Avenue S. This is a total barrier to both anadromous and resident salmonids. The two cmps under SR 509 are over 100-feet long, contain no baffles, and are likely velocity barriers to both anadromous and resident salmonids under high and low flows; they may be passable under moderate flow conditions. The concrete box culvert at S. 160th Street appears to be a barrier to upstream anadromous and resident fish passage under all flows. Under low-flow conditions the vertical drop is greater than 1.5 feet and the plunge pool is a foot or less deep beneath the culvert outlet. In addition, there are no baffles or velocity breaks in the culvert bottom, making the culvert a potential velocity barrier during high-flow conditions. During low-flow conditions, there is not enough water for salmonids to pass (<0.1 foot deep). An approximately 8-foot high waterfall located about 0.2 mile upstream of S. 160th Street is a barrier to resident salmonids. There is a deep pool below this waterfall, making this possibly passable to anadromous fish during flow events that raise the elevation of the pool below the waterfall. These seasonal and year-round barriers to upstream fish passage limit the availability of fish habitat in reaches above these barriers to anadromous and residential salmonids. Clearing culvert obstructions, constructing backwater pools, or replacing culverts could remove these barriers to upstream fish passage and make habitat upstream available to anadromous and resident salmonids.

There are few eroding banks, landslides, slumps, or debris jams within the study reach that could be major contributors to sediment loading. Seven notable eroding banks or landslides were observed at the time of the verification study. Five cutbanks appeared to be more than two years old, well colonized by riparian vegetation or composed of erosion resistant glaciolacustrine material, and stable. The approximate location and size of these are as follows:

- Right bank (RB), 15-feet high x 50-feet long, located 100 feet downstream of Ambaum Avenue;
- RB, 6.5-feet high x 20-feet long, located 100 feet downstream of S. 160th Street;
- Left bank (LB), 3-feet high x 40-feet long, located 160 feet downstream of South 160th Street;
- RB, 7-feet high x 26-feet long, located 300 feet upstream of S. 160th Street; and
- LB, 7-feet high x 40-feet long, located 350 feet upstream of S. 160th Street.

Two sites, a cutbank and a landslide, appear to be more recent and potentially unstable. The approximate location and size of these areas are:

- A slump/landslide on the LB near the confluence of Miller Creek with the Burien Lake tributary is 16-feet high x 40-feet long; and
- A cutbank on the RB 11-feet high x 23-feet long 150 feet upstream 1200 upstream of S. 160th Street;

Because most of these areas appear to be stable, streambanks in the study reach do not appear to be major sediment sources to downstream areas of Miller Creek. In fact, many of the glides and runs upstream of First Avenue S. appear to be aggrading and have accumulated large volumes of silt and sand from upstream sources. These deposits have buried spawning gravels and filled interstitial spaces between gravels and cobbles, reducing habitat complexity and quality. Escape cover for juvenile salmonids and habitat for aquatic invertebrates is reduced or eliminated by accumulations of fine-textured sediments, reducing the invertebrate and salmonid production within these reaches.

Habitat complexity and quality also is reduced by the lack of debris jams and low LWD loading. Only two debris jams were observed in the study reach. One was located downstream of First Avenue S. near the confluence with the Burien Lake tributary. The other was located between S. 160th Street and 8th Avenue S. Both debris jams were older and appeared to be relatively stable. A relatively high quality lateral and bottom scour pool had formed downstream of the latter debris jam. Both debris jams appeared to be good energy dissipaters and provide refuge to salmonids during high-flow events.

In addition to the lack of debris jams, there is not very much high-quality woody debris in the study reach. In undisturbed Puget Lowland streams large logs, particularly conifer logs, are important structural elements. Unlike hardwood logs, such as red alder and black cottonwood, which sometimes are rotten when they enter creek systems or decompose relatively rapidly, conifer logs have more resin and resist decomposition, thus may last over 100 years in water. LWD creates dammed and scour pools that provide habitat to aquatic invertebrates and salmonids. Pools formed by large woody debris often provide high-quality, high- and low-flow habitat because they are deep and provide cover for salmonids. In addition, pools are often holding areas for spawning salmonids and pool tailouts are often important spawning areas. Because of urbanization and loss of riparian vegetation, there is a limited abundance of large woody debris and deep scour pools in this section of Miller Creek. Lack of these important structures has contributed to a lack of high-quality, high- and low-flow habitat and spawning areas dependent on gravel source and gradient in this section of Miller Creek.

Although salmonid habitat has been degraded by urbanization, this section of Miller Creek continues to support apparently small populations of salmonids and nongame fish. Coho salmon (*Oncorhynchus kisutch*) historically have been observed in the study reach up to S. 160th Street.[4] Juvenile coho remain in freshwater for about one year before migrating to Puget Sound during their second year of life. No juvenile coho were observed during the verification study and areas upstream of First Avenue S. are currently inaccessible (as described previously). Resident salmonids, probably cutthroat trout, were observed throughout the study reach from below First Avenue S. up to the waterfall located approximately 0.2 mile upstream of South 160th Street. In addition, other fish (possibly pumpkinseed sunfish), were observed in glides and runs with silt and sand substrates from about 8th Avenue S. up to Lora Lake.

Aquatic invertebrate communities; composed of relatively abundant numbers of mayflies, caddis flies, and black flies, were observed in gravels and cobbles downstream of First Avenue S. Upstream of First Avenue S., medium coarse and coarse gravels are limited to only a few, small areas. Fewer taxa and smaller numbers of macroinvertebrates were observed in gravels upstream of First Avenue S. Accumulations of silt and sand substrates are predominant in the glide and run type habitats upstream of First Avenue S. It is assumed that these support primarily midges and worms that are typically found in silt and sand substrates. Mayflies, caddis flies, stoneflies, and other aquatic invertebrates typically associated with larger gravel and cobble substrates and associated periphyton are likely absent in many of these silt- and sand-dominated habitats. Substrate homogeneity (e.g., large accumulations of silt and sand over large areas) contributes to a lack of habitat complexity and suitable habitat for some of the mayflies, caddis flies, and stoneflies often found in small second- and third-order streams found in the Puget Lowland area.

There appear to be substantial restoration opportunities in the study reach. Habitat improvements, including creation of high- and low-flow habitat that contribute to habitat diversity and complexity, would be beneficial to salmonid and aquatic invertebrate production. Deeper scour pools could be created and seeded with coarser substrate (e.g., cobbles and rubble). In addition, instream structures of large organic debris (e.g., root wads) could be placed to provide high flow refugia.

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[4]Personal communication with the author. Miller, Alan. Stream Restoration Coordinator, Des Moines Salmon Chapter of Trout Unlimited, 1994.

Creation or enhancement of scour pools and instream structures requires careful hydraulic analysis to determine the appropriate locations for sustaining these habitats. In addition, careful consideration must be given to activities in the watershed upstream of potential mitigation sites before habitat restoration feasibility can be better determined. Upstream sources of sediment first must be controlled in order to ensure a higher likelihood that instream structures would provide sustainable fish habitat. Deposition of sediment in created or enhanced pools, for example, would adversely affect the long-term function of such habitat. Ensuring that upstream impacts on the stream can be controlled would make potential restoration and habitat enhancement or creation opportunities appear to be viable. Conceptual habitat restoration, enhancement, or creation opportunities should focus on increasing high-quality pools with instream cover, including large woody debris and interstitial spaces in stream substrate that provide habitat for macroinvertebrates, periphyton, and fish.

ATTACHMENT A

1993 Trout Unlimited Miller Creek Stream Survey Results

STREAM #: 0371 (Miller) STREAM ORDER: 3 SURVEY LENGTH: RM 11878.5 TO RM 18116.5
WEATHER CONDITIONS: CLEAR SUNNY 70'S
INVESTIGATORS: A. MILLER, A. PATCHO, D. MARSCHALL, L. GAMMON, J. RICHARDSON

RF	HT	W	D	L	CV	CD	SS/WIDTH/TY (LB-RB)	SBST	PQI	LWD LE	DI	ST	V	CN	TY
1	13	13.5	1.4	65	15	2.2	3/100/M-3/100/M	2		50	1	A			
2	13			176	18	2.3	3/100/M-3/100/M	2							
3	14			88	13	1.6	3/100/M-3/50/M	2		30	1	A			
3.1	11	4	1.8	13				2	3						
4.0	14	13	0.8	96	16.5	2.3	3/100/M-3/100/M	3							
5	15	13.3	.8	66	15.0	2.9	3/100/M-3/100/M	3							
5.1	11	6	1.3	20					2						
6	1	10.9	.5	108	14.9	.5	3/100/M-3/100/M	3							
6.1	Note (1)														
6.2	Note (2)								(2)						
7.0	22	10	1.2	56	13	2.4	3/100/M-3/100/M	3	3.5 max	Rootwad					
8	14	10	1.2	57	13	2.4	3/100/M-3/100/M	3		12	1.2	A			
9	14	11.6	.4	67	12.6	1.6	3/100/M-3/20/M	5/3							
10	11	11.6	1.3	42	12.6	2.3	3/100/M-3/10/M	5	(2)						
11	1	10.6	.4	49	12.6	1.5	0/100/grass-0/100/-grass	6							
12	15	12	1.0	36.5	18.5	2.1	3/100/M-3/100/M	6							
13	1	13	.6	18	15.5	1.6	3/100/M-3/10/M	6							
14	14	12	1.0	31.5	15.5	2.1	3/100/M-3/100/M	6/3							
15	1	13	.4	17	18	1.1	3/100/M-3/100/M	6							
16	22	16.5	1.5	194	18.5	2.6	3/100/M-3/100/M	2	4						
17	1	13	.5	29	15	1.3	3/50/M-3/50/M	6							2
18	9	15	1.4	10	15	2.1	3/100/M-3/20/M	2	2 1.5 max						2
19	9	18.2	1.1	97.5	20.7	1.9	3/100/M-3/20/M	2	2 1.5 max						
20	9	17.4	0.9	99.5	18.2	1.6	4/100/M-3/100/M	2	3 3.1 max						
21	9	16.7	1.0	33	19.8	1.5	4/100/M-3/100/M	2	2						
22	9	18.4	1.0	22	19.2	1.8	4/100/M-3/50/M	2	5 3.5 max						
23	9	18.4	0.8	39	23	1.6	4/100/M-3/100/M	2	4 2.8 max						
24	culvert under			509	Hiway				2.8 max						
25	9	12	1.0	29.5	16.9	1.6	4/100/M-3/100/M	3	4 2.5 max						
26	9	15.2	1.3	20.5	18.7	2.2	4/100/M-3/100/M	3	4						
27	9	16.5	1.2	12.5	20.3	1.6	3/100/M-3/100/M	3	3						
28	14	8.8	.9	50	11	1.9	3/100/M-3/10/M	3							
29	1	12	.2	21	15.3	1.1	4/100/M-4/90/M	3							
30	14	7.5	.5	82	8.5	1.4	4/100/M-4/100/M	3							
30.1	11	4	2.5	18					3						
31	1	6.7	.3	46.5	8.9	.9	4/100/M-4/100/M	3							
32	22	9.4	1.6	27	9.3	2.3	4/100/M-4/100/M	4	4 2.2 max						
33	15	6.2	1.2	54	7.0	1.8	4/100/M-4/100/M	3-4							

KEY:
RF= REFERENCE HT= HABITAT TYPE CW= CHANNEL WIDTH at OHWM
CD= MEAN CHANNEL DEPTH at OHWM L= LENGTH of HT
W= MEAN WIDTH OF HT (> 5 msrmts) D= MEAN DEPTH of HT (> 5 msrmts)
SS= STREAMSIDE STRUCTURE: 0= NO RIPARIAN ZONE [If 0, indicate lawn, road, buildings, etc.] 1- MATURE COMPLEX FOREST 2-IMMATURE/EVEN-AGE/DISTURBED 3- SHRUB-DOMINATED (< 20' HIGH) 4-GRASSLAND/MEADOW/PASTURE 5-WETLAND
VEGETATED (WIDTH)/LB-RB=LEFT BNK-RGT BNK (TY)PE=(C)ONIFEROUS/(D)ECIDUOUS/(M)IXED
SBST= DOMINANT/SUBDOMINANT SUBSTRATE THROUGHOUT HABITAT TYPE: 1=BEDROCK 2=SILT/ORGANIC 3=SAND 4=GRAVEL(< 25 mm) 5=GRAVEL(25mm - 100mm) 6=COBBLE(100mm-256mm) 7=BOULDER PQI= POOL QUALITY INDEX
LWD= LARGE WOODY DEBRIS: (LE)NGTH, MEAN (DI)AMETER, (ST)ABILITY: (A)NCHORED (U)NANCHORED (?)UNKNOWN (V)ARIETY: (C)ONIFEROUS/(D)ECIDUOUS/(?)UNCERTAIN
CN=CONDITION: (S)OLID: (R)ECENT/(O)LD (M)ODERATE: (R)ECENT/(O)LD
(R)OTTED: (R)ECENT/(O)LD (TY)PE: (J)AM LOGS: (F)LOATING/(S)TRANDED
(B)RIDGE: (C)OLLAPSED/(P)ARTIAL (L)ATERAL (W)EIR: (P)ARTIAL/(F)ULL
(S)TUMP

AR 039441

STREAM #: 0371 STREAM ORDER: ___ SURVEY LENGTH: RM 11,578.5 TO RM 12,116.5
WEATHER CONDITIONS: ______
INVESTIGATORS: ______

RF	HT	W	D	L	CW	CD	SS/WIDTH/TY (LB-RB)	SBST	PQI	LWD LE	LWD DI	LWD ST	LWD V	CN	TY
(6) 34	14	9.3	.7	68	10.2	1.6	3/100/M-4/100/[illegible]	3							
35	17	8	2.0	23	8.8	2.9	3/100/M-4/100/	6	4 2max						
36	14	8	.8	18	10.4	1.6	3/100/M-4/100/	3							
37	21	9.7	.9	25	9.2	2.4	3/100/M-4/100/	3	2 1.6max						
(7) 38	1	9.9	.4	29	11.7	1.3	3/100/M-4/100/	3		~~[illegible]~~	~~1.1~~	~~?~~			
39	22	12	1.3	18	14	2.3	3/100/M-4/100/		2 1.6max	75	1.1	A			
40	1	7.8	.2	17	12.3	1.2	3/100/M-3/100/M	4							
(8) 41	14	8.6	.9	29	10.6	1.8	4/100/ -4/100/	4	2 1.5						
42	~~?~~ 22	9.2	1.1	49	11	2.1	4/100/ -4/100/	3							
43	15	6.5	.7	45	8.6	1.6	4/100/ -4/100/	3							
(9) 44	1	6.8	.5	35	8.9	.9	4/100/ -4/100/	4							
(10) 45	14	4.5	1.4	60	4.5	1.9	culvert / /	culvert at 8th Ave S							
46	1	12.5	.3	19.5	14.0	1.1	0/100/gravel-3/100/M	4							
47	17	10.5	1.4	24.0	13.0	2.1	3/100/M-3/100/M	3	2 1.5max						
48	22	9.0	1.4	33	10	2.2	3/100/D-3/100/D	3	2 1.5m						
49	~~17~~	10.8	1.4	19	12	2.4	3/100/D-3/100/D	3	2 1.5						
(11) 50	14	7.8	1.0	29	7.8	1.8	3/100/D-0/100/gravel	4							
(22) 51	14	7.4	0.9	77	7.4	1.7	3/100/D-0/100/yard	3							
23 52	14	6.0	.8	47	6.5	1.8	0/100/ -0/100/	3							
53	1	6.6	.6	30	9.3	1.5	3/100/M-0/100/yard	4							
54	14	6.2	.9	41	6.5	1.9	4/100/ -0/100/yard	4							
4 55	14	7.2	0.7	44	7.6	1.7	4/100/ -0/100/	3							
56	14	8	1.5	18	8.7	2.5	4/100/ -2/100/D	4							
57	1	4.3	.4	16.2	6.6	1.4	2/100/M-2/100/D	4							
58	1	8.3	.5	[illegible]	9.9	1.5	2/100/D-2/100/D	4							
59	17	11.3	1.4	37	13.2	2.3	4/100/D-0/100/	3	3						
(3) 60	15	6.4	.3	30	9.0	1.3	4/100/D-0/100/	4							
61	15	8.5	.6	74	11	1.5	0/100/ -0/100/yard	4							
62	14	9.0	1.2	51	9.5	2.5	4/100/M-4/100/-	6							
63	14	6.5	.7	37.5	7.5	1.7	4/100/D-4/100/D	3							
64	1	9.6	.4	32	12.9	1.8	4/100/D-4/100/D	4							
65	15	11.2	1.0	24	13.9	.9	2/100/D-4/100/D	3							
66	14	8.5	.9	38	13.5	1.9	2/100/D-2/100/D	3 2							
67	1	9.0	.3	22	12	1.8	2/100/D-2/100/D	4							
68	14	8.5	1.0	27	12	1.8	2/100/D-2/100/D	3 2							
69	14	7.5	.7	36	11	1.9	2/100/D-2/100/D	4							
70	15	6.6	0.7	142.7	9	2.0	3/100/D-3/100/D	4							
71	14	7.9	1.0	36	9.9	2.1	2/100/D-3/100/D	4							
72	1	9.9	.3	15	11.5	1.4	3/100/D-3/100/D	4							
73	19	6.6	1.6	9	18	3.0	3/100/D-3/100/D	2							

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CN=CONDITION: (S)OLID: (R)ECENT/(O)LD (M)ODERATE: (R)ECENT/(O)LD (R)OTTED: (R)ECENT/(O)LD (TY)PE: (J)AM LOGS: (F)LOATING/(S)TRANDED (B)RIDGE: (C)OLLAPSED/(P)ARTIAL (L)ATERAL (W)EIR: (P)ARTIAL/(F)ULL (S)TUMP

WRIA BASIN #: 07 KC BASIN #: ____ DATE: [illegible] TIME: [illegible]
STREAM #: ____ STREAM ORDER: 3 SURVEY LENGTH: RM 8745.8 TO RM 11,118.7 ft
WEATHER CONDITIONS: OVERCAST
INVESTIGATORS: JAN NOORDA, AL MILLER, PETER BARTON, JOHN MATSUMURA, LUTKER (NOTE. HAS BEEN RAINING — STREAM RUNNING HIGH)

RF	HT	W	D	L	CW	CD	SS/WIDTH/TY (LB-RB)	SBST	PQI	LWD LE	LWD DI	LWD ST	LWD V	LWD CN	LWD TY
1	LGR	10.5	.6	57.5	19.0	1.7	2/100/C - 2/100/C	5	—	24	12"	A	—	—	—
2	RUN	16.5	.6	27.0	21.0	1.8	"/"/" - "/"/"	4	—	—	—	—	—	—	—
3	SRN	17.0	.7	33.0	17.0	2.2	"/"/" - "/"/"	6	—	—	—	—	—	—	—
4	SRN	10.0	.6	28.4	21.0	1.8	"/"/" - "/"/"	4	—	60	2.8	A	—	—	—
5	LGR	15.0	.6	197.0	21.0	2.1	"/"/" - "/"/"	*	—	—	—	—	—	—	—
6	LGR	14.7	.6	20.5	20.6	2.4	"/"/" - "/"/"	*	2	—	—	—	—	—	—
7	LGR	21.0	.5	40.0	30.0	2.0	"/"/" - "/"/"	4	—	20	1.5	U	—	—	—
8	BWP	19.0	1.4	33.0	24.0	3.2	"/"/" - "/"/"	—	3	20	2.0	A	—	—	—
9	LGR(1)	17	0.7	83.5	20	1.9	2/100/M - 2/100/M	4	—	40	2.5	A	—	—	—
10	14	10	1.0	29	16	2.0	2/100/M - 2/100/M	5	—	—	—	—	—	—	—
11	15	8 / 1.1		59.5	25	2.9	2/100/M - 2/100/M	5	—	—	—	—	—	—	—
12	1	11	0.7	132	19	1.3	2/100/M - 2/100/M	5	—	—	—	—	—	—	—
13	16	15.0	.7	40	21.0	2.2	2/100/M - 2/100/M	7	3	—	—	—	—	—	—
14	15	11.0	1.0	35	27.0	1.6	2/100/M - 2/100/M	5	2	40	36"	A	—	—	—
15	14	16.0	.7	30	17.0	1.7	2/100/M - 2/100/M	4	4	—	—	—	—	—	—
16	1	12.0	.5	90.5	16.0	1.1	2/100/M - 2/100/M	5	—	—	—	—	—	—	—
17	1	13.0	.6	143.5	19.0	1.5	2/100/M - 2/100/M	5	—	X	SEE NOTES		—	—	—
18	14	12.4	1.5	49.0	16.8	2.3	2/100/M - 2/100/M	5	—	40	12"	A	—	—	—
19	15	7.0	.7	36.0	12.0	1.6	2/100/M - 2/100/M	5	—	—	—	—	—	—	—
20	1	11.5	.4	32.5	15.5	1.4	2/100/M - 2/100/M	6	—	—	—	—	—	—	—
21	15	12.0	.8	26.5	15.0	1.4	2/"/" - "/"/"	6	—	—	—	—	—	—	—
22	1	11.5	.5	34.0	15.0	1.3	2/"/" - "/"/"	5	—	—	—	—	—	—	—
23	8	12.0	1.4	74.0	19.0	2.7	"/"/" - "/"/"	CLAY	—	—	—	—	—	—	—
24	24	16.0	.15	17.0	23	1.0	"/"/" - "/"/"	CLAY	—	—	—	—	—	—	—
25	1	16.0	.4	27.0	22.0	1.3	"/"/" - "/"/"	CLAY	—	—	—	—	—	—	—
26	14	20.0	1.5	34.0	23.0	2.8	"/"/" - "/"/"	3	—	20	15"	A	—	—	—
										15	18"	A	—	—	—
27	1	14.5	.6	156.0	16.5	1.9	"/"/" - "/"/"	6	—	—	—	—	—	—	—
28	3	17.0	1.5	86.0	21.0	2.5	2/100/M - 2/100/M	CLAY	—	—	—	—	—	—	—
29	15	12.0	.7	34.5	15.0	1.2	2/100/M - 2/100/M	6	—	—	—	—	—	—	—
30	1	10.0	.8	200	12.5	1.7	2/100/M - 3/25/M	6	—	—	—	—	—	—	—
31	17	11.0	1.8	20'	11.5	2.2	"/"/" - 3/25/M	3	2	—	—	—	—	—	—
32	15	12.0	.9	125	14.0	1.7	"/"/" - "/"/"	2	2	—	—	—	—	—	—
33	1	18.0	.6	420	19	1.3	"/"/" - "/"/"	6	—	—	—	—	—	—	—
TO START OF 9' ϕ STEEL CULVERT UNDER 1ST AV SO. (NINE FT DIAMETER)															
34	CULVERT	—	—	299.0'	—	—	/ / - / /	—	—	—	—	—	—	—	—

KEY:
RF= REFERENCE HT= HABITAT TYPE CW= CHANNEL WIDTH at OHWM
CD= MEAN CHANNEL DEPTH at OHWM L= LENGTH of HT
W= MEAN WIDTH OF HT (> 5 msrmts) D= MEAN DEPTH of HT (> 5 msrmts)
SS= STREAMSIDE STRUCTURE: 0= NO RIPARIAN ZONE [If 0, indicate lawn, road, buildings, etc.] 1- MATURE COMPLEX FOREST 2-IMMATURE/EVEN-AGE/DISTURBED 3- SHRUB-DOMINATED (< 20' HIGH) 4-GRASSLAND/MEADOW/PASTURE 5-WETLAND VEGETATED (WIDTH)/LB-RB=LEFT BNK-RGT BNK (TY)PE=(C)ONIFEROUS/(D)ECIDUOUS/(M)IXED
SBST= DOMINANT/SUBDOMINANT SUBSTRATE THROUGHOUT HABITAT TYPE: 1=BEDROCK 2=SILT/ORGANIC 3=SAND 4=GRAVEL(< 25 mm) 5=GRAVEL(25mm - 100mm) 6=COBBLE(100mm-256mm) 7=BOULDER PQI= POOL QUALITY INDEX
LWD= LARGE WOODY DEBRIS: (LE)NGTH, MEAN (DI)AMETER, (ST)ABILITY: (A)NCHORED (U)NANCHORED (?)UNKNOWN (V)ARIETY: (C)ONIFEROUS/(D)ECIDUOUS/(?)UNCERTAIN
CN=CONDITION: (S)OLID: (R)ECENT/(O)LD (M)ODERATE: (R)ECENT/(O)LD (R)OTTED: (R)ECENT/(O)LD (TY)PE: (J)AM LOGS: (F)LOATING/(S)TRANDED (B)RIDGE: (C)OLLAPSED/(P)ARTIAL (L)ATERAL (W)EIR: (P)ARTIAL/(F)ULL (S)TUMP

WRIA BASIN #: 7 KC BASIN #: 12 DATE: 5-8-93 TIME: START 11:00
STREAM #: 0371 STREAM ORDER: 3 SURVEY LENGTH: RM ~~11.~~ 11.74 TO RM 11.8785
WEATHER CONDITIONS: OVERCAST 50°
INVESTIGATORS: JAN NOORDA, AL MILLER, JOHN MURAMATSU

RF	HT	W̄	D̄	L *	CW̄	CD̄	SS/WIDTH/TY (LB-RB)	SBST	PQI	LWD LE	DI	ST	V	CN	TY
1	13	25	2.0	300	40	4.0	2/100/M - 2/100/M	2	5	2					
2	14	12.0	1.0	61.1	27	2.5	2/100/M - 2/100/M	2	—	50'	12"	A	—	—	—
3	13	15.0	1.0	27.4	30.0	2.8	2/100/M - 2/100/M	2	4	12'	2.0'	A			
4	22	15.0	1.8	30.0	18.0	3.1	2/100/M - 2/100/M	2	4	—	—	—			
5	14	15.0	1.0	69.0	20.0	3.0	2/100/M - 2/100/M	2	—	—	—				
6	22	14.0	1.5	12.0	19.0	3.5	*/—/— - 2/100/M	2	2	—	—	—			
7	14	9.0	1.4	88	11.0	2.6	*/—/— - 2/100/M	2	—	20	2.8	A			
8	14	9.0	1.4	13	11.0	2.6	*/—/— - 2/100/M	6	—	—	—	—			
9	14	9.0	2.0	34.0	14.0	3.5	*/—/— - 2/100/M	2	—	50	3.0'	A			
10	14	12.0	1.1	40	19.0	2.6	*/—/— - 2/100/M	2	—	✓	✓	✓	CROSSES		
11	13	20	1.3	18	22.0	2.6	*/—/— - 2/100/M	2	4						
12				67.3			CULVERT — SEE NOTE			At Ambaum					

— CULVERT IS CONTINUATION OF POOL FROM Ref 11 - H/T

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AR 039444

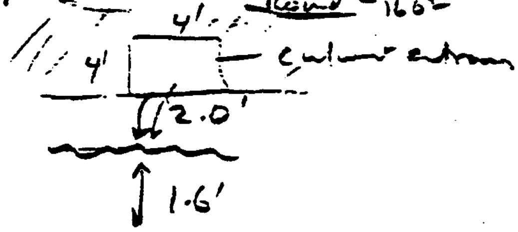
RM 11,878.5 to RM 18,116.5

Ref	HT	W̄	D̄	L	CW	CD						
							/	/	/	/	/	/ SUBST
73	15	7.0	.6	73	9.6	1.6						
74	15	8	1.0	90	10	2.0	3	100 D	3	100 D	4	
75	1	5.0	0.3	37	14.6	1.4	3	100 D	3	100 D	3	
76	22	12.6	1.4	20	17.0	2.4	3	100 D	3	100 D	4	
77	22	10	1.5	33	11.7	2.9	3 / 3	100 D / 100 D	3 / 3	100 D / 100 D	3 / 3	PQI = 2 / PQI = 2
78	1	8.6	.3	36	10.0	1.6	3	100 D	3	100 D	4	inlet stream on L/H Bank at end of Ref 77
79	15	10.6	0.6	36	12.5	1.8	3	100 D	3	100 D	4	inlet stream on L/H Bank at middle of Ref 78
80	22	10.5	.8	28.5	12.6	2.0	3	100 D	3	100 D	3	
81	1	8.8	.2	18	13.0	1.4	3	100 D	3	100 D	4	1.2 max PQI=2
82	22	6.0	.8	29	10	2.0	3	100 D	3	100 D	4	LWD PQI=2
83	1	8.3	.6	33	12.9	1.6	3	100 D	3	100 D	4	1.2 D [illegible]
84	14	7.0	0.5	50	12.4	1.7	3	100 D	3	100 D	4	
85	1	8.0	0.3	30.5	12.7	1.5	3	100 D	3	100 D	4	
86	22	9.6	1.6	18	13.0	2.8	3	100 D	3	100 D	4	PQI=2 1.9 max
87	14	7.9	.5	38	11.9	2.8	3	100 M	3	100 M	4	
88.5	22	13	1.5	21	21	2.5	3	100 M	3	100 M	3	1.0 D 30' / 2.0 max PQI=3
89	1	5.5	0.3	44	18		4	100	4	100	4	
90	13	16.6	1.2	21	26.6	2.4	4	100	4	100	3	1.3 max PQI=2
91	1	10.9	0.3	22	20.9	1.4	4	100	4	100	4	
92	14	7.9	0.9	57	17.9	2.0	4	100	4	100	3	
93	1	7.1	0.5	29	17.1	1.6	4	100	4	100	4	
94	22	10.4	0.9	39	20.4	2.0	4	100	4	100	3	2.3 max PQI=4
95	14	12.2	1.7	113	13.9	2.7	4	100	4	100	3	
96	22	18.3	1.3	26	19.3	2.8	3	100 M	3	100 M	2	PQI = 2
97	1	8	0.3	17	14.5	1.7	3	100 M	3	100 D	4	Rip Rap on R/H bank corner
98	14	7.5	0.8	30	9.5	1.9	3	100 M	3	100 M	4	1.3 D Anchor
99	14	10.8	0.7	57	18.8	2.0	3	100 M	3	100 M	4	
100	1	12.2	0.5	43	12.9	2.0	3	100 M	3	100 M	4	inlet stream on L/H Bank
101	14	12.0	0.9	29	22	2.0	3	100 M	3	100 M	3	
102	1	8	0.3	82	36	1.6	3	100 M	3	100 M	4	
103	9	14.5	1.9	14	26	3.0	3	100 M	3	100 M	3	[illegible]
104	15	8	0.4	82	18.6	1.7	4	100	3	100 M	3	
105	14	8.5	0.7	87	12.7	1.8	4	100	3	100 D	3	
106	22	9.7	1.1	54	14.6	2.0	4	100	3	100 D	3	PQI=2
107	11	8.2	1.2	25	10.9	2.3	3	100 M	3	100 M	3 4	
108	17	11.9	1.2	34	14	2.8	3	100 M	3	100 M	3	PQI=4 2.6 max
109	1	5.5	0.3	53	12	1.6	3	100 M	3	100 M	4	1.5 max
110	11	8	1.2	19	12	2.3	3	100 M	3	100 M	4	PQI=2

[illegible] p. [illegible]

RM 11,898.5 to RM 18,116.5

	HT	W	D	L	CW	CD	~~3 flows~~	/ / /	SUBST
111	1	8	0.3	~~3~~ 25	10	1.8	3 100 m	3 100 m	4
112	14	8.2	0.7	52	13.5	1.8	"	"	4
113	15	55	0.8	100	9.6	2.2	"	"	4
114	15	4	.6	41	10.6	1.6	0 100 yard	0 100 yard	4
115	22	8	1.3	18	11.0	2.3	"	"	4 — PQI = 3
~~116~~	~~15~~	~~4~~	~~0.6~~		~~11~~	~~1.9~~	~~"~~	~~"~~	~~4~~
116	15	4	0.6	90	"	1.9	"	"	4
					rire/concrete on R/H bank				
117	1	7	0.5	52	15.0	2.0	# 100 — "	0 100 yard "	
118	16	6	0.5	165	12.4	2.0	"	3 100 M	2.5 max
119	9	18.5	1.5	22	23 Round — 160	3.0	"	PQI = 4	



Good fish planting area

120 culvert ~ 0.3' deep All thru
Fish Need some help to get up

160 $ & Des Moi[illegible]
$ 9 $ s

STREAM #: 0371 STREAM ORDER: 3 SURVEY LENGTH: RM 18116.3 TO RM 19674.3

WEATHER CONDITIONS: OVERCAST 60°

INVESTIGATORS: AL MILLER, JAN NOORDA, LUTHER GAWLICK, ANDY BATCHO, JOHN MURAKATSU, BARBARA GREENLAW, STACIE BEVAN

16cm

RF	HT	$\bar{W}$	$\bar{D}$	L	$\overline{CW}$	$\overline{CD}$	SS/WIDTH/TY (LB-RB)	SBST	PQI	LWD LE	LWD DI	LWD ST	LWD V	CN	TY
1	CULVERT	15 / 540	0.3	46.8	arches		0/100/ROAD. 0/100/ROAD								
2	CULVERT EXT.		0.3	10.0			✓/✓/✓-✓/✓/✓								
3	1	6.3	.3	42.5	6.3	1.6	0/100 LAWN 0/100 ROAD	5							
4	16	7.3	.5	46.0	7.3	1.5	✓/✓/✓-✓/✓/✓	5							
5	1	7.0	.3	17.0	10	1.4	✓/✓/✓-✓/✓/✓	4							
6	15	7.6	.5	29.0	7.6	1.5	✓/✓/✓-✓/✓/✓	4							
7	1	8.0	.2	12.5	9.0	1.4	3/30/M-3/100/M	4							
8	11	9.0	.9	21.0	13.0	2.0	✓/✓/✓-✓/✓/✓	4	2						
9	1	11.5	.3	54.0	11.5	1.6	✓/✓/✓-✓/✓/✓	5							
10	1	10.5	.7	17.0	11.5	1.6	✓/100/✓-✓/✓/								
11	9	7.0	1.7	28.0	7.0	2.8	✓/✓/✓-/ /	3	4						
12	14	7.0	.7	68.0	8.0	1.5	0/100 LAWN 0/50/LAWN	5							
13	13	13.0	.7	58.0	13.0	2.2	✓/✓/✓-✓/✓/✓	2	4-5						
14	14	13.0	.6	71.0	13.0	1.6	3/100/M-3/100/M	5		w/SILT					
15	1	11.0	.3	17.0	14.0	1.5	✓/✓/✓-3/50/D	6							
16	14	11.0	1.1	21.0	12.0	2.1	✓/✓/✓-✓/✓/✓	6							
17	1	7.0	.2	14.0	11.0	1.8	✓/✓/M-✓/✓/✓	5							
18	22	10.0	.6	9.0	12.0	1.8	✓/✓/M-✓/✓/✓	5	3						
19	1	5.0	.4	28.0	6.0	1.7	✓/✓/✓-✓/✓/✓	5							
20	14	10.5	.6	43.0	12.5	1.9	✓/✓/✓-✓/✓/✓	5							
21	15	9.0	.5	45.0	12.0	1.8	3/50/✓-D/20/M	5							
22	1	10	.3	21.0	14	1.4	3/10/M-3/100/M		BLK.HD ON L.B						
23	17	9.5	1.5	57.0	9.5	2.8	✓/50/M-3/50/LAWN	4	4						
24	14	12.0	1.0	450	12.0	2.0	✓/✓/✓-✓/✓ LAWN	4							
25	1	8.3	.5	32.0	11.5	1.7	✓/✓/✓-✓/✓/M	4							
26	15	9.0	.5	46.0	14.0	1.6	✓/✓/✓-✓/✓/✓	4							
27	14	7.0	.8	96.0	11.0	1.1	✓/✓/✓-✓/30/LAWN	6	& SAND						
28	15	7.5	.7	26.0	10.5	2.1	✓/✓/✓-✓/50/LAWN	5							
29	1	10.5	.4	40.0	15.5	1.2	✓/✓/✓-✓/✓/✓	5							
30	9	25.0	5.0	26.0	27.0	6.5	✓/✓/✓-✓/✓/✓	5	5						
31	24*	7.0	.7	49.0	10.0	2.7	✓/✓/✓-0/50/LAWN	-							
32	17	14.0	.9	107.0	14.0	2.0	✓/✓/✓-✓/✓/✓								
33	14	12.5	.9	44.0	12.5	1.9	✓/✓/✓-✓/✓/M								
34	16	15.5	.7	109.0	18.0	1.6	✓/✓/✓-✓/✓/✓	4							
35	20	9.0	1.0	29.0	10.6	1.1	✓/✓/✓-✓/✓/✓	2							
36	14	7.0	.5	23.0	9.0	2.0	✓/✓/✓-✓/✓/	4							
37	CULVERT			70.0	6'H X 5' WIDE		→ 157TH PLACE								
38	13	11.5	1.1	24.0	13.0	3.1	3/40/M-3/30/M	4/2	3						
39	1	10.6	.4	14.0	14.0	1.6	✓/✓/✓-✓/✓/✓	4							
40	14	9.0	.5	50	11.5	1.6	/ / - / /	2							

1557.8
28
3845.8

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STREAM #: 0371 STREAM ORDER: 3 SURVEY LENGTH: RM 19674.3 TO RM 21962.3

2
5/29/93

WEATHER CONDITIONS: Sunny, low overcast alternate ~60F

INVESTIGATORS: Miller, Nodtche, Gamman, Batcha, Muramatsu, Greenlaw, Bevan

RF	HT	$\bar{W}$	$\bar{D}$	L	$\overline{CW}$	$\overline{CD}$	SS/WIDTH/TY (LB-RB)	SBST	PQI	LWD LE	LWD DI	LWD ST	LWD V	LWD CN	LWD TY
41	14	9.0	.9	49.0	12.7	1.9	0/40/Lawn 0/20/House	4							
42	1	5.0	.4	21.0	7.8	1.5	✓/✓/✓-✓/50/Lawn	4							
43	22	9.5	.5	40.0	9.5	1.6	✓/✓/✓-✓/✓/✓	6/2	3						
44	14	11.0	.7	76.0	11.8	1.7	0/50/Lawn 0/100/Lawn	4/2							
45	1	7.0	.3	43.0	8.9	1.9	✓/✓/✓-✓/✓/✓	5							
46	13	19.0	1.5	32.0	21.0	2.5	3/50/M-0/50/✓	3	4						
47	1	9.0	.5	77.0	12.7	1.5	✓/✓/✓-✓/✓/✓	6	Bridge at 15m						
48	14	11.8	1.2	30.0	15.8	2.2	✓/✓/✓-0/✓/✓	6							
49	15	7.0	1.3	24.0	8.0	2.8	0/✓/Lawn 0/100/✓	2		DOGS!!					
50	14	7.0	1.3	81.0	8.0	2.8	✓/✓/✓-✓/✓/✓	2							
51	14	10.0	.9	284.0	12.0	2.0	✓/✓/✓-✓/✓/✓	2							
52	14	8.5	1.0	273.0	9.0	2.7	✓/✓/✓-✓/✓/✓	3/2							
53	14	14.0	.7	163.0	13.5	1.7	✓/✓/✓-0/100/(F)	2	→ OPEN FARM						
54	CULVERT			40'			✓/40/✓-✓/✓/Farm	2							
55	14	11.0	.6	331.0	11.0	1.8	✓/100/✓-✓/✓/✓	2		(.8 SILT)					
56	CULVER	3 CULVERTS - 2 WORKING/ 36" DIA. X 130"													
57	17	8	2.0	12.0	10.0	3.0	0/100/Lawn 0/100/Farm	2	5						
58	14	8.0	.8	590.0	10.0	1.7	✓/✓/✓-✓/✓/✓	2							
59	1	8.0	.6	13.0	10.0	1.5	✓/✓/✓-✓/✓/✓	2							
60	14	8.0	.8	96.0	11.0	1.4	✓/✓/✓-✓/✓/	2							

KEY:

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2284

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W= MEAN WIDTH OF HT (> 5 msrmts) D= MEAN DEPTH of HT(> 5 msrmts)

SS= STREAMSIDE STRUCTURE: 0= NO RIPARIAN ZONE [If 0, indicate lawn, road, buildings,etc.] 1- MATURE COMPLEX FOREST 2-IMMATURE/EVEN-AGE/DISTURBED 3- SHRUB-DOMINATED (< 20' HIGH) 4-GRASSLAND/MEADOW/PASTURE 5-WETLAND VEGETATED (WIDTH)/LB-RB=LEFT BNK-RGT BNK (TY)PE=(C)ONIFEROUS/(D)ECIDUOUS/(M)IXED

SBST= DOMINANT/SUBDOMINANT SUBSTRATE THROUGHOUT HABITAT TYPE: 1=BEDROCK 2=SILT/ORGANIC 3=SAND 4=GRAVEL(< 25 mm) 5=GRAVEL(25mm - 100mm) 6=COBBLE(100mm-256mm) 7=BOULDER PQI= POOL QUALITY INDEX

LWD= LARGE WOODY DEBRIS: (LE)NGTH, MEAN (DI)AMETER, (ST)ABILITY: (A)NCHORED (U)NANCHORED (?)UNKNOWN (V)ARIETY: (C)ONIFEROUS/(D)ECIDUOUS/(?)UNCERTAIN

CN=CONDITION: (S)OLID: (R)ECENT/(O)LD (M)ODERATE: (R)ECENT/(O)LD (R)OTTED: (R)ECENT/(O)LD (TY)PE: (J)AM LOGS: (F)LOATING/(S)TRANDED (B)RIDGE: (C)OLLAPSED/(P)ARTIAL (L)ATERAL (W)EIR: (P)ARTIAL/(F)ULL (S)TUMP

AR 039448

STREAM #: 0371 STREAM ORDER: ___ SURVEY LENGTH: RM _____ TO RM _____

WEATHER CONDITIONS: SUNNY 65° (DICK THOMAS VIDEO)

INVESTIGATORS: AL MILLER JAN NOORDA ANDY DATCHO JOHN WILLIAMS

STARTING @ FENCE ON 12TH ENTERING AIRPORT PROPERTY

RF	HT	W	D	L	CW	CD	SS/WIDTH/TY (LB-RB)	SBST	PQI	LWD LE	DI	ST	V	CN	TY
1	14	13.0	.6	46	20.0	1.9	4/100/M-4/100/M	4							
2	9	12.2	1.0	15.7	SAME (CONT)		–/–/– – –/–/–	4	5						
3	13	12.2	1.7	10.4	✓	✓	–/–/– – –/–/–		5						
4	13	SEE NOTES	1.0	351.0	SEE NOTES		3/100/M-3/100/M	2	5						
5	CULVERT	4'ϕ	1.9	45.0			ROAD/GRAVEL ROAD	2	–						
6	17	SEE TABLE		553.0	SEE TABLE		3/100/M-3/100/M	2	5						
7	14	2.6	.6	23.0	14.1	2.1	✓/✓/✓-✓/✓/✓								
8	17	6.5	1.0	487.5	12.0	2.5	✓/✓/✓-✓/✓/✓	2(3)	(SEE NOTE)						
9	15	4.0	.3	57.0	8.0	1.7	✓/✓/✓-✓/✓/✓	3							

→ END AT CULVERTS UNDER 5&B / SEE PREVIOUS DATA SHEETS

1563.1

KEY:
RF= REFERENCE HT= HABITAT TYPE CW= CHANNEL WIDTH at OHWM
CD= MEAN CHANNEL DEPTH at OHWM L= LENGTH of HT
W= MEAN WIDTH OF HT (> 5 msrmts) D= MEAN DEPTH of HT (> 5 msrmts)
SS= STREAMSIDE STRUCTURE: 0= NO RIPARIAN ZONE [If 0, indicate lawn, road, buildings, etc.] 1- MATURE COMPLEX FOREST 2-IMMATURE/EVEN-AGE/DISTURBED 3- SHRUB-DOMINATED (< 20' HIGH) 4-GRASSLAND/MEADOW/PASTURE 5-WETLAND
VEGETATED (WIDTH)/LB-RB=LEFT BNK-RGT BNK (TY)PE=(C)ONIFEROUS/(D)ECIDUOUS/(M)IXED
SBST= DOMINANT/SUBDOMINANT SUBSTRATE THROUGHOUT HABITAT TYPE: 1=BEDROCK 2=SILT/ORGANIC 3=SAND 4=GRAVEL(< 25 mm) 5=GRAVEL(25mm - 100mm) 6=COBBLE(100mm-256mm) 7=BOULDER PQI= POOL QUALITY INDEX
LWD= LARGE WOODY DEBRIS: (LE)NGTH, MEAN (DI)AMETER, (ST)ABILITY: (A)NCHORED (U)NANCHORED (?)UNKNOWN (V)ARIETY: (C)ONIFEROUS/(D)ECIDUOUS/(?)UNCERTAIN
CN=CONDITION: (S)OLID: (R)ECENT/(O)LD (M)ODERATE: (R)ECENT/(O)LD (R)OTTED: (R)ECENT/(O)LD (TY)PE: (J)AM LOGS: (F)LOATING/(S)TRANDED (B)RIDGE: (C)OLLAPSED/(P)ARTIAL (L)ATERAL (W)EIR: (P)ARTIAL/(F)ULL (S)TUMP

ATTACHMENT B

Miller Creek Study Reach Photo Log

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PHOTO LOG

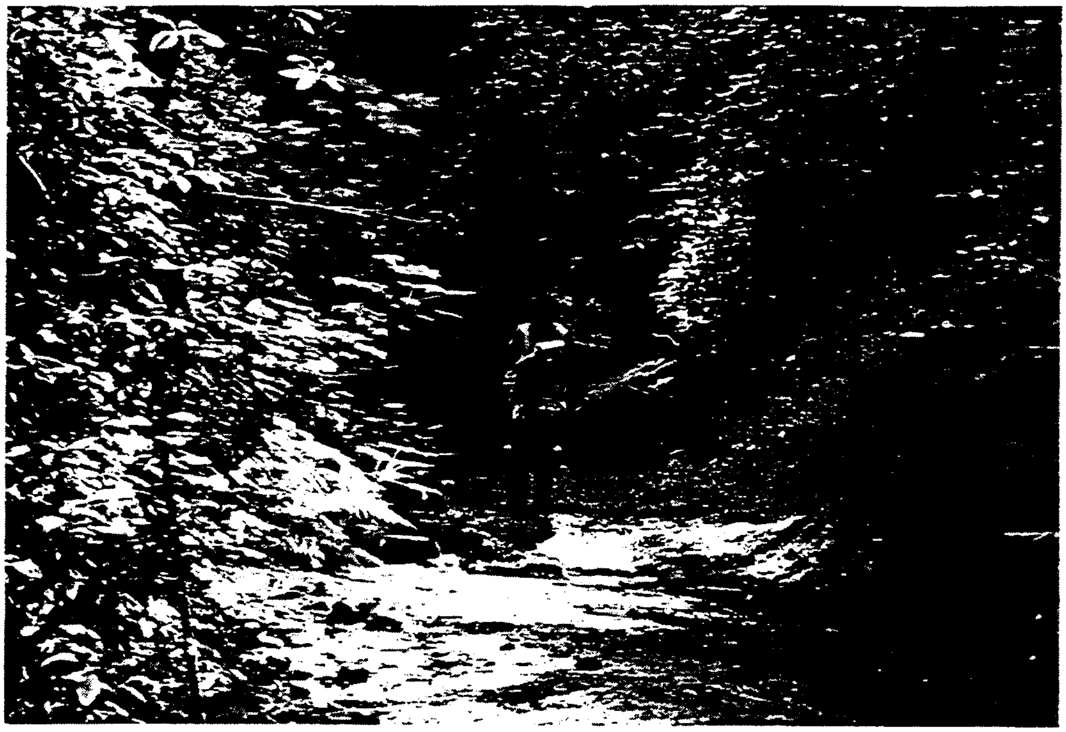
Photo	Photo Date	Stream Survey Reference No.	Subject
1	6/22/94	Ref. 23 4/24/93	Glaciolacustrine consolidated till downstream of First Avenue S.
2	6/22/94	Ref. 23 4/24/93	Close up of consolidated till-like material in previous photo.
3	6/22/94	Ref. 26 4/24/93	Debris dam composed primarily of hardwoods < 12" diameter located between tributary 0354 and First Avenue S.
4	6/22/94	Ref. 27 4/24/93	Low gradient riffle downstream of First Avenue S. with cobble, gravel, and small boulder substrate.
5	6/22/94	Ref. 28 4/24/93	Series of four concrete weirs downstream of First Avenue S.
6	6/22/94	Ref. 30 4/24/93	Low gradient riffle, confined and channelized area just downstream of the corrugated metal pipe beneath First Avenue S.
7	6/22/94	Ref. 30 4/24/93	Milky-colored discharge at outlet from detention pond on the tributary entering Miller Creek near First Avenue S.
8	6/22/94	Ref. 1 5/8/93	Barrier to fish passage at upstream end of 9' cmp at First Avenue S.
9	6/22/94	Ref. 3 5/8/93	Typical glide and pool habitat between First Avenue S. and Ambaum Avenue Dam formed by a beaver. Note 3' diam. cmp.
10	6/22/94	Ref. 1-3 5/15/93	Typical pool and glide habitat just above Ambaum Avenue. Note beaver-felled red alder and fine sediment accumulations.
11-12	6/22/94	Ref. 8-10 5/15/93	Riffle and glide habitat between Ambaum Avenue and SR 509. Small gravel (0.25-0.5" dia.) and sand are the dominant substrate.
13	6/22/94	Ref. 23 5/15/93	Furthest upstream weir on the west side of SR 509. Note oil absorbent boom on water in the background. No oil sheen or petroleum hydrocarbon odors evident. Purple loosestrife invading along RB. Lots of sand and silt in dammed pools created by weirs.

Photo Log (continued)

Photo	Photo Date	Stream Survey Reference No.	Subject
14	6/22/94	Ref. 41 5/15/93	Looking downstream at typical glide habitat in reach between 8th Avenue S. and SR 509 (just below 8th Avenue S.). Note dense riparian vegetation, including salmonberry, red alders, yellow iris, and assorted grasses. Riparian vegetation provides good overhead cover and thermal protection but instream cover is generally limited to riprap banks.
15	6/22/94	Ref. 43 5/15/93	Looking downstream at representative riffle habitat between 8th Avenue S. and S. 160th Street Note riprap and encroachment of residential development in background, which is typical of this reach.
16	6/22/94	Ref. 44 5/15/93	Typical riffle/run habitat and dense riparian vegetation at 8th Avenue S.
17	7/1/94	Ref. 1 5/15/93	Downstream end of box culvert at S. 160th Street. Two foot vertical drop, lack of a jump pool, and high water velocities are a barrier to fish passage.
18	7/1/94	Ref. 114 5/15/93	Potential flow constraint at reed canarygrass, yellow iris, and willow choked section of channel approximately 200 feet downstream of S. 160th Street. Old tires uses are riprap on RB.
19	7/1/94	Ref. 116 5/15/93	Typical glide habitat in reach between S. 160th Street and SR 509 (just downstream of S. 160th Street. Salmonberry and giant knotweed form a canopy over the stream.
20-22	7/1/94	Ref. 95 5/15/93	Palustrine emergent, palustrine forested wetland north of pasture area. Possible flood storage location and habitat mitigation site. Photo 21 looking NE (upstream) at wetland outlet. Photo 22 looking NW (upstream) at typical low gradient riffle in the reach between S. 160th Street and 8th Avenue S.
23-24	7/1/94	Ref. 2 5/29/93	Box culvert outlet (barrier to fish passage) and emergent vegetation choked channel at upstream end of box culvert located at S. 160th Street.
25	7/1/94	Ref. 15 5/29/93	Eroding LB approximately 700 feet upstream of S. 160th Street. Well stabilized by trees and shrubs, this eroding bank is approximately 12 m long x 2 m high.
26	7/1/94	Ref. 28 5/29/93	Typical residential development encroachment and associated plantings in reach between S. 160th Street and S. 156th Street. Note invasive vegetation on RB.
27	7/1/94	Ref. 30 5/29/93	Five foot waterfall, barrier to fish passage upstream of S. 160th Street. Deep plunge pool below falls.

Photo Log (continued)

Photo	Photo Date	Stream Survey Reference No.	Subject
28	7/1/94	Ref. 44 5/29/93	Typical glide habitat in reach between Lake Lora and S. 156th Street. Lots of silt and sand deposited in this reach. Residential development encroaches on both banks.
29	7/1/94	Ref. 56 5/29/93	Looking north (upstream) at Vacca farm pump intake and dense cattail stand. Dense emergent vegetation instream traps fine sediments and constrains flows in the ditch-like channel through much of the reach between S. 156th Street and Lake Lora.
30	7/1/94	Ref. 56 5/29/93	Looking south (downstream) at residential development and channelized, ditch configuration and sediment laden glide habitat that is typical of the reach between S. 156th Street and Lake Lora.



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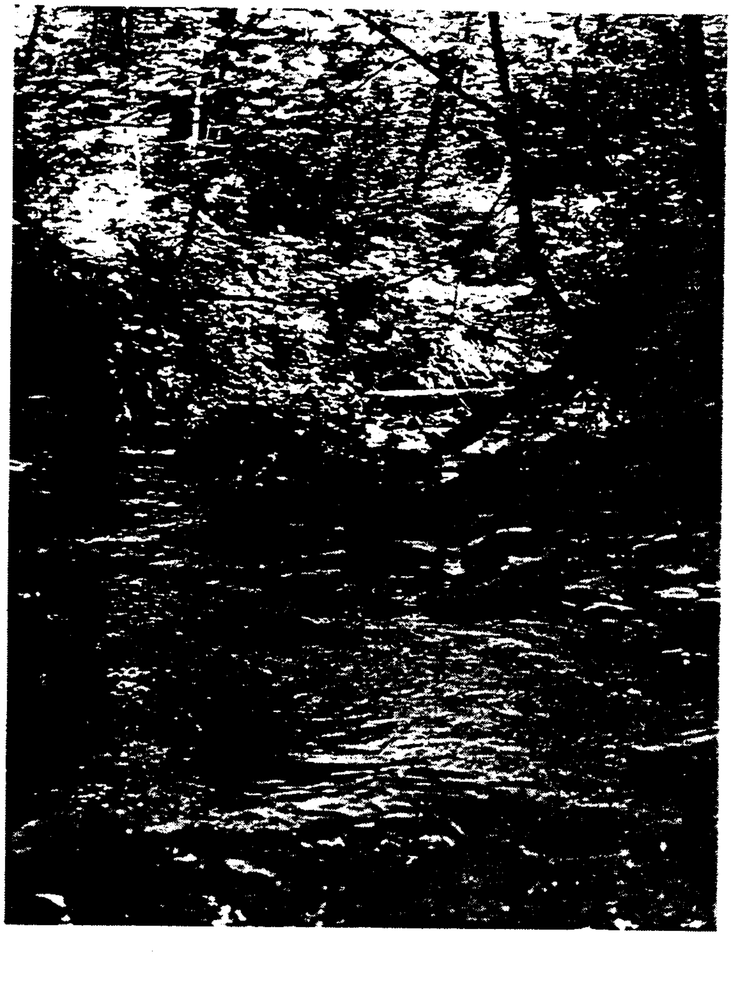

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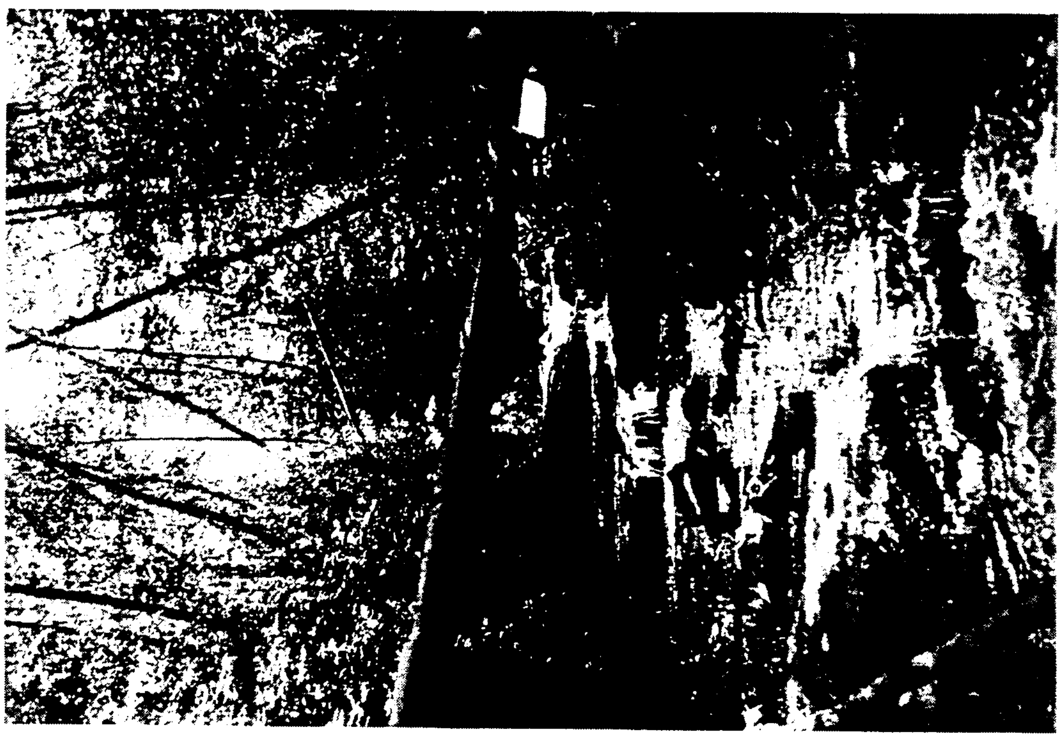

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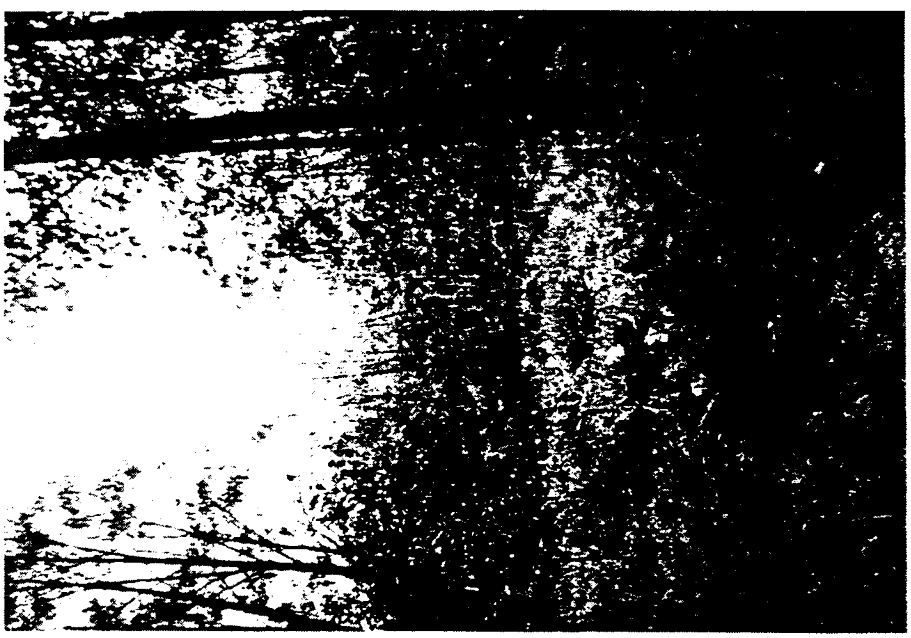

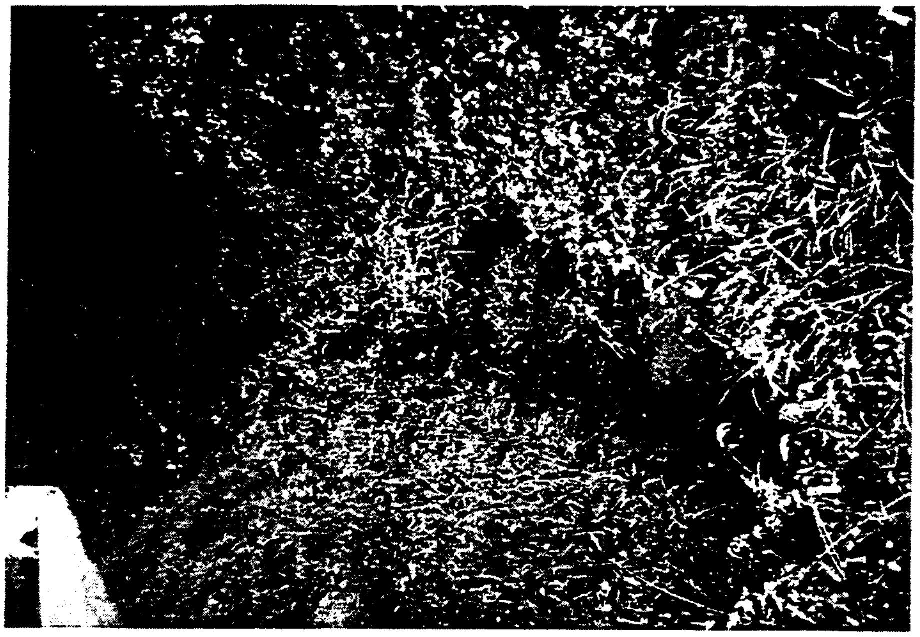

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APPENDIX G

HSP-F HYDROLOGICAL MODELING ANALYSIS

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APPENDIX G

HYDROLOGIC MODELING STUDY
For SeaTac Airport
Master Plan Update EIS

April 7, 1995
Revised November 16, 1995

MONTGOMERY WATER GROUP, INC.
Water Resources•Environmental•Civil Engineering

620 KIRKLAND WAY, SUITE 202, P.O. BOX 2517, KIRKLAND, WA 98083-2517
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TABLE OF CONTENTS

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1.0 INTRODUCTION

This report summarizes the hydrological modeling analyses of Miller Creek and Des Moines Creek using the Hydrological Simulation Program - Fortran (HSPF) model, a continuous simulation rainfall runoff and streamflow routing model. The analyses was conducted by Montgomery Water Group, Inc., under subcontract to Shapiro and Associates as part of the Environmental Impact Statement (EIS) for the Seattle-Tacoma International Airport (SeaTac Airport) Master Plan Update.

This report was first prepared for the Draft EIS submission on April 7, 1995. For the Final EIS, several modifications were made to the HSPF modeling analysis. One involved a revision of the pervious and impervious areas within the SeaTac Airport drainage subbasins. Recently revised estimates of these areas, developed during ongoing studies of the SeaTac Airport stormwater drainage system (SDS), were incorporated into the HSPF models. This revision resulted in significant changes to the Des Moines Creek model, but had little effect on the Miller Creek model. A second revision involved a reanalysis of the stormwater detention requirements. A more in-depth analysis of the offsite stormwater flows was performed to estimate the total detention volume needed to completely meet the stormwater detention criteria. Finally, the analysis of the effects of the proposal on low flows was expanded to include a separate verification of the HSPF modeling results.

1.1 PURPOSE

The HSPF modeling analyses were performed to evaluate the effect of land use changes proposed in the Master Use Plan Update on streamflow characteristics in Miller and Des Moines Creek. Those streams are the receiving waters for stormwater runoff from SeaTac Airport. Land use changes proposed in the Master Use Plan Update include an increase in the impervious surface for the proposed SeaTac Airport 3rd runway, new areas of compacted fill which cover areas that are currently occupied by low density housing or open space, and expansion of terminal facilities. Potential effects to streamflows in Miller and Des Moines Creek were evaluated by comparing the hydrologic regime of the creeks under proposed land use conditions to their current hydrologic regime. The comparison was performed using statistical measures of flood frequency, annual flow duration, flow volumes, and monthly flow exceedence.

The HSPF modeling analyses focused on assessing the effects of the proposed project on offsite streams. Detailed modeling of the existing SDS within SeaTac Airport was not conducted because the HSPF model is not suitable for modeling structural elements of complex storm drainage systems. A separate stormwater system modeling analysis using WATERWORKS, a hydraulic analysis computer program capable of modeling complex storm drainage systems, is currently underway by the Port of Seattle. For this study, a representation of the proposed airport expansion was created in the HSPF model using available data on existing drainage patterns, available streamflow data for calibrating an existing conditions model, overall proposed land use changes, and likely offsite stormwater discharge limitations. These data allowed for an accurate assessment of the effect of current and proposed SeaTac Airport stormwater drainage on the two receiving streams.

1.2 METHODOLOGY

Hydrologic modeling of Miller Creek and Des Moines Creek was performed using the HSPF Version 10 (USEPA, 1993) continuous simulation model. The HSPF model is accepted by local agencies and is the preferred method for evaluating effects of stormwater runoff on receiving streams. The hydrologic simulation of both basins used the 47-year record of historical SeaTac hourly precipitation (October 1948 to July 1994).

HSPF models which simulate existing hydrologic conditions were created and calibrated for the Miller Creek and Des Moines Creek Watersheds. Figure 1 shows the location of Miller and Des Moines Creek relative to SeaTac Airport. Current land use characteristics within these watersheds are summarized in Table 1-1. The land use within the Miller Creek Basin is largely residential, whereas the majority of the land use within the Des Moines Creek Basin is airport and other commercial uses.

The Miller Creek HSPF model covers the entire drainage basin. It was adapted from an earlier HSPF model developed by Northwest Hydraulic Consultants (NHC) for the feasibility analysis of the Lake Reba Regional Detention Pond (NHC, 1989). For this study, the NHC model was revised using updated stream and watershed data and then recalibrated using five years of recorded streamflow data (July 1989 to June 1994). The streamflow data was collected by King County from sites at the Lake Reba Detention Pond discharge and at lower Miller Creek near the mouth.

TABLE 1-1
SUMMARY OF CURRENT LAND USE IN MILLER CREEK
AND DES MOINES CREEK WATERSHEDS

Land Use	Des Moines Creek		Miller Creek	
	Area, acres	Percent of Total	Area, acres	Percent of Total
Commercial - Airport	983	27%	193	4%
Commercial	814	23%	727	14%
Multi-family	197	5%	250	5%
Residential	855	24%	2988	57%
Open	735	21%	720	14%
Forest/wetland	0[a]	0%	305	6%
Total	**3585**	**100%**	**5183**	**100%**

[a] Forested and wetland areas in Des Moines Creek are included in the other land use classifications.

The Des Moines Creek HSPF model was assembled from data and information compiled in previous hydraulic modeling studies of the stream. The Des Moines Creek HSPF model covers 2,700 acres, which is about 75 percent of the 3,585 acre Des Moines Creek Watershed. The model extends from the headwaters of the basin to South 208th Street. The Des Moines Creek HSPF model was also calibrated using five years of streamflow data collected from a site at the inflow to Tyee Detention Pond.

The proposed condition models evaluated the potential effects of the changed land use on the hydrologic regimes of Miller and Des Moines Creek. The proposed action will change the amounts and types of impervious and pervious surface area in the subbasins draining from SeaTac Airport. Land use changes incorporated into the proposed condition models included increased impervious surface area from the 3rd runway and changes in pervious surface area from new fill. To mitigate increased stormwater runoff, stormwater detention storage was also included in the proposed conditions models. Detention storage requirements were calculated using detention criteria from the Stormwater Management Manual for Puget Sound (Ecology, 1992). The stormwater detention criteria included detention of the 2-year storm and release at a rate no greater than 50 percent of the existing 2-year runoff rate, and detention of the 10-year and 100-year storms and release at existing rates for those storms.

1.3 DATA SOURCES

The HSPF models of Miller and Des Moines Creek were created or adapted using existing hydraulic models and other relevant data. The data sources are listed below.

1.3.1 Miller Creek

Miller Creek Regional Stormwater Detention Facilities Design Hydrologic Modeling (NHC, 1990). A HSPF model of Miller Creek was prepared for that study to evaluate the Lake Reba Regional Detention Facility. Land use characteristics, subbasin delineation and some structural data from the NHC model was the framework for the revised HSPF model of Miller Creek described in this study.

Miller Creek Regional Stormwater Detention Facilities Draft Feasibility Report (Parametrix, 1990). That report evaluates Lake Reba detention alternatives. Additional details on the selected alternative are included in this study.

Miller Creek, Normandy Park, Washington, Limited Map Maintenance Study (NHC, 1991). That study was prepared for the Federal Emergency Management Agency to delineate the 100-year floodplain along Miller Creek. The study produced a HEC-2 model for Miller Creek, beginning at Lake Reba and extending to Puget Sound. Stream hydraulic modeling results from the HEC-2 model were incorporated into the revised HSPF model of Miller Creek prepared for this study.

Lake Reba Regional Detention Facility Dam Safety Analysis (Parametrix, 1992). Storage-elevation-discharge rating curves for Lake Reba were obtained from that report and used in the revised HSPF model of Miller Creek.

Lake Reba Regional Pond, Miller Creek, Design Drawings (KCSWM, 1992). Design elevations for the Lake Reba outlet works were obtained from the design drawings to verify storage-elevation-discharge rating curves.

Lake Reba Operation and Maintenance Manual (KCSWM, no date). That brief document provided miscellaneous operational data for Lake Reba.

Brief Description Report of Ambaum Regional Water Quality Detention Pond (KCSWM, 1989). That report and the accompanying TR-20 modeling files describe the operational characteristics of the Ambaum Pond. The HSPF model of Miller Creek was prepared for this study and incorporated in the Ambaum Pond facility.

Ambaum Regional Pond, Miller Creek, Design Drawings (KCSWM, 1991). Design elevations for the Ambaum Pond outlet works were obtained from the design drawings to verify storage-elevation-discharge rating curves. The Ambaum Regional Pond was built in 1992.

1.3.2 Des Moines Creek

Des Moines Creek Watershed Management Plan (Herrera, 1989). That report provides documentation of a hydrologic model of Des Moines Creek that was previously created by King County Surface Water Management Division, (SWM). The model, based on the Soil Conservation Service's TR-20 model, was used to evaluate various detention pond alternatives for Des Moines Creek. One of the alternatives, Tyee Pond (termed Pond C in the report), was eventually built by King County. Subbasin model structure and stream hydraulic data from the TR-20 model were incorporated into the new HSPF model of Des Moines Creek.

TR-20 Model Files for Des Moines Creek Pond C (Tyee Pond) (KCSWM, 1989). Computer model files for Des Moines Creek were obtained from King County. The model of Des Moines Creek was revised by King County during the Tyee Pond design to evaluate various outlet works options. A storage-elevation-discharge rating curve for Tyee Pond was obtained from these files.

Des Moines Creek Regional Pond, Tyee Valley Golf Course, As-Built Design Drawings (KCSWM, 1992). Design elevations for the Tyee Pond outlet works were obtained from the design drawings to verify storage-elevation-discharge rating curves.

Tyee Regional Pond Operations and Maintenance Manual (KCSWM, no date). That brief document provided miscellaneous operational data for Tyee Pond.

Final Environmental Impact Statement (Parametrix, 1994). A drainage analysis of the South Aviation Support Area (SASA) was conducted for that EIS. The drainage analysis adapted and used the King County TR-20 model of Des Moines Creek. Assumptions on total impervious area and drainage to the Industrial Wastewater System (IWS) were incorporated into the HSPF model of Des Moines Creek.

Des Moines Creek GIS Study (Gambrell Urban, 1994). Land use data for Des Moines Creek were obtained from these maps which are being prepared for the SeaTac Airport Master Use Update.

Geologic Map of the Des Moines Quadrangle, Washington (Waldron, 1962). Soil mapping units representing till, outwash, and wetland soils were derived from this map.

1:25,000-Scale Metric Topographic-Bathymetric Map of Burien, Washington (USGS, 1983). Delineation of the Des Moines Creek subbasins were largely based on this map.

1.3.3 Sea-Tac Airport

Sea-Tac International IWS and Storm Water Systems, August 1992 (Anne Symonds, 1992). The 1" = 200' maps of the airport prepared by Anne Symonds provide a detailed inventory of the SDS and IWS conveyance systems, drainage subbasin boundaries, and outfall locations. Onsite drainage boundaries and pathways used for this study were based on information contained on these maps.

WATERWORKS Model Data for SeaTac Airport (Anne Symonds, 1994). Preliminary WATERWORKS model files of the SDS system developed by Anne Symonds were used to determine total impervious surface area within each of the eight SeaTac Airport stormwater drainage systems. That data was used to describe SeaTac subbasin land use in the HSPF models prepared for this study. The WATERWORKS model of SeaTac Airport was still under development and was not yet available at the time this study was performed. Updated estimates of impervious and pervious areas were obtained for the Final EIS analysis (Minton, G., personal communication, October 5, 1995).

Preliminary Maps of SeaTac Master Use Plan Alternatives (P&D Aviation, 1994). A delineation of the 3rd runway and other proposed facilities was obtained from AutoCAD maps supplied by P&D Aviation. The plans for the 8,500-foot runway with the central terminal were used to determine new impervious areas in the HSPF models prepared for this study.

1.3.4 Precipitation And Streamflow

SeaTac Precipitation and Evaporation WDM File (KCSWM, 1994). A HSPF Watershed Data Management (WDM) file containing precipitation and evaporation data for the period October, 1948 to July 1993 was obtained from King County Surface Water Management. The precipitation data, which were collected at the SeaTac Airport Weather Station, were recorded at hourly intervals. Daily evaporation rates were derived from historical monthly pan evaporation rates recorded at Puyallup.

Hourly Precipitation Data, Seattle-Tacoma Airport (NCDC, 1994). SeaTac precipitation records for the period of July 1993 to July 1994, used to update the WDM file, were obtained from the National Climatic Data Center.

King County Surface Water Management Stream Gauge Data (KCSWM, 1994). Provisional stream gauging data for various locations in Miller and Des Moines Creek were obtained from King County Surface Water Management. Sites used for calibrating the HSPF models included Gauge 42A, Miller Creek at Southwest 175th Place in Normandy Park; Gauge 42B, Lake Reba outflow (Miller Creek); and Gauge 11A, Tyee Pond discharge (Des Moines Creek). The period of record for the gauges generally runs from 1988 to 1944; a comparison of the available records is provided in Figure 2.

1.4 MODELING ASSUMPTIONS

As with any hydrologic model, assumptions were made regarding use of existing data, how basin features were incorporated into the model, and how proposed conditions were simulated. The following paragraphs describe the primary assumptions used in the modeling process.

- Modeling data obtained from existing models were still valid. For example, land use data for Miller Creek developed in 1989 were still considered valid for our modeling effort.

- A single HSPF model using land use characteristics of the 8500-foot runway proposal was developed to evaluate Alternatives 2-4 relative to current conditions (Alternative 1). The 8500-foot runway alternative has the greatest area of new impervious surface and therefore represents the largest potential increase in storm stormwater runoff of all alternatives.

- The existing stormwater drainage system (SDS) at SeaTac Airport was not incorporated into the HSPF models because of its complexity. Flow from the SDS was modeled by simulating runoff from pervious and impervious surfaces that are quantified in the current WATERWORKS model of the SDS.

- For the same reason, the existing IWS was also not incorporated into the HSPF models. The IWS collects runoff from industrial areas (e.g, fueling, maintenance and de-icing locations) for treatment at the lagoon treatment system. A pipeline drains the effluent to Puget Sound. The IWS has a hydraulic capacity of between the 10- and 25-year storm events and overflows to the SDS during larger storm events. It was assumed that all runoff from the IWS drains to Puget Sound. Therefore, these areas were removed from the HSPF models.

- Land use changes associated with the proposal were simulated by replacing affected areas with impervious surface and pervious fill area, and by adding detention storage to mitigate the increased stormwater runoff. Detention facilities were located at locations where stormwater is likely to discharge offsite and enter the mainstem channels of Miller and Des Moines Creek. The effects of changed land use in the proposed borrow source areas were not considered in the HSPF modeling analysis.

- Stormwater drainage will following existing drainage pathways under proposed conditions, with no transfer of drainage area between Miller and Des Moines Creeks.

2.0 CURRENT CONDITIONS ANALYSES

A discussion of the methodology and results of the HSPF modeling for current conditions is contained in the following sections.

2.1 MILLER CREEK MODEL

The Miller Creek current conditions HSPF model was adapted from a previous HSPF model that was developed for the *Miller Creek Regional Stormwater Facilities Design Hydrologic Modeling* (NHC, 1990). The NHC model was modified and improved for this study using updated stream watershed data from recent studies providing better information on SeaTac Airport subbasin characteristics, and more extensive streamflow data for calibration.

The Miller Creek Watershed subbasins used in the current conditions HSPF model are shown in Figure 3. A more detailed depiction of drainage basin boundaries in the vicinity of SeaTac Airport is shown in Figure 4.

Land cover data used in the Miller Creek HSPF model for current conditions are summarized in Table A-1 (Appendix A). Table A-1 gives the acreage of land use types, soil types and slope combinations within each subbasin. A schematic of the HSPF model of Miller Creek for current conditions, illustrating the arrangement of subbasins and stream reaches in the model, is shown in Figure 5.

Land cover data for the SeaTac Airport SDS and IWS drainage basins are summarized in Table 2-1. These estimates of drainage areas were developed during current modeling studies of the SDS and IWS. Since the IWS discharges directly to Puget Sound, the IWS area were assumed to not contribute any runoff to Miller and Des Moines Creeks.

Most subbasins are represented by a single set of land cover data within the HSPF models. However, the SeaTac Airport subbasins each have two sets of land cover data. These basins are identified by a pair of numbers, such as 20/25 in Figures 3 and 4. Land cover data in the first subbasin number represents the area drained by the SDS system for that subbasin (i.e., the areas in Table 2-1), and land cover data in the second subbasin number represents the remaining area in the

TABLE 2-1
SEATAC AIRPORT SDS AND IWS AREAS

Subbasin	SDS (acres)			IWS (acres)	Drains to:
	Pervious	Impervious	Total		
SDE-4	28	92	120	--	Des Moines Creek
SDN-1	0	14	14	--	Miller Creek
SDN-2	7	27	34	--	Miller Creek
SDN-3	43	16	59	--	Miller Creek
SDN-4[a]	7	3	10	--	Miller Creek
SDS-1	0	40	40	--	Des Moines Creek
SDS-2[b]	13	0	13	--	Des Moines Creek
SDS-3	221	209	430	--	Des Moines Creek
SDS-4	26	18	44	--	Des Moines Creek
SDW-3	14	10	24	--	Des Moines Creek
IWS Air Cargo /Runway	--	--	--	106[c]	Puget Sound
IWS Terminal	--	--	--	148[d]	Puget Sound
TOTAL	359	429	788	254	--

[a] Included in SDN-3 in HSPF model.
[b] Included in Subbasin 11 in HSPF model.
[c] Located in Subbasins SDE-4 (56 acres) in Des Moines Creek model, and SDN-1 (25 acres) and SDN-2 (25 acres) in Miller Creek model.
[d] Located in Subbasin SDS-1 in Des Moines Creek model.

subbasin (e.g., not drained by the SDS system). The model was constructed this way to allow the SDS components to be modeled individually if necessary.

For this study, several changes were made to the HSPF model prepared by NHC. One change was made to correct an error in the stream network. The NHC model showed the SeaTac "I" Pond subbasin (Subbasin No. 20) draining to Walker Creek, located below the stream gauge site on lower Miller Creek. Subbasin 20 actually joins Miller Creek a short distance below 1st Avenue South, above the stream gauge site. Another change to the HSPF model prepared by NHC was a revision of the subbasin boundaries in the vicinity of SeaTac Airport to those shown on the SDS drainage basin maps recently prepared by Anne Symonds (1992). Current drainage basin boundaries are shown in Figure 4. Changing the boundaries required modification of land use data in subbasins adjoining SeaTac Airport. Land use and soils data from NHC (1990) were used for this purpose.

Other changes made to the HSPF model included revisions to stream reach data for Miller Creek below Lake Reba. New routing data was derived using the results of the FEMA HEC-2 hydraulic model of Miller Creek (NHC, 1991). The change resulted in a more accurate representation of streamflow routing in the HSPF model. Elevation-storage-discharge relationships for the Lake Reba and Ambaum Detention Facilities were also incorporated into the HSPF model based on information contained in the King County TR-20 models, as-built drawings, and dam safety reports.

2.2 DES MOINES CREEK MODEL

The Des Moines Creek HSPF model prepared for this study used hydraulic modeling data contained in the TR-20 model that was originally developed by King County. The TR-20 model was used in several studies including the Des Moines Creek Watershed Plan and the Tyee Pond Detention Facility design. The TR-20 model included the east and west branches of Des Moines Creek (draining from Tyee Pond and Northwest Ponds, respectively), and extended downstream to South 208th Street.

A map of the subbasins used in the Des Moines Creek HSPF model is shown in Figure 6. A more detailed description of the drainage basin boundaries in the vicinity of SeaTac Airport is shown in Figure 4.

Land cover data for the SeaTac Airport SDS drainage subbasins are summarized in Table 2-1. Table A-2 in Appendix A summarizes the land cover parameters used in the HSPF model for Des Moines Creek under current conditions. Table A-2 gives the acreage of land use types, soil types and slope combinations within each subbasin. Subbasin land use data were derived from a geographical information system (GIS) analysis of land use and soil maps which was performed by Gambrell Urban. A schematic of the HSPF model of Des Moines Creek for current conditions, illustrating the arrangement of subbasins and stream reaches in the model, is shown in Figure 7.

To create the Des Moines Creek HSPF model, the following adaptations from the TR-20 model were performed:

- The number of subbasins from the TR-20 model was reduced to group similar land use areas together and to simplify the stream network.
- Stream cross-sections from the TR-20 model (XSECTN) were modified and combined to create FTABLES stream reach data in the HSPF model.

2.3 CALIBRATION

Calibration is the process whereby model parameters are adjusted to achieve a close match between recorded streamflows and simulated streamflows over a time period when streamflow data are available. Nearly five years of recorded streamflow, from October 1989 to July 1994, were used in the calibration process.

Hydrologic modeling using HSPF requires refinement of many different parameters that describe different streamflow-producing processes. These processes are based on the concepts of the Stanford Watershed Model. The dominant processes in HSPF include rainfall runoff from pervious and impervious surfaces, infiltration of rainfall to shallow and deep soils, soil moisture accounting, flow of groundwater from shallow soils to streams (i.e., interflow), flow of groundwater from deep soils to streams, and loss of groundwater to deep aquifers. Each of these physical processes are controlled by several parameters. Typically, standard parameters that have been developed for the Puget Sound lowland region (Dinicola, 1990), are used as the initial starting point in the calibration process. This is followed by parameter adjustments to achieve a better match between simulated and recorded streamflows.

As a general guide, the following objectives were established for calibration:

- Achieve a good match of peak flow magnitudes and hydrograph recession characteristics for the larger storms of record, particularly the January 1990, November 1990, and early 1991 events.
- Achieve a good match between recorded and simulated average monthly flows (i.e., runoff volume).

- Achieve a good match between recorded and simulated flow duration curves.

A goal of matching peak flows and volumes to within plus or minus 10 percent (on average) was the target for calibration. However, greater emphasis was placed on accurate calibration of the largest recorded storms to achieve accurate flood frequency estimates.

The final HSPF parameters arrived at in the calibration process for the Miller Creek and Des Moines Creek HSPF models are summarized in Tables 2-2 and 2-3, respectively. Model parameters listed in Tables 2-2 and 2-3 were adjusted on a watershed-wide basis, rather than by individual subbasins during the calibration process. Thus, in the Miller Creek HSPF model the parameters in Table 2-2 were used for the drainage areas above each of the two stream gauges. Total impervious area and active groundwater outflow (in the pervious runoff function) were also adjusted during the calibration process to match peak runoff and baseflow rates, respectively. These parameters were adjusted separately for each drainage area that is tributary to a stream gauge to improve the match of simulated flows to recorded flows.

TABLE 2-2
MILLER CREEK HSPF MODEL PARAMETERS

Land Segment[a]	LZSN (in)	INFILT (in/hr)	LSUR (ft)	SLSUR	KVARY (1/in)	AGWRC (1/day)	INFEXP	INFILD	BASETP	AGWETP	CEPSC (in)	UZSN (in)	NSUR	INTFW	IRC (1/day)	LZETP	RETSC (in/hr)
TFF	4.5	0.10	400	0.05	0.5	0.980	2.5	2.0	0.0	0.0	0.10	0.25	0.35	1.7	0.12	0.70	N/A
TFM	4.5	0.10	400	0.11	0.5	0.980	2.0	2.0	0.0	0.0	0.10	0.25	0.35	1.7	0.12	0.70	N/A
TFS	4.5	0.10	200	0.20	0.5	0.980	1.5	2.0	0.0	0.0	0.10	0.25	0.35	1.7	0.12	0.70	N/A
TGF	4.5	0.10	400	0.05	0.5	0.980	3.5	2.0	0.0	0.0	0.10	0.25	0.25	1.7	0.12	0.25	N/A
TGM	4.5	0.10	400	0.10	0.5	0.980	2.0	2.0	0.0	0.0	0.10	0.25	0.25	1.7	0.12	0.25	N/A
TGS	4.5	0.10	200	0.20	0.5	0.980	1.5	2.0	0.0	0.0	0.10	0.15	0.25	1.7	0.12	0.25	N/A
OF	5.0	1.50	400	0.05	0.3	0.980	2.0	2.0	0.0	0.0	0.10	0.25	0.35	1.7	0.12	0.7	N/A
OG	5.0	0.70	400	0.05	0.3	0.980	2.0	2.0	0.0	0.0	0.10	0.25	0.25	0.0	0.12	0.25	N/A
SA	4.0	1.00	100	0.001	0.5	0.980	10.0	2.0	0.0	0.7	0.10	3.00	0.50	1.0	0.12	0.80	N/A
EIA	N/A	N/A	500	0.05	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.100	N/A	N/A	N/A	0.10

a Land Segments:
TFF - Till, forested, flat
TFM - Till, forested, moderate
TFS - Till, forested, steep
TGF - Till, grass, flat
TGM - Till, grass, moderate
TGS - Till, grass, steep
OF - Outwash forest
OG- Outwash grass
SA - Wetlands
EIA - Effective impervious area

N/A - Not applicable

TABLE 2-3
DES MOINES CREEK HSPF MODEL PARAMETERS

Land Segment[a]	LZSN (in)	INFILT (in/hr)	LSUR (ft)	SLSUR	KVARY (1/in)	AGWRC (1/day)	INFEXP	INFILD	BASETP	AGWETP	CEPSC (in)	UZSN (in)	NSUR	INTFW	IRC (1/day)	LZETP	RETSC (in/hr)
TFF	4.5	0.30	400	0.05	0.5	0.996	3.5	2.0	0.0	0.0	0.20	1.00	0.35	3.0	0.3	0.70	N/A
TFM	4.5	0.30	400	0.10	0.5	0.996	2.0	2.0	0.0	0.0	0.20	0.50	0.35	3.0	0.3	0.70	N/A
TFS	4.5	0.30	200	0.20	0.5	0.996	1.5	2.0	0.0	0.0	0.20	0.30	0.35	3.0	0.3	0.70	N/A
TGF	4.5	0.30	400	0.05	0.5	0.996	3.5	2.0	0.0	0.0	0.20	1.00	0.25	3.0	0.7	0.25	N/A
TGM	4.5	0.30	400	0.10	0.5	0.996	2.0	2.0	0.0	0.0	0.20	0.50	0.25	6.0	0.5	0.25	N/A
TGS	4.5	0.30	200	0.20	0.5	0.996	1.5	2.0	0.0	0.0	0.20	0.30	0.25	7.0	0.3	0.25	N/A
OF	5.0	2.00	400	0.05	0.3	0.996	2.0	2.0	0.0	0.0	0.20	0.50	0.35	2.0	0.8	0.7	N/A
OG	5.0	0.80	400	0.05	0.3	0.996	2.0	2.0	0.0	0.0	0.10	0.50	0.25	2.0	0.8	0.25	N/A
SA	4.0	2.00	100	0.001	0.5	0.996	10.0	2.0	0.0	0.7	0.20	3.00	0.50	1.0	0.8	0.80	N/A
EIA	N/A	N/A	100	0.05	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.15	N/A	N/A	N/A	0.20

a Land Segments:
TFF - Till, forested, flat
TFM - Till, forested, moderate
TFS - Till, forested, steep
TGF - Till, grass, flat
TGM - Till, grass, moderate
TGS - Till, grass, steep
OF - Outwash forest
OG- Outwash grass
SA - Wetlands
EIA - Effective impervious area

N/A - Not applicable

Results from the HSPF model calibration process for the 5-year period of recorded streamflows are shown in Figures 8 and 9. Figure 8 is a plot comparing recorded and simulated monthly peak flows at two locations: Miller Creek near its mouth and Des Moines Creek at South 208th Street. Figure 9 is a plot comparing recorded and simulated monthly average flows, which are representative of flow volume, for the same two locations. Data used to create the plots are contained in Tables B-1 to B-3 (Appendix B).

In the study for the Lake Reba Detention Facility (NHC, 1990), the HSPF model was calibrated using streamflow data from a single gauging station at lower Miller Creek for the period of 1988-1989. For this study, the HSPF model for Miller Creek was calibrated at two locations: Miller Creek below Lake Reba (King County Gauge 42B) and Miller Creek at S.W. 175th Pl. in Normandy Park (King County Gauge 42A), which is located near the mouth of the creek. Model parameters were modified to calibrate the model to five years of recorded streamflow data (1989-1994), including the three largest storms on record which occurred in 1990 and 1991. Because the Lake Reba and Ambaum detention facilities were built in 1992, model calibration was performed for pre- and post-detention conditions. All subsequent simulation runs were based on post-detention conditions.

The Des Moines Creek HSPF model was calibrated to streamflow data collected from the stream gauge located at the east branch of Des Moines Creek above Tyee Pond (King County Gauge 11C). Model parameters were modified to calibrate the model to five years of recorded streamflow data (1989-1994). Stream gauge data for the Tyee Pond outlet were not used because King County noted that stage readings from this gauge were affected by debris. Also, unknown amounts of streamflow bypassed the outlet gauge during the January and November 1990 storms when water flowed over the emergency spillway. Stream gauge data from a gauge located near the mouth of the stream in Des Moines were available but were not used for calibration because the basin model did not extend downstream to that location.

In general, good calibration results were achieved at the lower Miller Creek gauge for both peak flows (Figure 8) and flow volume (Figure 9). The simulated monthly peak flows averaged 89 percent of the corresponding recorded flows (Table B-1). The simulated flow volume achieved better results, with the simulated volume equal to 99 percent of recorded volume. However, data in Table B-1 show that simulation accuracies varied from year to year. The variations may be caused by several factors, including inaccurate peak flow estimates in the stream gauge data, variable precipitation patterns in the watershed (HSPF assumes a uniform distribution using data recorded at the airport), or inaccuracy in subbasin characterization in the HSPF model. Calibration results at the Des Moines Creek inflow to Tyee Pond were similar, with simulated peak flows averaging 101 percent of the recorded flows and a simulated flow volume averaging 114 percent of the recorded volume (Table B-3). The simulated peak flows were also quite variable, probably due to the difficulty of simulating runoff from a basin that has a high percentage of impermeable surface area. The Des Moines Creek basin has approximately 50 percent of its area in commercial and airport uses.

Calibration results for Miller Creek below Lake Reba are summarized in Table B-2 (Appendix B). A good match of peak flows was obtained, but the simulated flow volumes were only 60 percent of the recorded flow volumes. The calibration problem was caused by difficult modeling conditions in the upper Miller Creek Watershed. Streamflow monitoring data for this section of the Miller Creek Basin (recorded at SR 518 above Lake Reba) showed very low peak flow magnitudes for the relatively large basin size. That may be a result of a combination of highly permeable soils, groundwater that drains to deep aquifers rather than to Miller Creek, several natural lakes that may retain large amounts of stormwater runoff, and inaccurate stream gauge data. Runoff volumes were underestimated at Miller Creek below Lake Reba because impervious areas had to be significantly reduced to achieve a good match of peak flows.

In addition to a calibration of the models using the parameters listed in Tables 2-2 and 2-3, test runs were made using the parameters from the NHC model for Miller Creek and the USGS regional parameters for Des Moines Creek. The test runs were made to compare the performance of our calibration parameters to parameters used in previous modeling studies.

A comparison of flow duration characteristics between recorded and simulated flows is shown in Figure B-1 (Appendix B). Two duration curves for simulated flows are shown: one for the calibrated model and one for the test runs using either the USGS regional parameters or the NHC parameters. The duration curves illustrate that the model calibration using our parameters resulted in a closer match to recorded flows.

Hydrograph plots of simulated versus recorded flows for major storms are shown in Figures B-2 to B-4 (Appendix B) for each of the stream gauge locations (Miller Creek near its mouth, Miller Creek below Lake Reba, and Des Moines Creek above Tyee Pond) during the storms of January 1990, November 1990, and April 1991. In addition, a fourth set of hydrograph plots are shown (Figure B-5) comparing simulated Des Moines Creek flows at South 208th Street with recorded flows near the mouth. The stream gauge on lower Des Moines Creek was established in late 1991, and therefore the hydrograph plots are for storms that occurred after this time. Although these two locations are somewhat separated from each other, good matches of storm peak and shape were achieved.

Hydrograph plots of the entire 5-year calibration period are also included in Figures B-6 and B-7 (Appendix B). These plots show daily peak hourly flows for recorded and simulated records at Miller Creek near its mouth and at the Des Moines Creek inflow to Tyee Pond.

2.4 LONG TERM SIMULATION RESULTS

Following calibration of the HSPF models, long-term hydrologic simulations of current conditions for Miller and Des Moines Creek were performed. These simulations were run for the 1948-1994 (47-year) period using hourly SeaTac Airport precipitation and daily Puyallup evaporation data as input. HSPF input data files, called user control input (UCI) files, for the current conditions simulation are contained in Appendix D. The UCI files that were used for the calibration runs are identical to the long-term simulation UCI files contained in Appendix D, except that simulation time and output file specifications were changed.

The results of the current conditions analyses were summarized using flood frequency and flow duration statistical measures. The summaries were completed for selected locations along Miller and Des Moines Creeks. The locations, which spatially represent streamflow conditions along the creeks, are as follows:

- Miller Creek:
  - Below Lake Reba
  - At 1st Avenue South
  - Near mouth

- Des Moines Creek:
  - below Confluence (of east and west branches)
  - at South 208th Street

Flood Frequency

Flood frequency estimates for current conditions are summarized in Table 2-4. Flood frequency estimates were calculated using annual peak flows produced by the HSPF simulation and the Corps of Engineers computer program HEC-FFA, Flood Frequency Analysis (COE, 1992). Exceedence probability graphs of flood frequency data are included as Figures C-1 to C-5 (Appendix C).

TABLE 2-4
FLOOD FREQUENCY ESTIMATES FOR
CURRENT CONDITIONS

		Flow (cfs)				
		Miller Creek			Des Moines Creek	
Probability	Return Period (years)	below Lk. Reba	at 1st Avenue	near Mouth	below Confluence	at S. 208th
0.01	100	171	293	468	232	280
0.02	50	158	259	412	207	247
0.05	20	140	217	343	176	206
0.10	10	125	185	293	154	178
0.20	5	108	154	243	132	150
0.50	2	80	109	173	103	112
0.80	1.25	57	77	124	83	86
0.90	1.11	47	64	104	74	76
0.95	1.05	40	55	91	69	69
0.99	1.01	28	40	69	60	58

The estimated 100-year flood for lower Miller Creek is 468 cfs. This compares to an estimate of 562 cfs by NHC using the previous HSPF model of Miller Creek (NHC, 1990) for the scenario of current land use without the Lake Reba Detention Facility, and 479 cfs for the scenario of future land use with the Lake Reba Detention Facility. NHC did not report an estimate of flood flows for the scenario of current land use with the Lake Reba Detention Facility. That scenario was modeled in this study.

In the proposed conditions analysis described in Section 3, representative 2-year, 10-year, and 100-year storms were selected for use in calculating total detention storage requirements. Those storms were selected from the historical simulation period by choosing storms whose peak flows most closely matched the flood frequency estimates. The selected storms were December 2-5, 1975 for the 2-year event; February 26-29, 1972 for the 10-year event; and January 8-11, 1990 for the 100-year event.

Flow Duration

Flow duration analyses under current conditions were also completed. The results are summarized in a comparative analysis to proposed land use conditions in Section 4.

2.5 MODELING AND CALIBRATION CHALLENGES

Several difficulties in model development and calibration were encountered during the study. The following paragraphs briefly describe difficulties encountered during the modeling process.

- The primary challenge to model calibration was the difficulty simulating the very rapid hydrograph recession in Miller Creek flows. This hydrograph characteristic is probably the result of the large amount of impervious surface in the watershed. During the calibration process, the interflow and recession parameters were extended beyond their "normal" range. This resulted in improved simulation. Future modeling efforts should consider reanalyses of land use characteristics for the entire watershed and more emphasis on adjustment of effective impervious areas in the calibration process.

- A large groundwater loss was needed to simulate recorded flow volumes in both Miller and Des Moines Creek. This was achieved by increasing infiltration and deep-groundwater recharge rates. Recorded peak runoff rates from upper Miller Creek (above SR-518) were particularly low relative to the basin area. The low runoff rates may be due to very pervious soil conditions and lake retention. A large reduction in effective impervious area was made in the HSPF model input to properly simulate the recorded peak flow rates.

- Much difficulty was encountered while trying to establish the current outlet rating curves for the Lake Reba, Ambaum, and Tyee Pond detention facilities, and for Bow Lake and Pond B. Accurate elevation-storage-discharge relationships for these facilities and lakes should be developed for future modeling efforts using as-built drawings and flow monitoring. Relationships that were derived during pre-design studies are apparently still being used by King County for their stream gauging.

- Streamflow data used for calibration were provided by King County with the qualifier "provisional data - do not distribute". The records had numerous gaps due to gauge failure and many high flow readings appeared erroneous, particularly the Lake Reba outflow data. The data should be further reviewed and checked by King County.

3.0 PROPOSED CONDITIONS ANALYSES

The tasks performed in the proposed conditions analyses included modifying the Miller Creek and Des Moines Creek models to reflect additional impervious area and other changed land use in the SeaTac Airport subbasins, calculating detention storage required to meet offsite discharge criteria, running the 47-year simulations, and comparing the resulting streamflow to existing condition streamflow.

A detailed representation of proposed stormwater facilities (i.e., conveyance pipes and stormwater ponds) was not incorporated into the HSPF models for two primary reasons. First, the design process for the runway drainage system had not begun, and no details of a potential system were available for incorporation into this study. Second, such a system would have been too complex to incorporate into an HSPF model. The only significant change made to the modeling network was the addition of detention storage ponds at certain subbasin nodes. Other minor changes were made to the network structure to help simplify the modeling of detention storage facilities. This included joining adjacent subbasins at a single node so that the combined runoff entered a single detention pond.

3.1 LAND USE CHANGES

Figure 10 illustrates the land use changes associated with the proposal. Changes in land use are based on the alternative that includes a 8,500-foot runway located 1,700 feet west of existing Runway 16R-34L. Also included with this alternative is the proposed South Aviation Support Area (SASA) in the southeast corner of the airport, new expansion of parking and cargo areas north of

SR-518, and new areas of fill. Other facilities such as terminal facilities and central parking were not incorporated into the HSPF models because they do not add new impervious area or they currently drain to the IWS. Also, future conversions of SDS areas to connect to the IWS (for water quality improvements) were not incorporated into the HSPF models because study efforts regarding these potential actions are still in progress.

Table 3-1 summarizes the current and proposed land use in the SeaTac Airport subbasins. Land use changes are detailed by subbasin in Table 3-2. New impervious area was assumed to be 100 percent effective, and new fill was assumed to have runoff characteristics equal to flat till. Subbasin areas and parameters for the proposed conditions model are summarized in Table A-3 (Appendix A).

Under the proposal, impervious surface area will increase by 95.4 acres in the Des Moines Creek Watershed and by 97.4 acres in the Miller Creek Watershed, for a total of 192.8 acres. Another 65.7 acres of impervious surface area will be located in the SASA area, but will drain to Puget Sound via the IWS. That area was excluded from the model. In addition, the total area of fill is increased by about 550 acres over both watersheds.

3.2 DETENTION REQUIREMENTS

The Stormwater Management Manual for the Puget Sound Basin (Ecology, 1992) was used as a guide to determine stormwater detention volumes and release rates. The detention criteria used for this analysis included detention of the 2-year storm and release at 50 percent of the existing 2-year runoff rate, and detention of the 10-year and 100-year storms and release at 100 percent of existing runoff rates for those storm events.

Detention storage required to meet Ecology's standards was estimated through the use of design storms hydrographs produced by the HSPF model. As described in Section 2.4, design storms were selected from the historical simulation period to represent 2-year, 10-year, and 100-year recurrence interval storms. The selected storms were December 2-5, 1975 for the 2-year event; February 26-29, 1972 for the 10-year event; and January 8-11, 1990 for the 100-year event. The recorded flows at lower Miller Creek during these design storms are 172 cfs, 277 cfs, and 433 cfs, respectively, compared to the flood frequency estimates of 173 cfs, 293 cfs, and 468 cfs, respectively (for the

TABLE 3-1
SUMMARY OF LAND USE CHANGES IN SEATAC SUBBASINS
ASSUMED FOR PROPOSAL

	Des Moines Creek (acres)	Miller Creek (acres)	Total
CURRENT LAND USE			
- SDS impervious area[a]	369	60	429
- IWS[a]	204	50	254
- Fill and other[a]	410	83	493
- Non-airport[b]	204	326	530
Total	**1,187**	**519**	**1,706**
PROPOSED CHANGES			
- New SDS impervious area	95.4	97.4	192.8
- New IWS	65.7	0	65.7
- New fill	282.5	262.3	544.8
PROPOSED LAND USE			
- SDS impervious area	464.4	157.4	621.8
- IWS	269.7	50	319.7
- Fill and other	452.9	311.6	764.5
Total	**1,187**	**519**	**1,706**

[a] Includes Subbasins 19 and 24 (SDW-3), 20 and 25 (SDS-3), 21 and 26 (SDS-1), and 23 and 28 (SDE-4) in Des Moines Creek, and Subbasins 23 and 27 (SDN-1), 24 and 28 (SDN-2), and 25 and 29 (SDN-3 and SDN-4) in Miller Creek.

[b] Areas in other subbasins affected by airport expansion.

2-year, 10-year, and 100-year return intervals). Since the January 1990 runoff event was less than the estimated 100-year flow, the hourly precipitation amounts in this storm were proportionately increased by a factor of 1.10, which raises the total runoff volume from that event to an amount equal to the average of the January and November 1990 runoff events (the two largest events on record).

TABLE 3-2
DETAIL OF LAND USE CHANGES IN SEATAC SUBBASINS
ASSUMED FOR PROPOSAL

Location	Subbasin Number	Modified Land Use (acres)	
		Compacted Fill	Impervious Surface
MILLER CREEK			
- Drainage to Lake Reba (node 40)	6	32.7	37.9
	7	24.5	0
	25/29	16.3	3.6
- Drainage to middle creek (node 47)	8	67.3	13.7
	26	71.0	24.5
- Drainage to lower creek (node 46)	20	50.5	17.7
Subtotal		**262.3**	**97.4**
DES MOINES CREEK			
- Drainage to Northwest Pond (node 66)	19/24	26.6	1.0
	20/25	144.3	55.0
- Drainage to Tyee Pond (node 50)	4	7.7	0.0
	5	26.8	27.2
	6	27.0	42.7
- Drainage below confluence (node 67)	12	12.6	0.0
	13	13.2	28.1
	21/26	24.3	7.1
- Less drainage to IWS		0.0	(65.7)
Subtotal		**282.5**	**95.4**
TOTAL		**544.8**	**192.8**

The first step in determining detention volumes was to calculate existing runoff rates from the area in each subbasin that were affected by proposed land use changes (i.e., the areas in Table 3-2). Those rates were determined by performing an HSPF model run with the areas removed. Existing rates of runoff were calculated by comparing these flows to the existing conditions model. The second step was to calculate the allowable runoff rate from each subbasin as defined by the stormwater detention criteria. For the 2-year event, this was calculated as the existing subbasin flow minus one-half of the flow calculated in the first step. For the 10-year and 100-year events, the allowable runoff rate is equal to the existing subbasin flow. The last step was to modify the subbasin land use parameters to reflect the proposed land use and to add the required detention storage.

Detention pond sizes were estimated using the King County Surface Water Management Division computer program RDFAC. Ninety-six hour hydrographs were extracted from the HSPF models to perform a routing analysis with RDFAC. A "generic" configuration of a stormwater pond was assumed in all cases. The stormwater ponds were assumed to be 6-foot deep basins with two outlet orifices. The bottom orifice was sized for the allowable release rate during a 2-year event, and the top orifice was sized for the allowable release rates during 10- and 100-year events. This analysis resulted in an initial estimate of stormwater detention volumes. To derive the final stormwater detention volumes, a series of full HSPF simulations were conducted, with each HSPF simulation using an incrementally larger storage volume. After each simulation a flood frequency analysis was conducted at each of the evaluation points along Miller and Des Moines Creek to verify whether the detention criteria were met. The final storage volumes in the Miller Creek model were increased by 50 percent over those initially estimated using the design storms, and the storage volumes in the Des Moines Creek model were increased by 20 percent. The Miller Creek model needed a significantly larger increase in storage volumes. The reason for this may be the presence of a large amount of existing storage along this stream (mostly behind roadway culverts), which alters the flood routing characteristics of this stream, and the timing of runoff from the three SeaTac subbasins that enter Miller Creek at different points in the basin.

The volume of stormwater detention used in the proposed conditions analysis is summarized in Table 3-3. We assumed that three detention ponds would be placed within each watershed. The locations were selected to represent the likely locations of stormwater discharge after the change in land use at the airport.

TABLE 3-3
ASSUMED ONSITE DETENTION VOLUMES

Location	Total Detention Volume[a] (ac-ft)
MILLER CREEK	
- Drainage to Lake Reba	14.9
- Drainage to middle creek	35.3
- Drainage to lower creek	10.4
Subtotal	**60.6**
DES MOINES CREEK	
- Drainage to Tyee Pond	4.6
- Drainage to Northwest Ponds	24.4
- Drainage below confluence	2.4
Subtotal	**31.4**
TOTAL	**92.0**

[a] Includes active storage volume only (i.e., to 100-year storm level).

3.3 RESULTS

The estimated discharge from airport areas under existing and proposed conditions is summarized in Table 3-4. The results are from HSPF runs using the design storm events discussed in Section 2.4. In all cases, the discharge under proposed conditions is lower than the current discharge. In fact, in order to meet the stormwater detention criteria at offsite stream locations, in many cases runoff rates are significantly lower under proposed conditions compared to existing conditions. The discharges listed in Table 3-4 include runoff from areas not affected by proposed land use changes in addition to the areas with land use changes. Thus, a full 50 percent reduction in the 2-year discharge from all airport areas would not be realized.

The performance of the detention ponds in attenuating stormwater runoff is illustrated by hydrographs in Figure 11. The hydrographs are of stormwater discharge from a representative subbasin, Miller Creek Subbasin 24, under three scenarios: existing conditions, proposed conditions without detention, and proposed conditions with detention. Stormwater detention reduces the peak flow rate but increases the rate of flow during the period of hydrograph recession. Stormwater detention has the greatest relative effect during the 2-year storm because detention used in the analyses called for a 50 percent reduction in peak flows during that event.

TABLE 3-4
DESIGN STORM DISCHARGES FROM ONSITE SUBBASINS

Location	Flow Event[a]	Discharge (cfs)	
		Existing	Proposed
MILLER CREEK			
- Lake Reba inflow	2-Year	22.4	16.1
	10-Year	55.9	39.2
	100-Year	93.2	82.4
- Middle creek	2-Year	13.7	6.4
	10-Year	51.4	23.8
	100-Year	94.5	72.8
- Lower creek	2-Year	18.7	12.4
	10-Year	46.8	33.1
	100-Year	78.8	69.6
DES MOINES CREEK			
- NW Pond inflow	2-Year	53.4	44.8
	10-Year	89.5	80.5
	100-Year	145.3	138.5
- Tyee Pond inflow	2-Year	25.7	22.3
	10-Year	44.5	37.6
	100-Year	63.8	60.2
- Below confluence	2-Year	8.0	6.2
	10-Year	17.8	13.4
	100-Year	26.2	24.5

[a] 2-Year event: December 2, 1975
10-Year event: February 27, 1972
100-Year event: January 9, 1990 (with precipitation factored by 1.10)

Simulated peak flow rates in Miller and Des Moines Creeks under current and proposed land use conditions for the three design storm events are summarized in Table 3-5. The simulated peak flows under proposed conditions were found to be less than current peak flows. HSPF input data files for the proposed conditions analyses are contained in Appendix E.

TABLE 3-5
DESIGN STORM DISCHARGES AT OFFSITE STREAMFLOW LOCATIONS

Location	Flow Event[a]	Flow (cfs)	
		Existing	Proposed
MILLER CREEK			
- Near mouth (node 17)	2-Year	172	169
	10-Year	298	282
	100-Year	434	414
- at 1st Ave. S. (node 33)	2-Year	106	103
	10-Year	188	169
	100-Year	247	233
- Lake Reba outflow (node 7)	2-Year	78	76
	10-Year	124	123
	100-Year	147	144
DES MOINES CREEK			
- At S. 208th St. (node 18)	2-Year	99	98
	10-Year	171	162
	100-Year	259	248
- Below confluence (node 13)	2-Year	90	88
	10-Year	145	139
	100-Year	222	213

[a] 2-Year event: December 2, 1975
10-Year event: February 27, 1972
100-Year event: January 9, 1990

4.0 ANALYSIS OF IMPACTS

Potential effects of the proposed land use changes on streamflows in Miller and Des Moines Creeks were determined by comparing HSPF model simulation results from the proposed conditions model, which included increased impervious surfaces and stormwater detention, with results from the current conditions model. Statistical measures of flood frequency, flow duration, and flow exceedence were used in the comparative analysis.

4.1 FLOOD FREQUENCY

A 47-year simulation using the historical precipitation record was run with the proposed condition models. A flood frequency analysis of the results of that simulation can determine whether the detention ponds, whose design was based on a representative design storm, can have similar performance over other individual or sequences of storms contained in the historical period of the precipitation record.

The flood frequency analysis was performed using annual peak flows derived from the 47-year simulation period and the HEC-FFA software package. Estimated peak flows for various flood frequencies are summarized in Tables 4-1 and 4-2 for Miller Creek and Des Moines Creek, respectively. The tables also present the difference between estimates of peak flows under proposed and current conditions. The analysis using a full 47-year period of record indicated that peak flows under proposed conditions will not exceed those predicted for existing conditions. As discussed in Section 3.2, the HSPF models were used to verify the amount of stormwater detention volume that would be required under the proposed development scenario. The flood frequency values for proposed conditions that are contained in Tables 4-1 and 4-2 reflect the amount of stormwater detention volume needed to limit offsite flood peaks to no greater than existing conditions.

4.2 ANNUAL FLOW DURATION AND VOLUME

A flow duration analysis quantifies changes in streamflow rates at incremental flow intervals over the entire range of streamflow. Table 4-3 summarizes a comparison of flow duration characteristics between current and proposed conditions. The flow duration analyses were prepared using simulated hourly flows and the USGS SWSTAT computer program which is a surface water statistical analysis program (USGS, 1993).

TABLE 4-1
FLOOD FREQUENCY ESTIMATES FOR
PROPOSED CONDITIONS - MILLER CREEK

Probability	Return Period (years)	Location					
		Below Lake Reba		At 1st Avenue		Near Mouth	
		Flow (cfs)	Difference[a] (cfs)	Flow (cfs)	Difference[a] (cfs)	Flow (cfs)	Difference[a] (cfs)
0.01	100	166	-5	292	-1	454	-14
0.02	50	152	-6	256	-3	400	-12
0.05	20	134	-6	212	-5	334	-9
0.10	10	119	-6	181	-4	285	-8
0.20	5	103	-5	150	-4	238	-5
0.50	2	76	-4	105	-4	170	-3
0.80	1.25	55	-3	75	-2	122	-2
0.90	1.11	46	-1	63	-1	103	-1
0.95	1.05	39	-1	54	-1	89	-2
0.99	1.01	28	0	41	+1	68	-1

[a] Compared to existing conditions (Table 2-4).

TABLE 4-2
FLOOD FREQUENCY ESTIMATES FOR
PROPOSED CONDITIONS - DES MOINES CREEK

Probability	Return Period (years)	Location			
		Below Confluence		At S. 208th Street	
		Flow (cfs)	Difference[a] (cfs)	Flow (cfs)	Difference[a] (cfs)
0.01	100	232	0	280	0
0.02	50	205	-2	244	-3
0.05	20	172	-4	202	-4
0.10	10	149	-5	173	-5
0.20	5	127	-5	145	-5
0.50	2	96	-7	108	-4
0.80	1.25	76	-7	84	-4
0.90	1.11	68	-6	74	-2
0.95	1.05	62	-7	68	-1
0.99	1.01	54	-6	58	0

[a] Compared to existing conditions (Table 2-4).

TABLE 4-3
FLOW DURATION CHARACTERISTICS AT OFFSITE STREAM LOCATIONS

Miller Creek near Mouth (Node 17)										
		Existing Conditions			Proposed Conditions			Difference		
Flow Interval (cfs)		Percent Time in Flow Interval	Percent Time Flow Exceeds Lower Limit	Annual Flow Volume (ac-ft)	Percent Time in Flow Interval	Percent Time Flow Exceeds Lower Limit	Annual Flow Volume (ac-ft)	Total Volume (ac-ft)	Percent Volume	Duration of Flow (hours)
0	2	34.52	100.00	250	34.25	100.00	248	-2	-1%	-24
2	4	34.89	65.48	758	33.66	65.75	731	-27	-4%	-108
4	6	7.57	30.60	274	7.47	32.09	270	-4	-1%	-9
6	8	4.07	23.03	206	4.18	24.62	212	6	3%	10
8	10	2.89	18.96	188	3.00	20.44	195	7	4%	10
10	15	4.79	16.07	433	5.08	17.44	460	26	6%	25
15	20	2.98	11.28	378	3.25	12.36	412	34	9%	24
20	25	2.00	8.30	326	2.21	9.11	360	34	11%	18
25	30	1.43	6.30	285	1.56	6.91	311	26	9%	11
30	35	1.08	4.87	254	1.16	5.34	273	19	7%	7
35	40	0.80	3.79	217	0.87	4.19	236	19	9%	6
40	45	0.62	2.99	191	0.67	3.31	206	15	8%	4
45	50	0.48	2.37	165	0.54	2.64	186	21	13%	5
50	60	0.62	1.89	247	0.68	2.10	271	24	10%	5
60	70	0.38	1.27	179	0.44	1.42	207	28	16%	5
70	80	0.25	0.89	136	0.28	0.98	152	16	12%	3
80	90	0.16	0.64	98	0.18	0.70	111	12	12%	2
90	100	0.11	0.48	76	0.12	0.52	83	7	9%	1
100	120	0.14	0.37	111	0.16	0.40	127	16	14%	2
120	140	0.09	0.23	85	0.09	0.23	85	0	0%	0
140	160	0.04	0.14	43	0.05	0.14	54	11	25%	1
160	180	0.02	0.10	25	0.02	0.10	25	0	0%	0
180	200	0.03	0.07	41	0.03	0.07	41	0	0%	0
200	220	0.02	0.05	30	0.02	0.04	30	0	0%	0
220	240	0.01	0.03	17	0.01	0.03	17	0	0%	0
240	260	0.00	0.02	0	0.01	0.02	18	18	0%	1
260	280	0.01	0.02	20	0.01	0.02	20	0	0%	0
280	300	0.01	0.01	21	0.01	0.01	21	0	0%	0
300	320	0.00	0.00	0	0.00	0.00	0	0	0%	0
			Acre-feet/year:	5,054		Acre-feet/year:	5,361	307		
			Average flow:	6.99 (cfs)		Average flow:	7.42 (cfs)	0.43 (cfs)		

Miller Creek at 1st Avenue (Node 33)										
		Existing Conditions			Proposed Conditions			Difference		
Flow Interval (cfs)		Percent Time in Flow Interval	Percent Time Flow Exceeds Lower Limit	Annual Flow Volume (ac-ft)	Percent Time in Flow Interval	Percent Time Flow Exceeds Lower Limit	Annual Flow Volume (ac-ft)	Total Volume (ac-ft)	Percent Volume	Duration of Flow (hours)
0	2	71.99	100.00	521	69.98	100.00	507	-15	-3%	-176
2	4	8.23	28.01	179	8.31	30.02	180	2	1%	7
4	6	4.40	19.78	159	4.63	21.70	168	8	5%	20
6	8	3.04	15.38	154	3.25	17.07	165	11	7%	18
8	10	2.24	12.34	146	2.46	13.82	160	14	10%	19
10	15	3.68	10.10	333	4.11	11.36	372	39	12%	38
15	20	2.13	6.42	270	2.36	7.25	299	29	11%	20
20	25	1.37	4.29	223	1.55	4.90	252	29	13%	16
25	30	0.89	2.92	177	1.01	3.34	201	24	13%	11
30	35	0.56	2.03	132	0.64	2.33	151	19	14%	7
35	40	0.39	1.47	106	0.44	1.69	119	14	13%	4
40	45	0.27	1.08	83	0.32	1.25	98	15	19%	4
45	50	0.18	0.81	62	0.21	0.92	72	10	17%	3
50	60	0.22	0.63	88	0.25	0.71	100	12	14%	3
60	70	0.12	0.41	56	0.14	0.46	66	9	17%	2
70	80	0.08	0.29	43	0.10	0.32	54	11	25%	2
80	90	0.06	0.21	37	0.07	0.22	43	6	17%	1
90	100	0.04	0.15	28	0.05	0.15	34	7	25%	1
100	120	0.04	0.10	32	0.05	0.10	40	8	25%	1
120	140	0.03	0.06	28	0.02	0.05	19	-9	-33%	-1
140	160	0.01	0.03	11	0.01	0.03	11	0	0%	0
160	180	0.01	0.02	12	0.01	0.02	12	0	0%	0
180	200	0.00	0.01	0	0.00	0.01	0	0	0%	0
200	220	0.00	0.00	0	0.00	0.00	0	0	0%	0
			Acre-feet/year:	2,880		Acre-feet/year:	3,124	244		
			Average flow:	3.99 (cfs)		Average flow:	4.32 (cfs)	0.34 (cfs)		

TABLE 4-3 (CONTINUED)
FLOW DURATION CHARACTERISTICS AT OFFSITE STREAM LOCATIONS

Miller Creek below Lake Reba (Node 7)										
		Existing Conditions			Proposed Conditions			Difference		
Flow Interval (cfs)		Percent Time in Flow Interval	Percent Time Flow Exceeds Lower Limit	Annual Flow Volume (ac-ft)	Percent Time in Flow Interval	Percent Time Flow Exceeds Lower Limit	Annual Flow Volume (ac-ft)	Total Volume (ac-ft)	Percent Volume	Duration of Flow (hours)
0	2	81.32	100.00	589	80.12	100.00	580	-9	-1%	-105
2	4	7.64	18.68	166	7.84	19.88	170	4	3%	18
4	6	3.69	11.05	134	3.88	12.04	140	7	5%	17
6	8	2.10	7.36	106	2.25	8.16	114	8	7%	13
8	10	1.30	5.26	85	1.46	5.91	95	10	12%	14
10	15	1.81	3.96	164	1.97	4.46	178	14	9%	14
15	20	0.86	2.15	109	0.97	2.49	123	14	13%	10
20	25	0.48	1.29	78	0.54	1.52	88	10	13%	5
25	30	0.26	0.81	52	0.32	0.98	64	12	23%	5
30	35	0.16	0.55	38	0.19	0.66	45	7	19%	3
35	40	0.10	0.39	27	0.13	0.47	35	8	30%	3
40	45	0.07	0.29	22	0.08	0.34	25	3	14%	1
45	50	0.05	0.22	17	0.06	0.26	21	3	20%	1
50	60	0.06	0.17	24	0.07	0.20	28	4	17%	1
60	70	0.03	0.12	14	0.04	0.13	19	5	33%	1
70	80	0.02	0.09	11	0.02	0.09	11	0	0%	0
80	90	0.01	0.07	6	0.01	0.07	6	0	0%	0
90	100	0.02	0.06	14	0.02	0.05	14	0	0%	0
100	120	0.02	0.04	16	0.02	0.03	16	0	0%	0
120	140	0.01	0.01	9	0.01	0.01	9	0	0%	0
140	160	0.00	0.00	0	0.00	0.00	0	0	0%	0
			Acre-feet/year:	1,680		Acre-feet/year:	1,781	101		
			Average flow:	2.32 (cfs)		Average flow:	2.46 (cfs)	0.14 (cfs)		

Des Moines Creek at S 208th Street (Node 18)										
		Existing Conditions			Proposed Conditions			Difference		
Flow Interval (cfs)		Percent Time in Flow Interval	Percent Time Flow Exceeds Lower Limit	Annual Flow Volume (ac-ft)	Percent Time in Flow Interval	Percent Time Flow Exceeds Lower Limit	Annual Flow Volume (ac-ft)	Total Volume (ac-ft)	Percent Volume	Duration of Flow (hours)
0	2	32.07	100.00	232	35.62	100.00	258	26	11%	311
2	4	31.26	67.93	679	29.29	64.38	636	-43	-6%	-173
4	6	13.12	36.67	475	11.58	35.09	419	-56	-12%	-135
6	8	6.55	23.55	332	6.11	23.51	310	-22	-7%	-39
8	10	3.99	17.01	260	3.78	17.40	246	-14	-5%	-18
10	15	5.27	13.01	477	5.32	13.62	481	5	1%	4
15	20	2.51	7.75	318	2.65	8.31	336	18	6%	12
20	25	1.45	5.23	236	1.51	5.65	246	10	4%	5
25	30	0.93	3.78	185	1.01	4.14	201	16	9%	7
30	35	0.73	2.85	172	0.78	3.13	184	12	7%	4
35	40	0.52	2.12	141	0.57	2.35	155	14	10%	4
40	45	0.43	1.61	132	0.47	1.78	145	12	9%	4
45	50	0.31	1.17	107	0.35	1.31	120	14	13%	4
50	60	0.38	0.87	151	0.42	0.96	167	16	11%	4
60	70	0.22	0.49	104	0.25	0.54	118	14	14%	3
70	80	0.11	0.27	60	0.13	0.29	71	11	18%	2
80	90	0.06	0.16	37	0.06	0.17	37	0	0%	0
90	100	0.03	0.10	21	0.03	0.11	21	0	0%	0
100	120	0.03	0.07	24	0.04	0.08	32	8	33%	1
120	140	0.02	0.04	19	0.02	0.05	19	0	0%	0
140	160	0.01	0.02	11	0.01	0.03	11	0	0%	0
160	180	0.01	0.01	12	0.01	0.01	12	0	0%	0
180	200	0.00	0.00	0	0.00	0.01	0	0	0%	0
200	220	0.00	0.00	0	0.00	0.00	0	0	0%	0
			Total acre-feet:	4,184		Total acre-feet:	4,223	39		
			Average flow:	5.79 (cfs)		Average flow:	5.84 (cfs)	0.05 (cfs)		

TABLE 4-3 (CONTINUED)
FLOW DURATION CHARACTERISTICS AT OFFSITE STREAM LOCATIONS

Des Moines Creek below Confluence (Node 13)										
		Existing Conditions			Proposed Conditions			Difference		
Flow Interval (cfs)		Percent Time in Flow Interval	Percent Time Flow Exceeds Lower Limit	Annual Flow Volume (ac-ft)	Percent Time in Flow Interval	Percent Time Flow Exceeds Lower Limit	Annual Flow Volume (ac-ft)	Total Volume (ac-ft)	Percent Volume	Duration of Flow (hours)
0	2	41.32	100.00	299	44.59	100.00	323	24	8%	286
2	4	28.31	58.68	615	25.89	55.41	562	-53	-9%	-212
4	6	10.19	30.37	369	9.06	29.52	328	-41	-11%	-99
6	8	5.68	20.18	288	5.32	20.45	270	-18	-6%	-32
8	10	3.50	14.50	228	3.40	15.13	222	-7	-3%	-9
10	15	4.72	11.00	427	4.84	11.73	438	11	3%	11
15	20	2.18	6.28	276	2.33	6.89	295	19	7%	13
20	25	1.31	4.10	213	1.40	4.56	228	15	7%	8
25	30	0.82	2.79	163	0.93	3.16	185	22	13%	10
30	35	0.59	1.96	139	0.64	2.22	151	12	8%	4
35	40	0.40	1.38	109	0.47	1.58	128	19	17%	6
40	45	0.27	0.97	83	0.32	1.11	98	15	19%	4
45	50	0.19	0.71	65	0.20	0.79	69	3	5%	1
50	60	0.23	0.51	92	0.27	0.59	108	16	17%	4
60	70	0.11	0.29	52	0.12	0.32	56	5	9%	1
70	80	0.06	0.18	33	0.08	0.19	43	11	33%	2
80	90	0.04	0.11	25	0.04	0.12	25	0	0%	0
90	100	0.02	0.07	14	0.02	0.08	14	0	0%	0
100	120	0.02	0.05	16	0.03	0.05	24	8	50%	1
120	140	0.01	0.02	9	0.01	0.03	9	0	0%	0
140	160	0.01	0.01	11	0.01	0.01	11	0	0%	0
160	180	0.00	0.00	0	0.00	0.00	0	0	0%	0
180	200	0.00	0.00	0	0.00	0.00	0	0	0%	0
200	220	0.00	0.00	0	0.00	0.00	0	0	0%	0
			Total acre-feet:	3,525		Total acre-feet:	3,586	61		
			Average flow:	4.88 (cfs)		Average flow:	4.96 (cfs)	0.08 (cfs)		

The flow duration analyses predict that flow volumes in lower Miller Creek will increase by approximately 300 acre-feet per year on average, or an increase of approximately 6 percent. Flow volumes in Des Moines Creek are predicted to increase by approximately 60 acre-feet per year, or an increase of approximately 1 percent. The increase in flow volumes is caused by the additional impervious area, which reduces infiltration and evapotranspiration. The smaller increase found for Des Moines Creek was a result of the diversion of surface water runoff in the South Aviation Support Area to Puget Sound via the IWS.

The increase in flow volumes occur in the lower flow ranges. In Miller Creek near the mouth, the increase occurs mostly below the 120 cfs flow level, which is equal to about the 1.25-year storm frequency. (The 1.25-year flood occurs on average about every 4 out of 5 years). In Des Moines Creek at South 208th Street, the increase occurs below the 80 cfs flow level, which is also equal to about the 1.25 year flow magnitude. This is the range of flow that occurs when the detention ponds discharge their storage to the streams after a storm event. For storms larger than the 2-year event, the increased volume of flow is not significant.

Under low flow conditions, the HSPF model predicts that streamflows will decrease. The reduction is due to less interflow and groundwater recharge that could occur when impervious surface area is increased. In Miller Creek, streamflows below the 6 cfs magnitude, which occur about 77 percent of the time over the year, would be reduced by about 3 percent as a result of the proposal. The greatest effect to streamflows would be in the 2-4 cfs range, where the flow would be reduced by up to 4 percent.

The effects of the proposal on low flows are more pronounced in Des Moines Creek. Streamflows below the 10 cfs magnitude, which currently occur about 87 percent of the time over the year in Des Moines Creek, would be reduced by about 6 percent as a result of the airport project. The greatest decrease would be in the 4-6 cfs range, where streamflows would be reduced by up to 11 percent. The effects are greater in Des Moines Creek than in Miller Creek because diversion of runoff to the IWS further decreases the amount of water reaching the stream.

4.3 SEASONAL FLOW EXCEEDENCE CHARACTERISTICS

The potential change in seasonal runoff characteristics was assessed using a flow exceedence analysis for different periods of the year. For the analysis, flow exceedence levels of 90 percent, 50 percent and 10 percent were selected to represent low, median, and high streamflow conditions, respectively. To assess seasonal differences, the calendar year was divided into 48 periods, or 4 per month. This analysis allows one, for example, to determine how the proposal will affect August streamflow rates during a low flow year. A computer program developed by the USGS (Program B17) and modified by Bruce Barker of the Department of Ecology Water Resources Division was used for this analysis.

The seasonal flow exceedence analysis is summarized in Table 4-4. The analysis was conducted at each of the five evaluation points on Miller and Des Moines Creek. The results show that, due to the proposed land use change, summer streamflows during low flow years (i.e., exceeded 90 percent of the time) may decrease by up to about 0.1 cfs in Miller Creek, and by up to 0.2 cfs in Des Moines Creek. Summer streamflow is predicted to increase during median and high flow years in Miller Creek, but decrease in Des Moines Creek. The latter is due to diversion of SASA runoff to the IWS.

TABLE 4-4

FLOW EXCEEDENCE CHARACTERISTICS AT OFFSITE STREAM LOCATIONS

		Miller Creek near Mouth (Node 17)								
		Average Daily Flow Rate (cfs)								
		Current Conditions			Proposed Conditions			Difference		
Period	Month	Low Flow	Median Flow	High Flow	Low Flow	Median Flow	High Flow	Low Flow	Median Flow	High Flow
1	Jan	3.1	9.4	29.7	3.1	9.8	31.8	0.0	0.4	2.1
2		3.7	10.5	29.6	3.8	11.0	31.4	0.1	0.5	1.8
3		3.2	9.9	33.9	3.2	10.5	36.3	0.0	0.6	2.4
4		3.5	11.3	29.6	3.6	11.8	31.6	0.1	0.5	2.0
5	Feb	2.8	8.1	24.4	2.8	8.4	26.0	0.0	0.3	1.6
6		3.4	8.7	25.0	3.4	9.1	26.7	0.0	0.4	1.7
7		3.4	10.4	27.5	3.4	10.9	29.4	0.0	0.5	1.9
8		3.2	8.1	23.0	3.2	8.4	24.5	0.0	0.3	1.5
9	Mar	3.4	7.4	21.8	3.4	7.7	23.1	0.0	0.3	1.3
10		2.8	7.1	19.6	2.8	7.4	20.9	0.0	0.3	1.3
11		2.7	5.6	14.8	2.7	5.8	15.7	0.0	0.2	0.9
12		2.9	6.2	14.0	2.9	6.4	14.9	0.0	0.2	0.9
13	Apr	2.4	4.5	13.7	2.4	4.6	14.5	0.0	0.1	0.8
14		2.3	4.6	11.2	2.3	4.8	11.9	0.0	0.2	0.7
15		2.0	3.9	11.0	2.0	4.0	11.7	0.0	0.1	0.7
16		2.3	3.6	6.8	2.3	3.7	7.1	0.0	0.1	0.3
17	May	2.1	3.1	6.0	2.1	3.2	6.3	0.0	0.1	0.3
18		1.9	2.8	4.6	1.9	2.8	4.8	0.0	0.0	0.2
19		1.8	2.6	4.5	1.8	2.7	4.7	0.0	0.1	0.2
20		1.8	2.8	5.6	1.8	2.9	5.9	0.0	0.1	0.3
21	Jun	1.7	2.5	6.5	1.6	2.6	6.9	-0.1	0.1	0.4
22		1.6	2.5	5.1	1.6	2.6	5.4	0.0	0.1	0.3
23		1.7	2.2	4.4	1.7	2.2	4.6	0.0	0.0	0.2
24		1.6	2.4	4.2	1.6	2.4	4.4	0.0	0.0	0.2
25	Jul	1.6	2.2	3.7	1.6	2.2	3.8	0.0	0.0	0.1
26		1.5	2.1	3.8	1.5	2.1	3.9	0.0	0.0	0.1
27		1.6	1.8	2.8	1.6	1.9	2.9	0.0	0.1	0.1
28		1.6	1.8	2.6	1.6	1.8	2.6	0.0	0.0	0.0
29	Aug	1.5	1.7	3.0	1.5	1.7	3.1	0.0	0.0	0.1
30		1.5	1.7	3.0	1.5	1.7	3.2	0.0	0.0	0.2
31		1.4	1.8	3.9	1.3	1.9	4.1	-0.1	0.1	0.2
32		1.5	2.0	4.7	1.4	2.0	5.0	-0.1	0.0	0.3
33	Sep	1.3	2.0	4.1	1.3	2.0	4.3	0.0	0.0	0.2
34		1.4	2.1	4.0	1.4	2.2	4.2	0.0	0.1	0.2
35		1.4	2.5	6.1	1.3	2.6	6.6	-0.1	0.1	0.5
36		1.3	2.6	7.2	1.3	2.7	7.8	0.0	0.1	0.6
37	Oct	1.4	2.4	7.4	1.4	2.5	8.0	0.0	0.1	0.6
38		1.5	3.2	9.0	1.5	3.4	9.8	0.0	0.2	0.8
39		1.6	3.5	9.8	1.6	3.7	10.6	0.0	0.2	0.8
40		2.3	5.0	11.6	2.4	5.3	12.7	0.1	0.3	1.1
41	Nov	2.2	5.8	15.5	2.2	6.2	16.9	0.0	0.4	1.4
42		2.6	7.8	22.2	2.7	8.4	24.1	0.1	0.6	1.9
43		2.6	8.5	26.2	2.7	9.0	28.3	0.1	0.5	2.1
44		3.7	10.8	27.9	3.8	11.5	29.9	0.1	0.7	2.0
45	Dec	4.2	11.9	27.6	4.3	12.7	29.8	0.1	0.8	2.2
46		3.8	10.8	28.2	3.9	11.5	30.3	0.1	0.7	2.1
47		3.6	10.3	29.1	3.7	10.9	31.1	0.1	0.6	2.0
48		3.9	10.4	25.3	4.0	11.0	27.2	0.1	0.6	1.9

Notes:
1) Low, median and high flow are defined as flows exceeding 90%, 50% and 10% of the time, respectively.
2) Each month is divided into 4 equal periods, for a total of 48 periods in the year.
3) Flows are based on HSPF model results for a 1948-1994 simulation period.

TABLE 4-4 (CONTINUED)

FLOW EXCEEDENCE CHARACTERISTICS AT OFFSITE STREAM LOCATIONS

Miller Creek above 1st Avenue (Node 33)										
		Average Daily Flow Rate (cfs)								
		Current Conditions			Proposed Conditions			Difference		
Period	Month	Low Flow	Median Flow	High Flow	Low Flow	Median Flow	High Flow	Low Flow	Median Flow	High Flow
1	Jan	1.1	5.0	19.1	1.1	5.4	21.0	0.0	0.4	1.9
2		1.5	5.7	18.8	1.6	6.2	20.4	0.1	0.5	1.6
3		1.2	5.3	21.8	1.3	5.7	24.0	0.1	0.4	2.2
4		1.3	6.2	19.1	1.4	6.7	21.1	0.1	0.5	2.0
5	Feb	0.9	4.2	15.6	1.0	4.4	17.1	0.1	0.2	1.5
6		1.3	4.6	15.7	1.4	5.0	17.2	0.1	0.4	1.5
7		1.2	5.7	17.7	1.3	6.1	19.4	0.1	0.4	1.7
8		1.2	4.2	14.4	1.2	4.5	15.8	0.0	0.3	1.4
9	Mar	1.3	3.8	13.3	1.4	4.1	14.6	0.1	0.3	1.3
10		1.0	3.5	12.2	1.0	3.7	13.4	0.0	0.2	1.2
11		0.9	2.7	8.9	0.9	2.9	9.7	0.0	0.2	0.8
12		1.0	3.0	8.4	1.0	3.2	9.2	0.0	0.2	0.8
13	Apr	0.7	2.0	8.0	0.7	2.1	8.7	0.0	0.1	0.7
14		0.6	2.0	6.5	0.6	2.1	7.2	0.0	0.1	0.7
15		0.5	1.5	6.2	0.5	1.6	6.8	0.0	0.1	0.6
16		0.6	1.4	3.5	0.6	1.5	3.8	0.0	0.1	0.3
17	May	0.5	1.1	2.9	0.5	1.1	3.2	0.0	0.0	0.3
18		0.4	0.8	2.1	0.4	0.9	2.3	0.0	0.1	0.2
19		0.3	0.7	2.0	0.3	0.8	2.2	0.0	0.1	0.2
20		0.3	0.8	2.7	0.3	0.9	3.0	0.0	0.1	0.3
21	Jun	0.2	0.7	3.1	0.2	0.7	3.4	0.0	0.0	0.3
22		0.2	0.6	2.3	0.2	0.6	2.6	0.0	0.0	0.3
23		0.2	0.5	1.8	0.2	0.5	1.9	0.0	0.0	0.1
24		0.2	0.5	1.8	0.2	0.5	2.0	0.0	0.0	0.2
25	Jul	0.2	0.4	1.4	0.2	0.4	1.5	0.0	0.0	0.1
26		0.1	0.4	1.4	0.1	0.4	1.5	0.0	0.0	0.1
27		0.1	0.3	0.8	0.1	0.3	0.9	0.0	0.0	0.1
28		0.1	0.2	0.6	0.1	0.2	0.7	0.0	0.0	0.1
29	Aug	0.1	0.2	0.8	0.1	0.2	0.9	0.0	0.0	0.1
30		0.1	0.2	0.9	0.1	0.2	0.9	0.0	0.0	0.0
31		0.1	0.2	1.3	0.1	0.2	1.4	0.0	0.0	0.1
32		0.1	0.3	1.9	0.1	0.3	2.2	0.0	0,0	0.3
33	Sep	0.1	0.2	1.5	0.1	0.3	1.7	0.0	0.1	0.2
34		0.1	0.3	1.7	0.1	0.3	1.9	0.0	0.0	0.2
35		0.1	0.4	3.1	0.1	0.5	3.7	0.0	0.1	0.6
36		0.1	0.5	4.0	0.1	0.5	4.6	0.0	0.0	0.6
37	Oct	0.1	0.5	4.1	0.1	0.6	4.6	0.0	0.1	0.5
38		0.1	0.9	5.6	0.1	1.0	6.4	0.0	0.1	0.8
39		0.2	1.1	6.0	0.2	1.2	6.8	0.0	0.1	0.8
40		0.5	2.2	6.8	0.6	2.4	7.7	0.1	0.2	0.9
41	Nov	0.4	2.7	10.0	0.5	3.0	11.2	0.1	0.3	1.2
42		0.6	4.2	14.0	0.6	4.7	15.7	0.0	0.5	1.7
43		0.7	4.5	17.0	0.7	5.0	18.9	0.0	0.5	1.9
44		1.2	6.4	17.3	1.3	7.1	18.9	0.1	0.7	1.6
45	Dec	1.6	6.9	17.3	1.7	7.6	19.1	0.1	0.7	1.8
46		1.4	6.1	17.8	1.6	6.6	19.6	0.2	0.5	1.8
47		1.4	5.7	18.5	1.4	6.2	20.4	0.0	0.5	1.9
48		1.6	5.7	15.9	1.7	6.2	17.6	0.1	0.5	1.7

Notes:
1) Low, median and high flow are defined as flows exceeding 90%, 50% and 10% of the time, respectively.
2) Each month is divided into 4 equal periods, for a total of 48 periods in the year.
3) Flows are based on HSPF model results for a 1948-1994 simulation period.

TABLE 4-4 (CONTINUED)

FLOW EXCEEDENCE CHARACTERISTICS AT OFFSITE STREAM LOCATIONS

Miller Creek below Lake Reba (Node 7)										
		Average Daily Flow Rate (cfs)								
		Current Conditions			Proposed Conditions			Difference		
Period	Month	Low Flow	Median Flow	High Flow	Low Flow	Median Flow	High Flow	Low Flow	Median Flow	High Flow
1	Jan	0.7	2.7	10.2	0.7	2.9	10.9	0.0	0.2	0.7
2		0.9	3.1	10.2	0.9	3.3	10.9	0.0	0.2	0.7
3		0.7	2.9	11.9	0.8	3.0	12.7	0.1	0.1	0.8
4		0.8	3.4	10.4	0.8	3.6	11.1	0.0	0.2	0.7
5	Feb	0.6	2.3	8.5	0.6	2.4	9.1	0.0	0.1	0.6
6		0.8	2.5	8.4	0.8	2.6	9.0	0.0	0.1	0.6
7		0.7	3.1	9.6	0.7	3.3	10.3	0.0	0.2	0.7
8		0.7	2.3	7.8	0.7	2.4	8.4	0.0	0.1	0.6
9	Mar	0.8	2.1	7.3	0.8	2.2	7.7	0.0	0.1	0.4
10		0.6	1.9	6.5	0.6	2.0	7.0	0.0	0.1	0.5
11		0.5	1.5	4.7	0.5	1.5	5.1	0.0	0.0	0.4
12		0.6	1.6	4.4	0.6	1.7	4.7	0.0	0.1	0.3
13	Apr	0.4	1.0	4.2	0.4	1.1	4.5	0.0	0.1	0.3
14		0.4	1.0	3.3	0.4	1.1	3.6	0.0	0.1	0.3
15		0.3	0.8	3.2	0.3	0.8	3.4	0.0	0.0	0.2
16		0.3	0.7	1.7	0.4	0.7	1.8	0.1	0.0	0.1
17	May	0.3	0.5	1.3	0.3	0.6	1.5	0.0	0.1	0.2
18		0.3	0.4	0.9	0.3	0.5	1.0	0.0	0.1	0.1
19		0.2	0.4	0.8	0.2	0.4	0.9	0.0	0.0	0.1
20		0.2	0.4	1.1	0.2	0.4	1.2	0.0	0.0	0.1
21	Jun	0.2	0.3	1.3	0.2	0.4	1.5	0.0	0.1	0.2
22		0.2	0.3	1.0	0.2	0.3	1.1	0.0	0.0	0.1
23		0.2	0.3	0.7	0.2	0.3	0.8	0.0	0.0	0.1
24		0.1	0.3	0.7	0.1	0.3	0.8	0.0	0.0	0.1
25	Jul	0.1	0.2	0.5	0.1	0.2	0.6	0.0	0.0	0.1
26		0.1	0.2	0.5	0.1	0.2	0.6	0.0	0.0	0.1
27		0.1	0.2	0.4	0.1	0.2	0.4	0.0	0.0	0.0
28		0.1	0.1	0.3	0.1	0.1	0.3	0.0	0.0	0.0
29	Aug	0.1	0.1	0.3	0.1	0.1	0.4	0.0	0.0	0.1
30		0.1	0.1	0.3	0.1	0.1	0.4	0.0	0.0	0.1
31		0.1	0.1	0.4	0.1	0.1	0.5	0.0	0.0	0.1
32		0.1	0.1	0.6	0.1	0.2	0.8	0.0	0.1	0.2
33	Sep	0.0	0.1	0.5	0.0	0.1	0.6	0.0	0.0	0.1
34		0.1	0.1	0.5	0.1	0.2	0.6	0.0	0.1	0.1
35		0.0	0.2	0.9	0.0	0.2	1.1	0.0	0.0	0.2
36		0.0	0.2	1.2	0.0	0.2	1.5	0.0	0.0	0.3
37	Oct	0.1	0.2	1.3	0.1	0.2	1.6	0.0	0.0	0.3
38		0.1	0.3	1.8	0.1	0.4	2.2	0.0	0.1	0.4
39		0.1	0.4	1.8	0.1	0.5	2.3	0.0	0.1	0.5
40		0.2	0.7	2.4	0.3	0.9	2.9	0.1	0.2	0.5
41	Nov	0.2	1.0	3.8	0.2	1.2	4.5	0.0	0.2	0.7
42		0.3	1.7	6.1	0.3	1.9	6.9	0.0	0.2	0.8
43		0.3	2.0	8.2	0.4	2.2	9.0	0.1	0.2	0.8
44		0.5	3.0	9.3	0.6	3.3	9.9	0.1	0.3	0.6
45	Dec	0.8	3.3	9.0	0.9	3.6	9.7	0.1	0.3	0.7
46		0.8	3.1	9.4	0.8	3.3	10.1	0.0	0.2	0.7
47		0.7	3.0	9.8	0.8	3.2	10.6	0.1	0.2	0.8
48		0.9	3.0	8.7	0.9	3.2	9.3	0.0	0.2	0.6

Notes:

1) Low, median and high flow are defined as flows exceeding 90%, 50% and 10% of the time, respectively.
2) Each month is divided into 4 equal periods, for a total of 48 periods in the year.
3) Flows are based on HSPF model results for a 1948-1994 simulation period.

TABLE 4-4 (CONTINUED)

FLOW EXCEEDENCE CHARACTERISTICS AT OFFSITE STREAM LOCATIONS

Des Moines Creek below Confluence (Node 13)										
		Average Daily Flow Rate (cfs)								
		Current Conditions			Proposed Conditions			Difference		
Period	Month	Low Flow	Median Flow	High Flow	Low Flow	Median Flow	High Flow	Low Flow	Median Flow	High Flow
1	Jan	2.4	6.8	17.4	2.3	6.8	18.3	-0.1	0.0	0.9
2		3.0	7.6	17.6	2.8	7.7	18.4	-0.2	0.1	0.8
3		2.6	7.3	19.4	2.4	7.3	20.2	-0.2	0.0	0.8
4		2.6	8.1	18.1	2.5	8.1	18.8	-0.1	0.0	0.7
5	Feb	2.3	6.5	15.4	2.1	6.3	15.8	-0.2	-0.2	0.4
6		3.1	6.6	15.5	2.9	6.6	15.9	-0.2	0.0	0.4
7		2.8	7.7	16.4	2.6	7.6	17.0	-0.2	-0.1	0.6
8		2.8	6.5	14.3	2.7	6.3	14.6	-0.1	-0.2	0.3
9	Mar	3.1	5.9	13.8	2.9	5.8	14.1	-0.2	-0.1	0.3
10		2.7	5.7	12.9	2.5	5.6	13.1	-0.2	-0.1	0.2
11		2.4	4.9	10.4	2.2	4.7	10.5	-0.2	-0.2	0.1
12		2.8	5.1	9.3	2.5	4.9	9.5	-0.3	-0.2	0.2
13	Apr	2.2	4.0	9.7	2.0	3.9	9.8	-0.2	-0.1	0.1
14		2.0	4.1	8.3	1.8	3.9	8.4	-0.2	-0.2	0.1
15		1.8	3.6	7.8	1.6	3.4	7.9	-0.2	-0.2	0.1
16		1.9	3.4	5.5	1.8	3.3	5.5	-0.1	-0.1	0.0
17	May	2.0	2.9	4.8	1.8	2.7	4.8	-0.2	-0.2	0.0
18		1.6	2.6	4.1	1.5	2.4	4.1	-0.1	-0.2	0.0
19		1.5	2.4	4.0	1.3	2.2	4.0	-0.2	-0.2	0.0
20		1.5	2.5	4.5	1.4	2.4	4.6	-0.1	-0.1	0.1
21	Jun	1.3	2.3	5.2	1.2	2.1	5.4	-0.1	-0.2	0.2
22		1.3	2.1	4.3	1.1	2.0	4.3	-0.2	-0.1	0.0
23		1.2	1.9	3.7	1.1	1.7	3.7	-0.1	-0.2	0.0
24		1.2	1.9	3.6	1.0	1.8	3.7	-0.2	-0.1	0.1
25	Jul	1.2	1.7	3.2	1.0	1.6	3.2	-0.2	-0.1	0.0
26		1.0	1.6	3.2	0.9	1.5	3.2	-0.1	-0.1	0.0
27		1.0	1.4	2.5	0.9	1.3	2.4	-0.1	-0.1	-0.1
28		1.0	1.3	2.1	0.9	1.2	2.0	-0.1	-0.1	-0.1
29	Aug	0.9	1.2	2.4	0.8	1.1	2.3	-0.1	-0.1	-0.1
30		0.9	1.2	2.5	0.8	1.1	2.5	-0.1	-0.1	0.0
31		0.8	1.2	3.2	0.7	1.1	3.2	-0.1	-0.1	0.0
32		0.8	1.4	3.9	0.8	1.3	4.0	0.0	-0.1	0.1
33	Sep	0.8	1.4	3.4	0.7	1.3	3.5	-0.1	-0.1	0.1
34		0.8	1.5	3.1	0.7	1.4	3.3	-0.1	-0.1	0.2
35		0.8	1.8	5.1	0.7	1.7	5.4	-0.1	-0.1	0.3
36		0.8	1.9	6.0	0.7	1.8	6.4	-0.1	-0.1	0.4
37	Oct	0.8	1.8	5.7	0.7	1.7	6.1	-0.1	-0.1	0.4
38		0.9	2.4	7.2	0.8	2.4	7.8	-0.1	0.0	0.6
39		0.9	2.6	8.2	0.8	2.6	8.9	-0.1	0.0	0.7
40		1.6	3.9	9.4	1.5	4.1	10.3	-0.1	0.2	0.9
41	Nov	1.6	4.5	11.5	1.5	4.7	12.6	-0.1	0.2	1.1
42		1.9	6.0	14.6	1.8	6.3	16.1	-0.1	0.3	1.5
43		1.9	6.1	15.9	1.9	6.4	17.3	0.0	0.3	1.4
44		2.6	7.3	16.0	2.6	7.7	17.0	0.0	0.4	1.0
45	Dec	3.1	8.1	15.9	3.0	8.4	17.0	-0.1	0.3	1.1
46		2.8	7.5	16.5	2.8	7.7	17.5	0.0	0.2	1.0
47		2.7	7.0	17.1	2.6	7.1	18.1	-0.1	0.1	1.0
48		3.0	7.2	14.9	2.9	7.3	15.5	-0.1	0.1	0.6

Notes:
1) Low, median and high flow are defined as flows exceeding 90%, 50% and 10% of the time, respectively.
2) Each month is divided into 4 equal periods, for a total of 48 periods in the year.
3) Flows are based on HSPF model results for a 1948-1994 simulation period.

TABLE 4-4 (CONTINUED)

FLOW EXCEEDENCE CHARACTERISTICS AT OFFSITE STREAM LOCATIONS

		Des Moines Creek at S 208th Street (Node 18)								
		Average Daily Flow Rate (cfs)								
		Current Conditions			Proposed Conditions			Difference		
Period	Month	Low Flow	Median Flow	High Flow	Low Flow	Median Flow	High Flow	Low Flow	Median Flow	High Flow
1	Jan	2.9	8.0	20.2	2.8	8.0	21.0	-0.1	0.0	0.8
2		3.5	9.0	20.5	3.4	9.0	21.3	-0.1	0.0	0.8
3		3.1	8.7	22.5	3.0	8.6	23.3	-0.1	-0.1	0.8
4		3.2	9.6	21.1	3.0	9.6	21.7	-0.2	0.0	0.6
5	Feb	2.8	7.8	17.9	2.6	7.6	18.3	-0.2	-0.2	0.4
6		3.8	7.9	18.0	3.6	7.8	18.5	-0.2	-0.1	0.5
7		3.4	9.1	19.1	3.2	9.0	19.6	-0.2	-0.1	0.5
8		3.5	7.7	16.7	3.3	7.6	17.0	-0.2	-0.1	0.3
9	Mar	3.7	7.0	16.2	3.6	6.9	16.5	-0.1	-0.1	0.3
10		3.3	6.8	15.0	3.1	6.6	15.3	-0.2	-0.2	0.3
11		2.9	5.8	12.3	2.7	5.7	12.3	-0.2	-0.1	0.0
12		3.4	6.0	10.9	3.1	5.9	11.1	-0.3	-0.1	0.2
13	Apr	2.7	4.8	11.3	2.5	4.7	11.5	-0.2	-0.1	0.2
14		2.4	4.9	9.7	2.3	4.7	9.8	-0.1	-0.2	0.1
15		2.2	4.4	9.1	2.1	4.2	9.2	-0.1	-0.2	0.1
16		2.4	4.2	6.5	2.2	4.0	6.5	-0.2	-0.2	0.0
17	May	2.5	3.5	5.7	2.3	3.3	5.7	-0.2	-0.2	0.0
18		2.0	3.1	4.9	1.9	2.9	4.9	-0.1	-0.2	0.0
19		1.8	2.9	4.8	1.7	2.7	4.7	-0.1	-0.2	-0.1
20		1.9	3.1	5.4	1.7	2.9	5.5	-0.2	-0.2	0.1
21	Jun	1.7	2.7	6.2	1.5	2.6	6.3	-0.2	-0.1	0.1
22		1.6	2.6	5.0	1.4	2.5	5.1	-0.2	-0.1	0.1
23		1.6	2.3	4.5	1.4	2.2	4.5	-0.2	-0.1	0.0
24		1.5	2.3	4.3	1.3	2.2	4.4	-0.2	-0.1	0.1
25	Jul	1.4	2.1	3.8	1.3	2.0	3.8	-0.1	-0.1	0.0
26		1.3	2.0	3.8	1.2	1.9	3.8	-0.1	-0.1	0.0
27		1.2	1.8	3.0	1.1	1.6	2.9	-0.1	-0.2	-0.1
28		1.2	1.6	2.5	1.1	1.5	2.4	-0.1	-0.1	-0.1
29	Aug	1.1	1.5	2.9	1.0	1.4	2.8	-0.1	-0.1	-0.1
30		1.1	1.5	3.0	1.0	1.4	3.0	-0.1	-0.1	0.0
31		1.0	1.5	3.8	0.9	1.4	3.8	-0.1	-0.1	0.0
32		1.1	1.7	4.5	1.0	1.6	4.7	-0.1	-0.1	0.2
33	Sep	1.0	1.7	4.0	0.9	1.6	4.1	-0.1	-0.1	0.1
34		1.0	1.8	3.7	1.0	1.7	3.8	0.0	-0.1	0.1
35		1.0	2.1	5.9	0.9	2.1	6.2	-0.1	0.0	0.3
36		1.0	2.3	6.9	0.9	2.2	7.3	-0.1	-0.1	0.4
37	Oct	1.0	2.2	6.7	0.9	2.1	7.1	-0.1	-0.1	0.4
38		1.1	2.8	8.3	1.1	2.9	8.9	0.0	0.1	0.6
39		1.1	3.1	9.4	1.0	3.1	10.1	-0.1	0.0	0.7
40		1.9	4.6	10.8	1.9	4.8	11.6	0.0	0.2	0.8
41	Nov	1.9	5.3	13.3	1.8	5.5	14.3	-0.1	0.2	1.0
42		2.2	7.0	16.8	2.2	7.3	18.2	0.0	0.3	1.4
43		2.3	7.1	18.2	2.2	7.4	19.7	-0.1	0.3	1.5
44		3.0	8.5	18.5	3.0	8.9	19.5	0.0	0.4	1.0
45	Dec	3.7	9.4	18.3	3.6	9.7	19.4	-0.1	0.3	1.1
46		3.4	8.8	19.0	3.3	9.0	20.0	-0.1	0.2	1.0
47		3.2	8.2	19.9	3.1	8.4	20.8	-0.1	0.2	0.9
48		3.6	8.4	17.3	3.5	8.5	17.9	-0.1	0.1	0.6

Notes:

1) Low, median and high flow are defined as flows exceeding 90%, 50% and 10% of the time, respectively.
2) Each month is divided into 4 equal periods, for a total of 48 periods in the year.
3) Flows are based on HSPF model results for a 1948-1994 simulation period.

4.4 LOW FLOWS

The discussion of HSPF modeling results in Sections 4.2 and 4.3 included an assessment of how the proposed development would affect low flows in Miller Creek and Des Moines Creek. In the analysis of annual flow duration, the total low flow volume below the 6 cfs magnitude was predicted to decrease by about 3 percent in Miller Creek, and the total low flow volume below the 10 cfs magnitude was predicted to decrease by about 6 percent in Des Moines Creek. In the seasonal flow exceedence analysis, the summer stream flow rates were predicted to decrease by up to 0.1 cfs in Miller Creek and by up to 0.2 cfs in Des Moines Creek.

To verify these HSPF-modeled estimates, a separate analysis was conducted to review the potential effects of land use changes on low flows. The basis of this analysis was an assumption that land use changes that increase the impervious area within a basin will result in a proportional reduction in rainfall infiltration to groundwater aquifers. Since summer low flows are supplied by groundwater sources, a change in groundwater recharge will most likely have a similar effect on the magnitude of low flows in the streams. The evaluation of effects on low flows was made at one point on each stream, at the lower-most points in the modeled systems.

Changes to Groundwater Recharge Potential

In this analysis, groundwater recharge refers to water that reaches deeper aquifers. It does not include recharge of the interflow zone. The interflow zone is the shallow soil layer near the surface that typically supplies water to streams for short to intermediate periods of time following a rainfall event. In contrast, discharge from aquifers is the predominant source of water for streams during extended periods of dry weather, which typically occurs during late summer and early fall. Interflow (also called subsurface flow) is the predominant runoff mechanism in areas of glacial till deposits and groundwater flow is the predominate runoff mechanism on glacial outwash deposits (Dinicola, 1990). Thus, development in areas of outwash soils would have a much greater potential for affecting groundwater recharge and low streamflows than development in areas of till soils. The change in groundwater recharge potential was calculated from the change in land use.

Table 4-5 summarizes areas of differing soil types and land use under existing and proposed conditions, and the net change between the two. Areas that describe the recharge potential of different soils and land cover in the Miller and Des Moines Creek basins were categorized as till soil, outwash soil, wetland (or saturated) soil, and impervious area. Outwash soil has the greatest infiltration capacity because it consists of unconsolidated sand and gravel that are highly permeable. Till has very little infiltration capacity because it consists of compacted silt and clay (hardpan) that have low permeability. The change in land areas (as detailed in Table 3-2) results from replacement of pervious areas with impervious pavement, or from replacement of highly permeable soils such as outwash soil with less permeable soil such as till or compacted soil. The area of impervious surface within each basin was based on the percent impervious values listed in the land use summary tables in Appendix A. The change in impervious area in Table 4-5 is smaller than that shown in Tables 3-1 and 3-2 because it includes a small loss of existing impervious area in existing developed areas.

TABLE 4-5
CHANGE IN LAND USE COVERAGE

Affected Land Areas		Miller Creek			Des Moines Creek		
Soil Type	Infiltration Rate (in/hr)	Existing (acres)	Proposed (acres)	Net Change (acres)	Existing (acres)	Proposed (acres)	Net Change (acres)
Till or Compacted	0.06	2005.6	2070.4	+64.8	1208.1	1112.8	-95.3
Outwash	1.4	1851.4	1692.3	-159.1	415.9	358.1	-57.8
Wetland	2.0	101.5	101.5	0	65.9	65.9	0
Impervious	0.0	1224.2	1318.4	+94.2	1010.2	1163.3	153.1
Total	--	**5182.7**	**5182.7**	**0**	**2700.1**	**2700.1**	**0**

Infiltration rates listed in Table 4-5 are based on the regional parameters developed by the USGS, which were derived from soil survey data published by the Soil Conservation Service. All classifications for a particular soil type (e.g., forest and open) were grouped together under an average infiltration rate to simplify the calculation. This resulted in average infiltration rates for till, outwash, and wetland soils of 0.06, 1.4, and 2.0 inches per hour, respectively. As in the HSPF analysis, new fill associated with the airport expansion was assumed to be hydraulically equivalent to till soil.

In the Miller Creek basin the change in land use will result in an increase of 64.8 acres of low permeable till soil and 94.2 acres of impervious surface, and a decrease of 159.1 acres of higher permeable outwash soil. In the Des Moines Creek basin, the change in land use will result in an increase of 153.1 acres of impervious surface, and a decrease of 95.3 acres of till soil and 57.8 acres of outwash soil.

To determine how these land changes could affect infiltration to groundwater aquifers, the areas in Table 4-5 were multiplied by their respective soil infiltration rates and then added together to derive an index that describes the potential for groundwater recharge before and after construction of the project. Although this method cannot be used to quantify the total amount of recharge occurring, it can be used to estimate the relative change in infiltration rates that is caused by changed land use. The groundwater recharge indices for Miller and Des Moines Creek are as follows:

For Miller Creek:

$$Q_{exist} = C1 * [(2005.6*.06)+(1851.4*1.4)+(101.5*2.0)] = C1*2915$$
$$Q_{prop} = C1 * [(2070.6*.06)+(1692.3*1.4)+(101.5*2.0)] = C1*2696$$
$$Q_{prop} = Q_{exist} * 0.93$$

For Des Moines Creek:

$$Q_{exist} = C1 * [(1208.1*.06)+(415.9*1.4)+(65.9*2.0)] = C1*787$$
$$Q_{prop} = C1 * [(1112.8*.06)+(358.1*1.4)+(65.9*2.0)] = C1*670$$
$$Q_{prop} = Q_{exist} * 0.89$$

Where

Q_{exist} is the groundwater recharge rate under existing conditions

Q_{prop} is the groundwater recharge rate under proposed conditions

We conclude that, due to the proposed land use changes, potential groundwater recharge rates will decrease by approximately 7 percent in the Miller Creek basin and by 11 percent in the Des Moines Creek basin. These estimates should be considered approximate because groundwater recharge and discharge processes are more complex than accounted for in this analysis.

Changes to Summer Low Flows Due to Land Use Change

To estimate the effect of a reduction of groundwater recharge on low flows, it was assumed that low flows would be reduced in direct proportion to the reduction in potential groundwater recharge. The percentage decrease in potential groundwater recharge that was calculated above was applied to monthly low flows to estimate the net reduction in streamflow. Monthly low flows for existing conditions were obtained from the flow exceedence analysis that was summarized in Table 4-4. The low flows predicted in the HSPF modelling process were compared to historical flow monitoring data and it was found that the modelled flows generally corresponded to the historical flow monitoring data. For example, recorded flows from the late summer in the 1988-1994 time period at the mouth of Miller Creek typically ranged from 1.5-2.0 cfs. Those flow rates agree with the flow exceedence values from the HSPF simulation. The 1992-1994 monitoring data for Des Moines Creek near the mouth has a very similar range of summer low flow rates that, when translated upstream to the South 208th Street evaluation point, also generally agree with the simulation results.

The groundwater recharge analysis predicts that flows will reduce by about 0.1 cfs in both streams during late summer. The estimates for the predicted reduction of summer flows closely agree with the HSPF analysis summarized that was summarized in Table 4-4.

TABLE 4-6
LOW FLOW CHANGES ASSUMING DIRECT INFLUENCE
OF LAND USE CHANGE ON GROUNDWATER RECHARGE

	Miller Creek near mouth			Des Moines Creek at S.208th		
Month	Existing Low Flows (cfs)	Low Flows under Proposed Conditions (cfs)	Change (cfs)	Existing Low Flows (cfs)	Low Flows under Proposed Conditions (cfs)	Change (cfs)
July	1.5	1.4	-0.1	1.0	0.9	-0.1
August	1.4	1.3	-0.1	0.8	0.7	-0.1
September	1.3	1.2	-0.1	0.8	0.7	-0.1
October	1.4	1.3	-0.1	0.8	0.7	-0.1

5.0 SUMMARY AND CONCLUSIONS

This hydrologic modeling study for the SeaTac Airport Master Plan Update EIS accomplished the following tasks and analyses:

- Hydrologic models of Miller and Des Moines Creek were assembled using the HSPF model from available stream and watershed data. The models were calibrated using recorded streamflow data from the period 1989-1994.
- The calibrated models were run for a 47 year simulation period (1948-1994) using hourly precipitation data from SeaTac Airport.
- Current flow regimes of Miller Creek and Des Moines Creek were derived from the results of the HSPF current conditions models. Flow statistics of flood frequency, annual flow duration, and seasonal flow exceedence were derived.
- Proposed condition models that incorporated proposed features of the Master Plan Update were created by modifying land uses to reflect the addition of the 8,500-foot 3rd runway and expansion of terminal facilities.
- Detention storage volumes and release rates for stormwater runoff were calculated and the performance of the detention storage facilities were simulated in the HSPF models. Detention criteria from the Stormwater Management Manual for the Puget Sound Basin were used.
- The proposed conditions models were run for the 47-year simulation period. Flow statistics of the resulting streamflow regimes in Miller Creek and Des Moines Creek were derived.
- Streamflow characteristics in Miller Creek and Des Moines Creek under proposed conditions were then compared to current conditions to determine the effect of stormwater discharge on the receiving streams.

The comparison of current and proposed streamflow regimes in Miller Creek and Des Moines Creek resulted in the following conclusions:

- The current 100-year flow magnitudes for Miller Creek near the mouth (at the sewage treatment plant) and Des Moines Creek at South 208th Street are estimated to be 468 cfs and 280 cfs, respectively.
- Peak flows in Miller Creek and Des Moines Creek will not increase if adequate stormwater detention storage is provided. Approximate detention storage volumes of 61 acre-feet and 31 acre-feet were calculated for Miller and Des Moines Creek, respectively. With those detention volumes the HSPF simulation showed that peak flows in the streams will not increase.

- The total flow volume in Miller Creek near the mouth is predicted to increase by approximately 300 acre-feet per year, or 6 percent of the average annual flow. Flow volumes in Des Moines Creek will increase by approximately 60 acre-feet per year, or 1 percent. The increases are caused by the additional impervious area, which reduces infiltration of rainfall.

- The flow duration analysis showed that the increase in runoff occurs below the 1.25-year return period flow rate, which is in the 80-120 cfs range for both streams. The increase in runoff volume above those flow rates is not significant.

- The seasonal flow exceedence analysis showed that summer streamflows during low flow years (i.e., exceeded 90 percent of the time) could decrease by up to about 0.1 cfs in Miller Creek, and by up to about 0.2 cfs in Des Moines Creek. A water balance analysis based on an analysis of land use changes resulted in a similar estimate of potential changes to low flows. Summer streamflow could increase during median and high flow years in Miller Creek, but decrease in Des Moines Creek. Average monthly flows in the winter could increase by up to 2.1 cfs on Miller Creek and 1.3 cfs on Des Moines Creek during wetter, higher flow years.

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FIGURES

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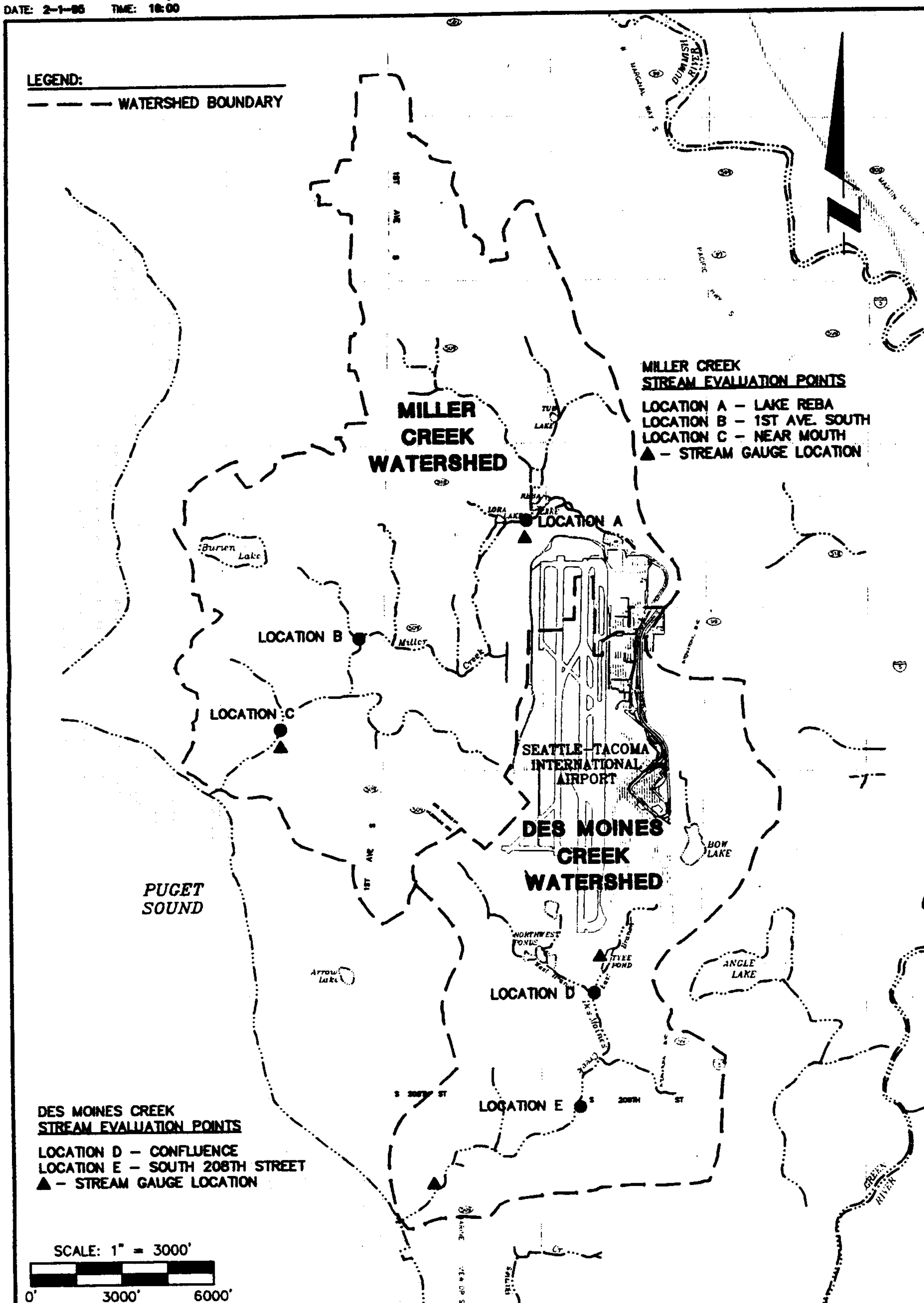
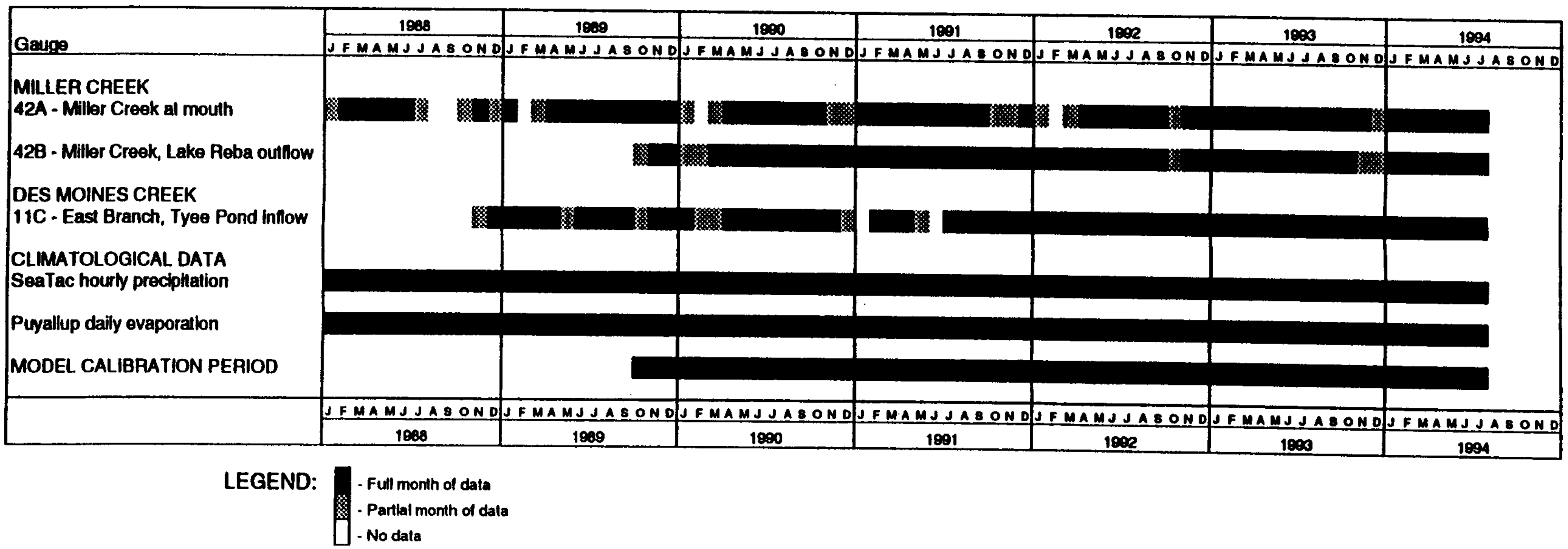


PROJECT NUMBER 94-121	FIGURE 1 MILLER CREEK AND DES MOINES CREEK WATERSHEDS
R.A. MONTGOMERY, PROJECT MANAGER	MONTGOMERY WATER GROUP, INC. Water Resources · Environmental · Civil Engineering



Availability of Recorded Streamflow Data

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Hydrologic Modeling Study

Figure 2

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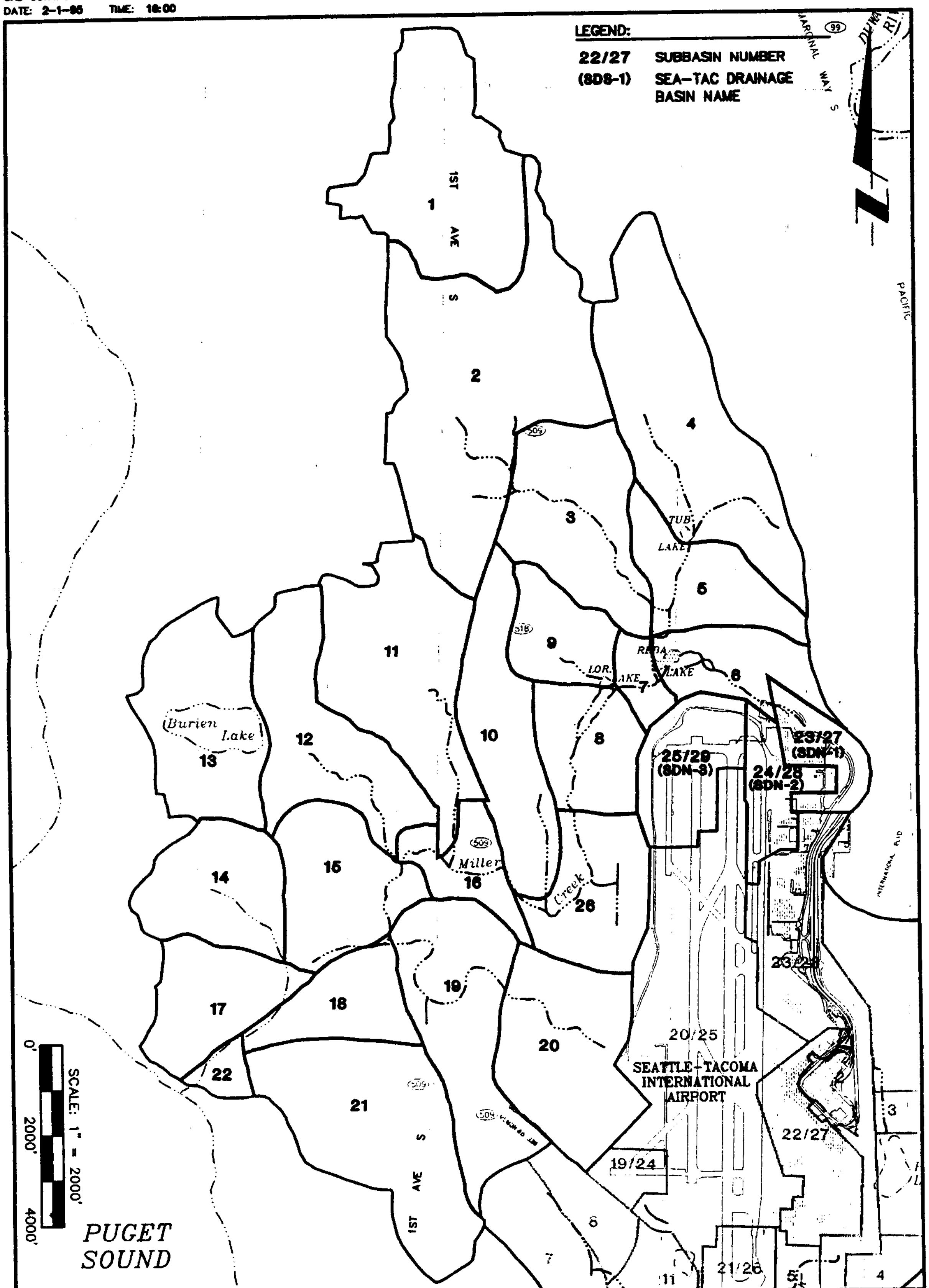

PROJECT NUMBER 94-121	DESIGNED K.B.B. / DRAWN M.D. / CHECKED R.A.M. / DATE 1-20-95 / R.A. MONTGOMERY PROJECT MANAGER	**FIGURE 3** MILLER CREEK WATERSHED SUBBASINS

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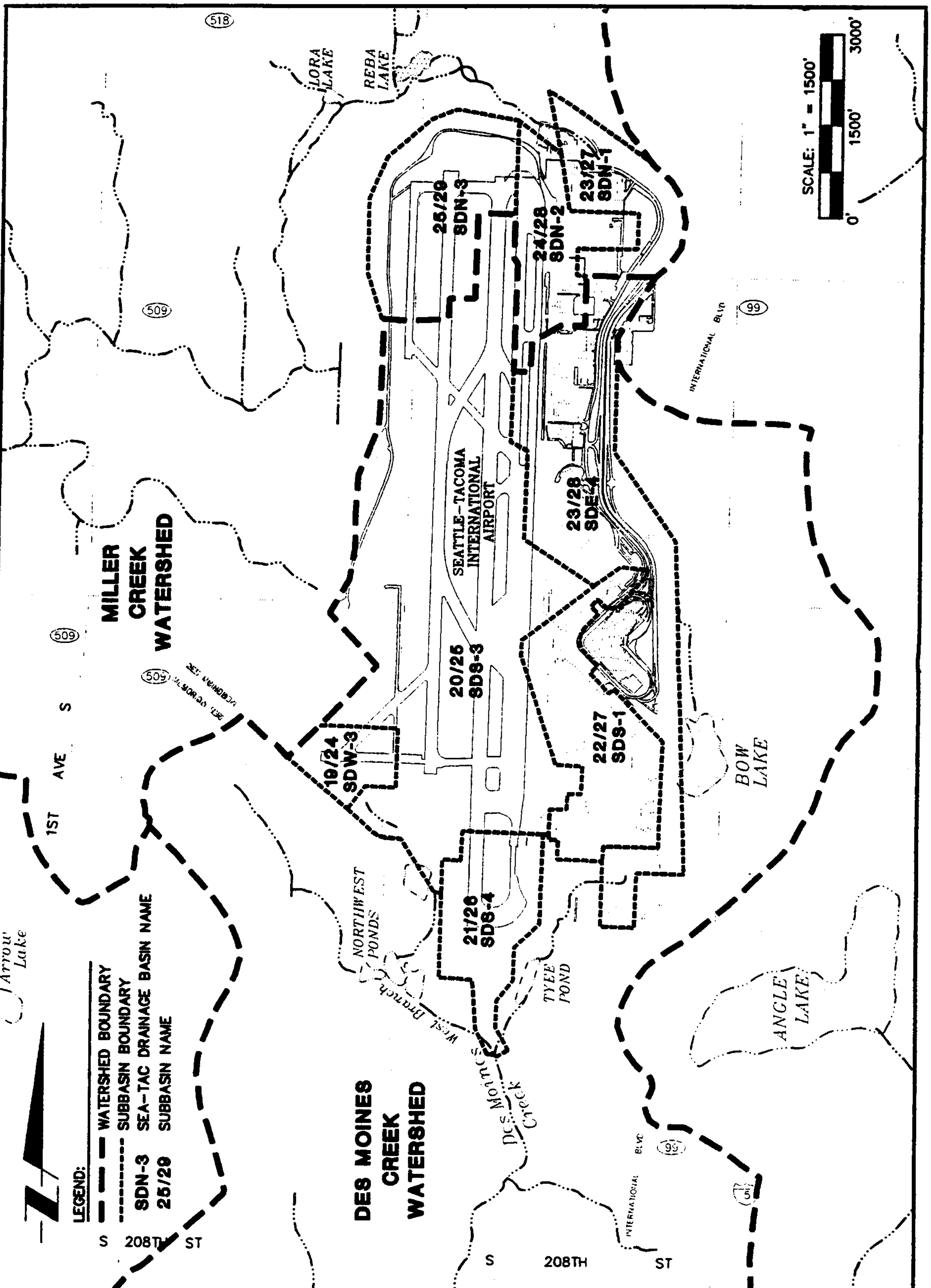

PROJECT NUMBER 94-121	DESIGNED E.W.R. DRAWN N.S. CHECKED R.A.M. DATE 1-26-95 R.A. MONTGOMERY PROJECT MANAGER	FIGURE 4 SEA-TAC AIRPORT SUBBASINS

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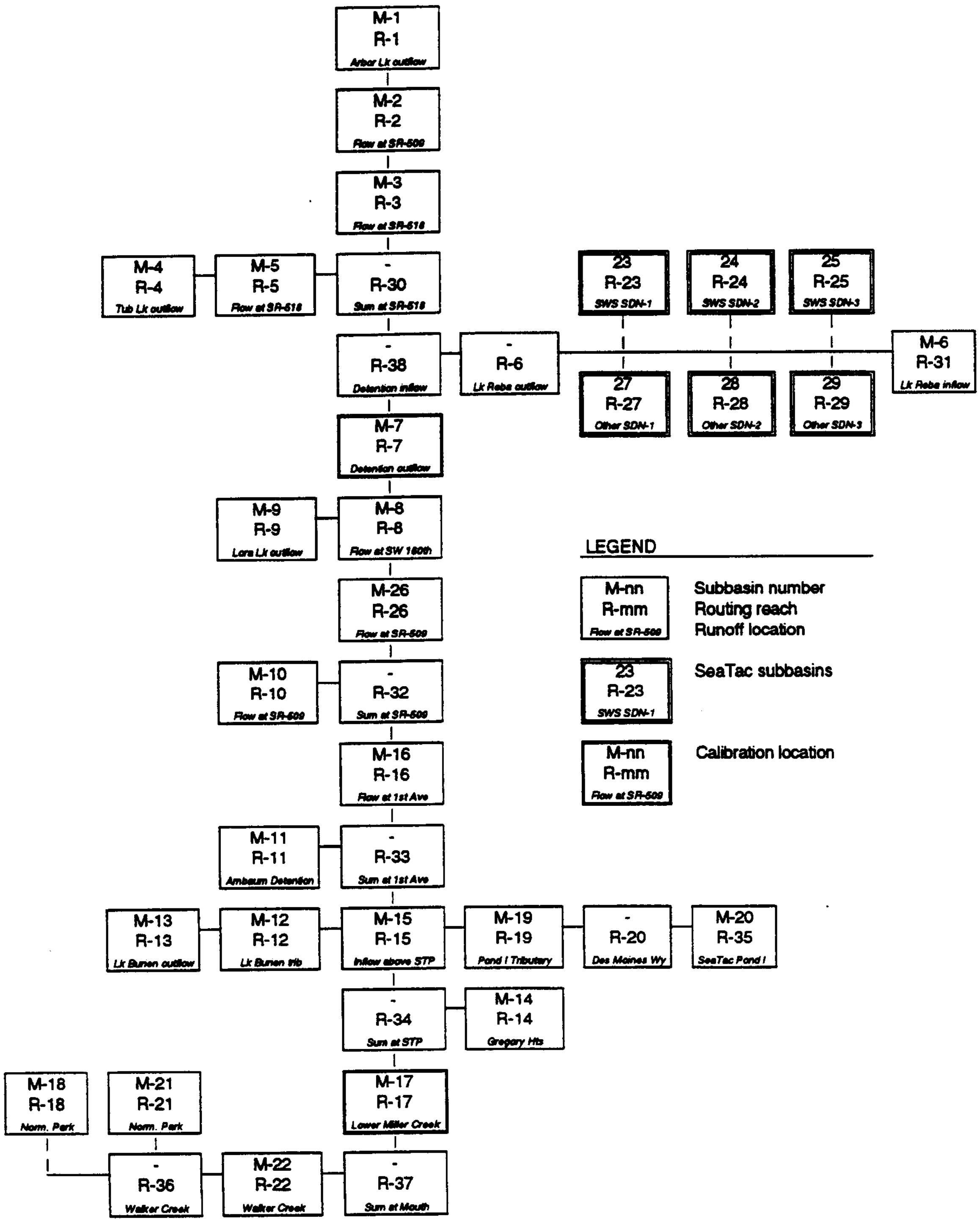

Miller Creek HSPF Model Schematic

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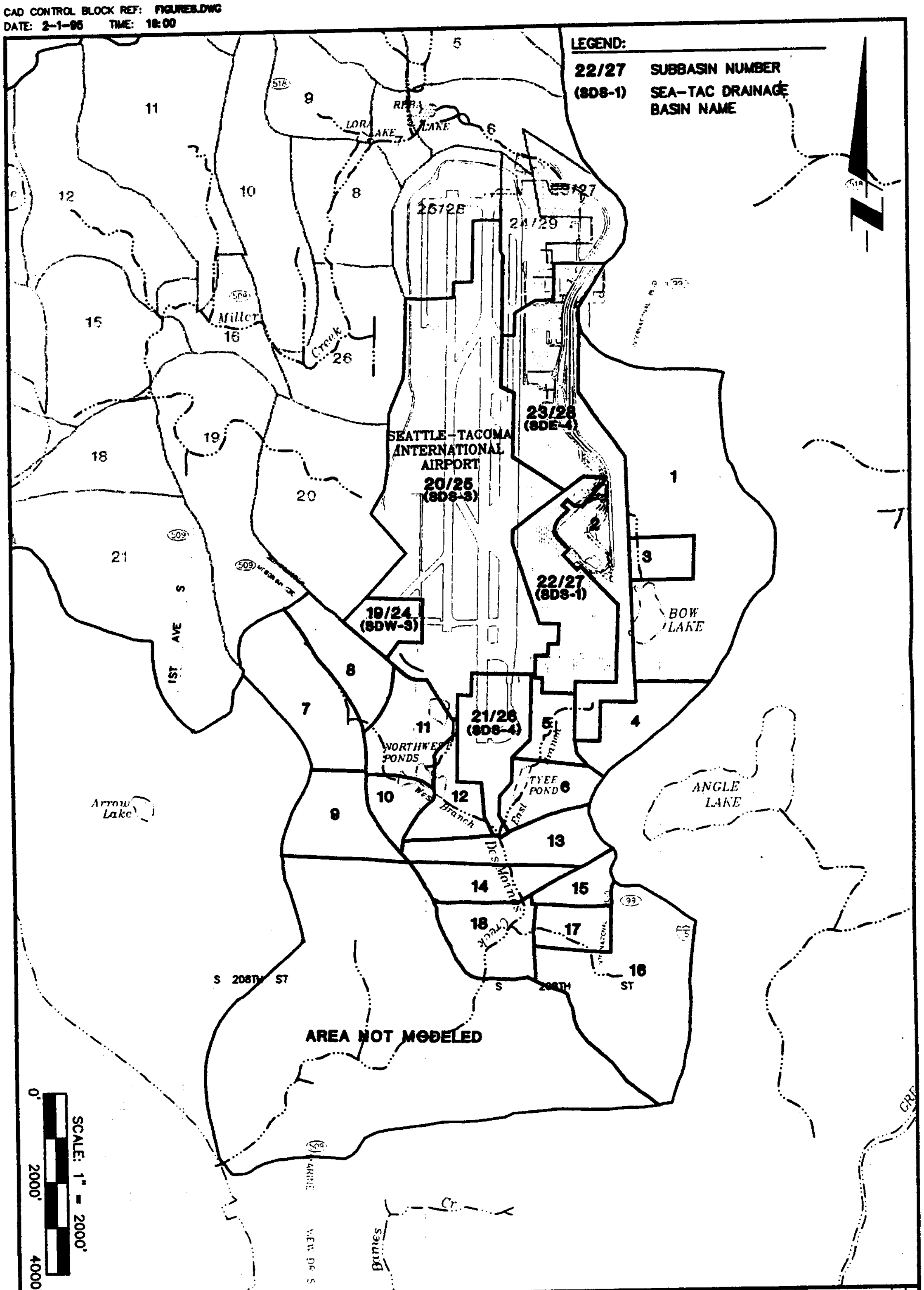

DESIGNED / DRAWN / CHECKED / DATE 1-25-95 / R.A. MONTGOMERY PROJECT MANAGER	PROJECT NUMBER 94-121

FIGURE 6
DES MOINES WATERSHED
SUBBASINS

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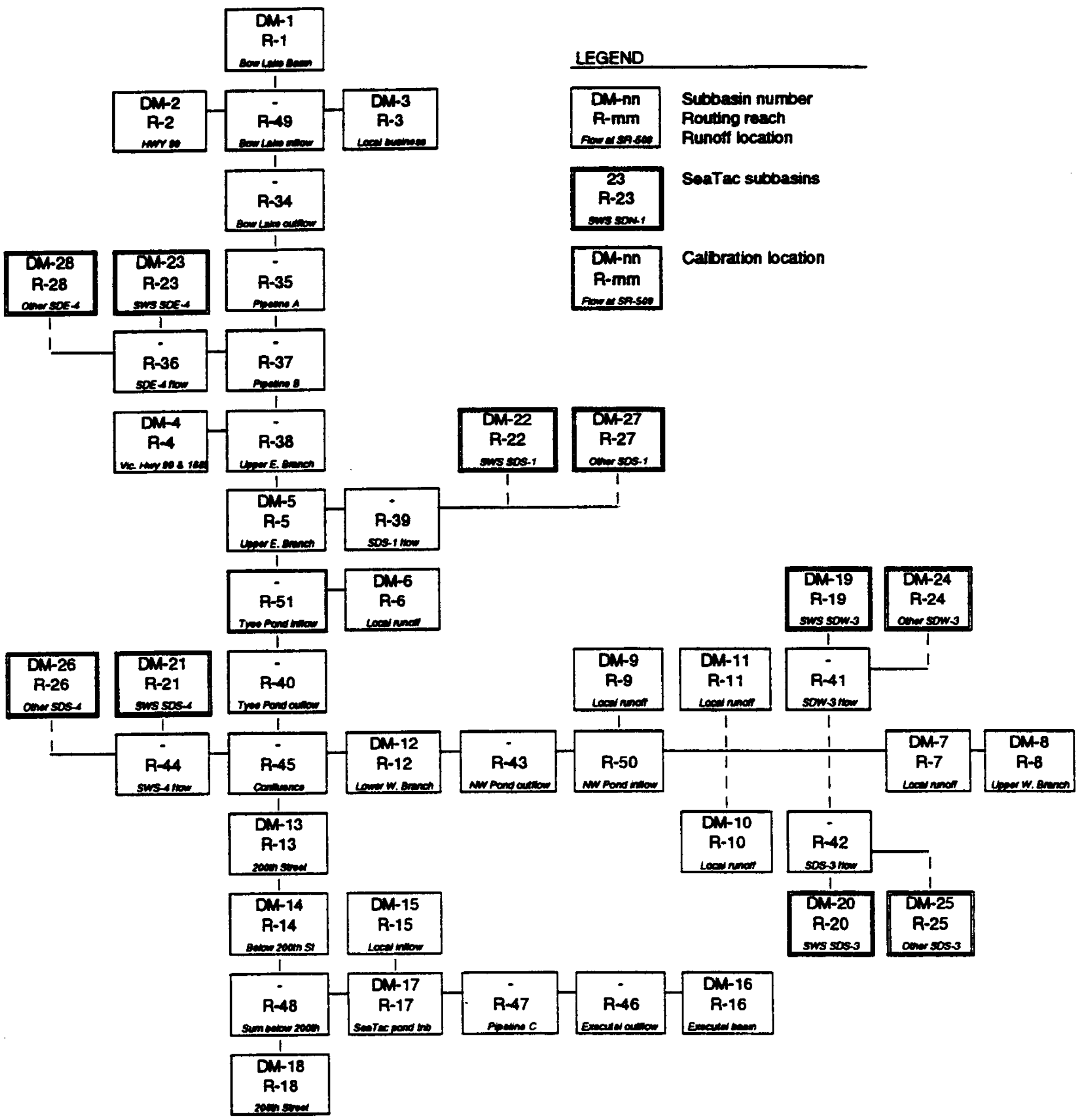
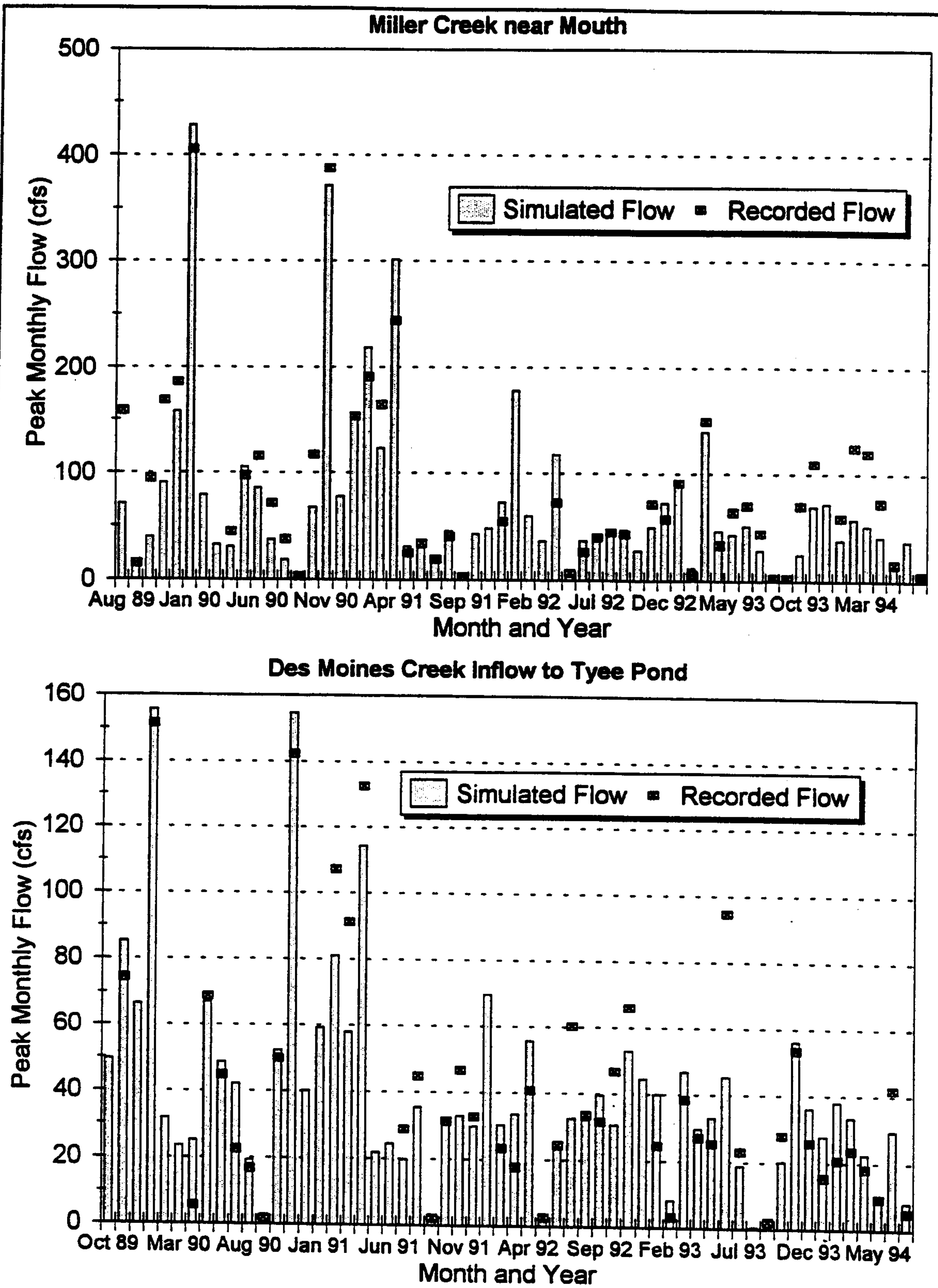


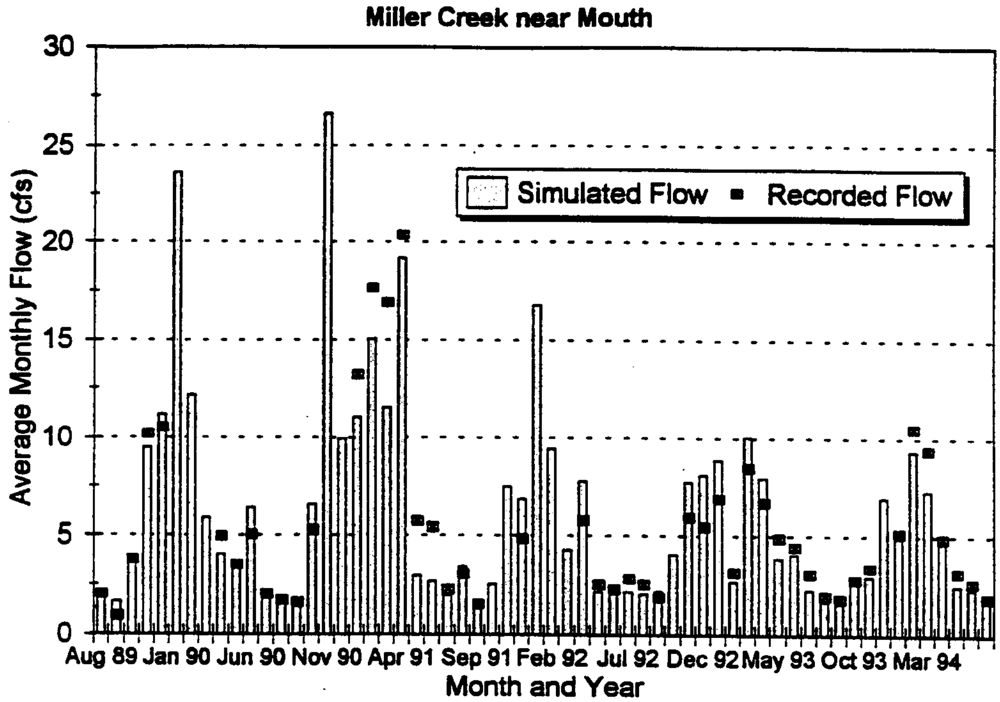
Des Moines Creek HSPF Model Schematic

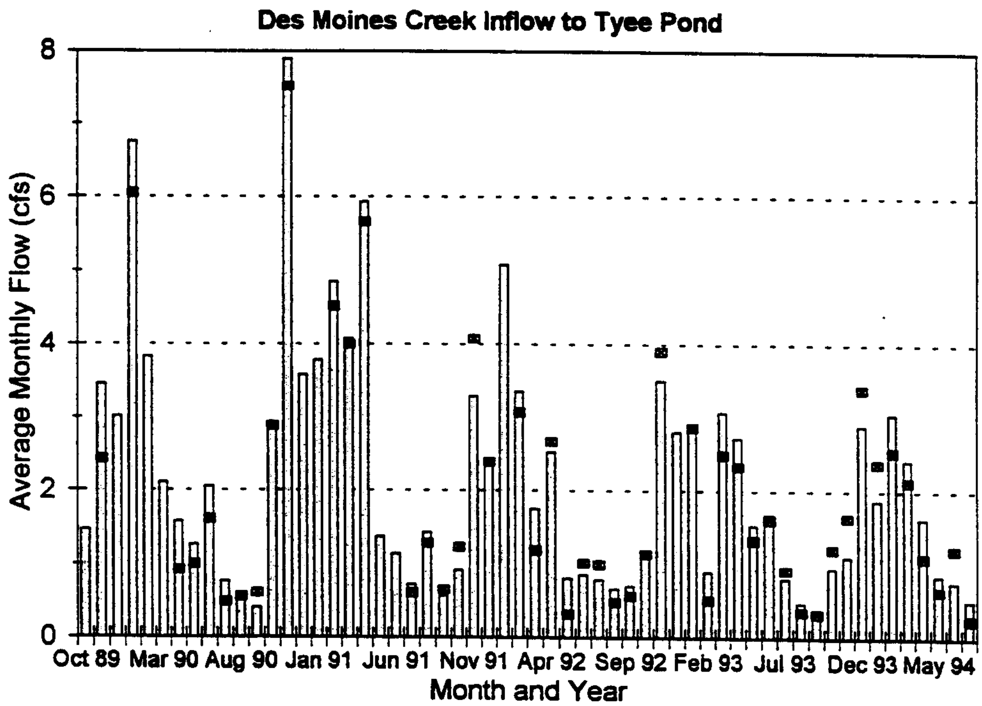
MONTGOMERY WATER GROUP, INC. Water Resources • Environmental • Civil Engineering	SeaTac Airport Master Plan Update EIS Hydrologic Modeling Study	Figure 7



Calibration Results - Monthly Peak Flows

MONTGOMERY WATER GROUP, INC. Water Resources • Environmental • Civil Engineering	SeaTac Airport Master Plan Update EIS Hydrologic Modeling Study	Figure 8





Calibration Results - Monthly Average Flows

Montgomery Water Group, Inc. Water Resources • Environmental • Civil Engineering	SeaTac Airport Master Plan Update EIS Hydrologic Modeling Study	Figure 9

CAD CONTROL BLOCK REF: FIGURE10.DWG
DATE: 2-1-95 TIME: 15:00

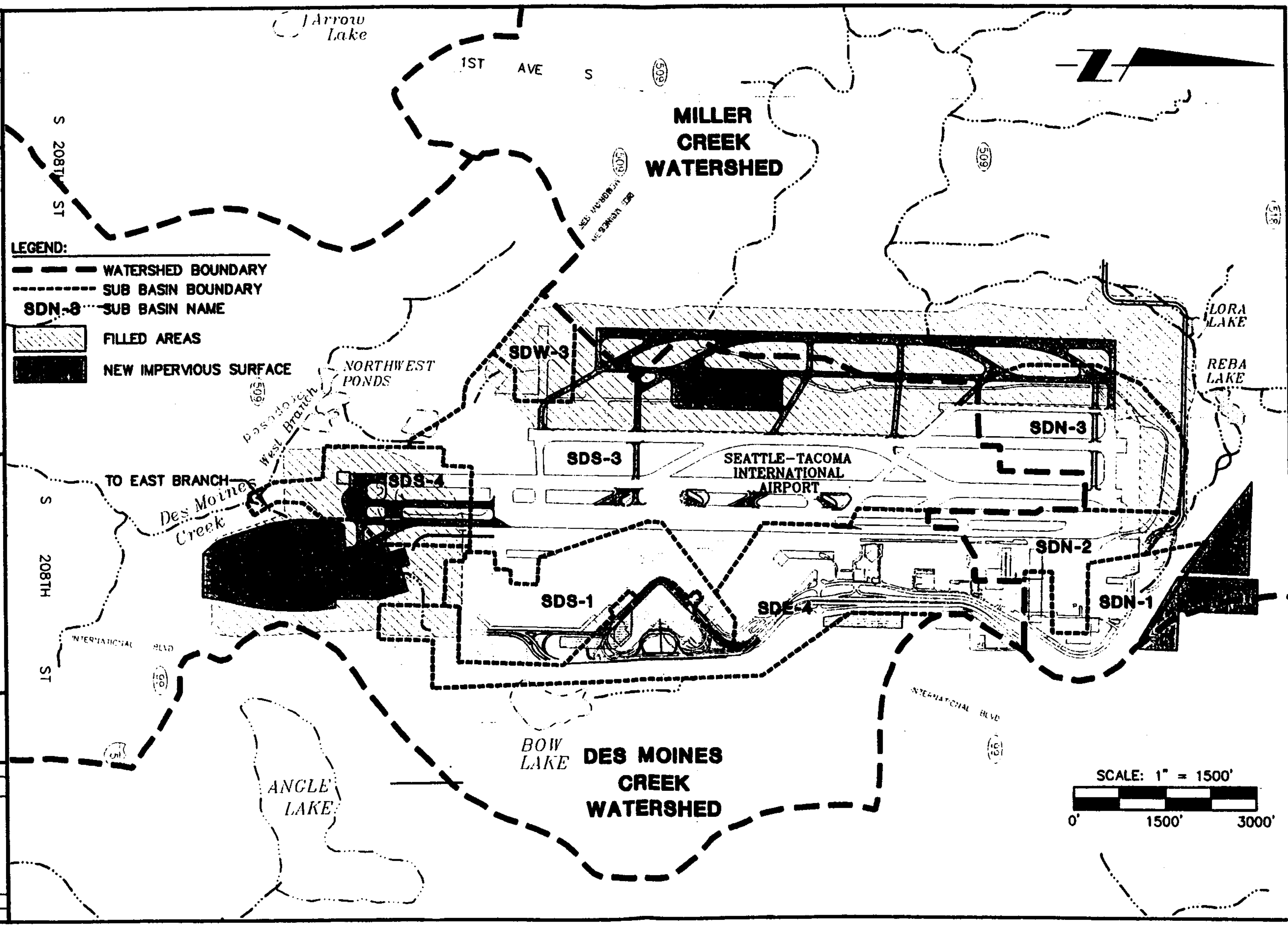
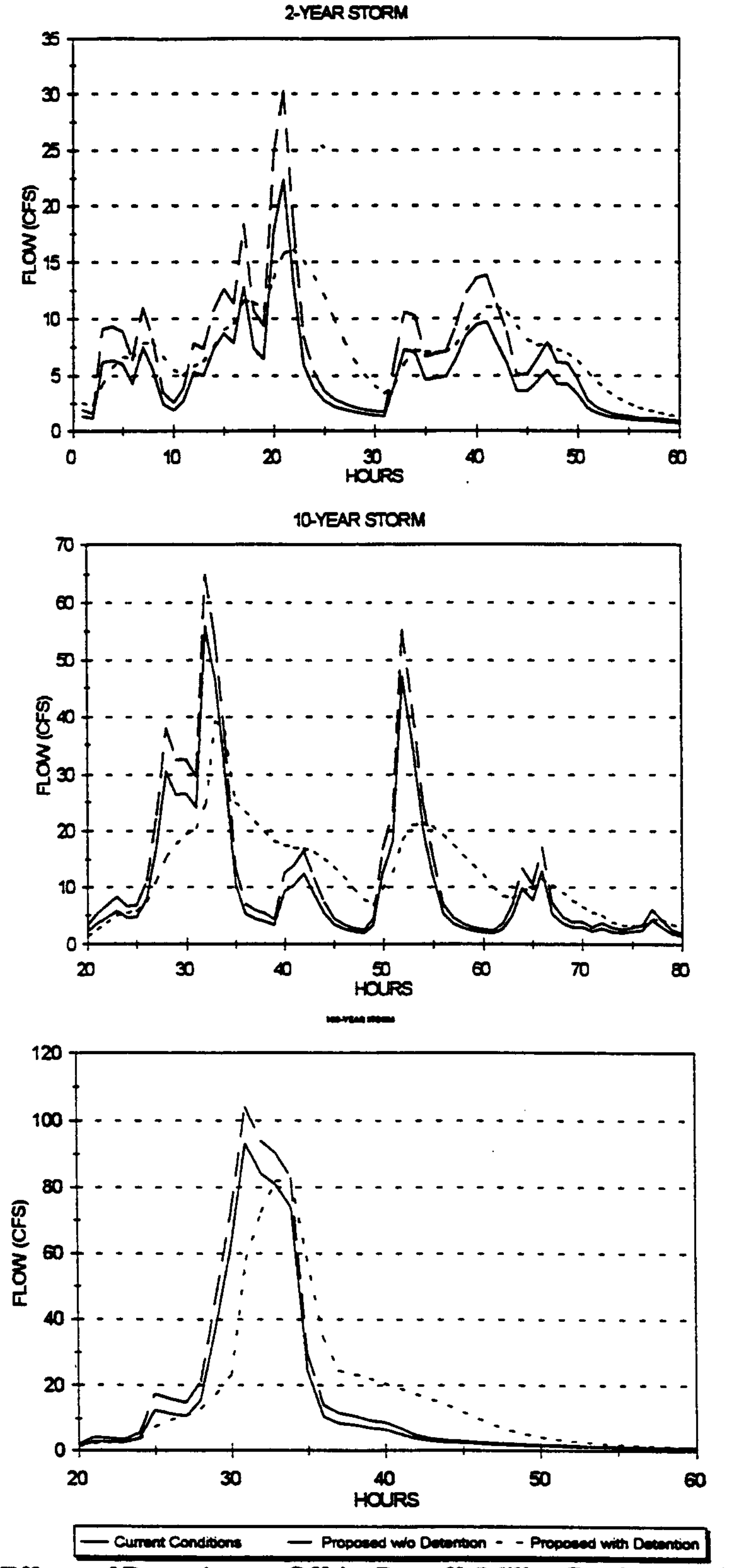


FIGURE 10
PROPOSED LAND USE CHANGES AT SEA-TAC AIRPORT

MONTGOMERY WATER GROUP, INC.
Water Resources · Environmental · Civil Engineering

PROJECT NUMBER 94-121
R.A. MONTGOMERY
PROJECT MANAGER

AR 039534



Effects of Detention on Offsite Runoff (Miller Creek Node 24)

MONTGOMERY WATER GROUP, INC. Water Resources • Environmental • Civil Engineering	SeaTac Airport Master Plan Update EIS Hydrologic Modeling Study	Figure 11

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APPENDIX A

HSPF SUBBASIN PARAMETERS

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Table A-1.
Miller Creek Subbasin Parameters for Current Conditions

Land Use: Use Type	Soil Type	% Imp.	Sub-basin Areas (acres): 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
C/AP	TGF	0%	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	EIA	100%	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
C	TGF	85%	16.5	87.3	2.8	14.7	14.7	13.1	-	-	0.9	4.6	81.8	53.3	20.2	-	-
	OG	85%	-	46.9	9.2	12.0	8.3	24.7	3.5	-	10.1	60.7	146.2	7.2	-	-	-
MF	TGM	47%	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5.5
	TGF	47%	-	-	-	-	-	-	-	-	-	-	6.4	23.0	-	-	-
	OG	47%	-	-	6.4	4.6	1.8	-	-	10.0	10.1	39.5	29.4	23.0	-	-	15.6
HD	TGM	15%	-	-	-	-	-	-	-	-	-	-	-	-	-	119.5	33.1
	TGF	15%	242.7	320.8	91.9	113.1	5.5	22.8	-	-	21.1	24.8	55.2	89.2	191.2	-	-
	OG	15%	40.4	69.9	22.1	130.5	-	-	-	27.9	52.4	11.0	7.4	27.6	-	23.0	19.3
LD	TGM	4%	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	TGF	4%	-	-	26.7	3.7	5.5	-	-	-	-	8.3	-	-	-	-	11.0
	OG	4%	-	-	73.5	3.7	14.7	-	-	45.5	8.3	60.7	-	-	-	-	59.8
	TFM	4%	-	-	-	-	-	-	-	-	-	-	-	-	-	15.6	-
	OF	4%	-	-	-	-	-	-	-	-	-	-	-	-	-	7.4	-
G	TGM	0%	-	-	-	-	-	-	-	-	-	-	-	-	-	4.6	-
	TGF	0%	8.3	8.3	-	33.1	34.0	29.5	4.3	27.8	-	7.4	-	2.8	5.5	-	-
	OG	0%	-	8.3	10.1	69.9	57.9	64.8	27.4	31.9	3.7	-	-	14.7	-	-	-
F	TFM	0%	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	TFF	0%	-	-	-	-	-	-	-	-	3.7	4.6	4.6	-	-	-	-
	OF	0%	-	-	-	-	-	-	-	-	-	-	1.8	5.5	-	14.7	46.9
–	SA	0%	-	-	-	6.4	8.3	16.1	15.3	11.4	-	-	-	8.3	-	-	-
Basin total:			307.9	541.5	242.7	391.7	150.7	171.0	50.5	154.5	110.3	221.6	332.8	254.6	216.9	184.8	191.2
PERLND areas:																	
	TGM		-	-	-	-	-	-	-	-	-	-	-	-	-	106.2	31.1
	TGF		217.1	294.1	104.2	135.0	46.2	50.8	4.3	27.8	18.1	37.1	62.6	98.8	171.1	-	10.6
	TFM		-	-	-	-	-	-	-	-	-	-	-	-	-	15.0	-
	TFF		-	-	-	-	-	-	-	-	3.7	4.6	4.6	-	-	-	-
	OG		34.3	74.8	104.2	188.6	74.2	68.5	27.9	104.6	63.1	97.7	43.8	51.4	-	19.6	82.1
	OF		-	-	-	-	-	-	-	-	-	-	1.8	5.5	-	21.8	46.9
	SA		-	-	-	6.4	8.3	16.1	15.3	11.4	-	-	-	8.3	-	-	-
	subtotal:		251.4	368.8	208.4	330.0	128.7	135.5	47.5	143.8	84.8	139.4	112.8	164.0	171.1	162.5	170.6
IMPLND areas:	EIA		56.5	172.7	34.3	61.7	22.0	35.6	3.0	10.7	25.5	82.2	220.0	90.6	45.9	22.3	20.6
IWS area:			-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Basin total:			307.9	541.5	242.7	391.7	150.7	171.0	50.5	154.5	110.3	221.6	332.8	254.6	216.9	184.8	191.2
			1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
NETWORK FACTORS																	
PERLND 26	(TGM)		-	-	-	-	-	-	-	-	-	-	-	-	-	8.848	2.588
PERLND 24	(TGF)		18.089	24.506	8.681	11.249	3.847	4.237	0.358	2.317	1.506	3.095	5.215	8.234	14.254	-	0.880
PERLND 16	(TFM)		-	-	-	-	-	-	-	-	-	-	-	-	-	1.248	-
PERLND 14	(TFF)		-	-	-	-	-	-	-	-	0.308	0.383	0.383	-	-	-	-
PERLND 44	(OG)		2.862	6.229	8.685	15.718	6.184	5.709	2.327	8.716	5.256	8.139	3.650	4.286	-	1.629	6.840
PERLND 34	(OF)		-	-	-	-	-	-	-	-	-	-	0.150	0.458	-	1.817	3.908
PERLND 54	(SA)		-	-	-	0.533	0.692	1.342	1.275	0.950	-	-	-	0.692	-	-	-
IMPLND 14	(EIA)		4.708	14.390	2.860	5.141	1.836	2.963	0.248	0.892	2.121	6.850	18.335	7.547	3.821	1.858	1.717

LEGEND

Soil Types:		Use Types:	
TGS	Till, grass, steep	C/AP	Commercial airport
TGM	Till, grass, moderate	C	Commercial
TGF	Till, grass, flat	MF	Multi-family
TGS	Till, grass, steep	HD	High density residential
TFM	Till, forest, moderate	LD	Low density residential
TFF	Till, forest, flat	G	Grass or open
OG	Outwash grass	F	Forest
OF	Outwash forest		
SA	Wetland		
EIA	Effective impervious area		

Table A-1 (cont.)
Miller Creek Subbasin Parameters for Current Conditions

Land Use: Use Type	Soil Type	% Imp.	16	17	18	19	20	21	22	23 (SDN-1)	24 (SDN-2)	25 (SDN-3)	26	27 (SDN-1X)	28 (SDN-2X)	29 (SDN-3X)	Total
			Sub-basin Areas (acres)														
C/AP	TGF	0%	-	-	-	-	-	-	-	-	7.0	50.0	-	-	-	-	57.0
	EIA	100%	-	-	-	-	-	-	-	14.0	27.0	19.0	-	-	-	-	60.0
C	TGF	85%	4.6	-	-	-	-	10.1	-	-	-	-	-	-	-	-	324.6
	OG	85%	1.8	-	-	11.0	71.4	-	-	-	-	-	7.2	7.7	-	-	427.9
MF	TGM	47%	-	-	-	-	-	6.4	-	-	-	-	-	-	-	-	11.9
	TGF	47%	0.9	-	-	4.6	-	-	-	-	-	-	-	-	-	-	34.9
	OG	47%	4.6	-	-	23.9	-	35.9	-	-	-	-	-	-	-	-	204.8
HD	TGM	15%	-	6.4	-	-	-	83.7	-	-	-	-	-	-	-	-	242.7
	TGF	15%	13.8	-	-	50.6	13.7	34.0	-	-	-	-	21.1	-	-	-	1311.5
	OG	15%	12.0	-	-	41.4	8.3	87.3	15.6	-	-	-	2.9	-	-	-	599.0
LD	TGM	4%	-	-	-	-	-	9.2	-	-	-	-	-	-	-	-	9.2
	TGF	4%	8.3	-	-	60.7	-	12.0	-	-	-	-	6.4	-	-	-	142.6
	OG	4%	3.7	-	-	39.5	18.4	-	-	-	-	-	73.3	-	-	-	401.1
	TFM	4%	-	13.8	19.3	-	-	7.4	-	-	-	-	-	-	-	-	56.1
	OF	4%	-	105.7	67.1	-	-	33.1	12.0	-	-	-	-	-	-	-	225.3
G	TGM	0%	-	-	-	-	-	7.4	-	-	-	-	-	-	-	-	12.0
	TGF	0%	-	-	-	1.8	53.4	22.1	-	-	-	-	53.9	-	-	15.3	307.5
	OG	0%	-	-	-	16.5	74.9	-	-	-	-	-	19.9	-	-	-	400.0
F	TFM	0%	-	1.8	-	-	-	-	-	-	-	-	-	-	-	-	1.8
	TFF	0%	9.2	-	-	11.0	-	-	-	-	-	-	-	-	-	-	33.1
	OF	0%	23.0	31.3	30.3	12.9	-	-	1.8	-	-	-	-	-	-	-	168.2
--	SA	0%	-	-	-	6.4	25.3	-	-	-	-	-	0.8	3.2	-	-	101.5
Basin total:			81.9	159.0	116.7	280.3	265.4	348.6	29.4	14.0	34.0	69.0	185.5	10.9	0.0	15.3	5132.7
PERLND areas:																	
	TGM		-	5.4	-	-	-	90.8	-	-	-	-	-	-	-	-	233.4
	TGF		20.9	-	-	105.5	65.0	64.0	-	-	7.0	50.0	78.0	-	-	15.3	1683.4
	TFM		-	15.0	18.5	-	-	7.1	-	-	-	-	-	-	-	-	55.7
	TFF		9.2	-	-	11.0	-	-	-	-	-	-	-	-	-	-	33.1
	OG		16.5	-	-	103.9	110.3	93.2	13.3	-	-	-	93.8	1.2	-	-	1466.9
	OF		23.0	132.8	94.7	12.9	-	31.8	13.3	-	-	-	-	-	-	-	384.5
	SA		-	-	-	6.4	25.3	-	-	-	-	-	0.8	3.2	-	-	101.5
	subtotal:		69.5	153.3	113.2	239.7	200.7	286.9	26.6	0.0	7.0	50.0	172.6	4.4	0.0	15.3	3958.5
IMPLND areas:																	
	EIA		12.4	5.7	3.5	40.6	64.7	61.7	2.8	14.0	27.0	19.0	12.9	6.5	0.0	0.0	1174.2
IWS area:			-	-	-	-	-	-	-	25.0	25.0	-	-	-	-	-	50.0
Basin total:			81.9	159.0	116.7	280.3	265.4	348.6	29.4	39.0	52.0	69.0	185.5	10.9	0.0	15.3	5182.7
NETWORK FACTORS			1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	
PERLND 26	(TGM)		-	0.453	-	-	-	7.564	-	-	-	-	-	-	-	-	
PERLND 24	(TGF)		1.739	-	-	8.793	5.420	5.336	-	-	0.583	4.167	6.498	-	-	1.275	
PERLND 16	(TFM)		-	1.254	1.544	-	-	0.592	-	-	-	-	-	-	-	-	
PERLND 14	(TFF)		0.767	-	-	0.917	-	-	-	-	-	-	-	-	-	-	
PERLND 44	(OG)		1.372	-	-	8.661	9.194	7.769	1.105	-	-	-	7.818	0.096	-	-	
PERLND 34	(OF)		1.917	11.064	7.893	1.075	-	2.648	1.110	-	-	-	-	-	-	-	
PERLND 54	(SA)		-	-	-	0.533	2.108	-	-	-	-	-	0.067	0.267	-	-	
IMPLND 14	(EIA)		1.031	0.478	0.288	3.379	5.394	5.140	0.235	1.167	2.250	1.583	1.076	0.545	-	-	

AR 039540

Table A-2.
Des Moines Creek Subbasin Parameters for Current Conditions

Land Use			Sub-basin																
Use Type	Soil Type	% Imp.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
C/AP	TGF	0%	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	TGM	0%	12.2	3.1	-	7.7	40.1	38.2	-	0.3	7.5	-	-	-	-	-	-	-	-
	EIA	100%	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	OG	0%	-	-	-	-	23.2	26.1	-	7.9	1.3	-	28.0	-	-	-	-	-	-
	TGS	0%	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
C	TGF	85%	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	TGM	85%	55.5	29.7	2.9	61.0	3.3	9.4	20.5	-	2.8	-	-	-	23.4	0.6	16.4	30.7	13.8
	OG	85%	6.1	21.8	9.9	-	-	-	11.8	24.9	0.6	-	3.7	-	-	4.9	-	-	-
	SA	85%	-	-	-	-	-	-	10.4	9.5	-	-	17.1	-	-	-	-	-	-
	TGS	85%	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MF	TGM	47%	63.5	1.4	8.4	3.2	-	-	-	-	0.9	-	-	-	1.0	-	6.8	39.0	3.1
	OG	47%	24.6	-	0.9	-	-	-	-	-	0.8	-	-	-	-	-	0.5	17.2	3.9
HD/LD	TGM	4%	214.5	0.3	-	35.8	-	2.2	23.5	-	35.8	-	-	-	0.6	3.2	3.6	91.7	12.5
	TGF	4%	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	OG	4%	-	-	-	-	-	-	12.1	2.2	7.2	-	-	-	-	1.8	2.7	14.9	5.5
	TGS	4%	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
G	TGM	0%	33.6	-	-	-	-	-	24.5	-	21.6	7.3	0.7	1.2	28.8	6.6	1.0	29.8	-
	TGF	0%	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	OG	0%	10.5	4.2	-	-	-	-	11.0	25.1	6.5	28.7	4.4	29.1	26.3	37.8	-	8.5	-
	SA	0%	-	-	-	-	-	-	9.3	1.5	-	1.2	26.5	21.8	-	-	-	-	-
	TGS	0%	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
F	TGM	0%	-	-	-	-	-	-	-	-	-	-	-	2.8	-	-	-	-	-
–	SA	0%	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Basin total:			420.5	60.5	22.1	107.7	66.6	75.9	123.1	71.4	85.0	37.2	80.4	54.9	80.1	54.9	31.0	231.8	38.8
PERLND areas:																			
	TGS		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	TGM		293.7	8.6	4.9	52.9	40.6	41.7	50.1	0.3	64.4	7.3	0.7	4.0	33.4	9.8	10.5	143.1	15.7
	TGF		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	OG		24.5	7.5	2.0	-	23.2	26.1	24.4	38.8	15.2	28.7	33.0	29.1	26.3	40.3	2.9	31.9	7.3
	SA		-	-	-	-	-	-	10.9	2.9	-	1.2	29.1	21.8	-	-	-	-	-
	subtotal:		318.2	16.1	6.8	52.9	63.8	67.8	85.4	42.1	79.6	37.2	62.7	54.9	59.7	50.0	13.4	175.0	23.1
IMPLND areas:																			
	EIA		102.3	44.4	15.3	54.8	2.8	8.1	37.7	29.3	5.4	0.0	17.7	-0.0	20.4	4.9	17.6	56.8	15.7
IWS area:			-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Basin total:			420.5	60.5	22.1	107.7	66.6	75.9	123.1	71.4	85.0	37.2	80.4	54.9	80.1	54.9	31.0	231.8	38.8

NETWORK FACTORS

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
PERLND 28	(TGS)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PERLND 26	(TGM)	24.475	0.715	0.407	4.410	3.383	3.477	4.178	0.025	5.364	0.608	0.058	0.333	2.785	0.814	0.877	11.926	1.309
PERLND 24	(TGF)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PERLND 16	(TFM)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PERLND 14	(TFF)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PERLND 44	(OG)	2.038	0.623	0.164	-	1.933	2.175	2.032	3.237	1.269	2.392	2.746	2.425	2.192	3.355	0.238	2.660	0.612
PERLND 34	(OF)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PERLND 54	(SA)	-	-	-	-	-	-	0.905	0.244	-	0.100	2.422	1.817	-	-	-	-	-
IMPLND 14	(EIA)	8.529	3.704	1.271	4.566	0.234	0.673	3.143	2.444	0.451	-	1.473		1.699	0.406	1.469	4.731	1.312

LEGEND

Soil Types:		Use Types:	
TGS	Till, grass, steep	C/AP	Commercial airport
TGM	Till, grass, moderate	C	Commercial
TGF	Till, grass, flat	MF	Multi-family
TGS	Till, grass, steep	HD	High density residential
TFM	Till, forest, moderate	LD	Low density residential
TFF	Till, forest, flat	G	Grass or open
OG	Outwash grass	F	Forest
OF	Outwash forest		
SA	Wetland		
EIA	Effective impervious area		

Table A-2 (cont.)
Des Moines Creek Subbasin Parameters for Current Conditions

Land Use				SDW-3	SDS-3	SDS-4	SDS-1	SDE-4	SDW-3X	SDS-3X	SDS-4X	SDS-1X	SDS-4X	<---subbasins below S. 288th--->					
Use Type	Soil Type	% Imp.	Sub-basin 18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	Total
C/AP	TGF	0%	0.5	14.0	221.0	26.0	-	28.0	-	-	-	-	-						289.5
	TGM	0%	7.0	-	-	-	-	-	-	-	-	-	-						116.1
	EIA	100%	-	10.0	209.0	18.0	40.0	92.0	-	-	-	-	-						369.0
	OG	0%	16.4	-	-	-	-	-	-	-	-	-	-						102.9
	TGS	0%	-	-	-	-	-	-	-	-	-	-	-						0.0
C	TGF	85%	-	-	-	-	-	-	-	-	-	-	-						0.0
	TGM	85%	-	-	-	-	-	-	-	-	-	-	-						270.0
	OG	85%	1.3	-	-	-	-	-	-	-	-	-	-						85.0
	SA	85%	-	-	-	-	-	-	-	-	-	-	-						37.0
	TGS	85%	-	-	-	-	-	-	-	-	-	-	-						0.0
MF	TGM	47%	2.6	-	-	-	-	-	-	-	-	-	-						129.9
	OG	47%	2.9	-	-	-	-	-	-	-	-	-	-						50.8
HD/LD	TGM	4%	2.1	-	-	-	-	-	-	-	-	-	-						425.8
	TGF	4%	-	-	-	-	-	-	-	-	-	-	-						0.0
	OG	4%	5.8	-	-	-	-	-	-	-	-	-	-						52.2
	TGS	4%	-	-	-	-	-	-	-	-	-	-	-						0.0
G	TGM	0%	5.1	-	-	-	-	-	-	-	-	-	-						160.2
	TGF	0%	-	-	-	-	-	-	13.6	92.9	14.9	-	-						121.4
	OG	0%	31.1	-	-	-	-	-	-	-	-	-	-						223.2
	SA	0%	-	-	-	-	-	-	-	-	-	-	-						60.3
	TGS	0%	-	-	-	-	-	-	-	-	-	-	-						0.0
F	TGM	0%	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2.8
–	SA	0%	-	-	-	-	-	-	-	-	-	-	-						0.0
Basin total:			74.8	24.0	430.0	44.0	40.0	120.0	13.6	92.9	14.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2496.1
PERLND areas:																			
	TGS		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.0
	TGM		15.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	797.2
	TGF		0.5	14.0	221.0	26.0	-	28.0	13.6	92.9	14.9	-	-	-	-	-	-	-	410.9
	OG		54.8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	415.9
	SA		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	65.9
	subtotal:		70.8	14.0	221.0	26.0	0.0	28.0	13.6	92.9	14.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1689.9
IMPLND areas:																			
	EIA		4.0	10.0	209.0	18.0	40.0	92.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	806.2
IWS area:			-	-	-	-	148.0	56.0	-	-	-	-	-	-	-	-	-	-	204.000
Basin total:			74.8	24.0	430.0	44.0	188.0	176.0	13.6	92.9	14.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2700.1

NETWORK FACTORS

		18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33
PERLND 28	(TGS)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PERLND 26	(TGM)	1.291	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PERLND 24	(TGF)	0.042	1.167	18.417	2.167	-	2.333	1.133	7.742	1.242	-	-	-	-	-	-	-
PERLND 16	(TFM)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PERLND 14	(TFF)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PERLND 44	(OG)	4.567	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PERLND 34	(OF)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PERLND 54	(SA)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
IMPLND 14	(EIA)	0.334	0.833	17.417	1.500	3.333	7.667	-	-	-	-	-	-	-	-	-	-

Table A-3.
Miller Creek Subbasin Parameters for Proposed Conditions

Land Use: Use Type	Soil Type	% Imp.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
			Sub-basin Areas (acres)																
C/AP	TGF	0%	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	EIA	100%	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
C	TGF	85%	16.5	87.3	2.8	14.7	14.7	13.1	-	-	0.9	4.6	81.8	53.3	20.2	-	-	4.6	-
	OG	85%	-	46.9	9.2	12.0	8.3	24.7	3.5	-	10.1	60.7	146.2	7.2	-	-	-	1.8	-
MF	TGM	47%	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5.5	-	-
	TGF	47%	-	-	-	-	-	-	-	-	-	-	6.4	23.0	-	-	-	0.9	-
	OG	47%	-	-	6.4	4.6	1.8	-	-	10.0	10.1	39.5	29.4	23.0	-	-	15.6	4.6	-
HD	TGM	15%	-	-	-	-	-	-	-	-	-	-	-	-	-	119.5	33.1	-	6.4
	TGF	15%	242.7	320.8	91.9	113.1	5.5	-	-	-	21.1	24.8	55.2	89.2	191.2	-	-	13.8	-
	OG	15%	40.4	69.9	22.1	130.5	-	-	-	12.3	52.4	11.0	7.4	27.6	-	23.0	19.3	12.0	-
LD	TGM	4%	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	TGF	4%	-	-	26.7	3.7	5.5	-	-	-	-	8.3	-	-	-	-	11.0	8.3	-
	OG	4%	-	-	73.5	3.7	14.7	-	-	32.9	8.3	60.7	-	-	-	-	59.8	3.7	-
	TFM	4%	-	-	-	-	-	-	-	-	-	-	-	-	-	15.6	-	-	13.8
	OF	4%	-	-	-	-	-	-	-	-	-	-	-	-	-	7.4	-	-	105.7
G	TGM	0%	-	-	-	-	-	-	-	-	-	-	-	-	-	4.6	-	-	-
	TGF	0%	8.3	8.3	-	33.1	34.0	14.4	4.3	-	-	7.4	-	2.8	5.5	-	-	-	-
	OG	0%	-	8.3	10.1	69.9	57.9	32.1	2.9	6.9	3.7	-	-	14.7	-	-	-	-	-
F	TFM	0%	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1.8
	TFF	0%	-	-	-	-	-	-	-	-	3.7	4.6	4.6	-	-	-	-	9.2	-
	OF	0%	-	-	-	-	-	-	-	-	-	-	1.8	5.5	-	14.7	46.9	23.0	31.3
–	SA	0%	-	-	-	6.4	8.3	16.1	15.3	11.4	-	-	-	8.3	-	-	-	-	-
Basin total:			307.9	541.5	242.7	391.7	150.7	100.4	26.0	73.5	110.3	221.6	332.8	254.6	216.9	184.8	191.2	81.9	159.0
PERLND areas:																			
	TGM		-	-	-	-	-	-	-	-	-	-	-	-	-	106.2	31.1	-	5.4
	TGF		217.1	294.1	104.2	135.0	46.2	16.4	4.3	-	18.1	37.1	62.6	98.8	171.1	-	10.6	20.9	-
	TFM		-	-	-	-	-	-	-	-	-	-	-	-	-	15.0	-	-	15.0
	TFF		-	-	-	-	-	-	-	-	3.7	4.6	4.6	-	-	-	-	9.2	-
	OG		34.3	74.8	104.2	188.6	74.2	35.8	3.4	54.2	63.1	97.7	43.8	51.4	-	19.6	82.1	16.5	-
	OF		-	-	-	-	-	-	-	-	-	-	1.8	5.5	-	21.8	46.9	23.0	132.8
	SA		-	-	-	6.4	8.3	16.1	15.3	11.4	-	-	-	8.3	-	-	-	-	-
	subtotal:		251.4	368.8	208.4	330.0	128.7	68.3	23.0	65.6	84.8	139.4	112.8	164.0	171.1	162.5	170.6	69.5	153.3
IMPLND areas:																			
	EIA		56.5	172.7	34.3	61.7	22.0	32.1	3.0	7.9	25.5	82.2	220.0	90.6	45.9	22.3	20.6	12.4	5.7
IWS area:			-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Basin total:			307.9	541.5	242.7	391.7	150.7	100.4	26.0	73.5	110.3	221.6	332.8	254.6	216.9	184.8	191.2	81.9	159.0

NETWORK FACTORS

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
PERLND 26	(TGM)	-	-	-	-	-	-	-	-	-	-	-	-	-	8.848	2.588	-	0.453
PERLND 24	(TGF)	18.089	24.506	8.681	11.249	3.847	1.364	0.358	-	1.506	3.095	5.215	8.234	14.254	-	0.880	1.739	-
PERLND 16	(TFM)	-	-	-	-	-	-	-	-	-	-	-	-	-	1.248	-	-	1.254
PERLND 14	(TFF)	-	-	-	-	-	-	-	-	0.308	0.383	0.383	-	-	-	-	0.767	-
PERLND 44	(OG)	2.862	6.229	8.685	15.718	6.184	2.984	0.285	4.520	5.256	8.139	3.650	4.286	-	1.629	6.840	1.372	-
PERLND 34	(OF)	-	-	-	-	-	-	-	-	-	-	0.150	0.458	-	1.817	3.908	1.917	11.064
PERLND 54	(SA)	-	-	-	0.533	0.692	1.342	1.275	0.950	-	-	-	0.692	-	-	-	-	-
IMPLND 14	(EIA)	4.708	14.390	2.860	5.141	1.836	2.678	0.248	0.655	2.121	6.850	18.335	7.547	3.821	1.858	1.717	1.031	0.478

LEGEND

Soil Types:		Use Types:	
TGS	Till, grass, steep	C/AP	Commercial airport
TGM	Till, grass, moderate	C	Commercial
TGF	Till, grass, flat	MF	Multi-family
TGS	Till, grass, steep	HD	High density residential
TFM	Till, forest, moderate	LD	Low density residential
TFF	Till, forest, flat	G	Grass or open
OG	Outwash grass	F	Forest
OF	Outwash forest		
SA	Wetland		
EIA	Effective impervious area		

Table A-3 (cont.)
Miller Creek Subbasin Parameters for Proposed Conditions

Land Use								SDN-1	SDN-2	SDN-3		SDN-1X	SDN-2X	SDN-3X	NEW	NEW	NEW	
Use	Soil	%	Sub-basin Areas (acres)															
Type	Type	Imp.	18	19	20	21	22	23	24	25	26	27	28	29	44	45	46	Total
C/AP	TGF	0%	-	-	-	-	-	-	7.0	30.1	-	-	-	-	162.8	49.0	50.5	299.4
	EIA	100%	-	-	-	-	-	14.0	27.0	19.0	-	-	-	-	38.2	41.5	17.7	157.4
C	TGF	85%	-	-	-	10.1	-	-	-	-	-	-	-	-	-	-	-	324.6
	OG	85%	-	11.0	71.4	-	-	-	-	-	7.2	7.7	-	-	-	-	-	427.9
MF	TGM	47%	-	-	-	6.4	-	-	-	-	-	-	-	-	-	-	-	11.9
	TGF	47%	-	4.6	-	-	-	-	-	-	-	-	-	-	-	-	-	34.9
	OG	47%	-	23.9	-	35.9	-	-	-	-	-	-	-	-	-	-	-	204.8
HD	TGM	15%	-	-	-	83.7	-	-	-	-	-	-	-	-	-	-	-	242.7
	TGF	15%	-	50.6	9.2	34.0	-	-	-	-	11.1	-	-	-	-	-	-	1274.2
	OG	15%	-	41.4	5.3	87.3	15.6	-	-	-	2.9	-	-	-	-	-	-	580.4
LD	TGM	4%	-	-	-	9.2	-	-	-	-	-	-	-	-	-	-	-	9.2
	TGF	4%	-	60.7	-	12.0	-	-	-	-	6.4	-	-	-	-	-	-	142.6
	OG	4%	-	39.5	18.4	-	-	-	-	-	61.6	-	-	-	-	-	-	376.8
	TFM	4%	19.3	-	-	7.4	-	-	-	-	-	-	-	-	-	-	-	56.1
	OF	4%	67.1	-	-	33.1	12.0	-	-	-	-	-	-	-	-	-	-	225.3
G	TGM	0%	-	-	-	7.4	-	-	-	-	-	-	-	-	-	-	-	12.0
	TGF	0%	-	1.8	8.4	22.1	-	-	-	-	-	-	-	15.3	-	-	-	165.7
	OG	0%	-	16.5	59.1	-	-	-	-	-	-	-	-	-	-	-	-	282.1
F	TFM	0%	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1.8
	TFF	0%	-	11.0	-	-	-	-	-	-	-	-	-	-	-	-	-	33.1
	OF	0%	30.3	12.9	-	-	1.8	-	-	-	-	-	-	-	-	-	-	168.2
--	SA	0%	-	6.4	25.3	-	-	-	-	-	0.8	3.2	-	-	-	-	-	101.5
Basin total:			116.7	280.3	197.1	348.6	29.4	14.0	34.0	49.1	90.0	10.9	0.0	15.3	201.0	90.5	68.2	5132.6
PERLND areas:																		
	TGM		-	-	-	90.8	-	-	-	-	-	-	-	-	-	-	-	233.4
	TGF		-	105.5	16.2	64.0	-	-	7.0	30.1	15.6	-	-	15.3	162.8	49.0	50.5	1752.3
	TFM		18.5	-	-	7.1	-	-	-	-	-	-	-	-	-	-	-	55.7
	TFF		-	11.0	-	-	-	-	-	-	-	-	-	-	-	-	-	33.1
	OG		-	103.9	92.0	93.2	13.3	-	-	-	62.7	1.2	-	-	-	-	-	1309.9
	OF		94.7	12.9	-	31.8	13.3	-	-	-	-	-	-	-	-	-	-	384.5
	SA		-	6.4	25.3	-	-	-	-	-	0.8	3.2	-	-	-	-	-	101.5
	subtotal:		113.2	239.7	133.5	286.9	26.6	0.0	7.0	30.1	79.1	4.4	0.0	15.3	162.8	49.0	50.5	3870.3
IMPLND areas:																		
	EIA		3.5	40.6	63.6	61.7	2.8	14.0	27.0	19.0	10.9	6.5	0.0	0.0	38.2	41.5	17.7	1262.3
IWS area:			-	-	-	-	-	25.0	25.0	-	-	0.0	0.0	-	-	-	-	50.0
Basin total:			116.7	280.3	197.1	348.6	29.4	14.0	34.0	49.1	90.0	10.9	0.0	15.3	201.0	90.5	68.2	5182.6

NETWORK FACTORS																
PERLND 26	(TGM)	-	-	-	7.564	-	-	-	-	-	-	-	-	-	-	-
PERLND 24	(TGF)	-	8.793	1.352	5.336	-	-	0.583	2.508	1.298	-	-	1.275	13.567	4.083	4.208
PERLND 16	(TFM)	1.544	-	-	0.592	-	-	-	-	-	-	-	-	-	-	-
PERLND 14	(TFF)	-	0.917	-	-	-	-	-	-	-	-	-	-	-	-	-
PERLND 44	(OG)	-	8.661	7.665	7.769	1.105	-	-	-	5.223	0.096	-	-	-	-	-
PERLND 34	(OF)	7.893	1.075	-	2.648	1.110	-	-	-	-	-	-	-	-	-	-
PERLND 54	(SA)	-	0.533	2.108	-	-	-	-	-	0.067	0.267	-	-	-	-	-
IMPLND 14	(EIA)	0.288	3.379	5.300	5.140	0.235	1.167	2.250	1.583	0.912	0.545	-	-	3.183	3.458	1.475

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Table A-4.
Des Moines Creek Subbasin Parameters for Proposed Conditions

Land Use: Use Type	Soil Type	% Imp.	Sub-basin 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
C/AP	TGF	0%	-	-	-	7.7	-	-	-	-	-	-	-	-	-	-	-	-	-
	TGM	0%	12.2	3.1	-	-	9.3	-	-	0.3	7.5	-	-	-	-	-	-	-	-
	EIA	100%	-	-	-	-	19.6	6.4	-	-	-	-	-	-	6.3	-	-	-	-
	OG	0%	-	-	-	-	-	4.0	-	7.9	1.3	-	28.0	-	-	-	-	-	-
	TGS	0%	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
C	TGF	85%	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	TGM	85%	55.5	29.7	2.9	61.0	3.3	-	20.5	-	2.8	-	-	-	23.4	0.6	16.4	30.7	13.8
	OG	85%	6.1	21.8	9.9	-	-	-	11.8	24.9	0.6	-	3.7	-	-	4.9	-	-	-
	SA	85%	-	-	-	-	-	-	10.4	9.5	-	-	17.1	-	-	-	-	-	-
	TGS	85%	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MF	TGM	47%	63.5	1.4	8.4	3.2	-	-	-	-	0.9	-	-	-	1.0	-	6.8	39.0	3.1
	OG	47%	24.6	-	0.9	-	-	-	-	-	0.8	-	-	-	-	-	0.5	17.2	3.9
HD/LD	TGM	4%	214.5	0.3	-	35.8	-	2.2	23.5	-	35.8	-	-	-	0.6	3.2	3.6	91.7	12.5
	TGF	4%	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	OG	4%	-	-	-	-	-	-	12.1	2.2	7.2	-	-	-	-	1.8	2.7	14.9	5.5
	TGS	4%	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
G	TGM	0%	33.6	-	-	-	-	-	24.5	-	21.6	7.3	0.7	1.2	-	6.6	1.0	29.8	-
	TGF	0%	-	-	-	-	26.8	27.0	-	-	-	-	-	12.6	13.2	-	-	-	-
	OG	0%	10.5	4.2	-	-	-	-	11.0	25.1	6.5	28.7	4.4	29.1	13.8	37.8	-	8.5	-
	SA	0%	-	-	-	-	-	-	9.3	1.5	-	1.2	26.5	9.2	-	-	-	-	-
	TGS	0%	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
F	TGM	0%	-	-	-	-	-	-	-	-	-	-	-	2.8	-	-	-	-	-
—	SA	0%	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Basin total:			420.5	60.5	22.1	107.7	59.0	39.6	123.1	71.4	85.0	37.2	80.4	54.9	58.3	54.9	31.0	231.8	38.8
PERLND areas:																			
	TGS		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	TGM		293.7	8.6	4.9	45.2	9.8	2.1	50.1	0.3	64.4	7.3	0.7	4.0	4.6	9.8	10.5	143.1	15.7
	TGF		-	-	-	7.7	26.8	27.0	-	-	-	-	-	12.6	13.2	-	-	-	-
	OG		24.5	7.5	2.0	-	-	4.0	24.4	38.8	15.2	28.7	33.0	29.1	13.8	40.3	2.9	31.9	7.3
	SA		-	-	-	-	-	-	10.9	2.9	-	1.2	29.1	9.2	-	-	-	-	-
	subtotal:		318.2	16.1	6.8	52.9	36.6	33.1	85.4	42.1	79.6	37.2	62.7	54.9	31.6	50.0	13.4	175.0	23.1
IMPLND areas:																			
	EIA		102.3	44.4	15.3	54.8	22.4	6.5	37.7	29.3	5.4	0.0	17.7	-0.0	26.7	4.9	17.6	56.8	15.7
IWS area:			-	-	-	-	7.6	36.3	-	-	-	-	-	-	21.8	-	-	-	-
Basin total:			420.5	60.5	22.1	107.7	66.6	75.9	123.1	71.4	85.0	37.2	80.4	54.9	80.1	54.9	31.0	231.8	38.8

NETWORK FACTORS

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
PERLND 28	(TGS)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PERLND 26	(TGM)	24.475	0.715	0.407	3.768	0.816	0.176	4.178	0.025	5.364	0.608	0.058	0.333	0.385	0.814	0.877	11.926	1.309
PERLND 24	(TGF)	-	-	-	0.642	2.233	2.250	-	-	-	-	-	1.050	1.100	-	-	-	-
PERLND 16	(TFM)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PERLND 14	(TFF)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PERLND 44	(OG)	2.038	0.623	0.164	-	-	0.333	2.032	3.237	1.269	2.392	2.746	2.425	1.150	3.355	0.238	2.660	0.612
PERLND 34	(OF)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PERLND 54	(SA)	-	-	-	-	-	-	0.905	0.244	-	0.100	2.422	0.767	-	-	-	-	-
IMPLND 14	(EIA)	8.529	3.704	1.271	4.566	1.867	0.541	3.143	2.444	0.451	-	1.473		2.224	0.406	1.469	4.731	1.312

LEGEND

Soil Types:		Use Types:	
TGS	Till, grass, steep	C/AP	Commercial airport
TGM	Till, grass, moderate	C	Commercial
TGF	Till, grass, flat	MF	Multi-family
TGS	Till, grass, steep	HD	High density residential
TFM	Till, forest, moderate	LD	Low density residential
TFF	Till, forest, flat	G	Grass or open
OG	Outwash grass	F	Forest
OF	Outwash forest		
SA	Wetland		
EIA	Effective impervious area		

Table A-4 (cont.)
Des Moines Creek Subbasin Parameters for Proposed Conditions

Land Use				SDW-3	SDS-3	SDS-4	SDS-1	SDE-4	SDW-3X	SDS-3X	SDS-4X	SDS-1X	SDS-4X		<—subbasins below S. 208th—>				
Use Type	Soil Type	% Imp.	Sub-basin 18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	Total
C/AP	TGF	0%	0.5	14.0	221.0	26.0	-	28.0	-	-	-	-	-						297.2
	TGM	0%	7.0	-	-	-	-	-	-	-	-	-	-						39.4
	EIA	100%	-	11.0	264.0	25.1	40.0	92.0	-	-	-	-	-						464.4
	OG	0%	16.4	-	-	-	-	-	-	-	-	-	-						57.6
	TGS	0%	-	-	-	-	-	-	-	-	-	-	-						0.0
C	TGF	85%	-	-	-	-	-	-	-	-	-	-	-						0.0
	TGM	85%	-	-	-	-	-	-	-	-	-	-	-						260.6
	OG	85%	1.3	-	-	-	-	-	-	-	-	-	-						85.0
	SA	85%	-	-	-	-	-	-	-	-	-	-	-						37.0
	TGS	85%	-	-	-	-	-	-	-	-	-	-	-						0.0
MF	TGM	47%	2.6	-	-	-	-	-	-	-	-	-	-						129.9
	OG	47%	2.9	-	-	-	-	-	-	-	-	-	-						50.8
HD/LD	TGM	4%	2.1	-	-	-	-	-	-	-	-	-	-						425.8
	TGF	4%	-	-	-	-	-	-	-	-	-	-	-						0.0
	OG	4%	5.8	-	-	-	-	-	-	-	-	-	-						52.2
	TGS	4%	-	-	-	-	-	-	-	-	-	-	-						0.0
G	TGM	0%	5.1	-	-	-	-	-	-	-	-	-	-						131.4
	TGF	0%	-	-	-	-	-	-	12.6	37.9	7.8	-	-						137.9
	OG	0%	31.1	-	-	-	-	-	-	-	-	-	-						210.7
	SA	0%	-	-	-	-	-	-	-	-	-	-	-						47.7
	TGS	0%	-	-	-	-	-	-	-	-	-	-	-						0.0
F	TGM	0%	-	-	-	-	-	-	-	-	-	-	-						2.8
–	SA	0%	-	-	-	-	-	-	-	-	-	-	-						0.0
Basin total:			74.8	25.0	485.0	51.1	40.0	120.0	12.6	37.9	7.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2430.4
PERLND areas:																			
	TGS		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.0
	TGM		15.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	690.3
	TGF		0.5	14.0	221.0	26.0	-	28.0	12.6	37.9	7.8	-	-	-	-	-	-	-	435.1
	OG		54.8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	358.1
	SA		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	53.3
	subtotal:		70.8	14.0	221.0	26.0	0.0	28.0	12.6	37.9	7.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1536.7
IMPLND areas:																			
	EIA		4.0	11.0	264.0	25.1	40.0	92.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	893.7
IWS area:			-	-	-	-	148.0	56.0	-	-	-	-	-	-	-	-	-	-	269.7
Basin total:			74.8	25.0	485.0	51.1	188.0	176.0	12.6	37.9	7.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2700.1

NETWORK FACTORS

		18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33
PERLND 28	(TGS)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PERLND 26	(TGM)	1.291	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PERLND 24	(TGF)	0.042	1.167	18.417	2.167	-	2.333	1.050	3.158	0.650	-	-	-	-	-	-	-
PERLND 16	(TFM)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PERLND 14	(TFF)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PERLND 44	(OG)	4.567	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PERLND 34	(OF)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PERLND 54	(SA)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
IMPLND 14	(EIA)	0.334	0.917	22.000	2.092	3.333	7.667	-	-	-	-	-	-	-	-	-	-

APPENDIX B

CALIBRATION DATA AND PLOTS

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Table B-1.
HSPF Calibration Data, Miller Creek near Mouth
(Gauge 42A, Node 17)

Month		Average Monthly Flow (cfs)			Peak Hourly Flow (cfs)		
		Recorded	Simulated	RPD	Recorded	Simulated	RPD
Aug	1989	2.05	2.18	1.06	158.50	70.50	44%
Sep	1989	0.96	1.66	1.73	15.50	14.98	97%
Oct	1989	3.82	3.83	1.00	94.50	39.59	42%
Nov	1989	10.19	9.48	0.93	168.30	90.77	54%
Dec	1989	10.54	11.20	1.06	186.00	158.10	85%
Jan	1990	n/a	23.58		406.30	428.43	105%
Feb	1990	n/a	12.18		n/a	78.94	
Mar	1990	n/a	5.84		n/a	33.13	
Apr	1990	4.97	4.09	0.82	45.30	30.80	68%
May	1990	3.55	3.50	0.99	97.50	105.32	108%
Jun	1990	5.05	6.34	1.26	116.30	85.86	74%
Jul	1990	2.05	2.22	1.08	71.30	37.74	53%
Aug	1990	1.74	1.90	1.09	37.80	18.63	49%
Sep	1990	1.64	1.58	0.96	3.40	2.22	65%
Oct	1990	5.27	6.50	1.23	117.30	67.33	57%
Nov	1990	n/a	26.61		388.00	371.45	96%
Dec	1990	n/a	9.93		n/a	77.54	
Jan	1991	13.20	11.07	0.84	153.50	151.38	99%
Feb	1991	17.67	15.06	0.85	190.80	219.14	115%
Mar	1991	16.90	11.58	0.69	164.30	123.82	75%
Apr	1991	20.37	19.18	0.94	244.00	301.81	124%
May	1991	5.72	2.96	0.52	25.30	31.59	125%
Jun	1991	5.41	2.67	0.49	34.30	30.56	89%
Jul	1991	2.28	1.96	0.86	19.80	22.07	111%
Aug	1991	3.08	3.43	1.11	40.80	45.88	112%
Sep	1991	1.55	1.70	1.10	3.70	4.13	112%
Oct	1991	n/a	2.53		n/a	43.24	
Nov	1991	n/a	7.47		n/a	48.53	
Dec	1991	4.86	6.79	1.40	54.80	72.37	132%
Jan	1992	n/a	16.74		n/a	177.51	
Feb	1992	n/a	9.42		n/a	59.95	
Mar	1992	n/a	4.30		n/a	36.39	
Apr	1992	5.74	7.75	1.35	72.50	117.87	163%
May	1992	2.54	2.17	0.85	7.30	4.95	68%
Jun	1992	2.30	2.40	1.04	26.80	36.72	137%
Jul	1992	2.83	2.18	0.77	40.30	40.60	101%
Aug	1992	2.53	2.04	0.81	45.00	45.33	101%
Sep	1992	1.90	2.19	1.15	43.30	47.20	109%
Oct	1992	n/a	4.09		n/a	28.04	
Nov	1992	5.91	7.71	1.30	71.30	49.87	70%
Dec	1992	5.46	8.13	1.49	57.80	71.90	124%
Jan	1993	6.83	8.88	1.30	91.30	89.09	98%
Feb	1993	3.15	2.68	0.85	6.10	11.76	193%
Mar	1993	8.49	10.04	1.18	149.30	139.20	93%
Apr	1993	6.65	7.95	1.20	33.80	46.57	138%
May	1993	4.89	3.89	0.80	64.00	42.89	67%
Jun	1993	4.45	4.08	0.92	70.00	51.11	73%
Jul	1993	3.08	2.25	0.73	44.30	28.14	64%
Aug	1993	1.98	1.69	0.85	3.50	1.79	51%
Sep	1993	1.82	1.58	0.87	3.00	1.62	54%
Oct	1993	2.80	2.69	0.96	69.80	24.82	36%
Nov	1993	3.39	2.93	0.86	109.50	68.99	63%
Dec	1993	n/a	6.87		n/a	71.49	
Jan	1994	5.15	5.30	1.03	59.00	37.83	64%
Feb	1994	10.50	9.33	0.89	125.30	57.84	46%
Mar	1994	9.40	7.25	0.77	120.00	51.22	43%
Apr	1994	4.93	4.69	0.95	73.00	41.00	56%
May	1994	3.16	2.48	0.78	16.00	13.55	85%
Jun	1994	2.62	2.31	0.88	n/a	37.06	
Jul	1994	1.89	1.87	0.99	5.70	8.93	157%
Average		1990		106%			75%
		1991		88%			109%
		1992		110%			109%
		1993		96%			84%
		1994		90%			75%
		1990-94		99%			89%

AR 039549

Table B-2.
HSPF Calibration Data, Miller Creek below Lake Reba
(Gauge 42B, Node 7)

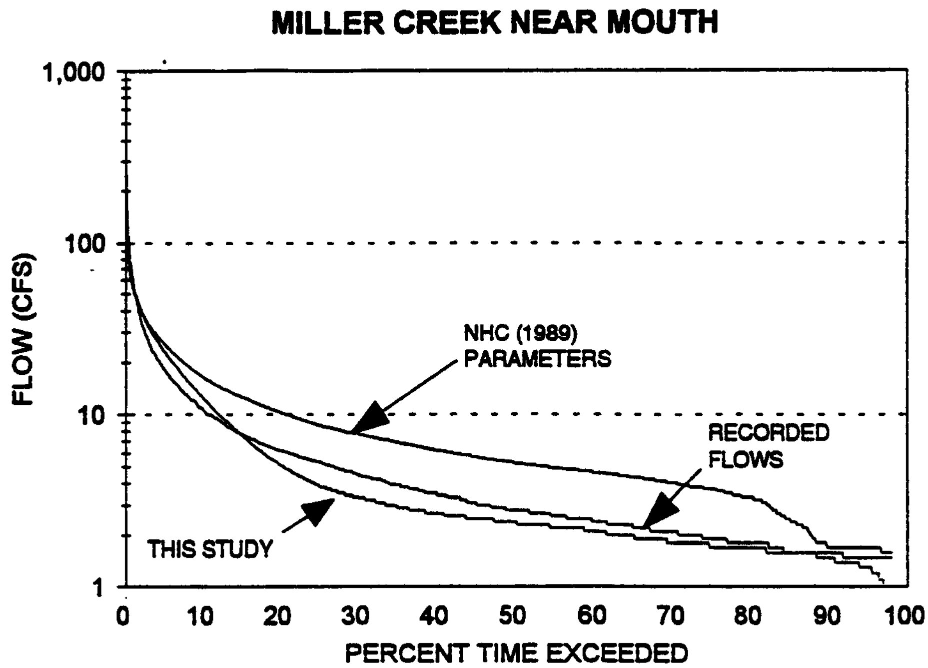
Month		Average Monthly Flow (cfs)			Peak Hourly Flow (cfs)		
		Recorded	Simulated	RPD	Recorded	Simulated	RPD
Nov	1989	3.39	2.01	0.59	31.80	21.94	69%
Dec	1989	4.09	3.41	0.83	43.00	62.00	144%
Jan	1990	n/a	8.12		n/a	268.66	
Feb	1990	n/a	3.92		n/a	32.81	
Mar	1990	3.02	1.59	0.53	16.30	9.40	58%
Apr	1990	1.38	0.82	0.59	8.50	5.58	66%
May	1990	1.01	0.65	0.64	15.80	27.42	174%
Jun	1990	1.59	1.68	1.06	17.00	30.79	181%
Jul	1990	0.57	0.27	0.47	11.00	6.12	56%
Aug	1990	0.57	0.15	0.26	5.60	2.75	49%
Sep	1990	0.35	0.06	0.17	0.60	0.17	28%
Oct	1990	2.06	0.95	0.46	24.00	13.99	58%
Nov	1990	10.93	8.89	0.81	221.80	231.37	104%
Dec	1990	4.28	3.09	0.72	39.30	29.43	75%
Jan	1991	4.70	3.49	0.74	43.80	72.98	167%
Feb	1991	5.73	5.08	0.89	38.80	152.77	394%
Mar	1991	5.52	3.72	0.67	33.80	73.01	216%
Apr	1991	n/a	6.80		n/a	197.16	
May	1991	n/a	0.53		9.10	5.33	59%
Jun	1991	2.76	0.37	0.13	11.00	5.05	46%
Jul	1991	0.65	0.19	0.29	6.10	3.43	56%
Aug	1991	0.88	0.41	0.47	12.00	8.45	70%
Sep	1991	0.52	0.12	0.23	1.40	0.47	34%
Oct	1991	0.87	0.23	0.26	10.50	7.54	72%
Nov	1991	3.74	1.31	0.35	19.00	11.83	62%
Dec	1991	3.00	1.75	0.58	26.00	22.88	88%
Jan	1992	6.10	5.36	0.88	38.00	96.33	254%
Feb	1992	5.65	2.94	0.52	20.00	22.51	113%
Mar	1992	1.79	1.04	0.58	11.00	9.06	82%
Apr	1992	2.09	2.18	1.04	24.00	57.51	240%
May	1992	0.78	0.33	0.42	1.90	1.29	68%
Jun	1992	0.63	0.26	0.41	7.40	6.80	92%
Jul	1992	0.65	0.21	0.32	9.90	7.31	74%
Aug	1992	0.46	0.15	0.33	9.80	8.09	83%
Sep	1992	0.72	0.15	0.21	11.00	8.67	79%
Oct	1992	n/a	0.85		n/a	14.22	
Nov	1992	2.02	1.44	0.71	11.00	11.13	101%
Dec	1992	2.08	2.14	1.03	16.50	22.08	134%
Jan	1993	2.51	2.49	0.99	31.00	33.56	108%
Feb	1993	0.88	0.57	0.65	1.60	2.18	136%
Mar	1993	2.86	2.97	1.04	40.00	55.41	139%
Apr	1993	2.55	2.24	0.88	9.60	15.91	166%
May	1993	1.91	0.76	0.40	10.00	8.29	83%
Jun	1993	1.31	0.78	0.60	12.00	13.05	109%
Jul	1993	0.62	0.27	0.44	7.00	5.07	72%
Aug	1993	0.34	0.12	0.35	0.40	0.17	43%
Sep	1993	0.28	0.06	0.21	0.40	0.09	23%
Oct	1993	0.34	0.23	0.68	9.10	4.22	46%
Nov	1993	n/a	0.29		n/a	15.02	
Dec	1993	n/a	1.22		n/a	13.79	
Jan	1994	1.67	1.16	0.69	11.00	8.06	73%
Feb	1994	3.35	2.51	0.75	15.00	19.87	132%
Mar	1994	2.90	2.06	0.71	13.00	17.53	135%
Apr	1994	1.27	1.14	0.90	10.00	13.03	130%
May	1994	0.54	0.36	0.67	3.40	2.30	68%
Jun	1994	0.53	0.27	0.51	7.80	6.98	89%
Jul	1994	0.22	0.15	0.68	0.60	1.43	238%
Average		1990		57%			85%
		1991		46%			115%
		1992		59%			120%
		1993		62%			92%
		1994		70%			124%
		1990-94		59%			107%

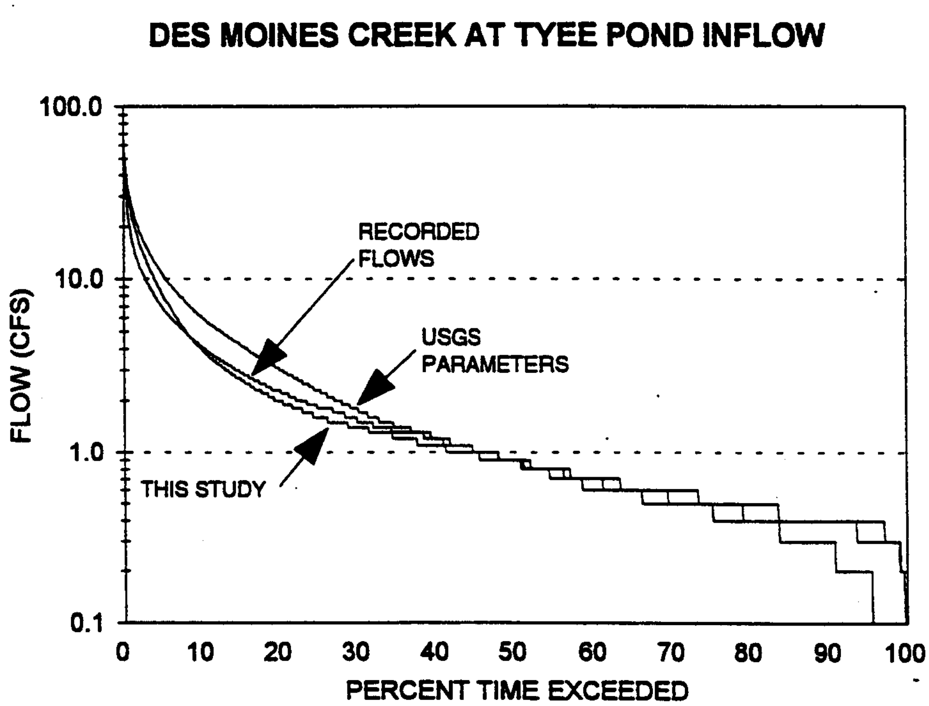
AR 039550

Table B-3.
HSPF Calibration Data, Des Moines Creek at Tyee Pond
(Gauge 11C, Node 51)

Month		Average Monthly Flow (cfs)			Peak Hourly Flow (cfs)		
		Recorded	Simulated	RPD	Recorded	Simulated	RPD
Oct	1989	n/a	1.46		n/a	49.58	
Nov	1989	2.43	3.45	142%	74.50	85.31	115%
Dec	1989	n/a	3.01		n/a	66.43	
Jan	1990	6.05	6.77	112%	151.50	155.67	103%
Feb	1990	n/a	3.82		n/a	31.71	
Mar	1990	n/a	2.11		n/a	23.33	
Apr	1990	0.92	1.57	171%	5.60	25.06	
May	1990	1.00	1.26	126%	68.80	67.07	97%
Jun	1990	1.61	2.05	127%	44.80	48.71	109%
Jul	1990	0.48	0.76	158%	22.50	42.12	187%
Aug	1990	0.55	0.55	100%	16.80	19.37	115%
Sep	1990	0.60	0.40	67%	1.80	0.72	40%
Oct	1990	2.88	2.89	100%	50.00	52.29	105%
Nov	1990	7.52	7.90	105%	142.30	154.76	109%
Dec	1990	n/a	3.58		n/a	40.08	
Jan	1991	n/a	3.78		n/a	59.09	
Feb	1991	4.52	4.85	107%	107.00	81.00	76%
Mar	1991	4.00	4.08	102%	91.30	57.94	63%
Apr	1991	5.67	5.93	105%	132.50	114.43	86%
May	1991	n/a	1.37		n/a	21.72	
Jun	1991	n/a	1.14		n/a	24.31	
Jul	1991	0.61	0.72	118%	28.80	19.66	68%
Aug	1991	1.29	1.43	111%	44.80	35.45	79%
Sep	1991	0.65	0.56	86%	2.20	1.50	68%
Oct	1991	1.23	0.92	75%	31.30	31.04	99%
Nov	1991	4.08	3.29	81%	46.80	32.74	70%
Dec	1991	2.39	2.39	100%	32.80	29.79	91%
Jan	1992	n/a	5.08		n/a	69.79	
Feb	1992	3.07	3.35	109%	23.30	30.30	130%
Mar	1992	1.19	1.75	147%	17.80	33.51	188%
Apr	1992	2.67	2.53	95%	40.80	55.75	137%
May	1992	0.32	0.81	253%	2.60	1.65	63%
Jun	1992	1.02	0.86	84%	24.30	23.62	97%
Jul	1992	1.00	0.79	79%	60.30	32.43	54%
Aug	1992	0.48	0.66	138%	33.50	32.08	96%
Sep	1992	0.57	0.70	123%	31.50	39.49	125%
Oct	1992	1.14	1.15	101%	46.80	30.61	65%
Nov	1992	3.91	3.51	90%	66.00	52.90	80%
Dec	1992	n/a	2.80		n/a	44.57	
Jan	1993	2.87	2.88	100%	24.50	39.96	163%
Feb	1993	0.51	0.90	176%	3.20	8.17	255%
Mar	1993	2.49	3.07	123%	38.50	46.80	122%
Apr	1993	2.34	2.72	116%	27.10	29.59	109%
May	1993	1.33	1.53	115%	25.30	32.96	130%
Jun	1993	1.61	1.68	104%	94.80	45.43	48%
Jul	1993	0.92	0.80	87%	23.00	18.91	82%
Aug	1993	0.36	0.47	131%	n/a	0.57	
Sep	1993	0.33	0.39	118%	2.20	0.42	19%
Oct	1993	1.21	0.95	79%	27.90	20.34	73%
Nov	1993	1.64	1.11	68%	53.50	56.18	105%
Dec	1993	3.39	2.89	85%	25.80	36.13	140%
Jan	1994	2.37	1.87	79%	15.50	27.65	178%
Feb	1994	2.54	3.05	120%	20.80	37.93	182%
Mar	1994	2.13	2.42	114%	23.50	33.26	142%
Apr	1994	1.10	1.63	148%	18.20	22.37	123%
May	1994	0.64	0.85	133%	9.30	9.11	n/a
Jun	1994	1.21	0.76	63%	41.80	29.30	70%
Jul	1994	0.26	0.51	196%	5.10	8.08	n/a
Average		1990		118%			108%
		1991		98%			78%
		1992		122%			104%
		1993		109%			113%
		1994		122%			99%
		1989-94		114%			101%

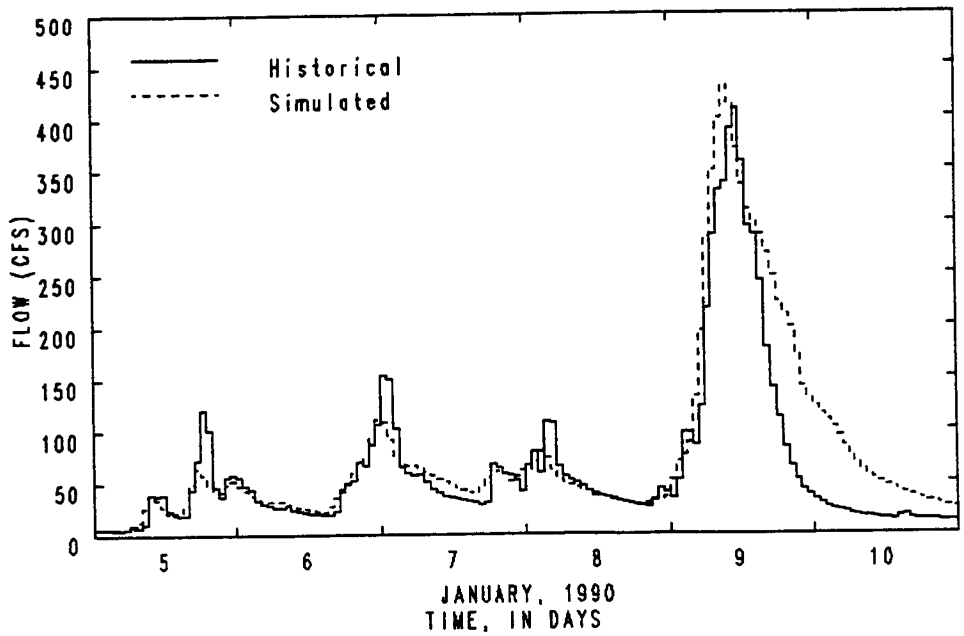
AR 039551



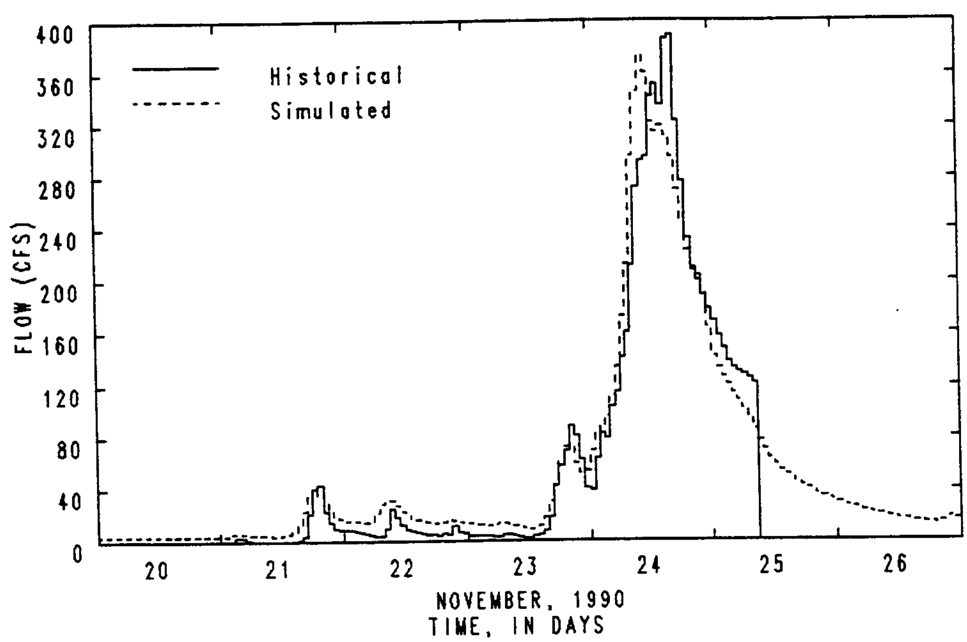


HSPF Calibration Flow Duration Curves

MONTGOMERY WATER GROUP, INC. Water Resources • Environmental • Civil Engineering	SeaTac Airport Master Plan Update EIS Hydrologic Modeling Study	Figure B-1



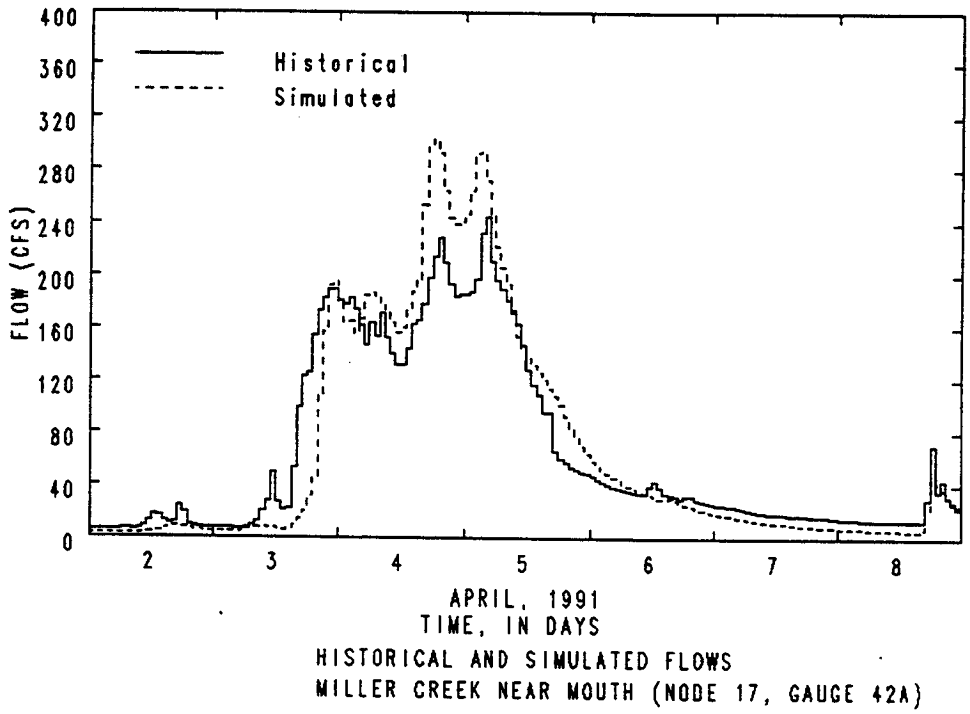
HISTORICAL AND SIMULATED FLOWS
MILLER CREEK NEAR MOUTH (NODE 17, GAUGE 42A)



HISTORICAL AND SIMULATED FLOWS
MILLER CREEK NEAR MOUTH (NODE 17, GAUGE 42A)

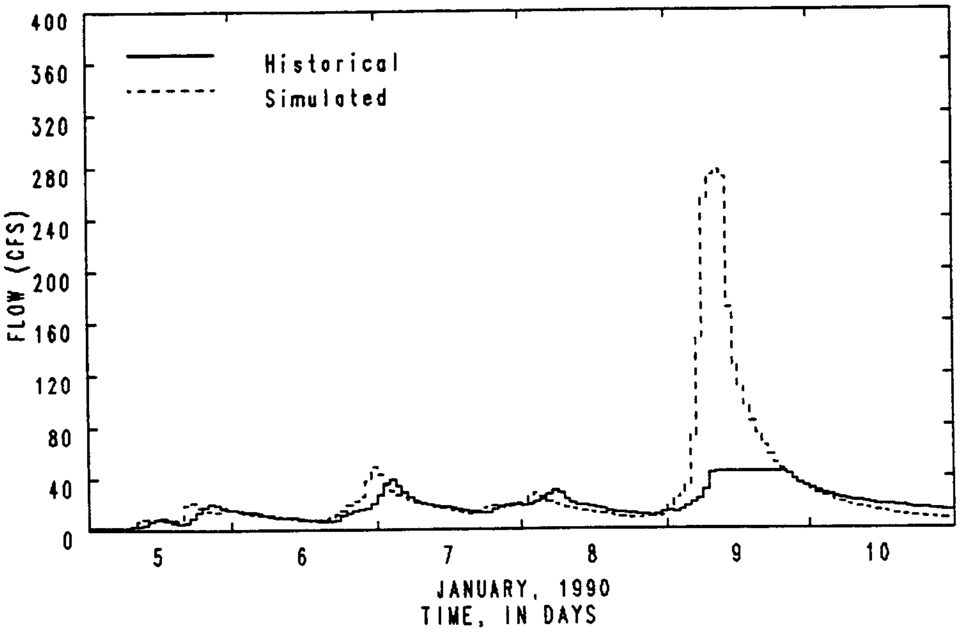
HSPF Calibration Plots, Peak Storm Events - Miller Creek near Mouth

MONTGOMERY WATER GROUP, INC. Water Resources • Environmental • Civil Engineering	SeaTac Airport Master Plan Update EIS Hydrologic Modeling Study	Figure B-2

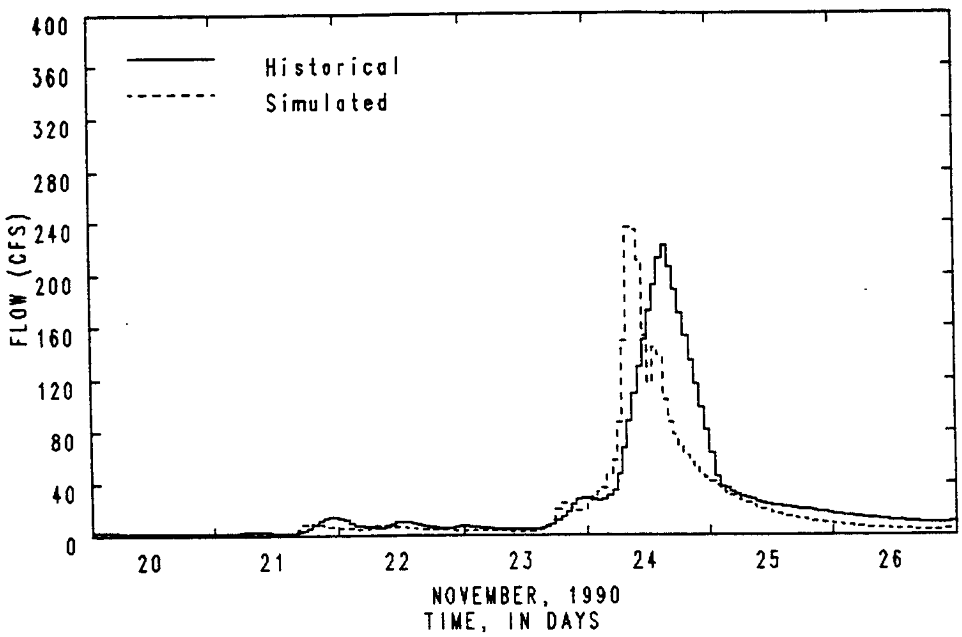


HSPF Calibration Plots, Peak Storm Events - Miller Creek near Mouth

MONTGOMERY WATER GROUP, INC. Water Resources • Environmental • Civil Engineering	SeaTac Airport Master Plan Update EIS Hydrologic Modeling Study	Figure B-2 (cont.)



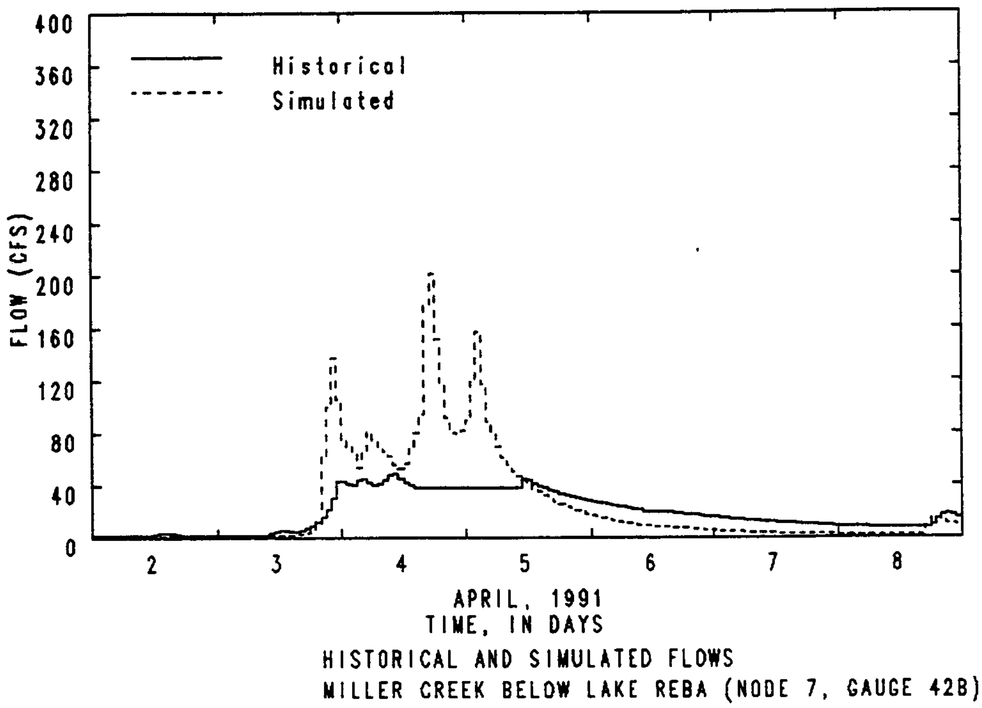
HISTORICAL AND SIMULATED FLOWS
MILLER CREEK BELOW LAKE REBA (NODE 7, GAUGE 42B)



HISTORICAL AND SIMULATED FLOWS
MILLER CREEK BELOW LAKE REBA (NODE 7, GAUGE 42B)

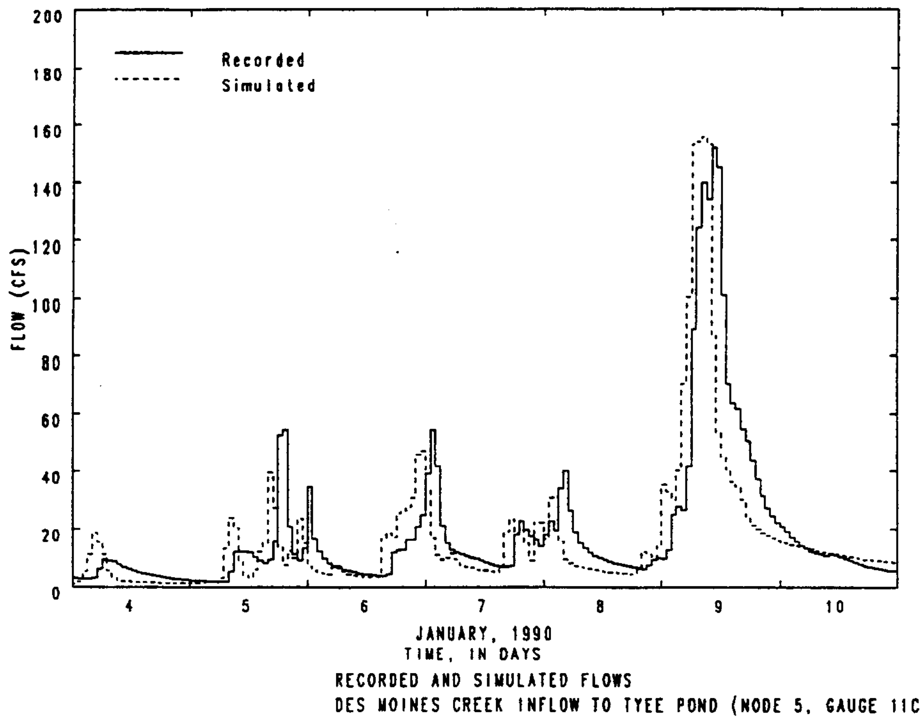
HSPF Calibration Plots, Peak Storm Events - Miller Creek below Lake Reba

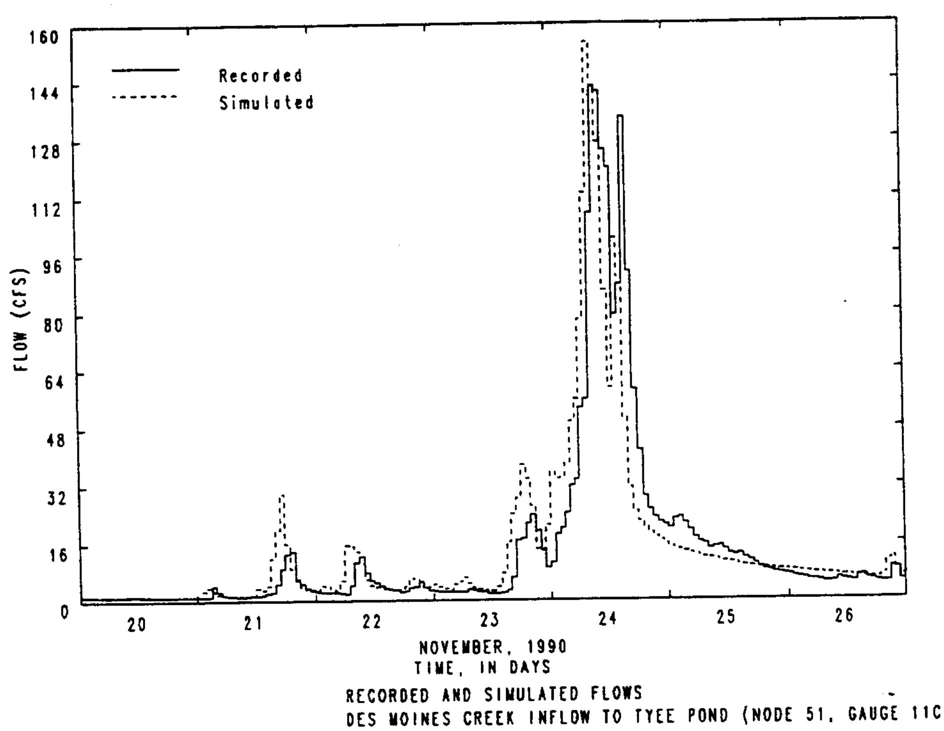
MONTGOMERY WATER GROUP, INC. Water Resources • Environmental • Civil Engineering	SeaTac Airport Master Plan Update EIS Hydrologic Modeling Study	Figure B-3



HSPF Calibration Plots, Peak Storm Events - Miller Creek below Lake Reba

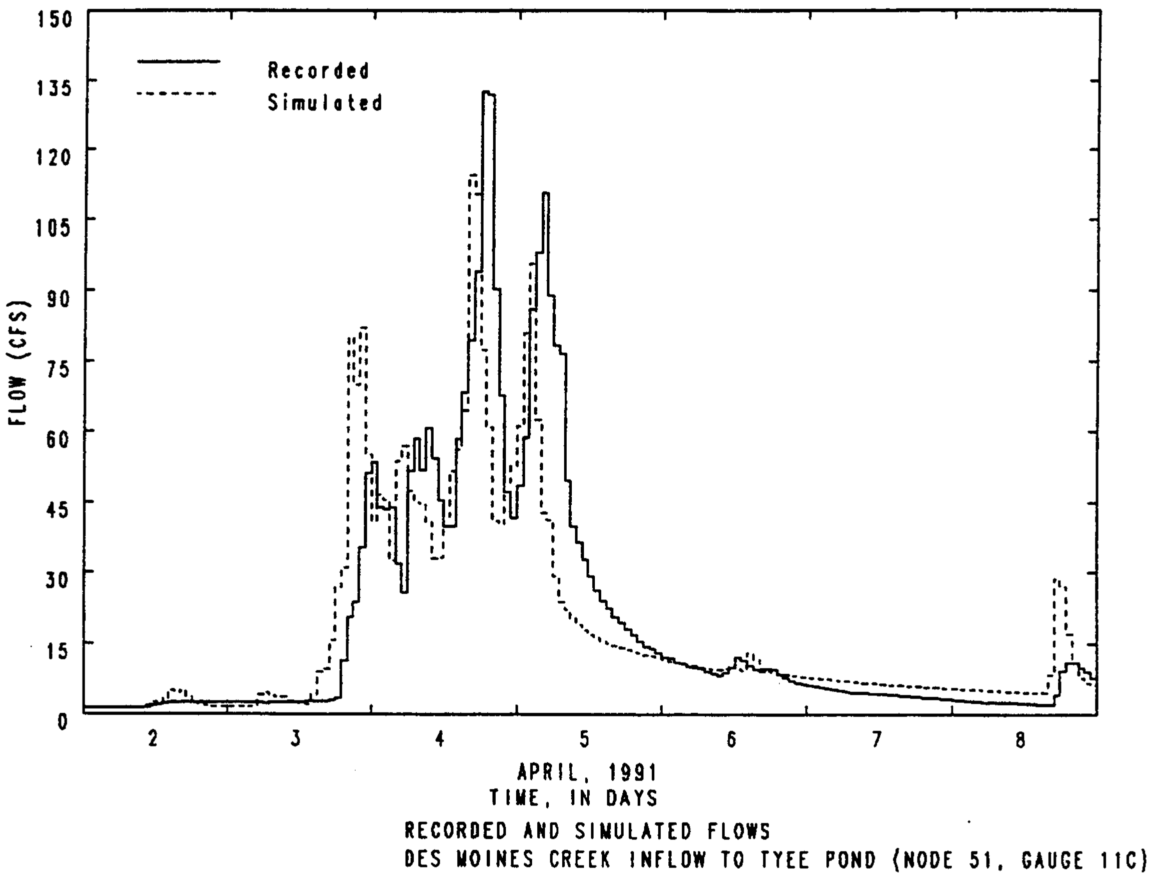
MONTGOMERY WATER GROUP, INC. Water Resources • Environmental • Civil Engineering	SeaTac Airport Master Plan Update EIS Hydrologic Modeling Study	Figure B-3 (cont.)





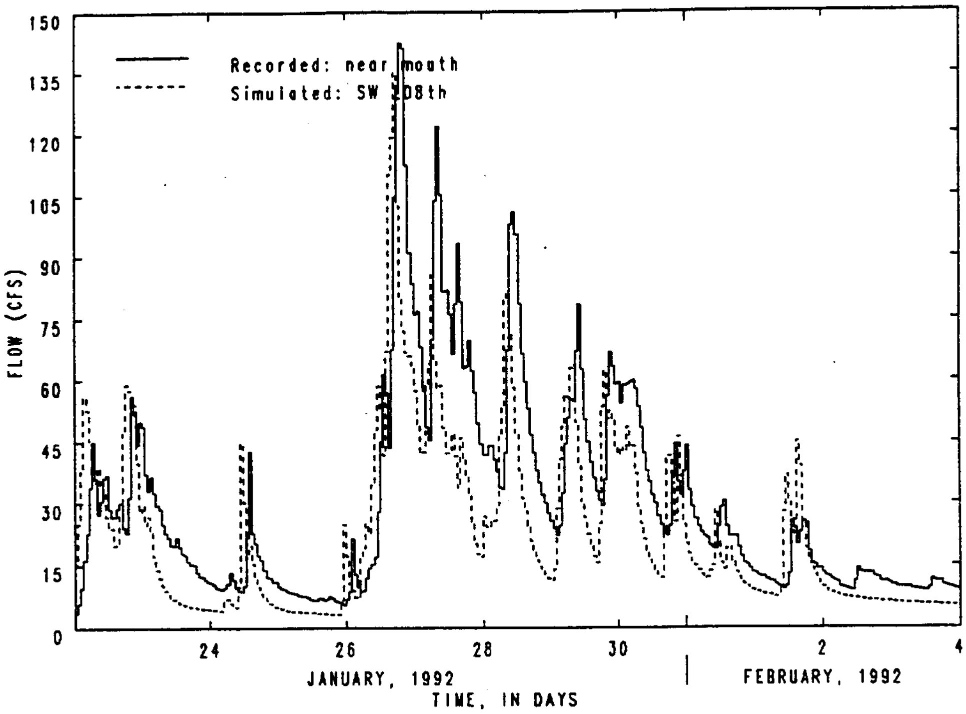
HSPF Calibration Plots, Peak Storm Events - Des Moines Creek Inflow to Tyee Pond

MONTGOMERY WATER GROUP, INC. Water Resources • Environmental • Civil Engineering	SeaTac Airport Master Plan Update EIS Hydrologic Modeling Study	Figure B-4

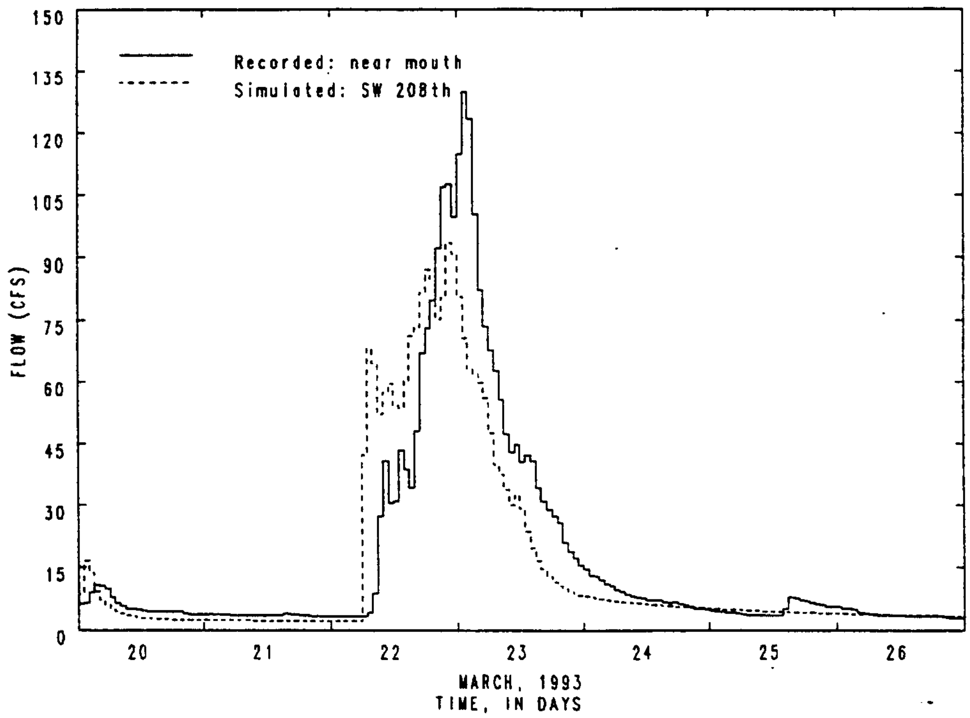


HSPF Calibration Plots, Peak Storm Events - Des Moines Creek Inflow to Tyee Pond

MONTGOMERY WATER GROUP, INC. Water Resources • Environmental • Civil Engineering	SeaTac Airport Master Plan Update EIS Hydrologic Modeling Study	Figure B-4 (cont.)



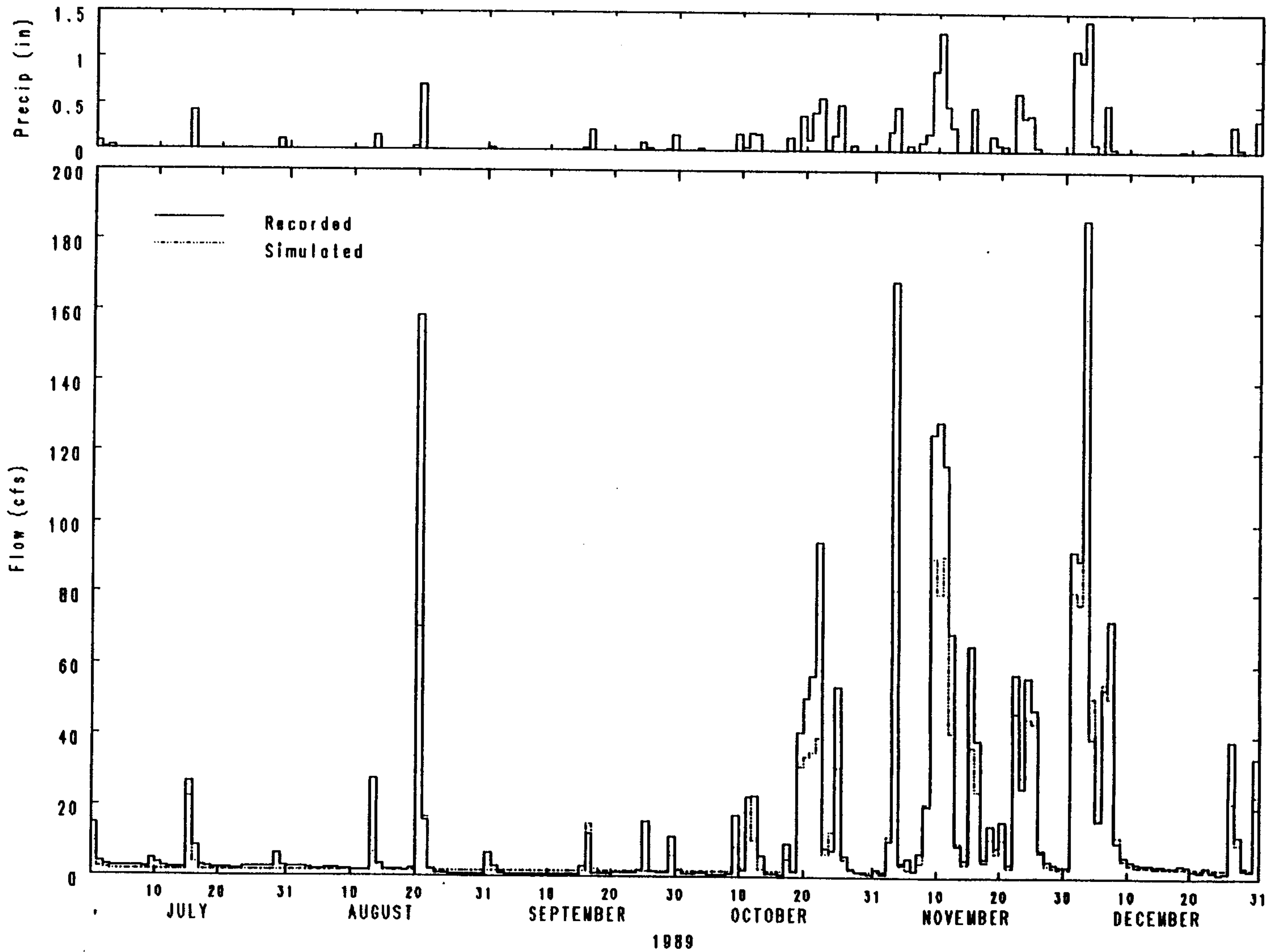
RECORDED AND SIMULATED FLOWS
LOWER DES MOINES CREEK



RECORDED AND SIMULATED FLOWS
LOWER DES MOINES CREEK

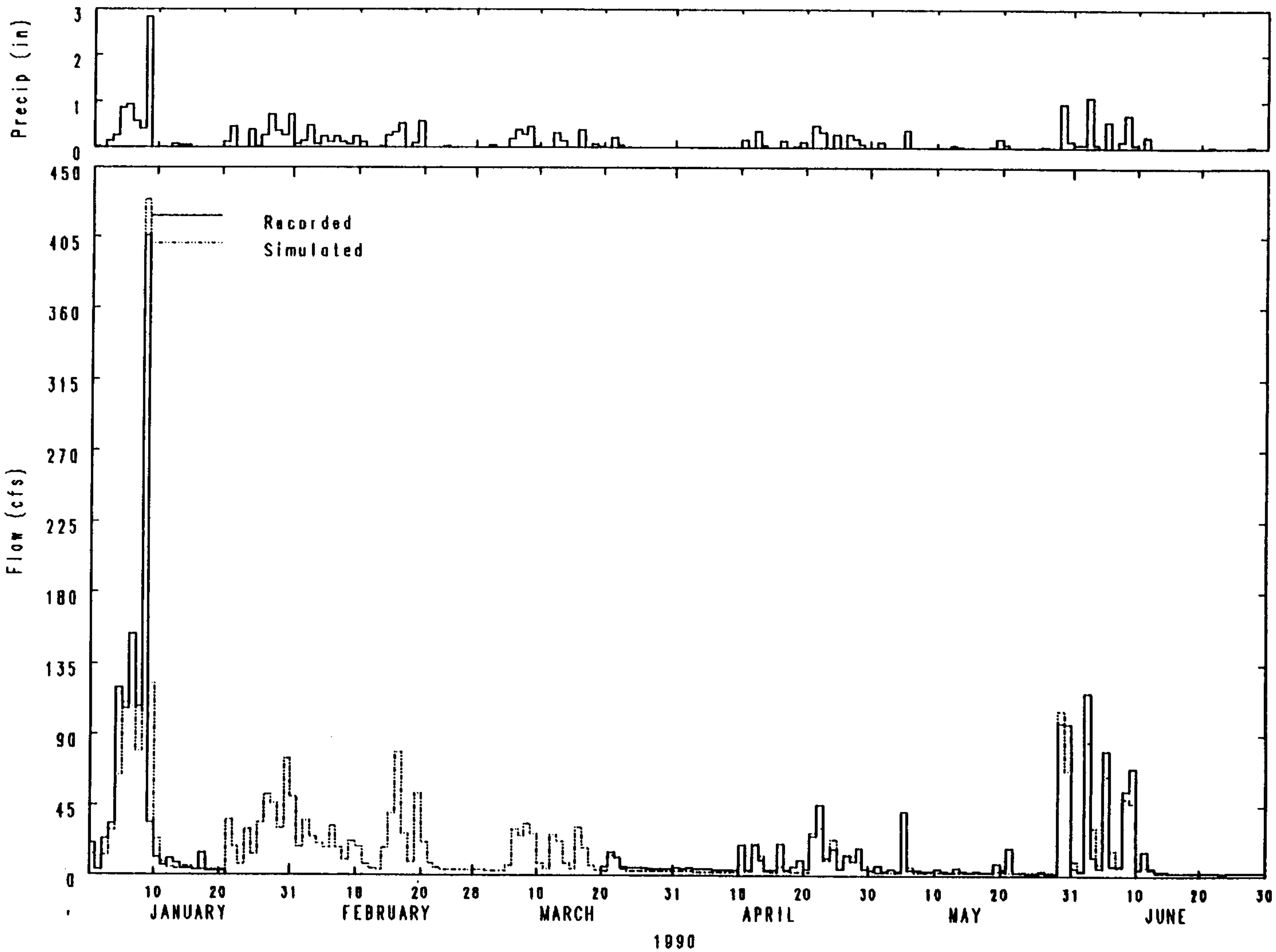
HSPF Calibration Plots, Peak Storm Events - Lower Des Moines Creek

MONTGOMERY WATER GROUP, INC. Water Resources • Environmental • Civil Engineering	SeaTac Airport Master Plan Update EIS Hydrologic Modeling Study	Figure B-5



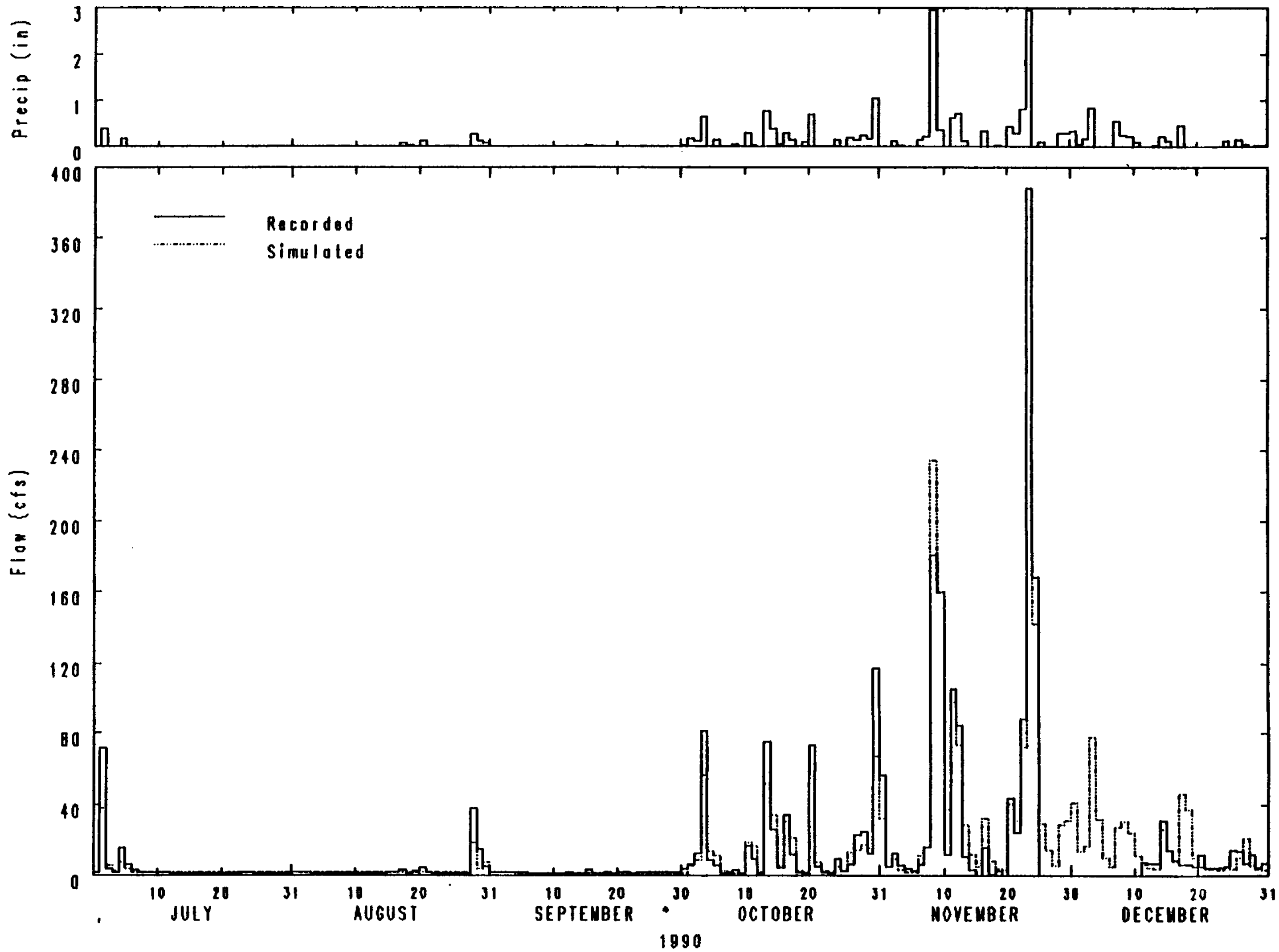
HSPF Calibration Plots, Daily Peak Hourly Flows - Miller Creek near Mouth

MONTGOMERY WATER GROUP, INC. Water Resources • Environmental • Civil Engineering	SeaTac Airport Master Plan Update EIS Hydrologic Modeling Study	Figure B-6



HSPF Calibration Plots, Daily Peak Hourly Flows - Miller Creek near Mouth

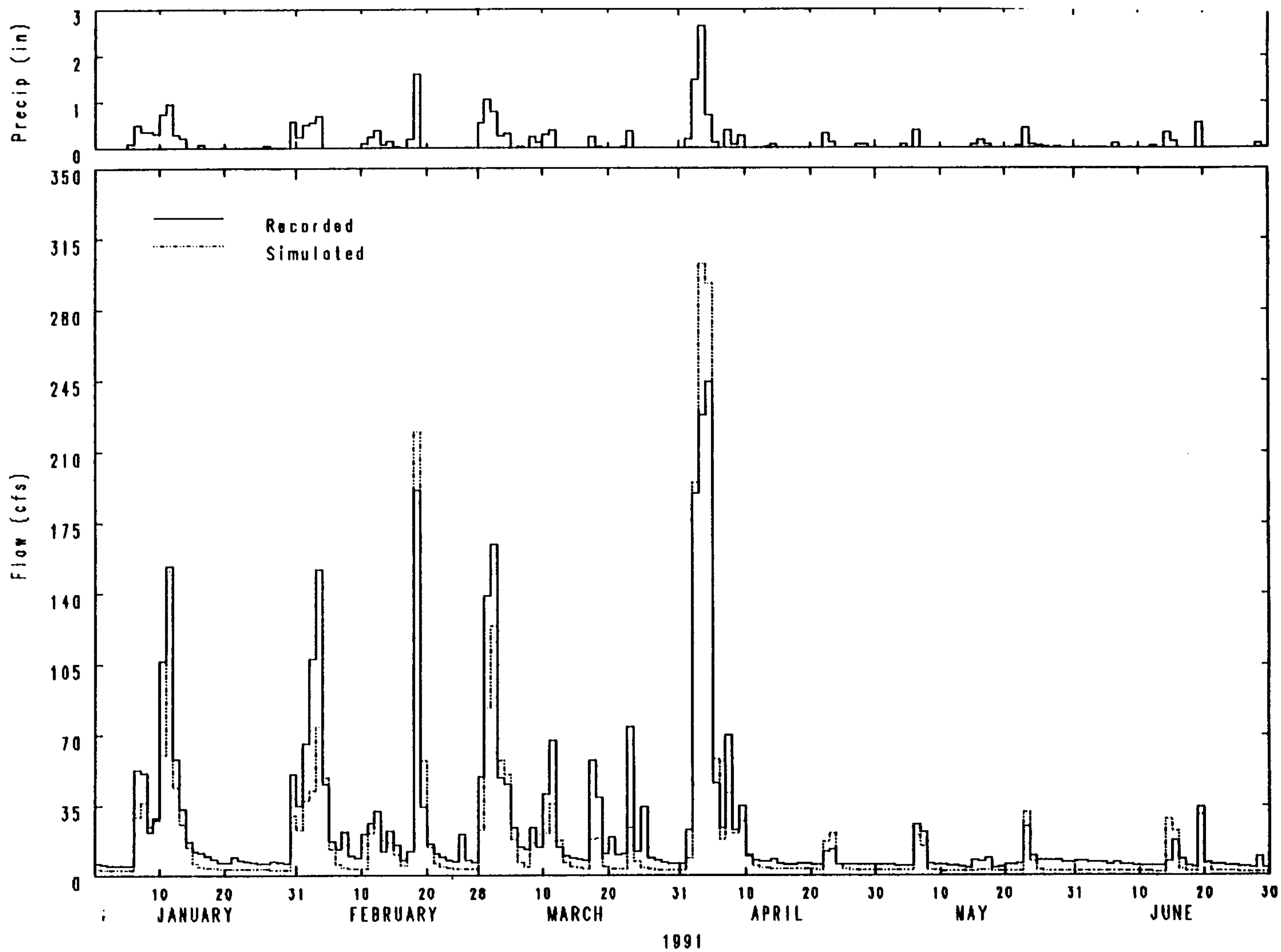
MONTGOMERY WATER GROUP, INC. Water Resources • Environmental • Civil Engineering	SeaTac Airport Master Plan Update EIS Hydrologic Modeling Study	Figure B-6 (cont.)



HSPF Calibration Plots, Daily Peak Hourly Flows - Miller Creek near Mouth

MONTGOMERY WATER GROUP, INC. Water Resources • Environmental • Civil Engineering	SeaTac Airport Master Plan Update EIS Hydrologic Modeling Study	Figure B-6 (cont.)

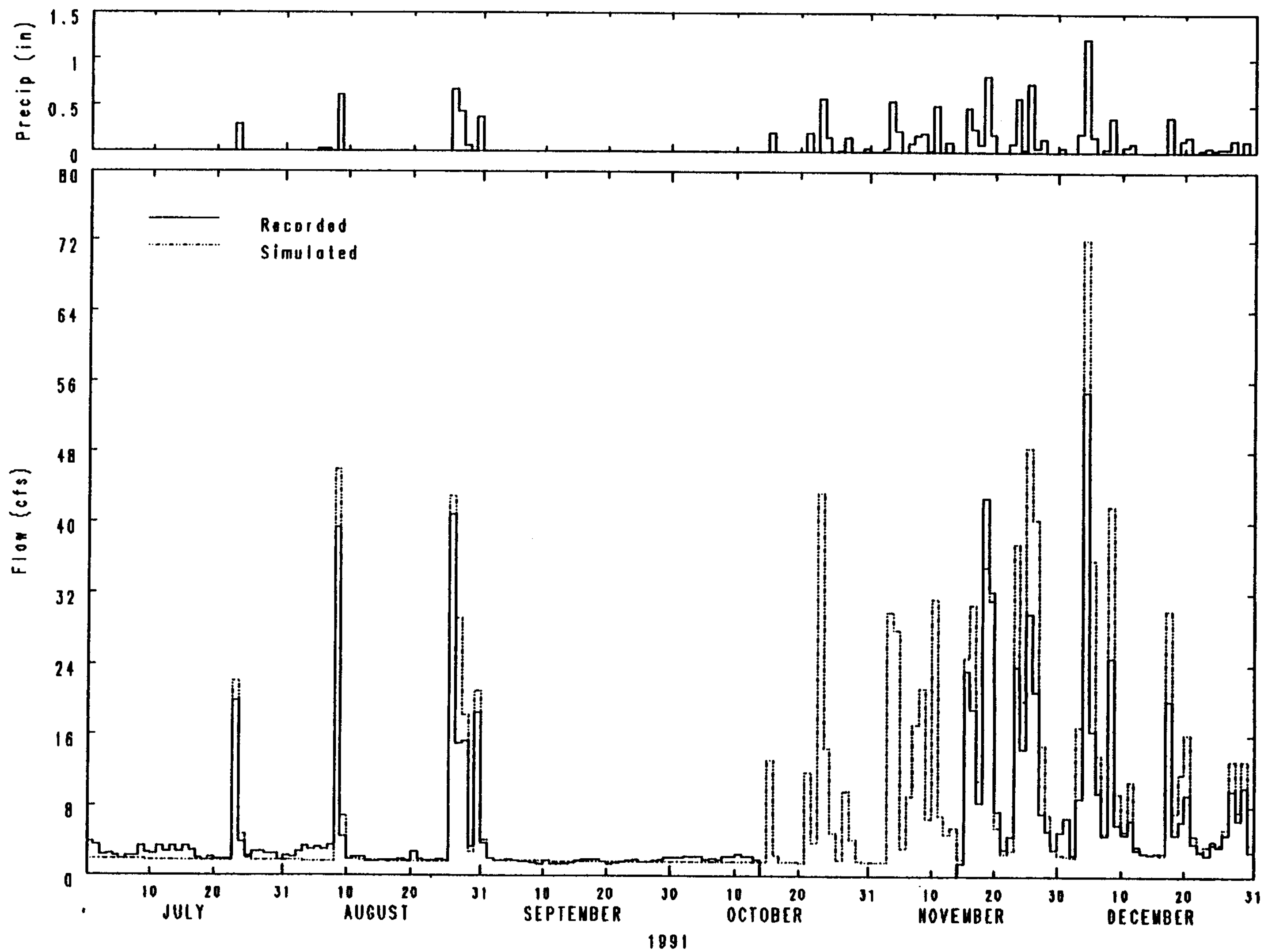
AR 039562



HSPF Calibration Plots, Daily Peak Hourly Flows - Miller Creek near Mouth

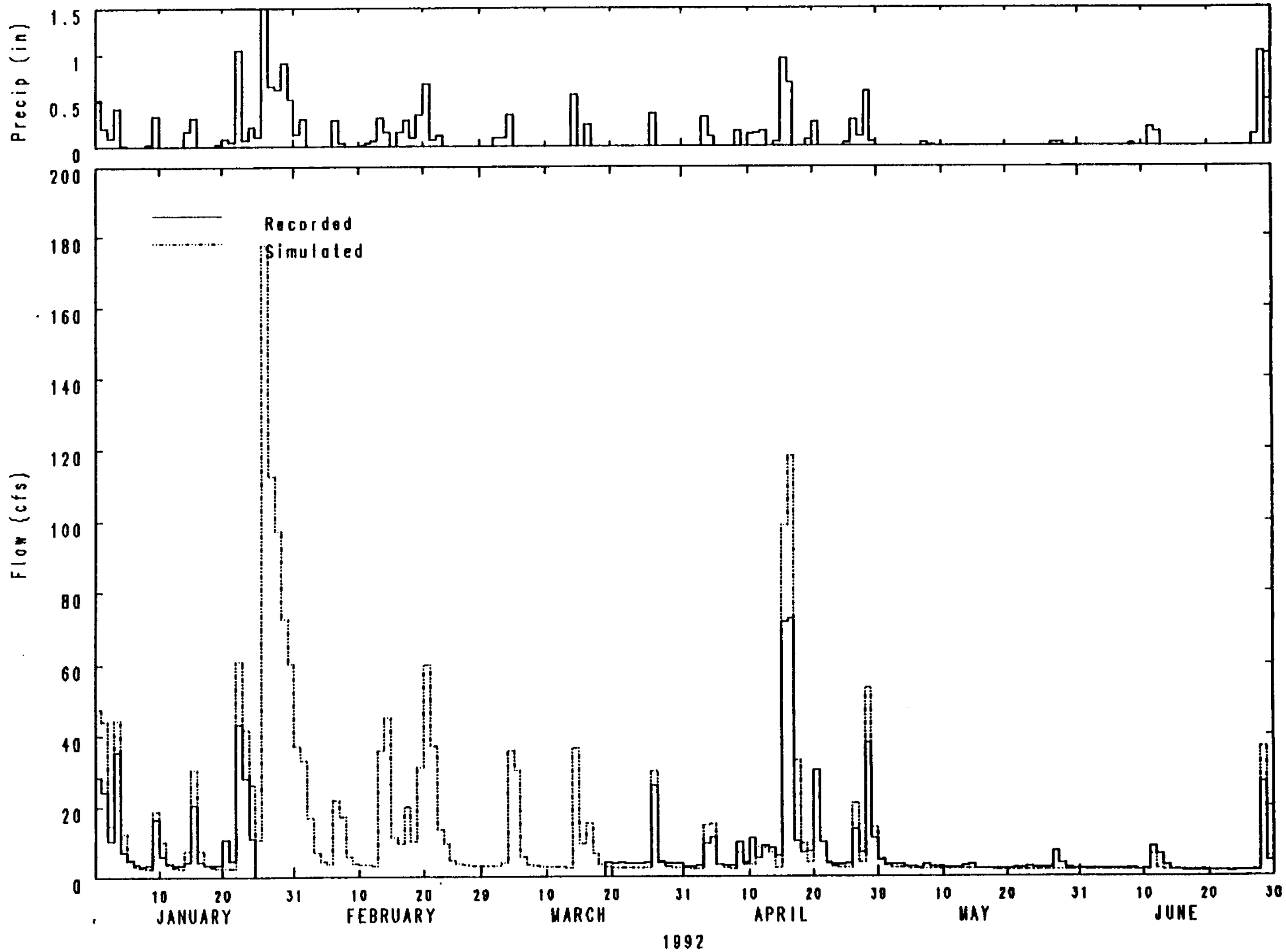
MONTGOMERY WATER GROUP, INC. Water Resources • Environmental • Civil Engineering	SeaTac Airport Master Plan Update EIS Hydrologic Modeling Study	Figure B-6 (cont.)

AR 039563



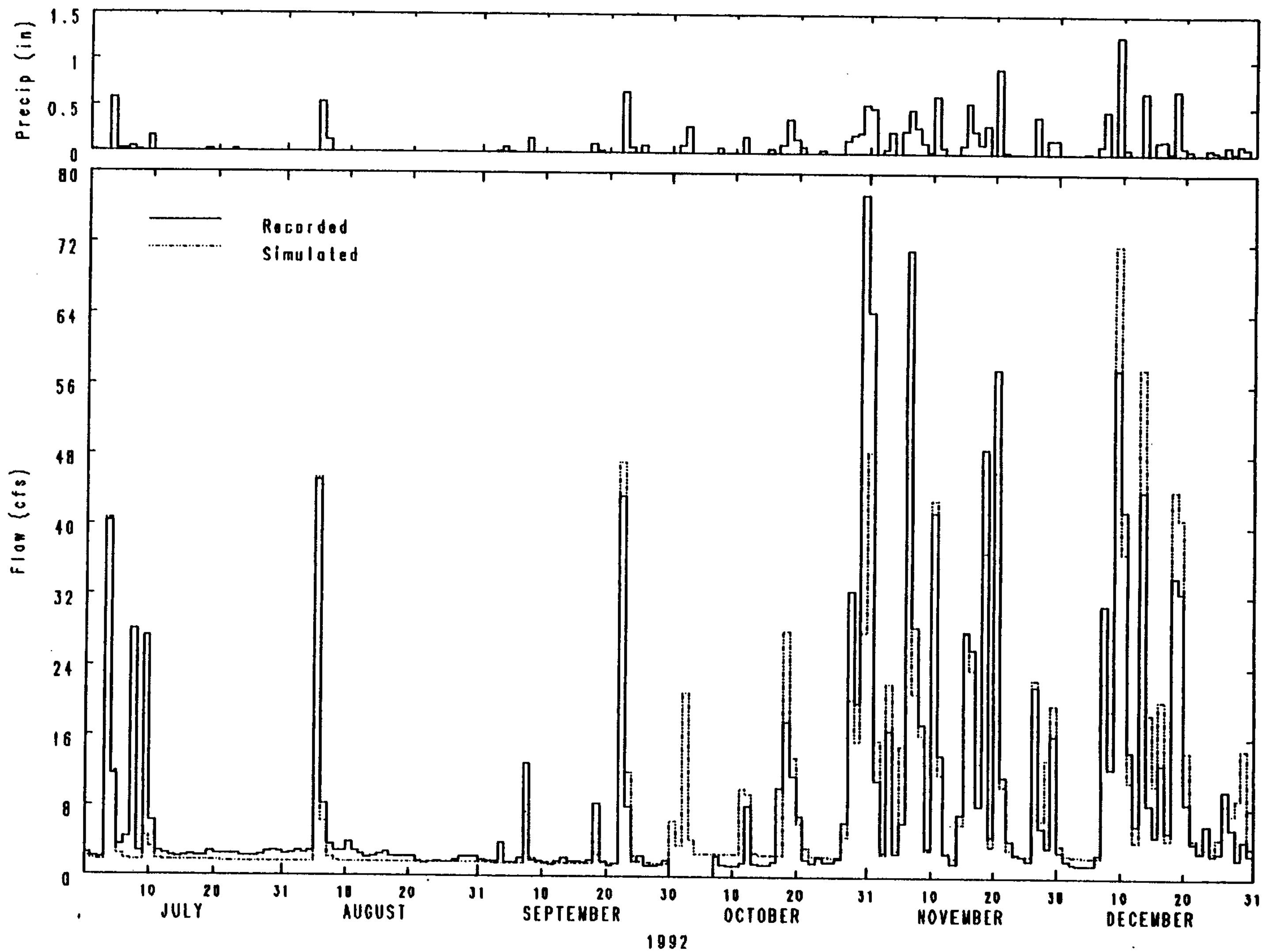
HSPF Calibration Plots, Daily Peak Hourly Flows - Miller Creek near Mouth

MONTGOMERY WATER GROUP, INC. Water Resources • Environmental • Civil Engineering	SeaTac Airport Master Plan Update EIS Hydrologic Modeling Study	Figure B-6 (cont.)



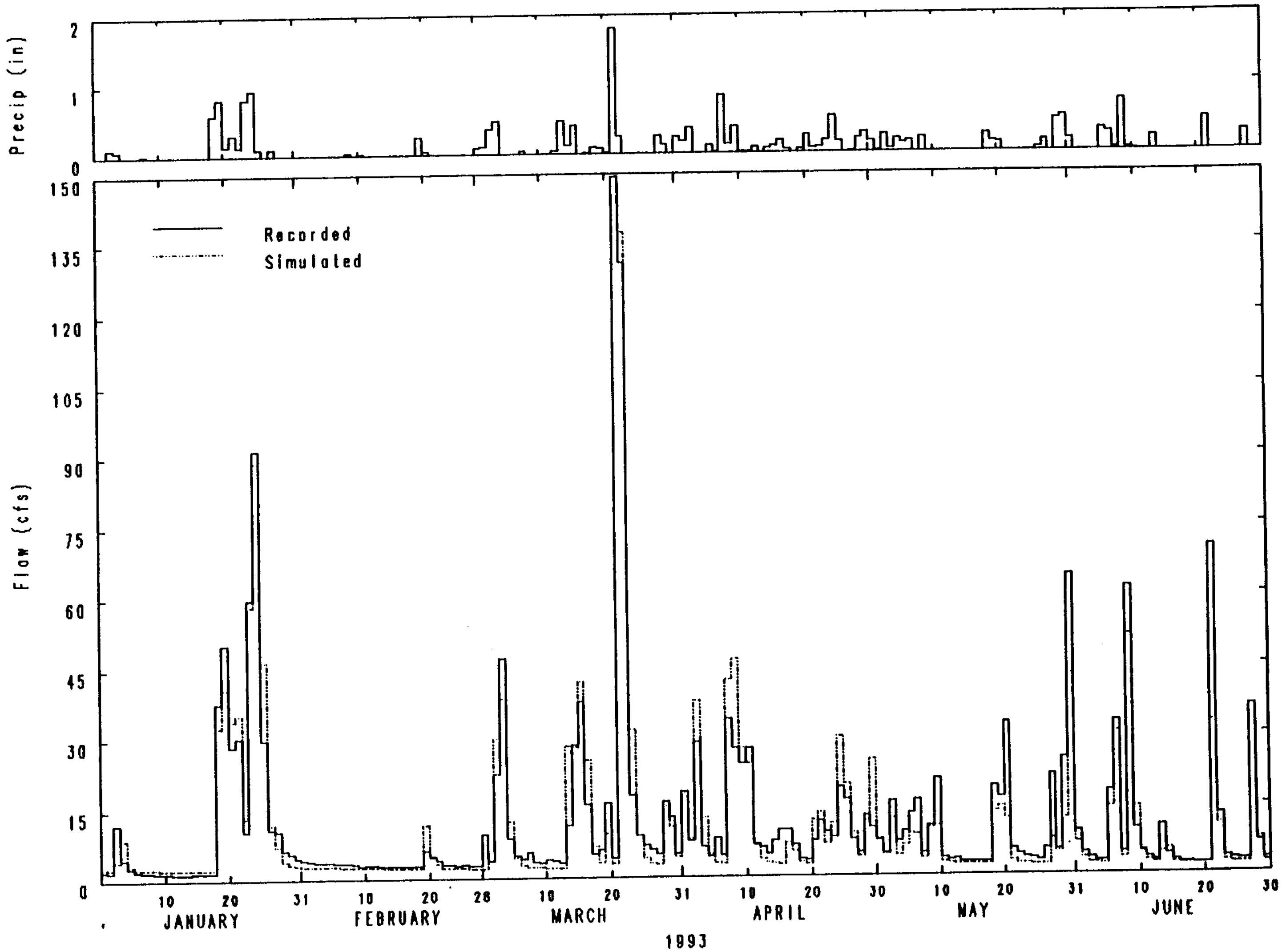
HSPF Calibration Plots, Daily Peak Hourly Flows - Miller Creek near Mouth

MONTGOMERY WATER GROUP, INC. Water Resources • Environmental • Civil Engineering	SeaTac Airport Master Plan Update EIS Hydrologic Modeling Study	Figure B-6 (cont.)



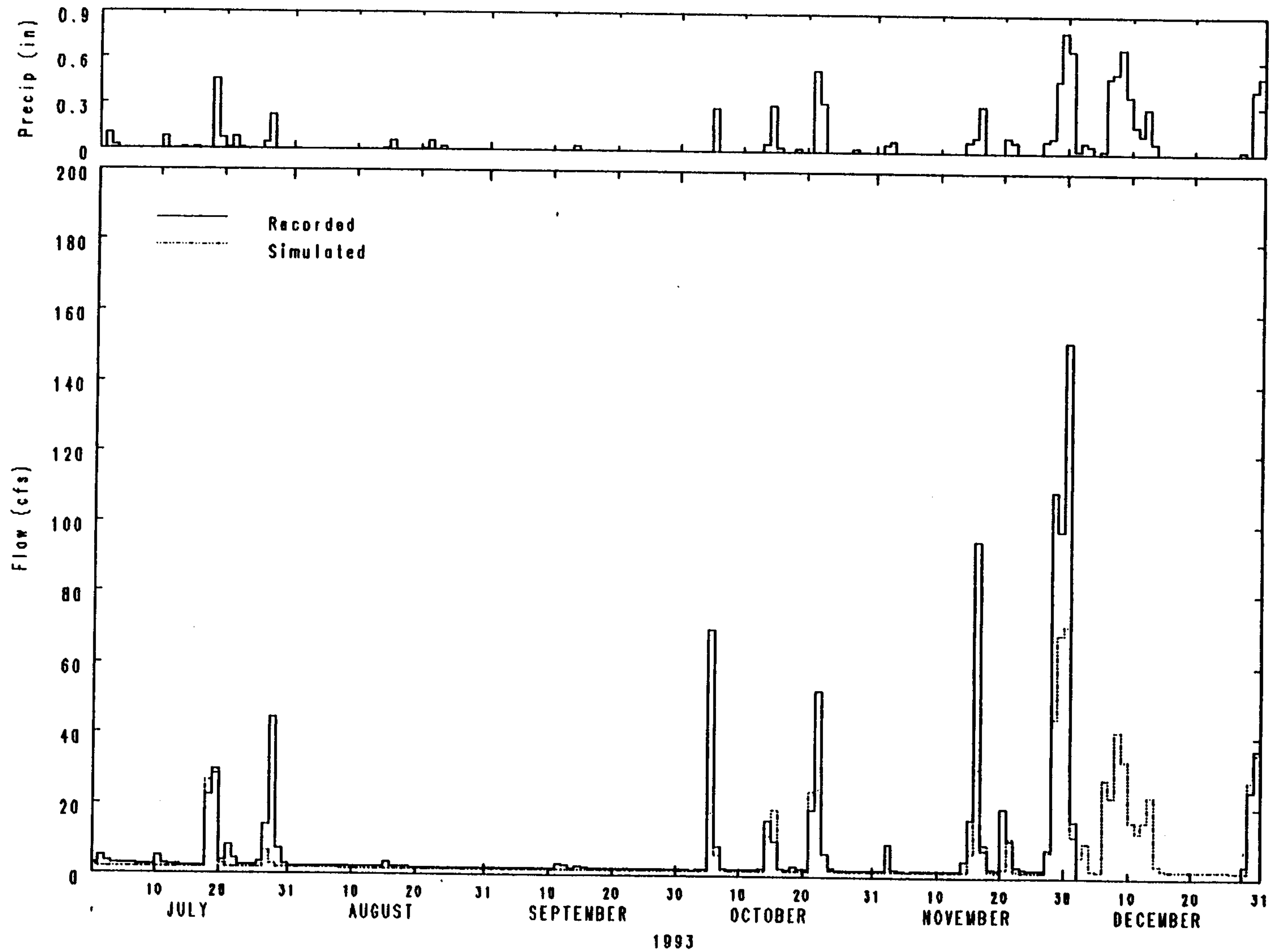
HSPF Calibration Plots, Daily Peak Hourly Flows - Miller Creek near Mouth

MONTGOMERY WATER GROUP, INC. Water Resources • Environmental • Civil Engineering	SeaTac Airport Master Plan Update EIS Hydrologic Modeling Study	Figure B-6 (cont.)



HSPF Calibration Plots, Daily Peak Hourly Flows - Miller Creek near Mouth

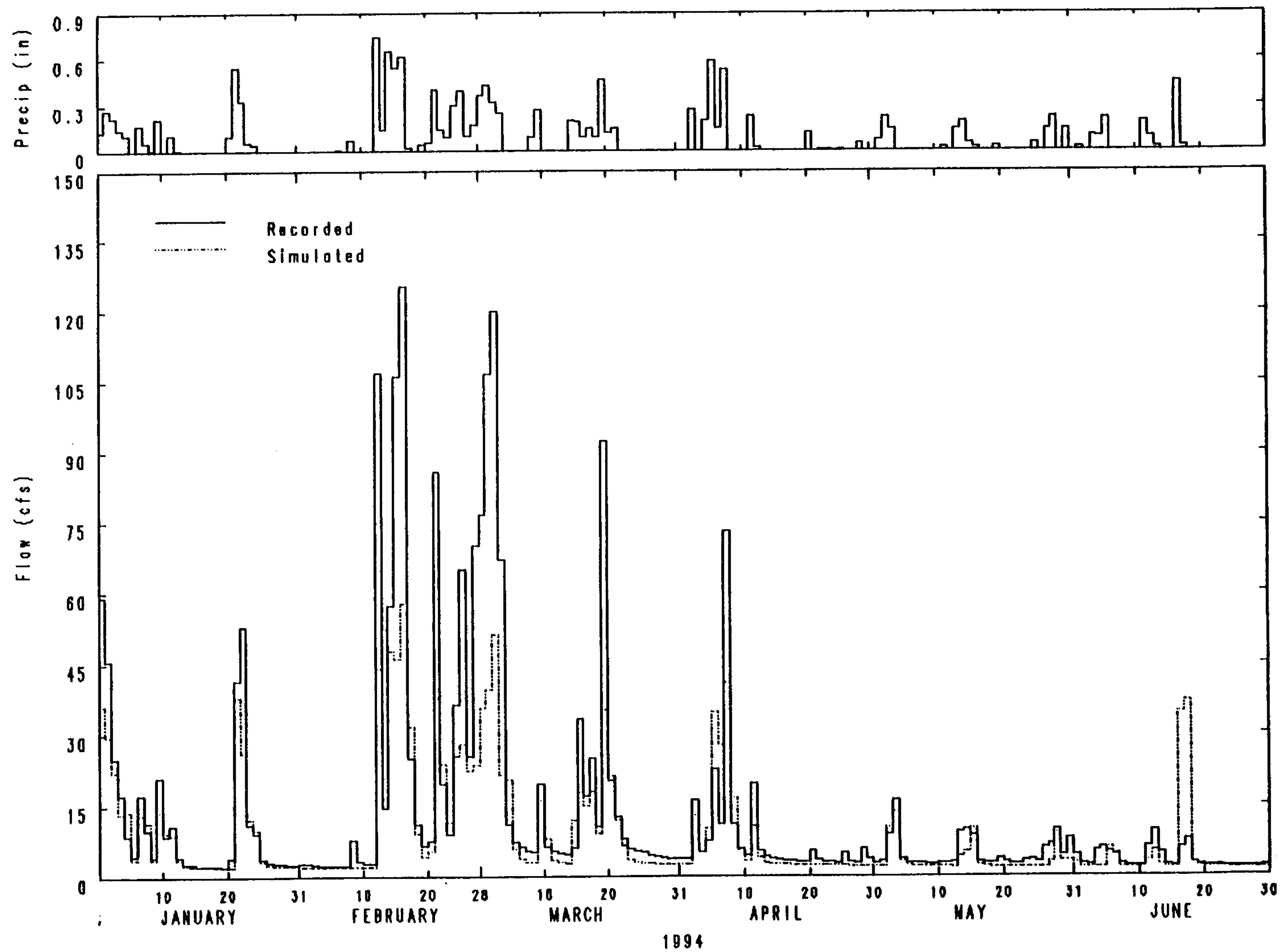
MONTGOMERY WATER GROUP, INC. Water Resources • Environmental • Civil Engineering	SeaTac Airport Master Plan Update EIS Hydrologic Modeling Study	Figure B-6 (cont.)



HSPF Calibration Plots, Daily Peak Hourly Flows - Miller Creek near Mouth

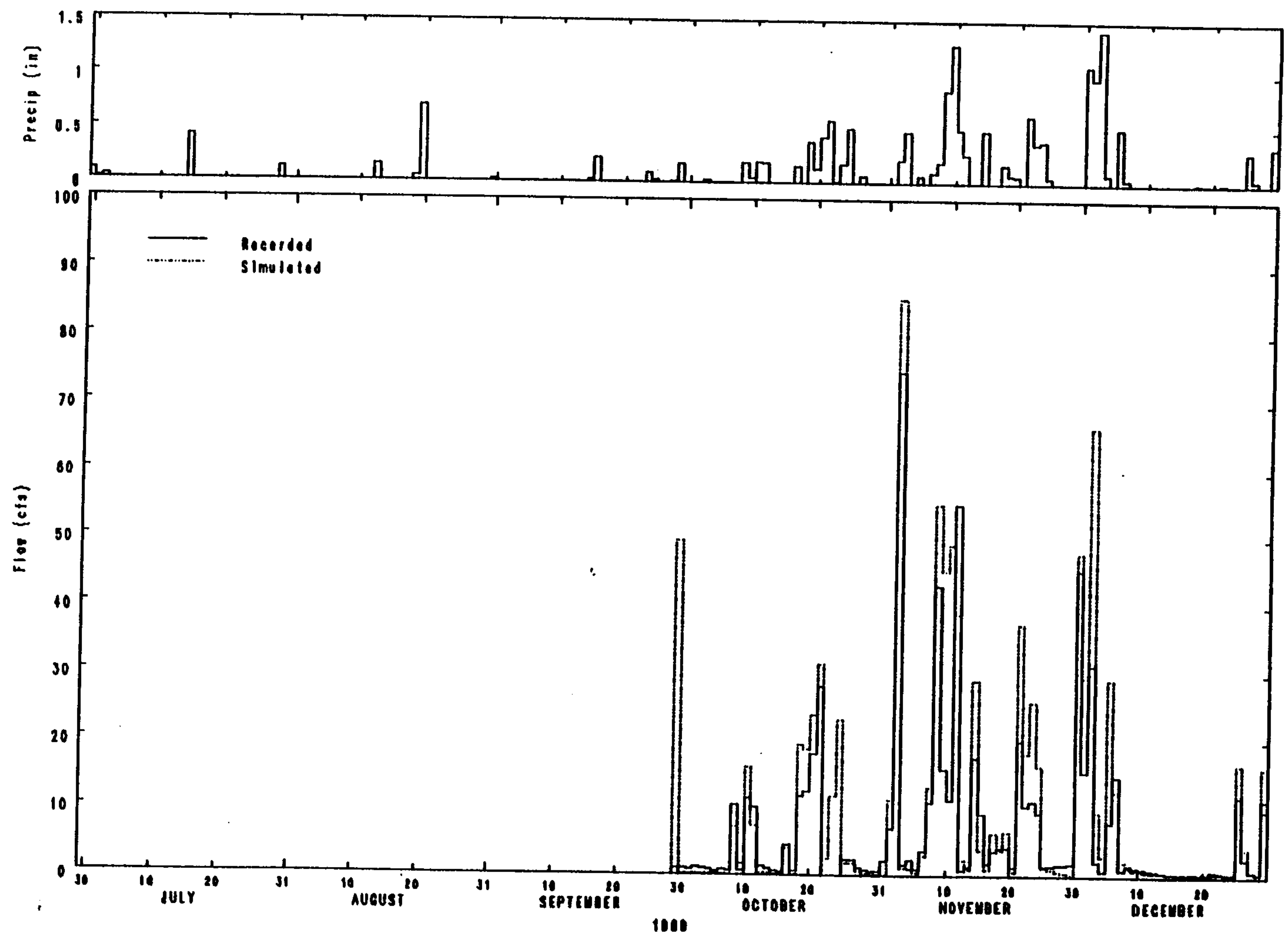
MONTGOMERY WATER GROUP, INC. Water Resources • Environmental • Civil Engineering	SeaTac Airport Master Plan Update EIS Hydrologic Modeling Study	Figure B-6 (cont.)

AR 039568



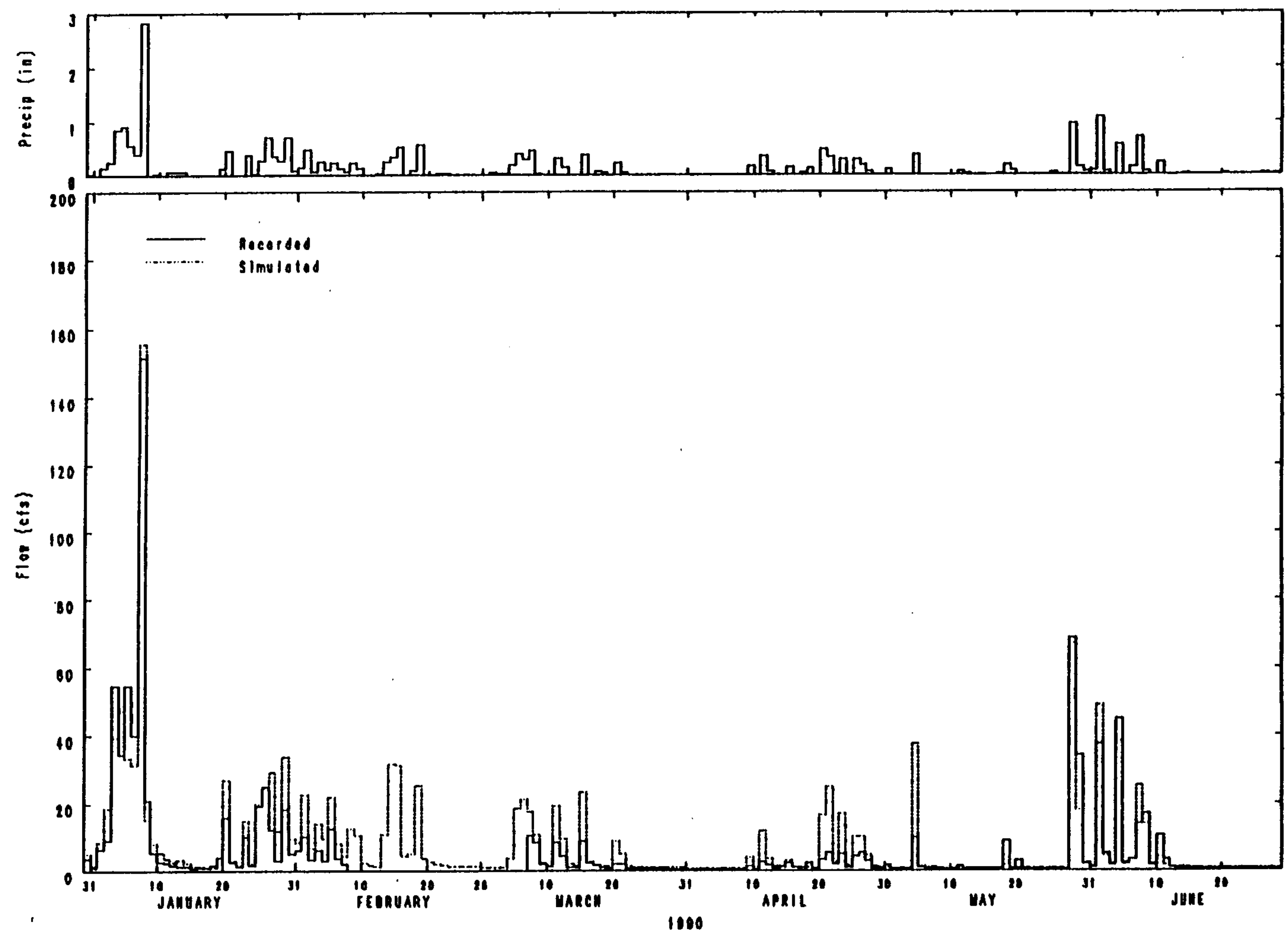
HSPF Calibration Plots, Daily Peak Hourly Flows - Miller Creek near Mouth

MONTGOMERY WATER GROUP, INC. Water Resources • Environmental • Civil Engineering	SeaTac Airport Master Plan Update EIS Hydrologic Modeling Study	Figure B-6 (cont.)



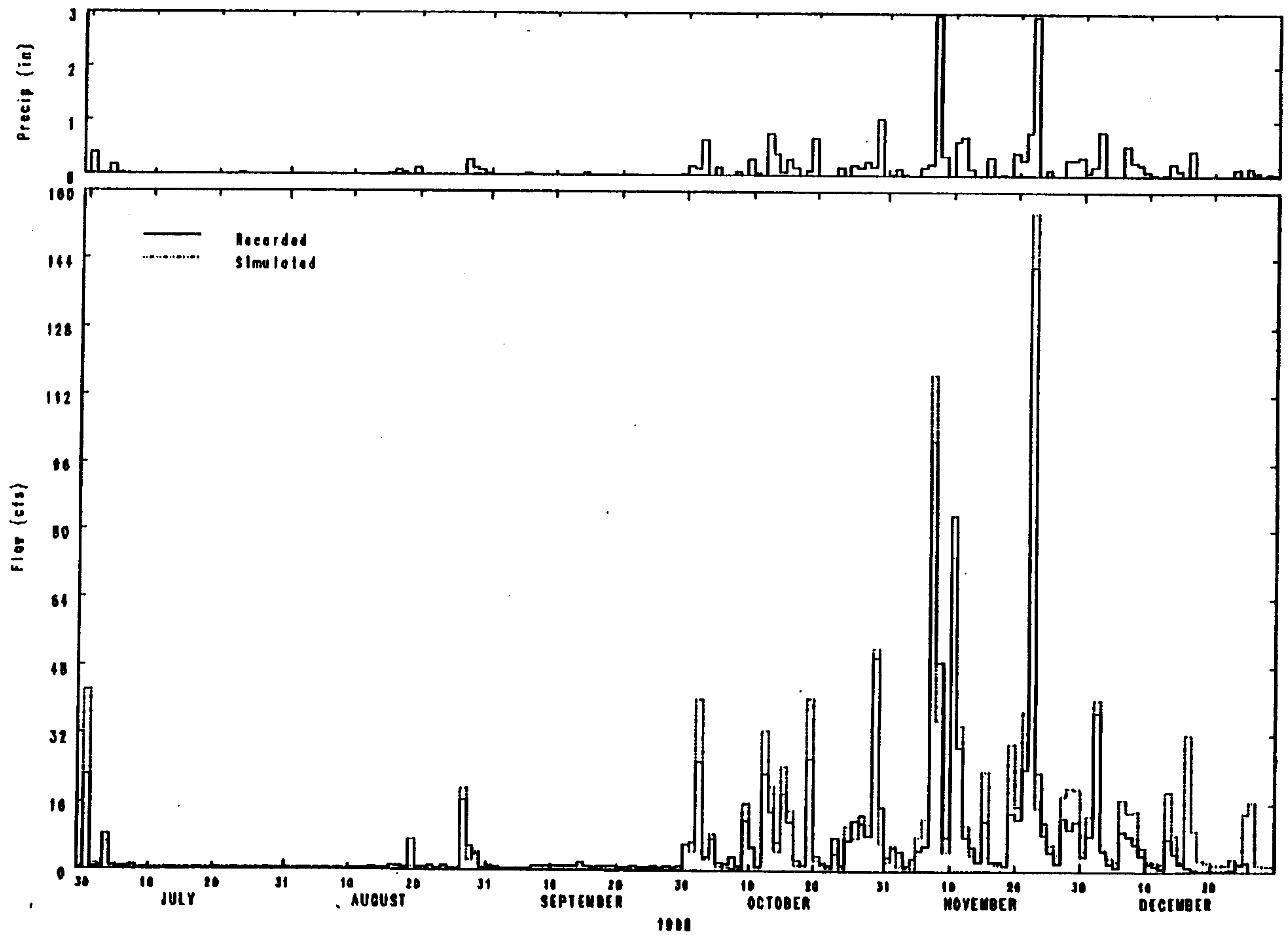
HSPF Calibration Plots, Daily Peak Hourly Flows - Des Moines Creek Inflow to Tyee Pond

MONTGOMERY WATER GROUP, INC. Water Resources • Environmental • Civil Engineering	SeaTac Airport Master Plan Update EIS Hydrologic Modeling Study	Figure B-7



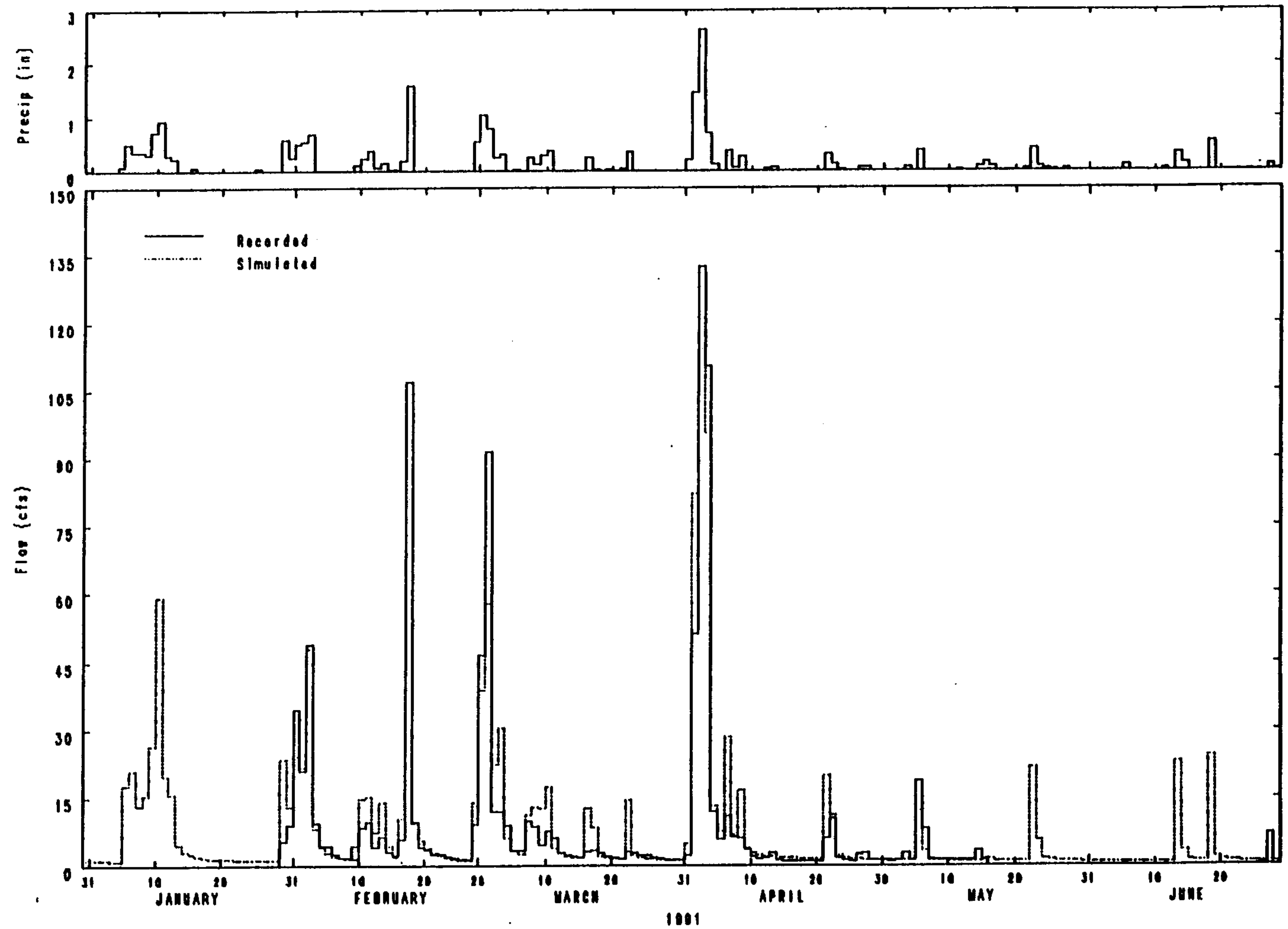
HSPF Calibration Plots, Daily Peak Hourly Flows - Des Moines Creek Inflow to Tyee Pond

MONTGOMERY WATER GROUP, INC. Water Resources • Environmental • Civil Engineering	SeaTac Airport Master Plan Update EIS Hydrologic Modeling Study	Figure B-7 (cont.)



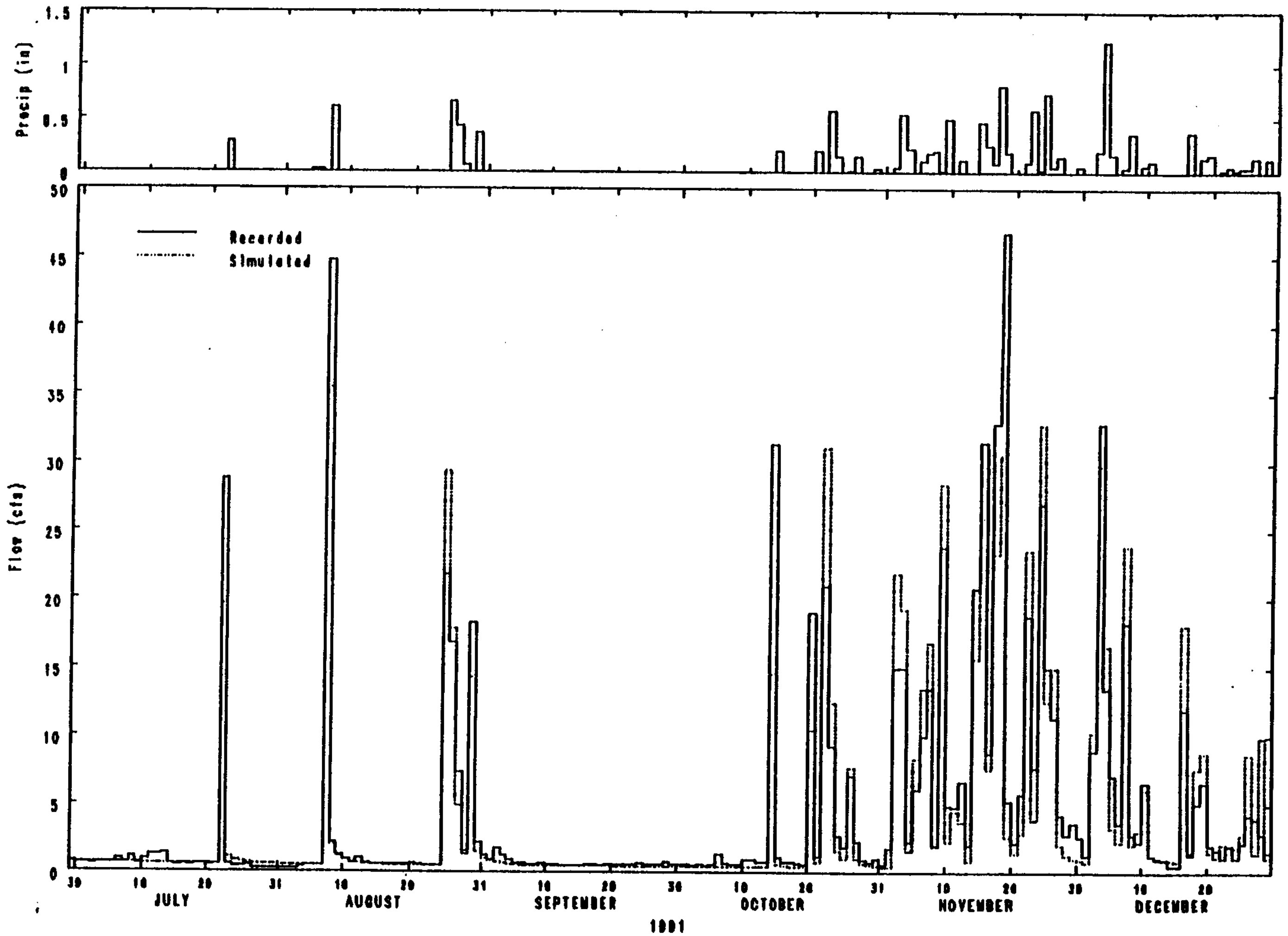
HSPF Calibration Plots, Daily Peak Hourly Flows - Des Moines Creek Inflow to Tyee Pond

MONTGOMERY WATER GROUP, INC. Water Resources • Environmental • Civil Engineering	SeaTac Airport Master Plan Update EIS Hydrologic Modeling Study	Figure B-7 (cont.)



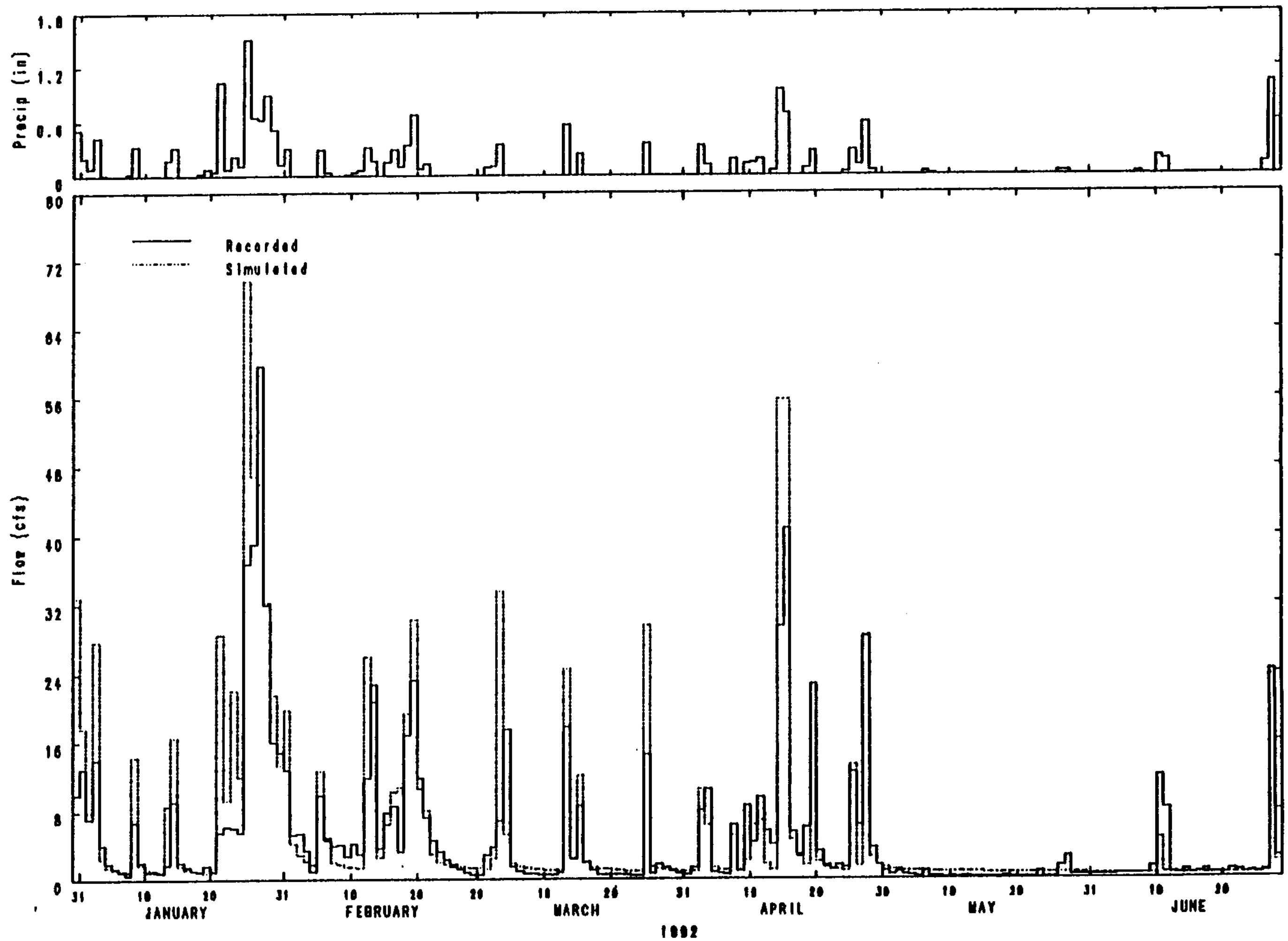
HSPF Calibration Plots, Daily Peak Hourly Flows - Des Moines Creek Inflow to Tyee Pond

MONTGOMERY WATER GROUP, INC. Water Resources • Environmental • Civil Engineering	SeaTac Airport Master Plan Update EIS Hydrologic Modeling Study	Figure B-7 (cont.)



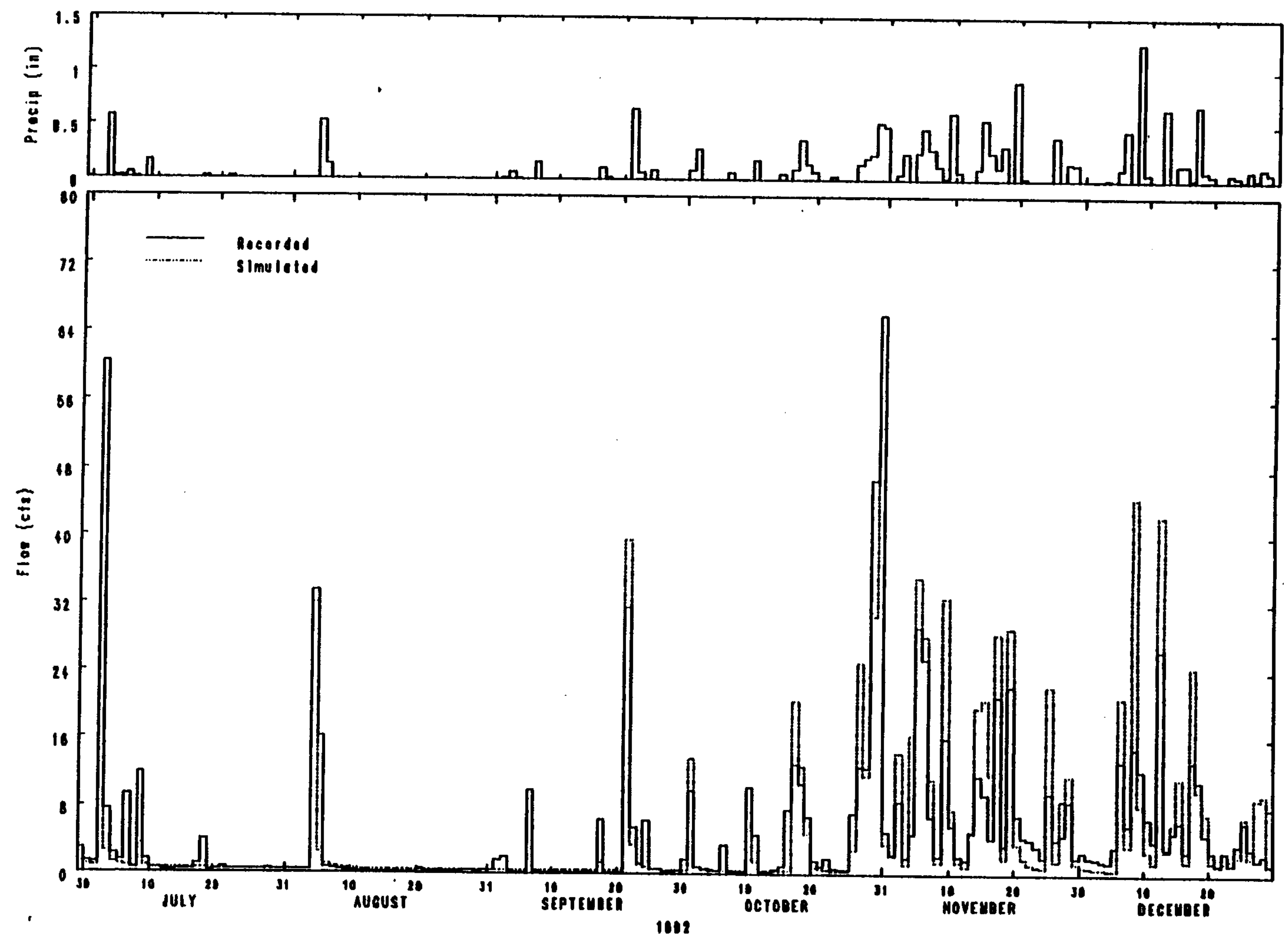
HSPF Calibration Plots, Daily Peak Hourly Flows - Des Moines Creek Inflow to Tyee Pond

MONTGOMERY WATER GROUP, INC. Water Resources • Environmental • Civil Engineering	SeaTac Airport Master Plan Update EIS Hydrologic Modeling Study	Figure B-7 (cont.)



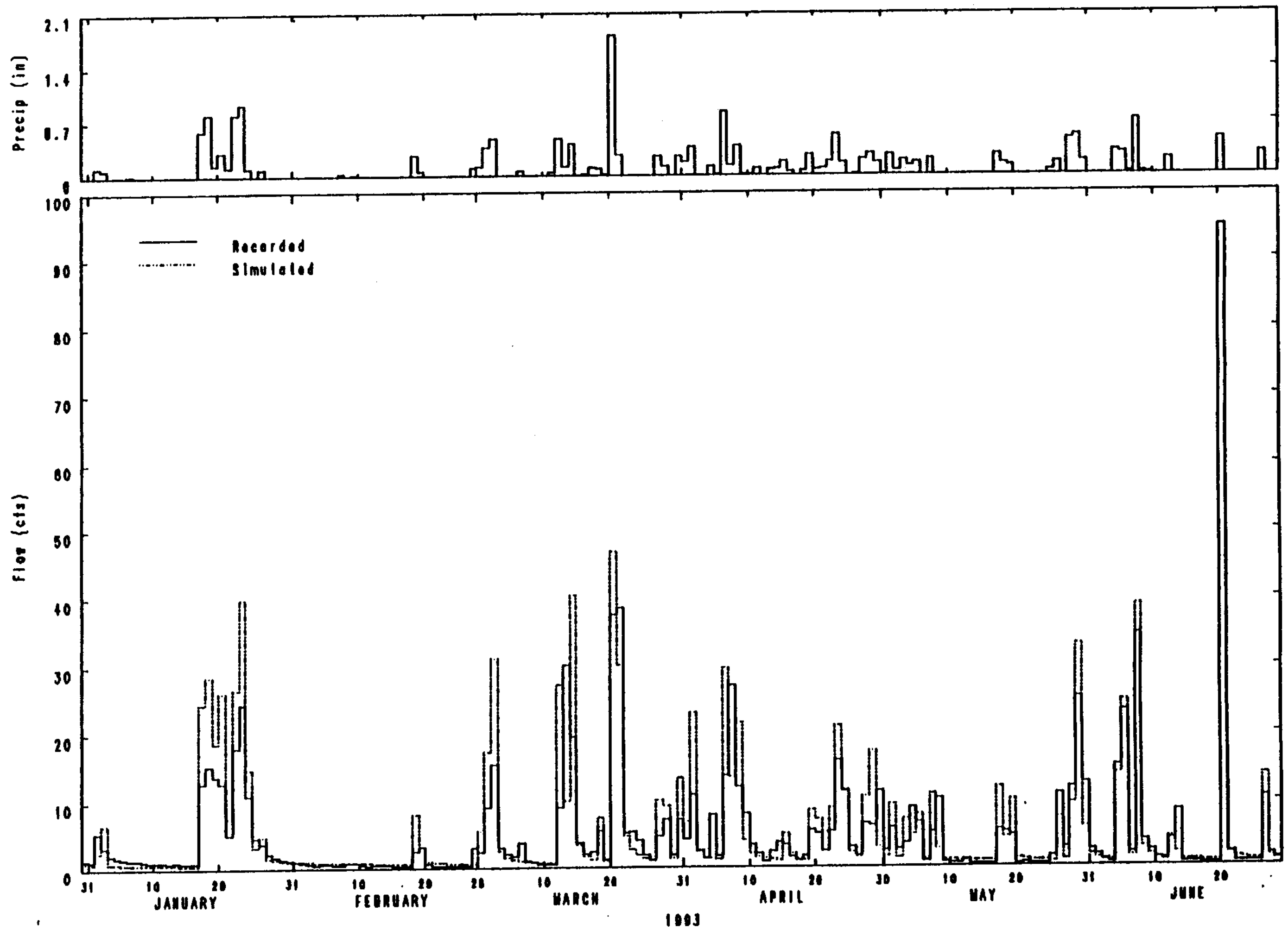
HSPF Calibration Plots, Daily Peak Hourly Flows - Des Moines Creek Inflow to Tyee Pond

MONTGOMERY WATER GROUP, INC. Water Resources • Environmental • Civil Engineering	SeaTac Airport Master Plan Update EIS Hydrologic Modeling Study	Figure B-7 (cont.)



HSPF Calibration Plots, Daily Peak Hourly Flows - Des Moines Creek Inflow to Tyee Pond

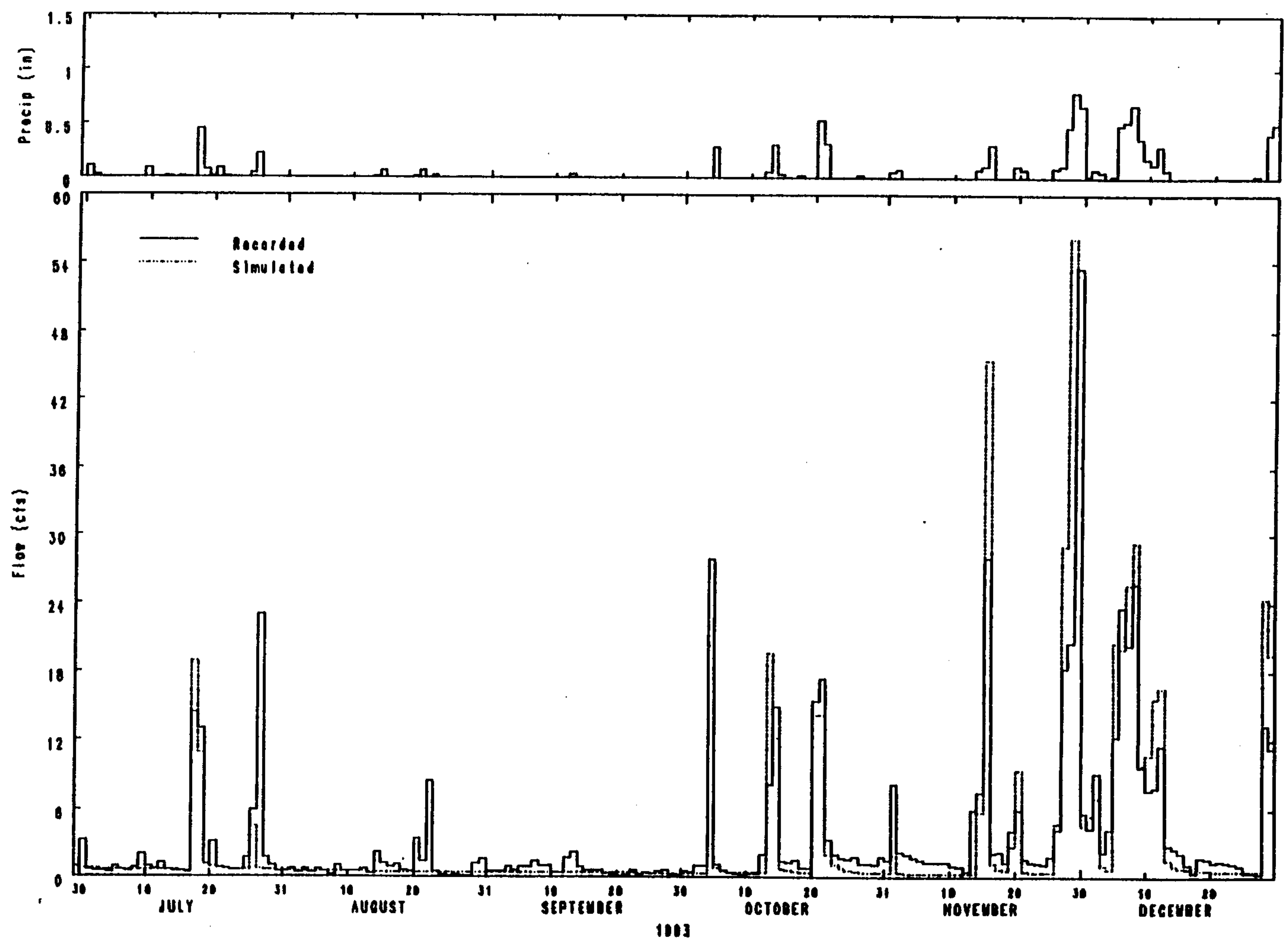
MONTGOMERY WATER GROUP, INC. Water Resources • Environmental • Civil Engineering	SeaTac Airport Master Plan Update EIS Hydrologic Modeling Study	Figure B-7 (cont.)



HSPF Calibration Plots, Daily Peak Hourly Flows - Des Moines Creek Inflow to Tyee Pond

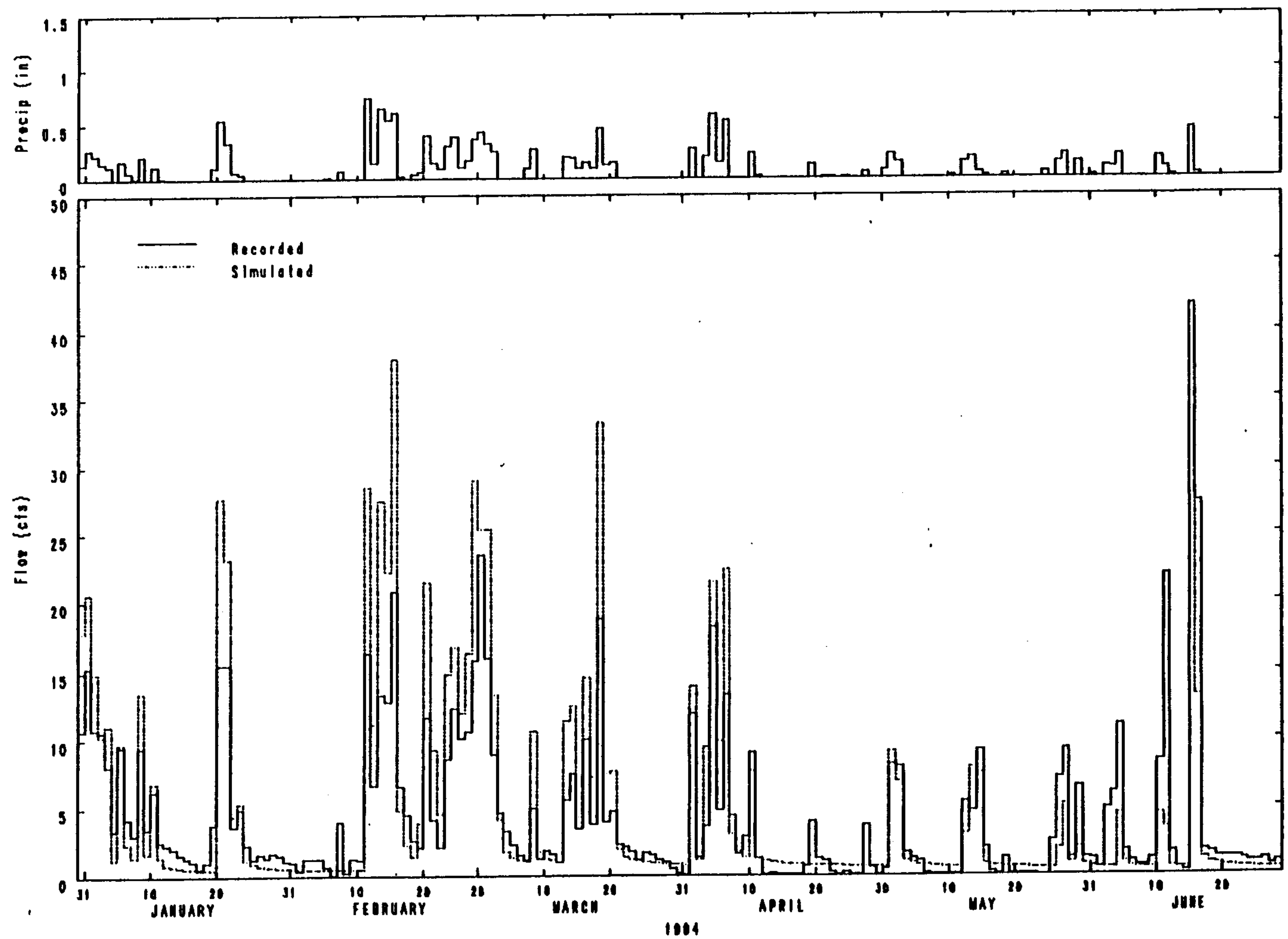
MONTGOMERY WATER GROUP, INC. Water Resources • Environmental • Civil Engineering	SeaTac Airport Master Plan Update EIS Hydrologic Modeling Study	Figure B-7 (cont.)

AR 039577



HSPF Calibration Plots, Daily Peak Hourly Flows - Des Moines Creek Inflow to Tyee Pond

MONTGOMERY WATER GROUP, INC. Water Resources • Environmental • Civil Engineering	SeaTac Airport Master Plan Update EIS Hydrologic Modeling Study	Figure B-7 (cont.)



HSPF Calibration Plots, Daily Peak Hourly Flows - Des Moines Creek Inflow to Tyee Pond

MONTGOMERY WATER GROUP, INC. Water Resources • Environmental • Civil Engineering	SeaTac Airport Master Plan Update EIS Hydrologic Modeling Study	Figure B-7 (cont.)

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APPENDIX C

EXCEEDENCE FREQUENCY GRAPHS

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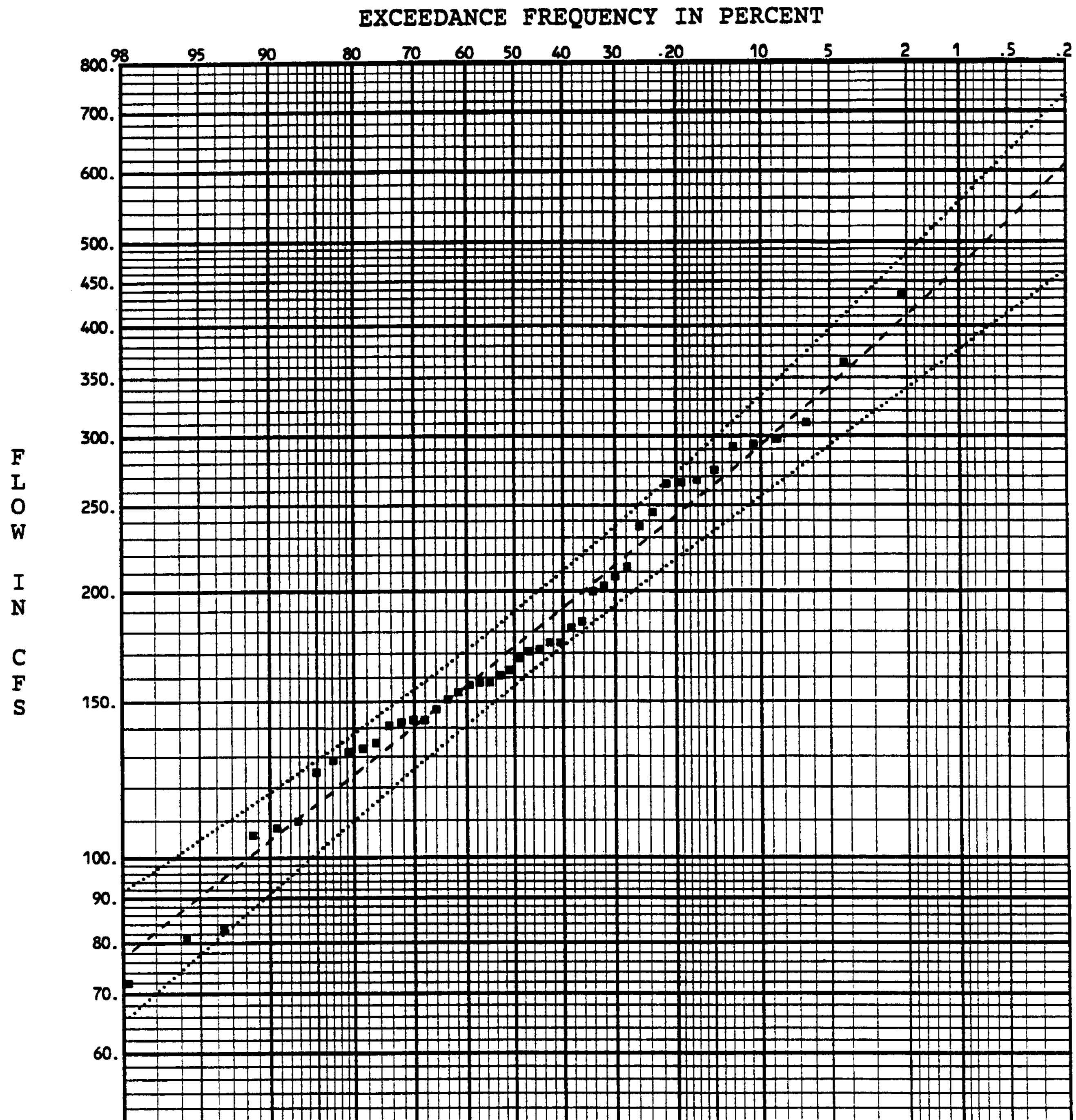
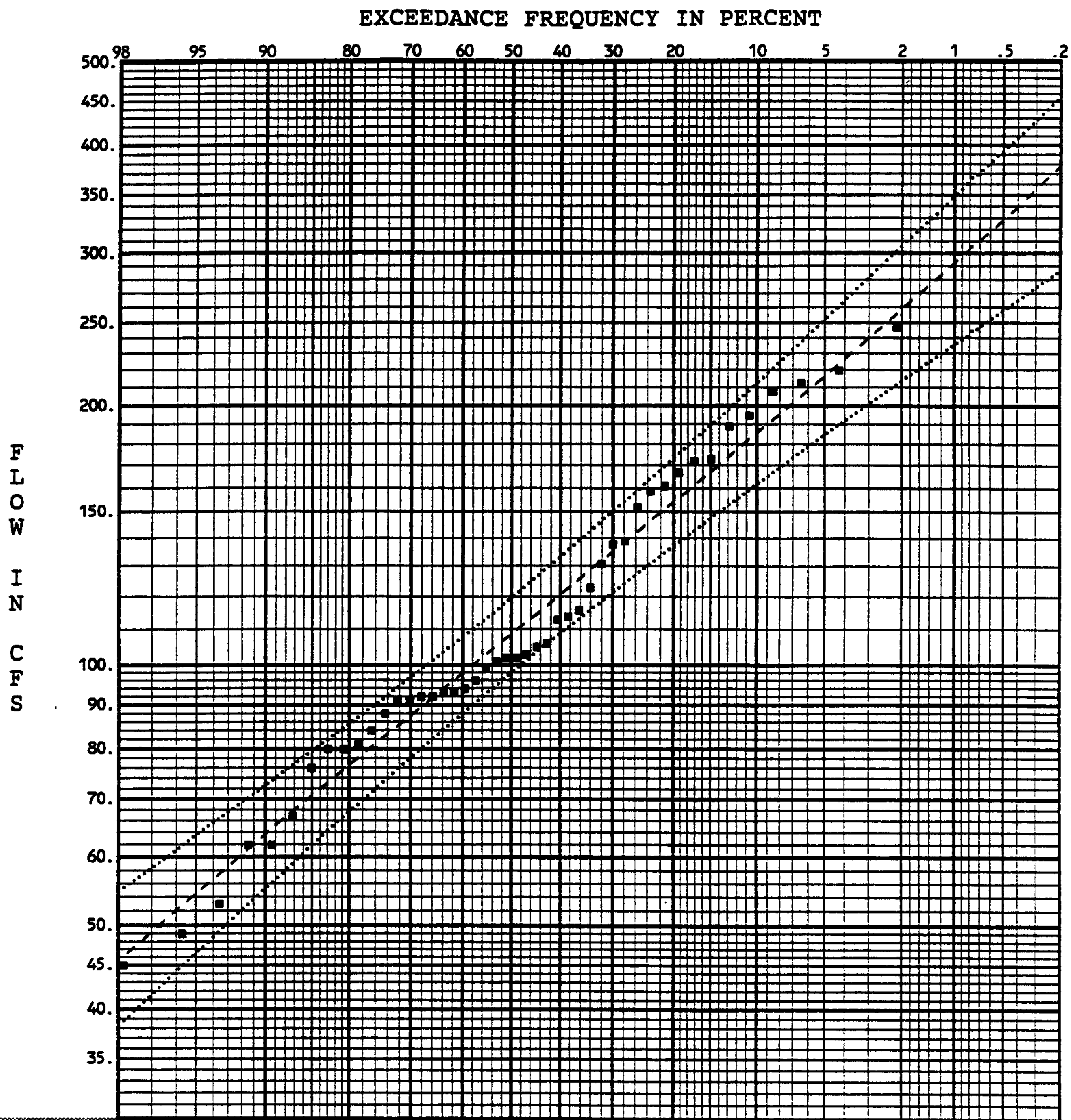


--- Flow Frequency (with Exp. Prob.)
■ Weibull Plotting Positions
······· 5% and 95% Confidence Limits

Miller Creek near Mouth
Current Conditions
1949-1994 Simulation

FREQUENCY STATISTICS

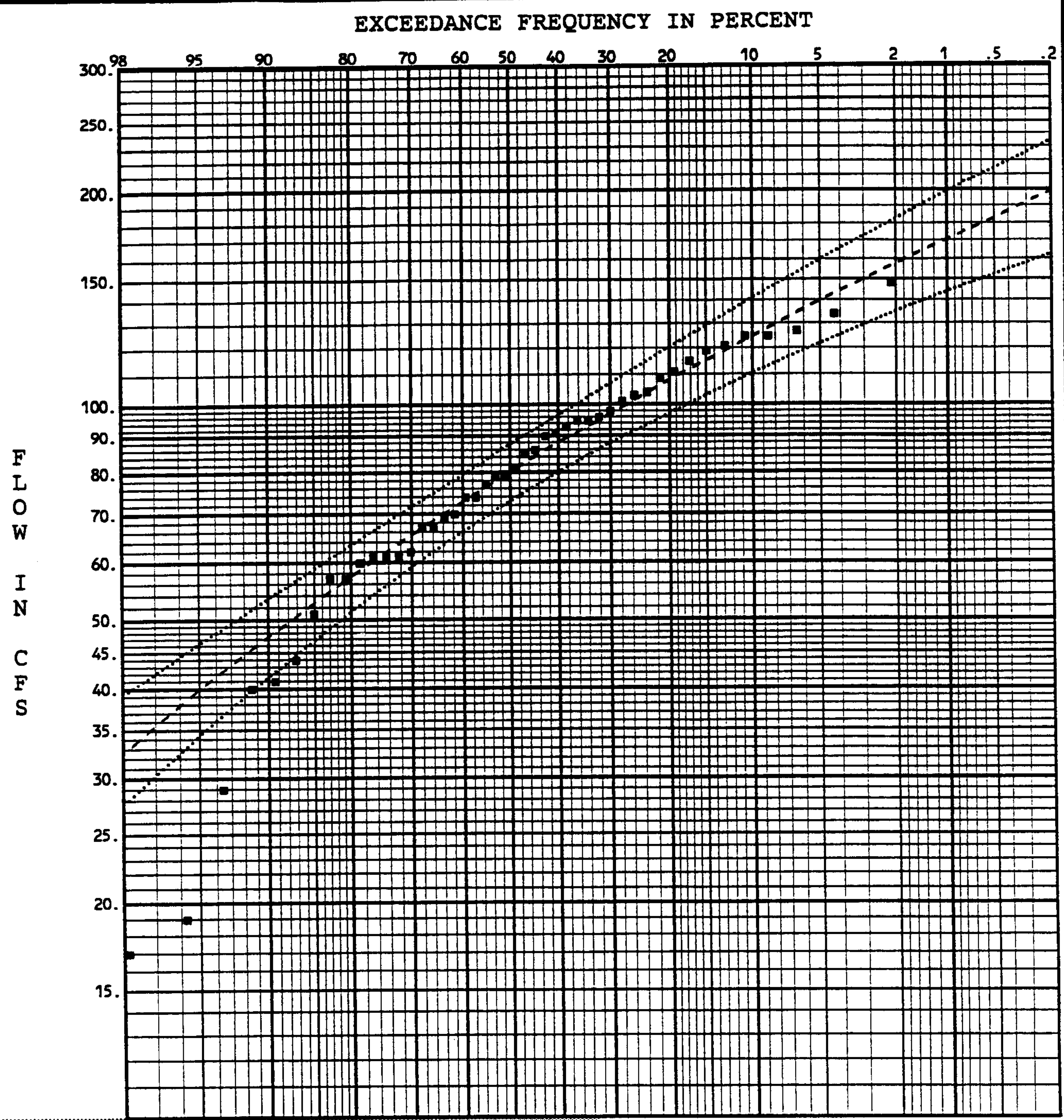
LOG TRANSFORM OF FLOW, CFS		NUMBER OF EVENTS	
MEAN	2.2406	HISTORIC EVENTS	0
STANDARD DEV	.1703	HIGH OUTLIERS	0
SKEW	.0723	LOW OUTLIERS	0
REGIONAL SKEW	.0200	ZERO OR MISSING	0
ADOPTED SKEW	.1000	SYSTEMATIC EVENTS	46



--- Flow Frequency (with Exp. Prob.)
■ Weibull Plotting Positions
.... 5% and 95% Confidence Limits

FREQUENCY STATISTICS LOG TRANSFORM OF FLOW, CFS		NUMBER OF EVENTS	
MEAN	2.0360	HISTORIC EVENTS	0
STANDARD DEV	.1764	HIGH OUTLIERS	0
SKEW	.0375	LOW OUTLIERS	0
REGIONAL SKEW	.0200	ZERO OR MISSING	0
ADOPTED SKEW	.0000	SYSTEMATIC EVENTS	46

Miller Creek at 1st Avenue
Current Conditions
1949-1994 Simulation

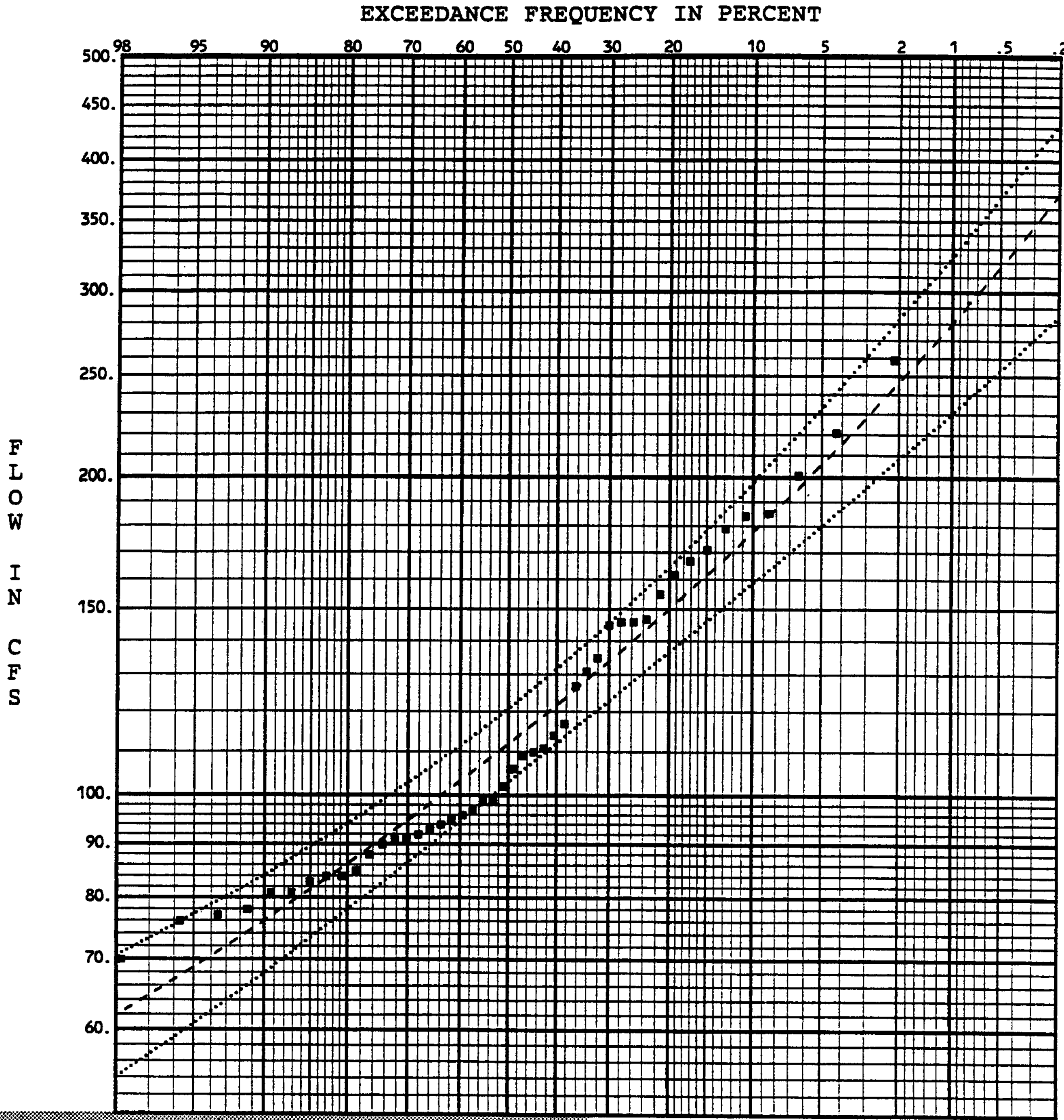


--- Flow Frequency (with Exp. Prob.)
■ Weibull Plotting Positions
········ 5% and 95% Confidence Limits

FREQUENCY STATISTICS

LOG TRANSFORM OF FLOW, CFS		NUMBER OF EVENTS	
MEAN	1.8935	HISTORIC EVENTS	0
STANDARD DEV	.1608	HIGH OUTLIERS	0
SKEW	-.6461	LOW OUTLIERS	2
REGIONAL SKEW	.0200	ZERO OR MISSING	0
ADOPTED SKEW	-.4000	SYSTEMATIC EVENTS	46

Miller Creek below Lake Reba
Current Conditions
1949-1994 Simulation

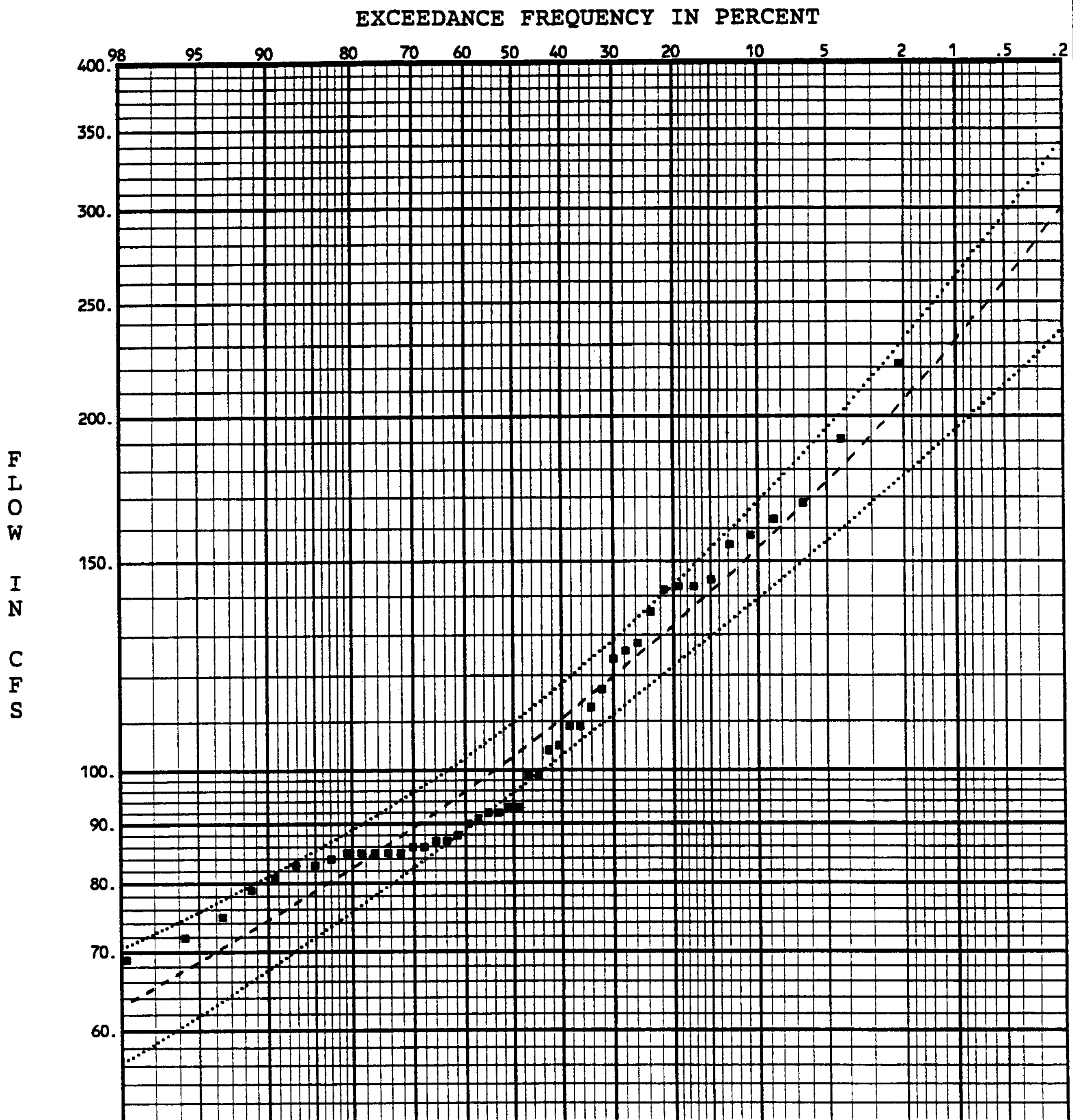


--- Flow Frequency (with Exp. Prob.)
■ Weibull Plotting Positions
.... 5% and 95% Confidence Limits

FREQUENCY STATISTICS
LOG TRANSFORM OF FLOW, CFS

		NUMBER OF EVENTS	
MEAN	2.0581	HISTORIC EVENTS	0
STANDARD DEV	.1409	HIGH OUTLIERS	0
SKEW	.6606	LOW OUTLIERS	0
REGIONAL SKEW	.0200	ZERO OR MISSING	0
ADOPTED SKEW	.4000	SYSTEMATIC EVENTS	46

Des Moines Creek at SW 208th
Current Conditions
1949-1994 Simulation



--- Flow Frequency (with Exp. Prob.)
■ Weibull Plotting Positions
.... 5% and 95% Confidence Limits

FREQUENCY STATISTICS
LOG TRANSFORM OF FLOW, CFS

		NUMBER OF EVENTS	
MEAN	2.0216	HISTORIC EVENTS	0
STANDARD DEV	.1209	HIGH OUTLIERS	0
SKEW	.8150	LOW OUTLIERS	0
REGIONAL SKEW	.0200	ZERO OR MISSING	0
ADOPTED SKEW	.5000	SYSTEMATIC EVENTS	46

Des Moines Creek below Conflu
Current Conditions
1949-1994 Simulation

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APPENDIX D

HSPF INPUT FILES - CURRENT CONDITION SIMULATION

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```
RUN
GLOBAL
  ***  FILE: MILL-SIM.UCI
  ***  SIMULATION RUN - CURRENT LAND USE - EXISTING CONDITIONS ***
  MILLER CREEK BASIN HSPF MODEL
  START       1948/10/01 00:00  END    1994/07/31 24:00
  RUN INTERP OUTPUT LEVEL    0
  RESUME     0 RUN     1
END GLOBAL

FILES
<type>  <fun>***<-----------fname------------------------------------------>
INFO      21   c:\hspf10\hspinf.da
ERROR     22   c:\hspf10\hsperr.da
WARN      23   c:\hspf10\hspwrn.da
MESSU     24   mill-sim.ech
WDM       25   MILL-SIM.WDM

END FILES

OPN SEQUENCE
    INGRP              INDELT 01:00
      PERLND      14
      PERLND      16
      PERLND      18
      PERLND      24
      PERLND      26
      PERLND      28
      PERLND      34
      PERLND      44
      PERLND      54
      IMPLND      14
      RCHRES       1
      RCHRES       2
      RCHRES       3
      RCHRES       4
      RCHRES       5
      RCHRES      30
      RCHRES      31
      RCHRES      23
      RCHRES      24
      RCHRES      25
      RCHRES      27
      RCHRES      28
      RCHRES      29
      RCHRES       6
      RCHRES      38
      RCHRES       7
      RCHRES       9
      RCHRES       8
      RCHRES      26
      RCHRES      10
      RCHRES      32
      RCHRES      16
      RCHRES      11
      RCHRES      33
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      RCHRES      13
      RCHRES      12
      RCHRES      35
      RCHRES      20
      RCHRES      19
      RCHRES      15
      RCHRES      14
      RCHRES      34
      RCHRES      17
      RCHRES      18
      RCHRES      21
      RCHRES      36
      RCHRES      22
      RCHRES      37
    END INGRP
END OPN SEQUENCE
                                                                       ***
PERLND
  GEN-INFO
    <PLS >       Name           NBLKS  Unit-systems   Printer          ***
    # -  #                            User  t-series Engl Metr         ***
                                            in  out                    ***
   14      TFF- TILL FOR FLT      1     1    1    1   60    0
   16      TFM- TILL FOR MOD      1     1    1    1   60    0
   18      TFS- TILL FOR STP      1     1    1    1   60    0
   24      TGF- TILL GR FLT       1     1    1    1   60    0
   26      TGM- TILL GR MOD       1     1    1    1   60    0
   28      TGS- TILL GR STP       1     1    1    1   60    0
   34      OF - OUTWASH FOR       1     1    1    1   60    0
   44      OG - OUTWASH GR        1     1    1    1   60    0
   54      SA - WETLANDS          1     1    1    1   60    0
  END GEN-INFO
  ACTIVITY
    <PLS > ************* Active Sections *****************************
    # -  # ATMP SNOW PWAT  SED  PST  PWG PQAL MSTL PEST NITR PHOS TRAC      ***
   14  200    0    0    1    0    0    0    0    0    0    0    0    0
  END ACTIVITY
  PRINT-INFO
    <PLS > ********************* Print-flags ************************* PIVL  PYR
    # -  # ATMP SNOW PWAT  SED  PST  PWG PQAL MSTL PEST NITR PHOS TRAC *********
   14  200    0    0    6    0    0    0    0    0    0    0    0    0    1    9
  END PRINT-INFO
  PWAT-PARM1
    <PLS > ***************** Flags ********************
    # -  # CSNO RTOP UZFG  VCS  VUZ  VNN VIFW VIRC  VLE                    ***
   14  200    0    0    0    0    0    0    0    0    0
  END PWAT-PARM1
  PWAT-PARM2
    <PLS > ***
    # -  # ***FOREST      LZSN    INFILT      LSUR     SLSUR     KVARY     AGWRC
   14                   4.5000    0.1000    400.00    0.0500    0.5000    0.9800
   16                   4.5000    0.1000    400.00    0.1100    0.5000    0.9800
   18                   4.5000    0.1000    200.00    0.2000    0.5000    0.9800
   24                   4.5000    0.1000    400.00    0.0500    0.5000    0.9800
   26                   4.5000    0.1000    400.00    0.1000    0.5000    0.9800
   28                   4.5000    0.1000    200.00    0.2000    0.5000    0.9800
```

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  34                 5.0000    1.5000    400.00    0.0500    0.3000    0.9800
  44                 5.0000    0.7000    400.00    0.0500    0.3000    0.9800
  54                 4.0000    1.0000    100.00    0.0010    0.5000    0.9800
END PWAT-PARM2
PWAT-PARM3
  <PLS >***
  # -  #*** PETMAX    PETMIN    INFEXP    INFILD    DEEPFR    BASETP    AGWETP
  14                           2.5000    2.0000       .80        0.        0.
  16                           2.0000    2.0000       .80        0.        0.
  18                           1.5000    2.0000       .80        0.        0.
  24                           3.5000    2.0000       .80        0.        0.
  26                           2.0000    2.0000       .80        0.        0.
  28                           1.5000    2.0000       .80        0.        0.
  34                           2.0000    2.0000       .90        0.        0.
  44                           2.0000    2.0000       .90        0.        0.
  54                           10.000    2.0000       .00        0.       0.7
END PWAT-PARM3
PWAT-PARM4
                                                                  ***
  <PLS >
  # -  #     CEPSC      UZSN      NSUR     INTFW       IRC     LZETP***
  14        0.1000    0.2500    0.3500     1.700    0.1200    0.7000
  16        0.1000    0.2500    0.3500     1.700    0.1200    0.7000
  18        0.1000    0.2500    0.3500     1.700    0.1200    0.7000
  24        0.1000    0.2500    0.2500     1.700    0.1200    0.2500
  26        0.1000    0.2500    0.2500     1.700    0.1200    0.2500
  28        0.1000    0.1500    0.2500     1.700    0.1200    0.2500
  34        0.1000    0.2500    0.3500     1.700    0.1200    0.7000
  44        0.1000    0.2500    0.2500      .000    0.1200    0.2500
  54        0.1000    3.0000    0.5000     1.000    0.1200    0.8000
END PWAT-PARM4
PWAT-STATE1
  <PLS >  PWATER state variables***
  # -  #***    CEPS      SURS       UZS      IFWS       LZS      AGWS      GWVS
  14           0.078        0.    0.0010        0.     0.077     0.698     0.023
  16           0.078        0.    0.0010        0.     0.075     0.667     0.026
  18           0.078        0.    0.0010        0.     0.074     0.628     0.027
  24           0.051        0.    0.0010        0.     0.300     0.681     0.053
  26           0.051        0.    0.0050        0.     0.300     0.680     0.049
  28           0.051        0.    0.0060        0.     0.300     0.659     0.048
  34           0.078        0.    0.0010        0.     0.090     0.675     0.038
  44           0.051        0.    0.0040        0.     0.300     0.414     0.152
  54           0.051        0.    0.3330        0.     0.622     0.400     0.000
END PWAT-STATE1
END PERLND
IMPLND
  GEN-INFO
    <ILS >       Name              Unit-systems   Printer                    ***
    # -  #                       User  t-series Engl Metr                    ***
                                        in  out                              ***
   14      IMPERVIOUS               1    1    1   60    0
  END GEN-INFO
  ACTIVITY
    <ILS > ************* Active Sections ****
    # -  # ATMP SNOW IWAT  SLD  IWG IQAL   ***
   14         0    0    1    0    0    0
  END ACTIVITY
```

```
  PRINT-INFO
    <ILS > ******** Print-flags ******** PIVL  PYR
    # -  # ATMP SNOW IWAT  SLD  IWG IQAL *********
   14         0    0    6    0    0    0    1    9
  END PRINT-INFO
  IWAT-PARM1
    <ILS >            Flags             ***                                    ***
    # -  # CSNO RTOP  VRS  VNN RTLI     ***                                    ***
   14         0    0    0    0    0
  END IWAT-PARM1
  IWAT-PARM2
    <ILS >                                                                     ***
    # -  #       LSUR     SLSUR      NSUR     RETSC                            ***
   14          500.00    0.0500    0.1000    0.1000
  END IWAT-PARM2
  IWAT-PARM3
    <ILS >                                                                     ***
    # -  #     PETMAX    PETMIN                                                ***
   14
  END IWAT-PARM3
  IWAT-STATE1
    <ILS >  IWATER state variables                                             ***
    # -  #       RETS      SURS                                                ***
   14        1.0000E-3 1.0000E-3
  END IWAT-STATE1
END IMPLND
                                                                               ***
EXT SOURCES
                                                                               ***
*** NOTE: The only RCHRES that precip and PET are applied to are lakes.
                                                                               ***
<-Volume-> <Member> SsysSgap<--Mult-->Tran <-Target vols> <-Grp> <-Member->  ***
<Name>   # <Name> # tem strg<-factor->strg <Name>   #   #        <Name> # #  ***
WDM      2 PREC     ENGLZERO               PERLND  14 200 EXTNL  PREC
WDM      2 PREC     ENGLZERO               IMPLND  14     EXTNL  PREC
WDM      3 EVAP     ENGLZERO  0.8     DIV  PERLND  14 200 EXTNL  PETINP
WDM      3 EVAP     ENGLZERO  0.8     DIV  IMPLND  14     EXTNL  PETINP
WDM      2 PREC     ENGLZERO               RCHRES   1     EXTNL  PREC
WDM      3 EVAP     ENGLZERO     0.8  DIV  RCHRES   1     EXTNL  PREC
WDM      2 PREC     ENGLZERO               RCHRES   4     EXTNL  PREC
WDM      3 EVAP     ENGLZERO     0.8  DIV  RCHRES   4     EXTNL  PREC
WDM      2 PREC     ENGLZERO               RCHRES   6     EXTNL  PREC
WDM      3 EVAP     ENGLZERO     0.8  DIV  RCHRES   6     EXTNL  PREC
WDM      2 PREC     ENGLZERO               RCHRES   9     EXTNL  PREC
WDM      3 EVAP     ENGLZERO     0.8  DIV  RCHRES   9     EXTNL  PREC
WDM      2 PREC     ENGLZERO               RCHRES  13     EXTNL  PREC
WDM      3 EVAP     ENGLZERO     0.8  DIV  RCHRES  13     EXTNL  PREC
WDM      2 PREC     ENGLZERO               RCHRES  20     EXTNL  PREC
WDM      3 EVAP     ENGLZERO     0.8  DIV  RCHRES  20     EXTNL  PREC
WDM      2 PREC     ENGLZERO               RCHRES  11     EXTNL  PREC
WDM      3 EVAP     ENGLZERO     0.8  DIV  RCHRES  11     EXTNL  PREC
WDM      2 PREC     ENGLZERO               RCHRES  38     EXTNL  PREC
WDM      3 EVAP     ENGLZERO     0.8  DIV  RCHRES  38     EXTNL  PREC

UNIT FLOW TO RCHRES, TO INPUT GROUNDWATER BASE FLOW ***
0.0825 IS EQUIVALENT TO 1 CFS (HSPF UNITS ARE AC-FT/HR)    ***
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WDM      4 FLOW     ENGLZERO   .120        RCHRES  35       EXTNL  IVOL
WDM      4 FLOW     ENGLZERO   .150        RCHRES  36       EXTNL  IVOL
END EXT SOURCES
                                                                        ***
NETWORK
                                                                        ***
***         <MEMBER> SSYSSGAP<--MULT-->TRAN <-TARGET VOLS>        <-MEMBER->
<NAME>   # <NAME>   TEM STRG<-FACTOR->STRG <NAME>   #    # <-GRP> <NAME> # # ***
*** SUB-BASIN  M  1
PERLND  24 PWATER PERO       18.0890       RCHRES   1       EXTNL  IVOL
PERLND  44 PWATER PERO        2.8620       RCHRES   1       EXTNL  IVOL
IMPLND  14 IWATER SURO        1.0000       RCHRES   1       EXTNL  IVOL
*** SUB-BASIN  M  2
PERLND  24 PWATER PERO       24.5040       RCHRES   2       EXTNL  IVOL
PERLND  44 PWATER PERO        6.2290       RCHRES   2       EXTNL  IVOL
IMPLND  14 IWATER SURO        1.0000       RCHRES   2       EXTNL  IVOL
*** SUB-BASIN  M  3
PERLND  24 PWATER PERO        8.6810       RCHRES   3       EXTNL  IVOL
PERLND  44 PWATER PERO        8.6850       RCHRES   3       EXTNL  IVOL
IMPLND  14 IWATER SURO        1.0000       RCHRES   3       EXTNL  IVOL
*** SUB-BASIN  M  4
PERLND  24 PWATER PERO       11.2490       RCHRES   4       EXTNL  IVOL
PERLND  44 PWATER PERO       15.7180       RCHRES   4       EXTNL  IVOL
PERLND  54 PWATER PERO        0.5330       RCHRES   4       EXTNL  IVOL
IMPLND  14 IWATER SURO        1.0000       RCHRES   4       EXTNL  IVOL
*** SUB-BASIN  M  5
PERLND  24 PWATER PERO        3.8470       RCHRES   5       EXTNL  IVOL
PERLND  44 PWATER PERO        6.1840       RCHRES   5       EXTNL  IVOL
PERLND  54 PWATER PERO        0.6920       RCHRES   5       EXTNL  IVOL
IMPLND  14 IWATER SURO        0.5000       RCHRES   5       EXTNL  IVOL
*** SUB-BASIN  M  6
PERLND  24 PWATER PERO        4.2370       RCHRES  31       EXTNL  IVOL
PERLND  44 PWATER PERO        5.7090       RCHRES  31       EXTNL  IVOL
PERLND  54 PWATER PERO        1.3420       RCHRES  31       EXTNL  IVOL
IMPLND  14 IWATER SURO        0.5000       RCHRES  31       EXTNL  IVOL
*** SUB-BASIN  M  7 - FLOWS TO RCHRES 26 IN MODIFIED NETWORK
PERLND  24 PWATER PERO        0.3580       RCHRES  26       EXTNL  IVOL
PERLND  44 PWATER PERO        2.3270       RCHRES  26       EXTNL  IVOL
PERLND  54 PWATER PERO        1.2750       RCHRES  26       EXTNL  IVOL
IMPLND  14 IWATER SURO        0.2480       RCHRES  26       EXTNL  IVOL
*** INCREASE IMP AREA FOR CALIBRATION
*** SUB-BASIN  M  8 - FLOWS TO RCHRES 26 IN MODIFIED NETWORK
PERLND  24 PWATER PERO        2.3170       RCHRES  26       EXTNL  IVOL
PERLND  44 PWATER PERO        8.7160       RCHRES  26       EXTNL  IVOL
PERLND  54 PWATER PERO        0.9500       RCHRES  26       EXTNL  IVOL
IMPLND  14 IWATER SURO        0.8920       RCHRES  26       EXTNL  IVOL
*** SUB-BASIN  M  9
PERLND  14 PWATER PERO        0.3080       RCHRES   9       EXTNL  IVOL
PERLND  24 PWATER PERO        1.5060       RCHRES   9       EXTNL  IVOL
PERLND  44 PWATER PERO        5.2560       RCHRES   9       EXTNL  IVOL
IMPLND  14 IWATER SURO        2.1200       RCHRES   9       EXTNL  IVOL
*** SUB-BASIN  M 10
PERLND  14 PWATER IFWO        0.3830       RCHRES  10       EXTNL  IVOL
PERLND  14 PWATER SURO        0.3830       RCHRES  10       EXTNL  IVOL
PERLND  24 PWATER IFWO        3.0950       RCHRES  10       EXTNL  IVOL
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PERLND  24 PWATER SURO       3.0950     RCHRES  10     EXTNL  IVOL
PERLND  44 PWATER PERO       8.1390     RCHRES  10     EXTNL  IVOL
IMPLND  14 IWATER SURO       6.8500     RCHRES  10     EXTNL  IVOL
*** SUB-BASIN  M 11
PERLND  14 PWATER IFWO       0.3830     RCHRES  11     EXTNL  IVOL
PERLND  14 PWATER SURO       0.3830     RCHRES  11     EXTNL  IVOL
PERLND  24 PWATER IFWO       5.2150     RCHRES  11     EXTNL  IVOL
PERLND  24 PWATER SURO       5.2150     RCHRES  11     EXTNL  IVOL
PERLND  34 PWATER PERO       0.1500     RCHRES  11     EXTNL  IVOL
PERLND  44 PWATER PERO       3.6250     RCHRES  11     EXTNL  IVOL
IMPLND  14 IWATER SURO      18.3350     RCHRES  11     EXTNL  IVOL
*** SUB-BASIN  M 12
PERLND  24 PWATER IFWO       8.2340     RCHRES  12     EXTNL  IVOL
PERLND  24 PWATER SURO       8.2340     RCHRES  12     EXTNL  IVOL
PERLND  34 PWATER PERO       0.4580     RCHRES  12     EXTNL  IVOL
PERLND  44 PWATER PERO       4.2860     RCHRES  12     EXTNL  IVOL
PERLND  54 PWATER PERO       0.6920     RCHRES  12     EXTNL  IVOL
IMPLND  14 IWATER SURO       7.5470     RCHRES  12     EXTNL  IVOL
*** SUB-BASIN  M 13
PERLND  24 PWATER IFWO      14.2540     RCHRES  13     EXTNL  IVOL
PERLND  24 PWATER SURO      14.2540     RCHRES  13     EXTNL  IVOL
IMPLND  14 IWATER SURO       3.8210     RCHRES  13     EXTNL  IVOL
*** SUB-BASIN  M 14
PERLND  16 PWATER IFWO       1.2480     RCHRES  14     EXTNL  IVOL
PERLND  16 PWATER SURO       1.2480     RCHRES  14     EXTNL  IVOL
PERLND  26 PWATER IFWO       8.8480     RCHRES  14     EXTNL  IVOL
PERLND  26 PWATER SURO       8.8480     RCHRES  14     EXTNL  IVOL
PERLND  34 PWATER PERO       1.8170     RCHRES  14     EXTNL  IVOL
PERLND  44 PWATER PERO       1.6290     RCHRES  14     EXTNL  IVOL
IMPLND  14 IWATER SURO       1.8580     RCHRES  14     EXTNL  IVOL
*** SUB-BASIN  M 15
PERLND  24 PWATER PERO       0.8800     RCHRES  15     EXTNL  IVOL
PERLND  26 PWATER PERO       2.5880     RCHRES  15     EXTNL  IVOL
PERLND  34 PWATER PERO       3.9080     RCHRES  15     EXTNL  IVOL
PERLND  44 PWATER PERO       6.8400     RCHRES  15     EXTNL  IVOL
IMPLND  14 IWATER SURO       1.7170     RCHRES  15     EXTNL  IVOL
*** SUB-BASIN  M 16
PERLND  14 PWATER PERO       0.7670     RCHRES  16     EXTNL  IVOL
PERLND  24 PWATER PERO       1.7390     RCHRES  16     EXTNL  IVOL
PERLND  34 PWATER PERO       1.9170     RCHRES  16     EXTNL  IVOL
PERLND  44 PWATER PERO       1.3720     RCHRES  16     EXTNL  IVOL
IMPLND  14 IWATER SURO       1.0310     RCHRES  16     EXTNL  IVOL
*** SUB-BASIN  M 17
PERLND  16 PWATER PERO       1.2510     RCHRES  17     EXTNL  IVOL
PERLND  26 PWATER PERO       0.4530     RCHRES  17     EXTNL  IVOL
PERLND  34 PWATER PERO      11.0640     RCHRES  17     EXTNL  IVOL
IMPLND  14 IWATER SURO       0.4780     RCHRES  17     EXTNL  IVOL
*** SUB-BASIN  M 18
PERLND  16 PWATER PERO       1.5440     RCHRES  18     EXTNL  IVOL
PERLND  24 PWATER PERO       7.8930     RCHRES  18     EXTNL  IVOL
IMPLND  14 IWATER SURO       0.2880     RCHRES  18     EXTNL  IVOL
*** SUB-BASIN  M 19
PERLND  14 PWATER PERO       0.9170     RCHRES  19     EXTNL  IVOL
PERLND  24 PWATER PERO       8.7930     RCHRES  19     EXTNL  IVOL
PERLND  34 PWATER PERO       1.0750     RCHRES  19     EXTNL  IVOL
PERLND  44 PWATER PERO       8.6610     RCHRES  19     EXTNL  IVOL
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PERLND  54 PWATER PERO        0.5330      RCHRES  19       EXTNL  IVOL
IMPLND  14 IWATER SURO        3.3790      RCHRES  19       EXTNL  IVOL
*** SUB-BASIN  M 20
PERLND  24 PWATER PERO        5.4200      RCHRES  35       EXTNL  IVOL
PERLND  44 PWATER PERO        9.1940      RCHRES  35       EXTNL  IVOL
PERLND  54 PWATER PERO        2.1080      RCHRES  35       EXTNL  IVOL
IMPLND  14 IWATER SURO        5.3940      RCHRES  35       EXTNL  IVOL
*** SUB-BASIN  M 21
PERLND  16 PWATER PERO        0.5920      RCHRES  21       EXTNL  IVOL
PERLND  24 PWATER PERO        5.3360      RCHRES  21       EXTNL  IVOL
PERLND  26 PWATER PERO        7.5640      RCHRES  21       EXTNL  IVOL
PERLND  34 PWATER PERO        2.6480      RCHRES  21       EXTNL  IVOL
PERLND  44 PWATER PERO        7.7690      RCHRES  21       EXTNL  IVOL
IMPLND  14 IWATER SURO        5.1400      RCHRES  21       EXTNL  IVOL
*** SUB-BASIN  M 22
PERLND  34 PWATER PERO        1.1100      RCHRES  22       EXTNL  IVOL
PERLND  44 PWATER PERO        1.1050      RCHRES  22       EXTNL  IVOL
IMPLND  14 IWATER SURO        0.2350      RCHRES  22       EXTNL  IVOL
*** SUB-BASIN  M 23
IMPLND  14 IWATER SURO        1.1670      RCHRES  23       EXTNL  IVOL
*** SUB-BASIN  M 24
PERLND  24 PWATER SURO        0.5830      RCHRES  24       EXTNL  IVOL
IMPLND  14 IWATER SURO        2.2500      RCHRES  24       EXTNL  IVOL
*** SUB-BASIN  M 25
PERLND  24 PWATER SURO        4.1670      RCHRES  25       EXTNL  IVOL
IMPLND  14 IWATER SURO        1.5830      RCHRES  25       EXTNL  IVOL
*** SUB-BASIN  M 26
PERLND  24 PWATER PERO        6.4980      RCHRES  26       EXTNL  IVOL
PERLND  44 PWATER PERO        7.8180      RCHRES  26       EXTNL  IVOL
PERLND  54 PWATER PERO        0.0670      RCHRES  26       EXTNL  IVOL
IMPLND  14 IWATER SURO        0.5000      RCHRES  26       EXTNL  IVOL
*** SUB-BASIN  M 27
PERLND  44 PWATER PERO        0.0960      RCHRES  27       EXTNL  IVOL
PERLND  54 PWATER PERO        0.2670      RCHRES  27       EXTNL  IVOL
IMPLND  14 IWATER SURO        0.5450      RCHRES  27       EXTNL  IVOL
*** SUB-BASIN  M 28
*** SUB-BASIN  M 29
PERLND  24 PWATER SURO        1.2750      RCHRES  28       EXTNL  IVOL
                                                                            ***
  *** CHANNEL NETWORK LINKAGES ***
                                                                            ***
*** NOTE: MFACTOR 12.1 CONVERTS ACRE-FEET OF RUNOFF TO AVERAGE CFS PER HOUR.
***       IT IS TIMESTEP DEPENDENT. THE OTHER MFACTORS CONVERT ACRE-FEET
***       OF RUNOFF TO INCHES.
                                                                            ***
RCHRES   1 HYDR   ROVOL  1                RCHRES   2       EXTNL  IVOL
RCHRES   2 HYDR   ROVOL  1                RCHRES   3       EXTNL  IVOL
RCHRES   3 HYDR   ROVOL  1                RCHRES  30       EXTNL  IVOL
RCHRES   4 HYDR   ROVOL  1                RCHRES   5       EXTNL  IVOL
RCHRES   5 HYDR   ROVOL  1                RCHRES  30       EXTNL  IVOL
RCHRES  30 HYDR   ROVOL  1                RCHRES  38       EXTNL  IVOL
RCHRES  27 HYDR   ROVOL  1                RCHRES   6       EXTNL  IVOL
RCHRES  28 HYDR   ROVOL  1                RCHRES   6       EXTNL  IVOL
RCHRES  29 HYDR   ROVOL  1                RCHRES   6       EXTNL  IVOL
RCHRES  23 HYDR   ROVOL  1                RCHRES   6       EXTNL  IVOL
RCHRES  24 HYDR   ROVOL  1                RCHRES   6       EXTNL  IVOL
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RCHRES  25 HYDR    ROVOL  1                  RCHRES   6      EXTNL  IVOL
RCHRES  31 HYDR    ROVOL  1                  RCHRES   6      EXTNL  IVOL
RCHRES   6 HYDR    ROVOL  1                  RCHRES  38      EXTNL  IVOL
RCHRES  38 HYDR    ROVOL  1                  RCHRES   7      EXTNL  IVOL
RCHRES   7 HYDR    ROVOL  1                  RCHRES   8      EXTNL  IVOL
RCHRES   9 HYDR    ROVOL  1                  RCHRES   8      EXTNL  IVOL
RCHRES   8 HYDR    ROVOL  1                  RCHRES  26      EXTNL  IVOL
RCHRES  26 HYDR    ROVOL  1                  RCHRES  32      EXTNL  IVOL
RCHRES  10 HYDR    ROVOL  1                  RCHRES  32      EXTNL  IVOL
RCHRES  32 HYDR    ROVOL  1                  RCHRES  16      EXTNL  IVOL
RCHRES  16 HYDR    ROVOL  1                  RCHRES  33      EXTNL  IVOL
RCHRES  11 HYDR    ROVOL  1                  RCHRES  33      EXTNL  IVOL
RCHRES  13 HYDR    ROVOL  1                  RCHRES  12      EXTNL  IVOL
RCHRES  12 HYDR    ROVOL  1                  RCHRES  15      EXTNL  IVOL
RCHRES  33 HYDR    ROVOL  1                  RCHRES  15      EXTNL  IVOL
RCHRES  35 HYDR    ROVOL  1                  RCHRES  20      EXTNL  IVOL
RCHRES  20 HYDR    ROVOL  1                  RCHRES  19      EXTNL  IVOL
RCHRES  19 HYDR    ROVOL  1                  RCHRES  15      EXTNL  IVOL
RCHRES  15 HYDR    ROVOL  1                  RCHRES  34      EXTNL  IVOL
RCHRES  14 HYDR    ROVOL  1                  RCHRES  34      EXTNL  IVOL
RCHRES  34 HYDR    ROVOL  1                  RCHRES  17      EXTNL  IVOL
RCHRES  17 HYDR    ROVOL  1                  RCHRES  37      EXTNL  IVOL
RCHRES  18 HYDR    ROVOL  1                  RCHRES  36      EXTNL  IVOL
RCHRES  21 HYDR    ROVOL  1                  RCHRES  36      EXTNL  IVOL
RCHRES  36 HYDR    ROVOL  1                  RCHRES  22      EXTNL  IVOL
RCHRES  22 HYDR    ROVOL  1                  RCHRES  37      EXTNL  IVOL
                                                                          ***
END NETWORK
                                                                          ***
EXT TARGETS
<-Volume-> <-Grp> <-Member-><--Mult-->Tran <-Volume-> <Member> Tsys Tgap Amd ***
<Name>   #        <Name> # #<-factor->strg <Name>   # <Name>    tem strg strg***
RCHRES  17 HYDR   RO                       WDM     20 FLOW     ENGL      REPL
RCHRES   7 HYDR   RO                       WDM     21 FLOW     ENGL      REPL
RCHRES  26 HYDR   RO                       WDM     22 FLOW     ENGL      REPL
RCHRES  33 HYDR   RO                       WDM     23 FLOW     ENGL      REPL
RCHRES  24 HYDR   RO                       WDM     24 FLOW     ENGL      REPL***
RCHRES  25 HYDR   RO                       WDM     25 FLOW     ENGL      REPL***
RCHRES  20 HYDR   RO                       WDM     26 FLOW     ENGL      REPL***
END EXT TARGETS
                                                                          ***
RCHRES
  GEN-INFO
    RCHRES       Name        Nexits   Unit Systems   Printer              ***
    # -  #<------------------><---> User T-series  Engl Metr LKFG         ***
                                           in  out                        ***
    1     Arbor Lake  M 1        1    1    1    1    0    0    0
    2     Arbor Ck -03710 M 2    1    1    1    1    0    0    0
    3     Arbor Ck    M 3        1    1    1    1    0    0    0
    4     Tub Lake    M 4        1    1    1    1    0    0    0
    5     Miller Ck SR518 M5     1    1    1    1    0    0    0
    6     Lake Reba out  M 6     1    1    1    1    0    0    0
    7     Miller Ck Detent M7    1    1    1    1    0    0    0
    8     Miller Ck SW160 M8     1    1    1    1    0    0    0
    9     Lora Lake   M 9        1    1    1    1    0    0    0
   10     Trib (03716)    M 10   1    1    1    1    0    0    0
```

```
  11     Miller Ck trib M 11    1    1    1    1    0    0    0
  12     Trib(0354)  M 12       1    1    1    1    0    0    0
  13     Burien Lake M 13       1    1    1    1    0    0    0
  14     Trib (0353) M 14       1    1    1    1    0    0    0
  15     Miller Ck above STP    1    1    1    1    0    0    0
  16     Miller Ck below 1st    1    1    1    1    0    0    0
  17     Miller Ck below STP    1    1    1    1    0    0    0
  18     Trib (0371A) M 18      1    1    1    1    0    0    0
  19     Trib (0371A) M 19      1    1    1    1    0    0    0
  36     confl. A + H tribs     1    1    1    1    0    0    0
  20     Trib   M 20            1    1    1    1    0    0    0
  21     Trib (0371H) M 21      1    1    1    1    0    0    0
  22     Trib (0371A) M 22      1    1    1    1    0    0    0
  23     SeaTac SDN-1 M 23      1    1    1    1    0    0    0
  24     SeaTac SDN-2 M 24      1    1    1    1    0    0    0
  25     SeaTac SDN-3 M 25      1    1    1    1    0    0    0
  26     Miller Ck SR509 M26    1    1    1    1    0    0    0
  27     SDN-1 other M 27       1    1    1    1    0    0    0
  28     SDN-2 other M 28       1    1    1    1    0    0    0
  29     SDN-2 other M 29       1    1    1    1    0    0    0
  30     sum at SR-518          1    1    1    1    0    0    0
  31     sum Lake Reba inflo    1    1    1    1    0    0    0
  32     sum at I-509           1    1    1    1    0    0    0
  33     sum at 1st Ave S.      1    1    1    1    0    0    0
  34     sum at STP             1    1    1    1    0    0    0
  35     SeaTac Pond I          1    1    1    1    0    0    0
  36     Walker Creek           1    1    1    1    0    0    0
  37     sum at sound           1    1    1    1    0    0    0
  38     sum below Reba LK      1    1    1    1    0    0    0
END GEN-INFO
ACTIVITY
  RCHRES *************** Active Sections *****************
  # -  # HYFG ADFG CNFG HTFG SDFG GQFG OXFG NUFG PKFG PHFG                  ***
  1   38    1    0    0    0    0    0    0    0    0    0
END ACTIVITY
PRINT-INFO
  RCHRES *************** Printout Flags ****************** PIVL  PYR
  # -  # HYDR ADCA CONS HEAT  SED  GQL OXRX NUTR PLNK PHCB *********
  1   38    6    0    0    0    0    0    0    0    0    0    1    9
END PRINT-INFO
HYDR-PARM1
  RCHRES  Flags for each HYDR Section                                      ***
  # -  #  VC A1 A2 A3  ODFVFG for each *** ODGTFG for each     FUNCT  for each
          FG FG FG FG  possible  exit  *** possible  exit      possible  exit
           *  *  *  *   *  *  *  *  *      *  *  *  *  *          ***
  1   38  0  0  0  0    4  0  0  0  0      0  0  0  0  0       2  2  2  2  2
END HYDR-PARM1
HYDR-PARM2
  RCHRES                                                                   ***
  # -  #    FTABNO       LEN     DELTH     STCOR        KS      DB50       ***
<------><--------><--------><--------><--------><--------><-------->       ***
  1              1   0.010                             0.3
  2              2   0.660                             0.3
  3              3   0.980                             0.3
  4              4   0.010                             0.3
  5              5   0.380                             0.3
```

```
    6            6   0.010                        0.3
    7            7   0.010                        0.3
    8            8   0.596                        0.3
    9            9   0.010                        0.3
   10           10   0.380                        0.3
   11           11   0.010                        0.3
   12           12   1.000                        0.3
   13           13   0.015                        0.3
   14           14   0.450                        0.3
   15           15   0.735                        0.3
   16           16   0.772                        0.3
   17           17   0.755                        0.3
   18           18   0.800                        0.3
   19           19   0.910                        0.3
   20           20   0.010                        0.3
   21           21   0.450                        0.3
   22           22   0.300                        0.3
   23           30   0.010                        0.3
   24           30   0.010                        0.3
   25           30   0.010                        0.3
   26           26   0.780                        0.3
   27           30   0.010                        0.3
   28           30   0.010                        0.3
   29           30   0.010                        0.3
   30           30   0.010                        0.0
   31           30   0.010                        0.0
   32           30   0.010                        0.0
   33           30   0.010                        0.0
   34           30   0.010                        0.0
   35           30   0.010                        0.0
   36           30   0.010                        0.0
   37           30   0.010                        0.0
   38           30   0.010                        0.0
END HYDR-PARM2
HYDR-INIT
  RCHRES  Initial conditions for each HYDR section                     ***
  # -  # ***   VOL    Initial  value  of COLIND   Initial  value  of OUTDGT
         *** ac-ft    for each possible exit      for each possible exit
<------><-------->    <---><---><---><---><---> *** <---><---><---><---><--->
   1    2.0             4.0
   2    0.1             4.0
   3    0.1             4.0
   4    2.0             4.0
   5    0.1             4.0
   6    2.0             4.0
   7    0.1             4.0
   8    0.10            4.0
   9    0.10            4.0
  10    0.10            4.0
  11    0.10            4.0
  12    0.10            4.0
  13    10.0            4.0
  14    0.10            4.0
  15    0.1             4.0
  16    0.1             4.0
  17    0.1             4.0
```

```
    18      0.1            4.0
    19      0.1            4.0
    20      1.0            4.0
    21      0.1            4.0
    22      0.1            4.0
    23      0.1            4.0
    24      0.1            4.0
    25      0.1            4.0
    26      0.1            4.0
    27      0.1            4.0
    28      0.1            4.0
    29      0.1            4.0
    30      0.0            4.0
    31      0.1            4.0
    32      0.0            4.0
    33      0.0            4.0
    34      0.0            4.0
    35      0.0            4.0
    36      0.0            4.0
    37      0.0            4.0
    38      0.0            4.0
  END HYDR-INIT
END RCHRES

FTABLES
  FTABLE      1
 ROWS COLS ***
   10    4
      DEPTH      AREA     VOLUME   OUTFLOW  ***
      0.000    3.0000     0.0000      0.00
      0.500    3.0000     1.5000      1.80
      1.000    3.0000     3.0000      5.00
      1.500    3.3000     4.6000     10.90
      2.000    3.6000     6.5000     17.50
      2.500    3.9000     8.4000     26.20
      3.000    4.1000     10.500     32.50
      3.500    4.3000     12.500     35.90
      4.000    4.5000     16.000     38.10
      6.000    5.0000     26.000     46.40
  END FTABLE  1

  FTABLE      2
 ROWS COLS ***
    9    4
      DEPTH      AREA     VOLUME   OUTFLOW  ***
      0.000    0.0000     0.0000      0.00
      0.100    0.2571     0.0129      0.16
      0.500    0.3873     0.1417      6.53
      1.000    0.5501     0.3761     25.95
      1.500    0.7128     0.6918     59.86
      2.000    0.8756     1.0889    110.67
      3.000    1.2011     2.1273    272.24
      3.500    1.3639     2.7685    387.38
      4.000    1.5266     3.4912    528.19
  END FTABLE  2
```

```
 FTABLE       3
ROWS COLS ***
  12    4
     DEPTH      AREA    VOLUME   OUTFLOW   ***
     0.000    0.0000    0.0000      0.00
     0.100    0.9669    0.0483      0.13
     0.500    1.0637    0.4545      4.92
     1.000    1.1846    1.0165     17.12
     1.500    1.3055    1.6390     34.92
     2.000    1.4264    2.3220     57.95
     2.500    1.5473    3.0654     86.14
     3.000    1.6682    3.8693    119.53
     3.500    1.7891    4.7336    158.24
     4.000    1.9100    5.6584    202.41
     4.500    2.0294    6.6310    251.52
     5.000    2.1488    7.6624    306.28
 END FTABLE  3

 FTABLE       4
ROWS COLS ***
   5    4
     DEPTH      AREA    VOLUME   OUTFLOW   ***
     0.000    3.8000    0.0000      0.00
     1.000    4.6000    4.0000      0.00
     2.000    6.8000    9.7000      4.00
     3.000    9.1000    17.700     12.00
     4.000    14.000    29.300     30.00
 END FTABLE  4

 FTABLE       5
ROWS COLS ***
  10    4
     DEPTH      AREA    VOLUME   OUTFLOW   ***
     0.000    0.0000    0.0000      0.00
     0.100    0.1010    0.0051      0.03
     0.500    0.1754    0.0603      1.46
     1.000    0.2684    0.1713      6.16
     1.500    0.3614    0.3288     14.89
     2.000    0.4544    0.5327     28.48
     2.500    0.5474    0.7832     47.70
     3.000    0.6404    1.0801     73.29
     3.500    0.7334    1.4236    105.94
     4.000    0.8264    1.8136    146.33
 END FTABLE  5

 FTABLE       6
LAKE REBA MAX DEPTH = 5.0 FEET ***
ROWS COLS ***
   9    4
     DEPTH      AREA    VOLUME   OUTFLOW   ***
     0.000    2.0000    0.0000      0.00
     0.500    2.0000    1.0000      3.00
     1.000    2.0000    2.0000     12.00
     2.000    2.0000    4.0000     33.00
     3.000    2.0000    6.0000     45.00
     4.000    2.3000    8.3000     54.00
```

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      5.000    2.6000    10.900     66.00
      5.500    2.6000    11.500    100.00
      6.000    2.6000    12.000    200.00
  END FTABLE  6

  FTABLE      77
 PRE-LAKE REBA DETENTION POND***
 ROWS COLS ***
   12    4
      DEPTH      AREA    VOLUME   OUTFLOW    ***
      0.000    0.0000    0.0000      0.00
      0.100    0.1860    0.0093      0.12
      0.500    0.2552    0.0975      4.84
      1.000    0.3417    0.2467     18.49
      1.500    0.4282    0.4392     41.30
      2.000    0.5148    0.6750     74.40
      2.500    0.6013    0.9540    119.01
      3.000    0.6878    1.2763    176.30
      3.500    0.7744    1.6418    247.41
      4.000    0.8609    2.0506    333.43
      4.500    0.9470    2.4992    434.59
      5.000    1.0331    2.9905    552.33
  END FTABLE 77

  FTABLE       7
 POST-LAKE REBA DETENTION POND***
 ROWS COLS ***
   22    4
      DEPTH      AREA    VOLUME   OUTFLOW    ***
      0.000    0.0000    0.0000      0.00
      0.500    0.2500    0.1000      9.70
      1.000    0.3400    0.2500     19.50
      1.500    0.4200    0.4400     29.20
      2.000    0.5100    0.6800     38.90
      2.500    0.6000    0.9500     48.70
      3.000    0.7700    1.2700     58.40
      3.500    0.8600    1.6400     68.10
      4.000    0.9000    2.0500     77.70
      4.500    1.5000    2.4900     86.50
      5.000    2.4000    2.9000     94.40
      5.500    4.8000    5.7000    101.70
      6.000    7.2000    8.6000    108.50
      7.000    11.900    14.400    121.00
      8.000    14.500    29.500    132.40
      9.000    17.100    44.600    142.80
     10.000    19.700    59.700    152.20
     11.000    23.000    74.800    161.60
     11.500    25.000    82.400    178.90
     12.000    27.000    89.900    288.40
     12.500    27.000    97.500    495.20
     13.000    27.000    105.10    750.00
  END FTABLE  7

  FTABLE       8
 ROWS COLS ***
   16    4
```

```
    DEPTH      AREA    VOLUME   OUTFLOW   ***
      0.0         0         0         0
      0.8      3.18      3.54        15
      1.5      6.35      7.08        29
      2.1      8.27     11.53        59
      2.8     13.83     21.56        88
      2.8     16.08     25.04       105
      2.9     19.99     27.77       121
      2.9     21.18     29.96       138
      2.9     24.36     35.20       148
      3.0     26.01     37.46       159
      3.0     26.67     40.13       170
      3.4     30.59     44.93       190
      3.8     33.20     50.42       210
      4.2     35.17     55.96       230
      4.9     37.92     67.06       315
      5.3     40.75     78.08       400
 END FTABLE  8

 FTABLE      9
ROWS COLS ***
   7    4
    DEPTH      AREA    VOLUME   OUTFLOW   ***
    0.000    0.0000    0.0000      0.00
    1.000    0.4000    0.4000      2.00
    1.500    0.5000    1.0000      4.00
    2.000    0.9000    1.3000     11.00
    2.500    1.3000    1.6000     15.00
    3.000    1.6000    2.0000     18.00
    3.500    1.9000    2.5000     20.80
 END FTABLE  9

 FTABLE     10
ROWS COLS ***
   9    4
    DEPTH      AREA    VOLUME   OUTFLOW   ***
    0.000    0.0000    0.0000      0.00
    0.100    0.1010    0.0051      0.06
    0.500    0.1660    0.0585      2.27
    1.000    0.2472    0.1618      9.32
    1.500    0.3285    0.3057     22.08
    2.000    0.4097    0.4902     41.66
    2.500    0.4909    0.7154     69.09
    3.000    0.5722    0.9811    105.37
    4.000    0.6887    1.6116    209.70
 END FTABLE 10

 PRE AMBAUM DETENTION ***
 FTABLE    111
ROWS COLS ***
  12    4
    DEPTH      AREA    VOLUME   OUTFLOW   ***
    0.000    0.0000    0.0000      0.00
    0.500    0.2160    0.0750      5.30
    1.000    0.2730    0.1990     21.10
    1.500    0.2890    0.3410     43.90
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```
      2.000     0.2900     0.4830      68.80
      2.500     0.2910     0.6070      89.10
      3.000     0.2950     0.6820      90.00
      3.500     0.3000     2.1000     100.00
      4.000     0.3050     2.5000     105.00
      4.500     0.3100     3.0000     110.00
      5.000     0.3200     3.5000     120.00
      5.500     0.3300     4.0000     130.00
  END FTABLE111

  POST AMBAUM DETENTION ***
  FTABLE     11
 ROWS COLS ***
   13    4
      DEPTH      AREA     VOLUME    OUTFLOW    ***
      0.000     0.0000     0.0000       0.00
      1.000     0.1000     0.2300       3.90
      2.000     0.2000     0.6000       6.30
      3.000     0.3000     0.9700       8.10
      4.000     0.4000     1.3400      11.10
      5.000     0.5000     1.8200      16.00
      6.000     0.6000     2.2700      19.10
      7.000     0.7000     2.8300      21.60
      8.000     0.8000     3.3700      30.80
      9.000     0.9000     4.0000      38.10
     10.000     1.0000     4.6500      74.10
     10.500     1.1000     5.2000     133.00
     11.000     1.1500     5.3000     500.00
  END FTABLE 11

  FTABLE     16
 ROWS COLS ***
   16    4
      DEPTH      AREA     VOLUME    OUTFLOW    ***
        0.0         0          0          0
        0.9      2.29       2.45         17
        1.8      4.58       4.90         33
        2.3      6.23       8.16         66
        2.7      7.32      11.16         99
        3.1      8.53      13.48        166
        3.2     12.50      15.95        134
        3.2     13.47      17.67        151
        3.4     14.13      19.45        167
        3.5     15.74      21.67        183
        3.6     16.47      24.05        200
        3.8     19.24      27.78        225
        4.0     20.77      31.80        250
        4.2     21.78      35.78        275
        4.4     23.32      43.05        312
        4.7     25.31      49.62        350
  END FTABLE 16

  FTABLE     13
 ROWS COLS ***
    7    4
      DEPTH      AREA     VOLUME    OUTFLOW    ***
```

```
      0.000    40.000    0.0000      0.00
      1.000    41.400    40.000      0.00
      1.500    42.000    60.000     10.00
      2.000    42.700    80.000     16.00
      2.500    43.300    100.00     20.00
      3.000    44.000    120.00     28.00
      5.000    45.000    210.00     45.00
  END FTABLE 13

  FTABLE     12
 ROWS COLS ***
   10    4
     DEPTH      AREA    VOLUME   OUTFLOW    ***
     0.000    0.0000    0.0000      0.00
     0.100    0.6327    0.0316      0.15
     0.500    0.7960    0.3174      5.87
     1.000    1.0002    0.7664     21.53
     1.500    1.2043    1.3176     46.43
     2.000    1.4085    1.9708     81.20
     3.000    1.8168    3.5834    183.79
     4.000    2.2251    5.6044    336.22
     5.000    2.6335    8.0337    545.30
     6.000    3.0418   10.8713    817.51
  END FTABLE 12

  FTABLE     15
 ROWS COLS ***
   16    4
     DEPTH      AREA    VOLUME   OUTFLOW    ***
       0.0         0         0         0
       0.7      1.63      1.69        26
       1.3      3.26      3.37        51
       1.8      4.78      5.84       103
       2.2      5.75      8.15       154
       2.4      6.49      9.41       182
       2.6     10.66     12.23       210
       2.8     11.50     13.58       239
       2.9     12.06     15.04       261
       3.1     13.11     16.89       289
       3.1     13.68     18.87       306
       3.4     16.29     21.96       347
       3.5     17.73     25.34       388
       3.7     18.63     28.64       429
       4.0     20.04     35.13       491
       4.2     21.87     40.52       552
  END FTABLE 15

  FTABLE     14
 ROWS COLS ***
    8    4
     DEPTH      AREA    VOLUME   OUTFLOW    ***
     0.000    0.0000    0.0000      0.00
     0.100    0.3361    0.0168      0.24
     0.500    0.3809    0.1602      9.04
     1.000    0.4370    0.3647     31.61
     1.500    0.4930    0.5972     65.00
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    2.000    0.5491    0.8577    108.85
    2.500    0.6051    1.1462    163.33
    3.000    0.6612    1.4628    228.78
  END FTABLE 14

  FTABLE     17
 ROWS COLS ***
   16    4
     DEPTH      AREA    VOLUME   OUTFLOW   ***
       0.0         0         0         0
       0.9      0.83      0.96        26
       1.9      1.66      1.91        51
       2.6      3.05      3.52       103
       3.2      3.92      5.12       154
       3.5      4.61      6.03       182
       3.8      8.72      8.50       210
       4.0      9.52      9.51       239
       4.2     10.04     10.71       261
       4.4     11.05     12.25       289
       4.5     11.60     14.04       306
       4.8     14.12     16.70       347
       5.0     15.41     19.65       388
       5.2     16.12     22.54       429
       5.5     17.26     28.37       491
       5.7     18.88     33.12       552
  END FTABLE 17

  FTABLE     18
 ROWS COLS ***
    7    4
     DEPTH      AREA    VOLUME   OUTFLOW   ***
     0.000    0.0000    0.0000      0.00
     0.100    0.9758    0.0488      0.36
     0.500    0.9884    0.4416     13.44
     1.000    1.0042    0.9398     44.63
     2.000    1.0262    1.9550    136.47
     3.000    1.0482    2.9923    253.70
     4.000    2.5069    4.7698    347.74
  END FTABLE 18

  FTABLE     19
 ROWS COLS ***
    7    4
     DEPTH      AREA    VOLUME   OUTFLOW   ***
     0.000    0.0000    0.0000      0.00
     0.100    0.5620    0.0281      0.09
     0.500    0.6174    0.2640      3.38
     1.000    0.6866    0.5900     11.42
     2.000    0.8250    1.3458     37.28
     3.000    0.9635    2.2400     75.10
     4.000    1.1019    3.2727    125.11
  END FTABLE 19

  FTABLE     20
 ROWS COLS ***
    6    4
```

```
    DEPTH      AREA    VOLUME   OUTFLOW   ***
    0.000    0.0000    0.0000      0.00
    1.000    5.0000    2.0000      5.00
    2.000    10.000    9.5000     16.00
    3.000    15.000    22.000     30.00
    4.000    19.000    39.000     35.00
    5.000    22.000    50.000     39.00
 END FTABLE 20

 FTABLE     21
ROWS COLS ***
   8    4
    DEPTH      AREA    VOLUME   OUTFLOW   ***
    0.000    0.0000    0.0000      0.00
    0.100    0.2259    0.0113      0.11
    0.500    0.2707    0.1106      4.27
    1.000    0.3268    0.2600     15.13
    1.500    0.3828    0.4374     31.67
    2.000    0.4389    0.6428     54.02
    2.500    0.4949    0.8763     82.52
    3.000    0.5510    1.1377    117.55
 END FTABLE 21

 FTABLE     22
ROWS COLS ***
   9    4
    DEPTH      AREA    VOLUME   OUTFLOW   ***
    0.000    0.0000    0.0000      0.00
    0.100    0.3680    0.0184      0.25
    0.500    0.3717    0.1664      9.39
    1.000    0.3763    0.3534     31.06
    2.000    0.3819    0.7325     94.37
    3.000    0.3874    1.1171    174.33
    4.000    0.3930    1.5073    265.38
    5.000    0.3985    1.9030    364.68
    6.000    0.4040    2.3043    470.60
 END FTABLE 22

 FTABLE     26
ROWS COLS ***
  16    4
    DEPTH      AREA    VOLUME   OUTFLOW   ***
      0.0         0         0         0
      0.9      2.81      3.11        11
      1.8      5.61      6.22        21
      2.5      7.45     10.18        42
      3.1      9.68     14.24        64
      3.4     11.88     17.36        71
      3.4     15.77     19.85        74
      3.4     16.92     21.82        79
      3.5     17.67     23.68        83
      3.6     19.32     26.07        87
      3.6     19.96     28.46        89
      3.9     23.79     33.18       118
      4.1     26.26     38.23       146
      4.4     28.10     43.26       175
```

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      4.8     30.56     52.23       218
      5.2     33.13     60.48       261
  END FTABLE 26

  FTABLE     30
 ROWS COLS ***
   8    4
     DEPTH      AREA    VOLUME   OUTFLOW   ***
     0.000    0.0000    0.0000      0.00
     1.000    0.1000    0.0100     100.0
     2.000    0.2000    0.0200     200.0
     3.000    0.3000    0.0300     300.0
     4.000    0.4000    0.0400     500.0
     6.000    0.6000    0.0600     700.0
     7.000    0.7000    0.0800     800.0
     8.000    0.8000    0.1000     999.9
  END FTABLE 30
                                                                  ***
END FTABLES
                                                                  ***
END RUN
```

```
RUN
GLOBAL
  ***  DES MOINES CREEK HSPF MODEL
  ***  SIMULATION RUN - CURRENT LAND USE - EXISTING CONDITIONS ***
  DES MOINES CREEK BASIN HSPF MODEL
  START       1948/10/01 00:00  END    1994/07/31 24:00
  RUN INTERP OUTPUT LEVEL    0
  RESUME     0 RUN     1
END GLOBAL

FILES
<type>  <fun>***<-----------fname---------------------------------------->
INFO       21   c:\hspf10\hspinf.da
ERROR      22   c:\hspf10\hsperr.da
WARN       23   c:\hspf10\hspwrn.da
MESSU      24   DESM-C.ECH
WDM        25   DESM-sim.wdm
           91   flow.plt
END FILES

OPN SEQUENCE
    INGRP              INDELT 01:00
      PERLND      14
      PERLND      16
      PERLND      18
      PERLND      24
      PERLND      26
      PERLND      28
      PERLND      34
      PERLND      44
      PERLND      54
      IMPLND      14
      RCHRES       1
      RCHRES       2
      RCHRES       3
      RCHRES      49
      RCHRES      34
      RCHRES      35
      RCHRES      23
      RCHRES      28
      RCHRES      36
      RCHRES      37
      RCHRES       4
      RCHRES      38
      RCHRES      22
      RCHRES      27
      RCHRES      39
      RCHRES       5
      RCHRES       6
      RCHRES      51
      RCHRES      40
      RCHRES      21
      RCHRES      26
      RCHRES      44
      RCHRES      19
      RCHRES      24
```

```
      RCHRES     41
      RCHRES      8
      RCHRES      7
      RCHRES     20
      RCHRES     25
      RCHRES     42
      RCHRES      9
      RCHRES     10
      RCHRES     11
      RCHRES     50
      RCHRES     43
      RCHRES     12
      RCHRES     45
      RCHRES     13
      RCHRES     14
      RCHRES     16
      RCHRES     46
      RCHRES     47
      RCHRES     15
      RCHRES     17
      RCHRES     48
      RCHRES     18
    END INGRP
END OPN SEQUENCE
                                                                    ***
PERLND
  GEN-INFO
    <PLS >      Name          NBLKS  Unit-systems   Printer          ***
    # -  #                        User  t-series Engl Metr           ***
                                        in  out                      ***
   14      TFF- TILL FOR FLT     1    1    1    1   60    0
   16      TFM- TILL FOR MOD     1    1    1    1   60    0
   18      TFS- TILL FOR STP     1    1    1    1   60    0
   24      TGF- TILL GR FLT      1    1    1    1   60    0
   26      TGM- TILL GR MOD      1    1    1    1   60    0
   28      TGS- TILL GR STP      1    1    1    1   60    0
   34      OF - OUTWASH FOR      1    1    1    1   60    0
   44      OG - OUTWASH GR       1    1    1    1   60    0
   54      SA - WETLANDS         1    1    1    1   60    0
  END GEN-INFO
  ACTIVITY
    <PLS > ************* Active Sections *****************************
    # -  # ATMP SNOW PWAT  SED  PST  PWG PQAL MSTL PEST NITR PHOS TRAC   ***
   14  200    0    0    1    0    0    0    0    0    0    0    0    0
  END ACTIVITY
  PRINT-INFO
    <PLS > ********************* Print-flags ************************ PIVL  PYR
    # -  # ATMP SNOW PWAT  SED  PST  PWG PQAL MSTL PEST NITR PHOS TRAC *********
   14  200    0    0    6    0    0    0    0    0    0    0    0    0    1    9
  END PRINT-INFO
  PWAT-PARM1
    <PLS > **************** Flags *******************
    # -  # CSNO RTOP UZFG  VCS  VUZ  VNN VIFW VIRC  VLE                  ***
   14  200    0    0    0    0    0    0    0    0    0
  END PWAT-PARM1
  PWAT-PARM2
```

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```
    <PLS > ***
    # -  # ***FOREST       LZSN    INFILT      LSUR     SLSUR     KVARY     AGWRC
   14                    4.5000    0.3000    400.00    0.0500    0.5000    0.9960
   16                    4.5000    0.3000    400.00    0.1000    0.5000    0.9960
   18                    4.5000    0.3000    200.00    0.2000    0.5000    0.9960
   24                    4.5000    0.3000    400.00    0.0500    0.5000    0.9960
   26                    4.5000    0.3000    400.00    0.1000    0.5000    0.9960
   28                    4.5000    0.3000    200.00    0.2000    0.5000    0.9960
   34                    5.0000    2.0000    400.00    0.0500    0.3000    0.9960
   44                    5.0000    0.8000    400.00    0.0500    0.3000    0.9960
   54                    4.0000    2.0000    100.00    0.0010    0.5000    0.9960
  END PWAT-PARM2
  PWAT-PARM3
    <PLS >***
    # -  #*** PETMAX    PETMIN    INFEXP    INFILD    DEEPFR    BASETP    AGWETP
   14                              3.5000    2.0000       .40        0.        0.
   16                              2.0000    2.0000       .40        0.        0.
   18                              1.5000    2.0000       .40        0.        0.
   24                              2.5000    2.0000       .40        0.        0.
   26                              2.0000    2.0000       .40        0.        0.
   28                              1.5000    2.0000       .40        0.        0.
   34                              2.0000    2.0000       .40        0.        0.
   44                              2.0000    2.0000       .40        0.        0.
   54                              10.000    2.0000       .40        0.       0.7
  END PWAT-PARM3
  PWAT-PARM4
    <PLS >                                                           ***
    # -  #     CEPSC      UZSN      NSUR     INTFW       IRC     LZETP***
   14         0.2000    1.0000    0.3500     3.000    0.3000    0.7000
   16         0.2000    0.5000    0.3500     3.000    0.3000    0.7000
   18         0.2000    0.3000    0.3500     3.000    0.3000    0.7000
   24         0.1000    1.0000    0.2500     3.000    0.7000    0.2500
   26         0.1000    0.5000    0.2500     6.000    0.5000    0.2500
   28         0.1000    0.3000    0.2500     7.000    0.3000    0.2500
   34         0.2000    0.5000    0.3500     2.000    0.8000    0.7000
   44         0.1000    0.5000    0.2500     2.000    0.8000    0.2500
   54         0.1000    3.0000    0.5000     1.000    0.8000    0.8000
  END PWAT-PARM4
  PWAT-STATE1
    <PLS >  PWATER state variables***
    # -  #***     CEPS      SURS       UZS      IFWS       LZS      AGWS      GWVS
   14            0.078        0.    0.0010        0.     0.077     0.698     0.023
   16            0.078        0.    0.0010        0.     0.075     0.667     0.026
   18            0.078        0.    0.0010        0.     0.074     0.628     0.027
   24            0.051        0.    0.0010        0.     0.300     0.681     0.053
   26            0.051        0.    0.0050        0.     0.300     0.680     0.049
   28            0.051        0.    0.0060        0.     0.300     0.659     0.048
   34            0.078        0.    0.0010        0.     0.090     0.675     0.038
   44            0.051        0.    0.0040        0.     0.300     0.414     0.152
   54            0.051        0.    0.3330        0.     0.622     0.400     0.000
  END PWAT-STATE1
END PERLND
IMPLND
  GEN-INFO
    <ILS >      Name             Unit-systems   Printer                      ***
    # -  #                     User  t-series Engl Metr                      ***
```

```
                                         in  out                         ***
   14  200 IMPERVIOUS              1    1    1   60    0
  END GEN-INFO
  ACTIVITY
    <ILS > ************* Active Sections ****
    # -  # ATMP SNOW IWAT  SLD  IWG IQAL  ***
   14  200    0    0    1    0    0    0
  END ACTIVITY
  PRINT-INFO
    <ILS > ******** Print-flags ******** PIVL  PYR
    # -  # ATMP SNOW IWAT  SLD  IWG IQAL *********
   14  200    0    0    6    0    0    0    1    9
  END PRINT-INFO
  IWAT-PARM1
    <ILS >          Flags          ***                                       ***
    # -  # CSNO RTOP  VRS  VNN RTLI    ***                                   ***
   14  200    0    0    0    0    0
  END IWAT-PARM1
  IWAT-PARM2
    <ILS >                                                                   ***
    # -  #       LSUR     SLSUR      NSUR     RETSC                          ***
   14  200    200.00    0.0500    0.1000    0.1000
  END IWAT-PARM2
  IWAT-PARM3
    <ILS >                                                                   ***
    # -  #    PETMAX    PETMIN                                               ***
   14  200
  END IWAT-PARM3
  IWAT-STATE1
    <ILS >  IWATER state variables                                           ***
    # -  #       RETS      SURS                                              ***
   14  200 1.0000E-3 1.0000E-3
  END IWAT-STATE1
END IMPLND
                                                                             ***
EXT SOURCES
                                                                             ***
*** NOTE: The only RCHRES that precip and PET are applied to are lakes.
                                                                             ***
<-Volume-> <Member> SsysSgap<--Mult-->Tran <-Target vols> <-Grp> <-Member->  ***
<Name>   # <Name> # tem strg<-factor->strg <Name>   #   #        <Name> # #  ***
WDM      2 PREC     ENGLZERO                PERLND  14  54 EXTNL  PREC
WDM      2 PREC     ENGLZERO                IMPLND  14     EXTNL  PREC
WDM      3 EVAP     ENGLZERO  0.8      DIV  PERLND  14  54 EXTNL  PETINP
WDM      3 EVAP     ENGLZERO  0.8      DIV  IMPLND  14     EXTNL  PETINP
WDM      2 PREC     ENGLZERO                RCHRES  49     EXTNL  PREC
WDM      3 EVAP     ENGLZERO     0.8   DIV  RCHRES  49     EXTNL  PREC
WDM      2 PREC     ENGLZERO                RCHRES  51     EXTNL  PREC
WDM      3 EVAP     ENGLZERO     0.8   DIV  RCHRES  51     EXTNL  PREC
END EXT SOURCES
                                                                             ***
NETWORK

PERLND  24 PWATER PERO          0.0000      RCHRES   1     EXTNL  IVOL
PERLND  26 PWATER PERO          0.0000      RCHRES   1     EXTNL  IVOL
PERLND  28 PWATER PERO          0.0000      RCHRES   1     EXTNL  IVOL
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PERLND  34 PWATER PERO         0.0000      RCHRES   1      EXTNL  IVOL
PERLND  44 PWATER PERO         0.0000      RCHRES   1      EXTNL  IVOL
PERLND  54 PWATER PERO         0.0000      RCHRES   1      EXTNL  IVOL

                                                                      ***
***         <MEMBER> SSYSSGAP<--MULT-->TRAN <-TARGET VOLS>        <-MEMBER->
<NAME>   # <NAME>    TEM STRG<-FACTOR->STRG <NAME>    #    # <-GRP> <NAME> # # ***
*** SUB-BASIN DM  1
PERLND  26 PWATER PERO        24.475       RCHRES   1      EXTNL  IVOL
PERLND  44 PWATER PERO         2.038       RCHRES   1      EXTNL  IVOL
IMPLND  14 IWATER SURO         8.529       RCHRES   1      EXTNL  IVOL
*** SUB-BASIN DM  2
PERLND  26 PWATER PERO         0.7150      RCHRES   2      EXTNL  IVOL
PERLND  44 PWATER PERO         0.6230      RCHRES   2      EXTNL  IVOL
IMPLND  14 IWATER SURO         3.7040      RCHRES   2      EXTNL  IVOL
*** SUB-BASIN DM  3
PERLND  26 PWATER PERO         0.4070      RCHRES   3      EXTNL  IVOL
PERLND  44 PWATER PERO         0.1640      RCHRES   3      EXTNL  IVOL
IMPLND  14 IWATER SURO         1.2710      RCHRES   3      EXTNL  IVOL
*** SUB-BASIN DM  4
PERLND  26 PWATER PERO         4.4100      RCHRES   4      EXTNL  IVOL
IMPLND  14 IWATER SURO         9.5000      RCHRES   4      EXTNL  IVOL
*** SUB-BASIN DM  5
PERLND  26 PWATER PERO         3.3830      RCHRES   5      EXTNL  IVOL
PERLND  44 PWATER PERO         1.9330      RCHRES   5      EXTNL  IVOL
IMPLND  14 IWATER SURO         0.2340      RCHRES   5      EXTNL  IVOL
*** SUB-BASIN DM  6
PERLND  26 PWATER PERO         3.4770      RCHRES   6      EXTNL  IVOL
PERLND  44 PWATER PERO         2.1750      RCHRES   6      EXTNL  IVOL
IMPLND  14 IWATER SURO         0.6730      RCHRES   6      EXTNL  IVOL
*** SUB-BASIN DM  7
PERLND  26 PWATER PERO         4.1780      RCHRES   7      EXTNL  IVOL
PERLND  44 PWATER PERO         2.0320      RCHRES   7      EXTNL  IVOL
PERLND  54 PWATER PERO         0.9050      RCHRES   7      EXTNL  IVOL
IMPLND  14 IWATER SURO         3.1430      RCHRES   7      EXTNL  IVOL
*** SUB-BASIN DM  8
PERLND  26 PWATER PERO         0.0250      RCHRES   8      EXTNL  IVOL
PERLND  44 PWATER PERO         3.2370      RCHRES   8      EXTNL  IVOL
PERLND  54 PWATER PERO         0.2440      RCHRES   8      EXTNL  IVOL
IMPLND  14 IWATER SURO         2.4440      RCHRES   8      EXTNL  IVOL
*** SUB-BASIN DM  9
PERLND  26 PWATER PERO         5.3640      RCHRES   9      EXTNL  IVOL
PERLND  44 PWATER PERO         1.2690      RCHRES   9      EXTNL  IVOL
IMPLND  14 IWATER SURO         0.4510      RCHRES   9      EXTNL  IVOL
*** SUB-BASIN DM 10
PERLND  26 PWATER PERO         0.6080      RCHRES  10      EXTNL  IVOL
PERLND  44 PWATER PERO         2.3920      RCHRES  10      EXTNL  IVOL
PERLND  54 PWATER PERO         0.1000      RCHRES  10      EXTNL  IVOL
*** SUB-BASIN DM 11
PERLND  26 PWATER PERO         0.0580      RCHRES  11      EXTNL  IVOL
PERLND  44 PWATER PERO         2.7460      RCHRES  11      EXTNL  IVOL
PERLND  54 PWATER PERO         2.4220      RCHRES  11      EXTNL  IVOL
IMPLND  14 IWATER SURO         1.4730      RCHRES  11      EXTNL  IVOL
*** SUB-BASIN DM 12
PERLND  26 PWATER PERO         0.3330      RCHRES  12      EXTNL  IVOL
PERLND  44 PWATER PERO         2.4250      RCHRES  12      EXTNL  IVOL
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PERLND  54 PWATER PERO        1.8170      RCHRES  12      EXTNL  IVOL
*** SUB-BASIN DM 13
PERLND  26 PWATER PERO        2.7850      RCHRES  13      EXTNL  IVOL
PERLND  44 PWATER PERO        2.1920      RCHRES  13      EXTNL  IVOL
IMPLND  14 IWATER SURO        1.6990      RCHRES  13      EXTNL  IVOL
*** SUB-BASIN DM 14
PERLND  26 PWATER PERO        0.8140      RCHRES  14      EXTNL  IVOL
PERLND  44 PWATER PERO        3.3550      RCHRES  14      EXTNL  IVOL
IMPLND  14 IWATER SURO        0.4060      RCHRES  14      EXTNL  IVOL
*** SUB-BASIN DM 15
PERLND  26 PWATER PERO        0.8770      RCHRES  15      EXTNL  IVOL
PERLND  44 PWATER PERO        0.2380      RCHRES  15      EXTNL  IVOL
IMPLND  14 IWATER SURO        1.4690      RCHRES  15      EXTNL  IVOL
*** SUB-BASIN DM 16
PERLND  26 PWATER PERO       11.9260      RCHRES  16      EXTNL  IVOL
PERLND  44 PWATER PERO        2.6600      RCHRES  16      EXTNL  IVOL
IMPLND  14 IWATER SURO        4.7310      RCHRES  16      EXTNL  IVOL
*** SUB-BASIN DM 17
PERLND  26 PWATER PERO        1.3090      RCHRES  17      EXTNL  IVOL
PERLND  44 PWATER PERO        0.6120      RCHRES  17      EXTNL  IVOL
IMPLND  14 IWATER SURO        1.3120      RCHRES  17      EXTNL  IVOL
*** SUB-BASIN DM 18
PERLND  24 PWATER PERO        0.0420      RCHRES  18      EXTNL  IVOL
PERLND  26 PWATER PERO        1.2910      RCHRES  18      EXTNL  IVOL
PERLND  44 PWATER PERO        4.5670      RCHRES  18      EXTNL  IVOL
IMPLND  14 IWATER SURO        0.3340      RCHRES  18      EXTNL  IVOL
*** SUB-BASINS DM-19 TO DM-23 ARE SWS BASINS
*** SUB-BASIN DM 19
PERLND  24 PWATER PERO        1.1670      RCHRES  19      EXTNL  IVOL
IMPLND  14 IWATER SURO        0.8330      RCHRES  19      EXTNL  IVOL
*** SUB-BASIN DM 20
PERLND  24 PWATER PERO       18.4170      RCHRES  20      EXTNL  IVOL
IMPLND  14 IWATER SURO       17.4170      RCHRES  20      EXTNL  IVOL
*** SUB-BASIN DM 21
PERLND  24 PWATER PERO        2.1670      RCHRES  21      EXTNL  IVOL
IMPLND  14 IWATER SURO        1.5000      RCHRES  21      EXTNL  IVOL
*** SUB-BASIN DM 22
IMPLND  14 IWATER SURO        3.3330      RCHRES  22      EXTNL  IVOL
*** SUB-BASIN DM 23
PERLND  24 PWATER PERO        2.3330      RCHRES  23      EXTNL  IVOL
IMPLND  14 IWATER SURO        7.6670      RCHRES  23      EXTNL  IVOL
*** SUB-BASINS DM-24 TO DM-28 ARE SWS-OTHER BASINS
*** SUB-BASIN DM 24
PERLND  24 PWATER PERO        1.1330      RCHRES  24      EXTNL  IVOL
*** SUB-BASIN DM 25
PERLND  24 PWATER PERO        7.7420      RCHRES  25      EXTNL  IVOL
*** SUB-BASIN DM 26
PERLND  24 PWATER PERO        1.2420      RCHRES  26      EXTNL  IVOL
*** SUB-BASIN DM 27
*** SUB-BASIN DM 28
                                                                          ***
 *** CHANNEL NETWORK LINKAGES ***
                                                                          ***
*** NOTE: MFACTOR 12.1 CONVERTS ACRE-FEET OF RUNOFF TO AVERAGE CFS PER HOUR.
***       IT IS TIMESTEP DEPENDENT. THE OTHER MFACTORS CONVERT ACRE-FEET
***       OF RUNOFF TO INCHES.
```

```
                                                                                ***
RCHRES   1 HYDR   ROVOL   1              RCHRES  49      EXTNL  IVOL
RCHRES   2 HYDR   ROVOL   1              RCHRES  49      EXTNL  IVOL
RCHRES   3 HYDR   ROVOL   1              RCHRES  49      EXTNL  IVOL
RCHRES  49 HYDR   ROVOL   1              RCHRES  34      EXTNL  IVOL
RCHRES  34 HYDR   ROVOL   1              RCHRES  35      EXTNL  IVOL
RCHRES  35 HYDR   ROVOL   1              RCHRES  37      EXTNL  IVOL
RCHRES  23 HYDR   ROVOL   1              RCHRES  36      EXTNL  IVOL
RCHRES  28 HYDR   ROVOL   1              RCHRES  36      EXTNL  IVOL
RCHRES  36 HYDR   ROVOL   1              RCHRES  37      EXTNL  IVOL
RCHRES  37 HYDR   ROVOL   1              RCHRES  38      EXTNL  IVOL
RCHRES   4 HYDR   ROVOL   1              RCHRES  38      EXTNL  IVOL
RCHRES  38 HYDR   ROVOL   1              RCHRES   5      EXTNL  IVOL
RCHRES  22 HYDR   ROVOL   1              RCHRES  39      EXTNL  IVOL
RCHRES  27 HYDR   ROVOL   1              RCHRES  39      EXTNL  IVOL
RCHRES  39 HYDR   ROVOL   1              RCHRES   5      EXTNL  IVOL
RCHRES   6 HYDR   ROVOL   1              RCHRES  51      EXTNL  IVOL
RCHRES   5 HYDR   ROVOL   1              RCHRES  51      EXTNL  IVOL
RCHRES  51 HYDR   ROVOL   1              RCHRES  40      EXTNL  IVOL
RCHRES  40 HYDR   ROVOL   1              RCHRES  45      EXTNL  IVOL
RCHRES  21 HYDR   ROVOL   1              RCHRES  44      EXTNL  IVOL
RCHRES  26 HYDR   ROVOL   1              RCHRES  44      EXTNL  IVOL
RCHRES  44 HYDR   ROVOL   1              RCHRES  45      EXTNL  IVOL
RCHRES  19 HYDR   ROVOL   1              RCHRES  41      EXTNL  IVOL
RCHRES  24 HYDR   ROVOL   1              RCHRES  41      EXTNL  IVOL
RCHRES  41 HYDR   ROVOL   1              RCHRES  50      EXTNL  IVOL
RCHRES   8 HYDR   ROVOL   1              RCHRES   7      EXTNL  IVOL
RCHRES   7 HYDR   ROVOL   1              RCHRES  50      EXTNL  IVOL
RCHRES  20 HYDR   ROVOL   1              RCHRES  42      EXTNL  IVOL
RCHRES  25 HYDR   ROVOL   1              RCHRES  42      EXTNL  IVOL
RCHRES  42 HYDR   ROVOL   1              RCHRES  50      EXTNL  IVOL
RCHRES   9 HYDR   ROVOL   1              RCHRES  50      EXTNL  IVOL
RCHRES  10 HYDR   ROVOL   1              RCHRES  50      EXTNL  IVOL
RCHRES  11 HYDR   ROVOL   1              RCHRES  50      EXTNL  IVOL
RCHRES  50 HYDR   ROVOL   1              RCHRES  43      EXTNL  IVOL
RCHRES  43 HYDR   ROVOL   1              RCHRES  12      EXTNL  IVOL
RCHRES  12 HYDR   ROVOL   1              RCHRES  45      EXTNL  IVOL
RCHRES  45 HYDR   ROVOL   1              RCHRES  13      EXTNL  IVOL
RCHRES  13 HYDR   ROVOL   1              RCHRES  14      EXTNL  IVOL
RCHRES  14 HYDR   ROVOL   1              RCHRES  48      EXTNL  IVOL
RCHRES  16 HYDR   ROVOL   1              RCHRES  46      EXTNL  IVOL
RCHRES  46 HYDR   ROVOL   1              RCHRES  47      EXTNL  IVOL
RCHRES  47 HYDR   ROVOL   1              RCHRES  17      EXTNL  IVOL
RCHRES  15 HYDR   ROVOL   1              RCHRES  17      EXTNL  IVOL
RCHRES  17 HYDR   ROVOL   1              RCHRES  48      EXTNL  IVOL
RCHRES  48 HYDR   ROVOL   1              RCHRES  18      EXTNL  IVOL
                                                                                ***
END NETWORK
                                                                                ***
EXT TARGETS
<-Volume-> <-Grp> <-Member-><--Mult-->Tran <-Volume-> <Member> Tsys Tgap Amd ***
<Name>   #        <Name> # #<-factor->strg <Name>   # <Name>    tem strg strg***
RCHRES  40 HYDR   RO                       WDM     20 FLOW     ENGL      REPL***
RCHRES  51 HYDR   RO                       WDM     21 FLOW     ENGL      REPL
RCHRES  43 HYDR   RO                       WDM     22 FLOW     ENGL      REPL
RCHRES  18 HYDR   RO                       WDM     23 FLOW     ENGL      REPL
```

```
RCHRES  13 HYDR   RO                          WDM      24 FLOW      ENGL       REPL
END EXT TARGETS
                                                                                      ***
RCHRES
  GEN-INFO
    RCHRES         Name         Nexits   Unit Systems   Printer                       ***
    # -  #<------------------><---> User T-series  Engl Metr LKFG                     ***
                                                in  out                                ***
     1     Bow Lake Basin         1    1    1    1    0    0    0
     2     HWY 99                 1    1    1    1    0    0    0
     3     Local SeaTac busines   1    1    1    1    0    0    0
     4     Hwy 99 & 188th         1    1    1    1    0    0    0
     5     Upper E. branch        1    1    1    1    0    0    0
     6     Lower E. branch        1    1    1    1    0    0    0
     7     Upper W. branch        1    1    1    1    0    0    0
     8     Upper W. branch        1    1    1    1    0    0    0
     9     Upper W. branch        1    1    1    1    0    0    0
    10     Upper W. branch        1    1    1    1    0    0    0
    11     Upper W. branch        1    1    1    1    0    0    0
    12     Lower W. branch        1    1    1    1    0    0    0
    13     Above 200th Street     1    1    1    1    0    0    0
    14     Below 200th Street     1    1    1    1    0    0    0
    15     Local inflow           1    1    1    1    0    0    0
    16     Executel pond inflow   1    1    1    1    0    0    0
    17     Trailer parks          1    1    1    1    0    0    0
    18     Above 208th Street     1    1    1    1    0    0    0
    19     SWS SDW-3              1    1    1    1    0    0    0
    20     SWS SDS-3              1    1    1    1    0    0    0
    21     SWS SDS-4              1    1    1    1    0    0    0
    22     SWS SDS-1              1    1    1    1    0    0    0
    23     SWS SDE-4              1    1    1    1    0    0    0
    24     SWS SDW-3 Other        1    1    1    1    0    0    0
    25     SWS SDS-3 Other        1    1    1    1    0    0    0
    26     SWS SDS-4 Other        1    1    1    1    0    0    0
    27     SWS SDS-1 Other        1    1    1    1    0    0    0
    28     SWS SDE-4 Other        1    1    1    1    0    0    0
    29     Below 208th Street     1    1    1    1    0    0    0
    30     Lower DMC trib         1    1    1    1    0    0    0
    31     Senior Center          1    1    1    1    0    0    0
    32     SR-509                 1    1    1    1    0    0    0
    33     Mouth                  1    1    1    1    0    0    0
    34     Bow Lake outflow       1    1    1    1    0    0    0
    35     Pipeline A             1    1    1    1    0    0    0
    36     SDE-4 combined flow    1    1    1    1    0    0    0
    37     Pipeline B             1    1    1    1    0    0    0
    38     Upper E. branch        1    1    1    1    0    0    0
    39     SDS-1 combined flow    1    1    1    1    0    0    0
    40     Tyee Pond outflow      1    1    1    1    0    0    0
    41     SDW-3 combined flow    1    1    1    1    0    0    0
    42     SDS-3 combined flow    1    1    1    1    0    0    0
    43     NW Pond outflow        1    1    1    1    0    0    0
    44     SWS-4 combined flow    1    1    1    1    0    0    0
    45     E & W Branch confl.    1    1    1    1    0    0    0
    46     Executel outflow       1    1    1    1    0    0    0
    47     Pipeline C             1    1    1    1    0    0    0
    48     Sum below 200th        1    1    1    1    0    0    0
```

```
  49    Bow Lake inflow         1    1    1    1    0    0    0
  50    NW Pond inflow          1    1    1    1    0    0    0
  51    Tyee Pond inflow        1    1    1    1    0    0    0
END GEN-INFO
ACTIVITY
  RCHRES *************** Active Sections *****************
  # -  # HYFG ADFG CNFG HTFG SDFG GQFG OXFG NUFG PKFG PHFG              ***
  1   51    1    0    0    0    0    0    0    0    0    0
END ACTIVITY
PRINT-INFO
  RCHRES *************** Printout Flags ***************** PIVL  PYR
  # -  # HYDR ADCA CONS HEAT  SED  GQL OXRX NUTR PLNK PHCB *********
  1   51    6    0    0    0    0    0    0    0    0    0    1    9
END PRINT-INFO
HYDR-PARM1
  RCHRES  Flags for each HYDR Section                                  ***
  # -  #  VC A1 A2 A3  ODFVFG for each *** ODGTFG for each    FUNCT  for each
          FG FG FG FG  possible  exit  *** possible  exit     possible  exit
           *  *  *  *    *  *  *  *  *       *  *  *  *  *       ***
  1   51   0  0  0  0    4  0  0  0  0       0  0  0  0  0      2  2  2  2  2
END HYDR-PARM1
HYDR-PARM2
  RCHRES                                                               ***
  # -  #     FTABNO       LEN     DELTH     STCOR        KS      DB50  ***
<------><--------><--------><--------><--------><--------><-------->   ***
  1             1   0.010                             0.0
  2             1   0.660                             0.3
  3             1   0.980                             0.3
  4             1   0.010                             0.3
  5           205   0.380                             0.3
  6             1   0.010                             0.3
  7           204   0.010                             0.3
  8            44   0.596                             0.3
  9           150   0.010                             0.3
 10             1   0.380                             0.3
 11             1   0.010                             0.3
 12           203   1.000                             0.3
 13           207   0.015                             0.3
 14            59   0.450                             0.3
 15             1   0.735                             0.3
 16             1   0.772                             0.3
 17           201   0.755                             0.3
 18           200   0.800                             0.3
 19             1   0.910                             0.3
 20             1   0.010                             0.3
 21             1   0.450                             0.3
 22             1   0.300                             0.3
 23             1   0.010                             0.3
 24             1   0.010                             0.3
 25             1   0.010                             0.3
 26             1   0.780                             0.3
 27             1   0.010                             0.3
 28             1   0.010                             0.3
 29             1   0.010                             0.3
 30             1   0.010                             0.0
 31             1   0.010                             0.0
```

```
  32              1  0.010                         0.0
  33              1  0.010                         0.0
  34             99  0.010                         0.0
  35              1  0.010                         0.0
  36              1  0.100                         0.0
  37              1  0.010                         0.0
  38              1  0.010                         0.0
  39              1  0.100                         0.0
  40             89  0.010                         0.0
  41            140  0.010                         0.0
  42            135  0.010                         0.0
  43             25  0.010                         0.0
  44              1  0.010                         0.0
  45              1  0.010                         0.0
  46             59  0.010                         0.0
  47            202  0.010                         0.0
  48              1  0.010                         0.0
  49              1  0.010                         0.0
  50              1  0.010                         0.0
  51              1  0.010                         0.0
END HYDR-PARM2
HYDR-INIT
  RCHRES  Initial conditions for each HYDR section                               ***
  # -  # ***    VOL     Initial  value  of COLIND    Initial  value  of OUTDGT
       *** ac-ft        for each possible exit       for each possible exit
<------><-------->      <---><---><---><---><---> *** <---><---><---><---><--->
   1   2.0                4.0
   2   0.1                4.0
   3   0.1                4.0
   4   2.0                4.0
   5   0.1                4.0
   6   2.0                4.0
   7   0.1                4.0
   8   0.10               4.0
   9   0.10               4.0
  10   0.10               4.0
  11   0.10               4.0
  12   0.10               4.0
  13   10.0               4.0
  14   0.10               4.0
  15   0.1                4.0
  16   0.1                4.0
  17   0.1                4.0
  18   0.1                4.0
  19   0.1                4.0
  20   1.0                4.0
  21   0.1                4.0
  22   0.1                4.0
  23   0.1                4.0
  24   0.1                4.0
  25   0.1                4.0
  26   0.1                4.0
  27   0.1                4.0
  28   0.1                4.0
  29   0.1                4.0
  30   0.0                4.0
```

```
    31    0.1            4.0
    32    0.0            4.0
    33    0.0            4.0
    34    0.0            4.0
    35    0.0            4.0
    36    0.0            4.0
    37    0.0            4.0
    38    0.0            4.0
    39    0.0            4.0
    40    0.0            4.0
    41    0.0            4.0
    42    0.0            4.0
    43    0.0            4.0
    44    0.0            4.0
    45    0.0            4.0
    46    0.0            4.0
    47    0.0            4.0
    48    0.0            4.0
    49    0.0            4.0
    50    0.0            4.0
    51    0.0            4.0
  END HYDR-INIT
END RCHRES

FTABLES
  FTABLE      1
 ROWS COLS ***
    8    4
     DEPTH      AREA    VOLUME   OUTFLOW   ***
     0.000    0.0000    0.0000      0.00
     1.000    0.1000    0.0100     100.0
     2.000    0.2000    0.0200     200.0
     3.000    0.3000    0.0300     300.0
     4.000    0.4000    0.0400     500.0
     6.000    0.6000    0.0600     700.0
     7.000    0.7000    0.0800     800.0
     8.000    0.8000    0.1000     999.9
  END FTABLE  1

  FTABLE    115
  LENGTH    750     ***
 ROWS COLS ***
    9    4
      .000      .000      .000      .000
      .500      .176      .850     9.200
     1.000      .194     3.575    30.400
     2.000      .232    10.325   105.800
     3.000      .271    31.075   228.900
     4.000      .310    50.825   405.800
     5.000      .349   138.575   642.700
     6.000      .387   217.325   945.700
     7.000      .426   320.075  1320.700
  END FTABLE115

  FTABLE    110
  LENGTH    570     ***
```

```
 ROWS COLS ***
  11    4
      .000      .000      .000      .000
      .250      .020      .033     2.200
      .500      .027      .153     9.400
      .750      .031      .390    21.000
     1.000      .035      .765    36.000
     1.250      .039     1.303    53.600
     1.500      .039     1.990    72.000
     1.750      .041     2.828    89.500
     2.000      .041     3.815   104.700
     2.250      .041     4.928   114.200
     2.500      .038     6.128   114.300
  END FTABLE110

  FTABLE     25
  POND B      1     ***
 ROWS COLS ***
  11    4
      .000    13.500      .000      .000
      .280    13.500     3.800      .500
      .590    13.500     9.000     2.000
      .930    13.500    13.800     4.800
     1.250    13.500    19.000     8.600
     1.600    13.500    24.000    13.500
     1.920    13.500    28.500    19.300
     2.250    13.500    33.500    26.000
     2.600    13.500    36.500    37.000
     2.900    13.500    40.500    39.000
     3.200    13.500    43.700    49.000
  END FTABLE 25

  FTABLE    120
  LENGTH    590     ***
 ROWS COLS ***
  13    4
      .000      .000      .000      .000
      .600      .051      .450     6.000
     1.200      .068     2.100    25.500
     1.800      .080     5.430    56.800
     2.400      .090    10.740    97.700
     3.000      .095    18.150   145.200
     3.600      .100    27.690   195.100
     4.200      .102    39.330   242.700
     4.800      .103    52.950   283.700
     5.400      .101    68.280   309.400
     6.000      .096    84.810   309.500
     8.000      .072   141.510   402.000
    10.000      .058   198.410   476.000
  END FTABLE120

  FTABLE    125
  LENGTH  10470     ***
 ROWS COLS ***
  11    4
      .000      .000      .000      .000
```

```
     .200      .361      .020      .800
     .400      .406      .085     3.400
     .600      .481      .210     7.600
     .800      .541      .410    13.000
    1.000      .577      .690    19.400
    1.200      .601     1.050    26.000
    1.400      .605     1.485    32.400
    1.600      .608     1.990    37.900
    1.800      .601     2.560    41.300
    2.000      .566     3.174    41.400
 END FTABLE125

 FTABLE    135
 LENGTH   1200    ***
ROWS COLS ***
  7    4
     .000      .000      .000      .000
     .500      .198      .600     9.000
    1.000      .236     2.625    30.900
    2.000      .306    12.875   115.800
    3.000      .376    33.925   265.500
    4.000      .446    69.175   491.800
    5.000      .517   122.025   806.300
 END FTABLE135

 FTABLE     40
 LENGTH    750    ***
ROWS COLS ***
 12    4
     .000      .000      .000      .000
     .350      .037      .087     2.900
     .700      .052      .420    12.400
    1.050      .059     1.085    27.800
    1.400      .066     2.135    47.700
    1.750      .071     3.605    70.900
    2.100      .074     5.495    95.300
    2.450      .076     7.805   118.500
    2.800      .077    10.517   138.500
    3.150      .075    13.563   151.100
    3.500      .071    16.835   151.200
    3.900      .064    20.677   170.000
 END FTABLE 40

 FTABLE    140
 LENGTH   2300    ***
ROWS COLS ***
 11    4
     .000      .000      .000      .000
     .300      .098      .056     2.100
     .600      .132      .261     8.800
     .900      .158      .681    19.600
    1.200      .172     1.341    33.600
    1.500      .185     2.256    50.000
    1.800      .194     3.441    67.100
    2.100      .200     4.896    83.500
    2.400      .201     6.606    97.600
```

```
    2.700      .197     8.526   106.500
    3.000      .185    10.581   106.600
  END FTABLE140

  FTABLE    145
  LENGTH    900     ***
 ROWS COLS ***
   8    4
     .000      .000      .000      .000
     .500      .180      .725     6.200
    1.000      .208     3.125    20.800
    2.000      .260    14.875    75.400
    3.000      .313    38.425   168.700
    4.000      .366    77.175   306.900
    5.000      .418   134.525   496.100
    6.000      .471   213.875   742.300
  END FTABLE145

  FTABLE     44
  LENGTH    900     ***
 ROWS COLS ***
   8    4
     .000      .000      .000      .000
     .500      .180      .725     6.200
    1.000      .208     3.125    20.800
    2.000      .260    14.875    75.400
    3.000      .313    38.425   168.700
    4.000      .366    77.175   306.900
    5.000      .418   134.525   496.100
    6.000      .471   213.875   742.300
  END FTABLE 44

  FTABLE    150
  LENGTH   1000     ***
 ROWS COLS ***
   8    4
     .000      .000      .000      .000
     .500      .200      .725     9.700
    1.000      .231     3.125    32.600
    2.000      .289    14.875   118.300
    3.000      .348    38.425   264.700
    4.000      .406    77.175   481.500
    5.000      .465   134.525   778.400
    6.000      .523   213.875  1164.600
  END FTABLE150

  FTABLE     59
  EXECUTEL POND     ***
 ROWS COLS ***
  19    4
     .000      .000      .000      .000
    1.000      .080      .080    24.420
    2.000      .230      .310    34.540
    3.000      .393      .703    42.300
    3.500      .494      .950    45.690
    4.000      .508     1.204    48.850
```

```
     4.500      .532     1.470    51.810
     5.000      .540     1.740    54.610
     5.500      .540     2.010    57.280
     6.000      .580     2.300    59.820
     6.500      .600     2.600    62.270
     7.000      .600     2.900    64.620
     7.500      .600     3.200    66.900
     8.000      .620     3.510    69.100
     8.500      .640     3.830    71.200
     9.000      .740     4.200    82.220
    10.000      .650     4.850   119.830
    11.000      .720     5.570   169.000
    12.000      .750     6.320   250.900
  END FTABLE 59

  FTABLE     99
  BOW LAKE        ***
 ROWS COLS ***
   15    4
      .000    14.000      .000      .000
      .230    14.000     3.800      .300
      .470    14.000     6.900     1.100
      .720    14.000    10.000     2.500
      .960    14.000    13.800     4.400
     1.200    14.000    17.000     6.700
     1.450    14.000    20.500    12.000
     1.700    14.000    23.800    20.000
     2.000    14.000    25.000    35.000
     3.000    14.000    27.800    65.000
     4.000    14.000    41.000    90.000
     5.000    14.000    54.200   110.000
     6.000    14.000    67.400   130.000
     7.000    14.000    80.600   155.000
     8.000    14.000    93.800   180.000
  END FTABLE 99

  FTABLE    105
  LENGTH    460   ***
 ROWS COLS ***
   11    4
      .000      .000      .000      .000
      .300      .020      .056     1.000
      .600      .026      .261     4.200
      .900      .032      .681     9.400
     1.200      .034     1.341    16.200
     1.500      .037     2.262    24.000
     1.800      .039     3.458    32.300
     2.100      .040     4.917    40.100
     2.400      .040     6.627    46.900
     2.700      .039     8.547    51.200
     3.000      .037    10.617    51.300
  END FTABLE105

  FTABLE    100
  LENGTH   5700   ***
 ROWS COLS ***
```

```
 11    4
     .000      .000      .000      .000
     .400      .343      .140     2.200
     .800      .442      .640     9.500
    1.200      .523     1.640    21.100
    1.600      .577     3.220    36.300
    2.000      .618     5.420    54.000
    2.400      .646     8.260    72.500
    2.800      .659    11.720    90.200
    3.200      .662    15.760   105.500
    3.600      .649    20.300   115.000
    4.000      .618    25.200   125.100
  END FTABLE100

  FTABLE    200
  LENGTH   2150     ***
 ROWS COLS ***
 14    4
     .000      .000      .000      .000
     .500      .572      .191     7.300
    1.000      .799      .438    23.200
    2.000      .968     1.001    75.700
    3.000     1.155     1.727   155.100
    4.000     1.317     2.542   262.700
    5.000     1.478     3.475   400.300
    6.000     1.643     4.545   570.200
    7.000     1.791     5.688   774.400
    8.000     1.932     6.822  1015.100
    9.000     1.945     7.025  1294.500
   10.000     1.958     7.244  1614.500
   11.000     1.970     7.481  1977.000
   12.000     1.983     7.734  2384.700
  END FTABLE200

  FTABLE    201
  LENGTH   1125     ***
 ROWS COLS ***
 10    4
     .000      .000      .000      .000
     .300      .169      .034     2.900
     .600      .192      .076     9.800
     .900      .215      .128    20.400
    1.200      .238      .189    35.100
    1.500      .259      .258    54.100
    1.800      .282      .336    77.700
    2.100      .303      .423   106.200
    3.100      .376      .779   245.000
    3.600      .412      .988   335.000
  END FTABLE201

  FTABLE    202
  LENGTH   1330     ***
 ROWS COLS ***
 11    4
     .000      .000      .000      .000
     .350      .069      .020     4.600
```

AR 039625

```
      .700       .096       .056     19.200
     1.050       .112       .099     42.800
     1.400       .124       .150     73.400
     1.750       .125       .203    109.000
     2.100       .121       .240    146.600
     2.450       .110       .264    182.400
     2.800       .096       .284    213.200
     3.150       .090       .290    232.400
     3.500       .088       .293    232.600
  END FTABLE202

  FTABLE    203
  LENGTH   1440      ***
 ROWS COLS ***
   9    4
      .000       .000       .000       .000
      .500       .291       .111      3.600
     1.000       .346       .263     12.400
     2.000       .450       .684     45.800
     3.000       .554      1.256    103.500
     4.000       .656      1.974    189.700
     5.000       .753      2.788    308.400
     6.000       .796      3.189    464.400
     7.000       .837      3.623    658.200
  END FTABLE203

  FTABLE    204
  LENGTH   1800      ***
 ROWS COLS ***
   8    4
      .000       .000       .000       .000
      .500       .360       .120      6.200
     1.000       .416       .276     20.800
     2.000       .520       .694     75.400
     3.000       .626      1.252    168.700
     4.000       .732      1.950    306.900
     5.000       .836      2.790    496.100
     6.000       .942      3.768    742.300
  END FTABLE204

  FTABLE    205
  LENGTH   2235      ***
 ROWS COLS ***
  13    4
      .000       .000       .000       .000
      .550       .290       .098      4.900
     1.100       .543       .299     20.800
     1.650       .609       .520     46.500
     2.200       .671       .774     80.000
     2.750       .732      1.040    118.700
     3.300       .778      1.288    159.500
     3.850       .819      1.519    198.400
     4.400       .849      1.701    231.900
     4.950       .866      1.817    252.900
     5.500       .865      1.820    253.000
     8.200       .973      2.565    400.000
```

```
   10.200      1.043      3.139    520.000
 END FTABLE205

 FTABLE    206
 LENGTH   2010      ***
ROWS COLS ***
  13    4
      .000       .000       .000       .000
      .450       .134       .045      4.800
      .900       .190       .133     20.300
     1.350       .225       .236     45.400
     1.800       .249       .348     78.000
     2.250       .266       .474    115.900
     2.700       .271       .610    155.800
     3.150       .264       .707    193.800
     3.600       .251       .772    226.500
     4.050       .238       .812    247.000
     4.500       .234       .825    247.100
     6.500       .185       .833    340.000
     8.500       .166       .838    415.000
 END FTABLE206

 FTABLE    207
 LENGTH    750      ***
ROWS COLS ***
   9    4
      .000       .000       .000       .000
      .500       .153       .051      4.300
     1.000       .272       .132     14.400
     2.000       .317       .312     50.400
     3.000       .360       .544    109.600
     4.000       .404       .826    195.000
     5.000       .450      1.163    309.500
     6.000       .497      1.548    456.300
     7.000       .542      1.984    638.000
 END FTABLE207

 FTABLE     89
 TYEE POND          ***
ROWS COLS ***
  19    4
      .000       .000       .000       .000
     1.000       .272       .010      5.000
     2.000       .317       .022     10.000
     3.500       .360       .070     18.000
     4.500       .404       .200     23.000
     5.500       .450       .500     30.000
     6.500       .497       .880     38.000
     7.500       .542      1.300     46.000
     8.500       .642      2.400     54.000
     9.500       .742      3.300     64.000
    10.500       .842      4.800     73.000
    11.500       .942      6.000     83.000
    12.500      1.042      9.400     94.000
    13.500      1.142     11.100    105.000
    14.500      1.242     15.300    115.000
```

```
    16.000     1.442    19.200   130.000
    16.500     1.542    20.300   135.000
    17.000     1.672    21.500   270.000
    17.500     1.742    23.300   520.000
  END FTABLE 89

END FTABLES

END RUN
```

***

APPENDIX E

HSPF INPUT FILES - PROPOSED CONDITION SIMULATION

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```
RUN
GLOBAL
  ***  FILE: MILL-P5.UCI - FULL SIMULATION
  ***  PROPOSED CONDITIONS - DEVELOPED AREAS INCLUDED WITH DETENTION
  ***  NETWORK MODIFIED TO SIMPLIFY INCLUSION OF DETENTION
  MILLER CREEK BASIN HSPF MODEL
  START       1948/10/01 00:00  END    1994/07/31 24:00
  RUN INTERP OUTPUT LEVEL    0
  RESUME     0 RUN     1
END GLOBAL

FILES
<type>  <fun>***<------------fname------------------------------------------>
INFO       21   c:\hspf10\hspinf.da
ERROR      22   c:\hspf10\hsperr.da
WARN       23   c:\hspf10\hspwrn.da
MESSU      24   mill-c.ech
WDM        25   MILL-P5.wdm

END FILES

OPN SEQUENCE
    INGRP              INDELT 01:00
      PERLND      14
      PERLND      16
      PERLND      18
      PERLND      24
      PERLND      26
      PERLND      28
      PERLND      34
      PERLND      44
      PERLND      54
      IMPLND      14
      RCHRES       1
      RCHRES       2
      RCHRES       3
      RCHRES       4
      RCHRES       5
      RCHRES      30
      RCHRES      31
      RCHRES      23
      RCHRES      24
      RCHRES      25
      RCHRES      27
      RCHRES      28
      RCHRES      29
      RCHRES      45
      RCHRES      40
      RCHRES       6
      RCHRES      38
      RCHRES      41
      RCHRES       7
      RCHRES       9
      RCHRES      42
      RCHRES       8
      RCHRES      44
```

```
      RCHRES      43
      RCHRES      47
      RCHRES      26
      RCHRES      10
      RCHRES      32
      RCHRES      16
      RCHRES      11
      RCHRES      33
      RCHRES      13
      RCHRES      12
      RCHRES      46
      RCHRES      35
      RCHRES      20
      RCHRES      19
      RCHRES      15
      RCHRES      14
      RCHRES      34
      RCHRES      17
      RCHRES      18
      RCHRES      21
      RCHRES      36
      RCHRES      22
      RCHRES      37
    END INGRP
END OPN SEQUENCE
                                                                           ***

PERLND
  GEN-INFO
    <PLS >      Name            NBLKS   Unit-systems   Printer             ***
    # - #                               User  t-series Engl Metr           ***
                                              in  out                      ***
   14      TFF- TILL FOR FLT       1     1     1    1   60    0
   16      TFM- TILL FOR MOD       1     1     1    1   60    0
   18      TFS- TILL FOR STP       1     1     1    1   60    0
   24      TGF- TILL GR FLT        1     1     1    1   60    0
   26      TGM- TILL GR MOD        1     1     1    1   60    0
   28      TGS- TILL GR STP        1     1     1    1   60    0
   34      OF - OUTWASH FOR        1     1     1    1   60    0
   44      OG - OUTWASH GR         1     1     1    1   60    0
   54      SA - WETLANDS           1     1     1    1   60    0
  END GEN-INFO
  ACTIVITY
    <PLS > ************* Active Sections *****************************
    # -  # ATMP SNOW PWAT  SED  PST  PWG PQAL MSTL PEST NITR PHOS TRAC      ***
   14  200    0    0    1    0    0    0    0    0    0    0    0    0
  END ACTIVITY
  PRINT-INFO
    <PLS > ******************** Print-flags ************************ PIVL  PYR
    # -  # ATMP SNOW PWAT  SED  PST  PWG PQAL MSTL PEST NITR PHOS TRAC *********
   14  200    0    0    6    0    0    0    0    0    0    0    0    0    1    9
  END PRINT-INFO
  PWAT-PARM1
    <PLS > **************** Flags ******************
    # -  # CSNO RTOP UZFG  VCS  VUZ  VNN VIFW VIRC  VLE                    ***
   14  200    0    0    0    0    0    0    0    0    0
  END PWAT-PARM1
```

```
  PWAT-PARM2
    <PLS > ***
    # -  # ***FOREST      LZSN    INFILT      LSUR     SLSUR     KVARY     AGWRC
   14                   4.5000    0.1000    400.00    0.0500    0.5000    0.9800
   16                   4.5000    0.1000    400.00    0.1100    0.5000    0.9800
   18                   4.5000    0.1000    200.00    0.2000    0.5000    0.9800
   24                   4.5000    0.1000    400.00    0.0500    0.5000    0.9800
   26                   4.5000    0.1000    400.00    0.1000    0.5000    0.9800
   28                   4.5000    0.1000    200.00    0.2000    0.5000    0.9800
   34                   5.0000    1.5000    400.00    0.0500    0.3000    0.9800
   44                   5.0000    0.7000    400.00    0.0500    0.3000    0.9800
   54                   4.0000    1.0000    100.00    0.0010    0.5000    0.9800
  END PWAT-PARM2
  PWAT-PARM3
    <PLS >***
    # -  #*** PETMAX    PETMIN    INFEXP    INFILD    DEEPFR    BASETP    AGWETP
   14                             2.5000    2.0000       .80        0.        0.
   16                             2.0000    2.0000       .80        0.        0.
   18                             1.5000    2.0000       .80        0.        0.
   24                             3.5000    2.0000       .80        0.        0.
   26                             2.0000    2.0000       .80        0.        0.
   28                             1.5000    2.0000       .80        0.        0.
   34                             2.0000    2.0000       .90        0.        0.
   44                             2.0000    2.0000       .90        0.        0.
   54                             10.000    2.0000       .00        0.       0.7
  END PWAT-PARM3
  PWAT-PARM4
    <PLS >                                                                ***
    # -  #      CEPSC      UZSN      NSUR     INTFW       IRC     LZETP***
   14          0.1000    0.2500    0.3500     1.700    0.1200    0.7000
   16          0.1000    0.2500    0.3500     1.700    0.1200    0.7000
   18          0.1000    0.2500    0.3500     1.700    0.1200    0.7000
   24          0.1000    0.2500    0.2500     1.700    0.1200    0.2500
   26          0.1000    0.2500    0.2500     1.700    0.1200    0.2500
   28          0.1000    0.1500    0.2500     1.700    0.1200    0.2500
   34          0.1000    0.2500    0.3500     1.700    0.1200    0.7000
   44          0.1000    0.2500    0.2500      .000    0.1200    0.2500
   54          0.1000    3.0000    0.5000     1.000    0.1200    0.8000
  END PWAT-PARM4
  PWAT-STATE1
    <PLS >  PWATER state variables***
    # -  #***    CEPS      SURS       UZS      IFWS       LZS      AGWS      GWVS
   14           0.078        0.    0.0010        0.     0.077     0.698     0.023
   16           0.078        0.    0.0010        0.     0.075     0.667     0.026
   18           0.078        0.    0.0010        0.     0.074     0.628     0.027
   24           0.051        0.    0.0010        0.     0.300     0.681     0.053
   26           0.051        0.    0.0050        0.     0.300     0.680     0.049
   28           0.051        0.    0.0060        0.     0.300     0.659     0.048
   34           0.078        0.    0.0010        0.     0.090     0.675     0.038
   44           0.051        0.    0.0040        0.     0.300     0.414     0.152
   54           0.051        0.    0.3330        0.     0.622     0.400     0.000
  END PWAT-STATE1
END PERLND
IMPLND
  GEN-INFO
    <ILS >      Name            Unit-systems   Printer                      ***
```

```
    # - #                     User  t-series Engl Metr                    ***
                                     in  out                              ***
   14     IMPERVIOUS             1    1    1   60    0
  END GEN-INFO
  ACTIVITY
    <ILS > ************* Active Sections ****
    # -  # ATMP SNOW IWAT  SLD  IWG IQAL  ***
   14         0    0    1    0    0    0
  END ACTIVITY
  PRINT-INFO
    <ILS > ******** Print-flags ******** PIVL  PYR
    # -  # ATMP SNOW IWAT  SLD  IWG IQAL *********
   14         0    0    6    0    0    0    1    9
  END PRINT-INFO
  IWAT-PARM1
    <ILS >          Flags            ***                                  ***
    # -  # CSNO RTOP  VRS  VNN RTLI  ***                                  ***
   14         0    0    0    0    0
  END IWAT-PARM1
  IWAT-PARM2
    <ILS >                                                                ***
    # -  #      LSUR     SLSUR      NSUR     RETSC                        ***
   14         500.00    0.0500    0.1000    0.1000
  END IWAT-PARM2
  IWAT-PARM3
    <ILS >                                                                ***
    # -  #    PETMAX    PETMIN                                            ***
   14
  END IWAT-PARM3
  IWAT-STATE1
    <ILS >  IWATER state variables                                        ***
    # -  #      RETS      SURS                                            ***
   14      1.0000E-3 1.0000E-3
  END IWAT-STATE1
END IMPLND
                                                                          ***
EXT SOURCES
                                                                          ***
*** NOTE: The only RCHRES that precip and PET are applied to are lakes.
                                                                          ***
<-Volume-> <Member> SsysSgap<--Mult-->Tran <-Target vols> <-Grp> <-Member->  ***
<Name>   # <Name> # tem strg<-factor->strg <Name>   #   #        <Name> # #  ***
WDM      2 PREC     ENGLZERO               PERLND  14 200 EXTNL  PREC
WDM      2 PREC     ENGLZERO               IMPLND  14     EXTNL  PREC
WDM      3 EVAP     ENGLZERO 0.8      DIV  PERLND  14 200 EXTNL  PETINP
WDM      3 EVAP     ENGLZERO 0.8      DIV  IMPLND  14     EXTNL  PETINP
WDM      2 PREC     ENGLZERO               RCHRES   1     EXTNL  PREC
WDM      3 EVAP     ENGLZERO    0.8   DIV  RCHRES   1     EXTNL  PREC
WDM      2 PREC     ENGLZERO               RCHRES   4     EXTNL  PREC
WDM      3 EVAP     ENGLZERO    0.8   DIV  RCHRES   4     EXTNL  PREC
WDM      2 PREC     ENGLZERO               RCHRES   6     EXTNL  PREC
WDM      3 EVAP     ENGLZERO    0.8   DIV  RCHRES   6     EXTNL  PREC
WDM      2 PREC     ENGLZERO               RCHRES   9     EXTNL  PREC
WDM      3 EVAP     ENGLZERO    0.8   DIV  RCHRES   9     EXTNL  PREC
WDM      2 PREC     ENGLZERO               RCHRES  13     EXTNL  PREC
WDM      3 EVAP     ENGLZERO    0.8   DIV  RCHRES  13     EXTNL  PREC
```

```
WDM      2 PREC      ENGLZERO                   RCHRES  20      EXTNL   PREC
WDM      3 EVAP      ENGLZERO    0.8      DIV   RCHRES  20      EXTNL   PREC
WDM      2 PREC      ENGLZERO                   RCHRES  11      EXTNL   PREC
WDM      3 EVAP      ENGLZERO    0.8      DIV   RCHRES  11      EXTNL   PREC
WDM      2 PREC      ENGLZERO                   RCHRES  38      EXTNL   PREC
WDM      3 EVAP      ENGLZERO    0.8      DIV   RCHRES  38      EXTNL   PREC

UNIT FLOW TO RCHRES, TO INPUT GROUNDWATER BASE FLOW ***
0.0825 IS EQUIVALENT TO 1 CFS (HSPF UNITS ARE AC-FT/HR)      ***

WDM      4 FLOW      ENGLZERO   .120            RCHRES  35      EXTNL   IVOL
WDM      4 FLOW      ENGLZERO   .150            RCHRES  36      EXTNL   IVOL
END EXT SOURCES
                                                                                    ***
NETWORK
                                                                                    ***
***          <MEMBER> SSYSSGAP<--MULT-->TRAN <-TARGET VOLS>        <-MEMBER->
<NAME>    # <NAME>    TEM STRG<-FACTOR->STRG <NAME>    #    # <-GRP> <NAME> # # ***
*** SUB-BASIN  M  1
PERLND  24 PWATER PERO        18.0890       RCHRES   1      EXTNL   IVOL
PERLND  44 PWATER PERO         2.8620       RCHRES   1      EXTNL   IVOL
IMPLND  14 IWATER SURO         1.0000       RCHRES   1      EXTNL   IVOL
*** SUB-BASIN  M  2
PERLND  24 PWATER PERO        24.5040       RCHRES   2      EXTNL   IVOL
PERLND  44 PWATER PERO         6.2290       RCHRES   2      EXTNL   IVOL
IMPLND  14 IWATER SURO         1.0000       RCHRES   2      EXTNL   IVOL
*** SUB-BASIN  M  3
PERLND  24 PWATER PERO         8.6810       RCHRES   3      EXTNL   IVOL
PERLND  44 PWATER PERO         8.6850       RCHRES   3      EXTNL   IVOL
IMPLND  14 IWATER SURO         1.0000       RCHRES   3      EXTNL   IVOL
*** SUB-BASIN  M  4
PERLND  24 PWATER PERO        11.2490       RCHRES   4      EXTNL   IVOL
PERLND  44 PWATER PERO        15.7180       RCHRES   4      EXTNL   IVOL
PERLND  54 PWATER PERO         0.5330       RCHRES   4      EXTNL   IVOL
IMPLND  14 IWATER SURO         1.0000       RCHRES   4      EXTNL   IVOL
*** SUB-BASIN  M  5
PERLND  24 PWATER PERO         3.8470       RCHRES   5      EXTNL   IVOL
PERLND  44 PWATER PERO         6.1840       RCHRES   5      EXTNL   IVOL
PERLND  54 PWATER PERO         0.6920       RCHRES   5      EXTNL   IVOL
IMPLND  14 IWATER SURO         0.5000       RCHRES   5      EXTNL   IVOL
*** SUB-BASIN  M  6
PERLND  24 PWATER PERO         1.3640       RCHRES  31      EXTNL   IVOL
PERLND  44 PWATER PERO         2.9840       RCHRES  31      EXTNL   IVOL
PERLND  54 PWATER PERO         1.3420       RCHRES  31      EXTNL   IVOL
IMPLND  14 IWATER SURO         0.2150       RCHRES  31      EXTNL   IVOL
*** SUB-BASIN  M  7
PERLND  24 PWATER PERO         0.3580       RCHRES  41      EXTNL   IVOL
PERLND  44 PWATER PERO         0.2850       RCHRES  41      EXTNL   IVOL
PERLND  54 PWATER PERO         1.2750       RCHRES  41      EXTNL   IVOL
IMPLND  14 IWATER SURO         0.2480       RCHRES  41      EXTNL   IVOL
*** INCREASE IMP AREA
*** SUB-BASIN  M  8
PERLND  24 PWATER PERO         0.0001       RCHRES  42      EXTNL   IVOL
PERLND  44 PWATER PERO         4.5200       RCHRES  42      EXTNL   IVOL
PERLND  54 PWATER PERO         0.9500       RCHRES  42      EXTNL   IVOL
IMPLND  14 IWATER SURO         0.6550       RCHRES  42      EXTNL   IVOL
```

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*** SUB-BASIN  M  9
PERLND  14 PWATER PERO        0.3080       RCHRES   9       EXTNL   IVOL
PERLND  24 PWATER PERO        1.5060       RCHRES   9       EXTNL   IVOL
PERLND  44 PWATER PERO        5.2560       RCHRES   9       EXTNL   IVOL
IMPLND  14 IWATER SURO        2.1200       RCHRES   9       EXTNL   IVOL
*** SUB-BASIN  M 10
PERLND  14 PWATER IFWO        0.3830       RCHRES  10       EXTNL   IVOL
PERLND  14 PWATER SURO        0.3830       RCHRES  10       EXTNL   IVOL
PERLND  24 PWATER IFWO        3.0950       RCHRES  10       EXTNL   IVOL
PERLND  24 PWATER SURO        3.0950       RCHRES  10       EXTNL   IVOL
PERLND  44 PWATER PERO        8.1390       RCHRES  10       EXTNL   IVOL
IMPLND  14 IWATER SURO        6.8500       RCHRES  10       EXTNL   IVOL
*** SUB-BASIN  M 11
PERLND  14 PWATER IFWO        0.3830       RCHRES  11       EXTNL   IVOL
PERLND  14 PWATER SURO        0.3830       RCHRES  11       EXTNL   IVOL
PERLND  24 PWATER IFWO        5.2150       RCHRES  11       EXTNL   IVOL
PERLND  24 PWATER SURO        5.2150       RCHRES  11       EXTNL   IVOL
PERLND  34 PWATER PERO        0.1500       RCHRES  11       EXTNL   IVOL
PERLND  44 PWATER PERO        3.6250       RCHRES  11       EXTNL   IVOL
IMPLND  14 IWATER SURO       18.3350       RCHRES  11       EXTNL   IVOL
*** SUB-BASIN  M 12
PERLND  24 PWATER IFWO        8.2340       RCHRES  12       EXTNL   IVOL
PERLND  24 PWATER SURO        8.2340       RCHRES  12       EXTNL   IVOL
PERLND  34 PWATER PERO        0.4580       RCHRES  12       EXTNL   IVOL
PERLND  44 PWATER PERO        4.2860       RCHRES  12       EXTNL   IVOL
PERLND  54 PWATER PERO        0.6920       RCHRES  12       EXTNL   IVOL
IMPLND  14 IWATER SURO        7.5470       RCHRES  12       EXTNL   IVOL
*** SUB-BASIN  M 13
PERLND  24 PWATER IFWO       14.2540       RCHRES  13       EXTNL   IVOL
PERLND  24 PWATER SURO       14.2540       RCHRES  13       EXTNL   IVOL
IMPLND  14 IWATER SURO        3.8210       RCHRES  13       EXTNL   IVOL
*** SUB-BASIN  M 14
PERLND  16 PWATER IFWO        1.2480       RCHRES  14       EXTNL   IVOL
PERLND  16 PWATER SURO        1.2480       RCHRES  14       EXTNL   IVOL
PERLND  26 PWATER IFWO        8.8480       RCHRES  14       EXTNL   IVOL
PERLND  26 PWATER SURO        8.8480       RCHRES  14       EXTNL   IVOL
PERLND  34 PWATER PERO        1.8170       RCHRES  14       EXTNL   IVOL
PERLND  44 PWATER PERO        1.6290       RCHRES  14       EXTNL   IVOL
IMPLND  14 IWATER SURO        1.8580       RCHRES  14       EXTNL   IVOL
*** SUB-BASIN  M 15
PERLND  24 PWATER PERO        0.8800       RCHRES  15       EXTNL   IVOL
PERLND  26 PWATER PERO        2.5880       RCHRES  15       EXTNL   IVOL
PERLND  34 PWATER PERO        3.9080       RCHRES  15       EXTNL   IVOL
PERLND  44 PWATER PERO        6.8400       RCHRES  15       EXTNL   IVOL
IMPLND  14 IWATER SURO        1.7170       RCHRES  15       EXTNL   IVOL
*** SUB-BASIN  M 16
PERLND  14 PWATER PERO        0.7670       RCHRES  16       EXTNL   IVOL
PERLND  24 PWATER PERO        1.7390       RCHRES  16       EXTNL   IVOL
PERLND  34 PWATER PERO        1.9170       RCHRES  16       EXTNL   IVOL
PERLND  44 PWATER PERO        1.3720       RCHRES  16       EXTNL   IVOL
IMPLND  14 IWATER SURO        1.0310       RCHRES  16       EXTNL   IVOL
*** SUB-BASIN  M 17
PERLND  16 PWATER PERO        1.2510       RCHRES  17       EXTNL   IVOL
PERLND  26 PWATER PERO        0.4530       RCHRES  17       EXTNL   IVOL
PERLND  34 PWATER PERO       11.0640       RCHRES  17       EXTNL   IVOL
IMPLND  14 IWATER SURO        0.4780       RCHRES  17       EXTNL   IVOL
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*** SUB-BASIN  M 18
PERLND  16 PWATER PERO        1.5440      RCHRES  18      EXTNL  IVOL
PERLND  24 PWATER PERO        7.8930      RCHRES  18      EXTNL  IVOL
IMPLND  14 IWATER SURO        0.2880      RCHRES  18      EXTNL  IVOL
*** SUB-BASIN  M 19
PERLND  14 PWATER PERO        0.9170      RCHRES  19      EXTNL  IVOL
PERLND  24 PWATER PERO        8.7930      RCHRES  19      EXTNL  IVOL
PERLND  34 PWATER PERO        1.0750      RCHRES  19      EXTNL  IVOL
PERLND  44 PWATER PERO        8.6610      RCHRES  19      EXTNL  IVOL
PERLND  54 PWATER PERO        0.5330      RCHRES  19      EXTNL  IVOL
IMPLND  14 IWATER SURO        3.3790      RCHRES  19      EXTNL  IVOL
*** SUB-BASIN  M 20
PERLND  24 PWATER PERO        1.3520      RCHRES  46      EXTNL  IVOL
PERLND  44 PWATER PERO        7.6650      RCHRES  46      EXTNL  IVOL
PERLND  54 PWATER PERO        2.1080      RCHRES  46      EXTNL  IVOL
IMPLND  14 IWATER SURO        5.3000      RCHRES  46      EXTNL  IVOL
*** SUB-BASIN  M 21
PERLND  16 PWATER PERO        0.5920      RCHRES  21      EXTNL  IVOL
PERLND  24 PWATER PERO        5.3360      RCHRES  21      EXTNL  IVOL
PERLND  26 PWATER PERO        7.5640      RCHRES  21      EXTNL  IVOL
PERLND  34 PWATER PERO        2.6480      RCHRES  21      EXTNL  IVOL
PERLND  44 PWATER PERO        7.7690      RCHRES  21      EXTNL  IVOL
IMPLND  14 IWATER SURO        5.1400      RCHRES  21      EXTNL  IVOL
*** SUB-BASIN  M 22
PERLND  34 PWATER PERO        1.1100      RCHRES  22      EXTNL  IVOL
PERLND  44 PWATER PERO        1.1050      RCHRES  22      EXTNL  IVOL
IMPLND  14 IWATER SURO        0.2350      RCHRES  22      EXTNL  IVOL
*** SUB-BASIN  M 23
IMPLND  14 IWATER SURO        1.1670      RCHRES  23      EXTNL  IVOL
*** SUB-BASIN  M 24
PERLND  24 PWATER SURO        0.5830      RCHRES  24      EXTNL  IVOL
IMPLND  14 IWATER SURO        2.2500      RCHRES  24      EXTNL  IVOL
*** SUB-BASIN  M 25
PERLND  24 PWATER SURO        2.5080      RCHRES  25      EXTNL  IVOL
IMPLND  14 IWATER SURO        1.5830      RCHRES  25      EXTNL  IVOL
*** SUB-BASIN  M 26
PERLND  24 PWATER PERO        1.2980      RCHRES  43      EXTNL  IVOL
PERLND  44 PWATER PERO        5.2230      RCHRES  43      EXTNL  IVOL
PERLND  54 PWATER PERO        0.0670      RCHRES  43      EXTNL  IVOL
IMPLND  14 IWATER SURO        0.3360      RCHRES  43      EXTNL  IVOL
*** SUB-BASIN  M 27
PERLND  44 PWATER PERO        0.0960      RCHRES  27      EXTNL  IVOL
PERLND  54 PWATER PERO        0.2670      RCHRES  27      EXTNL  IVOL
IMPLND  14 IWATER SURO        0.5450      RCHRES  27      EXTNL  IVOL
*** SUB-BASIN  M 28
*** SUB-BASIN  M 29
PERLND  24 PWATER SURO        1.2750      RCHRES  28      EXTNL  IVOL
*** SUB-BASIN  M 44
PERLND  24 PWATER PERO       13.5670      RCHRES  44      EXTNL  IVOL
IMPLND  14 IWATER SURO        3.1830      RCHRES  44      EXTNL  IVOL
*** SUB-BASIN  M 45
PERLND  24 PWATER PERO        4.0830      RCHRES  45      EXTNL  IVOL
IMPLND  14 IWATER SURO        3.4580      RCHRES  45      EXTNL  IVOL
*** SUB-BASIN  M 46
PERLND  24 PWATER PERO        4.2080      RCHRES  46      EXTNL  IVOL
IMPLND  14 IWATER SURO        1.4750      RCHRES  46      EXTNL  IVOL
```

```
                                                                                          ***
  *** CHANNEL NETWORK LINKAGES ***
                                                                                          ***
*** NOTE: MFACTOR 12.1 CONVERTS ACRE-FEET OF RUNOFF TO AVERAGE CFS PER HOUR.
***       IT IS TIMESTEP DEPENDENT. THE OTHER MFACTORS CONVERT ACRE-FEET
***       OF RUNOFF TO INCHES.
                                                                                          ***
RCHRES   1 HYDR   ROVOL  1              RCHRES   2    EXTNL  IVOL
RCHRES   2 HYDR   ROVOL  1              RCHRES   3    EXTNL  IVOL
RCHRES   3 HYDR   ROVOL  1              RCHRES  30    EXTNL  IVOL
RCHRES   4 HYDR   ROVOL  1              RCHRES   5    EXTNL  IVOL
RCHRES   5 HYDR   ROVOL  1              RCHRES  30    EXTNL  IVOL
RCHRES  30 HYDR   ROVOL  1              RCHRES  38    EXTNL  IVOL
RCHRES  27 HYDR   ROVOL  1              RCHRES  40    EXTNL  IVOL
RCHRES  28 HYDR   ROVOL  1              RCHRES  40    EXTNL  IVOL
RCHRES  29 HYDR   ROVOL  1              RCHRES  40    EXTNL  IVOL
RCHRES  23 HYDR   ROVOL  1              RCHRES  40    EXTNL  IVOL
RCHRES  24 HYDR   ROVOL  1              RCHRES  40    EXTNL  IVOL
RCHRES  25 HYDR   ROVOL  1              RCHRES  40    EXTNL  IVOL
RCHRES  31 HYDR   ROVOL  1              RCHRES  40    EXTNL  IVOL
RCHRES  45 HYDR   ROVOL  1              RCHRES  40    EXTNL  IVOL
RCHRES  40 HYDR   ROVOL  1              RCHRES   6    EXTNL  IVOL
RCHRES   6 HYDR   ROVOL  1              RCHRES  38    EXTNL  IVOL
RCHRES  38 HYDR   ROVOL  1              RCHRES   7    EXTNL  IVOL
RCHRES  41 HYDR   ROVOL  1              RCHRES   7    EXTNL  IVOL***
RCHRES   7 HYDR   ROVOL  1              RCHRES   8    EXTNL  IVOL
RCHRES   9 HYDR   ROVOL  1              RCHRES   8    EXTNL  IVOL
RCHRES  42 HYDR   ROVOL  1              RCHRES   8    EXTNL  IVOL***
RCHRES  43 HYDR   ROVOL  1              RCHRES  26    EXTNL  IVOL***
RCHRES  44 HYDR   ROVOL  1              RCHRES  26    EXTNL  IVOL***
RCHRES  41 HYDR   ROVOL  1              RCHRES  47    EXTNL  IVOL
RCHRES  42 HYDR   ROVOL  1              RCHRES  47    EXTNL  IVOL
RCHRES  43 HYDR   ROVOL  1              RCHRES  47    EXTNL  IVOL
RCHRES  44 HYDR   ROVOL  1              RCHRES  47    EXTNL  IVOL
RCHRES  47 HYDR   ROVOL  1              RCHRES  26    EXTNL  IVOL
RCHRES   8 HYDR   ROVOL  1              RCHRES  26    EXTNL  IVOL
RCHRES  26 HYDR   ROVOL  1              RCHRES  32    EXTNL  IVOL
RCHRES  10 HYDR   ROVOL  1              RCHRES  32    EXTNL  IVOL
RCHRES  32 HYDR   ROVOL  1              RCHRES  16    EXTNL  IVOL
RCHRES  16 HYDR   ROVOL  1              RCHRES  33    EXTNL  IVOL
RCHRES  11 HYDR   ROVOL  1              RCHRES  33    EXTNL  IVOL
RCHRES  13 HYDR   ROVOL  1              RCHRES  12    EXTNL  IVOL
RCHRES  12 HYDR   ROVOL  1              RCHRES  15    EXTNL  IVOL
RCHRES  33 HYDR   ROVOL  1              RCHRES  15    EXTNL  IVOL
RCHRES  46 HYDR   ROVOL  1              RCHRES  35    EXTNL  IVOL
RCHRES  35 HYDR   ROVOL  1              RCHRES  20    EXTNL  IVOL
RCHRES  20 HYDR   ROVOL  1              RCHRES  19    EXTNL  IVOL
RCHRES  19 HYDR   ROVOL  1              RCHRES  15    EXTNL  IVOL
RCHRES  15 HYDR   ROVOL  1              RCHRES  34    EXTNL  IVOL
RCHRES  14 HYDR   ROVOL  1              RCHRES  34    EXTNL  IVOL
RCHRES  34 HYDR   ROVOL  1              RCHRES  17    EXTNL  IVOL
RCHRES  17 HYDR   ROVOL  1              RCHRES  37    EXTNL  IVOL
RCHRES  18 HYDR   ROVOL  1              RCHRES  36    EXTNL  IVOL
RCHRES  21 HYDR   ROVOL  1              RCHRES  36    EXTNL  IVOL
RCHRES  36 HYDR   ROVOL  1              RCHRES  22    EXTNL  IVOL
RCHRES  22 HYDR   ROVOL  1              RCHRES  37    EXTNL  IVOL
```

```
                                                                              ***
END NETWORK
                                                                              ***
EXT TARGETS
<-Volume-> <-Grp> <-Member-><--Mult-->Tran <-Volume-> <Member> Tsys Tgap Amd ***
<Name>   #        <Name> # #<-factor->strg <Name>   # <Name>    tem strg strg***
RCHRES  17 HYDR   RO                       WDM     20 FLOW     ENGL      REPL
RCHRES   7 HYDR   RO                       WDM     21 FLOW     ENGL      REPL
RCHRES  26 HYDR   RO                       WDM     22 FLOW     ENGL      REPL
RCHRES  33 HYDR   RO                       WDM     23 FLOW     ENGL      REPL
RCHRES  40 HYDR   RO                       WDM     24 FLOW     ENGL      REPL***
RCHRES  47 HYDR   RO                       WDM     25 FLOW     ENGL      REPL***
RCHRES  46 HYDR   RO                       WDM     26 FLOW     ENGL      REPL***
END EXT TARGETS
                                                                              ***
RCHRES
  GEN-INFO
    RCHRES       Name        Nexits   Unit Systems   Printer                  ***
    # -  #<------------------><---> User T-series  Engl Metr LKFG             ***
                                          in  out                             ***
     1     Arbor Lake  M 1         1    1    1    1    0    0    0
     2     Arbor Ck -03710 M 2     1    1    1    1    0    0    0
     3     Arbor Ck    M 3         1    1    1    1    0    0    0
     4     Tub Lake    M 4         1    1    1    1    0    0    0
     5     Miller Ck SR518 M5      1    1    1    1    0    0    0
     6     Lake Reba out  M 6      1    1    1    1    0    0    0
     7     Miller Ck Detent M7     1    1    1    1    0    0    0
     8     Miller Ck SW160 M8      1    1    1    1    0    0    0
     9     Lora Lake   M 9         1    1    1    1    0    0    0
    10     Trib (0371G)   M 10     1    1    1    1    0    0    0
    11     Miller Ck trib M 11     1    1    1    1    0    0    0
    12     Trib(0354)  M 12        1    1    1    1    0    0    0
    13     Burien Lake M 13        1    1    1    1    0    0    0
    14     Trib (0353) M 14        1    1    1    1    0    0    0
    15     Miller Ck above STP     1    1    1    1    0    0    0
    16     Miller Ck below 1st     1    1    1    1    0    0    0
    17     Miller Ck below STP     1    1    1    1    0    0    0
    18     Trib (0371A) M 18       1    1    1    1    0    0    0
    19     Trib (0371A) M 19       1    1    1    1    0    0    0
    36     confl. A + H tribs      1    1    1    1    0    0    0
    20     Trib    M 20            1    1    1    1    0    0    0
    21     Trib (0371H) M 21       1    1    1    1    0    0    0
    22     Trib (0371A) M 22       1    1    1    1    0    0    0
    23     SeaTac SDN-1 M 23       1    1    1    1    0    0    0
    24     SeaTac SDN-2 M 24       1    1    1    1    0    0    0
    25     SeaTac SDN-3 M 25       1    1    1    1    0    0    0
    26     Miller Ck SR509 M26     1    1    1    1    0    0    0
    27     SDN-1 other M 27        1    1    1    1    0    0    0
    28     SDN-2 other M 28        1    1    1    1    0    0    0
    29     SDN-2 other M 29        1    1    1    1    0    0    0
    30     sum at SR-518           1    1    1    1    0    0    0
    31     sum Lake Reba inflo     1    1    1    1    0    0    0
    32     sum at I-509            1    1    1    1    0    0    0
    33     sum at 1st Ave S.       1    1    1    1    0    0    0
    34     sum at STP              1    1    1    1    0    0    0
    35     SeaTac Pond I           1    1    1    1    0    0    0
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  36     Walker Creek           1    1    1    1    0    0    0
  37     sum at sound           1    1    1    1    0    0    0
  38     sum below Reba LK      1    1    1    1    0    0    0
  40     Lake Reba inflow       1    1    1    1    0    0    0
  41     M-7 flow               1    1    1    1    0    0    0
  42     M-8 flow               1    1    1    1    0    0    0
  43     M-26 flow              1    1    1    1    0    0    0
  44     Flow sum               1    1    1    1    0    0    0
  45     Flow sum               1    1    1    1    0    0    0
  46     Flow sum               1    1    1    1    0    0    0
  47     Flow sum               1    1    1    1    0    0    0
END GEN-INFO
ACTIVITY
  RCHRES *************** Active Sections ****************
  # -  # HYFG ADFG CNFG HTFG SDFG GQFG OXFG NUFG PKFG PHFG                 ***
  1   47    1    0    0    0    0    0    0    0    0    0
END ACTIVITY
PRINT-INFO
  RCHRES *************** Printout Flags ****************** PIVL  PYR
  # -  # HYDR ADCA CONS HEAT  SED  GQL OXRX NUTR PLNK PHCB *********
  1   47    6    0    0    0    0    0    0    0    0    0    1    9
END PRINT-INFO
HYDR-PARM1
  RCHRES  Flags for each HYDR Section                                      ***
  # -  #  VC A1 A2 A3  ODFVFG for each *** ODGTFG for each     FUNCT  for each
          FG FG FG FG  possible  exit  *** possible  exit      possible  exit
           *  *  *  *    *  *  *  *  *       *  *  *  *  *         ***
  1   47   0  0  0  0    4  0  0  0  0       0  0  0  0  0       2  2  2  2  2
END HYDR-PARM1
HYDR-PARM2
  RCHRES                                                                   ***
  # -  #    FTABNO       LEN     DELTH     STCOR        KS      DB50       ***
<------><--------><--------><--------><--------><--------><-------->       ***
  1              1  0.010                               0.3
  2              2  0.660                               0.3
  3              3  0.980                               0.3
  4              4  0.010                               0.3
  5              5  0.380                               0.3
  6              6  0.010                               0.3
  7              7  0.010                               0.3
  8              8  0.596                               0.3
  9              9  0.010                               0.3
 10             10  0.380                               0.3
 11             11  0.010                               0.3
 12             12  1.000                               0.3
 13             13  0.015                               0.3
 14             14  0.450                               0.3
 15             15  0.735                               0.3
 16             16  0.772                               0.3
 17             17  0.755                               0.3
 18             18  0.800                               0.3
 19             19  0.910                               0.3
 20             20  0.010                               0.3
 21             21  0.450                               0.3
 22             22  0.300                               0.3
 23             30  0.010                               0.3
```

```
   24              30   0.010                               0.3
   25              30   0.010                               0.3
   26              26   0.780                               0.3
   27              30   0.010                               0.3
   28              30   0.010                               0.3
   29              30   0.010                               0.3
   30              30   0.010                               0.0
   31              30   0.010                               0.0
   32              30   0.010                               0.0
   33              30   0.010                               0.0
   34              30   0.010                               0.0
   35              30   0.010                               0.0
   36              30   0.010                               0.0
   37              30   0.010                               0.0
   38              30   0.010                               0.0
   40              40   0.010                               0.0
   41              30   0.010                               0.0
   42              30   0.010                               0.0
   43              30   0.010                               0.0
   44              30   0.010                               0.0
   45              30   0.010                               0.0
   46              46   0.010                               0.0
   47              47   0.010                               0.0
  END HYDR-PARM2
  HYDR-INIT
    RCHRES  Initial conditions for each HYDR section                  ***
    # -  # ***   VOL      Initial  value  of COLIND     Initial  value  of OUTDGT
           *** ac-ft      for each possible exit        for each possible exit
  <------><-------->      <---><---><---><---><---> *** <---><---><---><---><--->
     1     2.0              4.0
     2     0.1              4.0
     3     0.1              4.0
     4     2.0              4.0
     5     0.1              4.0
     6     2.0              4.0
     7     0.1              4.0
     8     0.10             4.0
     9     0.10             4.0
    10     0.10             4.0
    11     0.10             4.0
    12     0.10             4.0
    13     10.0             4.0
    14     0.10             4.0
    15     0.1              4.0
    16     0.1              4.0
    17     0.1              4.0
    18     0.1              4.0
    19     0.1              4.0
    20     1.0              4.0
    21     0.1              4.0
    22     0.1              4.0
    23     0.1              4.0
    24     0.1              4.0
    25     0.1              4.0
    26     0.1              4.0
    27     0.1              4.0
```

```
   28      0.1                4.0
   29      0.1                4.0
   30      0.0                4.0
   31      0.1                4.0
   32      0.0                4.0
   33      0.0                4.0
   34      0.0                4.0
   35      0.0                4.0
   36      0.0                4.0
   37      0.0                4.0
   38      0.0                4.0
   40      0.0                4.0
   41      0.0                4.0
   42      0.0                4.0
   43      0.0                4.0
   44      0.0                4.0
   45      0.0                4.0
   46      0.0                4.0
   47      0.0                4.0
  END HYDR-INIT
END RCHRES

FTABLES
  FTABLE      1
 ROWS COLS ***
   10    4
     DEPTH      AREA     VOLUME    OUTFLOW   ***
     0.000    3.0000     0.0000       0.00
     0.500    3.0000     1.5000       1.80
     1.000    3.0000     3.0000       5.00
     1.500    3.3000     4.6000      10.90
     2.000    3.6000     6.5000      17.50
     2.500    3.9000     8.4000      26.20
     3.000    4.1000     10.500      32.50
     3.500    4.3000     12.500      35.90
     4.000    4.5000     16.000      38.10
     6.000    5.0000     26.000      46.40
  END FTABLE  1

  FTABLE      2
 ROWS COLS ***
    9    4
     DEPTH      AREA     VOLUME    OUTFLOW   ***
     0.000    0.0000     0.0000       0.00
     0.100    0.2571     0.0129       0.16
     0.500    0.3873     0.1417       6.53
     1.000    0.5501     0.3761      25.95
     1.500    0.7128     0.6918      59.86
     2.000    0.8756     1.0889     110.67
     3.000    1.2011     2.1273     272.24
     3.500    1.3639     2.7685     387.38
     4.000    1.5266     3.4912     528.19
  END FTABLE  2

  FTABLE      3
 ROWS COLS ***
```

```
   12    4
     DEPTH      AREA    VOLUME   OUTFLOW   ***
     0.000    0.0000    0.0000      0.00
     0.100    0.9669    0.0483      0.13
     0.500    1.0637    0.4545      4.92
     1.000    1.1846    1.0165     17.12
     1.500    1.3055    1.6390     34.92
     2.000    1.4264    2.3220     57.95
     2.500    1.5473    3.0654     86.14
     3.000    1.6682    3.8693    119.53
     3.500    1.7891    4.7336    158.24
     4.000    1.9100    5.6584    202.41
     4.500    2.0294    6.6310    251.52
     5.000    2.1488    7.6624    306.28
  END FTABLE  3

  FTABLE      4
 ROWS COLS ***
    5    4
     DEPTH      AREA    VOLUME   OUTFLOW   ***
     0.000    3.8000    0.0000      0.00
     1.000    4.6000    4.0000      0.00
     2.000    6.8000    9.7000      4.00
     3.000    9.1000    17.700     12.00
     4.000    14.000    29.300     30.00
  END FTABLE  4

  FTABLE      5
 ROWS COLS ***
   10    4
     DEPTH      AREA    VOLUME   OUTFLOW   ***
     0.000    0.0000    0.0000      0.00
     0.100    0.1010    0.0051      0.03
     0.500    0.1754    0.0603      1.46
     1.000    0.2684    0.1713      6.16
     1.500    0.3614    0.3288     14.89
     2.000    0.4544    0.5327     28.48
     2.500    0.5474    0.7832     47.70
     3.000    0.6404    1.0801     73.29
     3.500    0.7334    1.4236    105.94
     4.000    0.8264    1.8136    146.33
  END FTABLE  5

  FTABLE      6
 LAKE REBA MAX DEPTH = 5.0 FEET ***
 ROWS COLS ***
    9    4
     DEPTH      AREA    VOLUME   OUTFLOW   ***
     0.000    2.0000    0.0000      0.00
     0.500    2.0000    1.0000      3.00
     1.000    2.0000    2.0000     12.00
     2.000    2.0000    4.0000     33.00
     3.000    2.0000    6.0000     45.00
     4.000    2.3000    8.3000     54.00
     5.000    2.6000    10.900     66.00
     5.500    2.6000    11.500    100.00
```

```
    6.000    2.6000    12.000    200.00
  END FTABLE  6

  FTABLE     77
 PRE-LAKE REBA DETENTION POND***
 ROWS COLS ***
   12    4
    DEPTH      AREA    VOLUME   OUTFLOW    ***
    0.000    0.0000    0.0000      0.00
    0.100    0.1860    0.0093      0.12
    0.500    0.2552    0.0975      4.84
    1.000    0.3417    0.2467     18.49
    1.500    0.4282    0.4392     41.30
    2.000    0.5148    0.6750     74.40
    2.500    0.6013    0.9540    119.01
    3.000    0.6878    1.2763    176.30
    3.500    0.7744    1.6418    247.41
    4.000    0.8609    2.0506    333.43
    4.500    0.9470    2.4992    434.59
    5.000    1.0331    2.9905    552.33
  END FTABLE 77

  FTABLE      7
 POST-LAKE REBA DETENTION POND***
 ROWS COLS ***
   22    4
    DEPTH      AREA    VOLUME   OUTFLOW    ***
    0.000    0.0000    0.0000      0.00
    0.500    0.2500    0.1000      9.70
    1.000    0.3400    0.2500     19.50
    1.500    0.4200    0.4400     29.20
    2.000    0.5100    0.6800     38.90
    2.500    0.6000    0.9500     48.70
    3.000    0.7700    1.2700     58.40
    3.500    0.8600    1.6400     68.10
    4.000    0.9000    2.0500     77.70
    4.500    1.5000    2.4900     86.50
    5.000    2.4000    2.9000     94.40
    5.500    4.8000    5.7000    101.70
    6.000    7.2000    8.6000    108.50
    7.000    11.900    14.400    121.00
    8.000    14.500    29.500    132.40
    9.000    17.100    44.600    142.80
   10.000    19.700    59.700    152.20
   11.000    23.000    74.800    161.60
   11.500    25.000    82.400    178.90
   12.000    27.000    89.900    288.40
   12.500    27.000    97.500    495.20
   13.000    27.000    105.10    750.00
  END FTABLE  7

  FTABLE      8
 ROWS COLS ***
   16    4
    DEPTH      AREA    VOLUME   OUTFLOW    ***
      0.0         0         0         0
```

```
      0.8      3.18      3.54        15
      1.5      6.35      7.08        29
      2.1      8.27     11.53        59
      2.8     13.83     21.56        88
      2.8     16.08     25.04       105
      2.9     19.99     27.77       121
      2.9     21.18     29.96       138
      2.9     24.36     35.20       148
      3.0     26.01     37.46       159
      3.0     26.67     40.13       170
      3.4     30.59     44.93       190
      3.8     33.20     50.42       210
      4.2     35.17     55.96       230
      4.9     37.92     67.06       315
      5.3     40.75     78.08       400
  END FTABLE  8

  FTABLE      9
 ROWS COLS ***
   7    4
     DEPTH      AREA    VOLUME   OUTFLOW   ***
     0.000    0.0000    0.0000      0.00
     1.000    0.4000    0.4000      2.00
     1.500    0.5000    1.0000      4.00
     2.000    0.9000    1.3000     11.00
     2.500    1.3000    1.6000     15.00
     3.000    1.6000    2.0000     18.00
     3.500    1.9000    2.5000     20.80
  END FTABLE  9

  FTABLE     10
 ROWS COLS ***
   9    4
     DEPTH      AREA    VOLUME   OUTFLOW   ***
     0.000    0.0000    0.0000      0.00
     0.100    0.1010    0.0051      0.06
     0.500    0.1660    0.0585      2.27
     1.000    0.2472    0.1618      9.32
     1.500    0.3285    0.3057     22.08
     2.000    0.4097    0.4902     41.66
     2.500    0.4909    0.7154     69.09
     3.000    0.5722    0.9811    105.37
     4.000    0.6887    1.6116    209.70
  END FTABLE 10

  PRE AMBAUM DETENTION ***
  FTABLE    111
 ROWS COLS ***
  12    4
     DEPTH      AREA    VOLUME   OUTFLOW   ***
     0.000    0.0000    0.0000      0.00
     0.500    0.2160    0.0750      5.30
     1.000    0.2730    0.1990     21.10
     1.500    0.2890    0.3410     43.90
     2.000    0.2900    0.4830     68.80
     2.500    0.2910    0.6070     89.10
```

```
     3.000    0.2950    0.6820     90.00
     3.500    0.3000    2.1000    100.00
     4.000    0.3050    2.5000    105.00
     4.500    0.3100    3.0000    110.00
     5.000    0.3200    3.5000    120.00
     5.500    0.3300    4.0000    130.00
  END FTABLE111

  POST AMBAUM DETENTION ***
  FTABLE     11
 ROWS COLS ***
   13    4
     DEPTH      AREA    VOLUME   OUTFLOW   ***
     0.000    0.0000    0.0000      0.00
     1.000    0.1000    0.2300      3.90
     2.000    0.2000    0.6000      6.30
     3.000    0.3000    0.9700      8.10
     4.000    0.4000    1.3400     11.10
     5.000    0.5000    1.8200     16.00
     6.000    0.6000    2.2700     19.10
     7.000    0.7000    2.8300     21.60
     8.000    0.8000    3.3700     30.80
     9.000    0.9000    4.0000     38.10
    10.000    1.0000    4.6500     74.10
    10.500    1.1000    5.2000    133.00
    11.000    1.1500    5.3000    500.00
  END FTABLE 11

  FTABLE     16
 ROWS COLS ***
   16    4
     DEPTH      AREA    VOLUME   OUTFLOW   ***
       0.0         0         0         0
       0.9      2.29      2.45        17
       1.8      4.58      4.90        33
       2.3      6.23      8.16        66
       2.7      7.32     11.16        99
       3.1      8.53     13.48       166
       3.2     12.50     15.95       134
       3.2     13.47     17.67       151
       3.4     14.13     19.45       167
       3.5     15.74     21.67       183
       3.6     16.47     24.05       200
       3.8     19.24     27.78       225
       4.0     20.77     31.80       250
       4.2     21.78     35.78       275
       4.4     23.32     43.05       312
       4.7     25.31     49.62       350
  END FTABLE 16

  FTABLE     13
 ROWS COLS ***
    7    4
     DEPTH      AREA    VOLUME   OUTFLOW   ***
     0.000    40.000    0.0000      0.00
     1.000    41.400    40.000      0.00
```

```
    1.500    42.000    60.000     10.00
    2.000    42.700    80.000     16.00
    2.500    43.300    100.00     20.00
    3.000    44.000    120.00     28.00
    5.000    45.000    210.00     45.00
 END FTABLE 13

 FTABLE     12
ROWS COLS ***
  10    4
    DEPTH      AREA    VOLUME   OUTFLOW   ***
    0.000    0.0000    0.0000      0.00
    0.100    0.6327    0.0316      0.15
    0.500    0.7960    0.3174      5.87
    1.000    1.0002    0.7664     21.53
    1.500    1.2043    1.3176     46.43
    2.000    1.4085    1.9708     81.20
    3.000    1.8168    3.5834    183.79
    4.000    2.2251    5.6044    336.22
    5.000    2.6335    8.0337    545.30
    6.000    3.0418   10.8713    817.51
 END FTABLE 12

 FTABLE     15
ROWS COLS ***
  16    4
    DEPTH      AREA    VOLUME   OUTFLOW   ***
      0.0         0         0         0
      0.7      1.63      1.69        26
      1.3      3.26      3.37        51
      1.8      4.78      5.84       103
      2.2      5.75      8.15       154
      2.4      6.49      9.41       182
      2.6     10.66     12.23       210
      2.8     11.50     13.58       239
      2.9     12.06     15.04       261
      3.1     13.11     16.89       289
      3.1     13.68     18.87       306
      3.4     16.29     21.96       347
      3.5     17.73     25.34       388
      3.7     18.63     28.64       429
      4.0     20.04     35.13       491
      4.2     21.87     40.52       552
 END FTABLE 15

 FTABLE     14
ROWS COLS ***
   8    4
    DEPTH      AREA    VOLUME   OUTFLOW   ***
    0.000    0.0000    0.0000      0.00
    0.100    0.3361    0.0168      0.24
    0.500    0.3809    0.1602      9.04
    1.000    0.4370    0.3647     31.61
    1.500    0.4930    0.5972     65.00
    2.000    0.5491    0.8577    108.85
    2.500    0.6051    1.1462    163.33
```

```
   3.000   0.6612   1.4628   228.78
 END FTABLE 14

 FTABLE     17
ROWS COLS ***
 16    4
   DEPTH      AREA   VOLUME  OUTFLOW   ***
     0.0         0        0        0
     0.9      0.83     0.96       26
     1.9      1.66     1.91       51
     2.6      3.05     3.52      103
     3.2      3.92     5.12      154
     3.5      4.61     6.03      182
     3.8      8.72     8.50      210
     4.0      9.52     9.51      239
     4.2     10.04    10.71      261
     4.4     11.05    12.25      289
     4.5     11.60    14.04      306
     4.8     14.12    16.70      347
     5.0     15.41    19.65      388
     5.2     16.12    22.54      429
     5.5     17.26    28.37      491
     5.7     18.88    33.12      552
 END FTABLE 17

 FTABLE     18
ROWS COLS ***
  7    4
   DEPTH      AREA   VOLUME  OUTFLOW   ***
   0.000    0.0000   0.0000     0.00
   0.100    0.9758   0.0488     0.36
   0.500    0.9884   0.4416    13.44
   1.000    1.0042   0.9398    44.63
   2.000    1.0262   1.9550   136.47
   3.000    1.0482   2.9923   253.70
   4.000    2.5069   4.7698   347.74
 END FTABLE 18

 FTABLE     19
ROWS COLS ***
  7    4
   DEPTH      AREA   VOLUME  OUTFLOW   ***
   0.000    0.0000   0.0000     0.00
   0.100    0.5620   0.0281     0.09
   0.500    0.6174   0.2640     3.38
   1.000    0.6866   0.5900    11.42
   2.000    0.8250   1.3458    37.28
   3.000    0.9635   2.2400    75.10
   4.000    1.1019   3.2727   125.11
 END FTABLE 19

 FTABLE     20
ROWS COLS ***
  6    4
   DEPTH      AREA   VOLUME  OUTFLOW   ***
   0.000    0.0000   0.0000     0.00
```

```
    1.000     5.0000    2.0000       5.00
    2.000     10.000    9.5000      16.00
    3.000     15.000    22.000      30.00
    4.000     19.000    39.000      35.00
    5.000     22.000    50.000      39.00
  END FTABLE 20

  FTABLE     21
 ROWS COLS ***
    8    4
     DEPTH       AREA     VOLUME    OUTFLOW    ***
     0.000     0.0000    0.0000       0.00
     0.100     0.2259    0.0113       0.11
     0.500     0.2707    0.1106       4.27
     1.000     0.3268    0.2600      15.13
     1.500     0.3828    0.4374      31.67
     2.000     0.4389    0.6428      54.02
     2.500     0.4949    0.8763      82.52
     3.000     0.5510    1.1377     117.55
  END FTABLE 21

  FTABLE     22
 ROWS COLS ***
    9    4
     DEPTH       AREA     VOLUME    OUTFLOW    ***
     0.000     0.0000    0.0000       0.00
     0.100     0.3680    0.0184       0.25
     0.500     0.3717    0.1664       9.39
     1.000     0.3763    0.3534      31.06
     2.000     0.3819    0.7325      94.37
     3.000     0.3874    1.1171     174.33
     4.000     0.3930    1.5073     265.38
     5.000     0.3985    1.9030     364.68
     6.000     0.4040    2.3043     470.60
  END FTABLE 22

  FTABLE     26
 ROWS COLS ***
   16    4
     DEPTH       AREA     VOLUME    OUTFLOW    ***
       0.0          0          0          0
       0.9       2.81       3.11         11
       1.8       5.61       6.22         21
       2.5       7.45      10.18         42
       3.1       9.68      14.24         64
       3.4      11.88      17.36         71
       3.4      15.77      19.85         74
       3.4      16.92      21.82         79
       3.5      17.67      23.68         83
       3.6      19.32      26.07         87
       3.6      19.96      28.46         89
       3.9      23.79      33.18        118
       4.1      26.26      38.23        146
       4.4      28.10      43.26        175
       4.8      30.56      52.23        218
       5.2      33.13      60.48        261
```

```
  END FTABLE 26

  FTABLE      30
 ROWS COLS ***
   8    4
     DEPTH      AREA     VOLUME   OUTFLOW   ***
     0.000     0.0000    0.0000     0.00
     1.000     0.1000    0.0100    100.0
     2.000     0.2000    0.0200    200.0
     3.000     0.3000    0.0300    300.0
     4.000     0.4000    0.0400    500.0
     6.000     0.6000    0.0600    700.0
     7.000     0.7000    0.0800    800.0
     8.000     0.8000    0.1000    999.9
  END FTABLE 30

*** VOLUME INCREASED BY 50%, DISCHARGE DECREASED BY 30%

  FTABLE      40
  11    4
      .000     1.660      .000      .000
      .600     1.660     1.920     9.246
     1.200     1.660     2.987    13.060
     2.400     1.660     5.978    18.480
     3.600     1.660     8.965    22.640
     4.400     1.660    10.956    25.030
     5.400     1.660    13.446    61.230
     6.000     1.660    14.942    71.600
     6.400     1.660    15.943    85.150
     6.800     1.660    16.923   104.460
     7.200     1.660    17.930   127.460
  END FTABLE 40

  FTABLE      47
  11    4
      .000     3.922      .000      .000
      .600     3.922     4.130     3.640
     1.200     3.922     7.059     5.160
     2.400     3.922    14.111     7.300
     3.600     3.922    21.180     8.940
     4.200     3.922    24.708    32.770
     5.400     3.922    31.770    62.620
     6.000     3.922    35.299    72.690
     6.400     3.922    37.652    86.220
     6.800     3.922    40.000   105.670
     7.200     3.922    42.345   128.600
  END FTABLE 47

  FTABLE      46
  11    4
      .000     1.151      .000      .000
      .600     1.151     1.035     7.300
     1.200     1.151     2.070    10.300
     2.400     1.151     4.141    14.590
     3.600     1.151     6.214    17.870
     4.600     1.151     7.938    20.200
```

```
     5.400     1.151      9.320    50.270
     6.000     1.151     10.355    60.600
     6.400     1.151     11.045    73.970
     6.800     1.151     11.732    93.070
     7.200     1.151     12.425   115.800
  END FTABLE 46                                        ***

END FTABLES                                            ***

END RUN
```

```
RUN
GLOBAL
  ***  FILE:DESM-P5.UCI - FULL SIMULATION
  ***  PROPOSED CONDITIONS - DEVELOPED AREAS INCLUDED WITH DETENTION
  ***  NETWORK MODIFIED TO SIMPLIFY INCLUSION OF DETENTION
  DES MOINES CREEK BASIN HSPF MODEL
  START       1948/10/01 00:00  END    1994/07/31 24:00
  RUN INTERP OUTPUT LEVEL    0
  RESUME     0 RUN     1
END GLOBAL

FILES
<type>  <fun>***<-------------fname------------------------------------------->
INFO       21   c:\hspf10\hspinf.da
ERROR      22   c:\hspf10\hsperr.da
WARN       23   c:\hspf10\hspwrn.da
MESSU      24   DESM-C.ECH
WDM        25   DESM-P5.wdm
           91   flow.plt
END FILES

OPN SEQUENCE
    INGRP              INDELT 01:00
      PERLND     14
      PERLND     16
      PERLND     18
      PERLND     24
      PERLND     26
      PERLND     28
      PERLND     34
      PERLND     44
      PERLND     54
      IMPLND     14
      RCHRES      1
      RCHRES      2
      RCHRES      3
      RCHRES     49
      RCHRES     34
      RCHRES     35
      RCHRES     23
      RCHRES     28
      RCHRES     36
      RCHRES     37
      RCHRES      4
      RCHRES     38
      RCHRES     22
      RCHRES     27
      RCHRES     39
      RCHRES     63
      RCHRES      5
      RCHRES      6
      RCHRES     61
      RCHRES     66
      RCHRES     51
      RCHRES     40
      RCHRES     21
```

```
      RCHRES      26
      RCHRES      44
      RCHRES      19
      RCHRES      24
      RCHRES      41
      RCHRES       8
      RCHRES       7
      RCHRES      20
      RCHRES      25
      RCHRES      42
      RCHRES       9
      RCHRES      10
      RCHRES      11
      RCHRES      60
      RCHRES      50
      RCHRES      43
      RCHRES      64
      RCHRES      12
      RCHRES      45
      RCHRES      62
      RCHRES      65
      RCHRES      67
      RCHRES      13
      RCHRES      14
      RCHRES      16
      RCHRES      46
      RCHRES      47
      RCHRES      15
      RCHRES      17
      RCHRES      48
      RCHRES      18
    END INGRP
END OPN SEQUENCE
                                                                              ***
PERLND
  GEN-INFO
    <PLS >      Name           NBLKS   Unit-systems   Printer                 ***
    # -  #                          User  t-series Engl Metr                  ***
                                              in  out                         ***
   14      TFF- TILL FOR FLT       1    1    1    1   60    0
   16      TFM- TILL FOR MOD       1    1    1    1   60    0
   18      TFS- TILL FOR STP       1    1    1    1   60    0
   24      TGF- TILL GR FLT        1    1    1    1   60    0
   26      TGM- TILL GR MOD        1    1    1    1   60    0
   28      TGS- TILL GR STP        1    1    1    1   60    0
   34      OF - OUTWASH FOR        1    1    1    1   60    0
   44      OG - OUTWASH GR         1    1    1    1   60    0
   54      SA - WETLANDS           1    1    1    1   60   .0
  END GEN-INFO
  ACTIVITY
    <PLS > ************* Active Sections *****************************
    # -  # ATMP SNOW PWAT  SED  PST  PWG PQAL MSTL PEST NITR PHOS TRAC         ***
   14  200    0    0    1    0    0    0    0    0    0    0    0    0
  END ACTIVITY
  PRINT-INFO
    <PLS > ********************* Print-flags ************************* PIVL  PYR
```

AR 039653

```
  # -  # ATMP SNOW PWAT  SED  PST  PWG PQAL MSTL PEST NITR PHOS TRAC *********
 14  200    0    0    6    0    0    0    0    0    0    0    0    0    1    9
END PRINT-INFO
PWAT-PARM1
  <PLS > **************** Flags *******************
  # -  # CSNO RTOP UZFG  VCS  VUZ  VNN VIFW VIRC  VLE                      ***
 14  200    0    0    0    0    0    0    0    0    0
END PWAT-PARM1
PWAT-PARM2
  <PLS > ***
  # -  # ***FOREST      LZSN    INFILT      LSUR     SLSUR     KVARY     AGWRC
 14                   4.5000    0.3000    400.00    0.0500    0.5000    0.9960
 16                   4.5000    0.3000    400.00    0.1000    0.5000    0.9960
 18                   4.5000    0.3000    200.00    0.2000    0.5000    0.9960
 24                   4.5000    0.3000    400.00    0.0500    0.5000    0.9960
 26                   4.5000    0.3000    400.00    0.1000    0.5000    0.9960
 28                   4.5000    0.3000    200.00    0.2000    0.5000    0.9960
 34                   5.0000    2.0000    400.00    0.0500    0.3000    0.9960
 44                   5.0000    0.8000    400.00    0.0500    0.3000    0.9960
 54                   4.0000    2.0000    100.00    0.0010    0.5000    0.9960
END PWAT-PARM2
PWAT-PARM3
  <PLS >***
  # -  #*** PETMAX    PETMIN    INFEXP    INFILD    DEEPFR    BASETP    AGWETP
 14                             3.5000    2.0000       .40        0.        0.
 16                             2.0000    2.0000       .40        0.        0.
 18                             1.5000    2.0000       .40        0.        0.
 24                             2.5000    2.0000       .40        0.        0.
 26                             2.0000    2.0000       .40        0.        0.
 28                             1.5000    2.0000       .40        0.        0.
 34                             2.0000    2.0000       .40        0.        0.
 44                             2.0000    2.0000       .40        0.        0.
 54                             10.000    2.0000       .40        0.       0.7
END PWAT-PARM3
PWAT-PARM4
  <PLS >                                                         ***
  # -  #     CEPSC      UZSN      NSUR     INTFW       IRC     LZETP***
 14         0.2000    1.0000    0.3500     3.000    0.3000    0.7000
 16         0.2000    0.5000    0.3500     3.000    0.3000    0.7000
 18         0.2000    0.3000    0.3500     3.000    0.3000    0.7000
 24         0.1000    1.0000    0.2500     3.000    0.7000    0.2500
 26         0.1000    0.5000    0.2500     6.000    0.5000    0.2500
 28         0.1000    0.3000    0.2500     7.000    0.3000    0.2500
 34         0.2000    0.5000    0.3500     2.000    0.8000    0.7000
 44         0.1000    0.5000    0.2500     2.000    0.8000    0.2500
 54         0.1000    3.0000    0.5000     1.000    0.8000    0.8000
END PWAT-PARM4
PWAT-STATE1
  <PLS >  PWATER state variables***
  # -  #***   CEPS      SURS       UZS      IFWS       LZS      AGWS      GWVS
 14          0.078        0.    0.0010        0.     0.077     0.698     0.023
 16          0.078        0.    0.0010        0.     0.075     0.667     0.026
 18          0.078        0.    0.0010        0.     0.074     0.628     0.027
 24          0.051        0.    0.0010        0.     0.300     0.681     0.053
 26          0.051        0.    0.0050        0.     0.300     0.680     0.049
 28          0.051        0.    0.0060        0.     0.300     0.659     0.048
```

```
   34          0.078       0.    0.0010        0.     0.090    0.675    0.038
   44          0.051       0.    0.0040        0.     0.300    0.414    0.152
   54          0.051       0.    0.3330        0.     0.622    0.400    0.000
  END PWAT-STATE1
END PERLND
IMPLND
  GEN-INFO
    <ILS >      Name              Unit-systems   Printer                     ***
    # -  #                    User  t-series Engl Metr                       ***
                                     in   out                                ***
   14  200 IMPERVIOUS            1    1    1   60    0
  END GEN-INFO
  ACTIVITY
    <ILS > ************* Active Sections ****
    # -  # ATMP SNOW IWAT  SLD  IWG IQAL  ***
   14  200    0    0    1    0    0    0
  END ACTIVITY
  PRINT-INFO
    <ILS > ******** Print-flags ******** PIVL  PYR
    # -  # ATMP SNOW IWAT  SLD  IWG IQAL *********
   14  200    0    0    6    0    0    0    1    9
  END PRINT-INFO
  IWAT-PARM1
    <ILS >            Flags          ***                                     ***
    # -  # CSNO RTOP  VRS  VNN RTLI  ***                                     ***
   14  200    0    0    0    0    0
  END IWAT-PARM1
  IWAT-PARM2
    <ILS >                                                                   ***
    # -  #      LSUR     SLSUR      NSUR     RETSC                           ***
   14  200    200.00    0.0500    0.1000    0.1000
  END IWAT-PARM2
  IWAT-PARM3
    <ILS >                                                                   ***
    # -  #    PETMAX    PETMIN                                               ***
   14  200
  END IWAT-PARM3
  IWAT-STATE1
    <ILS >  IWATER state variables                                           ***
    # -  #      RETS      SURS                                               ***
   14  200 1.0000E-3 1.0000E-3
  END IWAT-STATE1
END IMPLND
                                                                             ***
EXT SOURCES
                                                                             ***
*** NOTE: The only RCHRES that precip and PET are applied to are lakes.
                                                                             ***
<-Volume-> <Member> SsysSgap<--Mult-->Tran <-Target vols> <-Grp> <-Member->  ***
<Name>   # <Name> # tem strg<-factor->strg <Name>   #   #        <Name> # #  ***
WDM      2 PREC     ENGLZERO               PERLND  14  54 EXTNL  PREC
WDM      2 PREC     ENGLZERO               IMPLND  14     EXTNL  PREC
WDM      3 EVAP     ENGLZERO  0.8      DIV PERLND  14  54 EXTNL  PETINP
WDM      3 EVAP     ENGLZERO  0.8      DIV IMPLND  14     EXTNL  PETINP
WDM      2 PREC     ENGLZERO               RCHRES  49     EXTNL  PREC
WDM      3 EVAP     ENGLZERO    0.8    DIV RCHRES  49     EXTNL  PREC
```

```
WDM      2 PREC     ENGLZERO              RCHRES  51     EXTNL  PREC
WDM      3 EVAP     ENGLZERO    0.8   DIV RCHRES  51     EXTNL  PREC
END EXT SOURCES
                                                                          ***
NETWORK

PERLND  24 PWATER PERO         0.0000     RCHRES   1     EXTNL  IVOL
PERLND  26 PWATER PERO         0.0000     RCHRES   1     EXTNL  IVOL
PERLND  28 PWATER PERO         0.0000     RCHRES   1     EXTNL  IVOL
PERLND  34 PWATER PERO         0.0000     RCHRES   1     EXTNL  IVOL
PERLND  44 PWATER PERO         0.0000     RCHRES   1     EXTNL  IVOL
PERLND  54 PWATER PERO         0.0000     RCHRES   1     EXTNL  IVOL
                                                                          ***
***      <MEMBER> SSYSSGAP<--MULT-->TRAN <-TARGET VOLS>        <-MEMBER->
<NAME>   # <NAME>   TEM STRG<-FACTOR->STRG <NAME>    #   # <-GRP> <NAME> # # ***
*** SUB-BASIN DM  1
PERLND  26 PWATER PERO        24.475      RCHRES   1     EXTNL  IVOL
PERLND  44 PWATER PERO         2.038      RCHRES   1     EXTNL  IVOL
IMPLND  14 IWATER SURO         8.529      RCHRES   1     EXTNL  IVOL
*** SUB-BASIN DM  2
PERLND  26 PWATER PERO         0.7150     RCHRES   2     EXTNL  IVOL
PERLND  44 PWATER PERO         0.6230     RCHRES   2     EXTNL  IVOL
IMPLND  14 IWATER SURO         3.7040     RCHRES   2     EXTNL  IVOL
*** SUB-BASIN DM  3
PERLND  26 PWATER PERO         0.4070     RCHRES   3     EXTNL  IVOL
PERLND  44 PWATER PERO         0.1640     RCHRES   3     EXTNL  IVOL
IMPLND  14 IWATER SURO         1.2710     RCHRES   3     EXTNL  IVOL
*** SUB-BASIN DM  4
PERLND  26 PWATER PERO         3.7680     RCHRES   4     EXTNL  IVOL
PERLND  24 PWATER PERO         0.6420     RCHRES   4     EXTNL  IVOL
IMPLND  14 IWATER SURO         9.5000     RCHRES   4     EXTNL  IVOL
*** SUB-BASIN DM  5
PERLND  26 PWATER PERO         0.8160     RCHRES  63     EXTNL  IVOL
PERLND  24 PWATER PERO         2.2330     RCHRES  63     EXTNL  IVOL
PERLND  44 PWATER PERO         0.0001     RCHRES  63     EXTNL  IVOL
IMPLND  14 IWATER SURO         1.8670     RCHRES  63     EXTNL  IVOL
*** SUB-BASIN DM  6
PERLND  26 PWATER PERO         0.1760     RCHRES   6     EXTNL  IVOL
PERLND  24 PWATER PERO         2.2500     RCHRES   6     EXTNL  IVOL
PERLND  44 PWATER PERO         0.3330     RCHRES   6     EXTNL  IVOL
IMPLND  14 IWATER SURO         0.5410     RCHRES   6     EXTNL  IVOL
*** SUB-BASIN DM  7
PERLND  26 PWATER PERO         4.1780     RCHRES   7     EXTNL  IVOL
PERLND  44 PWATER PERO         2.0320     RCHRES   7     EXTNL  IVOL
PERLND  54 PWATER PERO         0.9050     RCHRES   7     EXTNL  IVOL
IMPLND  14 IWATER SURO         3.1430     RCHRES   7     EXTNL  IVOL
*** SUB-BASIN DM  8
PERLND  26 PWATER PERO         0.0250     RCHRES   8     EXTNL  IVOL
PERLND  44 PWATER PERO         3.2370     RCHRES   8     EXTNL  IVOL
PERLND  54 PWATER PERO         0.2440     RCHRES   8     EXTNL  IVOL
IMPLND  14 IWATER SURO         2.4440     RCHRES   8     EXTNL  IVOL
*** SUB-BASIN DM  9
PERLND  26 PWATER PERO         5.3640     RCHRES   9     EXTNL  IVOL
PERLND  44 PWATER PERO         1.2690     RCHRES   9     EXTNL  IVOL
IMPLND  14 IWATER SURO         0.4510     RCHRES   9     EXTNL  IVOL
*** SUB-BASIN DM 10
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PERLND  26 PWATER PERO        0.6080     RCHRES  10      EXTNL  IVOL
PERLND  44 PWATER PERO        2.3920     RCHRES  10      EXTNL  IVOL
PERLND  54 PWATER PERO        0.1000     RCHRES  10      EXTNL  IVOL
*** SUB-BASIN DM 11
PERLND  26 PWATER PERO        0.0580     RCHRES  11      EXTNL  IVOL
PERLND  44 PWATER PERO        2.7460     RCHRES  11      EXTNL  IVOL
PERLND  54 PWATER PERO        2.4220     RCHRES  11      EXTNL  IVOL
IMPLND  14 IWATER SURO        1.4730     RCHRES  11      EXTNL  IVOL
*** SUB-BASIN DM 12
PERLND  26 PWATER PERO        0.3330     RCHRES  64      EXTNL  IVOL
PERLND  24 PWATER PERO        1.0500     RCHRES  64      EXTNL  IVOL
PERLND  44 PWATER PERO        2.4250     RCHRES  64      EXTNL  IVOL
PERLND  54 PWATER PERO        0.0001     RCHRES  64      EXTNL  IVOL
*** SUB-BASIN DM 13
PERLND  26 PWATER PERO        0.3850     RCHRES  65      EXTNL  IVOL
PERLND  24 PWATER PERO        1.1000     RCHRES  65      EXTNL  IVOL
PERLND  44 PWATER PERO        1.1500     RCHRES  65      EXTNL  IVOL
IMPLND  14 IWATER SURO        2.2240     RCHRES  65      EXTNL  IVOL
*** SUB-BASIN DM 14
PERLND  26 PWATER PERO        0.8140     RCHRES  14      EXTNL  IVOL
PERLND  44 PWATER PERO        3.3550     RCHRES  14      EXTNL  IVOL
IMPLND  14 IWATER SURO        0.4060     RCHRES  14      EXTNL  IVOL
*** SUB-BASIN DM 15
PERLND  26 PWATER PERO        0.8770     RCHRES  15      EXTNL  IVOL
PERLND  44 PWATER PERO        0.2380     RCHRES  15      EXTNL  IVOL
IMPLND  14 IWATER SURO        1.4690     RCHRES  15      EXTNL  IVOL
*** SUB-BASIN DM 16
PERLND  26 PWATER PERO       11.9260     RCHRES  16      EXTNL  IVOL
PERLND  44 PWATER PERO        2.6600     RCHRES  16      EXTNL  IVOL
IMPLND  14 IWATER SURO        4.7310     RCHRES  16      EXTNL  IVOL
*** SUB-BASIN DM 17
PERLND  26 PWATER PERO        1.3090     RCHRES  17      EXTNL  IVOL
PERLND  44 PWATER PERO        0.6120     RCHRES  17      EXTNL  IVOL
IMPLND  14 IWATER SURO        1.3120     RCHRES  17      EXTNL  IVOL
*** SUB-BASIN DM 18
PERLND  24 PWATER PERO        0.0420     RCHRES  18      EXTNL  IVOL
PERLND  26 PWATER PERO        1.2910     RCHRES  18      EXTNL  IVOL
PERLND  44 PWATER PERO        4.5670     RCHRES  18      EXTNL  IVOL
IMPLND  14 IWATER SURO        0.3340     RCHRES  18      EXTNL  IVOL
*** SUB-BASINS DM-19 TO DM-23 ARE SWS BASINS
*** SUB-BASIN DM 19
PERLND  24 PWATER PERO        1.1670     RCHRES  19      EXTNL  IVOL
IMPLND  14 IWATER SURO        0.9170     RCHRES  19      EXTNL  IVOL
*** SUB-BASIN DM 20
PERLND  24 PWATER PERO       18.4170     RCHRES  20      EXTNL  IVOL
IMPLND  14 IWATER SURO       22.0000     RCHRES  20      EXTNL  IVOL
*** SUB-BASIN DM 21
PERLND  24 PWATER PERO        2.1670     RCHRES  21      EXTNL  IVOL
IMPLND  14 IWATER SURO        2.0920     RCHRES  21      EXTNL  IVOL
*** SUB-BASIN DM 22
IMPLND  14 IWATER SURO        3.3330     RCHRES  22      EXTNL  IVOL
*** SUB-BASIN DM 23
PERLND  24 PWATER PERO        2.3330     RCHRES  23      EXTNL  IVOL
IMPLND  14 IWATER SURO        7.6670     RCHRES  23      EXTNL  IVOL
*** SUB-BASINS DM-24 TO DM-28 ARE SWS-OTHER BASINS
*** SUB-BASIN DM 24
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PERLND  24 PWATER PERO        1.0500     RCHRES  24     EXTNL  IVOL
*** SUB-BASIN DM 25
PERLND  24 PWATER PERO        3.1580     RCHRES  25     EXTNL  IVOL
*** SUB-BASIN DM 26
PERLND  24 PWATER PERO        0.6500     RCHRES  26     EXTNL  IVOL
*** SUB-BASIN DM 27
*** SUB-BASIN DM 28
*** SUB-BASIN DM 60
IMPLND  14 IWATER SURO        0.0001     RCHRES  60     EXTNL  IVOL
*** SUB-BASIN DM 61
IMPLND  14 IWATER SURO        0.0001     RCHRES  61     EXTNL  IVOL
*** SUB-BASIN DM 62
IMPLND  14 IWATER SURO        0.0001     RCHRES  62     EXTNL  IVOL
                                                                          ***
  *** CHANNEL NETWORK LINKAGES ***
                                                                          ***
*** NOTE: MFACTOR 12.1 CONVERTS ACRE-FEET OF RUNOFF TO AVERAGE CFS PER HOUR.
***       IT IS TIMESTEP DEPENDENT. THE OTHER MFACTORS CONVERT ACRE-FEET
***       OF RUNOFF TO INCHES.
                                                                          ***
RCHRES   1 HYDR   ROVOL  1               RCHRES  49     EXTNL  IVOL
RCHRES   2 HYDR   ROVOL  1               RCHRES  49     EXTNL  IVOL
RCHRES   3 HYDR   ROVOL  1               RCHRES  49     EXTNL  IVOL
RCHRES  49 HYDR   ROVOL  1               RCHRES  34     EXTNL  IVOL
RCHRES  34 HYDR   ROVOL  1               RCHRES  35     EXTNL  IVOL
RCHRES  35 HYDR   ROVOL  1               RCHRES  37     EXTNL  IVOL
RCHRES  23 HYDR   ROVOL  1               RCHRES  36     EXTNL  IVOL
RCHRES  28 HYDR   ROVOL  1               RCHRES  36     EXTNL  IVOL
RCHRES  36 HYDR   ROVOL  1               RCHRES  37     EXTNL  IVOL
RCHRES  37 HYDR   ROVOL  1               RCHRES  38     EXTNL  IVOL
RCHRES   4 HYDR   ROVOL  1               RCHRES  38     EXTNL  IVOL***
RCHRES  38 HYDR   ROVOL  1               RCHRES   5     EXTNL  IVOL
RCHRES  22 HYDR   ROVOL  1               RCHRES  39     EXTNL  IVOL
RCHRES  27 HYDR   ROVOL  1               RCHRES  39     EXTNL  IVOL
RCHRES  39 HYDR   ROVOL  1               RCHRES   5     EXTNL  IVOL
RCHRES  63 HYDR   ROVOL  1               RCHRES   5     EXTNL  IVOL***
RCHRES   4 HYDR   ROVOL  1               RCHRES  66     EXTNL  IVOL
RCHRES  63 HYDR   ROVOL  1               RCHRES  66     EXTNL  IVOL
RCHRES   6 HYDR   ROVOL  1               RCHRES  66     EXTNL  IVOL
RCHRES  61 HYDR   ROVOL  1               RCHRES  66     EXTNL  IVOL
RCHRES   6 HYDR   ROVOL  1               RCHRES  51     EXTNL  IVOL***
RCHRES   5 HYDR   ROVOL  1               RCHRES  51     EXTNL  IVOL
RCHRES  66 HYDR   ROVOL  1               RCHRES  51     EXTNL  IVOL
RCHRES  61 HYDR   ROVOL  1               RCHRES  51     EXTNL  IVOL***
RCHRES  51 HYDR   ROVOL  1               RCHRES  40     EXTNL  IVOL
RCHRES  40 HYDR   ROVOL  1               RCHRES  45     EXTNL  IVOL
RCHRES  21 HYDR   ROVOL  1               RCHRES  44     EXTNL  IVOL
RCHRES  26 HYDR   ROVOL  1               RCHRES  44     EXTNL  IVOL
RCHRES  44 HYDR   ROVOL  1               RCHRES  45     EXTNL  IVOL***
RCHRES  19 HYDR   ROVOL  1               RCHRES  41     EXTNL  IVOL
RCHRES  24 HYDR   ROVOL  1               RCHRES  41     EXTNL  IVOL
RCHRES  41 HYDR   ROVOL  1               RCHRES  50     EXTNL  IVOL
RCHRES   8 HYDR   ROVOL  1               RCHRES   7     EXTNL  IVOL
RCHRES   7 HYDR   ROVOL  1               RCHRES  50     EXTNL  IVOL
RCHRES  20 HYDR   ROVOL  1               RCHRES  42     EXTNL  IVOL
RCHRES  25 HYDR   ROVOL  1               RCHRES  42     EXTNL  IVOL
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RCHRES  42 HYDR   ROVOL  1                RCHRES  50     EXTNL  IVOL
RCHRES   9 HYDR   ROVOL  1                RCHRES  50     EXTNL  IVOL
RCHRES  10 HYDR   ROVOL  1                RCHRES  50     EXTNL  IVOL
RCHRES  11 HYDR   ROVOL  1                RCHRES  50     EXTNL  IVOL
RCHRES  60 HYDR   ROVOL  1                RCHRES  50     EXTNL  IVOL
RCHRES  50 HYDR   ROVOL  1                RCHRES  43     EXTNL  IVOL
RCHRES  43 HYDR   ROVOL  1                RCHRES  12     EXTNL  IVOL
RCHRES  64 HYDR   ROVOL  1                RCHRES  12     EXTNL  IVOL***
RCHRES  12 HYDR   ROVOL  1                RCHRES  45     EXTNL  IVOL
RCHRES  44 HYDR   ROVOL  1                RCHRES  67     EXTNL  IVOL
RCHRES  64 HYDR   ROVOL  1                RCHRES  67     EXTNL  IVOL
RCHRES  65 HYDR   ROVOL  1                RCHRES  67     EXTNL  IVOL
RCHRES  62 HYDR   ROVOL  1                RCHRES  67     EXTNL  IVOL
RCHRES  45 HYDR   ROVOL  1                RCHRES  13     EXTNL  IVOL
RCHRES  67 HYDR   ROVOL  1                RCHRES  13     EXTNL  IVOL
RCHRES  62 HYDR   ROVOL  1                RCHRES  13     EXTNL  IVOL***
RCHRES  65 HYDR   ROVOL  1                RCHRES  13     EXTNL  IVOL***
RCHRES  13 HYDR   ROVOL  1                RCHRES  14     EXTNL  IVOL
RCHRES  14 HYDR   ROVOL  1                RCHRES  48     EXTNL  IVOL
RCHRES  16 HYDR   ROVOL  1                RCHRES  46     EXTNL  IVOL
RCHRES  46 HYDR   ROVOL  1                RCHRES  47     EXTNL  IVOL
RCHRES  47 HYDR   ROVOL  1                RCHRES  17     EXTNL  IVOL
RCHRES  15 HYDR   ROVOL  1                RCHRES  17     EXTNL  IVOL
RCHRES  17 HYDR   ROVOL  1                RCHRES  48     EXTNL  IVOL
RCHRES  48 HYDR   ROVOL  1                RCHRES  18     EXTNL  IVOL
                                                                          ***
END NETWORK
                                                                          ***
EXT TARGETS
<-Volume-> <-Grp> <-Member-><--Mult-->Tran <-Volume-> <Member> Tsys Tgap Amd ***
<Name>   #        <Name> # #<-factor->strg <Name>   # <Name>    tem strg strg***
RCHRES   5 HYDR   RO                       WDM     21 FLOW     ENGL      REPL
RCHRES  13 HYDR   RO                       WDM     22 FLOW     ENGL      REPL
RCHRES  18 HYDR   RO                       WDM     23 FLOW     ENGL      REPL
RCHRES  50 HYDR   RO                       WDM     24 FLOW     ENGL      REPL
RCHRES  50 HYDR   RO                       WDM     25 FLOW     ENGL      REPL***
RCHRES  66 HYDR   RO                       WDM     26 FLOW     ENGL      REPL***
RCHRES  67 HYDR   RO                       WDM     27 FLOW     ENGL      REPL***
END EXT TARGETS
                                                                          ***
RCHRES
  GEN-INFO
    RCHRES       Name         Nexits  Unit Systems   Printer                ***
    # -  #<------------------><---> User T-series  Engl Metr LKFG          ***
                                           in  out                          ***
     1     Bow Lake Basin        1    1    1    1    0    0    0
     2     HWY 99                1    1    1    1    0    0    0
     3     Local SeaTac busines  1    1    1    1    0    0    0
     4     Hwy 99 & 188th        1    1    1    1    0    0    0
     5     Upper E. branch       1    1    1    1    0    0    0
     6     Lower E. branch       1    1    1    1    0    0    0
     7     Upper W. branch       1    1    1    1    0    0    0
     8     Upper W. branch       1    1    1    1    0    0    0
     9     Upper W. branch       1    1    1    1    0    0    0
    10     Upper W. branch       1    1    1    1    0    0    0
    11     Upper W. branch       1    1    1    1    0    0    0
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  12     Lower W. branch        1    1    1    1    0    0    0
  13     Above 200th Street     1    1    1    1    0    0    0
  14     Below 200th Street     1    1    1    1    0    0    0
  15     Local inflow           1    1    1    1    0    0    0
  16     Executel pond inflow   1    1    1    1    0    0    0
  17     Trailer parks          1    1    1    1    0    0    0
  18     Above 208th Street     1    1    1    1    0    0    0
  19     SWS SDW-3              1    1    1    1    0    0    0
  20     SWS SDS-3              1    1    1    1    0    0    0
  21     SWS SDS-4              1    1    1    1    0    0    0
  22     SWS SDS-1              1    1    1    1    0    0    0
  23     SWS SDE-4              1    1    1    1    0    0    0
  24     SWS SDW-3 Other        1    1    1    1    0    0    0
  25     SWS SDS-3 Other        1    1    1    1    0    0    0
  26     SWS SDS-4 Other        1    1    1    1    0    0    0
  27     SWS SDS-1 Other        1    1    1    1    0    0    0
  28     SWS SDE-4 Other        1    1    1    1    0    0    0
  29     Below 208th Street     1    1    1    1    0    0    0
  30     Lower DMC trib         1    1    1    1    0    0    0
  31     Senior Center          1    1    1    1    0    0    0
  32     SR-509                 1    1    1    1    0    0    0
  33     Mouth                  1    1    1    1    0    0    0
  34     Bow Lake outflow       1    1    1    1    0    0    0
  35     Pipeline A             1    1    1    1    0    0    0
  36     SDE-4 combined flow    1    1    1    1    0    0    0
  37     Pipeline B             1    1    1    1    0    0    0
  38     Upper E. branch        1    1    1    1    0    0    0
  39     SDS-1 combined flow    1    1    1    1    0    0    0
  40     Tyee Pond outflow      1    1    1    1    0    0    0
  41     SDW-3 combined flow    1    1    1    1    0    0    0
  42     SDS-3 combined flow    1    1    1    1    0    0    0
  43     NW Pond outflow        1    1    1    1    0    0    0
  44     SWS-4 combined flow    1    1    1    1    0    0    0
  45     E & W Branch confl.    1    1    1    1    0    0    0
  46     Executel outflow       1    1    1    1    0    0    0
  47     Pipeline C             1    1    1    1    0    0    0
  48     Sum below 200th        1    1    1    1    0    0    0
  49     Bow Lake inflow        1    1    1    1    0    0    0
  50     NW Pond inflow         1    1    1    1    0    0    0
  51     Tyee Pond inflow       1    1    1    1    0    0    0
  60                            1    1    1    1    0    0    0
  61                            1    1    1    1    0    0    0
  62                            1    1    1    1    0    0    0
  63                            1    1    1    1    0    0    0
  64                            1    1    1    1    0    0    0
  65                            1    1    1    1    0    0    0
  66                            1    1    1    1    0    0    0
  67                            1    1    1    1    0    0    0
END GEN-INFO
ACTIVITY
  RCHRES *************** Active Sections *****************
  # -  # HYFG ADFG CNFG HTFG SDFG GQFG OXFG NUFG PKFG PHFG              ***
  1   67    1    0    0    0    0    0    0    0    0    0
END ACTIVITY
PRINT-INFO
  RCHRES *************** Printout Flags ***************** PIVL  PYR
```

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  # -  # HYDR ADCA CONS HEAT  SED  GQL OXRX NUTR PLNK PHCB *********
  1  67    6    0    0    0    0    0    0    0    0    0    1    9
END PRINT-INFO
HYDR-PARM1
  RCHRES  Flags for each HYDR Section                                  ***
  # -  #  VC A1 A2 A3  ODFVFG for each *** ODGTFG for each     FUNCT  for each
          FG FG FG FG  possible  exit  *** possible  exit      possible  exit
           *  *  *  *    *  *  *  *  *      *  *  *  *  *        ***
  1   67   0  0  0  0    4  0  0  0  0      0  0  0  0  0      2  2  2  2  2
END HYDR-PARM1
HYDR-PARM2
  RCHRES                                                               ***
  # -  #     FTABNO      LEN     DELTH     STCOR        KS      DB50   ***
<------><--------><--------><--------><--------><--------><-------->   ***
  1              1    0.010                           0.0
  2              1    0.660                           0.3
  3              1    0.980                           0.3
  4              1    0.010                           0.3
  5            205    0.380                           0.3
  6              1    0.010                           0.3
  7            204    0.010                           0.3
  8             44    0.596                           0.3
  9            150    0.010                           0.3
 10              1    0.380                           0.3
 11              1    0.010                           0.3
 12            203    1.000                           0.3
 13            207    0.015                           0.3
 14             59    0.450                           0.3
 15              1    0.735                           0.3
 16              1    0.772                           0.3
 17            201    0.755                           0.3
 18            200    0.800                           0.3
 19              1    0.910                           0.3
 20              1    0.010                           0.3
 21              1    0.450                           0.3
 22              1    0.300                           0.3
 23              1    0.010                           0.3
 24              1    0.010                           0.3
 25              1    0.010                           0.3
 26              1    0.780                           0.3
 27              1    0.010                           0.3
 28              1    0.010                           0.3
 29              1    0.010                           0.3
 30              1    0.010                           0.0
 31              1    0.010                           0.0
 32              1    0.010                           0.0
 33              1    0.010                           0.0
 34             99    0.010                           0.0
 35              1    0.010                           0.0
 36              1    0.100                           0.0
 37              1    0.010                           0.0
 38              1    0.010                           0.0
 39              1    0.100                           0.0
 40             89    0.010                           0.0
 41            140    0.010                           0.0
 42            135    0.010                           0.0
```

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  43          25  0.010                          0.0
  44           1  0.010                          0.0
  45           1  0.010                          0.0
  46          59  0.010                          0.0
  47         202  0.010                          0.0
  48           1  0.010                          0.0
  49           1  0.010                          0.0
  50          50  0.010                          0.0
  51           1  0.010                          0.0
  60           1  0.010                          0.0
  61           1  0.010                          0.0
  62           1  0.010                          0.0
  63           1  0.010                          0.0
  64           1  0.010                          0.0
  65           1  0.010                          0.0
  66          66  0.010                          0.0
  67          67  0.010                          0.0
END HYDR-PARM2
HYDR-INIT
  RCHRES  Initial conditions for each HYDR section                              ***
  # -  # ***   VOL     Initial  value  of COLIND     Initial  value  of OUTDGT
         *** ac-ft     for each possible exit        for each possible exit
<------><-------->     <---><---><---><---><---> *** <---><---><---><---><--->
   1    2.0              4.0
   2    0.1              4.0
   3    0.01             4.0
   4    2.0              4.0
   5    0.1              4.0
   6    2.0              4.0
   7    0.1              4.0
   8    0.10             4.0
   9    0.10             4.0
  10    0.10             4.0
  11    0.10             4.0
  12    0.10             4.0
  13    1.0              4.0
  14    0.10             4.0
  15    0.1              4.0
  16    0.1              4.0
  17    0.1              4.0
  18    0.1              4.0
  19    0.1              4.0
  20    1.0              4.0
  21    0.1              4.0
  22    0.1              4.0
  23    0.1              4.0
  24    0.1              4.0
  25    0.1              4.0
  26    0.1              4.0
  27    0.1              4.0
  28    0.1              4.0
  29    0.1              4.0
  30    0.0              4.0
  31    0.1              4.0
  32    0.0              4.0
  33    0.0              4.0
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    34    0.0            4.0
    35    0.0            4.0
    36    0.0            4.0
    37    0.0            4.0
    38    0.0            4.0
    39    0.0            4.0
    40    0.0            4.0
    41    0.0            4.0
    42    0.0            4.0
    43    0.0            4.0
    44    0.0            4.0
    45    0.0            4.0
    46    0.0            4.0
    47    0.0            4.0
    48    0.0            4.0
    49    0.0            4.0
    50    0.0            4.0
    51    0.0            4.0
    60    0.0            4.0
    61    0.0            4.0
    62    0.0            4.0
    63    0.0            4.0
    64    0.0            4.0
    65    0.0            4.0
    66    0.0            4.0
    67    0.0            4.0
  END HYDR-INIT
END RCHRES

FTABLES

  FTABLE      1
 ROWS COLS ***
    8    4
     DEPTH      AREA    VOLUME   OUTFLOW    ***
     0.000    0.0000    0.0000      0.00
     1.000    0.1000    0.0100     100.0
     2.000    0.2000    0.0200     200.0
     3.000    0.3000    0.0300     300.0
     4.000    0.4000    0.0400     500.0
     6.000    0.6000    0.0600     700.0
     7.000    0.7000    0.0800     800.0
     8.000    0.8000    0.1000     999.9
  END FTABLE  1

  FTABLE    115
  LENGTH    750     ***
 ROWS COLS ***
    9    4
      .000      .000      .000      .000
      .500      .176      .850     9.200
     1.000      .194     3.575    30.400
     2.000      .232    10.325   105.800
     3.000      .271    31.075   228.900
     4.000      .310    50.825   405.800
     5.000      .349   138.575   642.700
```

```
    6.000      .387   217.325   945.700
    7.000      .426   320.075  1320.700
  END FTABLE115

  FTABLE    110
  LENGTH    570    ***
 ROWS COLS ***
   11    4
     .000      .000      .000      .000
     .250      .020      .033     2.200
     .500      .027      .153     9.400
     .750      .031      .390    21.000
    1.000      .035      .765    36.000
    1.250      .039     1.303    53.600
    1.500      .039     1.990    72.000
    1.750      .041     2.828    89.500
    2.000      .041     3.815   104.700
    2.250      .041     4.928   114.200
    2.500      .038     6.128   114.300
  END FTABLE110

  FTABLE     25
  POND B      1    ***
 ROWS COLS ***
   11    4
     .000    13.500      .000      .000
     .280    13.500     3.800      .500
     .590    13.500     9.000     2.000
     .930    13.500    13.800     4.800
    1.250    13.500    19.000     8.600
    1.600    13.500    24.000    13.500
    1.920    13.500    28.500    19.300
    2.250    13.500    33.500    26.000
    2.600    13.500    36.500    37.000
    2.900    13.500    40.500    39.000
    3.200    13.500    43.700    49.000
  END FTABLE 25

  FTABLE    120
  LENGTH    590    ***
 ROWS COLS ***
   13    4
     .000      .000      .000      .000
     .600      .051      .450     6.000
    1.200      .068     2.100    25.500
    1.800      .080     5.430    56.800
    2.400      .090    10.740    97.700
    3.000      .095    18.150   145.200
    3.600      .100    27.690   195.100
    4.200      .102    39.330   242.700
    4.800      .103    52.950   283.700
    5.400      .101    68.280   309.400
    6.000      .096    84.810   309.500
    8.000      .072   141.510   402.000
   10.000      .058   198.410   476.000
  END FTABLE120
```

```
 FTABLE    125
 LENGTH  10470    ***
ROWS COLS ***
  11    4
     .000       .000       .000       .000
     .200       .361       .020       .800
     .400       .406       .085      3.400
     .600       .481       .210      7.600
     .800       .541       .410     13.000
    1.000       .577       .690     19.400
    1.200       .601      1.050     26.000
    1.400       .605      1.485     32.400
    1.600       .608      1.990     37.900
    1.800       .601      2.560     41.300
    2.000       .566      3.174     41.400
 END FTABLE125

 FTABLE    135
 LENGTH   1200    ***
ROWS COLS ***
   7    4
     .000       .000       .000       .000
     .500       .198       .600      9.000
    1.000       .236      2.625     30.900
    2.000       .306     12.875    115.800
    3.000       .376     33.925    265.500
    4.000       .446     69.175    491.800
    5.000       .517    122.025    806.300
 END FTABLE135

 FTABLE     40
 LENGTH    750    ***
ROWS COLS ***
  12    4
     .000       .000       .000       .000
     .350       .037       .087      2.900
     .700       .052       .420     12.400
    1.050       .059      1.085     27.800
    1.400       .066      2.135     47.700
    1.750       .071      3.605     70.900
    2.100       .074      5.495     95.300
    2.450       .076      7.805    118.500
    2.800       .077     10.517    138.500
    3.150       .075     13.563    151.100
    3.500       .071     16.835    151.200
    3.900       .064     20.677    170.000
 END FTABLE 40

 FTABLE    140
 LENGTH   2300    ***
ROWS COLS ***
  11    4
     .000       .000       .000       .000
     .300       .098       .056      2.100
     .600       .132       .261      8.800
```

```
      .900      .158       .681    19.600
     1.200      .172      1.341    33.600
     1.500      .185      2.256    50.000
     1.800      .194      3.441    67.100
     2.100      .200      4.896    83.500
     2.400      .201      6.606    97.600
     2.700      .197      8.526   106.500
     3.000      .185     10.581   106.600
  END FTABLE140

  FTABLE    145
  LENGTH    900     ***
 ROWS COLS ***
    8    4
      .000      .000       .000      .000
      .500      .180       .725     6.200
     1.000      .208      3.125    20.800
     2.000      .260     14.875    75.400
     3.000      .313     38.425   168.700
     4.000      .366     77.175   306.900
     5.000      .418    134.525   496.100
     6.000      .471    213.875   742.300
  END FTABLE145

  FTABLE     44
  LENGTH    900     ***
 ROWS COLS ***
    8    4
      .000      .000       .000      .000
      .500      .180       .725     6.200
     1.000      .208      3.125    20.800
     2.000      .260     14.875    75.400
     3.000      .313     38.425   168.700
     4.000      .366     77.175   306.900
     5.000      .418    134.525   496.100
     6.000      .471    213.875   742.300
  END FTABLE 44

  FTABLE    150
  LENGTH   1000     ***
 ROWS COLS ***
    8    4
      .000      .000       .000      .000
      .500      .200       .725     9.700
     1.000      .231      3.125    32.600
     2.000      .289     14.875   118.300
     3.000      .348     38.425   264.700
     4.000      .406     77.175   481.500
     5.000      .465    134.525   778.400
     6.000      .523    213.875  1164.600
  END FTABLE150

  FTABLE      59
  EXECUTEL POND     ***
 ROWS COLS ***
   19    4
```

```
       .000      .000      .000      .000
      1.000      .080      .080    24.420
      2.000      .230      .310    34.540
      3.000      .393      .703    42.300
      3.500      .494      .950    45.690
      4.000      .508     1.204    48.850
      4.500      .532     1.470    51.810
      5.000      .540     1.740    54.610
      5.500      .540     2.010    57.280
      6.000      .580     2.300    59.820
      6.500      .600     2.600    62.270
      7.000      .600     2.900    64.620
      7.500      .600     3.200    66.900
      8.000      .620     3.510    69.100
      8.500      .640     3.830    71.200
      9.000      .740     4.200    82.220
     10.000      .650     4.850   119.830
     11.000      .720     5.570   169.000
     12.000      .750     6.320   250.900
  END FTABLE 59

  FTABLE     99
  BOW LAKE          ***
 ROWS COLS ***
  15    4
       .000    14.000      .000      .000
       .230    14.000     3.800      .300
       .470    14.000     6.900     1.100
       .720    14.000    10.000     2.500
       .960    14.000    13.800     4.400
      1.200    14.000    17.000     6.700
      1.450    14.000    20.500    12.000
      1.700    14.000    23.800    20.000
      2.000    14.000    25.000    35.000
      3.000    14.000    27.800    65.000
      4.000    14.000    41.000    90.000
      5.000    14.000    54.200   110.000
      6.000    14.000    67.400   130.000
      7.000    14.000    80.600   155.000
      8.000    14.000    93.800   180.000
  END FTABLE 99

  FTABLE     105
  LENGTH     460      ***
 ROWS COLS ***
  11    4
       .000      .000      .000      .000
       .300      .020      .056     1.000
       .600      .026      .261     4.200
       .900      .032      .681     9.400
      1.200      .034     1.341    16.200
      1.500      .037     2.262    24.000
      1.800      .039     3.458    32.300
      2.100      .040     4.917    40.100
      2.400      .040     6.627    46.900
      2.700      .039     8.547    51.200
```

```
   3.000      .037    10.617     51.300
 END FTABLE105

 FTABLE    100
 LENGTH   5700      ***
ROWS COLS ***
  11    4
     .000      .000      .000       .000
     .400      .343      .140      2.200
     .800      .442      .640      9.500
    1.200      .523     1.640     21.100
    1.600      .577     3.220     36.300
    2.000      .618     5.420     54.000
    2.400      .646     8.260     72.500
    2.800      .659    11.720     90.200
    3.200      .662    15.760    105.500
    3.600      .649    20.300    115.000
    4.000      .618    25.200    125.100
 END FTABLE100

 FTABLE    200
 LENGTH   2150      ***
ROWS COLS ***
  14    4
     .000      .000      .000       .000
     .500      .572      .191      7.300
    1.000      .799      .438     23.200
    2.000      .968     1.001     75.700
    3.000     1.155     1.727    155.100
    4.000     1.317     2.542    262.700
    5.000     1.478     3.475    400.300
    6.000     1.643     4.545    570.200
    7.000     1.791     5.688    774.400
    8.000     1.932     6.822   1015.100
    9.000     1.945     7.025   1294.500
   10.000     1.958     7.244   1614.500
   11.000     1.970     7.481   1977.000
   12.000     1.983     7.734   2384.700
 END FTABLE200

 FTABLE    201
 LENGTH   1125      ***
ROWS COLS ***
  10    4
     .000      .000      .000       .000
     .300      .169      .034      2.900
     .600      .192      .076      9.800
     .900      .215      .128     20.400
    1.200      .238      .189     35.100
    1.500      .259      .258     54.100
    1.800      .282      .336     77.700
    2.100      .303      .423    106.200
    3.100      .376      .779    245.000
    3.600      .412      .988    335.000
 END FTABLE201
```

```
 FTABLE    202
 LENGTH   1330      ***
ROWS COLS ***
  11    4
      .000      .000      .000      .000
      .350      .069      .020     4.600
      .700      .096      .056    19.200
     1.050      .112      .099    42.800
     1.400      .124      .150    73.400
     1.750      .125      .203   109.000
     2.100      .121      .240   146.600
     2.450      .110      .264   182.400
     2.800      .096      .284   213.200
     3.150      .090      .290   232.400
     3.500      .088      .293   232.600
 END FTABLE202

 FTABLE    203
 LENGTH   1440      ***
ROWS COLS ***
   9    4
      .000      .000      .000      .000
      .500      .291      .111     3.600
     1.000      .346      .263    12.400
     2.000      .450      .684    45.800
     3.000      .554     1.256   103.500
     4.000      .656     1.974   189.700
     5.000      .753     2.788   308.400
     6.000      .796     3.189   464.400
     7.000      .837     3.623   658.200
 END FTABLE203

 FTABLE    204
 LENGTH   1800      ***
ROWS COLS ***
   8    4
      .000      .000      .000      .000
      .500      .360      .120     6.200
     1.000      .416      .276    20.800
     2.000      .520      .694    75.400
     3.000      .626     1.252   168.700
     4.000      .732     1.950   306.900
     5.000      .836     2.790   496.100
     6.000      .942     3.768   742.300
 END FTABLE204

 FTABLE    205
 LENGTH   2235      ***
ROWS COLS ***
  13    4
      .000      .000      .000      .000
      .550      .290      .098     4.900
     1.100      .543      .299    20.800
     1.650      .609      .520    46.500
     2.200      .671      .774    80.000
     2.750      .732     1.040   118.700
```

```
     3.300       .778     1.288   159.500
     3.850       .819     1.519   198.400
     4.400       .849     1.701   231.900
     4.950       .866     1.817   252.900
     5.500       .865     1.820   253.000
     8.200       .973     2.565   400.000
    10.200      1.043     3.139   520.000
  END FTABLE205

  FTABLE    206
  LENGTH   2010     ***
 ROWS COLS ***
  13    4
      .000       .000      .000      .000
      .450       .134      .045     4.800
      .900       .190      .133    20.300
     1.350       .225      .236    45.400
     1.800       .249      .348    78.000
     2.250       .266      .474   115.900
     2.700       .271      .610   155.800
     3.150       .264      .707   193.800
     3.600       .251      .772   226.500
     4.050       .238      .812   247.000
     4.500       .234      .825   247.100
     6.500       .185      .833   340.000
     8.500       .166      .838   415.000
  END FTABLE206

  FTABLE    207
  LENGTH    750     ***
 ROWS COLS ***
   9    4
      .000       .000      .000      .000
      .500       .153      .051     4.300
     1.000       .272      .132    14.400
     2.000       .317      .312    50.400
     3.000       .360      .544   109.600
     4.000       .404      .826   195.000
     5.000       .450     1.163   309.500
     6.000       .497     1.548   456.300
     7.000       .542     1.984   638.000
  END FTABLE207

  FTABLE     89
  TYEE POND         ***
 ROWS COLS ***
  19    4
      .000       .000      .000      .000
     1.000       .272      .010     5.000
     2.000       .317      .022    10.000
     3.500       .360      .070    18.000
     4.500       .404      .200    23.000
     5.500       .450      .500    30.000
     6.500       .497      .880    38.000
     7.500       .542     1.300    46.000
     8.500       .642     2.400    54.000
```

```
      9.500       .742     3.300    64.000
     10.500       .842     4.800    73.000
     11.500       .942     6.000    83.000
     12.500      1.042     9.400    94.000
     13.500      1.142    11.100   105.000
     14.500      1.242    15.300   115.000
     16.000      1.442    19.200   130.000
     16.500      1.542    20.300   135.000
     17.000      1.672    21.500   270.000
     17.500      1.742    23.300   520.000
  END FTABLE 89

*** storage increased 20%, discharge reduced 10%

  FTABLE     50
   11    4
       .000      3.392      .000      .000
       .600      3.392     3.441    31.310
      1.200      3.392     6.885    44.270
      2.400      3.392    10.769    62.610
      3.250      3.392    14.228    72.860
      4.200      3.392    17.100   101.500
      5.400      3.392    21.979   117.510
      6.000      3.392    24.423   130.770
      6.400      3.392    26.050   145.110
      6.800      3.392    27.678   166.590
      7.200      3.392    29.307   192.610
  END FTABLE 50

  FTABLE     66
   11    4
      0.000      0.643     0.000     0.000
      0.600      0.643     0.462    12.520
      1.200      0.643     0.925    17.710
      2.400      0.643     2.150    25.040
      3.250      0.643     2.606    29.140
      4.200      0.643     3.237    43.610
      5.400      0.643     4.165    53.330
      6.000      0.643     4.626    57.420
      6.400      0.643     4.935    68.840
      6.800      0.643     5.244    87.480
      7.200      0.643     5.552   110.830
  END FTABLE 66

  FTABLE     67
   11    4
       .000       .339      .000      .000
       .600       .339      .243     3.410
      1.200       .339      .487     4.830
      2.400       .339     1.500     6.830
      3.600       .339     1.761     8.370
      4.800       .339     2.151     9.657
      5.400       .339     2.396    18.330
      6.000       .339     2.440    23.580
      6.400       .339     2.602    35.100
      6.800       .339     2.765    53.700
```

```
    7.200      .339     2.923    76.820
  END FTABLE 67

END FTABLES

END RUN
```

***

APPENDIX P

NATURAL RESOURCE MITIGATION PLAN

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NATURAL RESOURCE MITIGATION PLAN

FOR THE PROPOSED MASTER PLAN UPDATE IMPROVEMENTS AT SEATTLE-TACOMA INTERNATIONAL AIRPORT

Prepared for

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Seattle-Tacoma International Airport
Project Consultant's Office MT Room 6434
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Prepared by

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January 15, 1996

TABLE OF CONTENTS

Page

AR 039676

TABLE OF CONTENTS (continued)

TABLE OF CONTENTS (continued)

LIST OF FIGURES

AR 039679

LIST OF TABLES

LIST OF TABLES (continued)

AR 039681

1. INTRODUCTION

1.1 PROJECT DESCRIPTION

The Port of Seattle (Port) is proposing to update the Master Plan of Seattle-Tacoma International Airport (Sea-Tac Airport). Implementation of the proposed updated Master Plan would result in development that could cause significant, unavoidable adverse impacts to natural resources in the project vicinity, most notably to Miller and Des Moines creeks, and 10.35 acres of wetlands (Figure 1.1-1). This report describes the mitigation to compensate for these natural resource impacts.

1.1.1 Purpose and Need

As currently configured, Sea-Tac Airport is unable to efficiently meet existing and future regional air travel demands. The airfield operates inefficiently during poor weather because it can accommodate only a single arrival stream. As a result, significant arrival delay occurs during poor weather. Aircraft are either held on the ground in their originating city, slowed en route, or they are placed in holding patterns to await clearance to land at Sea-Tac Airport. These conditions result in the inefficient operation of the existing airfield, as described in Chapter I of the Final EIS.

With or without airport development, airport activity is expected to increase as a consequence of regional population growth. As aviation demands grow, aircraft operating delay would increase exponentially. The increased passenger, cargo, and aircraft operations demands would place increasing burdens on the existing terminal and support facilities. Without improvements, the roadway system, terminal space, gates, cargo and freight processing space would become more inefficient and congested, and the quality of service would be reduced.

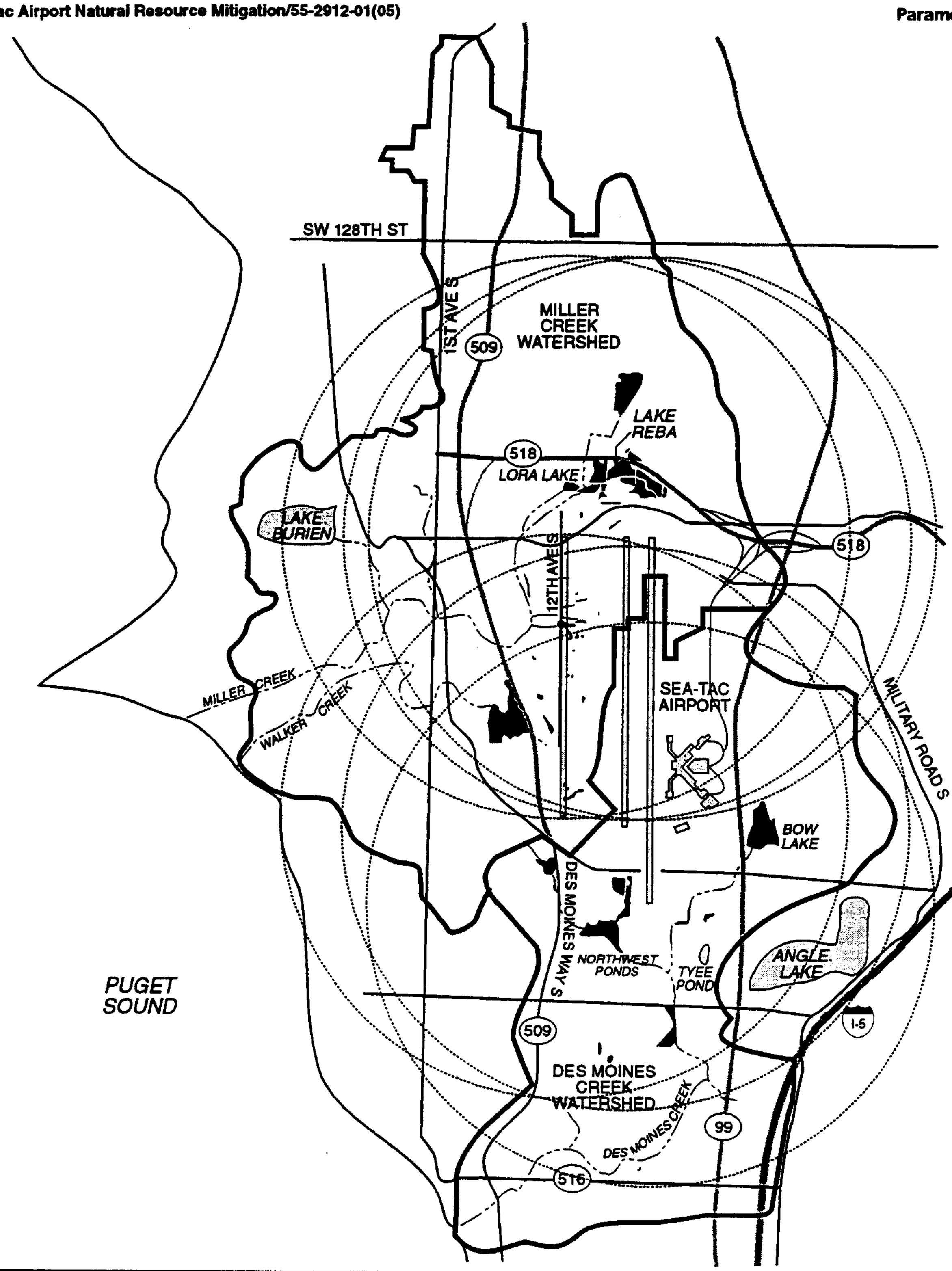
Before and during preparation of the proposed Master Plan Update, regional officials identified the following needs:

- Improve the poor weather airfield operating capability to accommodate aircraft activity with an acceptable level of aircraft delay;

- Provide sufficient runway length to accommodate either warm weather operations or payloads for aircraft types operating to the Pacific Rim;

- Provide Runway Safety Areas (RSAs) that meet current Federal Aviation Administration (FAA) standards; and

- Provide efficient and flexible landside facilities to accommodate future aviation demand.



Source: Shapiro 1995e

SCALE IN MILES
0 1

N

10,000 feet from end of runway

Watershed Boundary

Figure 1.1-1
Proposed Master Plan Update Impact Area

1.1.2 Key Project Elements

The proposed Master Plan Update includes the following major components:

- adding a third parallel runway (16X/34X) with a length of up to 8,500 ft and associated taxiway and navigational aids
- extending Runway 34R by 600 ft
- establishing standard RSAs for existing Runways 16R/34L and 16L/34R
- adding a new air traffic control tower
- improving and expanding the main terminal
- improving and expanding parking and access
- developing the South Aviation Support Area (SASA) for cargo and/or maintenance facilities
- relocating, redeveloping, and expanding support facilities.

Those proposed airport improvements that would have the greatest effect on wetlands and streams are the new runway, the Runway 34R extension, and the development of SASA. The analysis in this Natural Resource Mitigation Plan assumes the maximum buildout described in the proposed Master Plan Update Final EIS, including a new 8,500-ft runway. If the Port were to choose to build a shorter runway (less than 8,500 ft), impacts to natural resources, particularly Miller Creek, would be reduced.

1.1.3 Unavoidable Impacts to Wetlands and Streams

1.1.3.1 Wetlands

Some 55 individual wetlands totalling nearly 144 acres occur within the detailed study area used for analysis in the Master Plan Update EIS (EIS). Thirty-four individual wetlands could be directly affected by development at the Airport. The EIS identified 10.35 acres that would be directly affected by proposal implementation. The 21 wetlands that would not be affected include some of the larger wetlands on the airport site.

Significant unavoidable adverse impacts would occur to wetlands in the study area. The impacts include filling, grading, changing hydrology, and removing vegetation.

To mitigate for the unavoidable impacts to wetlands, the Port proposes to create new wetlands on a 47-acre site of an approximately 69-acre parcel located within the city limits of Auburn, Washington. Wetland mitigation at the Airport, within the watersheds where the impacts may occur, is not feasible for three reasons: (1) most of the area surrounding the Airport is developed, and not enough available land exists in the watershed to create compensatory mitigation wetlands without additional business and residential relocation; (2) the FAA is currently finalizing a Draft Circular that states that airports with "wildlife attractions" within 10,000 ft of the edge of any active runway is not recommended by the FAA; and (3) wildlife control activities in wetlands near the airport would conflict with wetland habitat mitigation goals. Because of wildlife attraction issues, the Port cannot commit to maintaining sites on or near the Airport as wetland habitat mitigation in perpetuity. If a site were to become a safety concern because of its attraction to wildlife, particularly birds, and jeopardize aircraft safety, the Port would be compelled to remove it. Safe airport operations are the Port's and the FAA's p: :ry concern. However, the hydrologic functions the wetlands perform would be replaced at airport site with the proposed storm water management facilities.

1.1.3.2 Streams

Proposed Master Plan Update improvements would affect two streams: Miller Creek, at the northwest corner of the airport property, and Des Moines Creek, at the southern end. Both would require relocation.

<u>Miller Creek</u>

The Airport Master Plan's proposed fill activities would directly affect three areas in the Miller Creek watershed (Shapiro 1995e) due to the proposed new parallel runway embankment. Area 1 includes approximately 980 ft of Miller Creek. The affected portions extend approximately 1,000 ft south of Lora Lake. Area 2 includes Class III tributaries, totaling 2,080 ft, that originate as seeps in the Airport Operations Area (AOA) then flow west to Miller Creek. Area 3 includes 200 ft of the Class III headwaters of Walker Creek. These waters, which originate from seepage and storm water runoff at the corner of 12th Avenue South and South 176th Street, flow northwest to State Route 509 (SR 509).

<u>Des Moines Creek</u>

The relocation of Des Moines Creek was first proposed in the *South Aviation Support Area (SASA) EIS*, a joint NEPA/SEPA document prepared by the Port of Seattle and the FAA. The Final EIS was released in March 1994; the FAA's Record of Decision was made final in September 1994. The proposed Master Plan Update has further refined the layout and contents of SASA, which would require a new realignment plan for Des Moines Creek. This new alignment is assessed in this mitigation plan. Because the proposed Master Plan Update would be implemented in phases, with development at the SASA location occurring relatively late in the process, the final SASA layout cannot be established until that time. If the layout is substantially different than outlined in the SASA Final EIS or the Master Plan Update Final EIS, supplemental environmental review could be required. At that time, the Port would apply for the necessary permits, including those required for the Des Moines Creek relocation, and a detailed mitigation plan would be prepared.

Regardless of the final layout, it is likely that 2.23 acres of wetlands would be filled for the SASA development. Building the compensatory wetlands when implementing the first phases of Master Plan would help ensure that they are functional by the time the actual impacts occur to the existing wetlands at the SASA site.

1.2 PROJECT LOCATION

The proposed project is located at Seattle-Tacoma International Airport, SeaTac, King County, Washington.

The impacted wetlands and streams are located in Sections 20, 21, 28, 29, 32, and 33, Township 23N, Range 4E; and Sections 4 and 5, Township 22N, Range 4E, Willamette Meridian in the Des Moines and Miller Creek watersheds.

The wetland mitigation site lies within the city limits of Auburn, King County, Washington in Section 31, Township 22N, Range 5E, Willamette Meridian in the Green River watershed.

1.3 RESPONSIBLE PARTIES

Proponent:
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P.O. Box 68727
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1.4 REPORT ORGANIZATION

The report is modeled after *Guidelines for Developing Freshwater Wetlands Mitigation Plans and Proposals* (Ecology 1994). The Natural Resource Mitigation Plan is divided into three major chapters; Wetlands, Miller Creek, and Des Moines Creek. Each chapter is intended to be a separate report that fully describes the mitigation proposal for that particular resource. The chapters discuss (1) the current resource conditions, (2) the goals, objectives, and performance standards of the proposed mitigation, (3) the proposed mitigation site, (4) the proposed mitigation site plan, and (5) provisions for monitoring, protecting, and maintaining the mitigation. Each chapter also discusses proposed contingency measures to be implemented if the established performance standards are not achieved.

2. MITIGATION APPROACH

Federal, state, and local natural resources regulatory programs share a common policy objective; that is, protecting and conserving the biological and physical integrity of our natural resource systems. The agencies implementing these programs have widely overlapping regulatory mandates, thereby requiring an integrated approach to project planning. The National Environmental Policy Act (NEPA) (40 CFR §1508.20) specifically defines the following sequential process for project planning to reduce adverse impacts:

- avoid the impact altogether by not taking a certain action or parts of an action;
- minimize impacts by limiting the degree of magnitude of the action and its implementation;
- rectify the impact by repairing, rehabilitating, or restoring the affected environment;
- reduce or eliminate the impact by preservation and maintenance operations during the life of the action (including monitoring and appropriate corrective measures;) and
- compensate for the impact by replacing or providing substitute resources or environments.

The Port of Seattle used this approach to develop the proposed Master Plan Update. This chapter documents that process. Section 2.1 discusses airport siting, operation, and design alternatives considered to avoid and minimize impacts to natural resources. Section 2.2 identifies the overall intent of the Master Plan Update to mitigate for unavoidable impacts to regulated natural resources. The broad Master Plan Update mitigation goals in Section 2.2 are further defined in separate sections for wetlands and streams (see Sections 3.3, 4.3 and 5.3), with specific goals, objectives, and performance standards.

2.1 MITIGATION SEQUENCING

The planning process that led to the proposal analyzed in the Master Plan Update EIS began in the mid 1980s. During this process, several alternatives that would avoid or minimize the impacts to the wetlands and streams at Sea-Tac Airport were considered. This section describes those alternatives.

2.1.1 Alternatives Considered to Avoid or Minimize Natural Resource Impacts

Several siting, operational, and design alternatives that would avoid or minimize natural resource impacts were analyzed during the Flight Plan Study, the New Major Supplemental Airport Siting Study, and the Master Plan Update. Chapter II and Appendix B of the Master Plan Update FEIS describe the alternatives in further detail.

2.1.1.1 Siting Alternatives

Flight Plan Study

Studies in the late 1980s concluded that the existing two runways at Sea-Tac would not meet regional air travel needs beyond the year 2000. As a result, the Port of Seattle and the regional planning council (now called the Puget Sound Regional Council or PSRC) co-sponsored a process, called the Flight Plan Study, to identify a long-term solution to the region's air transportation needs. The study analyzed alternatives to accommodate demand by replacing or supplementing Sea-Tac Airport. Based on this 2½-year effort, the 1992 Flight Plan Study recommended a multiple airport system that included a new runway at Sea-Tac Airport.

New Major Supplemental Airport Siting Study

In response to the Flight Plan Study and additional study by PSRC, the PSRC General Assembly adopted Resolution A-93-03 in April 1993 to amend the Regional Aviation Systems Plan. The PSRC resolution states " . . .that the region should pursue vigorously, as the preferred alternative, a major supplemental airport and a third runway at Sea-Tac."

The PSRC then studied the feasibility of a major supplemental airport in response to the recommendations of the Flight Plan Study and the subsequent Resolution A-93-03. The Major Supplemental Airport (MSA) Study was to be conducted in two phases. Phase I identified feasible sites and Phase II was to prepare a preliminary site plan for each of the feasible sites.

The Phase I studies resulted in three recommended sites; Arlington, Marysville, and Tanwax Lake. Due, in part, to significant public opposition, Phase II was not implemented. Executive Board Resolution EB-94-01 (October 27, 1994) states that ". . .the Executive Board concludes that there are no feasible sites for a major supplemental airport within the four-county region and that continued examination of any local site will prolong community anxiety while eroding the credibility of regional governance."

2.1.1.2 Operation Alternatives

As stated in Section 1.1.1, the following four operational needs have been identified:

- Improve the poor weather airfield operating capability to accommodate aircraft activity with an acceptable level of aircraft delay;
- Provide sufficient runway length to accommodate either warm weather operations or payloads for aircraft types operating to the Pacific Rim;
- Provide RSAs that meet current FAA standards; and
- Provide efficient and flexible landside facilities to accommodate future aviation demand.

The EIS for the proposed Master Plan Update Improvements, as required by NEPA and the State Environmental Policy Act (SEPA), analyzed a reasonable range of alternatives to meet these four needs. Table 2.1-1 addresses the various alternatives.

As the table suggests, several alternatives were considered that would avoid impacts to natural resources at the airport. The alternatives were rejected, however, because they did not meet the four operational needs identified in the proposed Master Plan Update.

2.1.1.3 Design Alternatives

The Master Plan Update EIS lists several design measures that would be implemented to minimize the natural resource impacts. These measures include:

- using off-site fill to avoid approximately 19 acres of wetlands in an otherwise feasible on-site borrow area
- using retaining walls rather than sloped fill to avoid direct impacts to portions of Miller Creek

2.1.2 <u>Proposed Compensation</u>

The remainder of this Natural Resource Mitigation Plan outlines the Port's proposal to compensate for the unavoidable impacts to wetlands and streams that full implementation of the proposed Master Plan Update would cause.

2.2 GOAL DEVELOPMENT FOR NATURAL RESOURCE MITIGATION PLAN

The federal wetlands "no net loss" standard aims to achieve no overall net loss of wetland acreage and function and to increase the nation's quality and quantity of wetlands resources through restoration and creation. This policy objective is central to the mitigation approach for unavoidable impacts to stream and wetland resources resulting from implementation of the proposed Master Plan Update. The goals for this program broadly define the intent to compensate for unavoidable wetland and stream impacts, by providing appropriate replacement resources both on- and off-site. The potential impacts to biological and physical functions (discussed in Sections 3.2, 4.2, and 5.2) are emphasized in the mitigation goals to ensure that objectives and performance standards are appropriate, measurable, and achievable. The overall goals identified below are further defined in separate sections for wetlands and Miller Creek (Sections 3.3 and 4.3, respectively); they are accompanied by design objectives and performance standards appropriate to each resource.

Goal 1. Achieve no overall net loss of wetland acreage and stream length.

Goal 2. Create diverse native wetland and riparian plant communities and streambed habitat with equal or greater functional value for wildlife and fish.

Goal 3. Enhance airport operations safety, consistent with FAA guidelines, by providing off-site replacement habitats for wildlife species that create a potential hazard for aircraft.

Goal 4. Achieve no net loss of 100-year floodplain storage.

Table 2.1-1. Summary of alternatives considered.

	Alternative	Evaluation
1.	**Improve the poor weather airfield operating capability to accommodate aircraft activity with an acceptable level of aircraft delay**	
A.	Use of other modes of transportation	Not considered further, as this alternative will not address the poor weather operating issues at Sea-Tac. Less than 5% of passengers using Sea-Tac are traveling to distances where surface transportation is efficient and cost effective.
B.	Use of other airports or construction of a new airport.	Not considered further. Regional consensus has been established through PSRC EB-94-01 as: (1) there is no sponsor or funding for a new airport; (2) extensive studies of these alternatives indicate that there are no feasible sites; (3) if a site could be identified, market forces and planning/development requirements would prevent the airport from successfully serving regional demand until 2010 or later. The FAA and Port have independently concluded that a new airport would not satisfy the needs addressed by the EIS.
C.	Activity/demand management	Not considered further, as these actions will not eliminate the poor weather operating need.
D.	Runway development at Sea-Tac	To be considered further: Runway lengths from 7,000 ft to 8,500 ft (Alternatives 2, 3, and 4 in the EIS).
E.	Use of Technology	Not considered further. No technologies currently exist, or are planned, to address the poor weather operating constraint at Sea-Tac.
F.	Delayed or Blended Alternative (Combination of other modes, use of existing airports, and activity/demand management)	The net result of this alternative would be a delay in the implementation of the Master Plan Update alternatives. Because there is no commitment to any individual or combination of elements and because aviation activity levels are currently growing at a rate slightly higher than forecast, this alternative was not considered further.
G.	Do-nothing/no-build	To be considered further (Alternative 1 in the EIS)
2.	**Provide sufficient runway length to accommodate warm weather operations without restricting passenger load factors or payloads for aircraft types operating to the Pacific Rim.**	
A.	Extension of Runway 16L/34R to 12,500 ft	To be considered further, as this is presently the longest runway.
B.	Extension of Runway 16R/34L to 12,500 ft	Not considered further due to the cost of addressing impacts to South 188th Street.
C.	Development of a new 12,500 ft long runway	Not considered further due to substantial community disruption and unnecessary cost that would result.
D.	Delayed Alternative	Not considered further, as it would not address the needs of Sea-Tac.
E.	Do-nothing/no-build	To be considered further (Alternative 1 in the EIS)

Table 2.1-1. Summary of alternatives considered (continued).

	Alternative	Evaluation
3.	**Provide RSAs that meet current FAA standards.**	
A.	Displaced threshold/declared distance procedures	Considered as the do-nothing/no-build
B.	Clearing, grading, and development of areas for 1,000 ft beyond the existing pavement	Considered further.
C.	Clearing, grading for 1,000 ft including the 600-ft extension to 34R	Considered further.
D.	Delayed Alternative	Not considered further, as it would not address the RSA requirements. However, this would be the same as do-nothing.
E.	Do nothing/no-build	To be considered further for declared distances (Alternative 1).
4.	**Provide efficient and flexible landside facilities to accommodate future aviation demand.**	
A.	Use of other modes of transportation	Not considered further, as less than 5% of the future passengers using Sea-Tac are traveling to distances where surface transportation is efficient and cost effective and likely to be used.
B.	Use of other airports or construction of a new airport	Not considered further. Regional consensus has been established through PSRC EB-94-01 as: (1) There is no sponsor or funding for a new airport; (2) Extensive studies of these alternatives indicate that there are no feasible sites; (3) If a site could be identified, market forces and planning/development requirements would prevent the airport from successfully serving regional demand until 2010 or later.
C.	Activity/demand management	Not considered further, as these actions will not reduce demand.
D.	Landside development at Sea-Tac	To be considered further: Three primary alternatives to be considered further: Central Terminal Development, North Unit Terminal Development and South Unit Terminal Development (Alternatives 2, 3, and 4, respectively in the EIS).
E.	Delayed or Blended alternative (combination of other modes, use of existing airports, and activity/demand management)	The net result of this alternative would be a delay in the implementation of the Master Plan Update alternatives. Because there is no commitment to any individual or combination of elements and because aviation activity levels are currently growing at a rate slightly higher than forecast, this alternative was not considered further.
F.	Do-nothing/no-build	To be considered further (Alternative 1 in the EIS).

Source: Landrum & Brown 1995

3. WETLANDS

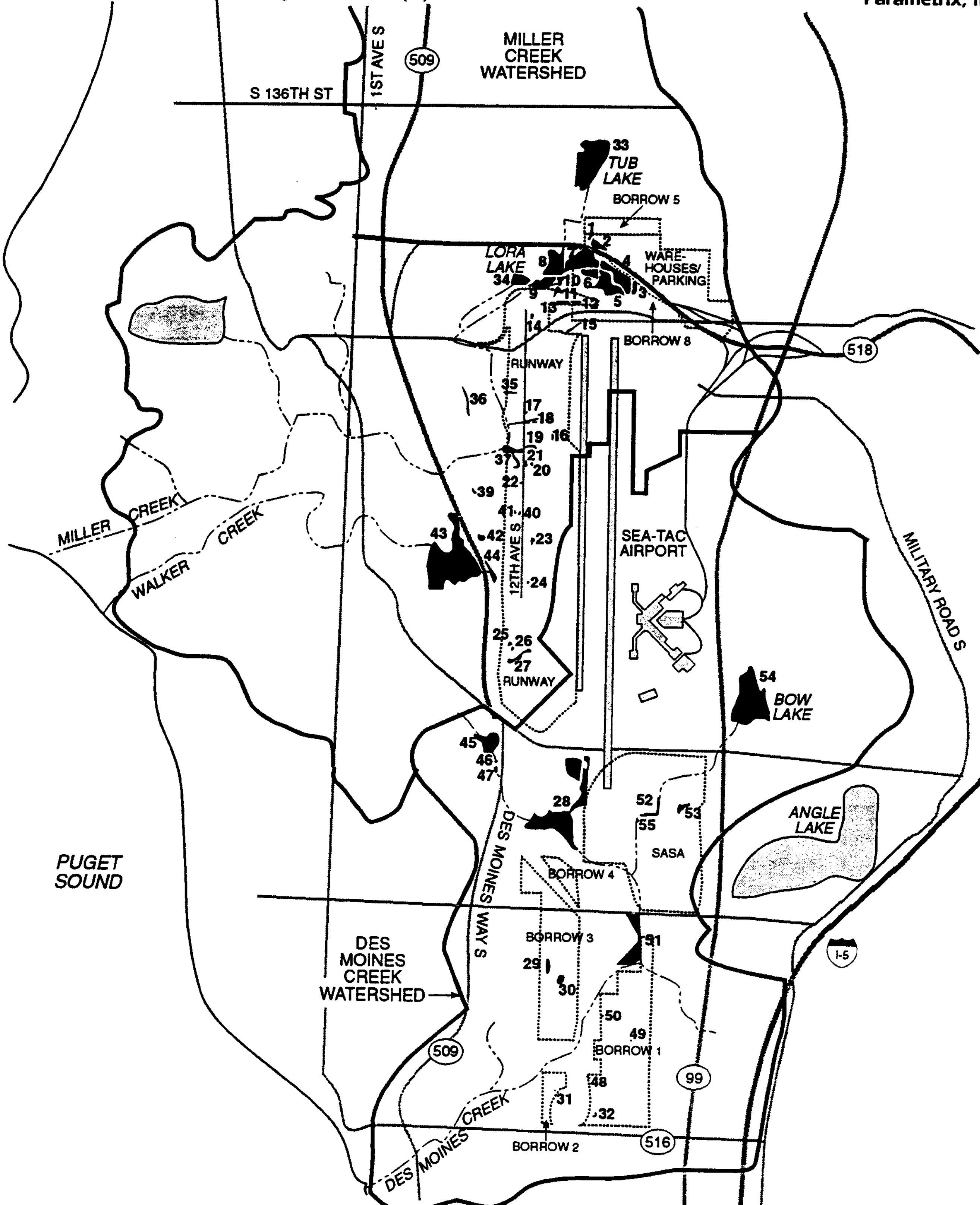
The mitigation plan for wetland impacts associated with proposed Master Plan Update improvements is presented in this chapter. Sections of the proposed plan generally correspond to *Guidelines for Developing Freshwater Wetlands Mitigation Plans and Proposals* (Ecology 1994). Affected wetlands were delineated and characterized for their biological and physical functions, which provided the basis for selecting a mitigation site and developing this plan. Goals, design objectives, and performance standards are identified to guide construction of the mitigation wetland and to provide long-term standards for measuring mitigation success.

3.1 WETLAND DELINEATION OF IMPACT AREA

Shapiro and Associates, Inc. conducted a detailed wetland investigation of the Sea-Tac Airport Master Plan Update study area from August to December 1994 (Shapiro 1995b). By reviewing existing literature, conducting a field reconnaissance, and using air photo interpretation, 55 wetlands were identified on both Port-owned and adjacent private land. Of these, 32 wetlands ranging in size from approximately 0.02 to 18.10 acres were delineated and surveyed as part of the Shapiro study. Wetland 27 is subject to fill under authority of an approved Section 404 Nationwide 26 permit. Wetlands were delineated using the criteria described in the *Federal Manual for Identifying and Delineating Jurisdictional Wetlands* (FICWD 1989). The Federal Manual's Intermediate-Level On-site Determination Method was chosen to determine wetland boundaries. Delineated wetland boundaries do not differ from those that would be identified using the criteria described in the *U.S. Army Corps of Engineers Wetlands Delineation Manual* (Environmental Laboratory 1987).

Of the remaining 23 wetlands not delineated by Shapiro, 10 had been inventoried during previous studies (CH2M Hill 1995; Parametrix 1994; Sea-Tac 1993; Sheldon 1992) and 13 wetlands were not delineated because permission to access private properties containing these wetlands could not be obtained. Figure 3.1-1 shows the locations of wetlands in the Sea-Tac Master Plan Update study area. Table 3.1-1 lists the size, Cowardin (1979) classification, and dominant vegetation communities for each wetland. The complete jurisdictional wetland determination for the proposed Sea-Tac Airport Master Plan Update improvements is included in the EIS as Appendix H-A (Shapiro 1995b).

Thirty-four individual wetlands would be impacted by implementation of the proposed Sea-Tac Airport Master Plan Update improvements. The total area of wetland impact is 10.35 acres. These impacts would occur mostly during Phase I of plan implementation, which includes



Source: Shapiro 1995e
Additional Data Compiled by Paramertix

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Palustrine Wetland

Potential Construction Impact Area

Figure 3.1-1
Wetlands Affected by Construction

Table 3.1-1. Classification, size, and impacts to wetlands in the proposed Sea-Tac Airport Master Plan Update study area.

Wetland Number	Classification [1]	Wetland Size (Acres)	Total Impact (Acres)	Vegetation Cover Type Impact (Acres)		
				FO	SS	EM
1	PFO	0.07	0.07	0.07		
2	PFO/EM (60/40)	0.74	0.74	0.44		0.29
3	PFO	0.56	0.56	0.56		
4	PFO	5.02	0.00			
5	PFO/SS	4.58	0.00			
6	PSS	0.87	0.00			
7	PFO/OW/EM	6.70	0.00			
8	PSS/EM	4.95	0.00			
9	PEM/FO (60/40)	2.85	0.13	0.05		0.08
10	PSS	0.31	0.00			
11	PFO/EM (80/20)	0.50	0.47	0.37		0.09
12	PEM/FO (80/20)	0.21	0.21	0.04		0.16
13	PEM	0.05	0.05			0.05
14	PFO	0.19	0.19	0.19		
15	PEM	0.28	0.28			0.28
16	PEM	0.06	0.06			0.06
17	PEM	0.03	0.03			0.03
18	PFO	0.12	0.12	0.12		
19	PFO	0.57	0.57	0.57		
20	PSS/EM (90/10)	0.06	0.06		0.06	0.01
21	PFO	0.22	0.22	0.22		
22	PEM/SS (90/10)	0.06	0.06		0.01	0.05
23	PEM	0.78	0.78			0.78
24	PEM	0.14	0.14			0.14
25	PFO	0.06	0.06	0.06		
26	PEM	0.02	0.02			0.02
27	PEM[2]	0.00	0.00			
28	POW/SS (O/100)	18.10	0.06		0.06	
29	PFO	0.74	0.74	0.74		
30	FO/PSS (80/20)	0.50	0.50	0.40	0.10	
31	PEM	0.05	0.00			
32	PEM	0.05	0.05			0.05
33	PFO/SS/EM/OW	17.60	0.00			
34	POW	1.40	0.00			
35	PEM	0.21	0.18			0.18
36	PFO/EM	0.30	0.00			
37	PFO/SS (70/30)	2.41	1.68	1.17		0.50
38	PEM/SS[3]	0.00	0.00			
39	PFO	0.07	0.00			
40	PFO	0.09	0.09	0.09		
41	PEM	0.08	0.08			0.08
42	PEM	0.50	0.00			
43	PEM/SS/FO/OW	30.30	0.00			
44	PFO/SS	0.70	0.00			
45	PEM	5.00	0.00			
46	POW	0.06	0.00			
47	POW	0.20	0.00			
48	PEM	0.02	0.00			
49	PSS	0.02	0.02		0.02	
50	PEM	0.03	0.03			0.03
51	PFO	8.10	0.48	0.48		
52	PFO/SS (90/10)	1.00	1.00	0.90	0.10	
53	PFO	0.60	0.60	0.60		
54	PSS/OW	25.70	0.00			
55	PSS	0.04	0.04		0.04	
TOTAL[4]		**143.86**	**10.35**	**7.08**	**0.39**	**2.88**

Source: Shapiro 1995b; additional data compiled by Parametrix

[1]Based on USFWS classification system (Cowardin et al. 1979). Where impacts would occur to more than one cover type, the percentages used for impact calculations are shown in parenthesis.

[2] Fill of this wetland has been approved by a Section 404 Nationwide 26 permit.

[3]This wetland was determined not to be a regulated wetland by the City of Sea-Tac and the Corps of Engineers.

[4]Values are rounded to two significant figures. Actual values differ slightly due to the effects of rounding.

construction of the new parallel runway, the Runway 34R extension, and RSA upgrades. Wetland mitigation is planned to compensate for all anticipated wetland impacts attributed to full implementation of the proposed Master Plan Update improvements.

3.2 ECOLOGICAL ASSESSMENT OF IMPACT SITE

Study area wetlands occur in two drainage basins (Des Moines Creek and Miller Creek basins) and in many cases are physically separated from other wetlands and upland habitats by urban and industrial development (refer to Figure 3.1-1). In addition to substantial fragmentation of wetland habitat, the small size of most impacted wetlands suggests that they may function independently rather than as an ecological system. However, many of the affected wetlands serve similar physical and biological functions and can be grouped for ecological assessment. The following sections discuss important ecological characteristics of wetlands within proposed impact areas. These characteristics have been incorporated into the mitigation design.

3.2.1 Existing Vegetation

Nineteen vegetation communities were identified in the proposed Master Plan Update study area, including 9 wetland and 10 upland vegetation communities (Landrum & Brown 1995). The 9 wetland vegetation communities may be further grouped into three vegetation cover types: (1) forested wetland; (2) shrub wetland; and (3) emergent wetlands. Vegetation in all wetlands and buffer areas shows characteristics of relatively recently disturbed plant communities, including a predominance of successional species, a young average age of canopy species (estimated from tree diameters), and evidence of past and ongoing human disturbance. These characteristics indicate that most wetlands support vegetation established within the past 25 to 50 years.

Tables 4 and 5 in Appendix H-A of the Sea-Tac Airport Master Plan Update EIS (Shapiro 1995b) list the wetland indicator status of observed plant species in wetlands and uplands in the Sea-Tac Master Plan Update study area. Plant communities in the study area are common to the region; no unique, threatened, or endangered species occur in the study area.

3.2.1.1 Forested Wetlands

Twenty-six wetlands in the Master Plan Update study area support a forested wetland vegetation class. Of these, 18 wetlands with a forested component would be impacted by implementation of the proposed Sea-Tac Airport Master Plan Update improvements. Impacts to forested wetland vegetation at individual sites, ranging in area from 0.04 acres to 1.17 acres, would affect 7.08 acres overall (Table 3.1-1).

Shapiro (1995b) characterized three types of forested wetland vegetation in the impact area: (1) red alder and salmonberry-dominated wetland; (2) willow-dominated wetland; and (3) mixed deciduous wetland.

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Red alder- and salmonberry-dominated wetlands are most prevalent in wetlands associated with stream corridors, including wetlands 19 and 37 in the Miller Creek corridor and wetlands 51 and 52 in the Des Moines Creek corridor. Isolated wetlands supporting red alder swamp include wetlands 21 and 40 near the western edge of the proposed airport operations area (AOA), Wetland 29 in the south Borrow Area 3, and Wetland 53 in the SASA area. Big-leaf maple, western red cedar, Sitka willow, and black cottonwood occur as associated species in the overstory. Associated understory plants include Indian plum, blackberry species, and English ivy. The most common herbaceous species observed included horsetail, lady-fern, and reed canarygrass. Other herbaceous plants found in red alder swamps included stinging nettle, tall mannagrass, creeping buttercup, bittersweet nightshade, and Watson's willow-herb. A total of 4.78 acres of red alder-dominated swamp would be affected by the proposed Master Plan improvements.

The greatest willow-dominated wetland concentration occurs in the Lake Reba wetland complex. However, impacts to this vegetation type have been substantially reduced by eliminating use of Borrow Area 8, which encompasses most of the Lake Reba wetland complex. Willow-dominated wetlands that would be impacted include wetlands 3 and 9 in the area proposed for improvements to South 154th Street, Wetland 25 near the western edge of the proposed AOA, and Wetland 30 in the south Borrow Area 3. Sitka and Pacific willow dominate this vegetation community. Red alder, black cottonwood, and Scouler's willow are associated canopy species. The understory is dominated by willow shrubs. Herbaceous species that grow under the relatively thick canopy include tall mannagrass, small-fruited bulrush, common and giant horsetail, lady-fern, creeping buttercup, watercress, American speedwell, and soft rush. The total area affected in willow-dominated wetlands would be 1.07 acres.

Mixed deciduous wetlands occur throughout the study area. Wetlands supporting this vegetation type that would experience impacts include wetlands 1 and 2 in the proposed warehousing and parking area and wetlands 11, 12, 14, and 18 along the northern and western edges of the proposed AOA. The overstory consists of a mixture of hydrophytic trees such as red alder, black cottonwood, Pacific willow, Sitka willow, and western red cedar. The undergrowth varies considerably with the hydroperiod, the amount of sunlight received, and soils. Some of the most commonly observed shrubs include Himalayan blackberry, willow, salmonberry, red elderberry, and Douglas spirea. Herbaceous species found growing below the canopy included creeping buttercup, bentgrass, soft rush, lady-fern, swordfern, reed canarygrass, and common horsetail. the proposed Master Plan Update improvements would affect 1.23 acres of mixed deciduous wetland.

3.2.1.2 Shrub Wetlands

Seventeen wetlands in the Master Plan Update study area support a shrub wetland vegetation class. Of these, seven wetlands with a shrub component would be impacted by build-out of the proposed Sea-Tac Airport Master Plan Update improvements. Acreages of shrub wetland vegetation affected at individual sites would range from 0.01 to 0.10 acres (Table 3.1-1).

Shrub wetland vegetation occurs in the southern and western portions of the AOA. These previously cleared areas are presently revegetating with tree saplings. The dominant vegetation species are red alder, black cottonwood, and willow. Common herbaceous plants include velvet-grass, soft rush, bentgrass, and Watson's willow-herb.

Willow-dominated shrub wetland occurs mainly in the north borrow area where soils are saturated to the surface for most of the year. Pacific willow and Sitka willow share dominance in these areas. Common understory herbaceous species are the same as those described for the willow-dominated forest community.

Salmonb dominated wetland occurs in the north borrow area upslope of the willow-dominate pressions. Herbaceous species that occur in this community are similar to those in the re...der- and salmonberry-forested wetland community.

3.2.1.3 Emergent Marsh

Twenty-eight wetlands in the Master Plan Update study area support an emergent wetland vegetation class. Of these, 18 wetlands with an emergent component would be impacted by build-out of the proposed Sea-Tac Airport Master Plan Update improvements. Impacts to emergent wetland vegetation at individual sites would affect areas ranging in size from 0.01 to 0.78 acres (Table 3.1-1).

Monotypic stands of reed canarygrass are located throughout the study area. These wetlands are often bordered by stands of Himalayan blackberry or forested wetland. Species found in association with the reed canarygrass stands include Canadian thistle, black mustard, bentgrass, cattail, and stinging nettle.

Two large stands of cattail occur on the site; one is located between Lake Reba and Lora Lake. The other stand is north of Tyee Valley Golf Course at the south end of the runways. The stand in the north borrow area is bordered on one side by a service road and on the remaining sides by reed canarygrass. Miller Creek provides water to this community year-round. Associated species include reed canarygrass, soft rush, and bittersweet nightshade. The community of cattail in the southern portion of the site has common reedgrass, soft rush, Watson's willow-herb, and reed canarygrass as associated species.

Mixed grass and forb emergent marsh occurs on the airfield in the AOA, in several depressions with compact soils, and in association with several hillside seeps. These areas are characterized by a mixture of hydrophytic forbs such as soft rush, toad rush, cudweed, Watson's willow-herb, common and giant horsetail, common cattail, and an array of hydrophytic grasses that include common velvet-grass, bentgrass, reed canarygrass, and foxtail.

3.2.2 Existing Water Regime

Wetlands in the Master Plan Update study area are associated with a variety of hydrologic features, including Lake Reba, Miller and Des Moines creeks, hillside seeps, roadside ditches, and numerous seasonally saturated to permanently flooded depressions. During field studies in the summer and fall of 1994 (Shapiro 1995b), observed on-site hydrology changed dramatically at the transition to the winter rainy season. Many areas that were dry to 30 inches below the ground surface during late summer had observable wetland hydrology during the latter part of the growing season after fall rains began. During the December 1994 field visits, recent storms had flooded several wetlands.

Wetlands that would be impacted by the proposed Master Plan Update improvements can be divided into two general impact categories, based on site hydrology: (1) wetlands with seasonal hydrology; and (2) wetlands with a year-around source of hydrology. Most wetlands that would be affected are associated with seeps and depressions having a fluctuating hydrologic regime influenced by seasonal rainfall. Acreage impacts to wetlands with seasonal hydrology would total 5.8 acres. Impacted wetlands with a year-around water source are associated with Lora Lake (wetlands 9 and 11), Miller Creek (wetlands 18, 19 and 37) and Des Moines Creek (wetlands 28, 51, 52 and 55). Impacts to these wetlands would total approximately 4.6 acres.

3.2.3 Existing Soils

Soils in the proposed Master Plan Update study area were characterized based on the soil survey of King County (USDA 1973) and field observation (Shapiro 1995b). The Soil Conservation Service (SCS) soil survey identifies soils only in the southernmost portion of the study area south of South 192nd Street. Because SCS typically does not map soils in urban areas, all of the study area north of South 192nd Street is unmapped. Soils in the unmapped area were, however, evaluated for their consistency with SCS-mapped soil series in the general vicinity and for hydric characteristics (Shapiro 1995b). SCS identifies six different soil series in the area, including: (1) Alderwood gravelly sandy loam; (2) Arents, Alderwood material; (3) Bellingham silt loam; (4) Everett gravelly sandy loam; (5) Indianola loamy fine sand; and (6) Norma sandy loam. Only the Bellingham and Norma series soils are identified as hydric (USDA 1991); however, hydric soil inclusions are relatively common in the non-hydric soil series occurring in the project area. An earlier soils survey of the study area (USDA 1952) identified Alderwood series soils as the predominant soil type in the region. This series typically has inclusions of hydric soils (Norma, Bellingham, Seattle, Tukwila, and Shalcar soils).

Shapiro (1995b) distinguished six basic soil types in the study area. Four of these six were determined to be hydric because of soil characteristics indicating saturated conditions, including mottles in a low-chroma matrix and gleyed color formation.

The most common upland soil observed by Shapiro in the study area is generally a brown (10YR 3/3) loam over light brown (10YR 4/3) sandy loam. These soils often are gravelly and appear to be fill material; they most closely match the SCS description of Arents, Alderwood material. Very dark grayish brown (10YR 3/2) loam soils without mottles were also encountered in the northern portions of the study area. These two soil types were not considered to be hydric because soil colors indicate they lack high water tables.

The most common hydric soils observed in the study area are very dark brown and black (10YR 3/2 and 10YR 2/1) loams and sandy loams overlying grayish brown (2.5Y 5/2) sandy loams and gravelly sandy loams. These soils typically have medium and coarse, strong brown (7.5YR 4/6), distinct and prominent mottles in the subsurface horizons. Soils matching this general description were observed in wetlands 2, 7, 11, 12, 16, 20, 22, 23, 31, and 39.

Shapiro (1995b) determined that the very dark grayish brown (10YR 3/2) to black (10YR 2/0) loam soils found throughout the northern portions of the study area were hydric where aquic soil moisture regimes and low-matrix chromas were encountered. Wetlands 6 and 29 contained this soil type.

Saturated, dark greenish gray (5G 4/1) sands were observed in wetlands in the northern borrow area and along the western study area boundary. Because these soils, observed in wetlands 3, 4, and 18, exhibit low-matrix chromas and an aquic moisture regime, they are considered hydric.

Throughout the AOA Shapiro (1995b) found dark brown (10YR 2/2) loams overlying grayish brown and dark grayish brown (10YR 5/1 and 2.5Y 5/2) silt loams, often with prominent mottles. These soils are considered hydric because they exhibit low-matrix chromas and mottles. Wetlands 1, 14, 15, and 21 contain soils matching this general description.

In the study area, Shapiro (1995b) observed two organic soils. The first generally has 6 to 8 inches of black (10YR 2/1) loam over highly decomposed muck. This soil was seen in wetlands 5 and 6. The second is generally a muck or mucky peat soil overlying gleyed mineral soils, as was observed in wetlands 5, 13 and 30. Wetland 5 also included areas of interbedded peat and mineral soil horizons. Soils with high organic contents are considered to be hydric.

3.2.4 Existing Fauna

The impacted wetlands within the study area support forested, palustrine, and emergent vegetation (Cowardin et al. 1979). Wildlife habitat in wetlands within the study area is fragmented by residential and commercial development which limits access to most large mammal, and many waterfowl, species (Landrum & Brown 1995). Water quality in these wetlands may be marginalized by developed buffers and surface contaminants. Amphibians are sensitive to water quality (Richter 1995) and some species that normally use wetlands similar to those being impacted may be absent due to degraded water quality. Faunal diversity in the study area is further limited since most of the impacted wetlands are too small to meet minimum habitat requirements for viable wildlife populations. There are, however, human-tolerant species using the study area.

Impacts to forested wetlands within the study area would generally be small, ranging from 0.04 to 1.17 acres, and most affected wetlands lack significant surface water features. These wetlands may be used by small passerine birds (such as varied thrushes, orange-crowned warblers, black-capped chickadees, and fox sparrows) for nesting and feeding (Ehrlich et al. 1988), small mammals (including mountain beaver, raccoon, opossum, Douglas squirrel, and deer mouse) for breeding and cover, and some amphibians (including northwestern salamander, Pacific chorus frog, and rough-skinned newt) for resting, foraging, and breeding (Nussbaum et al. 1983).

Shrub wetlands offer nesting and cover habitat for songbirds (such as Swainson's thrush, Bewick's wren, and kinglets) and small mammals (including the water shrew and Norway rat). Ponded areas in shrub wetlands are valuable for amphibian breeding, because they offer small vegetative stem structure, emerging from surface waters, that is suitable for egg mass attachment. However, without an associated forested component, shrub wetlands lack the woody debris which is desirable to terrestrial amphibians such as ensatina. The potentially impacted shrub wetlands in the study area are small (< 1.0 acre) and isolated from other natural areas, and this limits their habitat value.

Emergent wetlands provide habitat to songbird species, which use the vegetation for nesting and foraging (such as red-winged blackbirds, marsh wrens), small mammals (such as muskrat and water shrew) that forage on the vegetation and invertebrates, and amphibian species (including long-toed salamander, Western toad, and Pacific treefrog) that need vertical stems in standing water for egg mass attachment. Many of the potentially impacted emergent wetlands in the study area are small, isolated, and highly disturbed. Wetlands located within the current AOA, are maintained in a disturbed state which limits their value as wildlife habitat (Landrum & Brown 1995). Most emergent wetlands have intermittent surface flows or seasonal standing water which also limits their overall habitat value.

3.2.5 Wetland Functions and Values

The biological and physical functions of wetlands within the study area were assessed to identify important qualities that should be replicated by the mitigation design.

Functional assessment methodologies for wetlands typically identify and evaluate physical attributes that provide predictive rather than direct measurements of specific ecological functions of interest (Reimold 1994). The limitations of many of the available functional analysis methods make expert opinion critical when assessing wetland functions and values.

Several assessment methodologies are available to determine wetland functions; these include the *Wetland Evaluation Technique* (WET) (Adamus 1991) and the *Wetland Assessment Techniques* (Reppert et al. 1979). These assessment procedures are, however, frequently used to predict wetland functions over broad geographical areas such as entire drainage basins. These ethodologies typically do not recognize local variations in small wetlands on a scale such as ne proposed Master Plan Update study area. The methods emphasize the importance of waterfowl and flood control functions of wetlands, but they typically do not differentiate the functional value of smaller we ands that lack aquatic habitat similar to many wetlands within the Master Plan Update study area. Because of the diversity of wetland systems nationwide, general functional assessment procedures often do not recognize regional variations in wetlands with similar physical attributes. To address this gap in assessment methodologies, Hruby et al. (1995) developed a numeric assessment methodology (Indicator Value Assessment or IVA) that establishes relative functional values for wetlands within a limited geographic region. This system is based on professional opinion and the numeric evaluation of physical attributes observed in the field.

For this project, a combined approach was used to assess wetland functions by determining the presence of recognized indicators of biological and physical functions (Hruby 1995; Adamus 1991; and Reppert 1979) and by using professional judgement to evaluate the overall significance of these indicators to the function being considered. This assessment evaluated field indicators of habitat quality for fish and wildlife (Table 3.2-1) and indicators of hydrologic and water quality functions (Table 3.2-2). Field evaluations of wetlands were completed during August and September 1995. Wetlands in the study area were evaluated by recording the presence or absence of these field indicators within and adjacent to each wetland.

Because of the small size of most wetlands and their frequent lack of hydrologic connectivity, and because of the relatively similar vegetation types within wetland classes, most wetlands functions were evaluated for groups of wetlands with similar vegetation cover. Tables 3.2-3 and 3.2-4 summarize the physical and biological functions of forested and emergent wetlands in the study area. Total acreage impacts to shrub wetlands would be low, and most shrub wetlands are associated with other vegetation types. Functional impacts to shrub wetlands would be similar to the assessment for forested and emergent wetlands.

Table 3.2-1. Wetland attributes considered in evaluating biological functions of wetlands impacted by the Master Plan Update improvements.

	Function					
Wetland Attribute	Anadromous Fish	Resident Fish	Passerine Birds	Herptiles	Small Mammals	Waterfowl
Wetland cultivated or drained	X	X	X	X	X	X
Wetland ditched or drained				X		
Amount of impervious surface in wetland or watershed	X	X		X	X	
Amount of buffer in crops or pasture				X	X	
Amount of buffer in forest or shrub vegetation			X	X	X	X
Connection of wetland to other natural areas				X	X	X
Size of wetland			X	X	X	X
Number of Cowardin vegetation classes: 3			X		X	X
Vegetation interspersion			X	X	X	X
Amount of forested wetland			X	X	X	X
Evidence of seasonal ponding in forest vegetation classes			X	X		X
Areas of aquatic bed vegetation			X	X		X
Areas of emergent vegetation			X	X	X	X
Presence of invasive emergent vegetation			X	X	X	X
Amount and diversity of shrub wetland			X		X	
Presence of seeps and springs	X	X				
Wetland contains a seasonal/permanent channel/stream/ditch	X	X	X	X	X	X
Documented evidence of use by fish (within 3 yrs.)	X	X	X	X		
Channel/stream sinuous	X	X		X		
Stream velocities and indicators of erosion	X	X				
Pools and riffles present	X	X	X		X	X
Spawning gravels are present	X	X				
Presence of undercut banks	X	X				
Interspersion of water and emergent vegetation			X	X	X	X
Stream channel shores or OW overhanging vegetation	X	X	X		X	
Adjacent vegetation is deciduous	X	X			X	
Frequency and amount of flooding in wetland	X	X	X			X
Part of wetland is flooded at least once per year			X			
Depth and area of seasonal open water			X	X	X	X
Depth and area of permanent open water		X	X	X	X	X
Areas seasonally ponded, emergent vegetation			X	X	X	X
Perch sites adjacent to or above water			X			X
Conifers forest present with large woody debris	X	X	X	X	X	
Log, stump, or snag is >35" diameter within wetland			X		X	
Nature and amount of woody debris in stream or flooded portions of wetlands	X	X		X	X	
Hummocks/islands present in wetland			X	X	X	X
Upland/wetland edge irregular (W:L ratio >2:1)			X	X	X	X
Evidence of impacts from excess nutrients, toxic materials, or sediments	X	X		X		

Data compiled by Parametrix

Table 3.2-2. Wetland attributes considered in evaluating physical functions of wetlands impacted by the proposed Master Plan Update improvements.

	Function							
Wetland Attribute	Baseflow Support	Export of Production	Floodflow Desynchronization	Flood Storage	Surface Runoff Storage	Nutrient Retention/Transformation	Retention of Toxics	Sediment Trapping
Wetland ditched or drained	X	X	X	X	X	X	X	X
Wetland in pasture or cultivation		X				X	X	X
Wetland contains a seasonal/permanent channel/stream/ditch		X		X	X			
Multiple channels within wetland		X				X	X	X
Wetland on slope discharging to stream	X							
Amount and type of human activities in upstream watershed						X	X	
Manmade structures hold back water					X			
Evidence of beaver dams		X		X	X	X	X	X
Wetland has no inlet and no outlet					X	X	X	X
Wetland has outlet but no inlet	X							
Outflow present during summer but no inlet	X							
Topog[illegible] of wetland relative to outlet			X	X	X	X	X	X
Amo[illegible] looding within the wetland		X	X	X	X			
We[illegible] fluctuating water levels throughout year			X	X	X	X	X	X
Am[illegible] egetation present in flooded portions of we[illegible]						X	X	X
Di[illegible] ence of sediment trapping						X	X	X
Prese[illegible] of organic soils	X				X	X	X	
Underlying soil a clay, till, or hardpan	X							
Interspersion of vegetation and open water areas		X				X		
Water depths			X	X	X	X	X	X

Data compiled by Parametrix

Table 3.2-3. Functional assessment of emergent wetlands impacted by the proposed Master Plan Update improvements.

Function	Rating	Rationale
Resident and Anadromous Fish	Low Habitat Value	Most emergent wetlands (including wetlands 15, 16, 17, 23, 24, 32) are isolated from streams and other fish habitat; they also have only small amounts of standing water during winter and spring months, and are thus unable to provide this habitat function. Two emergent wetlands (wetlands 12 and 35) have intermittent connections to Miller Creek by artificial ditches; however, these connections provide no significant habitat to fish nor do they allow fish to access suitable habitat within emergent wetlands.
Passerine Bird Habitat Birds	Low to Moderate Habitat Value	Emergent wetlands are small and range in size from less than 0.1 acre to about 0.5 acre. Due to their small size and location in shallow, seasonally wet depressions, these wetlands lack many of the habitat attributes associated with high wildlife value for breeding birds. Emergent wetlands lack significant open water or standing water during the breeding season. They are often vegetated by reed canarygrass, velvet grass, or other emergent plant species with limited value to birds such as the marsh wren, red-winged blackbird, song sparrows, and common yellowthroat. Emergent wetlands that have associated forest or shrub wetland classes and buffers (wetlands 2, 12, 20, 22) provide habitat for a greater variety of breeding birds, including thrushes and flycatchers. In these wetlands, red alder and cottonwood provide nest and perch sites for birds, although trees are often too young to provide cavity nesting habitat.
Herptiles	Low to Moderate Habitat Value	Soil in emergent wetlands are typically saturated and lack significant amounts of standing water during the late spring and summer months. This condition limits the diversity of amphibians that can breed in the wetlands. Where extended seasonal ponding in ditches (wetlands 12, 35) is present, Pacific chorus frog, red-legged frog, and long-toed salamander may be present.
Small Mammals	Low to Moderate Habitat Value	Emergent wetlands, especially when bordered by forest or shrub communities (wetlands 36, 37, 39) are likely to provide habitat to small mammals. However, the small size of most of these wetlands, and the lack of diverse habitat structure within them, limits the value of these wetlands to small mammals.
Waterfowl	Low Habitat Value	Emergent wetlands affected by the proposed airport improvements lack significant open water or meadow areas that serve as foraging, nesting or resting areas for overwintering waterfowl.
Export of Production	Low	Due to the small size of the wetlands and the lack of permanent hydrologic connections to downstream systems, the wetlands do no provide significant export functions. Minor export could occur from wetlands during periods when flow in ditches (wetlands 12, 35) is present.
Baseflow Support	Low	Emergent wetlands generally occur in small, shallow depressions that seasonally collect storm runoff or intercept a seasonally high groundwater table. For most emergent wetlands, except during storms, there is little water movement through them and little evidence that they contribute to baseflow. Emergent wetlands 12, 17, and 35 provide some baseflow support to Miller Creek since they occur where the groundwater surfaces through seeps and springs. This flow is eventually conveyed to the creek.

Table 3.2-3. Functional assessment of emergent wetlands impacted by the proposed Master Plan Update (continued).

Function	Rating	Rationale
Flood Control	Low	Since the impacted emergent wetlands are generally not associated with floodplains, they do not provide flood control functions. Wetland 1 is associated with Miller Creek and may be within the 100-year floodplain of this creek. The wetland could provide flood control functions.
Surface Runoff Storage	Moderate	Emergent wetlands occurring in shallow depressions that seasonally collect storm runoff may reduce runoff rates during storm events. Wetland 1 is associated with Miller Creek and may provide storm water management functions.
Nutrient Retention/ Transformation	Moderate	Emergent wetlands located in shallow depressions, along ditches or other seasonal drainageways (wetlands 12, 35) provide biofiltration functions that likely result in water quality improvement, including nutrient retention, nutrient transformations, sedimentation, and removal of some chemical pollutants.

Data compiled by Parametrix

Table 3.2-4. Functional assessment of forested wetlands impacted by the proposed Master Plan Update.

Function	Rating	Rationale
Resident and Anadromous Fish	Low to Moderate Habitat Value	Most forested wetlands (wetlands 11, 14, 21, 25, 39, 40, 53) are isolated from streams and other fish habitat. They also contain only small amounts of standing water during winter and spring months and are thus unable to provide this function. Some forested wetlands (wetlands 18, 19, 52) have intermittent connections or border Miller or Des Moines creeks. These wetlands provide shade, buffer, and food resources to resident or migratory fish species.
Breeding Birds	Moderate to High Habitat Value	Several larger forested wetlands (wetlands 3, 19, 29, 37, 51, 52, 53) contain many attributes associated with high habitat value for breeding birds. These attributes include association with more than one wetland class, the presence of snags or logs, understory shrub and herbaceous vegetation, and forested buffers connecting to other habitat types. Forested wetlands generally lack significant open water or standing water during the breeding season. Forested wetlands are often dominated by willow, alder, and cottonwood (wetlands 11, 19, 37, 39, 53) that are too young to provide cavity nesting habitat. The lack of dense coniferous forest habitat in all forested wetlands also reduces their habitat value for some bird species.
Herptiles	Low to Moderate Habitat Value	Soil in forested wetlands is typically saturated and lacks significant amounts of standing water during the late spring and summer months. This condition limits the diversity of amphibians that can breed in the wetlands. Where extended seasonal ponding is present (wetlands 3, 37, 40), Pacific chorus frog, red-Legged frog, and long-toed salamander may be present.
Small Mammals	Moderate Habitat Value	Forested wetlands provide habitat to small mammals such as raccoon, opossum, squirrels, mice, and rats. The wetlands typically do not support burrowing animals due to seasonally saturated soils. Large mammals are generally absent from the project area due to urban development.
Waterfowl	Low Habitat Value	Forested wetlands lack significant open water or open areas to allow foraging, nesting, or resting by waterfowl.
Export of Production	Low Value	Forested wetlands located along Miller and Des Moines creeks (wetlands 31, 37, 51, 52) provide export functions, as detritus and insect production may be transported from the system stream flow. Other forested wetlands not hydrologically connected to stream systems do not provide export functions.
Baseflow Support	Low to Moderate Value	Forested wetlands along Miller and Des Moines creeks (wetlands 3, 21, 18, 19, 37, 39, 52) occur in areas of groundwater discharge and contribute to the base flow. Other forested wetlands occur in shallow depressions that seasonally collect storm runoff or that intercept a seasonally high groundwater table. There is little water movement through these wetlands during storms, and they do not appear to contribute to baseflow.
Flood Control	Low to Moderate Value	Since the impacted forested wetlands are not generally associated with floodplains, they do not provide flood control functions. Wetlands associated with Miller Creek (wetlands 3, 11) are within the 100-year floodplain and provide flood control functions.

Table 3.2-4. Functional assessment of forested wetlands impacted by the proposed Master Plan Update (continued).

Function	Rating	Rationale
Surface Runoff Storage	Low Value	No forested wetlands occur in shallow depressions that seasonally collect storm runoff; thus, the surface water storage function of these wetlands is low. Wetlands 3 and 11 are associated with Miller Creek and may provide limited storm water management functions.
Nutrient Retention/Transformation	Low to Moderate Value	Forested wetlands 3 and 11 may provide biofiltration functions that likely result in water quality improvement (including contaminant retention and transformations of nutrients and chemicals). Other forested wetlands are not likely to provide significant water quality functions due to their lack of connections to surface water.

Data compiled by Parametrix

The geohydrology of the Master Plan area is discussed in Chapter IV-4 of the FEIS. The groundwater recharge/discharge functions of wetlands was not specifically addressed in this analysis. However, based on interpretation of the landscape position of wetlands, the function of wetlands relative to groundwater movement can be inferred.

Groundwater discharge/recharge functions of wetlands appear to be variable throughout the site. For wetlands occurring on till soils above the Miller Creek and Des Moines Creek ravines, wetlands appear to form in localized depression where perched soils develop on low permeability till. Due to the low permeability of the till layer, it is unlikely these small wetlands contribute to recharge of groundwater. Wetlands located in the ravines associated with Miller and Des Moines Creek typically have intermittent or perennial seeps and springs that indicate groundwater discharge.

Since many of the wetlands that would be impacted by the proposed Master Plan improvements are small (< 0.5 acre); isolated from other significant aquatic or semi-aquatic habitat; and occur in a landscape fragmented by streets, commercial, residential, or airport development; their wildlife habitat functions are generally significant only to the local vicinity (rather than to a larger landscape or watershed) (Brinson 1993). However, hydrologic functions (such as flood storage, groundwater discharge, and storm water detention) are potentially important at the watershed level, because, when present, they help maintain fish habitat in Miller and Des Moines creeks.

3.3 WETLAND MITIGATION GOALS, OBJECTIVES AND PERFORMANCE STANDARDS

3.3.1 Goals and Objectives

Specific mitigation goals for unavoidable wetland impacts were developed to meet the federal standard of no net loss of wetland functions and area, while still recognizing the unique mitigation siting requirements imposed by FAA airport operation safety guidelines. An FAA draft Advisory Circular 150/5200, which is expected to be in effect in the near future, would require that careful consideration be given to preventing wildlife attractions. While it is preferable for wetland mitigation to be sited near the impact (to provide replacement habitat for displaced wildlife) and within the same drainage basin (to replace lost physical functions), the FAA draft Advisory Circular strongly contradicts this option. Due to topography and extensive development, there are no appropriate lands of sufficient size for wetland habitat mitigation within the Miller Creek and Des Moines Creek drainage basins and outside the 10,000-ft safety radius. Siting wetland mitigation within the Miller Creek or Des Moines Creek basins would require acquisition of additional land currently developed for residential and business uses. Therefore, mitigation for impacts to wildlife habitat would be located outside the basins. Mitigation for impacts to physical functions of wetlands, such as storm water storage and floodwater attenuation could be achieved without creating attractive habitat for wildlife and will be located within the Miller Creek and Des Moines Creek basins. Specific mitigation measures for these impacts are discussed in Sections 4 and 5 of this mitigation plan.

The ·ncle for selecting an off-site and out-of-basin wetland mitigation area is included in Sec: ʻ.3—Rationale for Site Selection. Based on federal policies regarding no net loss and airpc. :ety, the following specific wetland mitigation goals have been developed for the proposed Sea-Tac Airport Master Plan Update improvements:

Wetland Goal 1: Achieve no overall net loss of wetland acreage by establishing a diverse, in-kind replacement habitat with forested, shrub, and emergent wetland classes.

Wetland Goal 2: Provide in-kind wildlife habitat replacement outside the 10,000-ft aircraft operations safety radius.

Wetland Goal 3: Facilitate an increase in overall habitat functions.

3.3.2 Design Objectives, Design Criteria, and Final Performance Standards

Impacts of the proposed Master Plan Update improvements to wetland functions, design objectives to compensate for these impacts, and the compensation ratios that would be achieved by the wetland mitigation plan described in this chapter are summarized in Table 3.3-1. To achieve the wetland mitigation goals, specific design features will be implemented on a 47-acre site located 7.2 miles from Sea-Tac Airport in the city of Auburn. The off-site mitigation location would satisfy the unique wildlife habitat siting requirements associated with airport development by providing replacement habitats outside the recommended 10,000-ft safety radius identified in FAA draft Advisory Circular 150/5200. The size of the mitigation site would allow for development of an aggregate of habitat types that would provide greater overall habitat values than the collection of small, discontinuous wetlands that would be filled. Long-term site protection would be enhanced by allowing for consolidated management, monitoring, and contingency planning. Specific design objectives, design criteria, and final performance standards are identified for each wetland mitigation goal in Table 3.3-2. These performance standards are the basis for the monitoring program discussed in Section 3.6.

3.4 PROPOSED MITIGATION SITE

ˆ !.1 Site Description

The 47-acre mitigation site is part of a 69-acre parcel located within the City of Auburn immediately west of the Green River (Figure 3.4-1). The undeveloped parcel has been farmed in the recent past and currently supports a mix of upland pasture grasses and forbs that are ɔmmon to abandoned agricultural land in the Puget Sound basin. Approximately 4.3 acres of reed canarygrass-dominated wetland was delineated during previous site investigations (David Evans and Associates 1995) and is included in the 47-acre portion of the site proposed for mitigation. The remaining 22 acres would be designated as a reserve area for future

AR 039711

Table 3.3-1. Summary of wetland impacts and compensatory design objectives for the proposed Seattle-Tacoma International Airport Master Plan Update.

Project Impact	Compensatory Design Objectives	Acreage Provided	Compensation Ratio
Fill of 7.08 acres of forested wetland and loss of associated wildlife habitat.	Provide in-kind replacement of forested wetland vegetation cover and increase overall wildlife habitat value.	20.87 acres of forested wetland	minimum 2:1 maximum 2.95:1
Fill of 0.39 acre of shrub wetland and loss of associated wildlife habitat.	Provide in-kind replacement of shrub wetland vegetation cover and increase overall wildlife habitat value.	1.02 acres of shrub wetland	minimum 2:1 maximum 2.62:1
Fill of 2.88 acres of emergent wetland and loss of associated wildlife habitat.	Provide in-kind replacement of emergent wetland vegetation cover and increase wildlife habitat value.	5.43 acres of emergent wetland	minimum 1.5:1 maximum 1.89:1
Loss of some surface water treatment.	On-site replacement of surface water functions will be addressed in the final design of the proposed Master Plan Update components.	NA	NA
	Additional mitigation to provide flood storage capacity in the Green River drainage basin.	Approximately 30 to 60 acre-ft of flood storage capacity	NA
Loss of degraded wetland buffers.	In-kind replacement for upland buffer impacts and additional mitigation for wildlife using both wetland and non-wetland habitats.	Approximately 3 acres of forested upland buffer	NA

Data compiled by Parametrix
NA - Not applicable

Table 3.3-2. Mitigation goals with associated design objectives, design criteria, and final performance standards.

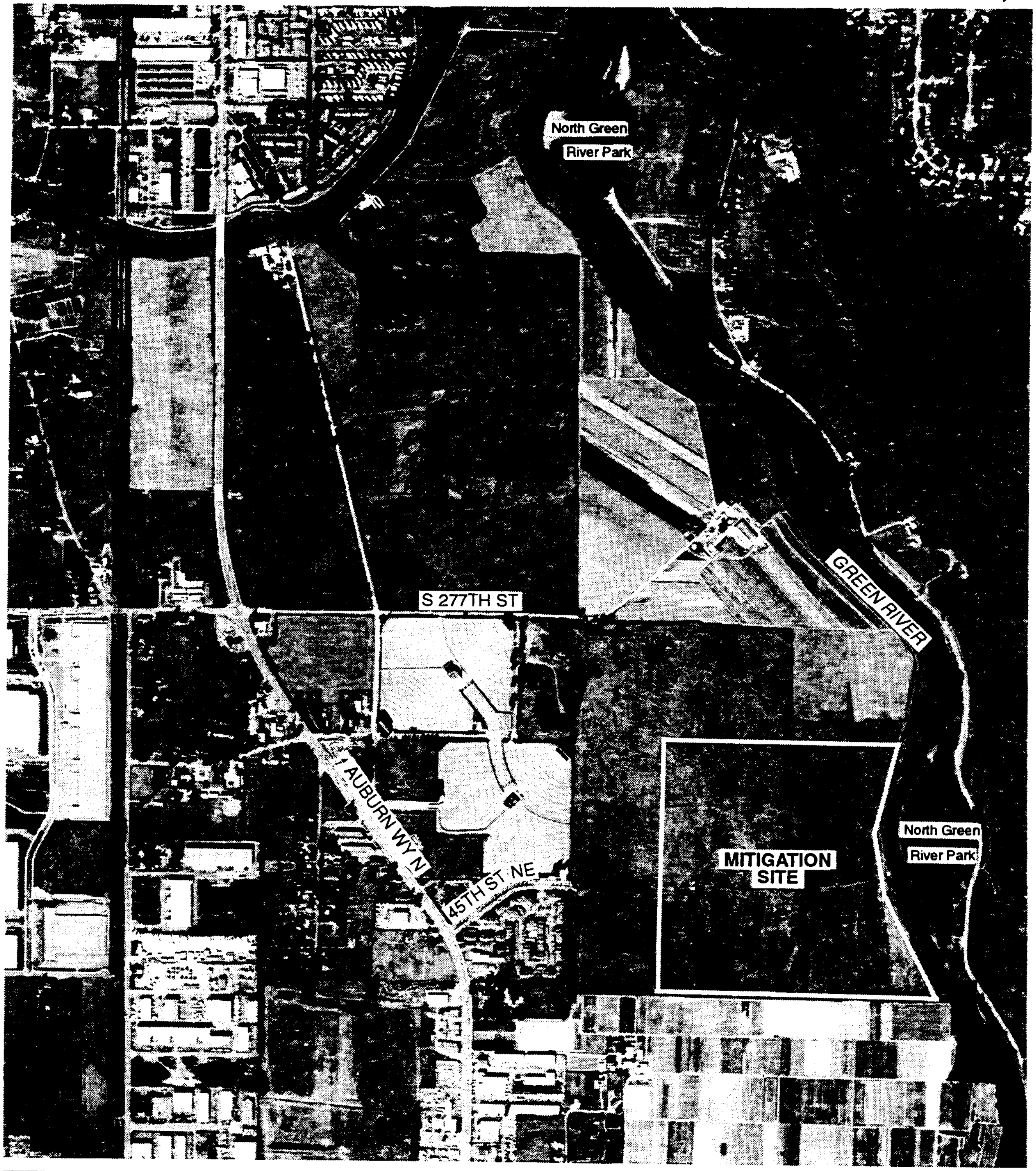
Design Objectives	Design Criteria[1]	Final Performance Standards[2]
Wetland Mitigation Goal 1: Achieve no overall net loss of wetland acreage by establishing a diverse, in-kind replacement habitat with forested, shrub, and emergent wetland classes.		
Provide seasonal to permanent wetland hydrology appropriate for each wetland vegetation cover type.	Create a perched water table by constructing a low-permeability soil layer overlain by topsoils with final grades of: 40.5 ft - 41.5 ft in emergent wetlands 41.5 ft - 42.0 ft in shrub wetlands 42.0 ft - 43.0 ft in forested wetlands	In forested areas, soils will be saturated[3] to approximately 12 inches of the surface (or less[4]) from late December through April in years of normal rainfall. In shrub areas, soils will be saturated at approximately the 6- to 12-inch depth year-round in normal rainfall years. Soils will be flooded with approximately 6 inches of water between December and late May. In emergent zones, soils will be saturated near the soil surface during normal rainfall years, and they will be flooded permanently where soil elevations are below 41 ft. Above 41 ft, flooding up to 24 inches deep will occur from late November through June.
Provide in-kind replacement for impacts to 7.08 acres of native forested wetland.	Plant five forested wetland plant associations that are similar in composition to naturally occurring plant associations. Use native deciduous and evergreen species such as black cottonwood, Oregon ash, red alder, western red cedar, and Sitka spruce. Plant a native shrub understory in 70% of the forested wetland area. Use native species such as salmonberry, twinberry, red-osier dogwood, red elderberry, willows, and vine maple. Plant native tree species at densities of at least 250 trees per acre (approximately 13 ft on-center). Plant native shrub species at densities of at least 500 plants per acre (approximately 9 ft on-center).	Forested wetlands will achieve a minimum in-kind replacement ratio of 2:1 by covering at least 14.6 acres of the mitigation site. Native wetland tree species will contribute at least 80% of tree density in each forested wetland plant association. Tree species density will exceed 200 trees per acre in forested wetland areas. Native wetland shrub species will contribute at least 80% of the shrub density in areas of the forested wetland that are planted with shrubs. Shrub density will exceed 400 stems per acre in areas of the forested wetland that are planted with shrubs. Native tree and shrub species will be in a healthy, vigorous growing condition, with average annual stem elongation of at least 2 inches during years 1-5 of the monitoring program.
Provide in-kind replacement for impacts to 0.39 acre of native shrub wetland.	Plant an association of native shrub wetland species that is similar in composition to naturally occurring shrub wetlands, including species such as Pacific willow, red-osier dogwood, bearberry honeysuckle, Douglas hawthorne, and Pacific ninebark. Plant native shrub species at densities of at least 500 plants per acre (approximately 9 ft on-center).	Shrub wetlands will achieve a minimum in-kind replacement ratio of 2:1 by covering at least 0.78 acre of the mitigation site. Native shrub wetland species will contribute at least 80% of shrub density in the shrub wetland association. Species composition in the shrub wetland will include at least a 5% component of each native species planted. Shrub density will exceed 400 stems per acre in shrub wetland areas. Native shrub species will be in a healthy, vigorous growing condition, with average annual stem elongation of at least 2 inches during years 1-5 of the monitoring program.
Provide in-kind replacement for impacts to 2.88 acres of native emergent wetland.	Plant an association of native emergent wetland species similar in composition to naturally occurring emergent wetlands. Use native species that are suited to seasonally and/or permanently flooded conditions, such as water parsley, slough sedge, hardstem bulrush, and common spike rush. Plant native emergent species in approximately 2,500-ft^2 monotypic patches at densities of 450 plants per 1,000 ft^2 (approximately 18 inches on-center).	Emergent wetlands will achieve a minimum in-kind replacement ratio of 1.5:1 by covering at least 4.32 acres of the mitigation site. Native emergent wetland species will contribute at least 70% of plant cover in areas planted with emergent species. Species composition (stem density or percent composition) in the emergent wetland will include at least a 5% component of each native species planted. Plant densities will exceed 1 stem per 1.5 ft^2 in areas planted with emergent species. Upland emergent species will colonize with 80% cover by native species.
Increase flood storage capacity in the Green River drainage basin.	Grade 29 acres of the mitigation area to an elevation of 45 ft or less. Provide a topographic connection between the site and the 100-year floodplain of the Green River backwater area.	A minimum of 29 acres of the mitigation site will be below the 45-ft elevation and directly connected to the 100-year floodplain.

Table 3.3-2. Mitigation goals with associated design objectives and final performance standards (continued).

Design Objectives	Design Criteria[1]	Final Performance Standards[2]
Wetland Mitigation Goal 2: Provide in-kind wildlife habitat replacement outside the 10,000-ft aircraft operations safety radius.		
Provide out-of-kind flooded emergent wetland habitat suitable for waterfowl feeding and resting during the winter and spring months.	Emergent wetlands will satisfy the design criteria for Wetland Mitigation Goal 1. Additional design criteria for waterfowl habitat include: Provide year-round shallow water (7-12 inches deep) with patches of emergent vegetation as feeding habitat for dabbling species. Provide ponded water with an emergent edge for water resting habitat. Provide adequate protection for waterfowl habitat by minimizing adjacent cover for predators.	Emergent wetlands will satisfy the final performance standards identified for Wetland Mitigation Goal 1. Additional performance standards for waterfowl habitat include: Permanently flooded emergent wetlands will have shallow-water habitat (<12 inches deep) near the edges, with emergent vegetation and bottom detritus interspersed throughout. Ponded water at least 6 inches deep will occur in open areas of at least 1 acre with low surrounding vegetation (<24 inches tall and covering an area at least 35 ft wide) between mid-September and April. Evidence of waterfowl use (nesting, breeding, staging, or foraging activities) will be present.
Provide in-kind emergent, shrub, and forested wetland habitat with feeding and breeding for songbirds.	Forested, shrub, and emergent wetlands will satisfy the design criteria for Wetland Mitigation Goal 1. Additional design criteria for songbird habitat include: Plant forested wetland adjacent to shrub, emergent, and standing-water habitats. Plant portions of the forested wetland with shrub understory species to provide a multiple-layered canopy adjacent to the shrub portion of the wetland.	Forested, shrub, and emergent wetlands will satisfy the final performance standards identified for Wetland Mitigation Goal 1. Additional final performance standards for songbird habitat include: Perch sites in the forested canopy will overhang emergent wetland areas. Forested wetlands will have a shrub understory of 400 stems per acre over 25% of the area. Evidence of songbird nesting (nest, breeding territories, or observations of breeding behavior) will be present.
Provide in-kind forested, shrub, and emergent wetland feeding and breeding habitat for small mammals.	Forested, shrub, and emergent wetlands will satisfy the design criteria identified for Wetland Mitigation Goal 1. Additional design criteria for small mammal habitat include: Large woody debris (stumps and logs of native species) placed throughout the forested wetland at densities of 70 pieces per acre (approximately 25 ft on-center) to provide year-round cover for small mammals. Low hummocks (with a minimum area of 150 ft^2 at elevation 43 ft) constructed in the shrub wetland areas to provide non-saturated soils for burrowing small mammals.	Forested, shrub, and emergent wetlands will satisfy the final performance standards identified for Wetland Mitigation Goal 1. Additional final performance standards for small mammal habitat include: Evidence of small mammal use (nests, feeding signs, observations) will be present. Shrub hummocks will have a minimum of 12 inches of non-saturated soil above the 42-ft winter ponding elevation and cover at least 10% of the shrub zone.
Provide in-kind breeding habitat for amphibians.	Forested, shrub, and emergent wetlands will satisfy the design criteria for Wetland Mitigation Goal 1. Additional design criteria for amphibian habitat include: Provide soil saturation in forested wetlands within approximately 12 inches of the soil surface from late December to April. Provide attachment substrate for breeding amphibian species consisting of emergent vegetation with stem diameters <0.25 inches in ponded water.	Forested, shrub, and emergent wetlands will satisfy the final performance standards for Wetland Mitigation Goal 1. Additional final performance standards for amphibian habitat include: Soils in forested wetland areas will be saturated within 12 inches of the soil surface from late December to April. Leaf litter and vegetative debris will be present to provide habitat for invertebrates. Invertebrates will be present in the ground litter. At least 50% of live and dead stems in ponded emergent areas will be species with stem diameters less than 0.25 inches. Evidence of amphibian breeding (egg masses; larval stages) will be present.
Wetland Mitigation Goal 3: Facilitate an increase in overall habitat functions.		
Consolidate mitigation for impacts to many small, discontinuous wetlands into a single, larger wetland to provide a more diverse aggregate of habitat types.	Construct a contiguous wetland system with forested, shrub, and emergent wetland types and wildlife habitat features that provide in-kind and out-of-kind habitat replacement.	The mitigation wetland will satisfy the final performance standards identified for Wetland Mitigation Goals 1 and 2.
Assure long-term protection of the mitigation site(s).	Screen the north and south perimeters of the wetland from off-site development with a 50-ft-wide forested and shrub buffer. Locate trails a minimum of 50 ft from emergent wetlands and provide shrub and forest vegetation as screening between trails and emergent wetlands. Provide permanent interpretive and notice signs along the perimeter of the mitigation area describing natural features and restrictions related to use of the wetland mitigation area.	Forested buffers will satisfy the final performance standards identified for forested wetlands for Wetland Mitigation Goal 1. All permanently and seasonally flooded wetlands will be screened from on-site trails by a minimum 50-ft-wide buffer of forest and shrub vegetation. Interpretive signs will be located at 500-ft intervals around the perimeter of the mitigation wetland.

Data compiled by Parametrix

[1] The rationale for design criteria is explained in Section 3.5, Mitigation Site Plan.
[2] Condition required at the end of the 10-yr monitoring program. Interim performance standards are included in the Contingency Plan, Section 3.7.
[3] Saturated soil is defined as the zone below the water surface in a hole or monitoring well.
[4] All references to depths of flooding or depth to saturated soil refer to depths anticipated during years of normal rainfall (rainfall statistically similar [$p > .10$] to the long-term average).



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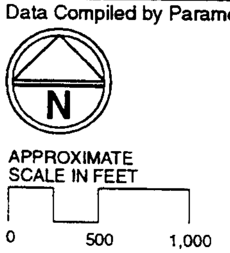

Figure 3.4-1
Aerial Photograph of Proposed Wetland Mitigation Site

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development of regional storm water facilities or other city-designated uses. The site is bounded by a variety of land uses including agriculture to the north and south; undeveloped land, multi-family housing, and a drive-in theater to the west; and the Green River, patches of riparian forest, and undeveloped, forested slopes to the east. A narrow strip of land along the western banks of the Green River is held by King County. The site is currently zoned R2 (single-family residential) by the City of Auburn and the 1995 Comprehensive Plan designation is single-family (Auburn 1995). The site is nearly level but gently slopes to the northwest, with elevations ranging from 45 ft in the northwest corner to 52 ft along the eastern property boundary. Detailed descriptions of on-site hydrology, soils, and vegetation are included in Section 3.4.4, Ecological Assessment of the Mitigation Site.

3.4.2 Ownership

The Port of Seattle owns the 69-acre site.

3.4.3 Rationale for Choice

Implementation of the proposed Sea-Tac Airport Master Plan Update improvements would result in impacts to wetland resources totaling 10.35 acres at 34 individual wetlands (Table 3.1-1). Because most of these wetlands are small and separated from other natural areas by large expanses of urban development, they provide limited ecological functions at the local and landscape scale. The overall intent of this proposed mitigation plan is to offset wetland impacts at a single site, thereby providing a regionally meaningful expanse of habitat with enhanced assurances for successful implementation and long-term protection. Because of draft FAA guidelines for airport operation safety, mitigation planning for impacts to wildlife habitat must seek opportunities for habitat replacement outside a 10,000-ft radius of Sea-Tac's runways.

The search for the mitigation site, which began in February 1995, was constrained by certain limiting parameters including:

- nonwetland sites with evidence of seasonally high water tables,
- vacant or substantially vacant parcels,
- parcels in excess of 10 acres,
- under single ownership (preferably),
- close to surface water features (preferably),
- within the Green River valley from South 180th Street south to the Pierce County border,
- available for purchase by the Port of Seattle.

The properties could not be within 5,000 ft of an existing general aviation airport (because of FAA considerations) in addition to the 10,000-ft guideline for Sea-Tac, or include land to which King County owns the development rights under the farmland preservation program. Also, the conversion of property to wetlands had to be economically feasible.

Although over 100 parcels were initially identified, the search focused to sites larger than 50 acres because of the acreage needed to mitigate impacts at the airport and the ecological and logistical advantages of developing mitigation on a single site. Of eleven sites larger than 50 acres, five sites were rejected because they were unsuitable because of the large amount of wetlands present. These sites offered little or no opportunity for improvement of habitat. Of the six remaining sites, two were not available for purchase, the development rights of two were owned by King County for farmland preservation, and one site had been recently purchased by the City of Kent for its own mitigation purposes.

The remaining site is the one analyzed in this mitigation plan. The site has several attributes that make it favorable for wetland mitigation. It is large enough to accommodate the entire wetland mitigation project and it has excellent physical features that would successfully support the proposed mitigation approach, including proximity to the Green River and to a 100-year floodplain.

In addition, the city of Auburn is planning a regional storm water detention facility to be located in the general vicinity of the proposed mitigation parcel, and the Port of Seattle is exploring options with Auburn to integrate these projects. The proposed wetland mitigation project could receive treated supplemental water from the detention facility, which would be beneficial to the wetland during summer months. Refer to Section 3.5.1 for complete discussion of wetland hydrology.

3.4.4 <u>Ecological Assessment of the Mitigation Site</u>

3.4.4.1 Existing Site Conditions

<u>Vegetation</u>

The mitigation site consists of abandoned agricultural land that is dominated by a mix of native and non-native herbaceous species, including thick stands of Canadian thistle. Grass species intermixed with the thistle include quackgrass, orchardgrass, colonial bentgrass, and a few small patches of reed canarygrass. Table 3.4-1 lists species observed on the mitigation site during site investigations in October 1995. Invasive and noxious species scattered throughout these areas include cocklebur, common dandelion, and climbing nightshade.

A narrow wetland swale bisects the parcel from north to south along the western boundary of the 47-acre mitigation site (Figure 3.4-2). This existing wetland is dominated by grasses that include red top, colonial bentgrass, quackgrass, tall fescue, velvet grass, and patches of reed canarygrass. Other herbaceous species in the wetland include soft rush and creeping buttercup. The mitigation would impact less than 0.1 acre of this existing wetland. Within the mitigation

Table 3.4-1. **Plant species observed on the mitigation site during October 1995.**

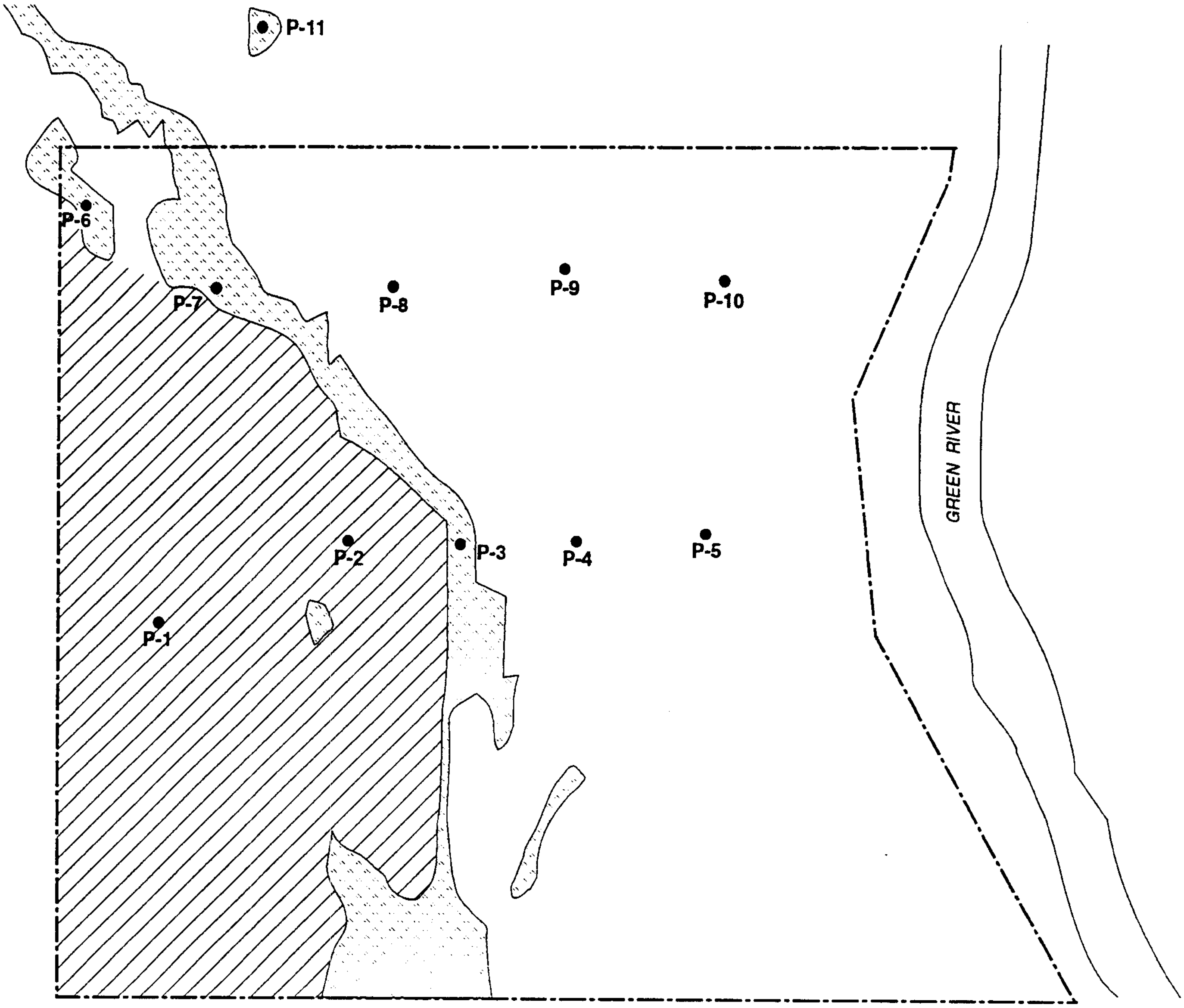
Scientific Name	Common Name	WIS[1]
Trees		
Alnus rubra	Red alder	FAC
Crataegus spp.	Hawthorn	FAC
Fraxinus latifolia	Oregon ash	FACW
Populus trichocarpa	Black cottonwood	FAC
Prunus emarginata	Bitter cherry	FACU
Shrubs		
Acer circinatum	Vine maple	FACU
Cornus stolonifera	Red-osier dogwood	FACW
Corylus cornuta	Beaked hazel-nut	FACU
Cytisus scoparius	Scot's broom	NI
Populus trichocarpa (saplings)	Black cottonwood	FAC
Rosa nutkana	Wood's rose	FAC
Rosa pisocarpa	Pearfruit rose	FAC
Rubus discolor	Himalayan blackberry	FACU
Rubus laciniatus	Evergreen blackberry	FACU
Rubus ursinus	Pacific blackberry	FACU
Salix spp.	Willow	FACW
Salix scoulerana	Scouler willow	FAC
Symphoricarpos albus	Snowberry	FACU
Herbs		
Agropyron repens	Quackgrass	FAC
Agrostis alba	Redtop	FACW
Agrostis tenuis	Colonial bentgrass	FAC
Alopecurus geniculatus	Water foxtail	OBL
Alopecurus pratensis	Meadow foxtail	FACW
Cirsium arvense	Creeping thistle	FACU
Cirsium vulgare	Bull thistle	FACU
Dactylis glomerata	Orchard grass	FACU
Dipsacus sylvestris	Teasel	FAC
Eleocharis palustris	Creeping spikerush	OBL
Epilobium ciliatum	Willow-herb	FACW
Equisetum arvense	Field horsetail	FAC
Festuca arundinacea	Tall fescue	FAC
Geranium spp.	Crane's-bill	FACU
Holcus lanatus	Common velvet grass	FAC
Juncus effusus	Soft rush	FACW
Juncus spp.	Rush	FACW
Lotus corniculatus	Birds foot trefoil	
Phalaris arundinacea	Reed canarygrass	FACW
Phleum pratense	Timothy	FAC

Table 3.4-1. Plant species observed on the mitigation site during October 1995 (continued).

Scientific Name	Common Name	WIS[1]
Phragmites communis	Common reed	FACW
Plantago lanceolata	English plantain	FAC
Poa pratensis	Kentucky bluegrass	FAC
Polystichum munitum	Sword fern	FACU
Ranunculus repens	Creeping buttercup	FACW
Rumex crispus	Curly dock	FAC
Scirpus acutus	Hard-stem bulrush	OBL
Solanum dulcamara	Climbing nightshade	FAC
Tanacetum vulgare	Common tansy	UPL
Taraxacum officinale	Common dandelion	FACU
Trifolium pratense	Red clover	FACU
Typha latifolia	Common cattail	OBL
Xanthium strumarium	Cockle-bur	FAC

Data compiled by Parametrix
[1]Wetland Indicator Status (Environmental Laboratory 1987)

Category	Symbol	Definition
Obligate Wetland Plants	OBL	Obligate wetland plants occur almost always (estimated probability >99%) in wetlands under natural conditions, but may also occur rarely (estimated probability <1%) in non-wetlands.
Facultative Wetlands Plants	FACW	Facultative wetland plants usually occur (estimated probability 67 to 99%) in wetlands, but may also occur (estimated probability 1 to 33%) in non-wetlands.
Facultative Plants	FAC	Facultative plants with a similar likelihood (estimated probability 33 to 67%) of occurring in both wetlands or non-wetlands.
Facultative Upland Plants	FACU	Facultative upland plants usually occur (estimated probability 67 to 99%) in non-wetlands, but also occur (estimated probability 1 to 33% of the time) in wetlands.
Obligate Upland Plants	UPL	Upland plants occur almost always (estimated probability >99%) in non-wetlands under natural conditions.



Note: Wetland boundaries approximate pending field verification by U.S. Army Corps of Engineers

Source: David Evans 1995
Additional Data Compiled by Parametrix

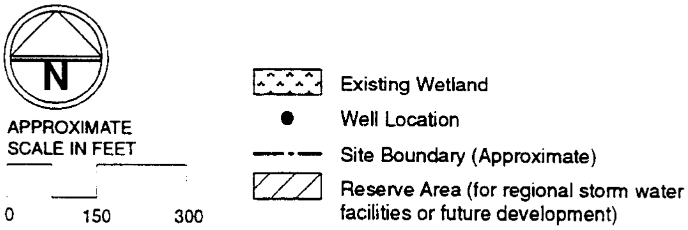


Figure 3.4-2
Wetlands and Groundwater Monitoring Well Locations on the Proposed Wetland Mitigation Site

site, a wetland (about 0.2 acre) is present. This wetland would be replaced by the mitigation project. The wetland is dominated by reed canarygrass, but includes other emergent plant species, as listed above.

The southern boundary of the mitigation site is a fence line dominated by shrubs with a few scattered trees. Himalayan blackberry is the dominant shrub, and reed canarygrass is the dominant herb. Other shrubs along the fenceline include vine maple, Woods rose, snowberry, and red-osier dogwood. Tree species scattered throughout the fence line consist of Douglas hawthorn, Oregon ash, and black cottonwood.

Water Regime

The mitigation site is very flat and without distinctive on-site drainage features. The Green River is located immediately east of the site. A small area of the 100-year floodplain in the northwest corner of the property drains to the Green River to the north (Figure 3.4-3). There is [illegible] hydraulic connection across the mitigation site between the mapped floodplain and the Green River. The narrow wetland swale (see Figure 3.4-2) that bisects the parcel is shallow (<6 inches topographic change) and displayed no wetland hydrology during site investigations for development of this plan (August-November 1995). However, soils in this area display hydric characteristics and do contain a high percentage of silts; this likely restricts their permeability. Drainage characteristics of on-site soils are discussed in Section 3.4.4.3.

Shallow groundwater monitoring began September 12, 1995 when 11 monitoring sites were established (see Figure 3.4-2) to assess the shallow groundwater gradient across the site and to measure any seasonal variations that may occur in response to rainfall and changes in river elevation. Based on these observations, the groundwater table appears to average 8.0 to 9.0 ft below the ground surface in the early fall months, with a rise in groundwater elevation during the transition to the rainy season beginning in November (Table 3.4-2).

Soils

The predominant soil type at the proposed mitigation site, below the 6 inches of organic surface material, is silt (or ML) according to the Uniform Soil Classification System (USCS). The silt varies in color from reddish brown to gray, with clay and clay mottles throughout. The Soil Conservation Service soil survey for King County (USDA 1973) identifies the predominant soil in the mitigation area as Oridia silt loam. Other SCS-mapped soils in the area include Renton silt loam and Briscot silt loam (Figure 3.4-4) and their drainage characteristics are listed in Table 3.4-3. The Oridia and Briscot series are described by SCS (USDA 1973) as somewhat poorly drained soils that formed in alluvium in river valleys. In a representative profile, the surface layer is dark grayish-brown silt loam about 9 inches thick. The subsoil is mottled grayish-brown, dark grayish-brown, and gray silt loam and stratified fine sandy loam that extends to a depth of 60 inches or more.

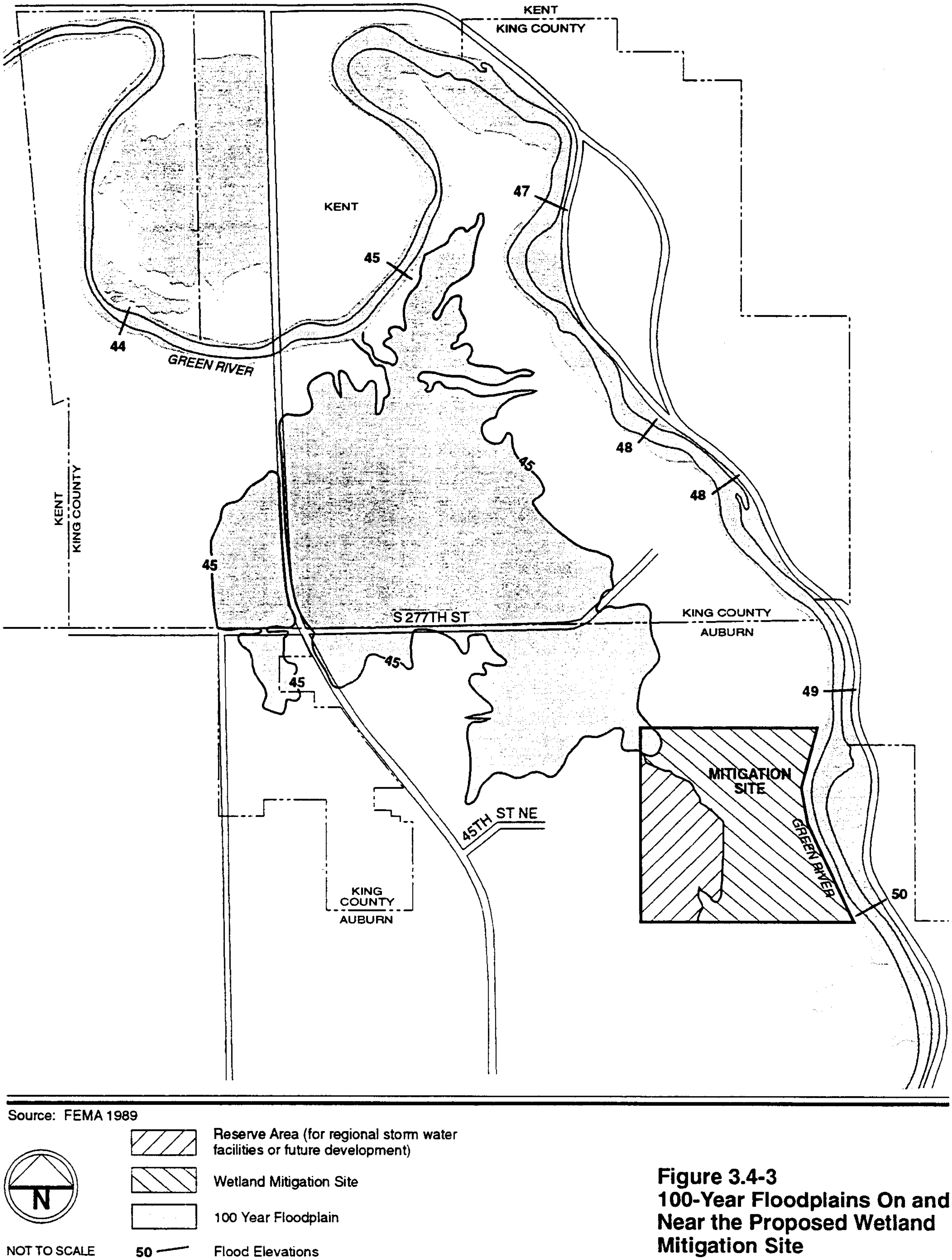
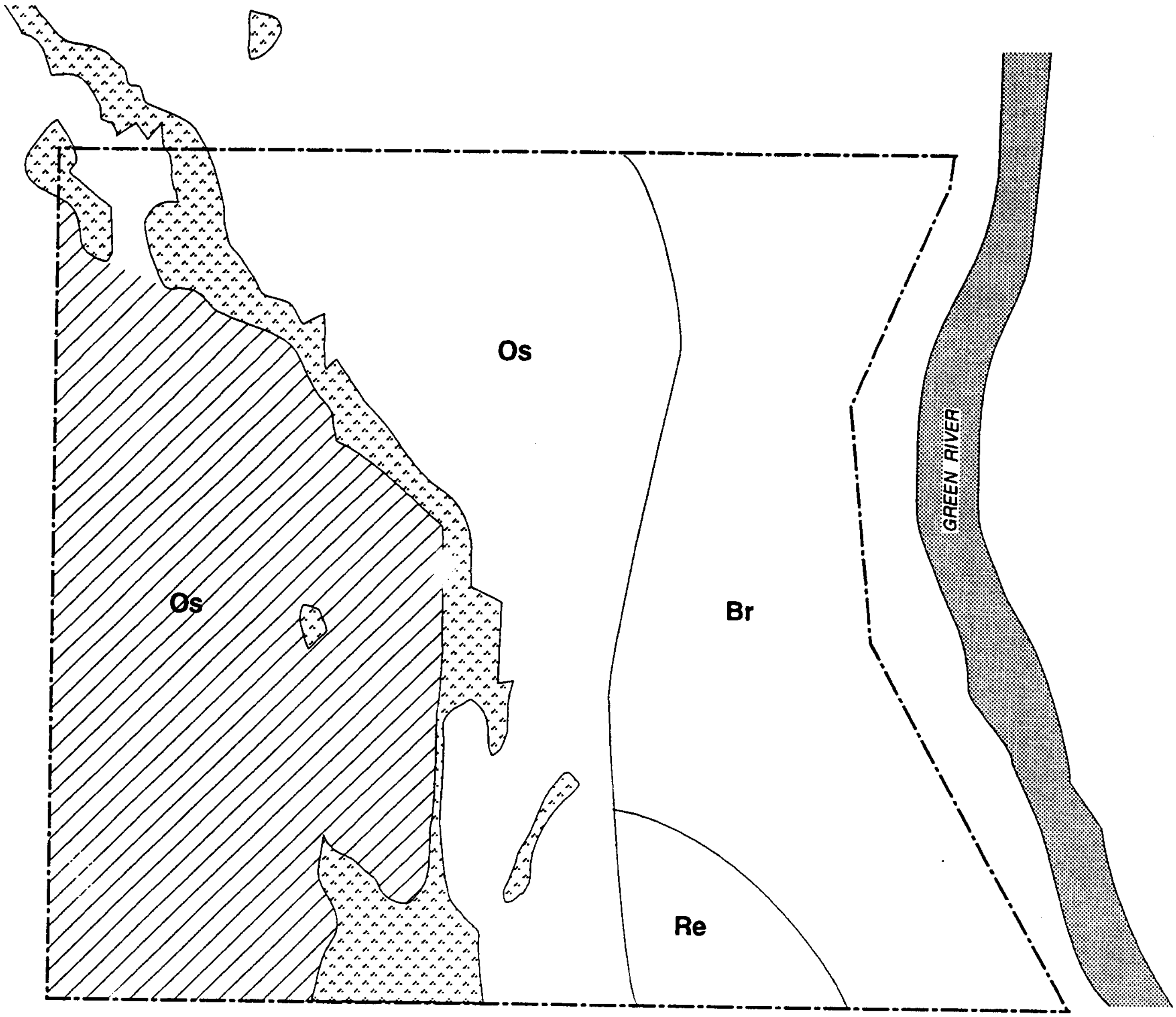
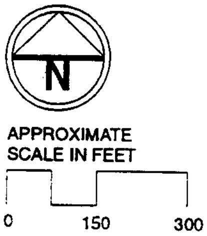


Figure 3.4-3
100-Year Floodplains On and Near the Proposed Wetland Mitigation Site



Note: Wetland boundaries approximate pending field verification by U.S. Army Corps of Engineers

Source: USDA 1973, David Evans 1995
Additional Data Compiled by Parametrix



Re Renton Silt Loam
Os Oridia Silt Loam
Br Briscot Silt Loam

Existing Wetland
Site Boundary (Approximate)
Reserve Area (for regional storm water facilities or future development)

Figure 3.4-4 Soil Types on the Proposed Wetland Mitigation Site

Table 3.4-2. Land surface and depth to groundwater on the proposed wetland mitigation site from September 8, 1995 to present.

Monitoring Well Number	Land Surface Elevation	Depth to Groundwater (ft) Date: 12 SEP	28 SEP	10 OCT	24 OCT	9 NOV
P-1	47.6	>9.0	>9.0	8.9	7.6	7.0
P-2	46.7	8.0	8.2	8.3	7.6	6.7
P-3	46.7	8.1	8.3	8.4	7.9	6.7
P-4	48.5	>8.8	>8.8	>8.8	>8.8	>8.8
P-5	50.1	>9.0	>9.0	>9.0	>9.0	>9.0
P-6				8.2	7.5	6.7
P-7				8.2	7.5	5.7
P-8				8.8	8.3	5.7
P-9				>7.8	>7.9	>7.9
P-10				>8.3	>8.3	>8.3
P-11				>6.5	>6.5	>6.5

Data compiled by Parametrix

Table 3.4-3. Drainage characteristics of soils on the mitigation site.

Soil Series[a]	Drainage Class	High Water Table: Permeability[b] (in/hr)	Depth (ft)	Months	Flooding: Frequency	Duration	Months
Briscot	Poorly	0.63-2.0	1 to -1	Nov-Apr	Occasional	Brief	Dec-Feb
Oridia (drained)	Poorly	0.20-2.0	1 to 3	Nov-Apr	Occasional	Brief	Nov-Apr
Renton	Somewhat poorly	2.0-6.3	1 to 1.5	Nov-Apr	Common	Brief	Nov-Apr

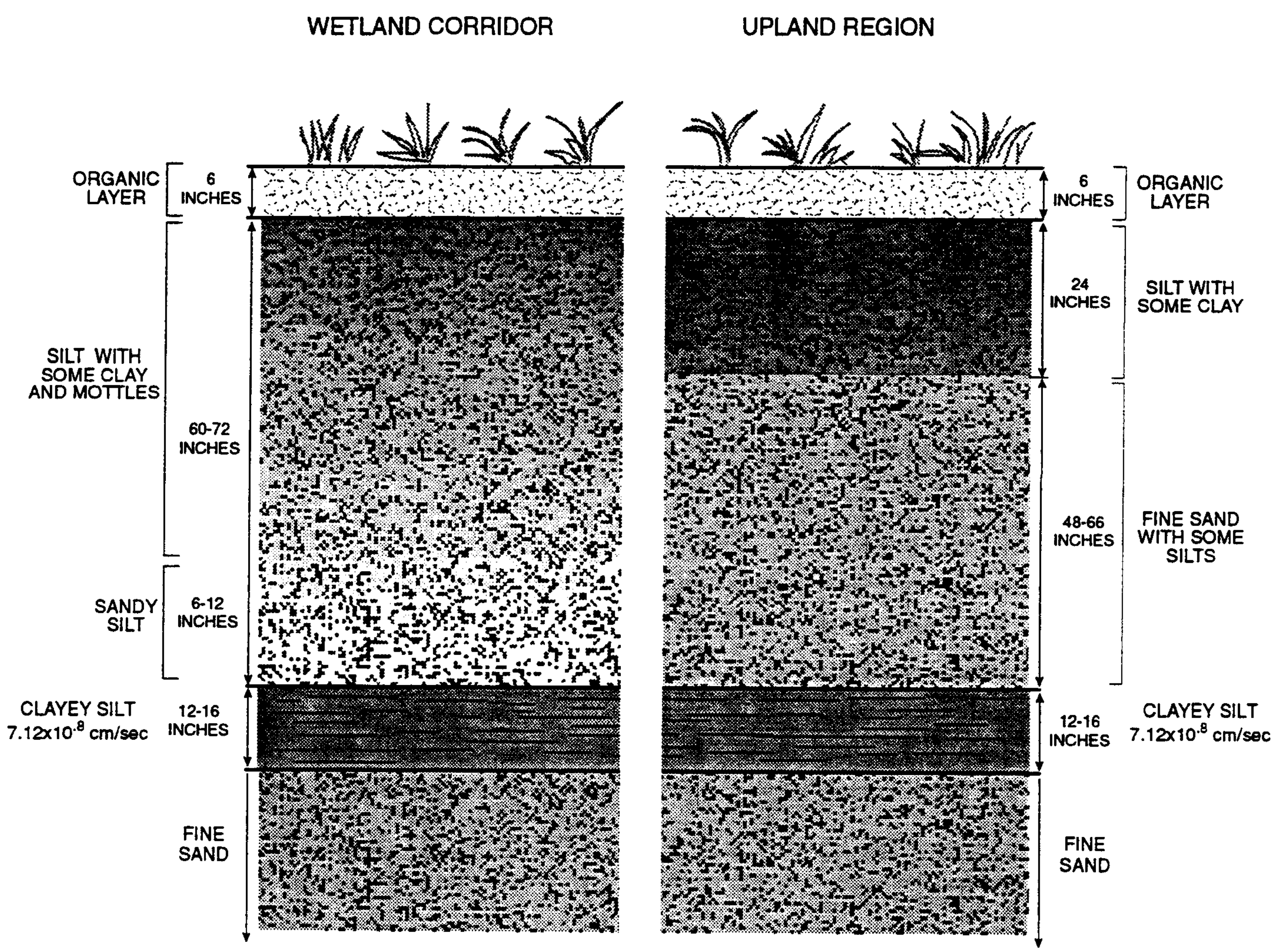
Source: USDA 1973

[a] All soils are classified as hydric (wetland); however, on-site conditions indicate only limited areas of hydric soils are present.

[b] Within the top 20 inches of soil.

This description is consistent with the findings of the soils laboratory testing and the field investigations performed by Parametrix in October 1995. Based on field observations and analytical test results, two distinct soil profiles occur at the proposed mitigation site. For this investigation, the two soil profiles are designated as the wetland corridor and the upland regions. The two soil profiles are presented for comparison in Figure 3.4-5.

The wetland corridor was delineated during previous site investigations and would not be substantially modified during site grading. The wetland corridor soil profile generally consists of a 6-inch acidic organic layer (pH=5.49; organic content = 6.77%) that covers a layer of



Data Compiled by Parametrix

Figure 3.4-5
Typical Soil Profiles at Wetland Mitigation Site

clayey silt. The first 24 inches of the clayey silt is uniform, with clay mottles dispersed throughout. This uniformity is possibly a result of agricultural tilling and cultivating at the site. Below the uniformly mixed silt, the soil is stratified to gray layers of silt and sandy silt that grades to a wet, sandy silt layer at a depth of about 72 inches. Below the wet sandy silt are 12 to 16 inches of very compact clayey silt with an average permeability that varies between 7.12×10^{-8} cm/sec and 2.36×10^{-7} cm/sec (determined at two locations). Below the clayey silt layer, the soil grades to a uniformly fine sand layer. Because of the thickness of the clayey silt layer and the absence of an underlying fine sand layer (similar to the upland soils described below), these soils drain slowly allowing hydric soil characteristics to develop.

The upland portion of the site includes those areas outside the wetland corridor that are planned to be modified as part of the grading plan. The typical soil profile of the upland region is similar to the existing wetland corridor for the first 30 inches, with a 6-inch acidic organic layer followed by a 24-inch, uniformly mixed layer of clayey silt with dispersed mottles. Below the clayey silt layer, the soil is predominantly fine sand, with some silt. The sand is uniform gray up to depths of 96 inches below the surface. A 6- to 8-inch-thick clayey silt layer was again encountered between the 72- and 96-inch depth. Below the clayey silt, the soil returns to a uniform fine sand. The 36- to 48-inch fine sand layer located near the soil surface allows surface soils to drain more quickly than wetland soils, and hydric characteristics have not developed.

Environmental Site Assessment

A Phase I Site Assessment of the mitigation property was conducted in December 1995 (Parametrix 1995) and is incorporated into this document by reference. The report was prepared according to guidelines described in American Society for Testing and Materials (ASTM) Standard Practice for Environmental Site Assessments: Phase I Environmental Site Assessment Process (ASTM E 1527). The assessment did not indicate environmental conditions of concern associated with past or current use of the site and adjacent properties.

Wildlife Habitat

The mitigation site is mostly abandoned agricultural land, which is dominated by grasses and forbs, and a non-flooded, emergent wetland swale. Adjacent areas to the north are still in agricultural use. The habitat south of the site is also disturbed by agricultural use and, to the west of the site, wildlife habitat has been mostly eliminated by residential development. No permanent surface water features occur on the site, and there is no evidence of seasonal surface flow. The most prominent associated habitat feature is the Green River on the eastern site boundary and the steep, forested slopes along the opposite bank of the Green River, which provide habitat connectivity to other natural areas.

The Washington Department of Fish and Wildlife Priority Habitats and Species database (WDFW 1995) identifies the palustrine emergent wetland that bisects the site as a priority habitat (all wetlands are identified by WDFW as priority habitat). The wetland is dominated by reed canarygrass, velvet grass, and soft rush. The habitat quality of the wetland and the adjacent grassy uplands is compromised by invasive species, low vegetative diversity, and lack of habitat structure. Small mammals may use the area for feeding and breeding, but lack cover from predation. The site may provide foraging habitat for raptors, such as Northern harriers—which may use nearby fenceposts as low perches—and red-tailed hawks. Grassy areas on the site lack habitat structure for nesting cover, protection from predation, thermal cover, or perching for passerine species.

A narrow band of shrub vegetation along the south fenceline consists of invasive blackberry species with reed canarygrass undergrowth. Himalayan and evergreen blackberry are non-native species that dominate disturbed habitats. The blackberries provide the only shrub habitat on the site. Although they bear fruit and provide habitat structure that would otherwise not be present, they are considered a nuisance species.

During field investigations in November 1995, tracks or scat of coyote, mink, deer, raccoon, and kingfisher were observed on the mitigation site. Species observed include common snipe, red-tailed hawk, common yellowthroat, and mallard duck.

3.4.4.2 Functions and Values of Mitigation Wetland

The off-site wetland mitigation site is designed to provide in-kind replacement of wetland biological functions affected by implementation of the proposed Sea-Tac Airport Master Plan Update improvements. The proposed design of the mitigation site would also provide additional mitigation for species using wetland buffer areas and other upland habitats at the airport. Although not related to impacts of the proposed Master Plan Update improvements, additional flood storage capacity would be considered as part of the design process. Vegetation cover and site hydrology following construction of the mitigation wetland are discussed in Sections 3.5.1 and 3.5.3.

<u>Wildlife Habitat</u>

Construction of the forested, shrub, and emergent wetlands would create conditions that provide habitat for a variety of wildlife species. Table 3.4-4 identifies a broad range of wildlife species that would be expected to occur over time in the mitigation wetland. However, habitat structure and availability would change as vegetation matures over the next several decades, and many listed species would begin using the site in future years. Table 3.4-5 identifies expected trends in wildlife use of the site through several stages of vegetation establishment, up to and beyond 25 years following construction.

Table 3.4-4. Wildlife species expected to occur in the wetland mitigation site after construction.

	Habitat Type					
	Permanently Flooded Emergent Wetland	Seasonally Flooded Emergent Wetland	Shrub Wetland	Forested Wetland	Riparian Forest	Abandoned Agricultural Land
Amphibians						
Northwestern salamander	X	X		X	X	
Long-toed salamander		X	X	X	X	
Pacific giant salamander	X			X	X	
Rough-skinned newt	X	X			X	
Ensatina					X	
Western toad	X	X				
Pacific chorus frog	X	X	X	X	X	
Red-legged frog	X	X	X	X	X	
Bullfrog (1)	X					
Reptiles						
Common garter snake	X	X	X	X	X	
Birds						
Great blue heron	X	X	X	X		
Canada goose	X	X				X
Green-winged teal	X	X				X
Mallard	X	X	X			X
Northern pintail	X	X				X
American wigeon	X	X				X
Osprey					X	
Bald eagle					X	
Northern harrier	X	X				X
Red-tailed hawk				X	X	X
Killdeer	X	X				X
Common snipe	X	X				
Herring gull	X					
Rock dove (1)						X
Western screech-owl				X	X	
Rufous hummingbird					X	X
Belted kingfisher	X					
Downy woodpecker				X	X	
Northern flicker				X	X	
Pileated woodpecker				X		
Willow flycatcher				X	X	
American/northwestern crow	X	X		X	X	X
Black-capped chickadee				X	X	
Bushtit				X	X	
Bewick's wren			X	X	X	
Winter wren					X	
Marsh wren	X		X			
Golden-crowned kinglet					X	
Ruby-crowned kinglet				X	X	
American robin		X		X	X	X

Table 3.4-4. Wildlife species expected to occur in the wetland mitigation site after construction (continued).

	Habitat Type					
	Permanently Flooded Emergent Wetland	Seasonally Flooded Emergent Wetland	Shrub Wetland	Forested Wetland	Riparian Forest	Abandoned Agricultural Land
Varied thrush				X	X	
European starling (1)				X	X	X
Yellow warbler				X	X	
Yellow-rumped warbler				X	X	
MacGillivray's warbler			X	X	X	
Common yellowthroat	X		X			
Wilson's warbler				X	X	
Rufous-sided towhee				X	X	
Fox sparrow				X	X	
Song sparrow	X	X	X	X	X	X
Dark-eyed junco				X	X	
Red-winged blackbird	X	X	X			X
Brown-headed cowbird	X	X	X	X	X	X
American goldfinch				X	X	
House sparrow (1)						X
Mammals						
Vagrant shrew		X	X	X	X	
Pacific water shrew	X	X				
Shrew-mole					X	
Pacific mole						X
Pacific jumping mouse				X	X	
Raccoon	X	X	X	X	X	
Mink	X	X	X	X	X	
Striped skunk					X	X
Coyote			X	X	X	
Red fox			X	X	X	

Data compiled by Parametrix.
[1] Non-endemic species.

Post-construction habitat structure in forested areas would be immature, similar to regenerating forest, and would develop mature forest habitat attributes after several decades. The proposed shrub understory would promote the development of habitat structure. Songbird use in early stages of habitat development would include leaf and bark gleaning species (kinglet/chickadee/bushtit/vireo) that forage in the area. Oregon ash, vine maple, willows, red cedar and hemlock produce seeds that are used by many songbird and mammal species. Small mammals would likely forage for seeds and invertebrates, even though optimal habitat conditions would not occur for one or more decades. As the canopy begins to develop, nesting opportunities and predator avoidance cover would increase.

Table 3.4-5. Potential wildlife use of constructed wetland habitats.

	Emergent Wetland				Shrub Wetland				Forested Wetland			
	Years[1]				Years[1]				Years[1]			
Wildlife Types	0-2	2-5	5-15	>15	0-2	2-5	5-15	>15	0-2	2-10	10-25	>25
Mammals												
Shrews and Mice		F	F	F	F	B/F	B/F	B/F	F	B/F	B/F	B/F
Squirrels						F	F	F	F	F	B/F	B/F
Raccoons, Mink		F	F	F		F	F	F		F	B/F	F/M
Fox, Coyote		F	F	F		F	F	F		F	F	F
Bats	F	F	F	F	F	F	F					
Birds												
Shrub-Nesting Songbirds		F	F/M	F/M	F/M	F/M	B/F/M	B/F/M	F/M	B/F/M	B/F/M	B/F/M
Swallows and Swifts	F	F	F	F	F							B/F
Forest-Dwelling Songbirds						F/M	F/M	F/M	F/M	F/M	B/F/M	B/F/M
Cavity-Nesting Birds						F	F	F		F	F	B/F
Marsh-Nesting Songbirds	F	F	B/F	B/F	F	F	B/F	B/F	F	F		
Raptors	F	F	F	F	F	F	F	F	F	F	F	B/F
Wading Birds		F/M	F/M	F/M	F/M	F/M						
Dabbling Waterfowl		F/M	F/M	F/M	F/M	F/M						
Diving Waterfowl		F/M	F/M	F/M								
Herpetofauna												
Reptiles		F	F	F	F	B/F	B/F	B/F	F	B/F	B/F	F
Terrestrial-Breeding Amphibians		F	F	F	F	F	F	F	F	B/F	B/F	B/F
Aquatic-Breeding Amphibians		F	B/F	B/F	F	B/F	B/F	B/F	F	F	F	F
Macroinvertebrates												
Aquatic Insects	B/F	B/F	B/F	B/F	B/F	B/F	B/F	B/F	B/F	B/F	B/F	B/F
Gastropods			B/F	B/F		B/F	B/F	B/F		B/F	B/F	B/F

Data compiled by Parametrix
B = Breeding F = Foraging M = Migration
[1]Years after construction.

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Tree nesting songbirds (such as thrushes, vireos, and warblers) would use horizontal branches for nesting when the canopy closes enough to provide cover. Leaf litter and forest detritus would begin to accumulate, providing habitat for the invertebrates (Pennak 1989) that amphibians (such as ensatina), small mammals, and ground-foraging birds feed on. Small mammals, in turn, would become food for predators (such as barred owls). Over the course of several decades, forest competition, disease, or climatic conditions would weaken some trees and likely result in mortality. Dead and decaying trees would eventually provide woody debris and snag habitat for flickers, woodpeckers, and small cavity-nesting birds.

The shrub and emergent wetlands should reach stable habitat conditions earlier than the forested wetland community. Shrub species should produce forage and nesting opportunities within two to ten years. Swainson's thrush and Wilson's warblers use moist shrub habitats for nesting and foraging. Berries produced by salmonberry, elderberry, and red-osier dogwood are used by several insectivorous songbird species to supplement fall and winter diets (Ehrlich et al. 1988). Mink, shrews, and other small mammals would readily exploit insect and aquatic invertebrate food sources. Wading birds, such as great blue herons and bitterns, can feed on small mammals and amphibians. Amphibian use, however, would likely be limited by immigration rates because of the lack of existing amphibian habitat in the area. Some species, such as Pacific giant salamander, northwestern salamander, and rough-skinned newt commonly migrate through terrestrial habitats and may be expected to use the mitigation site.

Although flooded emergent wetlands can provide substantial forage opportunities for ducks, habitat use would vary with proximity to upland predator cover. Waterfowl, which are wary of dense shrubs that allow predators to approach undetected, prefer interspersion of emergent vegetation and open water. Slough sedge, spike rush, and scouring rush are all species preferred by dabbling ducks and geese during migration (Payne 1992). Narrow-leaf burreed is preferred by dabblers and migrating wood ducks. As decaying vegetation builds up in flooded areas, shovelers, pintails and other diving species could use growing populations of plankton, algae, aquatic insects, and gastropods.

3.5 MITIGATION SITE PLAN

The mitigation site plan and general construction methods used to achieve mitigation design objectives are presented in this section. Considered in detail are the evaluation methods and justification for establishing the wetland water regime, the grading plan, revegetation plan, and monitoring and contingency plans for wetland development.

The potential impacts associated with developing the site for wetland mitigation were assessed in *Environmental Report: Port of Seattle Master Plan Improvements Wetland Mitigation Site, Auburn, Washington*, (Parametrix 1996) which is incorporated into this document by reference. The report found no significant environmental impacts associated with implementation of the mitigation project that could not be mitigated.

3.5.1 <u>Water Regime</u>

An adequate water regime is the most critical factor required to establish the desired forest, shrub, and emergent wetland vegetation classes on the mitigation site. The duration and amount of standing water, or soil saturation, control the wetland community types present on-site. (Throughout this report saturation depths refer to the level of water in a hole or monitoring well.) Based on the design objectives outlined in Table 3.3-2 and knowledge of typical hydrology in native Puget Sound wetland communities, a proposed hydrologic regime for the mitigation wetland was developed:

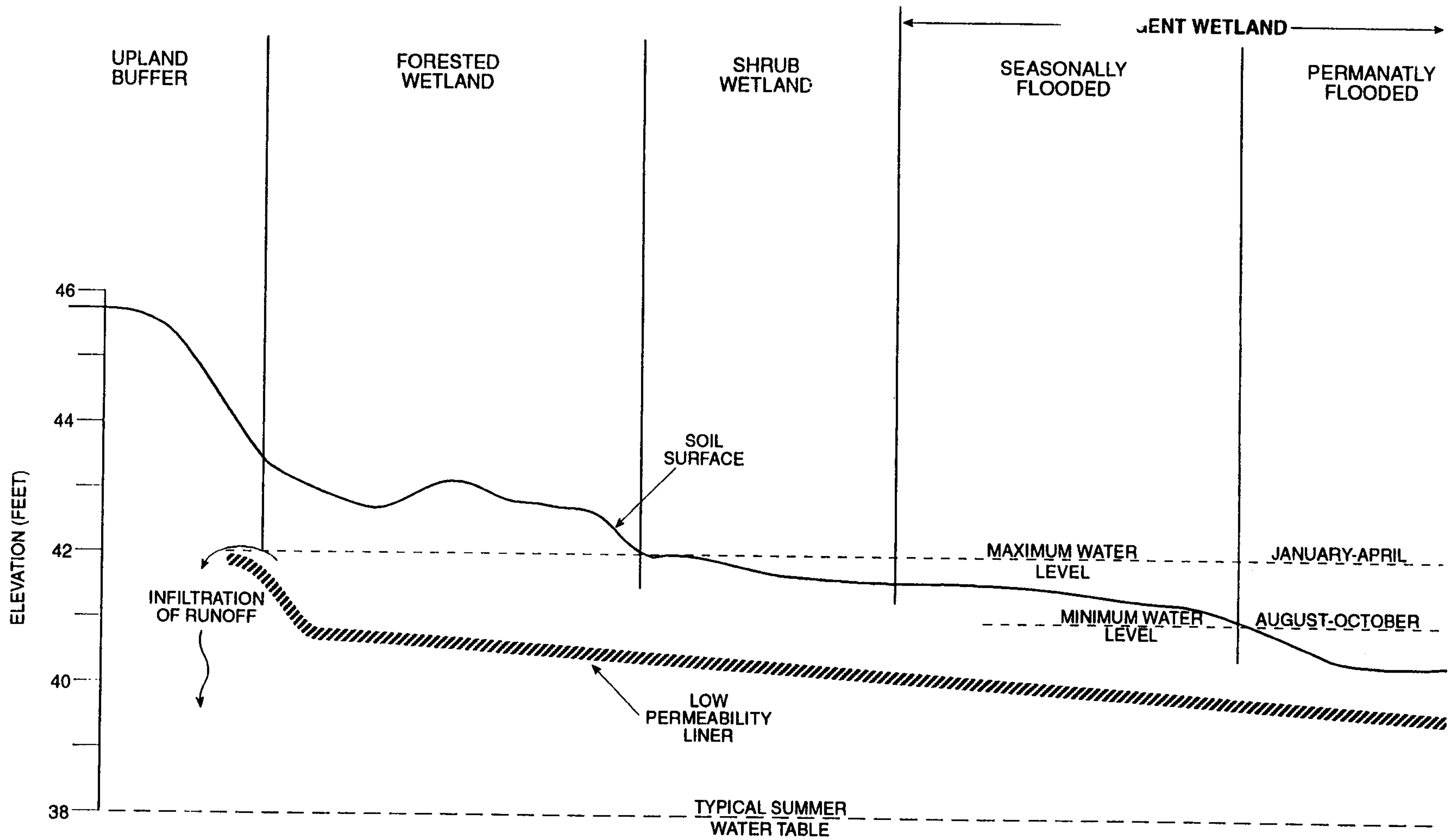
- **Forested Wetlands** would be established where soils are seasonally saturated during the winter and spring period (late December - April). Soil saturation in forested wetlands would be 12 to 18 inches below the soil surface during much of this period.

- **Shrub Wetlands** would be created in areas where soils remain wet throughout the year (saturated to within 6 to 12 inches of the soil surface). Flooding with up to 6 inches of standing water would occur during the December - May period.

- **Emergent Wetlands** would be established where extended periods of flooding (up to 12 inches deep) are present. In areas where flooding is not permanent, soils would remain moist or saturated to within 6 inches of the soil surface throughout the summer months.

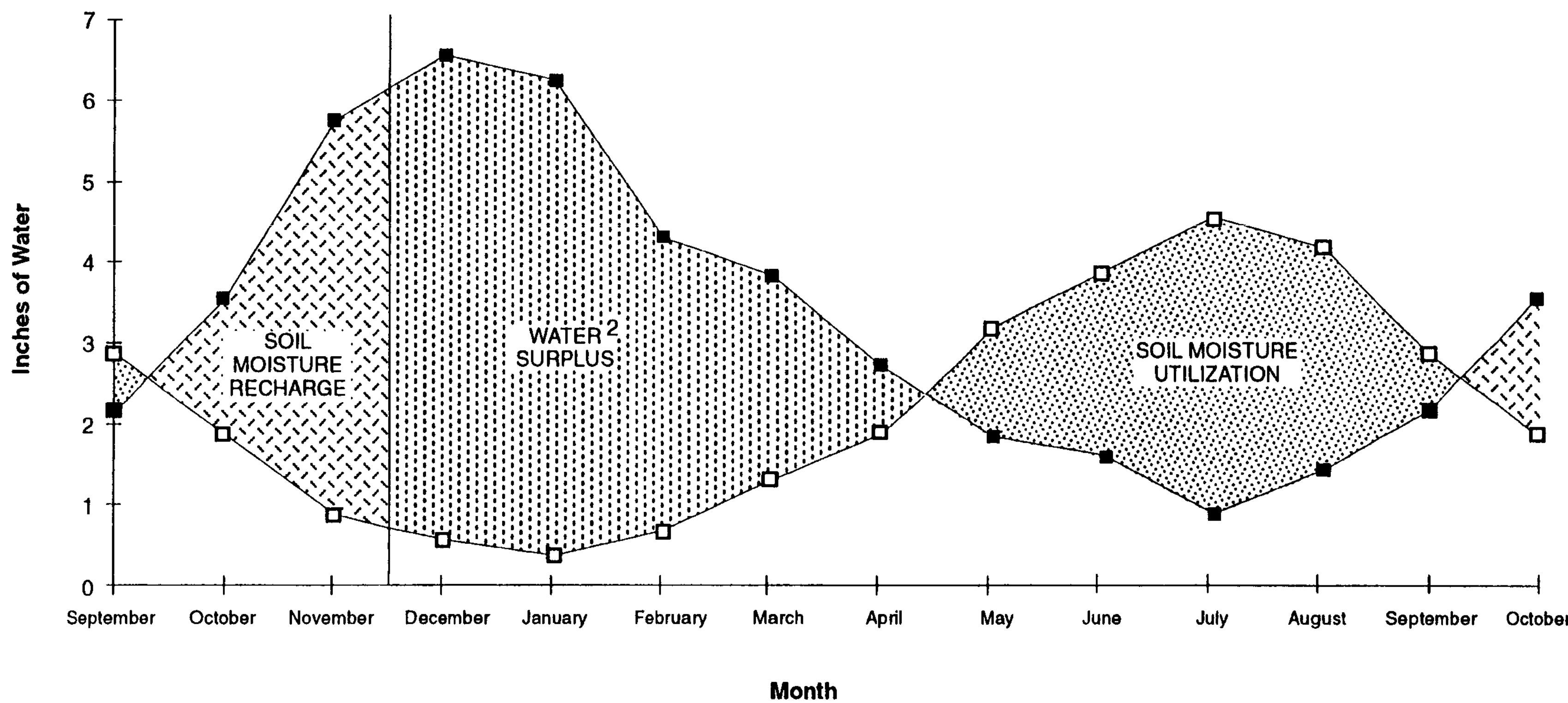
Groundwater monitoring on the mitigation site indicates that it is feasible to create the hydrologic conditions defined above by excavating a basin to intercept the shallow groundwater that occurs at depths of at least 8 to 9 ft below the ground surface during late summer months (see Table 3.4-2). However, to reduce overall earthwork, the above hydrologic regime would be established by creating a perched water table in an excavated basin that has been lined with low-permeability soils (native on-site soils compacted or amended with clay) (refer to Section 3.5.2, Site Grading). Water levels in the excavated basin would be controlled by seasonal patterns of precipitation and evapotranspiration, rather than by seasonal fluctuations in groundwater levels. The relationship of the proposed wetland vegetation zones to water levels and site topography are shown in Figure 3.5-1. The methods used for developing the water level regime are summarized below.

Seasonal precipitation and evapotranspiration patterns for the project area based on 30 years of rainfall data are summarized in Table 3.5-1. Figure 3.5-2 illustrates the annual soil moisture regime in a wetland based on the 30-year rainfall data for the area. The figure shows that over a 14-month period starting in September, there is a period of soil moisture recharge until about 6 inches of total precipitation has accumulated (typically by mid-November). Following this recharge, additional precipitation generates surplus water in the soil profile that results in soil saturation and runoff. Once a soil water surplus develops, water depths in the wetland basin increase throughout the winter months. During early spring, evapotranspiration increases to



Data Compiled by Parametrix

Figure 3.5-1
Relationship of Seasonal Water Level Variations and Surface Elevations to Proposed Wetland Vegetation Classes



[1] Based on precipitation data for Kent, Washington (Department of Commerce 1982) and estimated evapotranspiration data for Seattle-Tacoma Airport and the Puyallup Experiment Station (Cooperative Extension Service 1968). Soil moisture based on water-holding capacities of on-site soils (Snyder, et al. 1973).

[2] Water surplus is available to fill wetland basin to design capacities.

■ Average Monthly Precipitation

□ Average Monthly Potential Evapotranspiration and Infiltration

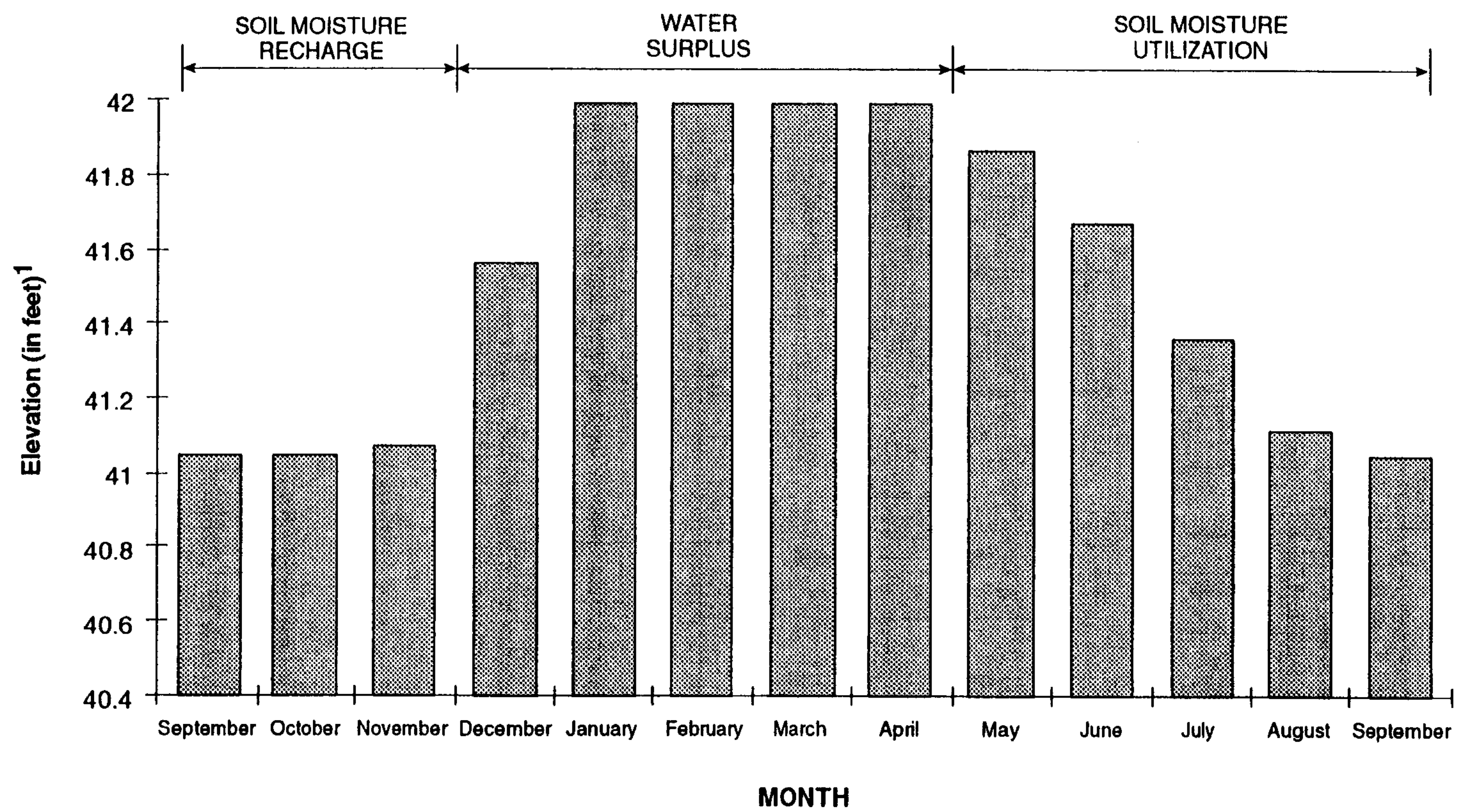
Figure 3.5-2
Moisture Regime for the Proposed Mitigation Wetland[1]

rates exceeding precipitation, resulting in the use of soil moisture and a gradual decline in water depths.

The model described above can be used to predict the hydrologic regime in a closed wetland basin such as the proposed mitigation wetland. The constructed basin would be lined with a low-permeability layer of compacted soil that would limit infiltration of precipitation into the underlying soil to less than 0.1 inch per month. Since Puget Sound is an area where annual precipitation exceeds the combined effects of evapotranspiration and infiltration, the wetland basin would fill with water and generate runoff during the winter months (Figure 3.5-3). Considering site topography and soil conditions, the wetland would be designed to accumulate water up to surface elevations of 42 ft (see Section 3.5-1). Above this elevation, the basin would be unlined, and runoff from the wetland would infiltrate into the subsoil on the site (as is presently the case). During spring and summer months, as soil water is used, water levels would decline to about 41 ft by late September. During October and early November, precipitation would recharge soil moisture and increase water levels to the 42-ft winter elevation.

Table 3.5-1 presents average precipitation values and shows an average annual excess of over 13 inches of water. Based on historical climate data (Department of Commerce 1982), even during record dry periods, sufficient rainfall would occur during the fall and winter months to fill the wetland basin. Thus, the wetland would have the designed water depths by April of each year. During years when below-normal rainfall occurs in the spring and summer months, water levels would decline more rapidly and to lower levels compared to average rates shown in Figure 3.5-3. During abnormally dry summers (when little or no rainfall may occur for 30 to 90 days), the emergent wetland communities could be dry from late June to mid October and shrub wetlands could be dry from late May to late October. Because of the infrequency of extended dry periods, and the fact that many shrub and emergent wetlands in Puget Sound are dry during late summer months, no long-term adverse effects from periodic drought are anticipated.

A regional storm water detention facility may be constructed by the city of Auburn in the general vicinity of the proposed mitigation parcel and could be used to enhance hydrologic conditions in the wetland. The mitigation wetland could receive treated supplemental water from the detention facility (treated and conveyed to the wetland through a biofiltration swale) during summer months when water levels are lowest. This additional water would be particularly beneficial during below-average rainfall years and could ensure that standing water would be present in emergent areas throughout the summer of all years. However, the feasibility of integrating the wetland with a storm water detention facility has not been fully investigated, and the wetland has been designed to function without supplemental water. Integration of the facilities would require only minor modifications of the mitigation plan for the addition of biofiltration swales and an adjustable flow control structure to divert a portion of the storm water into the wetland.



Data Compiled by Parametrix

[1] Water level elevations were calculated from changes in monthy excess of precipitation (Table 3.5-1), assuming maximum elevations of 42 feet and 6-inch water storage capacity of on-site soils

Figure 3.5-3
Predicted Seasonal Water Level Variations in Proposed Mitigation Wetland

Table 3.5-1. **Monthly precipitation, evapotranspiration, and cumulative water balance (in inches) for a lined wetland basin in Kent, Washington (1950-1980).**

		Water Losses			
Month	Average Rainfall	Potential Evapotranspiration[1]	Infiltration[2]	Monthly Excess[3]	Cumulative Excess
October	3.47	1.8	0.1	1.57	1.57
November	5.68	0.8	0.1	4.78	6.35
December	6.48	0.5	0.1	5.88	12.23
January	6.18	0.3	0.1	5.78	18.01
February	4.23	0.6	0.1	3.53	21.54
March	3.77	1.2	0.1	2.47	24.01
April	2.64	1.8	0.1	0.74	24.75
May	1.75	3.1	0.1	-1.45	23.3
June	1.52	3.8	0.1	-2.38	20.92
July	0.81	4.5	0.1	-3.79	17.13
Augus	1.34	4.1	0.1	-2.86	14.27
Septemoer	2.05	2.8	0.1	-0.85	13.42
Annual	**39.92**	**25.3**	**1.2**		**13.42[4]**

Source: Cooperative Extension Service 1968; Department of Commerce 1982

1 Evapotranspiration is the physical loss of water to the atmosphere from soil and water surfaces (evaporation) and the physiological loss of water from plant foliage to the atmosphere (transpiration). Potential evapotranspiration is the amount of water loss that occurs when available soil moisture exceeds that needed for transpiration (associated with plant growth) and evaporation. Since wetland conditions will exist year-round, soil moisture will not be limiting and potential evapotranspiration rates will control water levels in the wetland.

2 Infiltration is the amount of water lost from the proposed wetland through the low-permeability soil liner.

3 Equals rainfall minus water losses.

4 Annual excess is lost from the wetland by discharge to adjacent areas when water levels exceed elevation 42, which corresponds to the top edge of the low-permeability liner.

The proposed wetland would be located within the 100-year floodplain of Green River backwater areas (FEMA 1989). Within this area, the base 100-year flood elevation is 45 ft; thus, during 100-year flood events, forested and shrub wetland areas that are typically non-flooded would be flooded with up to 3 ft of water. Emergent wetland communities would also experience increased flooding of 3 ft (see Figures 3.5-1 and 3.5-5). Flooding of the wetland is not expected to alter wetland plant communities because of its infrequent occurrence and short duration. All wetland plant species included in the mitigation plan (Section 3.5.3) are adapted to saturated soil conditions and have established naturally in areas subject to periodic flooding along many Puget Sound rivers. It is anticipated that excess ponding from periodic floods would recede quickly due to lateral flux over the proposed liner.

3.5.2 Site Grading

The mitigation design objectives would be achieved by grading a basin to a range of depths and creating a perched water table several feet above the natural summer water table at the site (Figures 3.5-4 and 3.5-5). This section discusses the technical considerations, constructability issues, and limitations associated with grading the mitigation site.

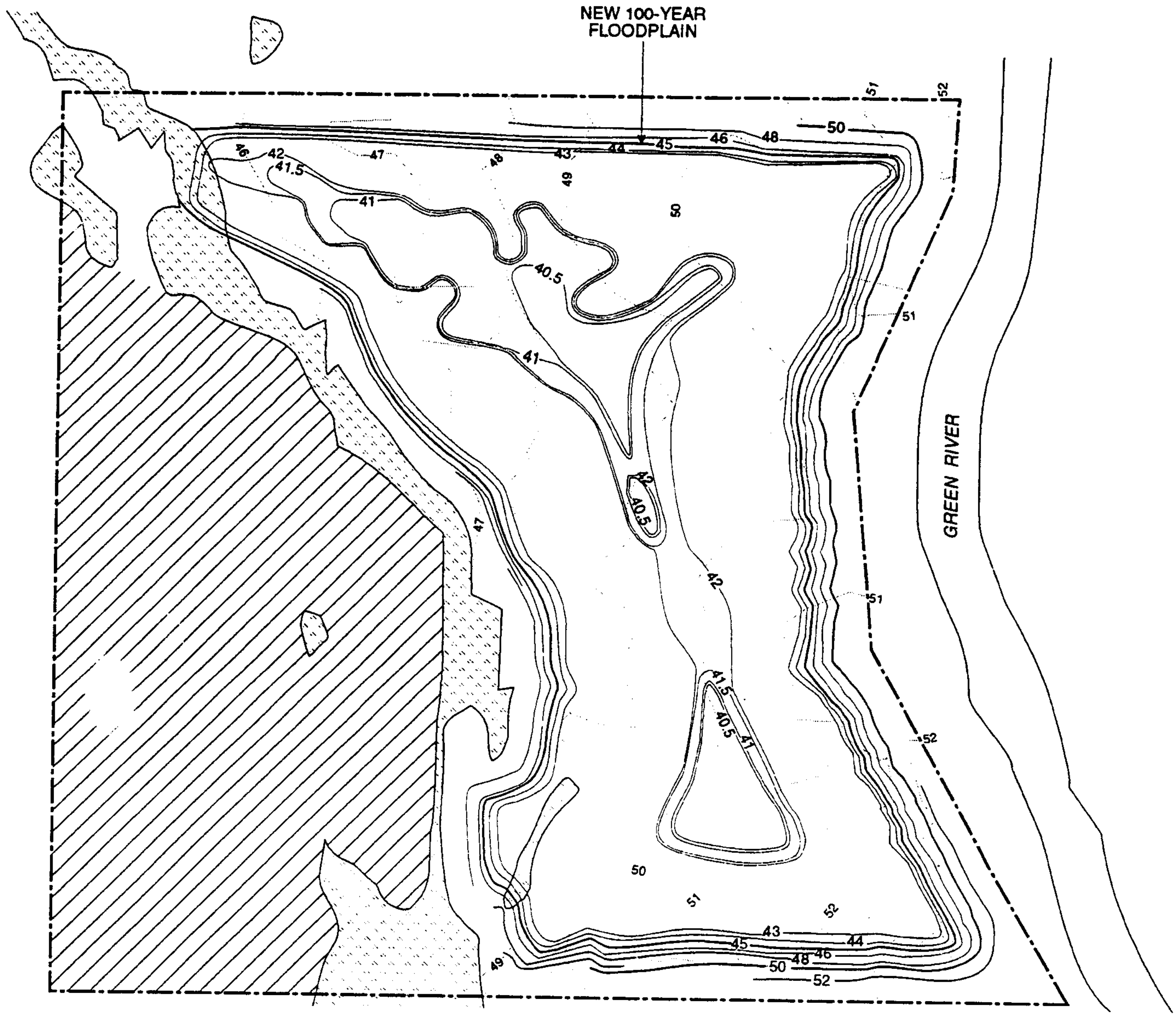
The proposed grading involves four earthwork construction steps. First, the top 6 inches of soil would be excavated and removed from the site. Five to 10 ft of underlying sandy silt-loam soils would be excavated to form a basin, with approximately one-third of the soil stockpiled for reuse on site (two-thirds available for off-site use). The third step is to line the basin with a 9- to 12-inch layer of compacted soil of low permeability, to create an artificial "perched" groundwater condition. The last grading step is to replace the stockpiled soil over the low-permeability layer. This soil would be graded at varying thicknesses to provide the appropriate rooting depth and zones of saturation for each of the desired wetland classes. The construction steps related to technical issues and approximate soil quantities are described below.

3.5.2.1 Surface Soil Removal

Surface soil would be removed because of potential adverse impacts from invasive plants. Excavation of 6 inches of surface soil in most areas would largely eliminate seeds, roots, and rhizomes and reduce colonization by most invasive plants; excavation depths may be slightly greater where reed canarygrass predominates. Based on a site grading area of 29 acres (including the wetland and floodplain areas below elevation 45) and removal of 6 inches of surface topsoil, the quantity of topsoil hauled off-site would be approximately 23,400 yd^3.

3.5.2.2 Basin Excavation

Approximately 400,000 yd^3 of soil would be excavated to create the wetland basin (Figure 3.5-5), with excavation depths ranging between 7 and 12 ft across the site. Approximately one-third of the excavated material would be selectively stockpiled on-site. Fine-grained clayey silt soils would be used to construct the low-permeability liner, and sandy loam soils would serve as backfill and replacement soils. The bottom of the excavation would have a slight slope toward the low point(s) in the basin. The transition slope, between the floor of the basin and the undisturbed grades around the perimeter of the mitigation area, would be approximately 10H:1V (horizontal to vertical) to facilitate planting and to minimize the potential for erosion.



Note: Wetland boundaries approximate pending field verification by U.S. Army Corps of Engineers

Source: David Evans 1995
Additional Data Compiled by Parametrix

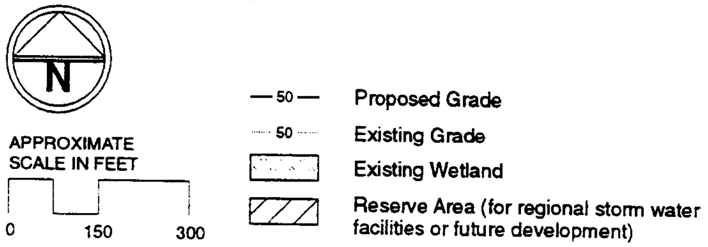
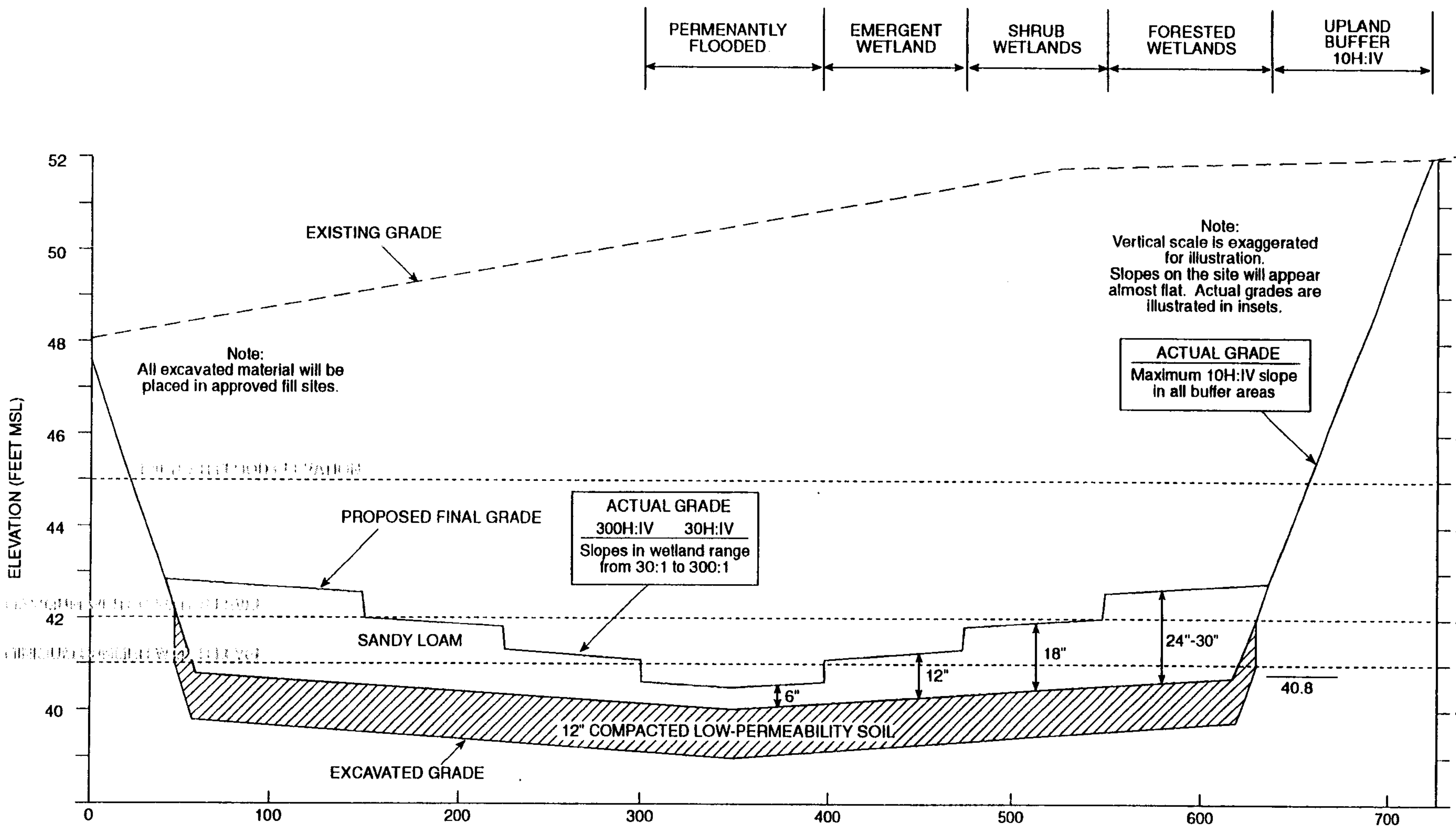


Figure 3.5-4
Site Grading



Data Compiled by Parametrix

Figure 3.5-5
Site Grading
Idealized Cross Section

3.5.2.3 Low-Permeability Layer Construction

The low-permeability layer construction would depend on the quantity and properties of the clayey silt encountered during excavation. It is anticipated that a 9- to 12-inch-thick layer would be constructed using compacted native soils, if sufficient quantities of suitable soils are found. Approximately 44,000 yd^3 of a compactable soil are needed to create a 12-inch-thick low-permeability layer over the 27-acre wetland area.

Preliminary site soils information (collected at monitoring well locations shown in Figure 3.4-2) shows that a clayey silt layer extends from the 6- to 30-inch depth. If the clay layer is continuous and 15 inches of the clayey silt are available after surface soil removal, a sufficient quantity of this material would be stockpiled for construction of the low-permeability layer. Another layer of clayey silt was found at depths ranging from 72 to 96 inches. The measured permeability of this lower clayey silt layer also appears adequate to meet project requirements. However, the extent and continuity of this lower layer is unknown, and the measured thickness of this layer (6 to 8 inches) would make it difficult to segregate during excavation. These soils would be considered for construction of the low-permeability liner only if sufficient quantities of the shallower clayey silt are unavailable. Additional field investigations within the proposed grading area will be conducted to further characterize the available soils.

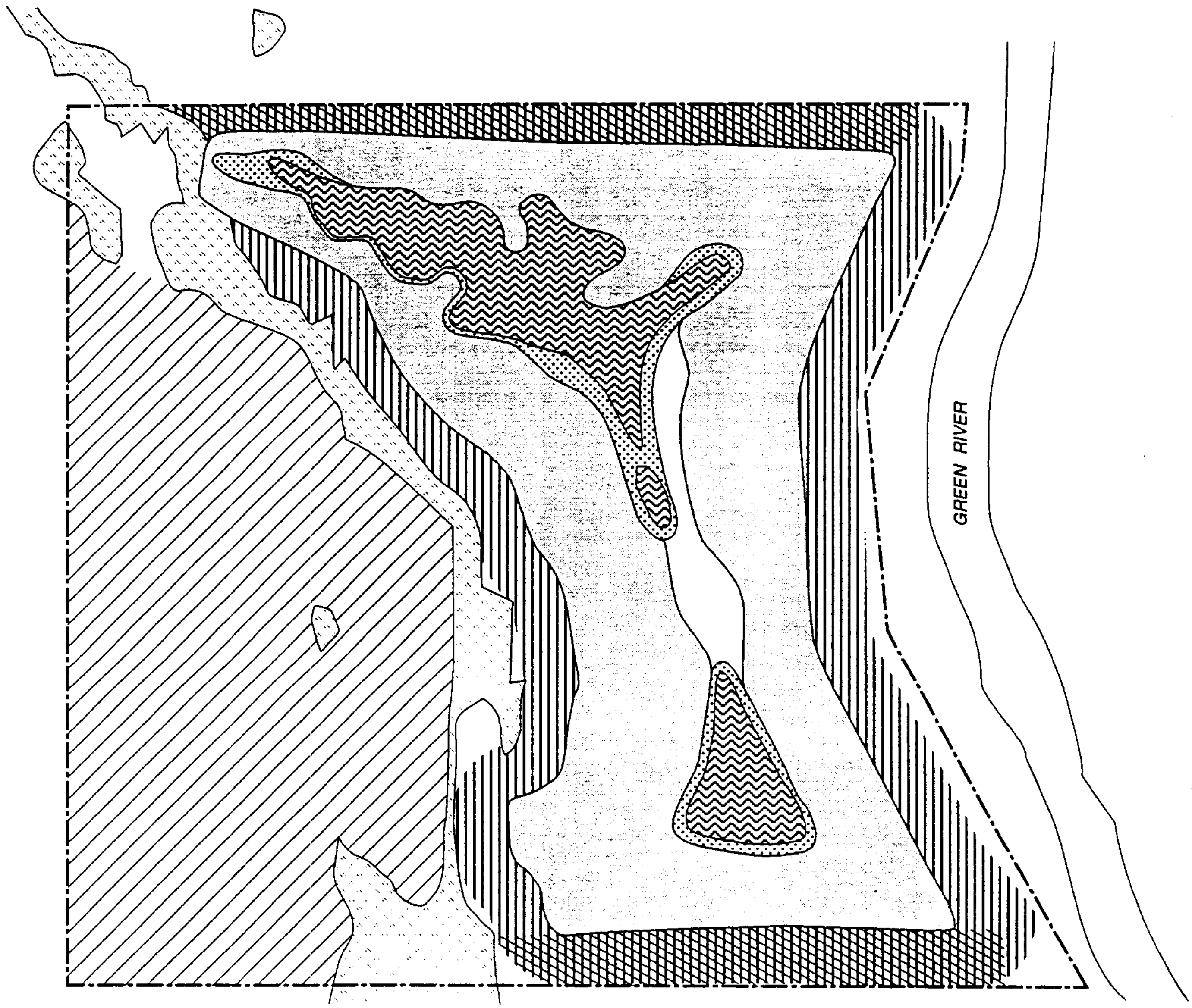
If suitable on-site soils are not found in sufficient quantity, bentonite would be used as a soil amendment to reduce the permeability characteristics of available soils. This method has been used successfully in other large-scale earthwork projects such as landfill and pond liner improvements, and is appropriate for wetland construction.

3.5.2.4 Soil Replacement and Finish Grading

As shown in Figure 3.5-5, soil would be placed and graded to varying thicknesses over the low-permeability layer to provide the proper rooting depth and zone of saturation for the selected vegetation classes. Generally, soil thickness would change in increments of approximately 6 inches between wetland classes, with the thickest soils occurring in forested areas. The proposed grading and wetland class acreages indicate that approximately 100,000 yd^3 of replacement soil are needed. The on-site sandy loam material would be used as a topsoil.

3.5.3 Landscape Plan

Four wetland vegetation classes would be planted in the mitigation area (Figure 3.5-6). These general classes would include eight wetland plant associations (Figure 3.5-7) typical of freshwater wetlands and forested uplands in the northern Puget Sound basin. These plant associations are groups of plants selected to mimic naturally occurring native plant groups that may be found within a wetland class. The species composition and relative abundance of species in each plant association and their wetland indicator status are listed in Table 3.5-2.



Note: Wetland boundaries approximate pending field verification by U.S. Army Corps of Engineers

Source: David Evans 1995
Additional Data Compiled by Parametrix

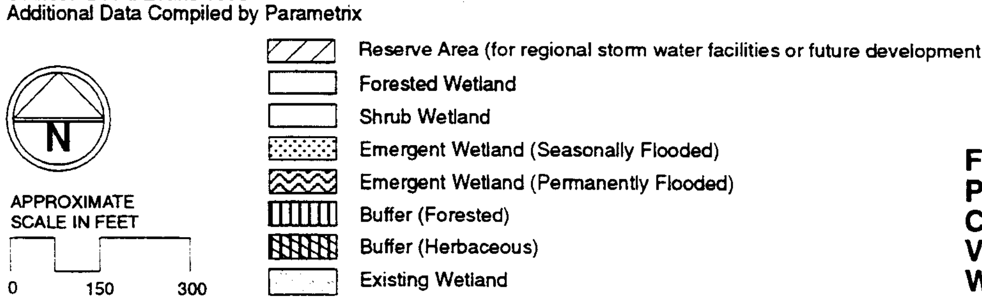
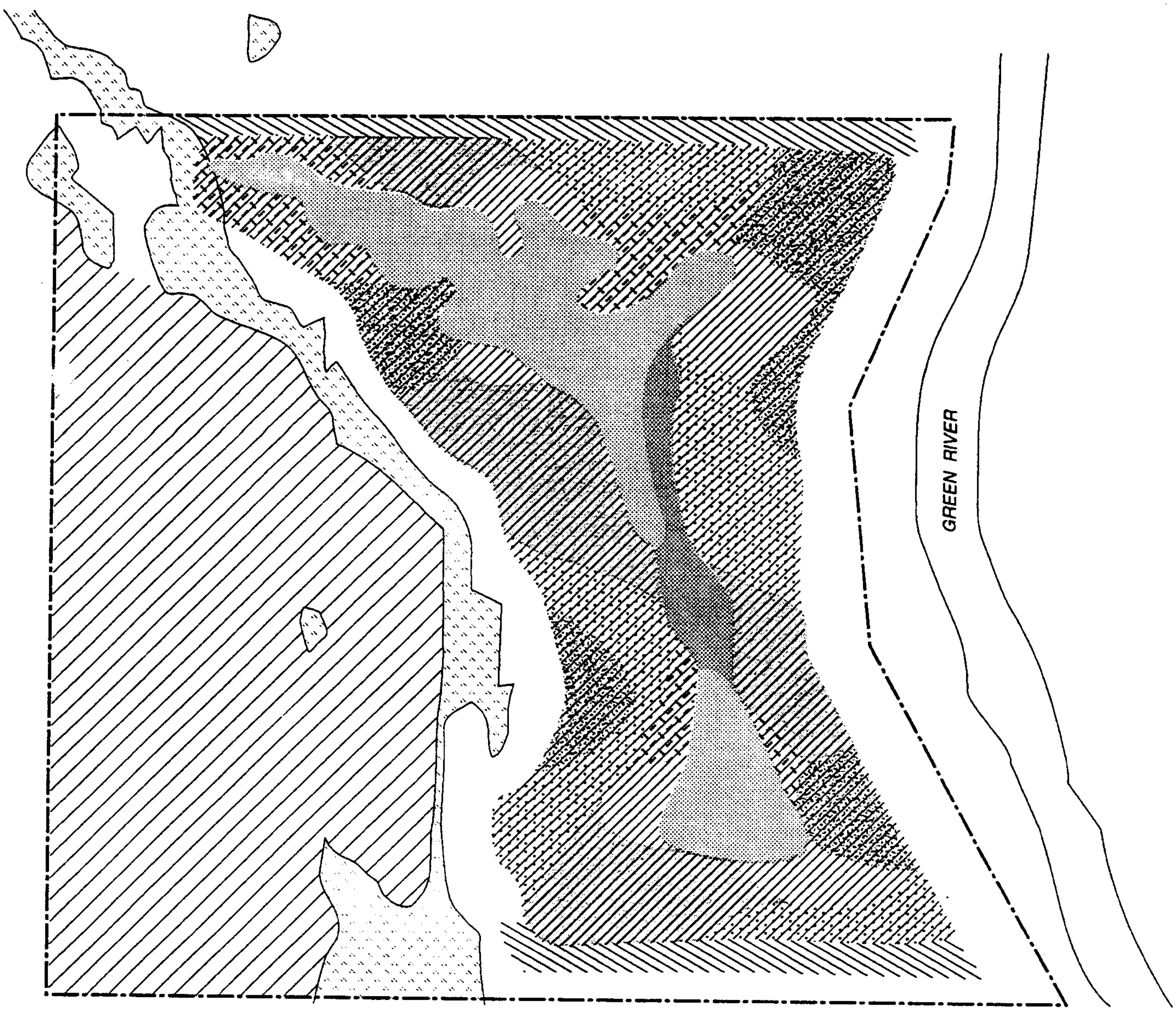


Figure 3.5-6 Proposed Wetland Classes and Buffer Vegetation Types for the Wetland Mitigation Site



Note: Wetland boundaries approximate pending field verification by U.S. Army Corps of Engineers

Source: David Evans 1995,
Additional Data Compiled by Parametrix

- Reserve Area (for regional storm water facilities or future development)
- Forested Wetland:
  - Black Cottonwood/Willow
  - Red Alder
  - Oregon Ash
  - Mixed Evergreen/Deciduous
  - Western Red Cedar/Hemlock
- Shrub Wetland
- Emergent Wetland
- Forested Upland Buffer
- Existing Wetland

N

APPROXIMATE SCALE IN FEET

0 150 300

Figure 3.5-7
Plant Associations Proposed for the Wetland Mitigation Site

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Table 3.5-2. Plant species proposed for the wetland mitigation area.

Scientific Name	Common Name	Indicator Status	Plant Associations[1]: Upland Hydroseed	Wetland Hydroseed	Buffer	Emergent	Shrub	Western Redcedar/Hemlock	Mixed Evergreen/Deciduous	Oregon Ash	Red Alder	Black Cottonwood/Willow
Trees												
Acer macrophyllum	Big-leaf maple	FACU			+							
Alnus rubra	Red alder	FAC							+	-	+	
Fraxinus latifolia	Oregon ash	FACW								+		-
Malus fusca	Western crabapple	FACW						-		-		-
Picea sitchensis	Sitka spruce	FAC						-				
Populus trichocarpa	Black cottonwood	FAC									-	+
Populus trichocarpa X *deltoides*	Hybrid cottonwood	FAC									-	+
Pseudotsuga menziesii	Douglas fir	FACU			+							
Salix sitchensis	Sitka willow	FACW								+		
Salix hookeriana	Hooker's willow	FACW-						+	+	-		
Salix lasiandra	Pacific willow	FACW+										+
Thuja plicata	Western red cedar	FAC						+	+		-	
Tsuga heterophylla	Western hemlock	FACU-			+			+			-	
Shrubs												
Acer circinatum	Vine maple	FAC-			+			+			+	
Cornus stolonifera	Red-osier dogwood	FACW					+				+	-
Corylus cornuta	Hazelnut	FACU			+			+				
Lonicera involucrata	Twinberry	FAC+						+			+	+
Oemleria cerasiformis	Indian plum	FACU			+			-				
Physocarpus purshiana	Pacific ninebark	FACW-					+	-	-		-	
Rosa nutkana	Nootka rose	FAC			-			-	-			
Rubus spectabilis	Salmonberry	FAC+								-	+	-
Salix scouleriana	Scouler's willow	FAC					+					

Table 3.5-2. Plant species proposed for the wetland mitigation area (continued).

Scientific Name	Common Name	Indicator Status	Plant Associations[1]: Upland Hydroseed	Wetland Hydroseed	Buffer	Emergent	Shrub	Western Redcedar/Hemlock	Mixed Evergreen/Deciduous	Oregon Ash	Red Alder	Black Cottonwood/Willow
Sambucus racemosa	Red elderberry	FACU			-						-	
Symphoricarpos albus	Snowberry	FACU			+							
Herbs												
Carex obnupta	Slough sedge	OBL				+	+			+		+
Eleocharis palustris	Common spike-rush	OBL				+						
Lolium multiflorum	Annual ryegrass	UPL	-	-		+						
Oenanthe sarmentosa	Water parsley	OBL				+	+			+		+
Polygonum amphibium	Water smartweed	OBL				+						
Potentilla palustris	Marsh cinquefoil	OBL				+	+					
Scirpus acutus	Hardstem bulrush	OBL				+						
Sparganium emersum	Narrow-leaf burreed	OBL				+	+					
Grasses												
Agrostis alba	Red top	FACW		+								
Alopecurus geniculatus	Water foxtail	OBL		+								
Alopecurus pratensis	Meadow foxtail	FACW		+								
Dactylus glomerata	Orchard grass	FACU	+									
Festuca arundinacea	Tall fescue	FAC	+									
Lotus corniculatus	Birdsfoot trefoil	FAC		-								
Phleum pratense	Timothy	FAC	+									
Trifolium pratense	Red clover	FACU	-									

Data compiled by Parametrix
[1]The symbols "+" and "-" indicate the relative abundance of selected species in each plant association.

These plant associations were selected because they are adapted to the expected soil moisture during normal rainfall years and they provide a range of moisture tolerance during unusually dry or wet years. The general relationship of wetland classes to site hydrology is illustrated in Figure 3.5-8. Plant species were also selected based on their value as food sources for wildlife. The hybrid cottonwood, *Populus trichocarpa x deltoides*, would be planted to provide rapid development of canopy cover and greater structural diversity in the early years of mitigation plan implementation. Plantings of native *Populus trichocarpa* would be intermingled with hybrid poplar, but these native trees would be spaced so as not to be shaded excessively by the hybrid poplar. Since the hybrid cottonwood is sterile, future colonization of cottonwood on the site would primarily be by native cottonwood; some colonization by hybrid cottonwood by fallen branches and suckering may occur.

The five forested wetland plant associations and one shrub wetland plant association used would both correspond to slight hydrologic variations in the wetland and provide habitat diversity. Selected species, including red alder, black cottonwood, Oregon ash, western red cedar, willow, salmonberry, and red-osier dogwood, are typical of lowland Puget Sound wetlands. Each association includes species that tolerate the seasonally saturated soil conditions expected on the site. However, some associations, such as the black cottonwood/willow- and Oregon ash-dominated associations, include a higher proportion of FACW species that are particularly adapted to wet soils. These associations are identified for planting adjacent to seasonally and permanently flooded emergent areas.

Following site grading, a wetland hydroseed mix that includes a small percentage of a sterile hybrid grass would be planted over all areas identified for shrub and forested wetland plantings. The hybrid grass would provide rapid soil stabilization while the slower-growing native grasses establish. Planting of overstory trees and shrubs in forest and shrub plant associations would occur during the first fall or spring season following site grading, when the soil moisture is near the ground surface and temperature conditions are favorable for establishing roots and plant growth. Two- to three-year old branched seedlings at least 24 inches tall would be planted at a density of approximately 250 stems per acre (or 13 ft on center). This density exceeds the final performance standard of 200 trees per acre (refer to Table 3.3-2), allowing for some natural mortality during the early years. Shrub understory species in the forested areas would be planted in patches at densities of 300 plants per acre to mimic their natural occurrence patterns. Shrubs in the shrub wetland area would be planted at a density of 400 plants per acre. Part of the site would be graded to a relatively abrupt shoreline, eliminating the shrub wetland zone between elevation 41.5 and 42 ft, thereby providing forested wetland cover and overhanging vegetation adjacent to permanently flooded emergent areas. Understory development in the forest and shrub wetland areas is expected to occur through colonization from adjacent seed sources.

Emergent wetlands would be planted with native emergent species common in the Green River Valley and the northern Puget Sound region. Since wetland hydrology is designed to create both seasonally and permanently flooded areas, selected plants that are tolerant of extended flooding and soil saturation would be established. Species would include water parsley, slough sedge, narrow-leafed burreed, hardstem bulrush, and common spike rush. The typical growth pattern for emergent marsh plants is in monotypic patches with some interspersion in open, less densely vegetated areas and proposed planting would mimic this pattern. Planting shoots with rhizomes 18 inches on center in monotypic stands of varying size and seeding a mix of emergent species in the areas between patches should achieve that result. Because ponding in emergent areas is expected well into the early summer, planting of emergent species would occur during the fall months when soils are becoming saturated but before water levels reach their winter maximum.

All vegetated upland areas disturbed during mitigation wetland construction would be hydroseeded using native upland grasses that typically occur in open fields in the area (Table 3.5-2). Following hydroseeding, forested buffers would be planted bordering the northern and southern boundaries of the mitigation wetland. These boundaries are most susceptible to outside disturbance from ongoing agricultural activities and from potential future urban development. Trees and shrubs would be planted at densities sufficient to attain the stem density performance standards identified for forested wetland habitat. Buffer plantings are not proposed for the eastern boundary, which is to remain undeveloped. A narrow strip of land to the east of the site, adjacent to the Green River, is owned by King County. Approximately 120 ft of open grassland would remain as an open space between the edge of the constructed mitigation wetland and the King County property boundary. Land along the western edge of the site is delineated as emergent wetland and would remain undeveloped.

3.6 MONITORING PLAN

The mitigation project would be monitored for a 10-year period, with monitoring focusing on the physical and ecological data necessary to determine whether performance standards for the project (Table 3.3-2) are being achieved. Monitoring reports would summarize the ecological condition of the wetland, and the degree of compliance with performance standards; as necessary contingency actions would be recommended. The first phase of preparing the monitoring report would be to complete an as-built report, as described below; Section 3.6.2 describes the activities and schedule during the monitoring period.

3.6.1 As-Built Report

An as-built wetland report that describes the mitigation as constructed and planted would be prepared to define the baseline conditions for measuring progress toward the defined mitigation goals and final performance standards. The as-built report also establishes all sampling locations for future monitoring activity. Any later significant deviations from plan documents would be noted, and the significance of these deviations evaluated and coordinated with the U.S. Army Corps of Engineers.

A detailed wetland map would be prepared from field surveys. Baseline observational data, with which future monitoring can be compared, would also be collected and mapped, as appropriate. These baseline data would include:

- topographic mapping
- locations of major plant community boundaries
- locations of surface water

The topographic survey is used to evaluate the amount of land added to the 100-year floodplain and to determine whether the performance standard for floodplains has been achieved.

For the as-built report, a staff gage assembly would be installed within the pond area, with the lower portion extending to the sediment surface of 40.5 ft. The staff gage would be mounted on a treated 4-inch x 4-inch post, and its location surveyed and mapped.

A visual site inspection to describe the types, condition, and locations of planted species in the wetland would be part of the as-built report. For each planting area, observations would include species, typical size and approximate ranges in size, the approximate spacing of plants, and their location relative to elevation and ground or surface water levels. In addition, the edge between wetland classes would be staked and mapped.

During future monitoring efforts (Section 3.6.2), transects would be used for sampling plant species composition, cover, and growth, allowing comparative analysis of these parameters over time. These transects, which would be field-staked during the as-built survey, must be randomly selected to eliminate sampling bias.

Photographs taken during the monitoring period can qualitatively document plant community development in both the wetland and adjacent buffer. Photographs would be used, therefore, to show the extent and rate of plant height and cover. Photographs can supplement quantitative vegetation characterization from the permanent transects. Photographic points established along transects and other appropriate viewpoints would then be described and labeled on maps.

An as-built report summarizes the existing wetland condition when construction is completed. The report would include descriptions of the aerial extent of the wetland (and each vegetation zone planted) relative to mitigation goals, the hydrologic condition of each wetland planting area, and the relationship between each planting zone and observed soil moisture. These wetland features would then be compared to those established as design criteria for the wetland (Table 3.3-1). Any deviations from design parameters would be noted and discussed, including the anticipated significance of any deviations on the eventual development of a functioning wetland system.

3.6.2 10-Year Monitoring Plan

Monitoring activities would focus on the collection of baseline hydrology, vegetation, and wildlife data to evaluate wetland function and compliance with the performance standards summarized in Table 3.6-1. Monitoring would also include photographic documentation of site features and the development of habitat on the site.

Table 3.6-1. Off-site wetland monitoring methods and reporting schedule.

Design Objective	Performance Standard	Method	Month	Frequency
Forested Wetland Vegetation	In-kind replacement ratio	Aerial photographic or ground-based mapping	May	As-built, Years 3, 5, 10
	Species Composition	Walk-through surveys and plot or belt transect sampling to document all plant species present	July	Years 1, 2, 3, 5, 7, 10
	Tree and shrub density	Measure by line-intercept method along transects	July	Years 3, 6, 10
	Plant growth	Walk-through surveys to estimate annual shoot growth and survival rates	July	Years 1, 2, 3, 5
	Vegetation structure	Describe from walk-through surveys, incorporating data from above analysis as available	July	Years 1, 2, 3, 5, 7, 10
Shrub wetland vegetation	In-kind replacement ratio	Aerial photographic or ground-based mapping	May	As-built, Years 3, 5, 10
	Species Composition	Walk-through surveys to document all plant species present	July	Years 1, 2, 3, 5, 7, 10
	Shrub density	Measure by line-intercept method along transects	July	Years 3, 6, 10
	Plant growth	Walk-through surveys to estimate annual shoot growth and survival rates	July	Years 1, 2, 3, 5
	Vegetation structure	Describe from walk-through surveys, incorporating data from above analysis as available	July	Years 1, 2, 3, 5, 7, 10
Emergent wetland vegetation	In-kind replacement ratio	Aerial photographic or ground-based mapping	May	As-built, Years 3, 5, 10
	Species Composition	Walk-through surveys to document all plant species present	July	Years 1, 2, 3, 5, 7, 10

Table 3.6-1. Off-site wetland monitoring methods and reporting schedule (continued).

Design Objective	Performance Standard	Method	Month	Frequency
	Herbaceous plant coverage/density	Measure by plot sampling method along transects	July	Years 3, 6, 10
	Plant growth	Walk-through surveys to estimate annual shoot growth and survival rates	July	Years 1, 2, 3, 5
	Vegetation structure	Describe from walk-through surveys, incorporating data from above analysis, as available	July	Years 1, 2, 3, 5, 7, 10
Wetlan logy	Soil saturation	Depth from the soil surface to groundwater measured at permanent sampling stations in forested, shrub, and emergent wetland zones	Monthly	Years 1, 2, 3;
			February, June	Years 5, 10
	Surface Water Depth	Water depths measured at permanent sampling stations in shrub and emergent wetland zones	Monthly	Years 1, 2, 3;
			February, June	Years 5, 10
Flood storage capacity	Topography	Analysis of as-built topographic survey		Year 0
Wildlife	Habitat Structure	Analysis of hydrologic and vegetation data from forested, shrub, and emergent wetlands	February, June	Years 1, 2, 3, 5, 10
		Description of habitat structure from walk-through surveys	February, June	Years 1, 2, 3, 5, 10
	Wildlife usage	Conduct surveys to record wildlife species and activities on-site.	January, April, June, November	Years 1, 2, 3, 5, 10
Long-term protection	Buffers, adjacent land uses	Description of buffer vegetation and adjacent landuses, including proximity and screening.	June	Years 5, 10
	Public access trails	Description of on-site trails and adjacent vegetation, including proximity and screening from permanently or seasonally flooded wetland habitat	June	Years 5, 10

Data compiled by Parametrix

under various hydrologic regimes, and other general observations relevant to mitigation design and implementation.

Most monitoring activities would be completed along the permanent transects and fixed points established and marked during the as-built survey; however, as determined in the field, additional monitoring may be needed to document unique conditions not present at pre-established sampling locations. All monitoring uses standard ecological techniques to sample, measure, or describe vegetation, hydrologic, and wildlife habitat conditions. These techniques include walk-through surveys, line-intercept sampling along transects (Canfield 1941), plot sampling (Daubenmire 1959), and wetland delineation (FICWD 1989; Environmental Laboratory 1987).

3.7 SITE PROTECTION

The Port of Seattle and the city of Auburn are currently negotiating the terms of site protection. A number of alternatives are being considered. The mitigation project would be protected against further development in perpetuity.

3.8 MAINTENANCE AND CONTINGENCY PLAN

The mitigation wetland is designed to achieve the final performance standards without ongoing maintenance. Wetland hydrology is dependent on rainfall and plant communities are adapted to the designed hydrologic regime. Supplemental irrigation during the first two seasons following planting may be necessary to assure plant establishment. This maintenance activity would depend on rainfall quantities and on ongoing planning for a regional storm water facility which could supplement summer water levels in the wetland. The monitoring activities outlined in Table 3.6-1 would identify conditions requiring contingency actions, which are outlined in Table 3.8-1. Contingency actions would be implemented in coordination with the U.S. Army Corps of Engineers.

Since reed canarygrass is present in adjacent wetland areas, and this aggressive species could invade the wetland through seed dispersal, maintenance actions may be require to control its spread. These actions could include periodic mowing, treatment with herbicide, and reseeding with native wetland grasses, or more extensive restoration of the on-site wetland that would remain.

Table 3.8-1. Contingency measures for the Sea-Tac Airport off-site wetland mitigation project.

Design Feature	Monitoring Year(s)	Condition	Contingency Action
Forested and Shrub Wetland Plantings	1-5	>80% survival of planted stock	None
		60 - 80% survival	Evaluate reason(s) for mortality, and replant to achieve performance standard.
		<60% survival	Evaluate reason(s) for mortality; consider species suitability for site conditions; replant with the same or alternate species.
	3-5	Average stem elongation (by species) of at least 2 inches	None
		Average stem elongation (by species) less than 2 inches	Evaluate potential reasons for lack of plant growth; consider fertilization; consider species suitability for the site; or increase planting quantities to achieve performance standard.
	5-10	Tree density at least 200 stems per acre.	None
		Tree density less than 200 stems per acre.	Evaluate reason(s) for mortality and replant to achieve performance standard.
		Presence of seed and/or fruit production on shrub species	None
		Lack of seed and/or fruit production on shrub species.	Evaluate potential reasons for lack of seed and/or fruit production; evaluate health and vigor; consider fertilization.

Table 3.8-1. Contingency measures for the Sea-Tac Airport off-site wetland mitigation project (continued).

Design Feature	Monitoring Year(s)	Condition	Contingency Action
Emergent Wetland Vegetation	1	Total cover by emergent wetland species at least 20%, and at least 10% cover by the emergent wetland species planted	None
		Total cover by emergent wetland species less than 20%, and less than 10% cover by the emergent wetland species planted	Re-evaluate the suitability of the plant species for site conditions and re-establish if necessary. Consider use of fertilizers or alternate species.
	2	Total cover by emergent wetland species at least 40%, and at least 20% cover by the emergent wetland species planted	None
		Total cover by emergent wetland species less than 40%, and less than 20% cover by the emergent wetland species planted	Re-evaluate the suitability of the plant species for site conditions and re-establish if necessary. Consider use of fertilizers or alternate species.
	3 - 10	Total cover by emergent wetland species at least 70%, and at least 30% cover by the emergent wetland species planted	None
		Total cover by emergent wetland species less than 70%, and less than 30% cover by the emergent wetland species planted	Re-evaluate the suitability of the plant species for site conditions and re-establish if necessary. Consider use of fertilizers or alternate species. When invasive species (reed canarygrass) represent greater than 20% cover, control of this species by herbicide will be evaluated.

Table 3.8-1. Contingency measures for the Sea-Tac Airport off-site wetland mitigation project (continued).

Design Feature	Monitoring Year(s)	Condition	Contingency Action
Hydrologic Regime	1-10	In forested areas, saturation within 12 inches of surface late December to April (normal rainfall years) In shrub areas, saturation within 6 to 12 inches of surface year-round (normal rainfall years); flooded up to 6 inches deep between December and May In emergent areas, saturation within 6 inches of surface year-round (normal rainfall years); flooded permanently below 41-ft elevation; flooded up to 24 inches deep above 41 -ft elevation November to June	Evaluate reasons for non-attainment. Possible solutions include modification of off-site drainage to wetland, revision of planting plan to correlate to the hydrologic regime, or addition of waterlevel control structures to regulate water levels.
Forested Buffer		[same standards as forest/shrub wetland]	[same contingency actions as forested wetlands]
Flood Storage Capacity	1-10	A minimum of 29 acres below 45-ft elevation; direct connection to 100-yr floodplain	Maintain hydraulic connection to 100-yr floodplain.

Data compiled by Parametrix

4. MILLER CREEK

4.1 ECOLOGICAL ASSESSMENT OF IMPACT SITE

The Miller Creek basin, located in southwest King County, is bordered on the east and southeast by Sea-Tac Airport; the city of Normandy Park lies to the south, the plateau above Seahurst to the west, and the hill north of Arbor Lake to the north. The basin encompasses about 8 mi^2 and includes a small portion of Sea-Tac Airport, as well as parts of the cities of SeaTac and Burien. Sea-Tac Airport covers an estimated 5 percent of the entire basin. The Miller Creek watershed consists of tributaries that originate at Arbor, Burien, and Tub lakes; surface water and seep drainages from the north end of Sea-Tac Airport; and overflows from Lake Reba and Lora Lake. The creek generally flows south and southwest toward Puget Sound.

4.1.1 Stream Classification

The lower reaches of Miller Creek are Class II salmon-bearing waters, as defined by the Washington State Department of Fish and Wildlife (WDFW). However, the upper reaches (starting about 0.2 mi upstream of Southwest 160th Street) are believed to be inaccessible to anadromous salmonids (Shapiro 1995e). The other tributary streams that flow through or adjacent to the study area are Class III or unclassified reaches that function primarily as drainage or groundwater conveyances. Class III streams are classified according to their intermittent or ephemeral characteristics during normal rainfall years. The watershed is generally classified by Ecology as having Class AA (extraordinary) water quality. Storm water runoff from residential, commercial and agricultural properties has contributed to water quality degradation. As a result, Miller Creek fails to meet many of the state water quality standards (Landrum & Brown 1995).

Water quality in the basin has degraded as a result of pollutants commonly found in urban storm water runoff. Nutrients, organics, metals, fecal coliform bacteria, and suspended solids have contributed to occasional violations of Class AA water quality standards and federal water quality criteria. In addition, occasional violations of Class AA water standards for pH, dissolved oxygen, and ammonia have also occurred in the basin (Landrum & Brown 1995).

4.1.2 Primary Uses/Function in the Watershed

Most of the 5,000-acre Miller Creek watershed is fully developed with residential and commercial properties. Approximately 60 percent of the land use in the basin is residential, 20 percent is commercial, and the remaining 20 percent is open space or forested. The single largest commercial facility in the watershed (approximately 5 percent of the area) is Sea-Tac Airport. Other commercial facilities are scattered along Des Moines Way, Ambaum Boulevard, and First Avenue South. Some agricultural uses are also found in the upper watershed, including the impact site. Although urbanization has significantly altered the stream and riparian habitat, these areas continue to support some fish and wildlife species.

4.1.3 Existing Fish Habitat

Historically, Miller Creek supported anadromous fish runs of coho and chum salmon and sea-run cutthroat trout, as well as resident populations of pumpkinseed sunfish, sculpin, and cutthroat trout (Landrum & Brown 1995). The creek currently supports a small coho salmon run that is maintained by annual releases of hatchery-reared fingerlings raised by the Des Moines Chapter of Trout Unlimited (Shapiro 1995e). The last WDFW-sponsored spawner survey in 1985 did not observe any spawning coho. However, the Des Moines Salmon Chapter of Trout Unlimited reported about 91 fish in a recent coho spawner survey. No comprehensive population study has been conducted on Miller Creek.

Residential development in the watershed has resulted in a general deterioration of fish habitat owing to the removal of native riparian vegetation, stream channelization and bank armoring, filling of riparian wetlands, reducing the availability of large organic debris, and increasing the non-point source pollution loading. The expansion of impervious surface area in the basin has also led to increased runoff volumes and velocities; the result has been increased bank erosion, downcutting, landslides, and debris jams. These factors have contributed to a general lack of (1) instream and overhead cover, (2) available low- and high-flow habitat or refugia, (3) available spawning habitat in the basin, (4) habitat complexity, and (5) high-quality water (KCSWM 1987; Landrum & Brown 1995; Shapiro 1995a).

In addition to the deteriorated habitat conditions in the basin, several natural and manmade barriers appear to be limiting anadromous fish species access to the upper basin. The most prominent barrier on Miller Creek is an 8-ft waterfall about 0.2 mi upstream of Southwest 160th Street. Other potential barriers in the basin include several corrugated metal and concrete box culverts (Shapiro 1995a). These seasonal or year-round barriers appear to limit upstream habitat use to non-salmonid resident fish species, such as pumpkinseed sunfish and sculpin (Shapiro 1995e).

In addition to these barriers, habitat availability may be contributing to the current fish distribution pattern. Shapiro (1995a) found suitable coho salmon spawning gravel limited to the area downstream of First Avenue South, while suitable cutthroat spawning habitat was scattered in small patches between South 156th Way and First Avenue South. Areas upstream of First Avenue South, however, consisted predominantly of fine silt and sand substrate, which is more suitable habitat for the non-salmonid fish species that occur there.

King County Surface Water Management (KCSWM; 1987) reported that natural, unaltered stream reaches in the basin are essentially nonexistent, and that major portions of the mainstem and all tributary streams are channelized or otherwise modified. The mainstem section that would be relocated as a result of the proposed airport development project is a low-gradient, channelized stream, with low-density riparian vegetation, no large woody debris, and limited habitat complexity. This reach is dominated by slow-flowing water and shows signs of excessive sedimentation. This sedimentation appears to be at least partially caused by agricultural runoff. Shapiro (1995e) estimated that some 10 tons of sediment are transported to the creek annually from the adjacent 11 acres of agricultural land. The factors mentioned contribute to the lack of high-quality fish-rearing pools in the reach. Such pools are important over-wintering habitats that provide refuge for fish during high-flow events (Shapiro 1995a).

Several small tributaries originating from groundwater seeps under the runway flow west to Miller Creek. These reaches are intermittent surface and groundwater conveyance ditches that do not appear to provide fish habitat at any time (Shapiro 1995b). The habitat in these reaches consists of a series of small, shallow, runs and riffles with occasional pocket-water. During winter flow periods, these tributary reaches consist of shallow rivulets that are approximately 1-3 inches deep and typically less that 1 ft wide.

4.1.4 Hydrology

The addition of fill and impervious surface areas as a result of the proposed Master Plan Update improvements would decrease the amount of rainfall infiltration in soils (groundwater recharge) and increase the volume and flow rate of storm water runoff in the basin. Unless mitigated, these changes are expected to cause increased flooding, erosion, and instream habitat degradation in areas downstream of the study area. These problems already occur in the area due to previous basin development.

KCSWM (1987) estimated that 40 percent of the basin's surface area was impervious in 1986; an increase to 50 percent was predicted when the area was fully developed. Increased runoff rates and volumes resulting from urbanization and development in the watershed have contributed to erosion and downcutting in the steep ravine areas, and sedimentation and aggradation in the low-gradient areas (Shapiro 1995e). The impervious surface areas also limit the groundwater recharge in the area, resulting in less groundwater seepage during low-flow periods.

Since 1991 (KCSWM 1994) KCSWM has monitored flow rates at the outlet of Lake Reba. The available flow data provide a good record of base flows, normal wet and dry season flows, and annual peak flows. Stream flow rates are typically highest between October and April and lowest between May and September (Landrum & Brown 1995). Montgomery Water Group (1995) modeled hydrologic characteristics in the basin and found that in some years no flow occurs in the upper watershed areas during portions of the summer. They also reported that summer flows only exceed 0.5 ft^3 per second (cfs) about 10 percent of the time. A range of flow rates for channel design have been determined from these data sets (Tables 4.1-1 and 4.1-2).

Table 4.1-1. Estimated base flow rates (cfs) at the Lake Reba outlet structure.

Base Flow Rates	Flow Rate (cfs)
Dry Season (May – September)	0.5
Wet Season (October – April)	5.0
Approximate Annual Peak	40.0

Source: KCSWM 1994

In addition to monitored flows, a detailed hydrologic study was prepared (Montgomery Water Group 1995) that includes a peak flow rate for flood frequencies up to the 100-year flood (Table 4.1-2). The 2-year-flood peak flow rate is estimated at about 75 cfs (just downstream of the Lake Reba detention facility), and the 100-year flow rate is about 175 cfs.

Table 4.1-2. Flood frequency estimates - Miller Creek at the Lake Reba control structure.

Return Period (years)	Peak Flow Rate (cfs)
1.01	21
1.11	40
2	75
10	125
20	141
50	161
10[illegible]	175

Sour[illegible] [illegible]ontgomery Water Group 1995

4.1.5 Channel Configuration

[illegible]iller Creek from the Lake Reba detention facility outlet to South 156th Way is not a natural [illegible]am; the creek has been dredged and straightened for farmland reclamation and wetland [illegible]inage. Land contours, soil types, and flat profiles indicate that the study segment was [illegible]istorically a poorly drained wetland that overflowed to the south where Miller Creek follows a topogra[illegible]ic incision. Ditches were constructed to connect the upper watershed, Lake Reba, and Lora [illegible]ake to Miller Creek south of the study area. The channel currently overflows its banks with at least a 2-year freq[illegible]ency with full flow velocity of 1.7 ft per second (Shapiro 1995e). Frequent flooding is pri[illegible]ly the result of inadequate channel capacity, in part because of the flat channel slope. A side channel in the study area runs parallel to the main channel, providing positive drainage for the farm fields. The side channel is not a true tributary, as it does not drain runoff from a subbasin area nor does it provide additional channel capacity to the main channel. Rather, its function is to provide positive drainage for a portion of the relatively flat farm located in the study area.

Miller Creek through the study area is approximately 4 to 10 ft wide at the bottom and two ft deep below the outfall of the Lake Reba detention facility. Large rocks line the edge of the creek in the upper segments near Lora Lake, and the channel has a very silty bottom. Red alder saplings shade the stream, and the banks are vegetated with nightshade and reed canarygrass. Stream floodplains in the lower segments are tilled and farmed.

4.1.6 Floodplain

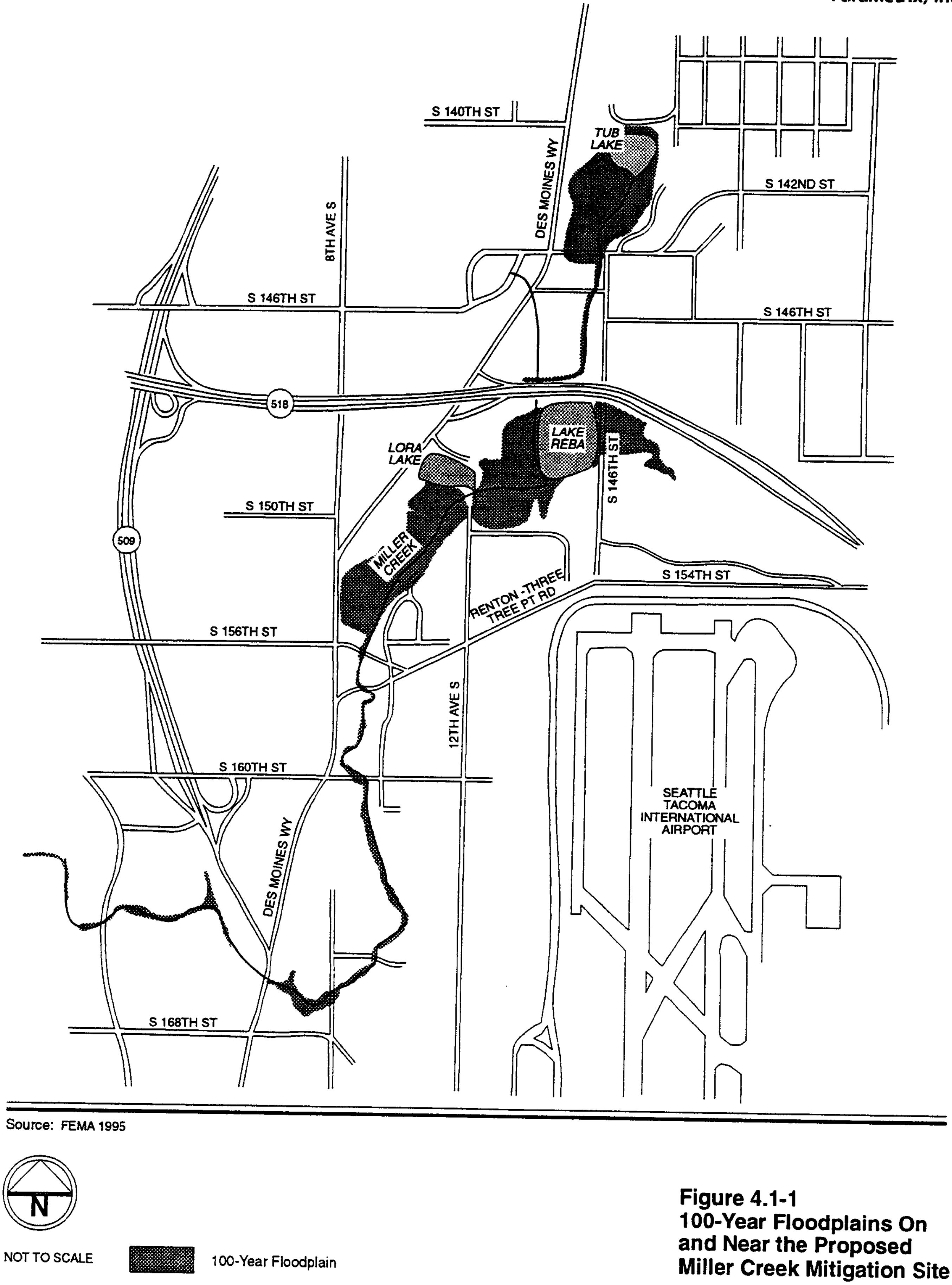
Existing floodplains have been significantly altered by urbanization and agricultural development in the Miller Creek basin. Development activities that have contributed to current floodplain conditions include the filling of wetlands, removal of riparian vegetation, and stream bank armoring. These activities have reduced both stream channel and floodplain capacities. In addition, the construction of roads, residences, and commercial facilities have increased storm water runoff rates and volumes. These factors have contributed to an increased flooding potential in the basin (Landrum & Brown 1995).

The 100-year floodplain in the vicinity of the channel relocation is quite extensive. The wetland ponding and poor drainage that existed prior to the land drainage activities are evident with the 100-year floodplain estimated by the Federal Emergency Management Agency (FEMA) (Figure 4.1-1). The approximate 100-year flood elevations, determined by FEMA as part of their study, vary from 266 ft at the Lake Reba Detention Facility outlet to 265 ft at the downstream end of the proposed stream relocation.

Without mitigation, construction and operation of the proposed Master Plan Update improvements could result in significant adverse floodplain impacts, including reductions in the 100-year floodplain area and storage capacity, increased storm water runoff rates and volumes, and increased flood potential in downstream areas. Ecology floodplain development standards and floodway management requirements prohibit reductions in floodplain area or storage capacity, or significant increases in peak flow rates. Therefore, the implementation of the mitigation plan is expected to result in no significant floodplain or flooding impacts.

4.1.7 Existing Riparian Vegetation

The riparian areas associated with Miller Creek and its tributaries are primarily classified as forested wetlands. Both upland and wetland plant communities are dominated by an overstory of Western red cedar, red alder, black cottonwood, and Pacific willow trees. The understory



Source: FEMA 1995

Figure 4.1-1
100-Year Floodplains On and Near the Proposed Miller Creek Mitigation Site

vegetation is dominated by Himalayan blackberry, Douglas spirea, salmonberry, lady-fern, field horsetail, cattail, soft rush, slough sedge, burreed, reed canarygrass, mixed grasses, and creeping buttercup (Landrum & Brown 1995; Shapiro 1995e; and Parametrix 1991).

4.2 CREEK MITIGATION GOALS, OBJECTIVES, AND PERFORMANCE STANDARDS

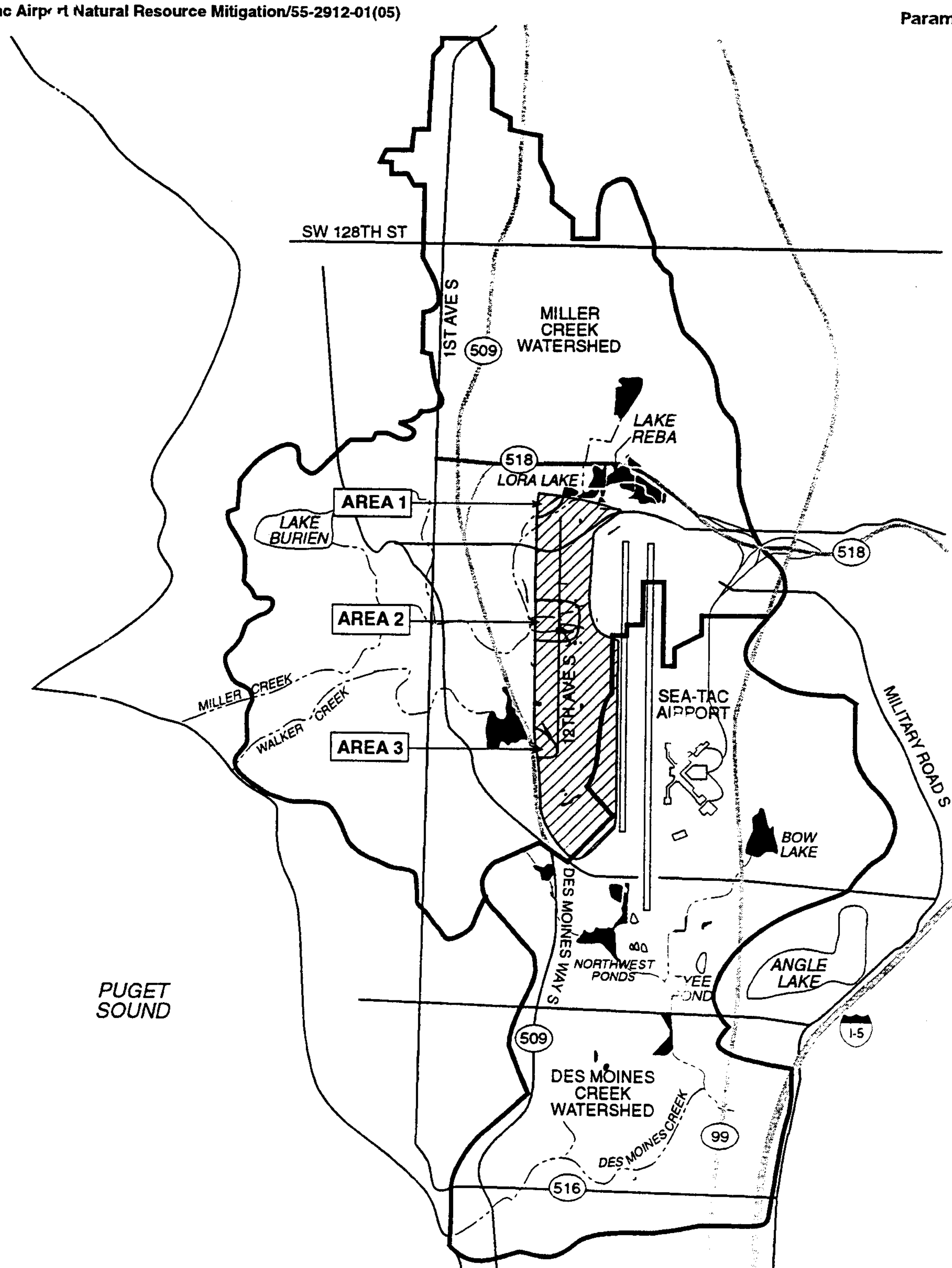
4.2.1 Goals and Objectives

The primary mitigation goal is to replace the basic characteristics and functions of the three portions of Miller Creek and its tributaries (Areas 1, 2, 3) that will be affected by the proposed airport improvements (Figure 4.2-1). Area 1 is located northwest of the current runway at the outlet of Lake Reba. Areas 2 and 3 are drainage tributaries flowing west from the runway embankment to Miller Creek. The impacts to Area 1 require relocating approximately 1,080 ft of Miller Creek. Areas 2 and 3 will be affected by the filling of the drainage channels from the western edge of the existing fill slope to the western edge of the proposed fill slope.

Miller Creek in Area 1 is not a natural stream because the creek has been dredged and straightened for farmland reclamation and wetland drainage. Land development, roadway construction, and past airport development have also altered the segment. Replicating the marginal existing stream habitat with the proposed mitigation channel is insufficient. The goal of the Miller Creek relocation (Area 1) is to provide a new stream channel with enhanced habitat features having at least the same length as the existing ditch.

A farm ditch located in the impact area flows parallel to Miller Creek for approximately 800 ft. The ditch provides positive drainage for the westerly portion of the farm, connecting to the main channel near South 156th Way. A small segment of the side channel (approximately 250 ft) would be impacted by the fill; however, because this segment is at the upper end of the side channel, drainage and conveyance would not be affected. No habitat would be impacted, since the ditch flows intermittently in response to rain, and has little riparian habitat due to farming. For these reasons, no mitigation is proposed.

Area 2 consists of two small intermittent ditches with an indication of minor seepage. Area 3, the headwater of Walker Creek, contains a short segment of drainage channel. All three tributaries have been affected by existing airport drainage, perimeter road crossings, or channelization. The mitigation goal for Areas 2 and 3 is replacing the drainage function of the tributaries.



Source: Shapiro 1995e

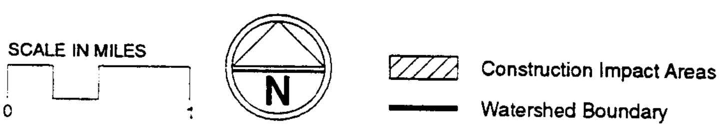


Figure 4.2-1
Areas Affected by the Proposed Earthwork

4.2.1.1 General Mitigation Objectives

The new Miller Creek channel would be constructed near the lowest path through the broad flat trough that defines the creek floodplain in the project area, with the channel edge offset from the proposed fill a minimum of 25 ft to provide a buffer. Channel slope and minimum flow depth would influence final channel alignment. The new creek would connect with the existing Miller Creek channel downstream at the earliest possible point to minimize stream relocation impacts. Channel relocation guidelines presented below may vary due to the limited space available between Lora Lake and the proposed fill area. High flows would be diverted through Lora Lake in the upper segments of the proposed Miller Creek channel.

Careful consideration of the benefits that Miller Creek and the three tributaries now provide must be given when determining the required features for the post-mitigation stream. Streams and waterways can provide many important functions such as conveying surface water and storm water, including flood waters, and providing in-stream and riparian habitat for fish and other water-dependent animals.

The proposed mitigation plan must ensure that present uses are not reduced and that other beneficial uses be included or enhanced. Beneficial use criteria provide design considerations and require consistency with the overall mitigation plan. Goals are prioritized from the most critical function that the existing channel provides to enhancements that would improve channel habitat. A list of impact compensation goals describes the decision-making priorities for the proposed relocated creek. If goals conflict, the higher priority takes precedence.

Miller Creek Goal 1:	The stream and tributaries must continue to provide base flow conveyance functions
Miller Creek Goal 2:	The new Miller Creek channel should provide improved fish habitat
Miller Creek Goal 3:	The channels must accommodate peak flows up to the 100-year flow; no net 100-year floodplain storage lost
Miller Creek Goal 4:	Minimum channel flow velocity should minimize fine sediment deposition
Miller Creek Goal 5:	The channels must replace or enhance riparian habitat
Miller Creek Goal 6:	The channels cannot include expansive, long-standing water pools or wetlands that could potentially attract wildlife
Miller Creek Goal 7:	The proposed Miller Creek corridor should accommodate passive recreational uses, such as walking trails

Three Miller Creek tributaries would be impacted by the fill for the proposed third parallel runway. All three would have fill placed from the outlet to the base of the proposed fill slope. The channels provide flow conveyance during storms, and minor seepage is collected as the channels drop down the bluff. Beneficial uses include flow conveyance, base flow seepage, water quality benefits from natural filtration, and limited habitat. Mitigating fill impacts would include:

Tributary Goal 1: The tributaries must continue to provide adequate flow conveyance.

Tributary Goal 2: The tributaries would collect seepage to maintain base flows.

Tributary Goal 3: The new tributary must provide an open channel of equivalent length as the existing tributary.

Specific Miller Creek and tributary design standards are described Tables 4.2-1 and 4.2-2.

4.2.1.2 Appropriate Habitat

Design and implementation of a mitigation program for the airport is especially challenging because of flight safety issues. Collisions between birds and aircraft are a serious safety issue. Open-water areas, wetlands, and tall trees can attract waterfowl, small flocking birds (such as starlings), and raptors that may feed on small resident mammals. Large fish populations can also attract many birds and small mammals to places where shorelines and open-water fish habitat are accessible. The closer these habitat features are to airport runways, the greater the potential for interference with aircraft.

That portion of Miller Creek lying within the proposed study area is characterized by sections of lower-quality instream and riparian habitat. Stream channelization, streambank armoring, riparian vegetation removal, filling of riparian wetlands, poor culvert design and installation, increased development, and non-point source pollution have degraded stream and riparian habitat in several locations in the watershed (KCSWM 1987; Shapiro 1995e). These conditions presently constrain aquatic production in the Miller Creek basin.

Because the proposed airport improvements would not change anadromous fish passage conditions, and because wildlife attractants are not encouraged (see Section 2.2), the mitigation plan for Miller Creek does not include measures to remove existing anadromous fish barriers. However, the plan does include design features that would enhance habitat for resident fish by using performance standards developed for the more environmentally sensitive salmonid species. Because resident fish typically do not experience the dramatic seasonal population changes that occur with anadromous fish, there is little likelihood that a wildlife attractant would be created by providing higher-quality resident fish habitat.

Table 4.2-1. Mitigation goals, design objectives, design criteria, and final performance standards for Miller Creek.

Goal / Design Objectives	Design Criteria	Final Performance Standard
Miller Creek Goal 1: The stream and tributaries must continue to provide base flow conveyance functions		
Provide minimum flow depth to prevent fish stranding and water quality problems	Design a natural channel assuming a gravelly or stony bottom and a Manning's *n* of 0.035	Minimum average flow depth is 0.25 ft (at 0.5 cfs)
	Construct vertical channel side slopes from the bottom up to 0.5 ft deep; construct side slopes at 1:1 or flatter (typical) from 0.5 to 1.0 ft to provide capacity for wet season base flow	Approximate wet season (October – April) average base flow (5.0 cfs) depth is 1 ft
	Set channel slope to provide minimum and maximum velocity criteria (Goal 4)	
	Adjust channel bottom width for minimum depth	
Maintain existing hydrology from Lora Lake	Construct overflow structure from Lora Lake that replicates the existing lake outflow hydrology	Lora Lake outflow structure replicates the existing discharge hydrology
Miller Creek Goal 2: The new Miller Creek channel should provide enhanced fish habitat		
Provide enhanced fish habitat without fish passage barriers	Provide minimum flow depth (Goal 1)	New channel meets design criteria (Goal 1)
	Provide a natural channel configuration, 0.5 ft vertical slopes, 1:1 slopes from 0.5 ft to 1 ft depth (Goal 1)	
	Provide habitat features, including in-stream features such as deflectors and overhanging logs as needed to maximize available habitat	Stream habitat features are stable
	Provide channel substrate that enhances habitat; design channel to manage flow velocity that is consistent with substrate types (Goal 4)	
	Reduce silting, sedimentation, and scouring by meeting minimum and maximum average flow velocity standards	

Table 4.2-1. Mitigation goals, design objectives, design criteria, and final performance standards for Miller Creek (continued).

Goal / Design Objectives	Design Criteria	Final Performance Standard
Miller Creek Goal 3: The channels must accommodate peak flows up to the 100-year flow; no net 100-year floodplain storage lost		
Accommodate the 100-year peak flow	Do not confine or constrict 100-year flood flows in the new channel; flows in excess of the channel design will freely overflow the channel into the flood plain	The 100-year flood stage outside the study area is not changed by more than 0.1 ft
Allow no net 100-year floodplain storage loss in the project area	Mitigate 100-year floodplain storage by providing lost storage compensation	The 100-year flood stage outside the study area is not changed by more than 0.1 ft
Limit channel scouring for the 100-year flow	Channel velocity cannot exceed the gravel movement velocity for the 100-year flow (Goal 4)	Channel substrate present; no bare scoured channel sections in excess of 25 ft
Miller Creek Goal 4: Minimum channel flow velocity should minimize fine sediment deposition		
Minimize sedimentation with minimum flow velocity	Adjust channel slope, by channel segment, to provide minimum dry season base flow velocity. Channel flow velocity for seasonal base flows cannot be less than the silt transport velocity (0.7 ft/sec)	Minimal summer season sedimentation in riffles or runs; minimal winter season sedimentation in riffles, runs or gravel substrate
	Adjust channel bottom width to achieve minimum velocity	
Minimize channel scouring with a maximum design flow velocity	Channel flow velocity cannot exceed the gravel movement velocity (4 ft/sec) for the 100-year flow	Channel substrate present; no bare scoured channel bottom sections in excess of 25 ft
	Increase channel capacity above 0.5 ft depth (up to 2 ft depth) to reduce peak flow channel velocity	
Divert high flows around channel Segment 1	Construct a stream diversion structure to reduce flows in channel Segment 1 to peak annual flow rate (40 cfs) for the 100-year peak flow	Peak flow less than 50 cfs in Segment 1 during the 100-year peak flow
Miller Creek Goal 5: The channels must replace or enhance riparian habitat		
Provide riparian habitat	Provide a minimum 25-ft buffer on the airport side (east) of the channel from the edge of the proposed channel	Buffers contains minimum densities of 200 trees per acre and 300 shrubs per acre. Eighty percent of trees and shrubs are native species
	Provide a minimum 50-ft buffer on the west side of the channel that accommodates public access (Goal 7)	

Table 4.2-1. Mitigation goals, design objectives, design criteria, and final performance standards for Miller Creek (continued).

Goal / Design Objectives	Design Criteria	Final Performance Standard
Miller Creek Goal 6: The channels cannot include expansive, long-standing water pools or wetlands that could potentially attract wildlife		
Provide surface drainage for depressions and pools in the replacement channel floodplain	Provide positive floodplain drainage to reduce persistent standing water	No permanent or persistent floodplain or riparian pools develop that support waterfowl habitat
Prevent long-term standing water in the Miller Creek floodplain	Provide positive floodplain drainage to reduce persistent standing water	
Miller Creek Goal 7: The proposed Miller Creek corridor should accommodate passive recreational uses, such as walking trails		
Provide for passive recreation and public access to the new channel	Provide a channel buffer that allows for pedestrian trail construction	A minimum buffer width is provided to allow for trail construction

Data compiled by Parametrix

Table 4.2-2. Mitigation goals, design objectives, design criteria, and final performance standards for Miller Creek tributaries.

Design Objectives	Design Criteria	Final Performance Standard
Miller Creek Tributary Goal 1:	The tributaries must continue to provide adequate flow conveyance functions	
Provide drainage flow capacity	Provide channel capacity for the 100-year, 24-hour design storm	Maximum flow depth 2 ft in proposed channel
	Provide adequate capacity and channel slope to minimize erosion during the design storm	Maximum channel velocity 6 ft per second
Collect runway surface drainage and convey to Miller Creek	Collect runway surface drainage at the existing and proposed discharge points	Flow patterns and drainage from the proposed airport improvements are not significantly different from existing drainage discharge points
Miller Creek Tributary Goal 2:	The tributaries would collect seepage to maintain base flows	
Collect existing seeps from slope for maintaining base flow in Miller Creek	Collect existing slope seepage near the source in subsurface drainage systems	More than 50% of the existing observed seepage is discharged into or collected by the proposed channel
Collect drainage and seepage from the base of the proposed fill slope	Collect seepage at the base of the fill on the uphill (east) side of the proposed perimeter road	More than 50% of the existing observed seepage is discharged into or collected by the proposed channel
Miller Creek Tributary Goal 3:	The new tributary must provide an open channel of equivalent length as the existing channel	
Construct new channels with equivalent length, substrate, and streamside vegetation	Construct new channels with equivalent channel lengths: 1,200 ft for Segment B, 200 ft for Segment C	New channels that provide conveyance with well-established vegetation and limited scouring, erosion, or bank failures.
	Minimum channel slope 1%; channel side slopes 4:1 or flatter	
	Stream banks and side slopes replanted with a native mix of plants for riparian habitat	
	Channel substrate a mix of sands and gravels; channel velocity below substrate erosion velocity	
	If steep channel slope is required, protect from downcutting with log weirs	

Data compiled by Parametrix

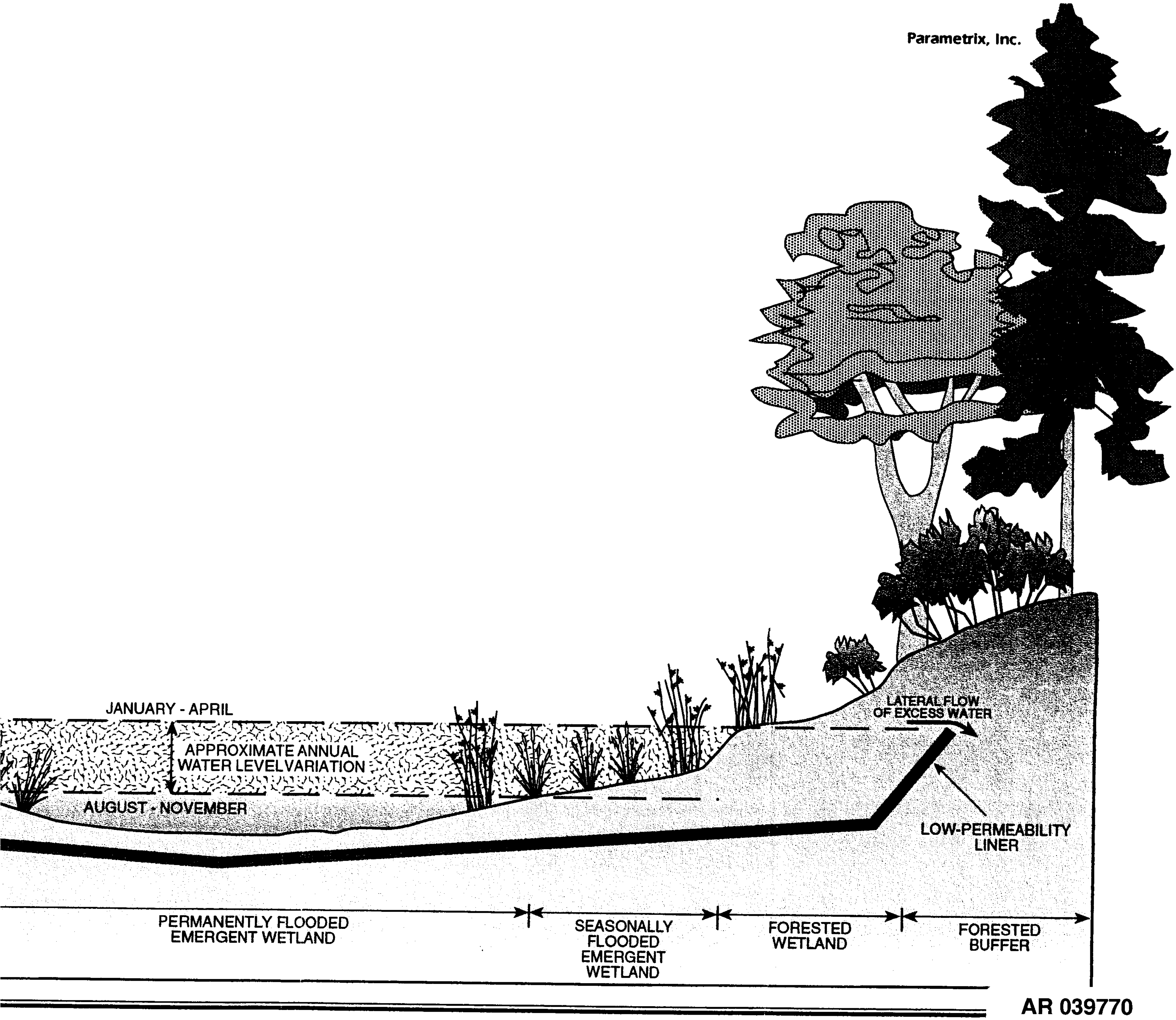


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Figure 3.5-8
Conceptual Wetland Design
Typical Restoration/Enhancement
Cross Section

Parametrix, Inc.

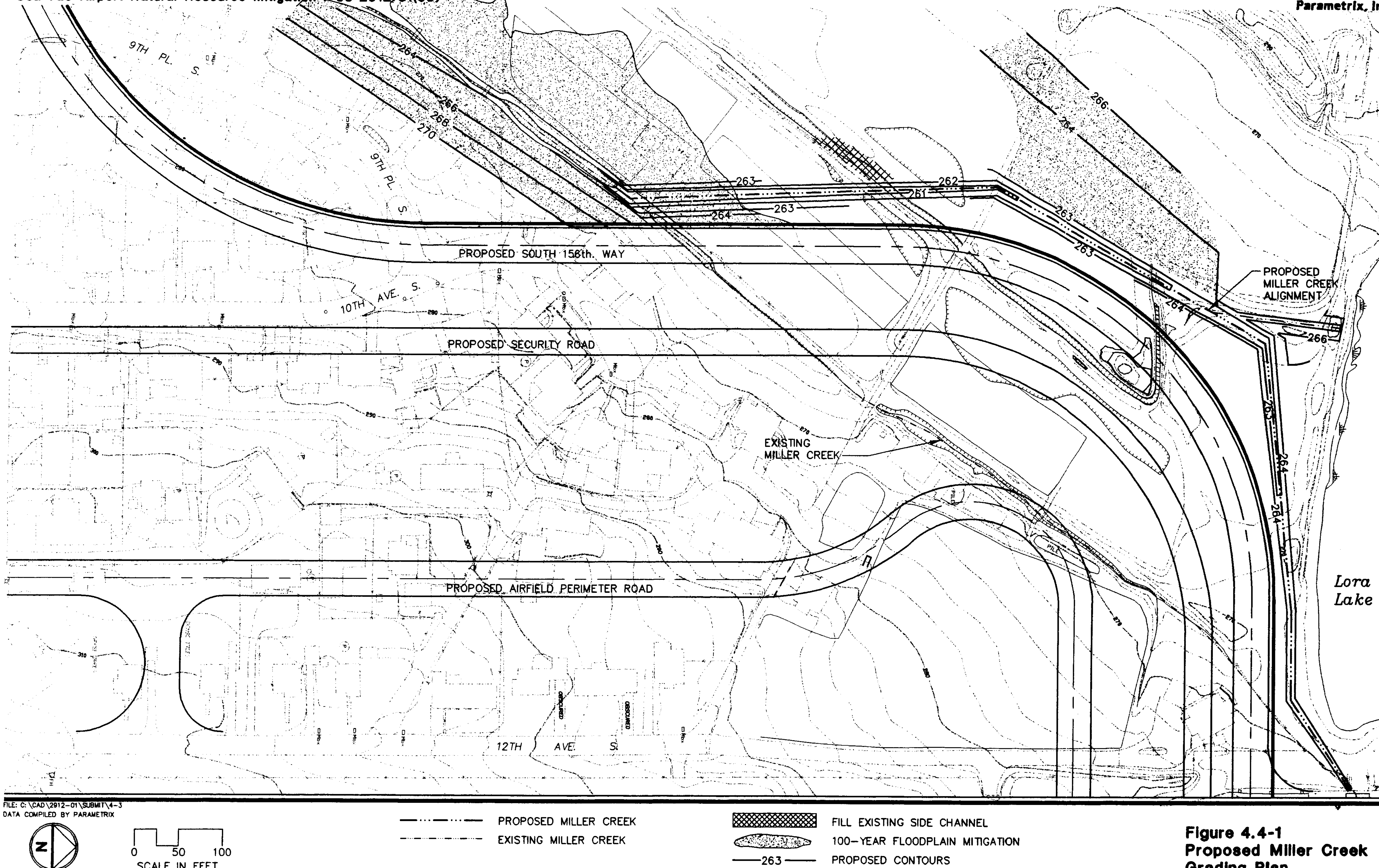

Figure 4.4-1
Proposed Miller Creek Grading Plan

4.3 PROPOSED MITIGATION SITE

4.3.1 Site Description

The proposed Miller Creek channel would be constructed near the bottom of a broad, flat valley located south of Lora Lake. The existing 1,080-ft-long main channel of Miller Creek would be displaced approximately 200 ft to the west (Figure 4.4-1).

The Miller Creek tributaries would be mitigated in the proposed new parallel runway embankment construction areas. Both mitigation channels would be constructed adjacent to the proposed airport perimeter access road. The road is in a restricted access area, and a vegetated filterstrip buffer must protect the proposed channel from road runoff.

4.3.2 Ownership

The land for the stream relocation would be purchased by the Port of Seattle as part of the larger property acquisition program for the proposed Master Plan Update improvements. It would be designated in airport planning documents as a sensitive area to be protected in perpetuity, with the exception of possible future bridge crossings.

4.3.3 Rationale for Choice

The mitigation site was chosen because it is relatively close to the edge of the parallel runway embankment, therefore, require the shortest stream relocation length. Also, extremely flat site conditions dictate that the proposed channel be as short as possible to provide the maximum possible slope. The proposed realigned creek would be located as close to the base of the proposed fill slope of the new parallel runway as possible. The channel would connect with the existing Miller Creek channel at the earliest possible point to minimize stream relocation impacts. The channel edge would be a minimum of 25 ft from the base of the slope, to accommodate a riparian buffer. However, because of the limited space between Lora Lake and the proposed embankment, narrower buffers might be required in this area. To compensate for the restrictive high flow area, flows in excess of channel capacity are planned to be diverted from the main channel of Miller Creek into Lora Lake and then reintroduced at the lake outlet channel.

The tributary mitigation site was selected as the only appropriate option for recreating the equivalent drainage length for the filled drainage channels. The existing channels could not be left undisturbed or reconstructed on the fill slope because of airport operation and fill stability requirements.

4.3.4 Ecological Assessment of the Mitigation Site

See Section 4.1, Ecological Assessment of the Impact Site.

4.3.5 Constraints

A few constraints outside of the Port's control could affect the success of the stream relocation. As discussed in Section 4.1.4, the water level of the Lake Reba complex is regulated by a control structure and gate downstream of the lake outlet. The gate is not moved in the present operation procedure. There are no existing plans to change the operation procedure, however, if a different control structure procedure were implemented, it would not affect the mitigation design because stream hydrology would not be significantly modified.

The proposed channels would be constructed on Port property and collect Port drainage. Although collecting all ground water in the vicinity of the existing seeps may prove difficult, base flows can be maintained by collecting seepage at both the source and at the toe of the proposed slope, the point where uncollected seepage water is expected to surface.

4.4 MITIGATION SITE PLAN

The description of the mitigation site plan is divided into two main sections: Miller Creek (Section 4.4.1) and the Miller Creek tributaries (Section 4.4.2).

4.4.1 Miller Creek

4.4.1.1 Site Grading

The proposed channels would be excavated and constructed as shown in Figure 4.4-1. Regrading is also necessary to provide floodplain mitigation. Approximately 5,030 yd^3 of floodplain storage would be lost in the proposed fill area. As shown in Figure 4.4-1 approximately 5,070 yd^3 of floodplain storage would be created, not including storage for the proposed stream channel. Although no additional site grading is proposed, some additional grading may be required to ensure a positive drainage flow to the new channel and prevent long periods of standing water in the floodplain.

4.4.1.2 Project Hydrology

The hydrologic design criteria for the Miller Creek mitigation plan are listed in Table 4.4-1. Because expected storm water runoff increases from the proposed airport improvements would be mitigated in separate storm water management facilities, this mitigation plan does not provide for increased flows.

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Table 4.4-1. Estimated flow rates for channel design.

Flow Regime	Flow Rate (cfs)
Dry season base flow	0.5
Wet season base flow	5
"Normal" storm flow	10
Annual peak flow	40
2-year peak flow	75
10-year peak flow	125
100-year peak flow	175

Source: Montgomery Water Group 1995;
additional data compiled by Parametrix

KCSWM has monitored flow rates at the outlet of Lake Reba since 1988 (1994). Although the period of record is short, the flow data provide a good record of "normal" base flows, seasonal peak flows, and average flows by season. Design criteria for base flow and annual peak flow conditions were established from these data (Table 4.4-1). No statistical analysis of the flow monitoring data was conducted; the design flow rates were selected by examining the data and using best professional judgment to identify data trends.

In addition to monitored flow rate data, a detailed hydrologic modeling study was prepared (Montgomery Water Group 1995) that calculated peak flow rates for flood frequencies up to the 100-year flood (Table 4.1-2). The flood return frequencies were calculated assuming that the Lake Reba detention system and control structure are in place. The calculated flow rates appear to be consistent with the flow monitoring data. The peak monitored flow rate (225 cfs) on November 24, 1990, was in excess of the predicted 100-year flood flow (approximately the 500-year flood flow). The control structure was constructed after the 1990 storm; it is likely that the peak flow rate of November 1990 would have been reduced by the detention system.

4.4.1.3 Creek Hydraulics

Creek hydraulics refer to existing or proposed physical conditions that influence the direction, depth, and flow velocity in the proposed relocated creek. Several factors influence flow hydraulics including: flow rates, channel slope, channel cross section, channel roughness, and flow depth. While several of these features would be designed, factors such as flow rate or average channel slope cannot generally be modified. The following sections describe the design parameters that apply to all channel segments, the design process used, and the proposed channel configuration for each segment. The proposed creek location is shown on Figure 4.4-2. Channel substrate design is included in Section 4.4.3, Habitat.

Channel Alignment

The proposed channel cross section is shown centered on the proposed alignment. However, the channel would be constructed to meander within the limits of the stream corridor (Figure 4.4-2). Meandering would be limited, however; minimum channel slope must be maintained to meet flow velocity goals.

Channel Roughness and Side Slopes

Channel roughness, a factor in determining channel capacity is described by using Manning's roughness factor, *n*. The assumed Manning's channel roughness for the relocated stream is 0.035; this corresponds to a natural channel with a gravelly or stony bottom and little instream vegetation.

The bottom 6 inches of the channel side slopes would be vertical (Figure 4.4-3). From 6 inches to 1 ft, channel side slopes would continue at 1:1 slopes, primarily to enhance stability, provide additional capacity, and simplify construction. From 1 to 2 ft, the side slope would be 6:1 or flatter, depending on channel capacity requirements and channel planting and buffer requirements. Above 2 ft of depth, natural grades would be used; however, if natural slopes are too flat, slope or drainage alterations would be considered to prevent ponding.

Channel Slope

Average channel slope is determined by the physical constraints of the site. The bottom elevation at the upstream end of the proposed channel (at the control structure outlet of Lake Reba) is approximately elevation 264.0 ft. The approximate elevation at the point where the relocated creek rejoins the existing channel is 260.0 ft. With a proposed channel length of approximately 1,080 ft, the average channel slope is 0.37 percent. However, natural land slope along the proposed stream channel does not drop continuously. The proposed alignment's existing grade is approximately level at the start, then gradually slopes as the alignment turns south. The alignment moves through a shallow depression, then begins to rise slightly before rejoining the existing stream. To work with existing topography, the channel was divided into three segments (A, B, and C) to determine how the slopes must vary through the proposed alignment.

Flow velocity that meets the proposed design goals is primarily a function of channel slope. Because the site offers little slope to increase flow velocity, compromises must be made for providing flows that minimize sedimentation. Slopes in segments A and B (0.3 percent and 0.4 percent, respectively) were designed to limit sand deposition at base flow, while Segment C (0.2

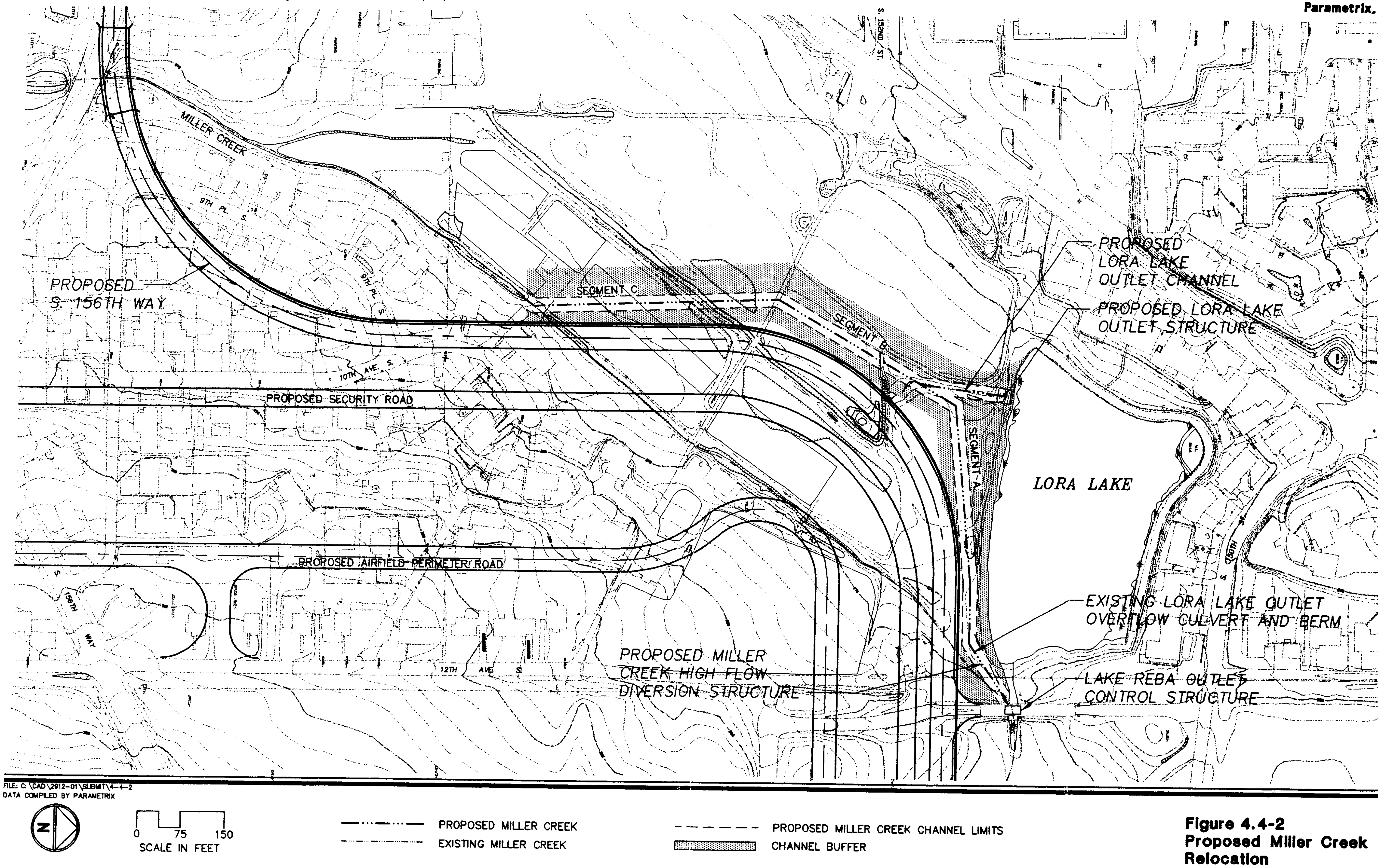

Figure 4.4-2
Proposed Miller Creek Relocation

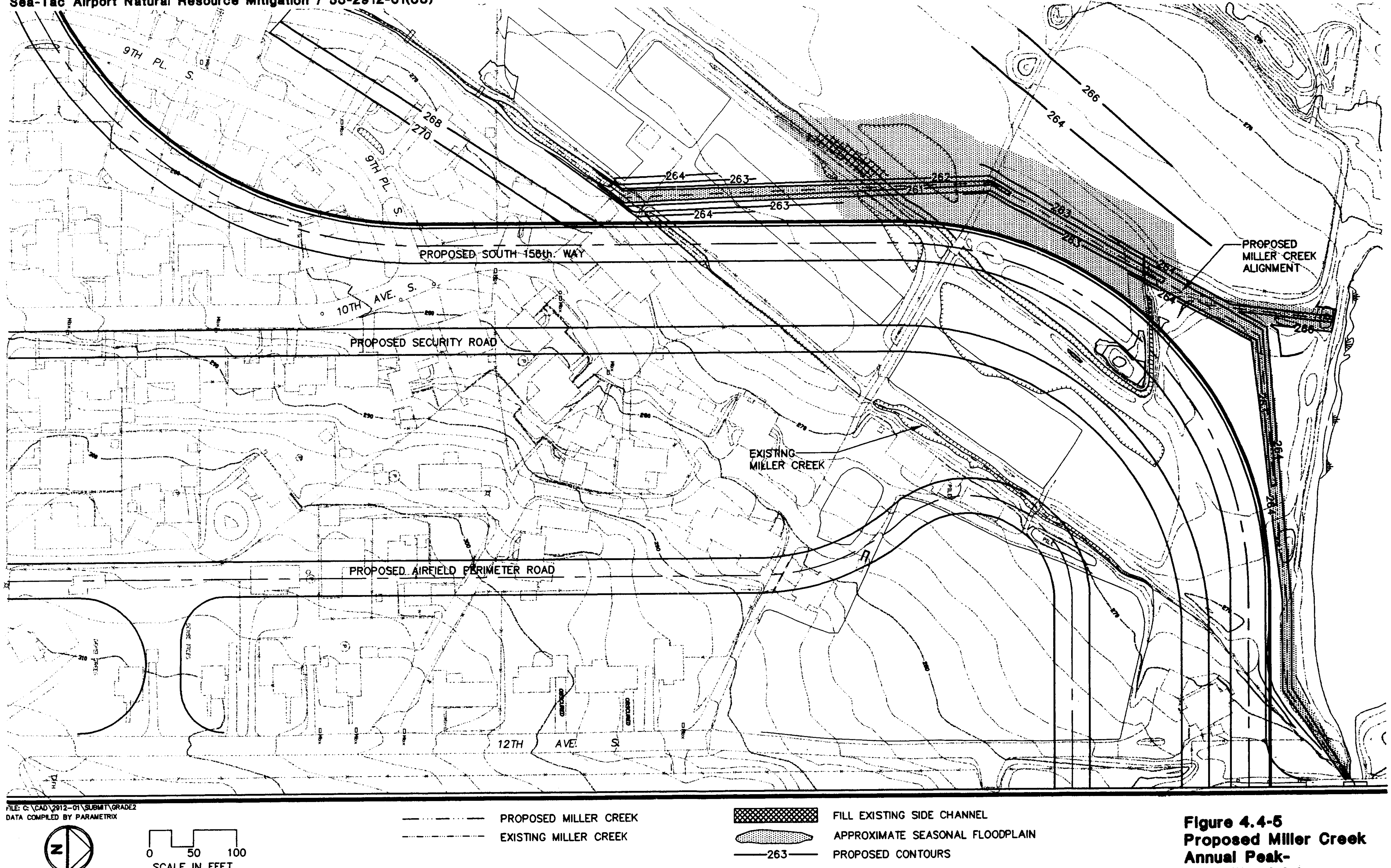

Figure 4.4-5
Proposed Miller Creek Annual Peak-Flow Floodplain

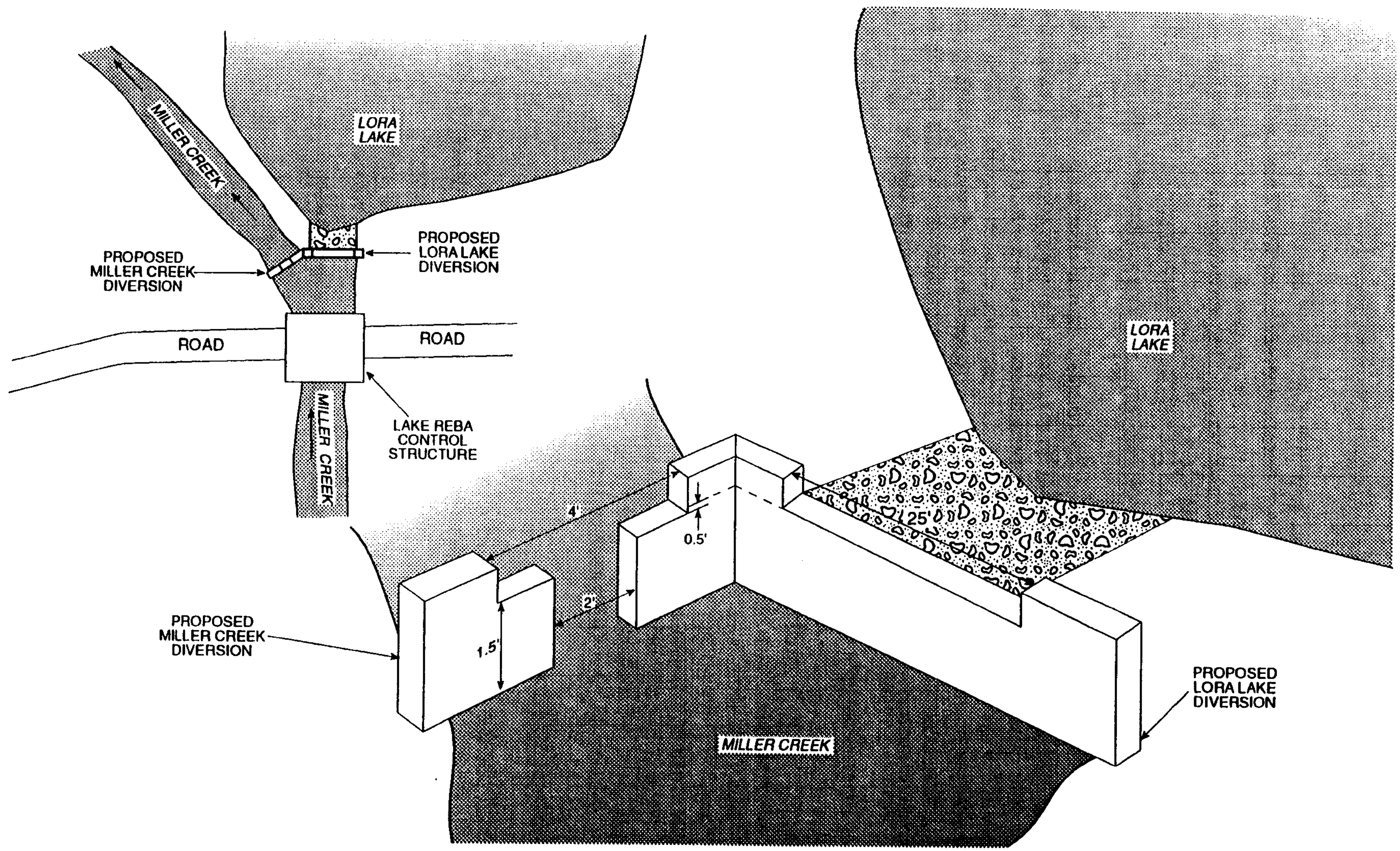

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Figure 4.4-6
Proposed Miller Creek High-Flow Bypass Structure

The Miller Creek tributaries mitigation plan has three requirements: to provide adequate capacity to handle the design flow (100-year storm), provide an equivalent open flow channel, and maintain base flows by capturing seepage from the proposed fill slope. Mitigation for all three tributaries would share the same design goals. The proposed mitigation channel for Tributary B is shown in Figures 4.4-7, and 4.4-8.

4.4.2.1 Channel Configuration

The tributary mitigation channels would be constructed on the east side of the proposed perimeter access road. The bottom channel width may vary, but a minimum 2-ft bottom would convey the peak design flow, assuming a one percent slope. The proposed channel would be incorporated into the fill slope; therefore, final design parameters, such as peak flow rates and channel slope, would be used to adjust the channel configuration. Minor modifications to the preliminary design would not significantly alter the proposed mitigation channels. A vegetated filter strip would separate the perimeter access road from the mitigation channel.

4.4.2.2 Channel Length

Equivalent channel length would be provided for each of the disturbed tributaries. Tributary B would be accommodated in a single mitigated channel constructed adjacent to the proposed perimeter road. Tributary A, the drainage ditch that collects runoff from the fill slope and perimeter road, provides little or no habitat functions. The proposed mitigation would replace the tributary's primary function, which is to provide drainage. Approximately 1,200 ft of Tributary A channel would be lost; the proposed channel would be the same length. Seepage and drainage from the Tributary A basin would be collected in the Tributary B mitigation channel. The Tributary C mitigation channel would be approximately 300 ft long.

4.4.2.3 Channel Size and Slope

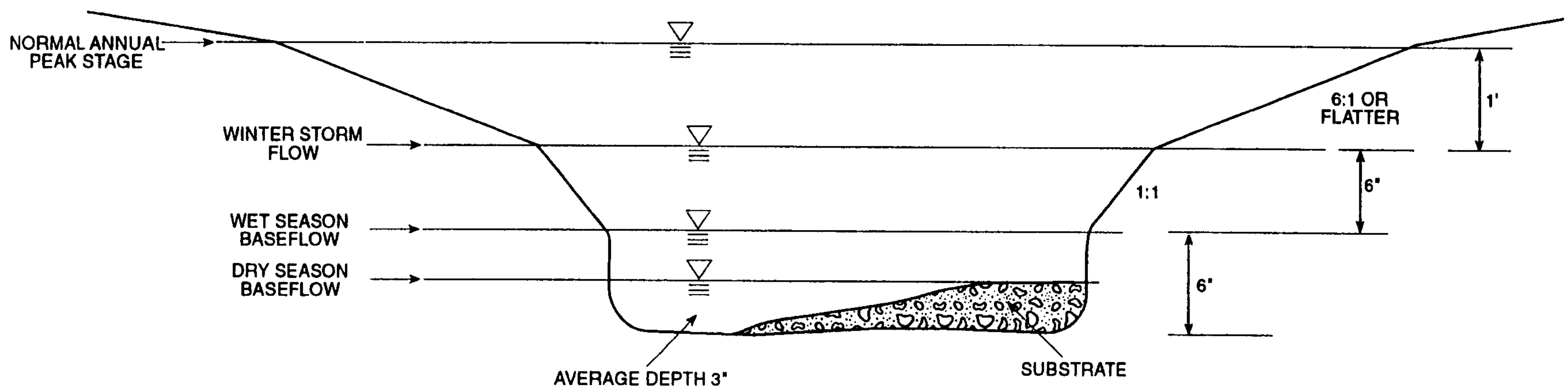
The proposed channel would be designed to convey the 100-year peak flow rate. While maximum flow depth would be determined by road design considerations, it would be less than 2 ft deep. Minimum slope would be 1 percent.

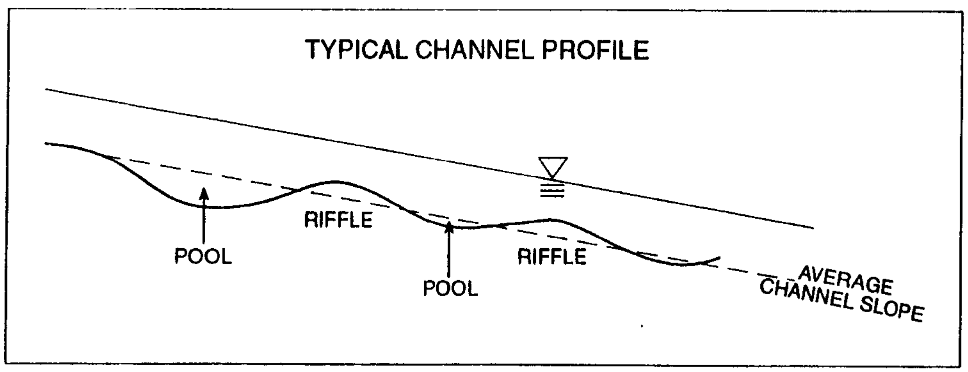
4.4.2.4 Discharge Point

Both mitigation channels would discharge into the existing channel at the edge of the proposed fill slope.

4.4.2.5 Channel Cross Section

The proposed channel cross section would have side slopes at a maximum slope of 4:1. The bottom width, to be determined in final design, would be controlled by the design depth and slope. Flow control would use check dams, log weirs, or channel widening to prevent erosion,





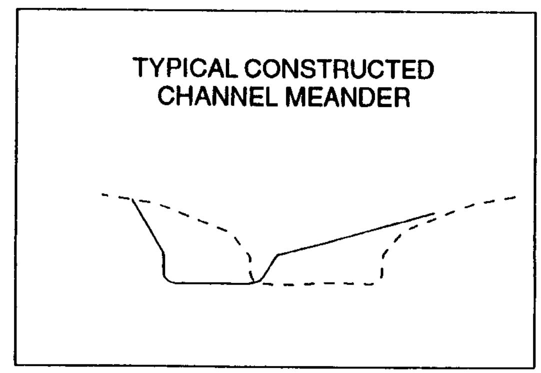


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Figure 4.4-3
Proposed Miller Creek Stream Channel

percent slope) was designed to prevent silt deposition at base flows. A more complete discus·ˑ·ɔn of flow velocity is included in the following section.

Flow ..ocity

Channel flow velocity is the primary variable influencing channel design. The goal is to minimize fine-grained (silt and finer) material sedimentation in all proposed channel segments during normal dry season base flows. If possible, sand deposition should also be limited. Conversely, the flow velocity at peak design flows must not exceed rates that would erode the channel and scour loose sediment and substrate larger than small gravel. With a minimum flow depth of 0.25 ft at the base flow rate, and with channel roughness and side slopes fixed, channel velocity is a function of channel bottom width and slope. Figure 4.4-4 shows the relationship between flow velocity and sediment transport velocity. If the flow velocity equals or exceeds that shown for each grain size, the sediment can be expected to move until the velocity decreases.

Channel design is a process whereby variables are adjusted until all of the design parameters are met. Initial channel slope was estimated using the available drop for Segment A. The corresponding channel bottom width was determined and adjusted until the minimum flow depth (0.25 ft) was achieved. The slope was then adjusted until the base flow velocity was strong enough to move sediments smaller than sand. Using the adjusted slope, the channel was then checked for peak flow rate velocity (in connection with maximum depths and channel configurations described in the following sections). Channel widths and flow depth were adjusted until flow velocity was less than the transport velocity for gravel. These steps were used in each alignment section.

Channel Bottom Width

The channel bottom width, within the narrow range of possible channel slopes and using the fixed side slope and roughness values, is controlled primarily by the minimum flow depth. Dry season base flow depth must average at least 0.25 ft to provide minimum depth for fish movement. To determine the channel bottom width, the base flow rate, slope, roughness, and side slopes were fixed, and the bottom width was adjusted until the flow depth was at least 0.25 ft. The results were checked to ensure that no other design criteria were changed to exceed design parameters.

Channel Flow Depth

ˋeveral design channel flow depths are available, depending on the flow rate and the design :ent. Three flow depth standards have been determined: (1) dry season base flow depth of 25 ft; (2) wet season base flow depth of 1 ft; (3) annual maximum flow rate depth of 2 ft. Flows greater than the annual maximum flow rate (40 cfs) will overflow into the floodplain.

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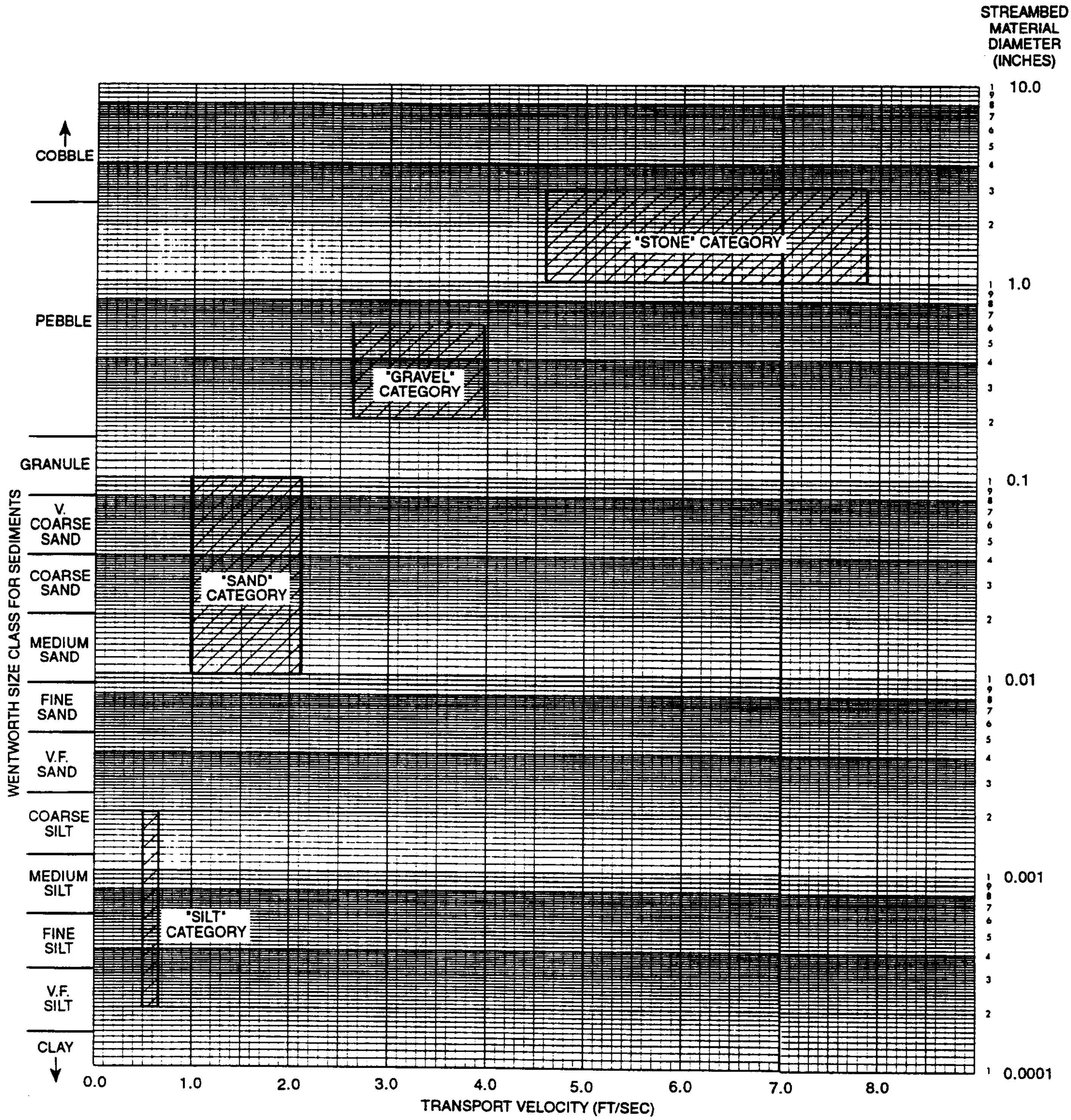

Source: B.C. Fisheries, 1980

Figure 4.4-4
Sediment Transport Velocity vs. Sediment Diameter

Figure 4.4-5 shows the approximate extent of the design storm floodplains.

Maximum Design Channel Flow

Segment A, located between Lora Lake and the proposed fill, is somewhat narrower than Segments B and C. As a result, limited area is available for constructing a large channel that can convey the 100-year storm, while maintaining a minimum flow depth for dry season base flows. This mitigation plan proposes a high-flow diversion structure near the beginning of the proposed channel relocation, to divert flows in excess of the channel capacity (the 2-year storm) through Lora Lake. The lake acts as a bypass channel that buffers peak flows and releases water at a reduced rate to other segments that have adequate capacity. The proposed control structure design is shown on Figure 4.4-6.

Lora Lake Outlet Channel and Structure

Runoff flowing into Lora Lake overflows into Miller Creek through a 12-inch concrete culvert located in a berm that forms the south shore of the lake (Figure 4.4-2). When inflow exceeds the lake storage and outlet pipe capacity, water flows over a low spot in the berm. In extreme conditions, it is likely that the lake becomes part of the Miller Creek floodplain and completely overwhelms the south shore berm.

The proposed Lora Lake outlet channel and structure is designed to release base flows in a manner approximating the existing outlet structure. The proposed structure has a controlled overflow feature that maximizes lake storage without adversely affecting lake stages or inflows. A 12-inch low-flow orifice and 10-ft overflow weir would be constructed. The elevations of the existing pipe and overflow basin would be used for the proposed outlet. The overflow weir would have a broad-crested overflow, approximately 5 ft wide, with erosion control such as rock and wire mesh. The existing Lora Lake outlet channel has similar design slopes to Segment A, and potentially provides stream habitat.

4.4.2 Miller Creek Tributaries

Three tributaries of Miller Creek in Areas 2 and 3 would be affected by the proposed airport improvement. All three are intermittent streams, primarily fed by rainfall, but supplemented by groundwater seepage. The tributaries flow intermittently from culverts at the airport and from seeps; however, no flow monitoring is available. The proposed channel design will be based on hydrologic model calculations. Portions of all three channels have been partially modified at road crossings, and Tributary B has been channelized for approximately 300 ft in a roadside ditch. The primary goals of tributary mitigation are to provide equivalent open channel lengths, peak storm conveyance, and groundwater seepage (base flows).

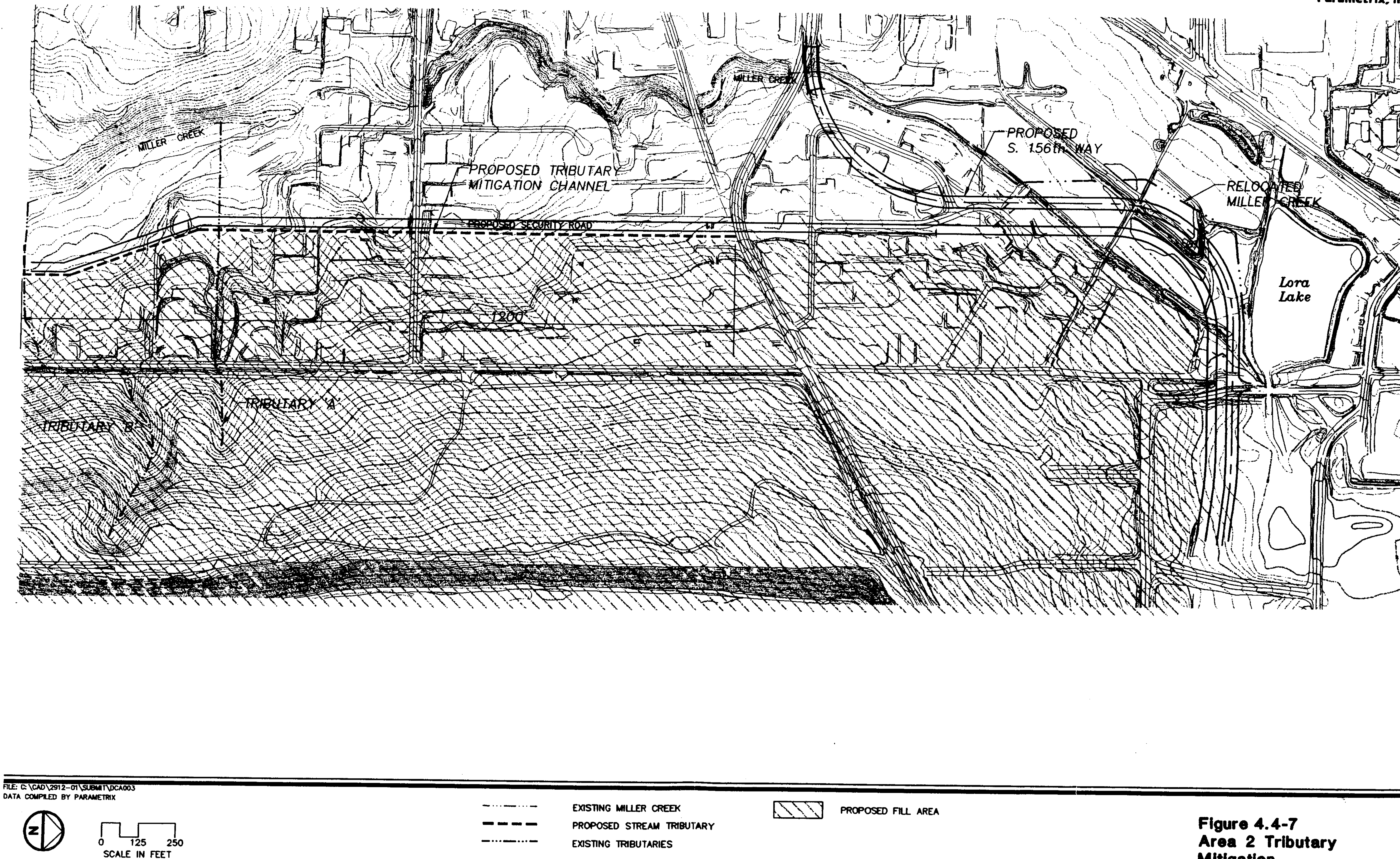

Figure 4.4-7
Area 2 Tributary Mitigation

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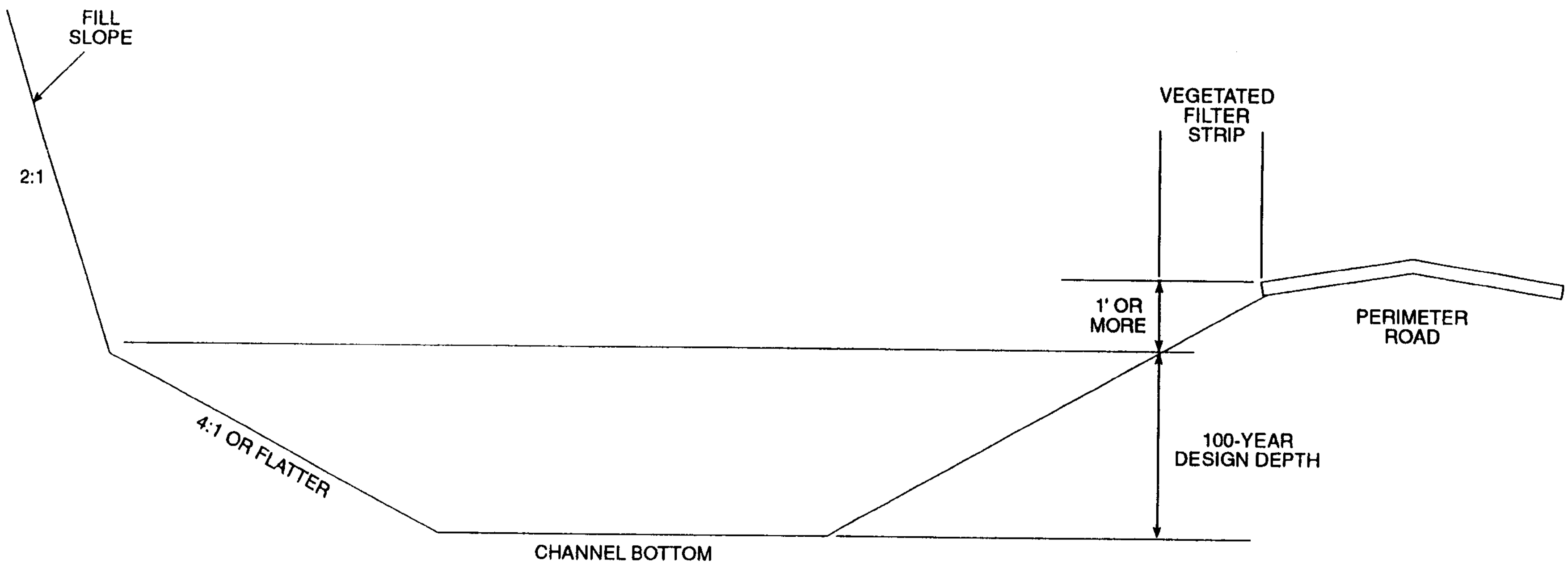


Data Compiled by Parametrix

Figure 4.4-8
Typical Tributary Channel Section

sedimentation, scouring and downstream deposition impacts. The structures would be built to control flow and not to provide habitat.

4.4.2.6 Channel Vegetation

The side slopes and buffers would be planted with native vegetation to provide shade and nutrient loading to the channel. Section 4.4.3.1 includes a discussion of appropriate plant species.

4.4.2.7 Groundwater Seepage and Hydrology

Hydrology would be maintained by constructing a subsurface drainage system to collect the seepage from the hillside that is currently surfacing to form the existing channels. The system would consist of a field of perforated pipes packed with highly porous sand or gravel. Seepage would be collected, conveyed, and discharged to the edge of the new fill slope at the head of the proposed channels.

4.4.3 <u>Habitat</u>

4.4.3.1 Instream Habitat

The instream habitat criteria used in the relocated channel design are based on general habitat requirements of salmonids. The purpose of using these criteria is to provide the highest quality habitat and environmental conditions for fish. A stream that provides quality salmon habitat is a community goal. Compared to most resident fish species, salmonids are typically very sensitive to environmental conditions such as habitat and water quality. Salmonid prey items, such as aquatic insects, also tend to have similar environmental requirements. Therefore, designing the relocated stream to meet the needs of these sensitive species would help ensure that the best possible fish habitat is created. Although anadromous salmonids are currently restricted from the proposed impact areas, resident cutthroat trout might be present.

In general, salmonids require cool, well-oxygenated water, spawning gravel that is free of accumulated silt, and abundant instream cover habitat. In addition, because habitat requirements vary as life stages change, habitat complexity within the stream is also necessary. General habitat requirements include:

- Access to habitat
- Stable flows
- Stream substrate
- Riparian and instream cover.

Habitat Access

The various habitat areas should be accessible to resident fish populations under all flow conditions. They should provide protected areas during high flows and avoid stranding problems during low-flow conditions. Fish access throughout the entire relocated stream section would be provided by the design minimum depth requirements. The channel is designed to provide an average minimum depth of 0.25 ft during dry season base flows. This minimum depth requirement allows fish access throughout the length of the channel to avoid stranding problems during low-flow periods.

Stable Flows

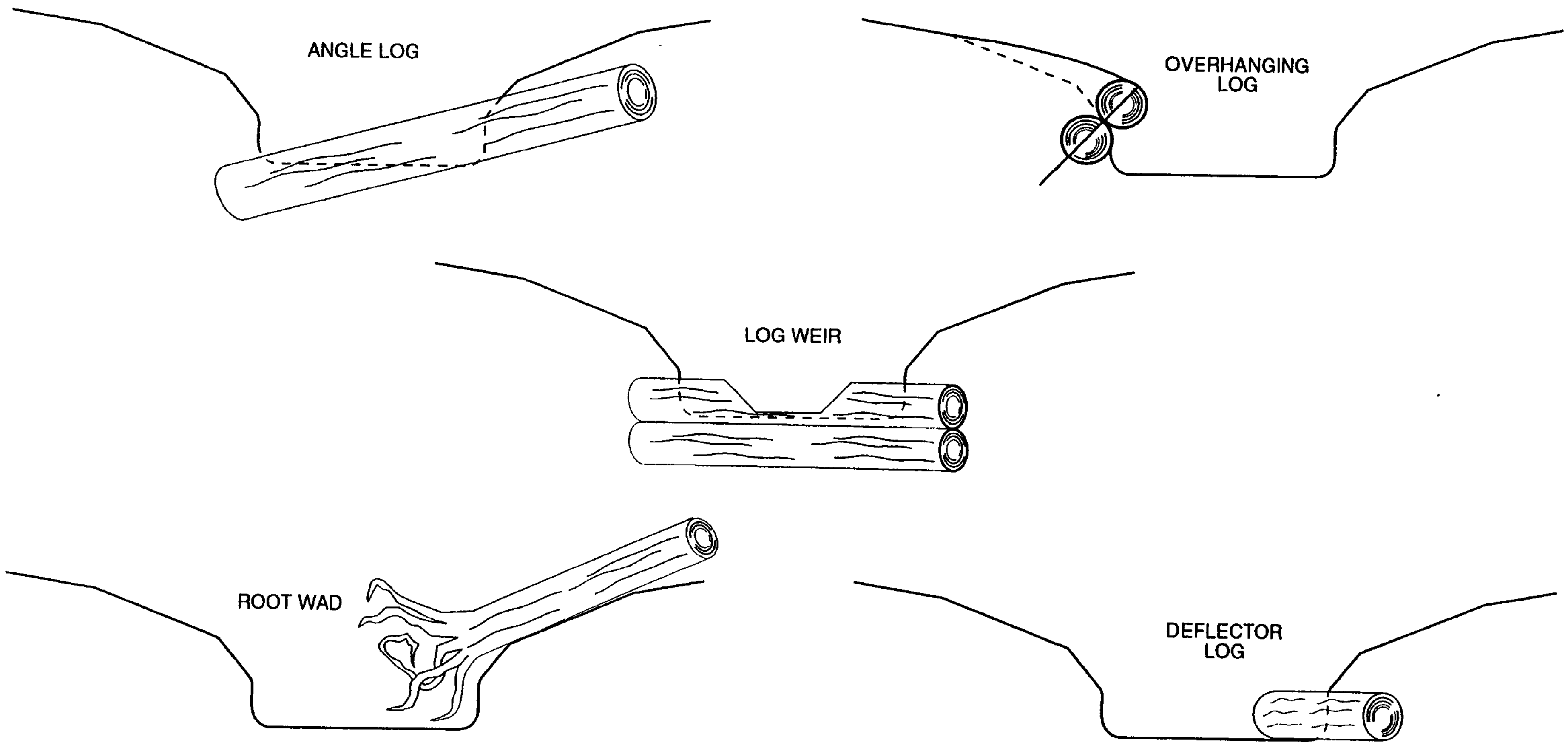
Stable flows ensure habitat access and protect the habitat against erosion or scouring; they also minimize the displacement of fish to less preferred habitats. The flow velocity criteria for the channel are set to minimize both the accumulation of fine-grained material in the channel during low-flow periods, and excessive scouring of larger-grained materials during high flows. However, since these flow velocities are also an average over the entire channel (similar to the depth criteria), sedimentation is expected to occur on the inside of bends and in deeper pools during low-flow periods. These sediments do, however, flush out again with higher flows. The channel width and bank slopes criteria have also been incorporated in the design to maintain relatively stable flow velocities throughout typical flow variations. In addition, a high-flow diversion structure has been included for Segment A to minimize erosion and fish displacement processes during unusually high-flow periods.

Stream Substrate

Salmonids typically require stable gravel that is essentially free of accumulated silt for spawning and early rearing life stages, as well as for optimum production of desired prey. Substrate in the relocated channel would consist of gravel and cobble material to provide good stable spawning and rearing habitat. However, portions of the channel would naturally be seeded with sandy material over time.

Riparian and Instream Cover

Salmonids require cover habitat provided by such features as undercut banks, logs and boulders, deep pools, and overhanging riparian vegetation for feeding, hiding, and resting. In addition, these features help to stabilize stream banks and substrate during high-flow periods. The relocated channel, which is designed with vertical banks in the low-flow depth range, would encourage minor undercutting to provide cover habitat during low-flow periods. Large woody debris (deflector logs, angle logs, and root wads), as well as boulders would be used to stabilize the substrate, protect the upper banks from excessive erosion, and provide hiding and holding habitat for fish during higher flow periods (Figure 4.4-9).



Data Compiled by Parametrix

Figure 4.4-9
Representative Fish Habitat Enhancement Features

Overhanging riparian vegetation would be used to maximize stream shade and provide overhanging cover habitat. This vegetation would deposit organic debris (leaves, branches, etc.) into the stream to provide a food source for aquatic insects; it also provides a mechanism for terrestrial insects to enter the stream, thereby providing valuable food sources for fish. Suitable plants include red-osier dogwood, Pacific willow, and salmonberry shrubs (Table 4.4-2).

Table 4.4-2. Suggested plants for riparian fringe relocation.

Scientific Name	Common Name	Streamside Zone	Upland Buffer Zone
Trees			
Acer circinatum	Vine maple	X	X
Alnus rubra	Red alder	X	X
Corylus cornuta	Western Hazel		X
Fraxinus latifolia	Oregon ash	X	
Rhamnus purshiana	Cascora		X
Salix scoulerana	Scouler willow	X	
Shrubs			
Cornus stolonifera	Red-osier dogwood	X	
Gaultheria shallon	Salal		X
Physocarpus capitatus	Pacific ninebark	X	X
Rosa woodsii	Wood's rose		X
Salix sitchensis	Sitka willow	X	
Salix lasiandra	Pacific willow	X	
Salix hookerana	Hooker willow	X	
Spiraea douglasii	Hardhack spirea	X	

Data compiled by Parametrix

Riparian and buffer areas would be planted with species that provide rapid development of woody plant cover to shade the stream and function as a riparian buffer, while minimizing the potential for attracting wildlife. Plants suitable for stream riparian areas are listed in Table 4.4-2. Riparian buffers plantings would have a tree density of about 250 stems per acre, and a shrub density of about 400 stems per acre. Buffers would extend 25 ft from the edge of the floodplain on the east side of the creek and 50 ft from the floodplain edge on the west side of the creek.

Several strategies have been used to ensure rapid development of shade along the relocated stream. The landscape design concentrates plantings on the stream bank to ensure partial shading of the stream immediately following planting. Streamside plantings including fast-growing willow and red-osier dogwood should provide substantial shade within 3 years.

Upland buffers would include a variety of plant species including red alder, cascara, western hazel, rose, and salal. Plant selection favored species that would be unlikely to attract large populations of birds (due to aircraft flight safety concerns). The planting design discourages human intrusion into the buffer by using thorn-bearing plants and/or split-post fencing. Exposed areas between plantings in the upland buffer would be hydroseeded with upland grass mixtures.

4.4.3.2 Channel Substrate

Erosion and movement of streambed sediments need to be considered when designing stream habitat features. As discharge increases in a stream channel, not only does the water level rise, but the streambed may be scoured. In general, smaller diameter particles tend to be transported at lower stream velocities relative to larger particles. The substrate criteria used in the relocated channel design are based on the general characteristics that encourage salmonid production. These criteria provide suitable spawning gravel, while minimizing the risks of scouring and transporting this material downstream during high flows.

The minimum transport velocities for various sizes of streambed particles are summarized in Figure 4.4-4. This figure was developed from data contained in the British Columbia Department of Fisheries and Oceans' *Stream Enhancement Guide* (British Columbia Fisheries 1980). If the maximum velocity of a specific section of a stream channel is known, an estimate of the size of the bed material that would be relatively stable can be determined. This is particularly important where gravel is being added to modify stream characteristics, such as to improve spawning conditions.

Miller Creek relocation requires a balance between a minimum base flow velocity, to prevent sedimentation, and a maximum peak flow velocity that could scour sediment. Therefore, it is desirable to have base flow velocities sufficient to transport finer-grained particles (such as silt), and peak flow velocities that do not remove coarser-grained particles such as gravel. High flows are required to initiate particle movement, and slightly lower flows have carrying power to keep the particle moving. Using Figure 4.4-4, the channel parameters were adjusted to maintain base flow velocity greater than the silt movement velocity, but less than the gravel movement velocity for peak flow. Gravel recruitment from upstream of the mitigation channel would be limited by the Lake Reba detention facility.

4.4.4 Floodplains

4.4.4.1 Floodplain Storage Mitigation

The proposed channel was designed not to impede the 100-year flood; however, flood flows are not expected to be completely contained within the stream banks. One hundred-year flood storage lost by the proposed fill would be approximately 5,030 yd^3. Equivalent effective floodplain storage, as shown on Figure 4.4-1, would provide approximately 5,070 yd^3 of floodplain storage mitigation.

4.4.4.2 Floodplain Conveyance

The 100-year floodplain elevation in the proposed study area was determined by FEMA when the Flood Insurance Rate Maps (FIRM) were prepared. The proposed channel capacity was checked for the 100-year flow rate peak capacity. No encroachment or fill is proposed in the 100-year conveyance area or floodway. No backwater calculations were made to estimate 100-year flood elevation impacts. However, no impacts are expected since the floodplain storage has not been altered and the 100-year conveyance channel has adequate capacity.

4.4.5 Implementation Schedule

Construction of the proposed parallel runway, which would affect Miller Creek, is currently scheduled as part of Phase I (1996 - 2000) of the proposed Master Plan Update implementation. The new stream channel must be constructed and fully stabilized before stream flow is diverted from the old channel. Therefore, the stream channel would need to be constructed during the early years of runway construction.

4.5 MONITORING PLAN

4.5.1 Hydrology and Hydraulics

The effectiveness of the relocated stream can be measured in several ways, but fish habitat stability is an important gauge. Because erosion and sedimentation are the primary indicators of stream hydraulic conditions, they are the critical criteria to be included in the proposed monitoring plan. The following activities would be included in the stream monitoring plan:

- Inspect the constructed habitat features (log weirs, root wads, etc.) to ensure that they have not been damaged or displaced (to the extent that they are not providing habitat).

- Inspect the substrate to ensure that sedimentation and erosion prevention goals are met.

- Inspect for erosion or scouring.

- Inspect stream structures and channel after major storms, as monitored by the KCSWM gage.
- Inspect for adverse flooding impacts and ponding water.
- ɿnspect diversion and outlet structures for debris accumulation, scouring, and damage.

4.5.1.1 Inspection Schedule

Table 4.5-1 includes the inspection schedule for monitoring the Miller Creek stream relocation and tributary enhancement. The schedule includes routine inspections and emergency inspections, in case of a major flood.

4.6 SITE PROTECTION

The site would be owned by the Port of Seattle and be designated in airport planning documents as a sensitive area to be protected in perpetuity. However, because of potential access needs, one or more road crossings may be developed sometime in the future.

4.7 MAINTENANCE AND CONTINGENCY PLAN

4.7.1 Maintenance

A design goal for the stream channel is that it functions as a natural channel, requiring little or no maintenance. To ensure that this goa! 's achieved, a monitoring program (described in Section 4.5) is required. Monitoring activ. .:s and frequencies are listed in Table 4-5.1. As indicated in this table, periodic maintenance may be required to correct a variety of detrimental conditions.

4.7.2 Contingency

The proposed channel configuration has two basic conveyance criteria: (1) maintain minimum flow depths and velocity for fish passage, water quality, and sedimentation; and (2) provide flow capacity for peak flows. The channel was configured to provide the required design criteria by developing a narrow channel cross section to accommodate base flow conditions and a wider channel cross section (at slightly higher elevations) to accommodate flood flow conditions. If flow rates and stream hydrology are substantially different from the design flows used to develop this plan, the channel may not function as designed. If channel hydrology is substantially different ᶠʳom data used to create this design, the channel section can be modified by:

Table 4.5-1. Miller Creek mitigation monitoring schedule.

Inspect	Frequency	Action Threshold	Action
Habitat structures	Annually (May), or after flows in excess of the 2-year peak flow	structure displaced[1], causing erosion or collecting debris	repair or replace[2]
Buffer Vegetation	Annually	Mortality results in less than 200 trees per acre or less than 300 shrub stems per acre	Evaluate reasons for mortality, replace plantings, and substitute with other species if appropriate.
Substrate	Semi-annually (February/August)	Winter - sediments (sand or smaller) in shallow, flowing segments or riffles Summer - Fine sediment (silt or smaller) in flowing segments or riffles	Prepare options for reducing stream bottom width (i.e., lateral logs, boulders) if sedimentation persists for a second year.
Erosion or Scouring	Annually (May), or after 2-year storm	bottom sediment gone; excessive streambank erosion causing sloughing; excessive habitat damage	Repair damage (bioengineering, etc.) and enlarge channel if damage increases in the 2nd year.
Control Structures	Annually (May), or after 2-year storm	structural damage or failure; obvious scouring or cavitation	determine cause and repair
Adverse Flooding	Twice yearly (November/February)	trapped standing or ponding water; persistent slow drainage	improve surface drainage paths

Data compiled by Parametrix

1 A structure can be damaged or displaced and still provide habitat consistent with mitigation goals.

2 The benefits of repair or replacement would be balanced against the potential impacts.

- widening the base flow channel width to reduce velocities, and improve capacity
- narrowing the base flow channel with logs or boulders to increase base flow depth and velocity.
- widening the flood flow of the channel (above 0.5 ft) to improve capacity and reduce velocity

- adding log weir "steps" to flatten stream slope, reducing velocity and increasing base flow depth.

- adding a bypass flow channel to convey peak flows past the main channel in Segments 2 and 3.

If standing water persists in the floodplain, side channels could be graded to provide positive drainage to the main channel.

KCSWM has a control structure at the outlet of Lake Reba with an adjustable gate. Under current operating conditions this gate is not adjusted and it is unlikely that operations would be modified to allow more water to discharge from Lake Reba. However, future needs could allow higher flows under certain conditions. Since the Miller Creek diversion structure would divert most floodwater into Lora Lake, increased flow from Lake Reba would have only a modest effect on the new stream channel. If the Lake Reba outlet were modified, contingency actions could include simple modifications to the diversion structure at the head of the channel to direct more flow into Lora Lake (for detention purposes) and away from the new Miller Creek channel.

Contingency measures for buffer vegetation include replanting areas if high mortality is observed. If significant plant loss occurs, site conditions would be evaluated to determine whether the conditions can support the species planted.

Major factors likely to contribute to large-scale plant loss include improper hydrologic condition, improper soil conditions, and pest infestation. Depending on the cause of the plant loss, a variety of remedial actions may be necessary to allow successful plant survival and restoration. If necessary, site conditions can be altered to enhance planting success. Poor soil conditions could be improved through amendments as necessary to optimize plant growth. Protection of plantings from herbivores and control of insect populations may be necessary to allow initial survival of young plant material.

5. DES MOINES CREEK

5.1 ECOLOGICAL ASSESSMENT OF IMPACT SITE

As mentioned in Chapter 1, the mitigation plan for the impacts to Des Moines Creek assumes that the layout for the SASA development described in the proposed Master Plan Update EIS would be built.

The impacts to wetlands in the SASA area have been considered in the development of the off-site wetland mitigation that is outlined in Chapter 3. Building the compensatory wetlands during the first phases of Master Plan Update would help ensure that they are functional by the time the actual impacts occur to the existing wetlands at the SASA site.

5.1.1 Stream Classification

As a tributary to Puget Sound, Des Moines Creek is designated as an extraordinary (Class AA) quality water body by the Water Quality Standards for Surface Waters of the State of Washington (WAC 173-201).

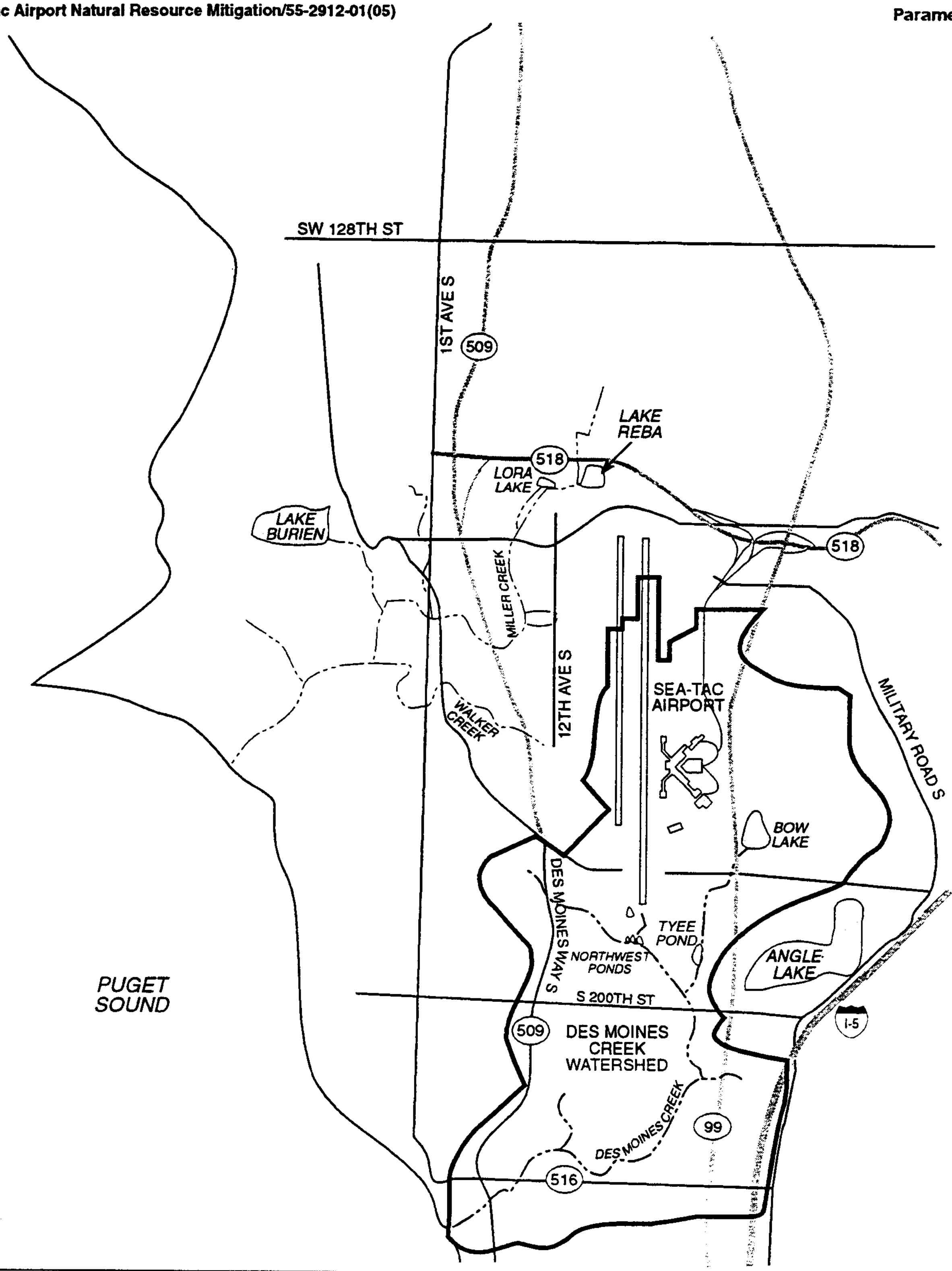
5.1.2 Primary Uses/Function in the Watershed

The Des Moines Creek watershed includes several large developed areas including parts of Sea-Tac International Airport, the city of SeaTac, and the city of Des Moines (Figure 5.1-1). Developed areas range from (1) highly impervious areas (mostly pavement and rooftops) found around the airport and commercial development along SR 99, to (2) areas with a moderate amount of impervious surfaces such as the residential areas in the city of Des Moines. Tyee Valley Golf Course and the airport clear zones are relatively undeveloped. The Des Moines Creek watershed extends from the northern parts of the airport at the headwaters to the mouth at Des Moines Beach Park on Puget Sound.

Des Moines Creek provides surface and storm water runoff conveyance and some limited fish habitat.

5.1.3 Existing Fish Habitat

The Des Moines Creek drainage basin consists of about 3,700 acres situated primarily south and southeast of the airport. The primary surface water conveyance in the basin is Des Moines Creek which originates from Bow Lake and extends about 3.5 miles southeast to Puget Sound, while dropping about 300 ft in elevation. Three major unnamed tributaries enter the creek at about river miles (RM) 0.7, 1.9, and 2.4 (Williams et al. 1975).



Source: Shapiro 1995e

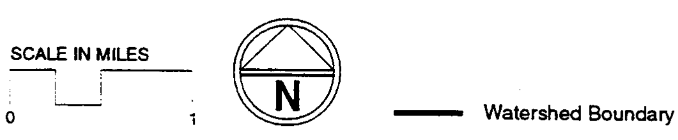


Figure 5.1-1
Des Moines Creek Basin

Des Moines Creek flows through a natural channel, except for the section at about South 200th Street, most of which is the SASA site. This reach includes a 3,600-ft-long culverted and channelized reach immediately downstream of Bow Lake. This culverted reach contains little or no salmon spawning or rearing habitat, although cutthroat trout and some warm-water fishes from Bow Lake may use it for some portion of their life stages. The streambed consists of silt and sand intermixed with small gravel. Bank vegetation in the open channel areas consists of very dense brush and small trees providing a good shade canopy.

The reach between RM 2.8 and South 200th Street (RM 2.1) flows through the Tyee Valley Golf Course. This reach is characterized by an open, grassy bank channel. The stream is culverted for 270 ft at the north end of the golf course and again at the outlet from the Tyee Pond at RM 2.4. The outlet structure appears to be a barrier to fish, and the stream channel provides little rearing habitat for fish. The detention facility is actually a large grass-lined bowl that the creek runs through during low flows; the facility only impounds water during storm events. This creek section consists primarily of a straight, narrow run reach (relatively shallow, fast-moving water) with virtually no pools, instream cover, or under-cut banks. As a result, there is very little fish-rearing habitat in this area.

Due to the presence of the golf course, and because of FAA and Port concerns about attracting birds to areas under the flight path, the canopy in this reach is largely absent. This lack of shade probably causes water temperatures to rise during summer months; this might be a problem for juvenile salmonids. The lack of trees also reduces the stability of the banks and results in excessive erosion and bank sloughing which increases the silt loading in the creek.

The golf course reach has limited salmonid spawning habitat and marginal rearing habitat. The wetlands on the west side of the golf course are probably not used extensively by juvenile salmon due to stagnant water and warm summer temperatures. Bass have been reported to inhabit these wetlands although the size of these populations or usage of the wetlands by other fish species is not known. These wetlands are connected to Des Moines Creek by an unnamed tributary at RM 2.4. This tributary is characterized by slow-moving water; soft, marshy banks; and heavy accumulation of fine sediment. The streambed in the rest of the golf course reach is predominantly sand and silt with some small patches of gravel and small cobble. Three drop weirs (dams) are located in the golf course just north of South 200th Street. The culvert at South 200th Street is flat-bottomed and at low flows its downstream end is higher than the plunge pool. This requires fish to leap into the culvert which at low flows does not have sufficient water depth for them to swim. The weirs, along with the box culvert under South 200th Street, might create problems for some fish. Although these barriers are probably not significant blockages for coho salmon, they might be for trout and other smaller fish species. In addition, the outlet control structure appears to be a barrier to most fish.

5.1.4 Hydrology

The Des Moines Creek watershed is highly urbanized and includes the cities of Des Moines, Normandy Park, SeaTac, and Burien. Sea-Tac Airport occupies approximately 20 percent of the watershed and is the watershed's dominant hydrological influence. The area directly southeast of the airport, once residential, has largely been purchased by the Port as part of the Noise Remedy Program. The Tyee Valley Golf Course occupies the area immediately south of the airport. The remainder of the watershed is mixed residential, commercial, and industrial uses.

The two branches of Des Moines Creek (formerly known as Bow Lake Creek) are shown on Figure 5.1-1. The west branch headwaters originate upstream of three wetlands areas, collectively identified as the Northwest Ponds on Figure 5.1-1. The west branch merges with the east branch approximately 1,200 ft north of South 200th Street.

The east branch headwaters originate from Bow Lake. Bow Lake provides significant flow attenuation before discharge to the east branch. The control structure that limits discharge from Bow Lake was evaluated to determine whether modifications could provide additional storage volume. The modeling conducted for the SASA EIS (Parametrix 1994) showed that Bow Lake is currently operating at its full capacity during the 100-year design storm.

After discharge from Bow Lake, Des Moines Creek flows through 2,000 ft of 36- to 54-inch storm sewers under South 188th Street and SR99/International Boulevard to the northwest corner of the SASA site, where it combines with pipes carrying runoff from SR99/International Boulevard and areas north and east of the airport. The creek comes into an open channel flowing west from the storm sewer in a narrow ravine that crosses the Alaska Airlines Training Facility parking lot. The creek corridor widens as it turns to the south. The creek then flows through several 84-inch-diameter, and smaller, culverts before discharging into the Tyee Detention Pond shown in Figure 5.1-1.

KCSWM constructed the Tyee Pond in 1989; it was a priority recommendation identified in the 1988 SeaTac Area Update for providing surface water flow controls in the Des Moines Creek basin. In addition to flow control, the pond was designed with an automatic shutoff gate and alarm that is activated by a hydrocarbon sensor. The shutoff gate was designed as a spill control device in response to two large jet fuel spills from the tank farm. The pond is "in-stream" which means that Des Moines Creek flows into the pond and out of the control structure at the south end of the pond. The pond has a peak capacity of 24 acre-ft. The outlet structure was designed to limit flows to non-erosive velocities during the 2-year frequency storm, and optimized to limit flooding for 25-year and 100-year storms. No stream flow data are available to compare flow rates before and after construction of the pond to verify performance.

The creek discharges from the detention pond control structure into an approximately 535-ft-long, 36-inch-diameter culvert. The 36-inch culvert discharges at the confluence of the creek with the west branch. The creek continues south under South 200th Street through wooded ravines approximately 2.25 miles to Puget Sound.

5.1.5 Floodplain

Because of the extensively developed area around the two main stream channels originating at Bow Lake and the Northwest Ponds and extending down to South 200th Street, no 100-year floodplain has been identified (Landrum & Brown 1995).

5.1.6 Existing Riparian Vegetation

With the exception of a short stretch of wooded area at the northeast corner of the SASA site, riparian vegetation along the section of Des Moines Creek flowing through the SASA site is primarily grass, which is regularly mowed.

5.2 CREEK MITIGATION GOALS, OBJECTIVES, AND PERFORMANCE STANDARDS

5.2.1 Goals and Objectives

Because of its large size, the proposed SASA development would require relocation of a portion of Des Moines Creek. Currently, the portion of the stream requiring relocation flows through a manmade channel. The primary mitigation goal is to retain the general drainage pattern within the Des Moines Creek valley. Improving fisheries habitat and access is a potential long-range goal.

To create a more natural stream course with increased fisheries habitat, the stream relocation plan could include habitat features such as meanders, weirs, spawning gravel, and streamside plantings. Meanders would replace the current straight alignment of most of the stream; shallow weirs would create small pools and riffles along the stream course. Plantings on the banks would shade the stream. Due to flight safety concerns, plantings would be selected to discourage use of the mitigation site by birds, particularly waterfowl, raptors, flocking birds, and blue heron.

5.2.2 Performance Standards

Specific performance standards would be similar to those proposed for Miller Creek (see Section 4.2).

5. PROPOSED MITIGATION SITE

5.3. Site Description

The available area for the relocation of Des Moines Creek is constrained by the development of the SASA site, the extension of Runway 34R and its RSA, and one possible alignment of the region's proposed South Access freeway. During the site planning for these projects, an appropriate corridor would be identified for Des Moines Creek. This corridor would include a 25-ft buffer on either side of the creek.

5.3.2 Ownership

The proposed mitigation site is owned by the Port of Seattle. The land the Tyee Valley Golf Course occupies is leased by the Port to the private golf course operator. The lease contains a ial termination provision that gives the Port the option to reclaim all, or a portion of, the to expand airport operations or facilities in the leased area. The lease expired in April 1992 has been renewed on a month-to-month basis, subject to closure after 30-days notice.

5.3.3 Rationale for Choice

The new stream channel location would limit the amount of stream relocation required. The ction to be relocated is limited primarily to reaches that are currently culverted, or that have been channelized or modified during previous development projects.

5.3.4 Ecological Assessment the Mitigation Site

See Section 5.1 for an ecological assessment of the area.

5.4 MITIGATION SITE PLAN

5.4.1 Grading Plan

Construction of the streambed would require excavation, grading, installation of habitat features, stabilization, and planting of wetland and riparian areas prior to the diversion of water from the existing stream channel. The grading plan must identify channel elevations, riparian wetland elevations, and buffer contours. The plan would design the stream channel to contain normal flows. The floodplain grade would help detain peak flood flows. Creation of upland buffers would provide a variety of micro-environments to sustain different plant species. This enhanced habitat would be partially accessible to fish currently inhabiting habitat south of South 200th Street. The barrier (a culvert at South 200th Street) could be removed as part of future project mitigation, if stream cover on the SASA site has developed enough to discourage other wildlife use of the stream.

5.4.2 Hydrology/Hydraulics

An assessment of the soils underlying the location of the proposed streambed must be made to determine whether significant amounts of surface water would be lost through seepage. If potential losses would be significant, the streambed design may need a clay layer to ensure that base flows are adequately maintained.

Any road crossings would be designed as box culverts or tunnels with natural streambeds. Channel widths would be designed to allow low-flow levels suitable for fish passage through these structures.

The use of large boulders, root wads, or logs could stabilize areas likely to experience erosion. These erosion-prone areas include the outside bank at the beginning of a curve in the stream, immediately upstream and downstream of weirs, and opposite banks of habitat features that alter flows, such as root wads and digger logs.

5.4.3 Erosion Control

An erosion control plan should include proper placement of sediment control fences and hay bales during site excavation to reduce erosion during construction. Before diverting stream flow from the old channel to the new, streambeds and stream banks should be allowed to stabilize to limit erosion and prevent sedimentation of downstream areas during early flows. Hydroseeding and mulching areas outside of the stream channel would also reduce erosion.

Diversion of Des Moines Creek flows into the new channel should be delayed as long as possible to allow plants to establish. Irrigation will be necessary during this period. To prevent washout of the stream channel, riparian fringe, or upland buffer caused by flood flows, a temporary bypass could also be created. A culvert or ditch bypass would shunt portions of storm flows past the newly relocated stream, allowing establishment of riparian vegetation. After plants are well established (2 to 3 years), storm flows are less likely to erode stream banks and wash away planted vegetation, and the by-pass channel could be removed.

5.4.4 Habitat Structures

Several fish habitat structures would be included in the stream relocation effort. These are described below.

Shallow weirs constructed across the stream channel would oxygenate the water and create pools and riffles. The notched weirs concentrate flows within the notch during dry periods and dissipate flows over a large area during flooding. Pools that develop behind the weirs provide rearing habitat for fish. Dense overhanging vegetation would be planned to minimize use by waterfowl; birds pose a flight safety threat for airport operations. High flow downstream of the weir would maintain spawning gravel beds created during stream construction. Weirs should be placed at approximately 200-ft intervals. In some areas greater numbers of weirs may be required to increase low oxygen levels which might occur during storms.

Other habitat features that could be included in the stream design include boulders, root wads, and digger logs to provide cover for fish, reduce water velocities, and encourage pool formation. Placed midstream, large boulders create areas of low flow and shelter for fish. Root wads and digger logs placed near the edge of the stream bank and anchored by buried cement blocks and/or riprap would provide cover for fish and shade the stream, while log-covered and rock-covered overhangs would create additional fish habitat. Fish habitat structures would be placed at approximately every 50 to 100 ft of open channel.

5.4.5 <u>Riparian and Buffer Plantings</u>

The landscape design of the riparian and buffer areas should emphasize rapid development of plant cover to shade the stream and creation of floodplain benches for wetland plants, while minimizing the potential for attracting wildlife. Plants suitable for the stream riparian areas are listed in Table 5.4-1, while plants suitable for the upland buffer area are listed in Table 5.4-2.

Several strategies would ensure rapid development of shade along the relocated stream. The landscape design should concentrate plantings on the stream bank to ensure partial shading of the stream immediately following planting. Larger nursery-grown red alders could be planted along the stream channel to provide an immediate source of summer shade. Streamside plantings including fast-growing willow and red-osier dogwood should provide substantial shade within 3 years.

Stream banks and riparian areas could be planted with emergent wetland species. Wetter streamside areas could be planted with bulrush, and arrowhead. Riparian floodplains could be planted with burreed, small-fruited bulrush, and slough sedge. Willow and red-osier dogwood may be included in both streamside and floodplain plantings. Exposed areas between plantings would be hydroseeded with a mixture of grasses including fescue, water foxtail, colonial bentgrass, and clover.

Upland buffers could include a variety of plant species including red alder, cascara, western hazel, rose, and salal. Plant selection should favor species that would not attract birds, due to aircraft flight safety concerns. Small trees should be planted within the clear zone because of flight safety. The planting design should discourage human intrusion into the buffer by including thorn-bearing plants and/or split-post fencing. Exposed areas between plantings in the upland buffer should be hydroseeded with upland grass mixtures.

Table 5.4-1. Suggested plants for Des Moines Creek riparian fringe.

Scientific Name	Common Name
Trees	
Acer circinatum	Vine maple
Alnus rubra	Red alder
Fraxinus latifolia	Oregon ash
Salix scoulerana	Scouler willow
Shrubs	
Cornus stolonifera	Red-osier dogwood
Physocarpus capitatus	Pacific ninebark
Salix hookerana	Hooker willow
Salix lasiandra	Pacific willow
Salix sitchensis	Sitka willow
Spiraea douglasii	Hardhack spirea
Herbs	
Alopecurus geniculatus	Water foxtail
Athyrium filix-femina	Lady-fern
Carex obnupta	Slough sedge
Juncus ensifolius	Daggerleaf rush
Oenanthe sarmentosa	Water-parsley
Sagittaria spp.	Arrowhead
Scirpus microparpa	Small-fruited bulrush
Sparganium emersum	Simplestem bur-reed
Tolmiea menziesii	Pig-a-back-plant
Veronica spp.	Speedwell

Data compiled by Parametrix

Table 5.4-2. Suggested plantings for upland buffer communities.

Scientific	Common Name
Trees	
Alnus rubra	Red alder
Acer circinatum	Vine maple
Cory!·· cornuta	Western hazel
Rha... purshiana	Cascara
Shrubs	
Gaultheria shallon	Salal
Physocarpus capitatus	Pacific nine-bark
Rosa woodsii	Wood's Rose
Herbs	
Agrostis tenius	Colonial Bentgrass
Alopecuris geniculatus	Water foxtail
Festuc arunchinacea	Tall Fescue
Trifolium sp	Clover

Data compiled by Parametrix

5.4.6 Implementation Schedule

Site exca ion and planting needs to occur prior to diversion of flows. To reduce the possibilit... of erosion and potentially damaging storm flows, construction of the relocated stream cha:nel is recommended during the dry season between mid-May and mid-October. irrig...ion of plants would be required to ensure their survival. Plantings should occur ..n mid-October and mid-May when water stress is low and transplant survival is highest. ...w stream channel would be constructed and fully stabilized before stream flow diversion . the old channel.

5.5 MONITORING PLAN

As stated in Section 5.2.2, in order to monitor and determine the success of the stream relocation project, a set of performance goals must be established. These performance standards allow determination of planting success, fisheries use, and retention of habitat features. Water quality parameters and flow rates would be monitored as identified in the storm water and water quality improvement facilities sections of this report.

Planting standards should include 100 percent shrub survivorship during the first year as guaranteed by the landscape contractor, and average survivorship rates of 85 percent over the first three years. Survivorship is determined by quantitative sampling of living tree and shrub species planted during the growing season. A series of 15 permanent transects should be established to measure percent cover; percent cover would be evaluated for the tree, shrub, and herb layer and identified for each species.

The success of fisheries habitat features, such as root wads, digger logs, weirs, and overhangs must be assessed. If greater than 10 percent of the designed habitat features are destroyed or significantly damaged, replacement should occur when the ecological benefits of the features outweigh the potential disturbance created by reconstruction.

While spawning habitat is included in this plan and would be constructed as part of the SASA-related stream relocation, the ultimate success of this element depends on future actions. Access to this habitat by downstream fisheries would be limited until modification or replacement of the South 200th Street culvert occurs. The monitoring program should assess the stability of this habitat; however, any failure may appropriately be addressed as part of future mitigation activities. Performance standards for the gravel spawning beds could assume retention of 50 percent of the spawning area placed in-stream. Extra bed area could be necessary to ensure success because some gravel beds are buried by silt or washed downstream. Qualified fisheries biologists should measure the area of gravel beds during site monitoring.

For the first five years following construction, annual reports would summarize the mitigation performance. The reports would evaluate performance standards, methods, and discussion of the reasons for success or failure of the restoration. The monitoring report would evaluate the success of the restoration, based on performance standards, and recommend appropriate action if standards are not met.

5.6 SITE PROTECTION

The site is owned by the Port of Seattle and would be designated in airport planning documents as a sensitive area to be protected in perpetuity.

5.7 MAINTENANCE AND CONTINGENCY PLAN

5.7.1 Hydrology

Maintenance of summer base flow and stormflows within design limits is essential. If flow rates exceed maximum rates, possible solutions could include the alteration of storm water control facilities to detain more water or construction of a permanent high-flow bypass channel.

A decline in low summer flows could result from the loss of water sources to the stream or infiltration into soils through the streambed. To determine the cause of water loss and identify appropriate action, a hydrologic analysis could be completed. Potential solutions to identified water losses could include increasing flow from other sources, and preventing loss of water from the streambed by using a synthetic liner. The current water sources and their flow rates suggest that significant loss of water flow appears unlikely.

5.7.2 Stream Channel

Due to the hydrologic forces associated with streams, some natural changes in the stream bank and channel are expected to occur. The plan would allow the stream channel to evolve without interference as long as it remains within the performance standards. Excessive erosion would require stabilization with plantings, logs, or other natural materials.

5.7.3 Habitat Features

Habitat features, such as root wads, digger logs, weirs, and overhangs, can be damaged by storm events, vandalism, or structural failure. If performance standards are not met, the damaged feature may be replaced. The monitoring ecologist may decide that replacement is necessary if: (1) replacing the structure coincides with the natural evolution of the stream; and (2) the ecological benefits of the habitat feature outweigh the disturbance created by its reconstruction. Any replacement will be done in conjunction with the U.S. Army Corps of Engineers.

If significant amounts of gravel beds are lost or silted, several corrective actions could be taken. New gravel beds could be created in high-flow areas as part of future project actions. Silted gravel beds could be cleaned, as long as the source of silt has been removed. However, extreme flow events in the SASA reach of Des Moines Creek are largely caused by conditions off-site in the upper watershed. Remedial measures due to high flows may need to be assessed jointly with upstream property owners, or through a city-wide rehabilitation program.

5.7.4 Plantings

Success of the restoration plan depends in a large part on the survival of the plantings. The landscape contractor, based on a guarantee required during the bidding process, would replace any plantings that die during the first year. If significant plant loss occurs, site conditions would be re-evaluated to determine whether the conditions can support the species planted.

Major factors likely to contribute to large-scale plant loss include improper hydrologic conditions, improper soil conditions, and pest infestation. Depending on the cause of the plant loss, a variety of remedial actions may be necessary to allow successful plant survival and restoration.

If necessary, site conditions can be altered to enhance planting success. Hydrologic conditions could be altered by adjustments to weirs or the outflow from the storm water detention facility. Poor soil conditions could be improved through amendments, as necessary, to optimize plant growth. Protection of plantings from herbivores and control of insect populations could be necessary to allow initial survival of young transplants.

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APPENDIX Q

WATER STUDIES

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AGI
TECHNOLOGIES

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APPENDIX Q-A
BASELINE GROUNDWATER STUDY
FINAL ENVIRONMENTAL IMPACT STATEMENT
PROPOSED MASTER PLAN UPDATE
SEA-TAC INTERNATIONAL AIRPORT
SEATAC, WASHINGTON

January 3, 1996

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AGI
TECHNOLOGIES

TABLE OF CONTENTS

AGI TECHNOLOGIES

TABLE OF CONTENTS

AGI TECHNOLOGIES

LIST OF TABLES

AGI
TECHNOLOGIES

LIST OF ILLUSTRATIONS

EXECUTIVE SUMMARY

This report characterizes the baseline hydrogeology of the Sea-Tac International Airport and vicinity, and evaluates potential groundwater quality and quantity impacts from proposed improvements associated with the updated Sea-Tac Airport Master Plan. The proposed improvements are discussed in the draft Environmental Impact Statement (EIS), which was issued in April 1995. Most of the improvements involve the development of a third runway and additional terminal facilities. These improvements will require extensive importation and placement of fill that will be excavated from a number of borrow areas within the study area. The purpose of this report is to respond to comments on the draft EIS. As such, this report addresses impacts to the aquifers below the EIS study area resulting from the development of impervious areas associated with airport facility development and utilization of Port-owned borrow source areas.

HYDROGEOLOGY

The sediments in the study area have been divided into 10 stratigraphically distinct nonglacial and glacial deposits including (from youngest to oldest): Fill (Qaf), Alluvium (Qal), Vashon Recessional Outwash (Qvr), Vashon Till (Qvt), Vashon Drift, Vashon Advance Outwash (Qva), Lawton Clay (Qvl), Third Coarse Grained Deposit (Qc[3]), Third Fine Grained Deposit (Qf[3]), Fourth Coarse Grained Deposit (Qc[4]), Fourth Fine Grained Deposit (Qf[4]), and Tertiary Bedrock (Tbr).

The uppermost groundwater is perched within Alluvium, Recessional Outwash, and discontinuous porous zones of till. The primary aquifers in the study area occur as the Shallow (Qva), Intermediate (Qc[3]), and Deep (Qc[4]) Aquifers. Groundwater in the study area generally flows downward through each of the aquifers, and outward towards Puget Sound and the Green River Valley.

POTENTIAL IMPACTS

In areas where fill will be placed and compacted, recharge to the Shallow (Qva) Aquifer will be reduced by an estimated 0.18 million gallons per day (mgd). In borrow areas where the till will be removed to expose the Esperance Sand, Shallow (Qva) Aquifer recharge will be increased an estimated 0.32 mgd. The proposed improvements may therefore result in a net increase in recharge to the Shallow (Qva) Aquifer of an estimated 0.14 mgd.

Regional groundwater flow directions are not likely to change as a result of the improvements. Small changes in local groundwater flow, however, could occur in the borrow areas as a result of the possible elevation of the water table in these areas. These changes are likely to occur primarily in the Shallow (Qva) Aquifer.

Elevation changes of the Shallow (Qva) Aquifer water table in the borrow areas associated with increased recharge may result in temporarily increased discharge to nearby streams, and to upstream expansion of zones of perennial flow in Des Moines or Miller Creeks, where they intersect the Shallow (Qva) Aquifer.

Groundwater quality in the Shallow (Qva) Aquifer could potentially be impacted by the proposed improvements through either infiltration of contaminated surface water associated with construction activities or with future airport operations or borrow area development.

Potential construction-related impacts to water quality include a range of pollutants used during construction. The potential for construction impacts is considered low due to the relatively short period of construction and the likely requirement for implementation of best management practices.

Potential operational impacts to groundwater quality in the proposed runway and ancillary improvement areas are related to new impervious surface area and associated stormwater runoff. This potential is also considered low because of plans to convey new surface water runoff to Des Moines Creek and Miller Creek, thereby eliminating infiltration. Potential groundwater quality impacts due to future airport operations are primarily those resulting from the use or leakage of hazardous materials. The potential for these contaminants to infiltrate is considered low if best management practices are implemented.

Because of the potential for direct recharge to the Shallow (Qva) Aquifer within borrow areas, future development in the areas could potentially present significant water quality impacts to the groundwater system. Application of proper management techniques can reduce or eliminate the potential for groundwater contamination.

MITIGATION MEASURES - AQUIFER RECHARGE AND DISCHARGE

The results of our study indicate a net increase in recharge to the study area groundwater system may result from the proposed improvements. Little or no mitigation will likely be needed under these circumstances. However, Shallow (Qva) Aquifer discharge from borrow areas may result if seasonal water table elevations rise above the base of borrow area excavations. Containment of this potential discharge could be constructed such that this water is detained within the borrow area, or the base of the borrow pit could be kept above the seasonally highest water table.

MITIGATION MEASURES - GROUNDWATER QUALITY

Most potential impacts to groundwater quality associated with the airport improvements will likely be prevented by continued implementation of existing management plans and techniques, and those that will be adopted for the improvements.

For construction of airport improvements and the borrow areas, potential contamination spills can be mitigated by implementation of best management practices, phasing of construction activities, and conducting activities during the dry season.

As indicated in the draft EIS, various mitigation requirements stipulated by applicable laws, policies, and design standards will be implemented during construction and operation of the proposed airport developments. It is assumed that construction and operational impacts on water quality will be mitigated through implementation of National Pollutant Discharge Elimination System (NPDES) permit requirements, and other guidelines.

In the event of future development of the borrow areas, mitigation against potential groundwater quality impacts to the Shallow (Qva) and Intermediate (Qc[3]) Aquifers will be necessary. This mitigation could include preventing surface water run-on into the borrow areas from outside areas, reserving the borrow areas for activities with little or no potential for groundwater contamination, or developing the borrow areas with appropriate engineering controls.

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1.0 INTRODUCTION

1.1 GENERAL

This report characterizes the baseline hydrogeology of the Sea-Tac International Airport and vicinity and evaluates potential groundwater quality and quantity impacts from proposed improvements associated with the Sea-Tac Airport Master Plan Update. AGI was retained by the Port of Seattle (Port) under a subconsultant agreement with Shapiro Associates to perform this study in response to comments on the Draft Environmental Impact Statement (EIS) for the Master Plan update. The Draft EIS was prepared by the Port and the Federal Aviation Administration (FAA) and was issued in April 1995. Information in this report will be incorporated into a Final EIS.

The airport is located in SeaTac, Washington, approximately 12 miles south of downtown Seattle. The area considered by this hydrogeologic characterization is a subarea of the Draft EIS study area and is shown on **Figure 1**. The study area encompasses the Master Plan improvements.

1.2 BACKGROUND

Sea-Tac Airport was first developed in 1943 and began operating commercially by 1948. When opened, the airport consisted of four runways, with the main runway approximately 6,100 feet in length. By 1956, the main runway was lengthened to 11,900 feet, and during the 1960s and 1970s, extensive additions and improvements were made to the passenger terminal. From 1967 to 1973, a second parallel runway, the north and south satellite terminals, and the passenger terminal were constructed. Airport physical features have not significantly changed since that time.

Most of the development alternatives proposed by the Master Plan Update are associated with a proposed third runway and additional terminal facilities. These improvements will require extensive importation and placement of fill that will be excavated from a number of sites within the study area. Details of the improvements are described in the Draft EIS.

This report is intended to be a companion report of the EIS. The Draft EIS is therefore referenced extensively in discussions of the proposed improvements. Information in this study was also derived from a number of investigations focused on the airport vicinity. The reference section at the end of this report lists selected documents available from these investigations.

1.3 PURPOSE AND SCOPE OF SERVICES

The purpose of the baseline hydrogeologic characterization is to identify the general hydrogeologic conditions of the EIS study area, based on existing hydrogeologic data, as a basis for evaluating effects of the proposed construction activities on groundwater recharge, quality, and flow. In particular, this study addresses impacts to the aquifers below the study area from increased impervious areas associated with airport facility development and from utilization of Port-owned borrow source areas. The specific objectives of the baseline hydrogeologic characterization are to:

- Characterize three-dimensional subsurface geology.
- Identify aquifers and aquitards.
- Characterize existing groundwater occurrence and movement, including recharge and discharge relationships.
- Qualitatively evaluate the impact of the proposed airport development on groundwater conditions.
- Identify mitigation measures, as appropriate.

To accomplish these objectives, we reviewed information obtained through meetings with the Port, Seattle Water Department, and Highline Water District (HWD). We also compiled and reviewed data from the following sources:

- Regional geologic literature
- Hydrogeologic studies of the Des Moines Upland
- Hydrogeologic studies of the Sea-Tac Airport vicinity
- Department of Ecology records
- Seattle Water Department records
- HWD records

The specific references we reviewed in preparing this report are listed in Section 5.0.

2.0 EXISTING CONDITIONS

2.1 REGIONAL PHYSIOGRAPHY

The study area is located on the Des Moines Upland within the Puget Lowland, a north-south trending structural and topographic depression bordered on the west by the Olympic Mountains and on the east by the Cascade Mountains. Sea-Tac Airport occupies approximately 2,500 acres of gently south- and west-sloping land near the crest of the Upland. Physiographic details of the study area are described in the Draft EIS (Port of Seattle, 1995). Topography of the study area is shown on **Figure 1**. Elevations at the airport range from approximately 350 to 420 feet above Mean Sea Level (elevations in this report refer to Mean Sea Level datum). Outside the study area, land surface elevations drop off steeply east and west to the Green River Valley and Puget Sound, respectively.

The study area includes watersheds of two streams: 1) Miller Creek, north and west of the airport, and 2) Des Moines Creek, south and southwest of the airport (**Figure 1**). The Des Moines and Miller Creek watersheds are discussed in the Draft EIS (Port of Seattle, 1995). The study area is primarily lightly to moderately forested land of mixed commercial, light industrial, and residential use. An undeveloped noise buffer area exists on the north, south, and west sides of the airport.

2.2 HYDROGEOLOGY

2.2.1 Regional Geologic History

The Des Moines Upland occurs as an elevated drift plain underlain by Quaternary glacial and non-glacial sediments and by Tertiary volcanic and sedimentary bedrock. Deposits of at least six glaciations have been identified in the Puget Lowland (Crandell, 1958; Easterbrook, 1967). The last of these major glaciations was named the Vashon. Armstrong, et al. (1965) renamed the youngest glaciation the Fraser, and modified it to include two glacial advances or stades, separated by one interstade. The youngest stade of the Fraser Glaciation is the Sumas and the oldest is the Vashon. Only deposits of the Vashon Stade are present in the study area.

The majority of surficial deposits and landforms in the study area can be attributed to fluvial, lacustrine, and direct ice contact processes associated with the advance and recession of the Vashon Glacier (Waldron, 1961, 1962). Glacial drifts from two older glaciations--Salmon Springs Glaciation and the older Stuck Glaciation--have also been mapped near the study area (Waldron, 1961, 1962), although more recent work by Easterbrook (1994) suggests that the widespread correlation of pre-Vashon deposits with Salmon Springs Drift may be invalid. Each of these glaciations had erosional and depositional processes similar to the Fraser Glaciation; consequently, deposits of the older glaciations often appear physically and hydraulically similar to those of Vashon age. Interglacial deposits commonly occur between glacial drift sequences and are often represented by volcanic ash, mudflow, and stream delta deposits.

2.2.2 *Study Area Geology*

Waldron (1962) completed the first surficial geologic map of the Des Moines 7.5 minute quadrangle, which includes the study area. His map shows deposits of the Vashon and Salmon Springs Glaciation and the Puyallup nonglacial sequence overlying Tertiary bedrock; no other pre-Vashon glacial or nonglacial deposits are recognized. However, a considerable number of geologic studies completed since 1962 in the Puget Lowland have suggested that additional glacial and nonglacial deposits occur between those of Vashon and Salmon Spring age (Easterbrook, et al., 1967; Luzier, 1969; Noble, 1990). In particular, geologic studies in the study area conducted for the South King County Groundwater Management Plan (SKCGMP) (South King County Advisory Committee, 1989) identified a number of previously unrecognized glacial and nonglacial sequences beneath the Des Moines drift plain. These include a nonglacial deposit between the Vashon and Salmon Springs drift, and a possible older glacial and nonglacial sequence beneath the Salmon Springs drift. Because the SKCGMP recognizes these additional deposits and presents the most comprehensive stratigraphic framework developed to date for the study area, this report generally follows the stratigraphic nomenclature used in the SKCGMP.

Sediments in the study area have been divided into 10 stratigraphically distinct deposits based on the SKCGMP nomenclature. Correlation of these deposits is based on common nomenclature in which upper Vashon and post-Vashon deposits are named based on their genesis, and deeper deposits are identified by their stratigraphic location and general particle size distribution. Study area deposits and their corresponding geologic map symbols are, from youngest to oldest:

- Fill (Qaf)
- Alluvium (Qal)
- Vashon Recessional Outwash (Qvr) ¦
- Vashon Till (Qvt) ¦ Vashon Drift
- Vashon Advance Outwash (Qva) ¦
- Lawton Clay (Qvl) ¦
- Third Coarse Grained Deposit (Qc[3])
- Third Fine Grained Deposit (Qf[3])
- Fourth Coarse Grained Deposit (Qc[4])
- Fourth Fine Grained Deposit (Qf[4])
- Tertiary Bedrock (Tbr)

These deposits are presented in order of increasing depth and age on the Generalized Stratigraphic Column shown on **Figure 2**. Surficial geology of the study area is shown on **Figure 3**. Generalized geology beneath the study area is depicted by Cross Sections A-A', B-B', and C-C', which intersect the study area as shown on **Figure 4**. Cross Sections A-A', B-B', and C-C' are shown on **Figures 5, 6, and 7**. Geology shown on these figures is based on well log information compiled from the references listed at the end of this report and is simplified to show general, large-scale subsurface relationships. Specific boring logs used to construct the cross sections are included in **Appendix A**. Actual geologic conditions are much more complex than depicted on the cross sections.

The following paragraphs describe the deposits in the study area in order of increasing depth and age.

Fill : Fill placed during construction of airport facilities is present over an extensive area as shown on **Figure 3**. Although fill is only shown on **Figure 3** as underlying the airport, fills also occur scattered throughout the study area supporting roads, buildings, and other structures. Fill deposits consist of a variety of earth materials, but typically comprise silty sand and gravel. Fill density ranges from loose in landscaped areas to dense where compacted below runways, roadways, and buildings. Fills in the study area may range up to approximately 30 feet in thickness.

Quaternary Alluvium (Qal) : Alluvium in the study area typically consists of loose fine-grained sand, silt, clay, and peat deposits, located in low-lying areas. These deposits are primarily associated with post-glacial fluvial and low energy depositional processes.

Vashon Recessional Outwash (Qvr) : Thin scattered deposits of Recessional Outwash occur below fill or at land surface across the study area. This deposit occurs in a variety of grain sizes, but is typically loose, coarse-grained sand and gravel. Recessional Outwash was primarily deposited by glacial meltwater streams near the front of the receding Vashon glacier.

Vashon Till (Qvt) : Vashon till underlies Recessional Outwash or fill where present, or is exposed at land surface in the study area. The till is typically very dense, and consists of a non-stratified, poorly sorted mixture of gray clay, silt, sand, and gravel, with occasional cobbles and boulders. The Vashon till is interpreted to have been deposited at the base of overriding Vashon glacial ice (lodgement till), causing its highly dense and compact character. The till typically averages approximately 10 to 50 feet in total thickness across most areas of the study area.

Vashon Advance Outwash (Qva) : Advance Outwash, also commonly named the Esperance Sand in the northern Puget Lowland, generally underlies Vashon Till, but also crops out at land surface in some parts of the study area. This deposit comprises beds of fluvial fine to medium-grained sand with minor gravel likely deposited in streams and lakes in front of the advancing Vashon ice. In comparison with the Recessional Outwash, the Advance Outwash is typically denser due to compaction beneath the overriding Vashon glacier. This deposit ranges from 50 to 150 feet thick in the study area.

Lawton Clay (Qvl) : This deposit is composed of beds of finely laminated to massive gray, brown, and blue-gray silt and clay, occurring beneath the Esperance Sand. This clay is absent in several locations beneath and north of Sea-Tac Airport, as shown on Cross Sections A-A' and B-B' (**Figures 5 and 6**). Regionally, the clay appears to pinch out southward. Lawton Clay was likely deposited in lacustrine environments. This deposit typically ranges from 50 to 100 feet thick where present in the study area.

Third Coarse-Grained Deposit (Qc[3]) : This deposit is ubiquitous throughout the study area, occurring below the Lawton Clay in most areas, and beneath the Esperance Sand where the Lawton Clay is absent. This deposit typically consists of a complex mixture of gravel, sandy gravel, and gravelly sand with varying proportions of silt and cobbles. Some drilled borings in the airport area have encountered wood debris and volcanic ash within this deposit. Qc(3) is interpreted by the SKCGMP and the Seattle Water Department (1990) to be outwash associated with the Salmon Springs Glaciation, and typically ranges from 50 to 250 feet thick in the study area.

Third Fine-Grained Deposit (Qf[3]) : This fine-grained deposit occurs immediately beneath the Salmon Springs. Qf(3) sediments are more heterogeneous than overlying deposits, but are characterized by fine to medium sand, silty sand, and silt fluvial deposits ranging in thickness up to several hundred feet. These sediments are thought to have been deposited during an interglacial period and to be correlative with the Puyallup Formation of Crandell, et al. (1958).

Fourth Coarse-Grained Deposit (Qc[4]) : This deposit typically consists of gravel and sandy gravel, and is likely associated with an older, pre-Salmon Springs Glaciation; however, its origin is uncertain.

Fourth Fine-Grained Deposit (Qf[4]) : This unit comprises predominantly silty clay which appears to occur uniformly below Qc(4) in the study area. The age and origin of the Fourth Fine-Grained Deposit is uncertain.

Tertiary Bedrock (Tbr) : The bedrock below the Des Moines Drift Plain is primarily arkosic, micaceous sandstone with interbedded shale and coal. The sandstone is reported to occasionally contain volcanic conglomerate, tuffaceous siltstone, tuff-breccia, and lava flows (South King County Groundwater Advisory Committee, 1989).

2.2.3 Aquifers and Aquitards

Groundwater in the study area occurs at least occasionally in each geologic deposit below ground surface. The uppermost groundwater occurs perched within Alluvium, Recessional Outwash, and discontinuous porous zones of the till. The primary aquifers in the study area, however, occur within the deeper glacial deposits, and are hydraulically delineated by the interposing deposits of glacial till or low permeability fine-grained sediments. Hydrostratigraphy of the study area is shown on the stratigraphic column (**Figure 2**).

Three deposits, Qva, Qc(3), and Qc(4), are considered the principal aquifers of the study area based on permeability and development as groundwater sources for water supply. These aquifers are identified as Shallow (Qva), Intermediate (Qc[3]), and Deep (Qc[4]). Cross sections A-A', B-B', and C-C' (**Figures 5, 6, and 7**) show these aquifers.

For this report we have generally adopted the aquifer names defined in Final Report; Highline Well Field Aquifer Storage and Recovery Project (Seattle Water Department, 1990). Study area stratigraphic deposits are defined hydrostratigraphically as follows:

• Fill (Qaf)	¦	
• Alluvium (Qal)	¦	Perched Zone
• Vashon Recessional Outwash (Qvr)	¦	
• Vashon Till (Qvt)	-	Aquitard
• Vashon Advance Outwash (Qva)	-	*Shallow (Qva) Aquifer*
• Lawton Clay (Qvl)	-	Aquitard
• Third Coarse Grained Deposit (Qc[3])	-	*Intermediate (Qc[3]) Aquifer*
• Puyallup Formation (Qf[3])	-	Aquitard
• Fourth Coarse Grained Deposit (Qc[4])	-	*Deep (Q[4]) Aquifer*
• Fourth Fine Grained Deposit (Qf[4])	-	Aquitard
• Tertiary Bedrock (Tbr)		

Hydrostratigraphy is shown on the Generalized Stratigraphic Column on **Figure 2**. Hydrostratigraphic units are described in the following paragraphs.

Perched Zone : Most of the perched groundwater in the study area occurs in Quaternary Alluvium and Recessional Outwash where they overlie the till. Groundwater is also occasionally perched within fill on top of till, or may be perched in discontinuous permeable zones within the till. These zones are generally seasonally present within a few tens of feet of land surface and have limited thickness and lateral extent.

First Aquitard : Where present in the study area, compact fill (Qaf) forms the uppermost aquitard restricting downward movement of water to underlying deposits. Over most of the study area, however, the Vashon Till (Qvt) forms the first significant aquitard. The fine-grained, compact nature of these deposits retards surface water infiltration and promotes runoff. Previous AGI studies indicate the vertical hydraulic conductivity of till in the study area is typically in the range of 10^{-5} to 10^{-7} cm/sec, which is several orders of magnitude less than that of the underlying Shallow (Qva) Aquifer (AGI, 1988).

Shallow (Qva) Aquifer : Groundwater in the Vashon Advance Outwash (Esperance Sand) comprises this uppermost aquifer. Groundwater in the Shallow (Qva) Aquifer generally occurs under unconfined (water table) conditions, and is typically protected from direct surface water infiltration by overlying fill or till. However, in some areas those upper deposits are absent, as shown on Cross Sections A-A', B-B', and C-C' (**Figures 5, 6, and 7**). The base of the Shallow Aquifer is between approximate Elevation 200 and 250, and its saturated thickness varies seasonally, typically ranging from approximately 50 to 75 feet. Water table elevations in the study area typically range from approximately 250 to 310 feet, or approximately 10 to 50 feet below ground surface.

The Shallow (Qva) Aquifer is considered to be of moderate permeability. Pumping test information reported by the South King County Groundwater Advisory Committee (1989) indicates a transmissivity of approximately 48,000 gallons per day per ft (gpd/ft). Water supply wells completed in the Shallow Aquifer may yield up to 500 gallons per minute (gpm) (South King County Groundwater Advisory Committee, 1989).

Qvl Aquitard : In most of the study area, the Shallow (Qva) Aquifer is separated from underlying aquifers by the Lawton Clay, which forms the Qvl Aquitard. Hydraulic conductivity of clays representative of the Lawton Clay are typically 10^{-7} to 10^{-10} cm/sec (Freeze and Cherry, 1979). The low permeability of the clay significantly retards flow between the overlying Qva and underlying Qc(3) Aquifer.

A window or gap in the Lawton Clay exists in the north portion of the study area as shown on Cross Section A-A' (**Figures** 5), and also in the middle and south portions of the study area where the Lawton Clay appears to pinch out to the south, as shown on Cross Section B-B' (**Figure 6**). In these areas, the Esperance Sand appears to directly overlie the Salmon Springs Drift, resulting in direct hydraulic connection between the Shallow and Intermediate Aquifers. These conditions may exist beneath portions of Sea-Tac Airport (see **Figure 6**), but existing data are inadequate to define this relationship.

Intermediate (Qc[3]) Aquifer : The Salmon Springs Drift has been studied as an important aquifer in the Des Moines Upland, and is extensively used for water supply. The City of Seattle Highline well field is completed in this aquifer. The aquifer exists under confined conditions where overlain by Lawton Clay. Unconfined conditions may occur south of the study area near Midway Landfill, where the Salmon Springs Drift is reported to occur at land surface (AGI, 1988).

The Intermediate Aquifer typically occurs between sea level and Elevation 200, with a saturated thickness ranging from approximately 50 to 250 feet. Water levels in wells screened in the Intermediate Aquifer are typically above the top of the deposit, but below water levels in the Shallow Aquifer.

Permeability of the Intermediate Aquifer is generally high. Aquifer test results for City of Seattle Highline wells indicate transmissivity of the Intermediate Aquifer in the study area ranges from 20,000 to 460,000 gpd/ft (Seattle Water Department, 1990; Hart Crowser, 1985b), and well yields of 1,500 to 3,000 gpm have been reported for Intermediate Aquifer production wells (South King County Groundwater Advisory Committee, 1989).

Qf(3) Aquitard : Fine-grained sand and silty sand below the Intermediate Aquifer form this aquitard. Significantly lower in permeability than the overlying Intermediate Aquifer, these fine-grained sediments retard downward movement from the Intermediate Aquifer; however, permeable zones within the aquitard may transmit appreciable volumes of water. The Qf(3) Aquitard typically occurs above approximately Elevation -100 and appears to range from approximately 50 to 100 feet thick beneath most of the study area.

Deep (Qc[4]) Aquifer : The Fourth Coarse-Grained Deposit forms the Deep Aquifer. The areal extent of this aquifer in the study area is not known; however, its depth is generally below Elevation -100. The Deep Aquifer is likely highly confined. Where the Deep Aquifer has been encountered, saturated thickness ranges up to 150 feet. Water levels in Deep Aquifer wells are typically above the top of the aquifer, but below water levels in Intermediate Aquifer wells.

Permeability of this aquifer is considered low to moderate, with reported transmissivities of approximately 2,000 to 30,000 gpd/ft (South King County Groundwater Advisory Committee, 1989; Hart Crowser, 1985b). Well yields for the more permeable portions of the Deep (Qc[4]) Aquifer range between 200 and 1,500 gpm (South King County Groundwater Advisory Committee, 1989).

Qf(4) Aquitard : The areal extent of the Qc(4) Aquitard in the study area is also not known. Silty clay comprises this deposit, and typically occurs below Elevation -150. The fine-grained nature of this deposit indicates it likely retards downward flow of groundwater from the Deep (Qc[4]) Aquifer.

2.2.4 <u>Groundwater Flow</u>

Upon entering the study area aquifers, groundwater generally flows outward toward the edges of the upland and downward from the Shallow (Qva) Aquifer to the Intermediate (Qc[3]) and Deep (Qc[4]) Aquifers (Luzier, 1969; South King County Groundwater Advisory Committee, 1989). It appears most groundwater eventually reaches Puget Sound to the west, or the Green River Valley to the east.

Local groundwater flow in the study area is complex, reflecting small-scale interlayering of glacial and nonglacial deposits within the subsurface deposits identified in **Section 2.2**. Local flow is also influenced by the distribution and magnitude of recharge and discharge, topography, water levels, and aquifer hydraulic properties. **Figures 8 and 9** show flow directions for the Shallow (Qva) and Intermediate (Qc[3]) Aquifers based on generalized aquifer potentiometric surface contours. Points shown on **Figures 8 and 9** are primarily compiled from the SKCGMP and Hart Crowser Technical Memorandum No. 1 - Summary of Data Review for Highline Well Field Study (1984a), respectively. Water level dates and well designations are not certain.

Groundwater flow in the Shallow (Qva) Aquifer generally appears to radiate outward from the highest portion of the upland toward the edges. A groundwater divide appears to be located east of the airport (**Figure 8**). The primary directions of flow are to the east toward the Green River Valley and to the west toward Puget Sound. In some areas, groundwater in the Shallow (Qva) Aquifer intersects ground surface and discharges to streams. Groundwater discharge is discussed in **Section 2.3**. Downward vertical flow also occurs from the Shallow (Qva) Aquifer, through the underlying Lawton Clay to the Intermediate (Qc[3]) Aquifer. Flow through the Lawton Clay is very slow due to its low permeability. However, in areas where the Lawton Clay Aquitard is absent, downward vertical flow from the Shallow (Qva) Aquifer to the underlying Intermediate Aquifer can occur more quickly.

Groundwater in the Intermediate (Qc[3]) Aquifer also generally flows outward from the crest of the Drift Plain (**Figure 9**). Like the Shallow (Qva) Aquifer, primary directions of flow within the Intermediate Aquifer appear to be east and west, and where the aquifer intersects ground surface, groundwater discharges to streams. Downward vertical flow also occurs in this aquifer, following the regional flow pattern described above. Some water in the Intermediate Aquifer likely eventually reaches the Deep (Qc[4]) Aquifer.

Groundwater flow in the Deep (Qc[4]) Aquifer is not known due to lack of wells completed in this aquifer.

2.3 GROUNDWATER RECHARGE AND DISCHARGE

2.3.1 *Groundwater Recharge and Discharge Areas*

Groundwater in the study area aquifers is recharged by infiltrating precipitation. Recharge occurs everywhere across the study area where impervious surfaces such as roadways, buildings, and airport runways do not exist and where groundwater does not discharge at ground surface. Recharge magnitude is largely governed by the permeability of the surface sediments and topography.

In relatively flat areas underlain by fine-grained, low permeability materials, such as till, peat, and compact fill, precipitation does infiltrate, but at very slow rates. These areas often contain bodies of water, including Angle Lake and Bow Lake (**Figure 1**). Sloped areas underlain by these same fine-grained deposits typically shed water at a much faster rate and allow less infiltration. In areas where till is overlain by alluvium or Recessional Outwash, infiltrating water may be temporarily detained in the Perched Zone. In contrast, areas underlain by coarse-grained sands or gravels allow considerable direct infiltration regardless of slope. These areas are typically considered recharge areas, and are represented in the study areas by exposures of Vashon Advance Outwash.

Figure 10 depicts our interpretation of existing recharge, discharge, and nonrecharge areas. Areas underlain by fill, till, or peat, and existing developed areas of the airport are considered nonrecharge zones despite the fact that some recharge does occur in these areas. Similarly, small-scale recharge/discharge features associated with local sloped and low-lying areas are not mapped. Areas with alluvium, Recessional Outwash, or Advance Outwash at the surface are considered to be recharge areas, except where the alluvium is predominantly peat or where discharge likely occurs. Most of the recharge areas shown on **Figure 10** are based on assumed direct surface exposure of Advance Outwash or absence of the till below the Recessional Outwash. Because boring log data indicate Advance Outwash likely reaches land surface in several locations across the study area (see **Figures 5, 6, and 7**), we assume areas mapped as Recessional Outwash on **Figure 2** (Luzier, 1969) are either areas where till is absent below the Recessional Outwash or where the outwash is actually Advance. In both cases we assume these areas represent direct recharge areas.

Infiltrating water passing through one of the identified recharge zones reaches the Shallow (Qva) Aquifer and provides direct recharge.

The Intermediate (Qc[3]) and Deep (Qc[4]) Aquifers are recharged by groundwater percolating downward from the Shallow (Qva) Aquifer. Most of the recharge from the Shallow to the Intermediate Aquifer probably occurs in areas where the Lawton Clay is absent, as shown on Cross Sections A-A' and B-B' (**Figures 5 and 6**).

Discharge from the study area aquifers primarily occurs as:

- Flow into perennial streams or springs discharging to Puget Sound or the Green River Valley, including Des Moines, Miller, and Walker Creeks, and other smaller, unnamed drainages.
- Underflow to the Green River Valley and Puget Sound.
- Pumping from municipal water supply wells in the Des Moines and Highline areas.

Figure 10 shows discharge areas within the study area. Des Moines and Miller Creek are the primary stream discharge and both generally sustain flow at their mouths throughout the year. While some of this water may come from seasonal water in the Perched Zone, the sustainable flow in these streams is largely attributable to baseflow discharging from aquifers identified in the study area. Below approximately Elevation 300, Des Moines Creek flows through exposures of the Shallow (Qva) and Intermediate (Qc[3]) Aquifers. Baseflow in this stream is therefore attributable to discharge from these aquifers. Miller Creek flows toward Puget Sound through exposures of the Shallow Aquifer west of the airport at elevations close to the water table in that area; some of Miller Creek's baseflow is therefore also likely due to discharge from the Shallow Aquifer.

Puget Sound and the Green River Valley are the other discharge areas for groundwater flowing downward and outward from the study area flow system. Discharge along the sea cliffs or walls of the Green River Valley forms springs. This discharge also likely occurs at depth as groundwater underflow to the Green River Valley and Puget Sound.

Groundwater possibly enters other aquifers not shown on Cross Sections A-A', B-B', and C-C'. However, previous studies indicate the Qf(4) Aquitard overlies, or is near Tertiary Bedrock (Tbr), which is thought to contain little groundwater.

Water supply accounts for a relatively small percentage of discharge from the study area groundwater system. Groundwater use from the Intermediate (Qc[3]) and Deep (Qc[4]) Aquifers is discussed in **Section 2.4**.

2.3.2 *Existing Water Balance*

Recharge and discharge relationships in the study area groundwater system are represented by the water balance schematic for the study area shown on **Figure 11**. The water balance indicates relative volumetric rates for recharge to and discharge from study area aquifers based on a simplified mass balance of the study area groundwater flow system. Generally, inflow enters the groundwater system as precipitation minus direct runoff, evaporation, and plant transpiration; water discharges from the groundwater system as baseflow to streams, as springs or underflow to the Green River Valley or Puget Sound, or as withdrawal from wells.

Inflow and outflow parameters used to develop the water balance are based on those used in previous investigations for the Des Moines Upland (Hart Crowser, 1985; South King County Groundwater Advisory Committee, 1989; Seattle Water Department, 1990). Averages of these parameters for the Des Moines Upland are listed below with volumetric rates based on the approximately 38,800-acre study area.

- Precipitation of approximately 39 inches per year (112.5 million gallons per day [mgd]).
- Evapotranspiration of approximately 17 inches per year, or 44 percent of precipitation (49 mgd).
- Runoff of approximately 8 inches per year, or 20 percent of precipitation (28 mgd).

Infiltration to the Shallow (Qva) Aquifer is the balance of water not lost to evapotranspiration or direct surface runoff as shown on **Figure 11**. The water balance assumes water entering the Shallow Aquifer either flows downward to the Intermediate (Qc[3]) Aquifer, or discharges to streams. Groundwater entering the Intermediate Aquifer either moves downward to the Deep (Qc[4]) Aquifer, out to streams, to Puget Sound or the Green River Valley, or to water supply wells. Similarly, Deep Aquifer groundwater flows to Puget Sound, the Green River Valley, or to water supply wells. Relative volumes of these flows are estimated as shown on **Figure 11**.

Total existing inflow to the Shallow (Qva) Aquifer in the study area is estimated to be approximately 35.5 mgd. Discharge from the study area aquifers that occurs as baseflow to streams is assumed to total approximately 5 mgd, based on data reported for Des Moines and Miller Creeks in SKCGMP and Seattle Water Department, 1990. Groundwater volumes discharged by wells are based on supply well production information discussed in the following section; these total approximately 4.5 mgd for the Shallow (Qva), Intermediate (Qc[3]), and Deep (Qc[4]) Aquifers. The balance of water in the groundwater system, approximately 26 mgd, is assumed to enter the Green or Duwamish River Valley or Puget Sound.

2.4 CURRENT GROUNDWATER USE

2.4.1 *Water Supply*

Each of the study area aquifers has been utilized historically as a source of groundwater for water supply. The Draft EIS states there is currently no known use of the Shallow (Qva) Aquifer water for drinking water supply in the study area; however, water rights information (discussed in **Section 2.4.2**) suggests there may be wells completed in this aquifer which may still be used for domestic, irrigation, commercial, or other uses. The Intermediate (Qc[3]) and Deep (Qc[4]) Aquifers are used by two major water purveyors for municipal water supply. The City of Seattle currently pumps from the Intermediate Aquifer via their Riverton Heights and Boulevard Park production wells located in the city's Highline Well Field located northeast of the airport. The HWD draws water from the Deep Aquifer via the Angle Lake and Des Moines production wells located south of the airport. Well locations are shown on **Figure 4**.

According to their respective records, the city's supply from the Intermediate (Qc[3]) Aquifer averages a total of approximately 1.5 mgd, and HWD's yield from the Deep (Qc[4]) Aquifer currently averages approximately 2.5 mgd. Total groundwater withdrawal by unknown or incidental wells throughout the area is not certain, but for purposes of the water balance we assume these do not exceed 0.5 mgd.

2.4.2 *Water Rights*

Current water rights issued by the Washington Department of Ecology for the study area are included in **Appendix B**. Rights to water supply in the study area provide for the following uses:

- Domestic
- Irrigation
- Commercial/Industrial
- Stock Watering
- Recreation and Beautification
- Fish Propagation
- Fire Protection

Approximately 40 percent of the listed water rights are for municipal and non-municipal wells. The remainder are designated for streams, springs, rivers, and lakes. The water rights information does not indicate which aquifers are screened by these wells; however, based on age and yield, it appears most non-municipal wells are likely completed in the Shallow (Qva) or Intermediate (Qc[3]) Aquifers. This study did not determine which water rights are being exercised; however, total yield from non-municipal wells is expected to be small compared with municipal withdrawals.

2.5 GROUNDWATER QUALITY

2.5.1 *General Groundwater Quality of Study Area Aquifers*

Representative general water quality data for the three study area aquifers are included in **Table 1**. Man's impact on Shallow (Qva) Aquifer groundwater quality is documented near the airport due to the many investigations of airport facility impacts in that area; these studies, however, do not typically identify general water quality parameters representative of background (non-impacted) conditions. Elsewhere, background water quality in the Shallow Aquifer is uncertain. **Table 1** shows data for several Shallow Aquifer wells as reported by Economic and Engineering Services, Inc. (1985). Shallow Aquifer groundwater is generally assumed to be of good quality (Port of Seattle, 1995).

Intermediate (Qc[3]) Aquifer water quality shown on **Table 1** is based largely on City of Seattle Highline Wellfield Studies (Seattle Water Department, 1990). Intermediate (Qc[3]) Aquifer water quality is generally considered to be excellent throughout most of the study area.

Deep (Qc[4]) Aquifer water quality is based on HWD records of recent testing. Based on these data and information in the Draft EIS, general water quality in the Deep (Qc[4]) Aquifer is excellent. The HWD data indicate manganese is occasionally elevated. However, naturally occurring manganese in the Deep (Qc[4]) Aquifer sediments are likely the source of these concentrations.

2.5.2 *Existing Contamination Sources*

Existing sources of contamination in the airport area are presented in the Draft EIS (Port of Seattle, 1995) and are documented in various airport area investigations (see Section 5.0). Several areas of known jet fuel hydrocarbon contamination exist in the Shallow (Qva) Aquifer near the airport. The Draft EIS reports this contamination has not migrated nor has it been identified at significant distances from its sources. Characterization and cleanup of these sources are reportedly underway (Port of Seattle, 1995).

There are also numerous sources of known and potential contamination throughout the study area outside of the airport. Commercial development along major transportation corridors and the overall increasing level of development in the area all pose potential long-term risk to groundwater quality in the Shallow (Qva) Aquifer and underlying aquifers. This risk cannot be quantified with the data available for the study.

Puget Sound is a potential source of high salinity to the Deep (Qc[4]) Aquifer, whereby high pumping rates in Deep Aquifer wells could reduce the hydrostatic pressure in this aquifer sufficiently to cause intrusion of Puget Sound water. Under these conditions, Deep Aquifer groundwater quality could deteriorate significantly.

2.5.3 *Contamination Receptors*

The contamination receptors of interest in the study area are currently operating water supply wells in the Intermediate (Qc[3]) and Deep (Qc[4]) Aquifers and Des Moines and Miller Creeks. Specific wells are the City of Seattle's Boulevard Park and Riverton Heights wells, which are completed in the Intermediate Aquifer, and HWD's Angle Lake and Des Moines wells, which are completed in the Deep Aquifer. Based on the groundwater system described in **Section 2.2.4**, contamination introduced at the ground surface may enter the Shallow (Qva) Aquifer, particularly in identified recharge areas. **Figure 10** shows areas where recharge conditions exist. Upon entry of contaminants to the Shallow Aquifer, direct or indirect downward flow routes could result in impacts to the underlying Intermediate, and possibly the Deep Aquifer. Although the Qvl and Qf(3) Aquitards significantly inhibit downward flow, areas where the Lawton Clay is absent provide a direct flow pathway from the Shallow to the Intermediate Aquifer.

3.0 POTENTIAL IMPACTS

3.1 PROPOSED IMPROVEMENTS

Improvements associated with the Master Plan Update are detailed in Section II of the Draft EIS. The EIS considers four alternatives; Alternative 1 is "Do Nothing" and is not considered further in this report. Alternatives 2, 3, and 4 consist of a new runway and associated taxiways or roads, and terminal facility improvements. The following basic elements are common to Alternatives 2, 3, and 4.

- A 7,000- or 8,500-foot-long by 150-foot-wide runway. The proposed runway will parallel the existing primary runway on the west. Runway grades will likely range between about Elevation 400 at the north end and about Elevation 350 at the south end.

- Other ancillary improvements, including: a safety area extending 250 feet west from the new runway centerline; a 75-foot-wide parallel taxiway situated 600 feet east of the proposed runway; and a 40-foot-wide perimeter access road with its centerline 285 feet west of the proposed runway centerline.

The three alternatives also include the following terminal improvements:

- Alternative 2: Centralized Terminal
- Alternative 3: North Unit Terminal
- Alternative 4: South Unit Terminal

Figure 12 shows existing airport facilities together with proposed improvements and borrow areas associated with Alternatives 2, 3, and 4.

Construction of the new runway and ancillary improvements associated with Alternatives 2, 3, and 4 will require importation and placement of substantial quantities of fill. Anticipated fill volumes and design thickness are referenced in Chapter 4, Section 24 of the EIS. Potential borrow areas for the new fill are located within Port-owned properties north and south of the airport. The borrow areas are shown as Areas 1 through 5 on **Figure 12**. The runway and ancillary facilities will be permanent. Long-term plans for the borrow areas are not currently defined.

Alternatives 2, 3, and 4 would each disturb surficial geology of the study area to some degree. Construction of the runway and other airport facilities will largely be completed by placing fill over native soil or other fill to reach design grades and foundations. Specifically, the 8,500-foot runway and other proposed improvements would result in approximately 193 acres of new impervious surfaced fill and 544 acres of unsurfaced fill area. The impervious area would be approximately 18 percent and less for the 7,000-foot runway than for the 8,500-foot runway (Port of Seattle, 1995). In the borrow areas, native soils will be removed for construction of the proposed airport facilities. **Table 2** summarizes the area and maximum volume of soil available from each borrow area.

3.2 POTENTIAL IMPACTS ON GROUNDWATER RECHARGE AND DISCHARGE

Construction and excavation associated with Alternatives 2, 3, and 4 will alter existing areas of recharge areas shown on **Figure 10**. In areas where fill will be placed and compacted, including the runway and airport facility improvements, direct surface water runoff will be increased and recharge reduced. According to the EIS, this water will be directed to Des Moines and Miller Creeks via stormwater management facilities. In borrow areas, recharge should increase since excavation will remove till and expose permeable Advance Outwash.

Alteration of recharge or discharge in the study area will change existing inflow to the groundwater balance depicted on **Figure 11**, and therefore will affect flow and volume in the Shallow (Qva), Intermediate (Qc[3]), and Deep (Qc[4]) Aquifers. Effects on groundwater recharge and discharge are discussed in more detail in the following sections.

3.2.1 *Aquifer Recharge Volume*

The new runway and airport facilities associated with Alternatives 2, 3, and 4 will generally be surfaced with impervious material, or be filled and compacted, significantly reducing surface permeability. With the 8,500-foot runway, approximately 97 acres of new impervious surface area and 262 acres of unsurfaced fill area would drain to Miller Creek, and approximately 95 acres of new impervious surface area and 283 acres of unsurfaced fill would drain to Des Moines Creek (Port of Seattle, 1995). For purposes of this study, we have assumed that all new fill areas will be nonrecharge areas (recognizing that some recharge does occur in these areas). **Figure 13** shows existing recharge areas defined by this study that would be filled by the proposed improvements, and thus be converted to non-recharge areas. The total reduction in recharge area based on **Figure 13** is approximately 77.5 acres (3,376,000 square feet).

Evapotranspiration and runoff in areas of direct recharge are less than the regionwide values used in **Section 2.3.2** due to more direct percolation of precipitation. For such areas, evapotranspiration and direct surface water runoff may each be estimated as approximately 10 percent of precipitation (Viessman, et al., 1989). Assuming these values, up to 31 inches of annual precipitation may infiltrate the recharge areas in **Figure 13** (39 inches minus 3.9 inches minus 3.9 inches). The reduction of 77.5 acres in recharge area would thereby reduce recharge to the Shallow (Qva) Aquifer approximately 0.18 mgd.

The Shallow (Qva) Aquifer is overlain by low-permeability till in portions of Borrow Areas 1, 2, 4, and 5. In these areas the till inhibits surface water infiltration to the Shallow Aquifer. In areas where the till will be removed sufficiently to expose the advance outwash, Shallow Aquifer recharge will be increased. Borrow Areas 1 and 5 appear to overlie zones in which the Lawton Clay is absent (see Cross Sections A-A', B-B', and C-C'); recharge from these borrow areas may also directly recharge the Intermediate (Qc[3]) Aquifer.

Current excavation plans suggest existing till will be completely removed from the borrow areas. **Table 2** provides estimates of the area of till that will likely be removed from each borrow area; **Figure 13** depicts these as recharge areas created by till removal. (Note that recent borrow studies indicate the till is not present in Area 3 despite its being mapped there on the surficial geology map (**Figure 3**). The total recharge area created by borrow area till excavation is approximately 158.3 acres (6,896,400 square feet). Assuming evapotranspiration and direct runoff total approximately 20 percent, as above, approximately 31 inches of precipitation would be available as direct recharge in the borrow areas as long as the excavations are unsurfaced and undeveloped. Total additional recharge to the Shallow (Qva) Aquifer associated with these new recharge areas would thereby total approximately 0.32 mgd. The estimated value of additional recharge per borrow area is included in **Table 2.**

In summary, our study indicates the Alternative 2, 3, and 4 improvements would reduce recharge approximately 0.18 mgd and borrow area development would increase recharge approximately 0.32 mgd. The balance of these effects indicates a net increase in recharge to the Shallow (Qva) Aquifer of approximately 0.14 mgd is likely as long as the borrow areas are undeveloped or unsurfaced.

3.2.2 *Aquifer Discharge Volume*

Discharge volumes from study area aquifers will increase in direct proportion to the increase in net recharge discussed above in Section 3.2.1. This increase will be expressed partly as greater discharge to Miller and Des Moines Creeks, and partly as greater underflow to Puget Sound and the Green River Valley. Greater discharge to the creeks would occur shortly after development; greater underflow would likely not be detectable for many years, perhaps centuries.

Greater discharge to area streams would be observable primarily near the proposed borrow areas, where increased recharge would cause the water table (Shallow [Qva] Aquifer) to rise. The rising water table would extend the area of perennial flow upstream and increase the volume of seepage into the stream.

The decrease in recharge associated with fill placement for the airport improvements might also have a localized effect on aquifer discharge. In the new fill areas the reduction in recharge could cause the water table to drop slightly, thus reducing seepage into either Des Moines or Miller Creeks. These effects should be offset by the greater discharge discussed above.

One other possible impact of increased recharge in the borrow areas is increased discharge if the water table rises to land surface and then flows out of the borrow area. This could only occur if the borrow area was excavated to below the seasonal high water table and an outlet was created for overflows.

3.2.3 *Groundwater Flow*

Regional groundwater flow directions are not likely to change as a result of the increased recharge associated with the Master Plan Update improvements. Small changes in local groundwater flow, however, could occur in the borrow areas through increased recharge. Elevation of the water table in these areas could result in higher hydraulic gradients than existing conditions, and therefore increase local groundwater velocities. Similarly, changes in groundwater discharge, particularly along segments of Des Moines and Miller Creeks, may temporarily change local flow directions toward the creeks. These effects are likely to occur primarily in the Shallow (Qva) Aquifer. Hydraulic gradients and groundwater velocity may also be reduced slightly below the proposed construction fill areas due to reductions in recharge.

3.3 GROUNDWATER QUALITY

Groundwater quality in the Shallow (Qva) Aquifer could be impacted by the proposed Alternative 2, 3, and 4 improvements through either infiltration of contaminated surface water associated with construction activities or with later airport operations or borrow area development. However, all of the potential impacts can be mitigated through proper planning and management.

Construction-Related Impacts : Potential construction-related impacts to groundwater quality associated with the airport runway and ancillary improvements would depend on local construction area size, the amount of exposed soil, topography, proximity to water bodies, and the effectiveness of erosion and sediment controls implemented. In the borrow areas, groundwater quality may be impacted by construction-related contaminants introduced by infiltrating surface water. In both the borrow and the airport improvement areas, the potential for construction impacts should be low based on the relatively short construction period and the restrictions likely to be applied by the permitting agencies.

Potential construction impacts on water quality include a range of substances used during construction, including fuels, lubricants, and other petroleum products, and construction waste such as concrete wash water. The Draft EIS identifies the potential for pollution resulting from accidental spills of these substances, from leaking storage containers, from refueling, and from construction equipment maintenance activities. The potential for these impacts should be minimized in areas of new impervious surfaces associated with the Alternative 2, 3, and 4 improvements.

Operations-Related Impacts : Operational impacts on groundwater quality in the proposed runway and ancillary improvement areas are related to new impervious surface area and associated stormwater runoff. The EIS reports that drainage from the new runway and taxiways would be detained on site and then conveyed to Des Moines Creek and Miller Creek. Potential impacts to surface water quality are discussed in Chapter IV of the Draft EIS. Essentially all of the new surface water runoff will leave the airport and not be available for infiltration. Thus, the potential for groundwater contamination from this source is low.

Potential groundwater quality impacts due to future airport operations in the improvement areas include those resulting from the use or leakage of hazardous materials (e.g., fuels and other petroleum products) stored at the airport. These contaminants could create conditions similar to those discussed in **Section 2.5.2**. However, the airport is currently undertaking studies aimed at reducing the potential for future groundwater quality impacts from this source.

In the borrow areas, operational impacts will depend on future development. The EIS reports the borrow areas may be cleared, graded, or surfaced; however, plans for the areas are currently undetermined. Because of the direct recharge to the Shallow (Qva) Aquifer from the borrow areas, future development in unsurfaced borrow areas could present significant water quality impacts to the groundwater system.

3.4 SUMMARY OF POTENTIAL IMPACTS

Potential impacts associated with Alternative 2, 3, and 4 improvements are summarized as follows:

Groundwater Recharge and Discharge Volumes

- In areas where fill will be placed and compacted, including the runway and airport facility improvements, direct surface water runoff will be increased and recharge reduced. This reduction in recharge to the Shallow (Qva) Aquifer is estimated to be approximately 0.18 mgd.
- In borrow areas where the till will be removed to expose the Esperance Sand, Shallow (Qva) Aquifer recharge will be increased. Total additional recharge to the Shallow Aquifer associated with these new recharge areas is estimated to total approximately 0.32 mgd.
- Alternative 2, 3, and 4 improvements may result in a net increase in recharge to the Shallow (Qva) Aquifer of approximately 0.14 mgd.
- Elevation of the Shallow (Qva) Aquifer water table in the borrow areas due to increased recharge may result in temporarily increased discharge to nearby streams, and to upstream expansion of zones of perennial flow in Des Moines or Miller Creeks, where they intersect the Shallow (Qva) Aquifer.
- A possibility exists for groundwater discharge directly out of the borrow areas if they are excavated below the seasonal high water table and an outlet is created for overflow.
- Borrow Areas 1 and 5 are in areas where the Lawton Clay is absent. Recharge in these areas may therefore directly affect the Intermediate (Qc[3]) Aquifer.

Groundwater Flow and Quality

- Regional groundwater flow directions are not likely to change as a result of the Master Plan Update improvements. Small changes in local groundwater flow, however, could occur in the borrow areas as a result of the possible elevation of the water table in these areas. These changes are likely to occur primarily in the Shallow (Qva) Aquifer.
- Groundwater quality in the Shallow (Qva) Aquifer could potentially be impacted by the proposed Alternative 2, 3, and 4 improvements through either infiltration of contaminated surface water associated with construction activities or with later airport operations or borrow area development.
- Potential construction impacts on water quality include a range of pollutants used during construction, including fuels, lubricants, and other petroleum products, and construction waste such as concrete wash water. The Draft EIS states pollution could result from accidental spills of these substances, from leaking storage containers, from refueling, and from construction equipment maintenance activities. The potential for construction impacts is considered low due to the short period of construction and implementation of best management practices.

- Operational impacts on groundwater quality in the proposed runway and ancillary improvement areas are related to new impervious surface area and associated stormwater runoff. This potential is also considered low because most stormwater will be transported off the airport and not be available for infiltration.

- Potential groundwater quality impacts due to future airport operations in the improvement areas are primarily those resulting from the use or leakage of hazardous materials (e.g., fuels and other petroleum products) stored at the airport. These contaminants could infiltrate similar to the existing contaminants discussed in **Section 2.5.2**. The potential for this to occur is considered low as described above.

- Because of the direct recharge to the Shallow (Qva) Aquifer from the borrow areas, future development in unsurfaced borrow areas could potentially present significant water quality impacts to the groundwater system.

- Application of proper management techniques can reduce or eliminate all the potential impacts listed above as sources of groundwater contamination.

4.0 MITIGATION MEASURES

Mitigation measures for impacts from construction and operation-related activities are discussed in the EIS, except where they relate to groundwater recharge or discharge. Mitigation measures identified by our study for potential impacts to groundwater are presented below.

4.1 AQUIFER RECHARGE AND DISCHARGE

Our study indicates a net increase in recharge to the study area groundwater system may result from the proposed Alternative 2, 3, and 4 improvements. Little or no mitigation will likely be needed under these circumstances. However, where Shallow (Qva) Aquifer discharge may result from seasonal water table elevations rising above the base of borrow area excavations, containment could be constructed such that this water is detained within the borrow area, or the base of the borrow pit could be kept above the seasonally highest water table.

4.2 GROUNDWATER QUALITY

Most potential impacts to groundwater quality associated with the airport improvements will likely be prevented by continued implementation of existing management plans and techniques, and those that will be adopted for the improvements.

For construction of the airport improvements and the borrow areas, potential contamination spills can be mitigated by implementation of best management practices such as construction waste handling plans and fueling and vehicle maintenance plans, and strict contractual requirements of contractors. Use of best management practices such as spill containment areas, phasing of construction activities (to minimize the amount of disturbed and exposed areas), and conducting activities during the dry season (April through September) also should prevent or reduce potential impacts on surface water and groundwater quality (Port of Seattle, 1995).

As indicated in the EIS, various mitigation requirements stipulated by federal, state, and applicable local laws, policies, and design standards, will be applicable to construction and operation of the new parallel runway development at the airport. It is assumed that construction and operational impacts on water quality will be mitigated through implementation of National Pollutant Discharge Elimination System (NPDES) permit requirements, detention requirements, and compliance with state waste and materials management requirements, water quality standards, and stormwater management guidelines (Port of Seattle, 1995).

Specific plans required as part of compliance with the Port's NPDES permit will need to be implemented to identify and control pollutants coming from the airport, and to prevent and control potential operational impacts on groundwater from industrial wastewater system (IWS) and storm drainage system (SDS) discharges.

In the event of future development of the borrow areas, mitigation against potential groundwater quality impacts to the Shallow (Qva) and Intermediate (Qc[3]) Aquifers will be necessary. This mitigation could include preventing surface water run-on into the borrow areas from outside areas, reserving the borrow areas for activities with little or no potential for groundwater contamination, or developing the borrow areas with appropriate controls.

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AGI
TECHNOLOGIES

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Attention: Mr. Ed McCarthy

Quality Assurance/Technical Review by:

for Mackey Smith, C.E.G.
Executive Vice President

AGI TECHNOLOGIES

Table 1
General Groundwater Chemistry
Shapiro/Sea-Tac EIS
SeaTac , Washington

Aquifer	Specific Conductance (µmhos/cm)	TDS	Alakalinity (mg/L)	Color	Iron (mg/L)	Manganese (mg/L)	Hardness (mg/L)	Sodium (mg/L)	Sulfate (mg/L)	Chloride (mg/L)	Nitrate as N (mg/L)
Shallow Aquifer											
Hellums, Ellaston, Washington Memorial Park, Brittenbach, & Gingrich Wells (E.E.S., 1985)	244 - 358	N/A	79.2 - 142	N/A	0.01 - 0.3	0.0 - 0.23	21.7 - 156	5.9 - 10.8	N/A	N/A	0.3 - 4.2
Intermediate Aquifer											
Boulevard Park and Riverton Heights Wells (Seattle Water Department, 1990)	153 -289	160 -195	N/A	3 - 5	0.04 - 0.6	0.012 - 0.065	N/A	4.78 - 8.12	4.7 - 35	3.0 - 7.55	0.02 - 3.3
Expected water quality based on historical analysis of inorganic parameters (E.E.S., 1984)	150	N/A	80	N/A	0.1 - 1.0	0.03 - 0.10	70	6	8	5	0.1
Deep Aquifer											
Angle Lake & Des Moines Wells (7-26-95) (Personal Communication - Highline Water District)	154 - 259	N/A	N/A	<5	<0.03	0.067 - 0.093	61 - 91	9 - 10	N/A	2 - 7	<0.02

Notes:

mg/L - Milligrams per liter.
N/A - Not available.
µmhos/cm - Micromhos per centimeter.

AGI TECHNOLOGIES

Table 2

Summary of Borrow Area Acreage, Fill Volume, and Estimated Recharge

Shapiro/Sea-Tac EIS

SeaTac, Washington

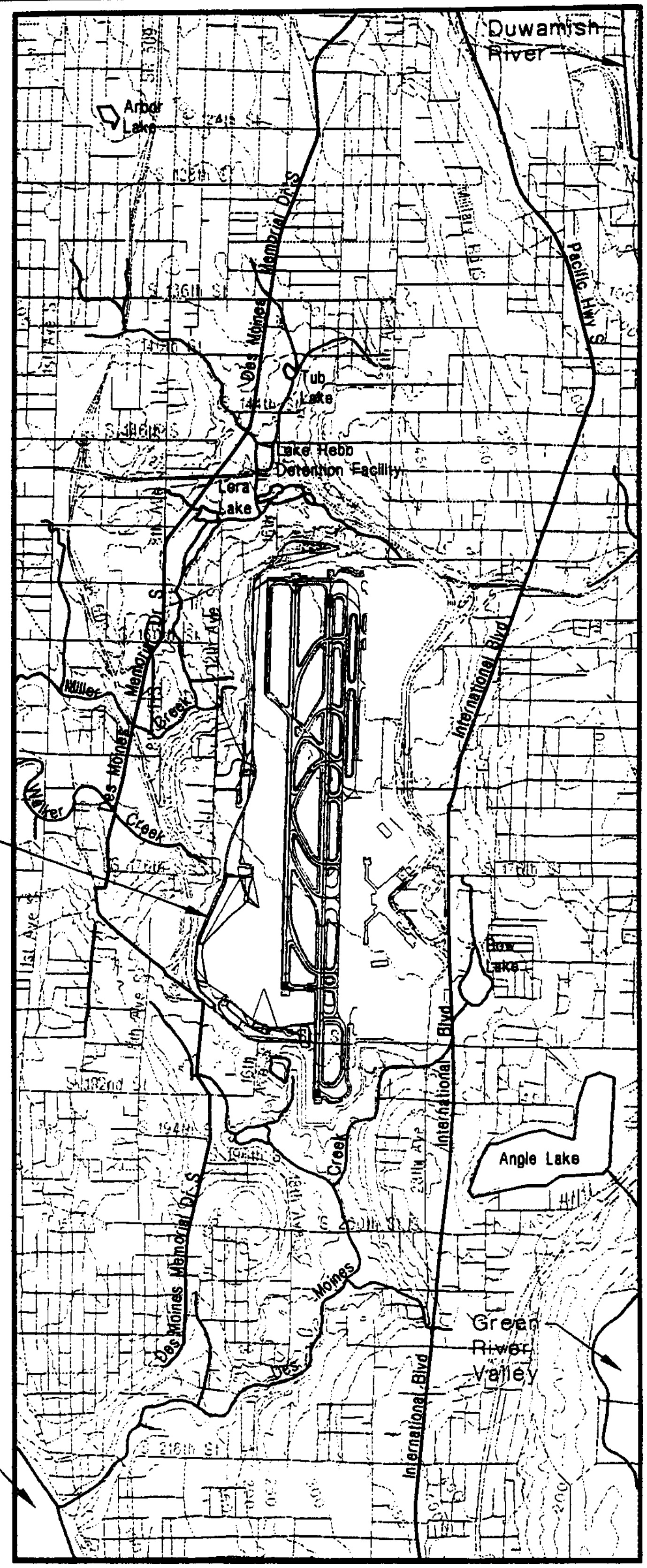
Area	Approximate Ground Surface Elevation Range [a] (feet)	Approximate Acreage	Maximum Volume of Soil Available for Excavation [b] (million cubic yards)	Approximate Area of Till (Qvt) to be Removed (square feet)	Additional Recharge to Groundwater Due to Removal of Till [c] (gallons/day)
1	250 to 350	110	0.5	3,537,215	188,471
2	175 to 275	20	0.65	450,552	24,006
3	250 to 350	60	2.90	0	0
4	290 to 395	40	2.20	447,595	23,849
5	275 to 475	60	1.75	1,523,534	81,177
TOTAL		290	8.0	5,958,896	317,503

Notes:

a) NGVD 1929 Datum.

b) From Shapiro, 1995.

c) Based on 39 inches precipitation, minus 10% evaporation and 10% runoff.



Reference:
Basemap: Port of Seattle, 1995

N

0 2000 4000
Scale in Feet

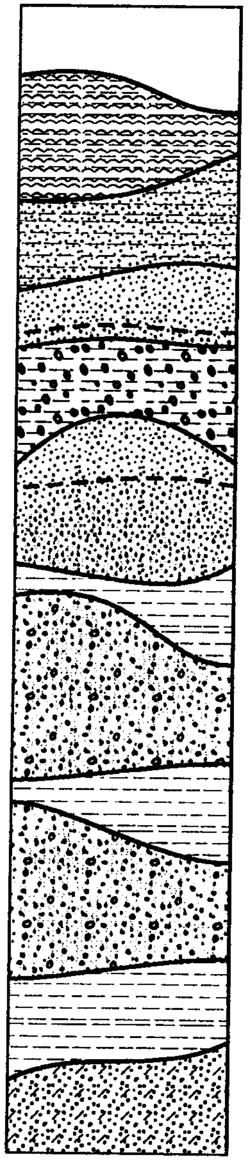
AGI TECHNOLOGIES

Study Area

Shapiro/Sea-Tac EIS
Seatac, Washington

FIGURE **1**

	PROJECT NO.	DRAWN	DATE	APPROVED	REVISED	DATE
studyar.dwg	14,887.003	BJA	Nov 95			



Symbol	Stratigraphic Unit As Identified in SKCGMP	Geologic Description and Regional Correlation	Hydrostratigraphic Unit Modified from HWFASR
Qaf	Fill	Miscellaneous surficial fills	**Perched Zone** Seasonally perched groundwater occurs at base of fills on top of till.
Qal	Recent Alluvium	Primarily fine grained sand, silt, clay, and peat deposited along stream channels and valley bottoms.	Seasonally perched groundwater occurs at base of alluvium at top of till.
Qvr	Vashon Recessional Outwash	Scattered deposits of well sorted sand and gravel. Typically include outwash deposits.	Seasonally perched groundwater occurs at base of Recessional Outwash on top of till.
Qvt	Vashon Till	Compact mixture of gravel in a gray clayey, silty sand matrix, with occasional boulders and lenses of sand and gravel. Typically mantles older Vashon glacial and nonglacial deposits in study area.	**Aquitard** Primarily of low permeability except for isolated lenses of sand which may contain water seasonally. Typically averages 10 to 50 feet thick.
Qva	Vashon Advance Outwash	Predominantly sand in study area. Locally may include very fine sand and silt (Esperance Sand of Mullineaux, 1965; Colvos Sand of Molenaar, 1963).	**Shallow [Qva] Aquifer** Moderately permeable aquifer with typically abundant water; primarily unconfined. Typically 50 to 150 feet thick.
Qvl	Lawton Clay	Glacio-lacustrine deposit primarily composed of laminated clayey silt, silty clay, silt, and fine sand (Mullineaux, 1965).	**Aquitard** Low permeability deposit which impedes downward flow to Qc(3) Aquifer. Typically 50 to 100 feet thick.
Qc(3)	Third Coarse-Grained Deposit	Typically oxidized glacial outwash sand and gravel (Salmon Springs Drift of Crandell, et al.,1958).	**Intermediate [Qc(3)] Aquifer** Typically saturated, high permeability aquifer, primarily confined. Regionally important for water supply. Supplies Seattle Water Department Highline Well Field.
Qf(3)	Third Fine-Grained Deposit	Composed primarily of fine to medium silty sand. Contains andesite grains imparting characteristic lavender hue (Puyallup Formation of Crandell, et al., 1958).	**Aquitard** Typically low permeability relative to overlying and underlying aquifers. Impedes vertical flow between Qc(3) and Qc(4) Aquifers. Thickness typically 50 to 250 feet.
Qc(4)	Fourth Coarse-Grained Deposit	Coarse grained deposits (formation uncertain).	**Deep [Qc(4)] Aquifer** High permeability, confined aquifer. Thickness uncertain. Regionally used for water supply. Supplies Highline Water District wells.
Qf(4)	Fourth Fine-Grained Deposit	Primarily silty clay (formation uncertain).	**Aquitard** Low permeability deposit which impedes downward flow. Thickness uncertain.
Tbr	Tertiary Bedrock	Principally arkosic, micaceous sandstone and interbedded shale and coal. Locally includes thick sequence of volcanic sandstone and conglomerate, tuffaceous siltstone, tuff-breccia, and lava flows (Puget Group of Waldron, et al., 1962).	**Bedrock** Hydraulic characteristics uncertain.

Notes:

SKCGMP - South King County Groundwater Management Plan (South King County Groundwater Advisory Committee, 1989)

HWFASR - Highline Well Field Aquifer Storage and Recovery Project (Seattle Water Department, 1994)

☐ Water Bearing Deposits

AGI TECHNOLOGIES

Generalized Stratigraphic Column

Shapiro/Sea-Tac EIS
Seatac, Washington

FIGURE 2

	PROJECT NO.	DRAWN	DATE	APPROVED	REVISED	DATE
stratcol.cdr	14,887.003	BJA	Nov 95	TWW		

AR 039854

Legend:

Qaf Construction Fill

Qal Quaternary Alluvium

Qvr Vashon Reccessional Outwash

Qvt Vashon Till

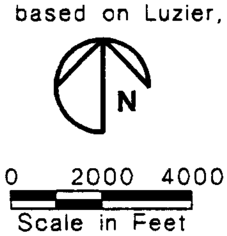
Qva Vashon Advance Outwash

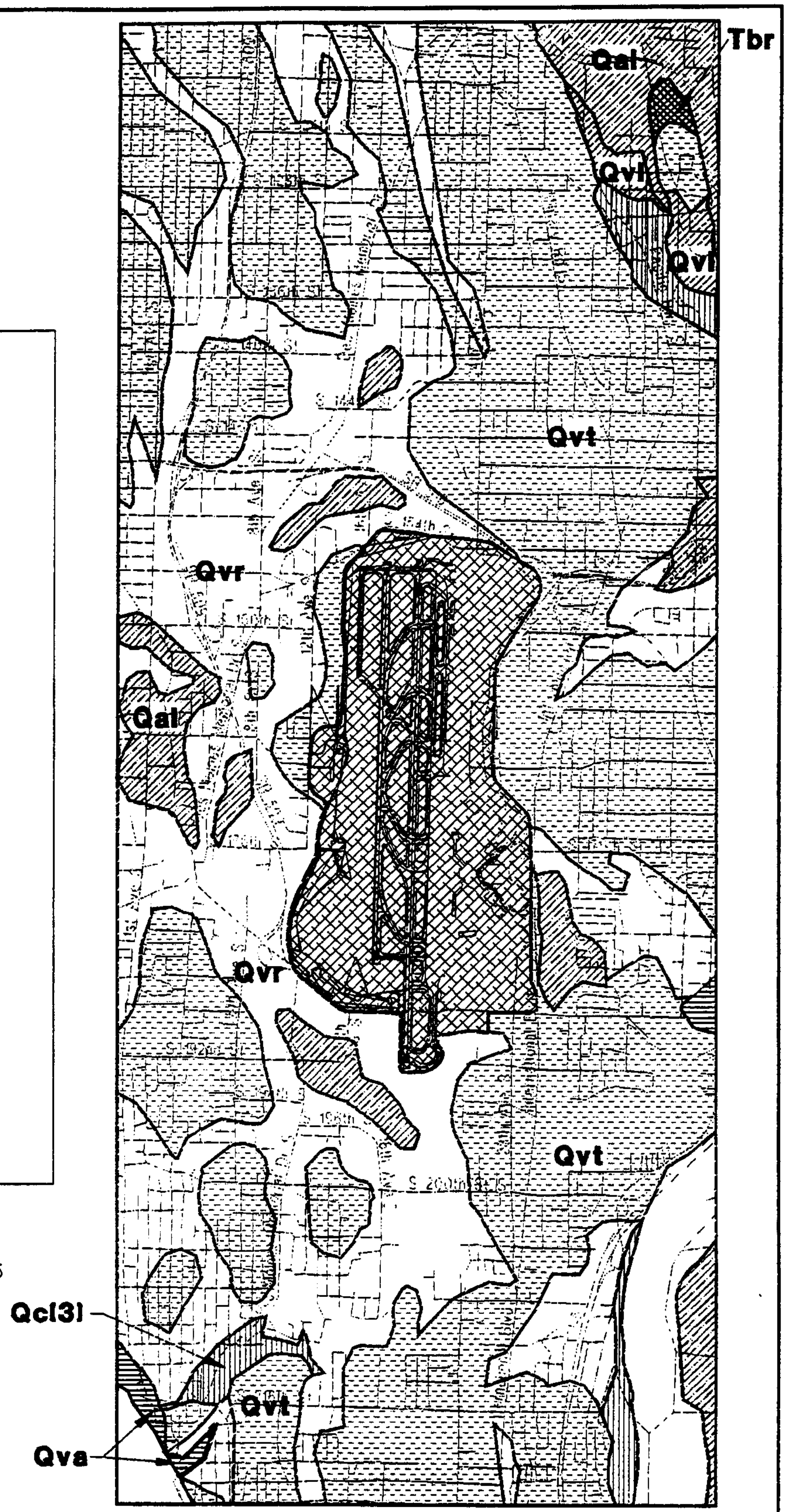
Qvl Lawton Clay

Qc[3] Salmon Springs Drift

Tbr Tertiary Bedrock

Reference:
Basemap: Port of Seattle, 1995
Geology based on Luzier, 1969





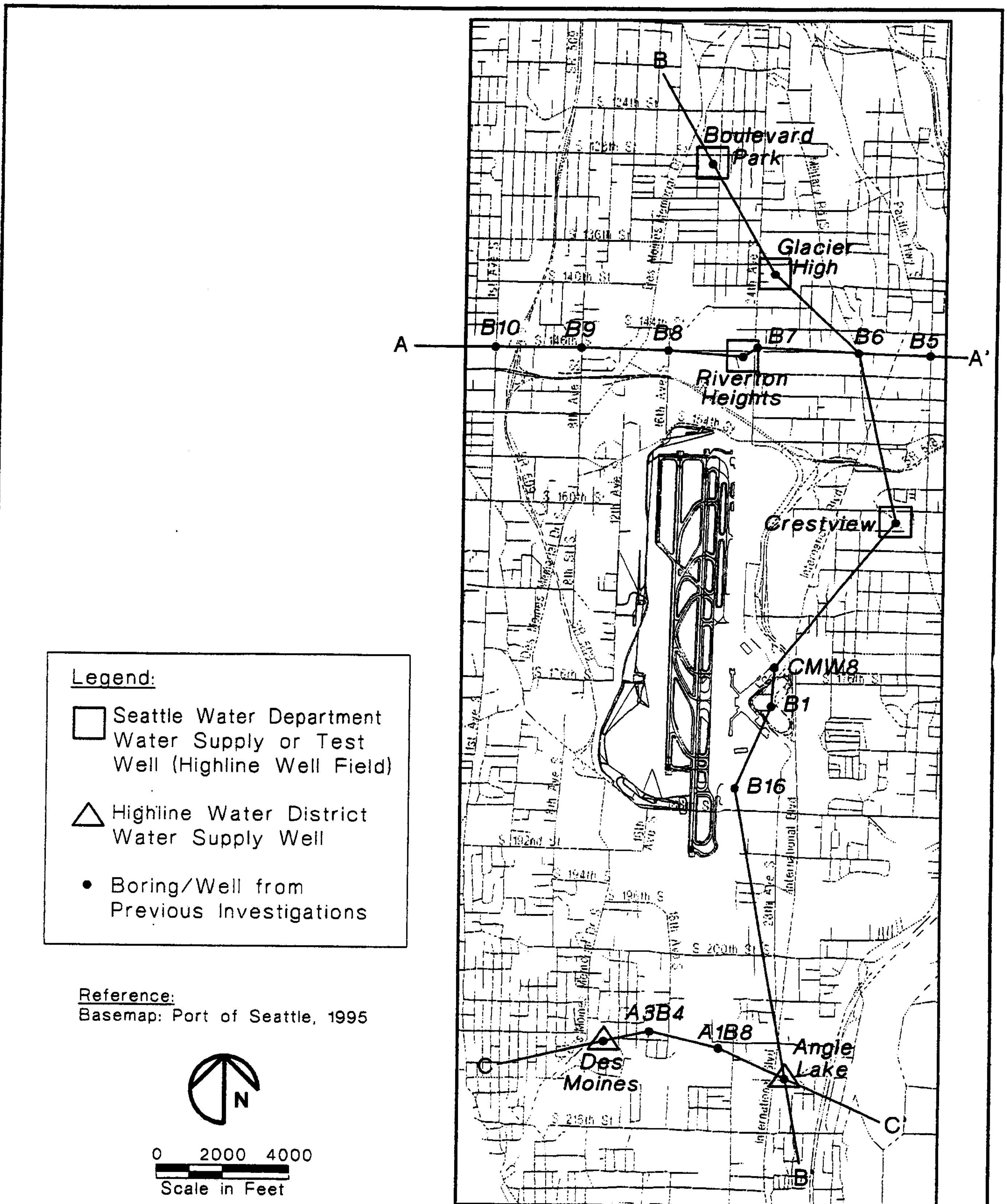
AGI TECHNOLOGIES

Surficial Geology

Shapiro/Sea-Tac EIS
Seatac, Washington

FIGURE **3**

	PROJECT NO.	DRAWN	DATE	APPROVED	REVISED	DATE
geology.dwg	14,887.003	BJA	Nov 95			



AGI TECHNOLOGIES

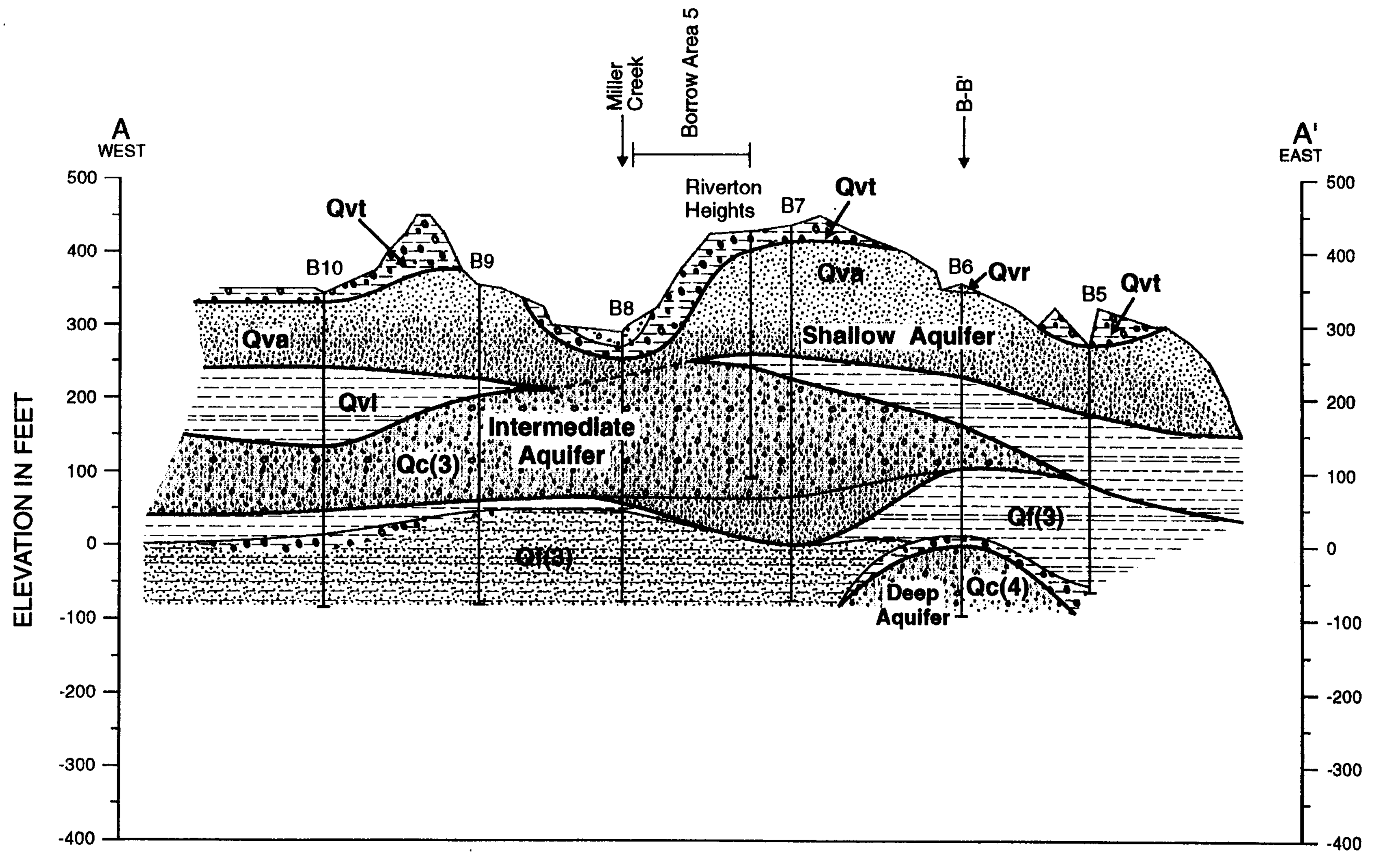
Well Locations and Cross Section Location Map

Shapiro/Sea-Tac EIS
Seatac, Washington

FIGURE **4**

crosssec.dwg	PROJECT NO.	DRAWN	DATE	APPROVED	REVISED	DATE
	14,887.003	BJA	Nov 95			

AR 039856



LEGEND:

Sand | Sand and Gravel | Silty Gravel | Silty Sand | Silt, Clay, and Silty Fine Sand | Water Bearing Zone

Approximate Scale in Feet: 0 – 2500 (horizontal); 0 – 200 (vertical)

Boring or Well (B9)

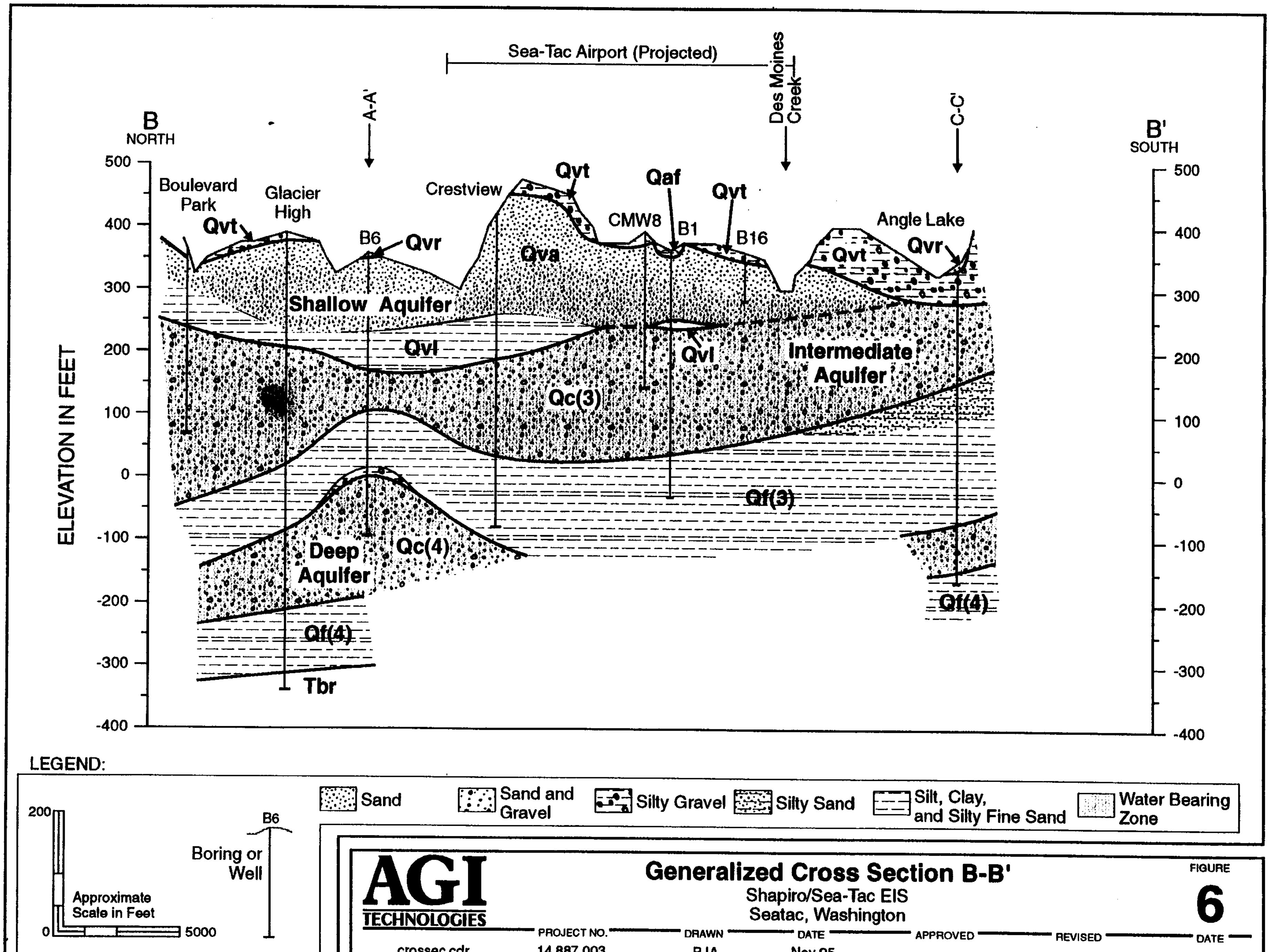
AGI TECHNOLOGIES

Generalized Cross Section A-A'

Shapiro/Sea-Tac EIS
Seatac, Washington

FIGURE **5**

	PROJECT NO.	DRAWN	DATE	APPROVED	REVISED	DATE
crossec.cdr	14,887.003	BJA	Nov 95	[signature]		



AGI TECHNOLOGIES

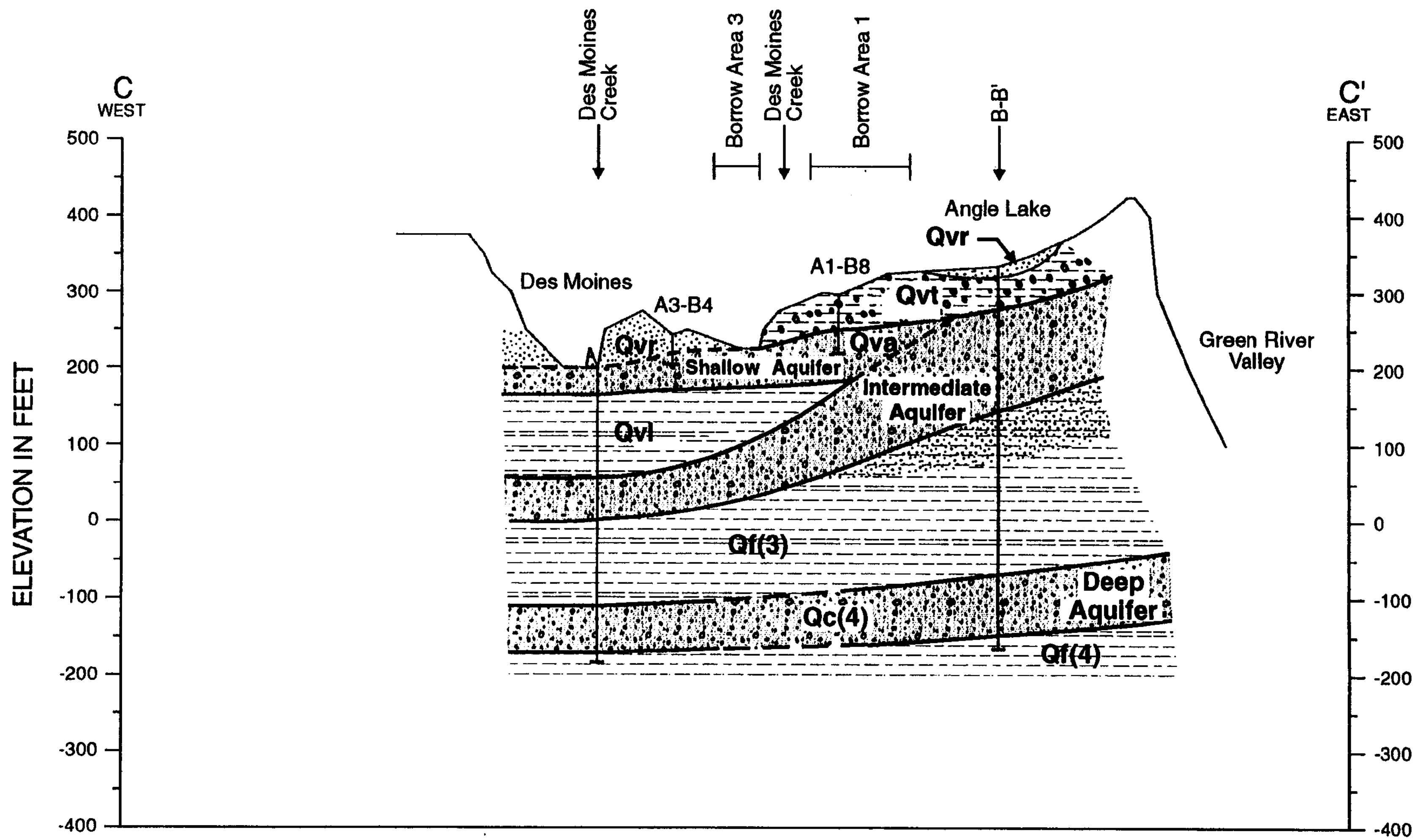
Generalized Cross Section B-B'

Shapiro/Sea-Tac EIS
Seatac, Washington

	PROJECT NO.	DRAWN	DATE	APPROVED	REVISED	DATE
crossec.cdr	14,887.003	BJA	Nov 95			

FIGURE
6

AR 039858



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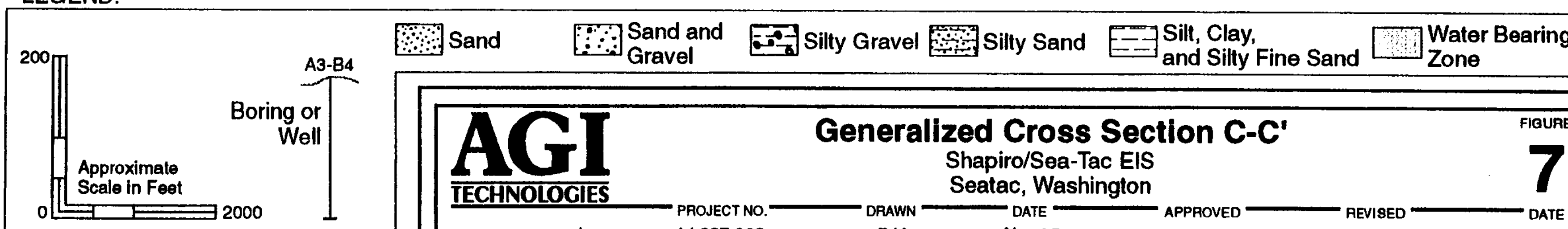

AGI TECHNOLOGIES

Generalized Cross Section C-C'

Shapiro/Sea-Tac EIS
Seatac, Washington

FIGURE **7**

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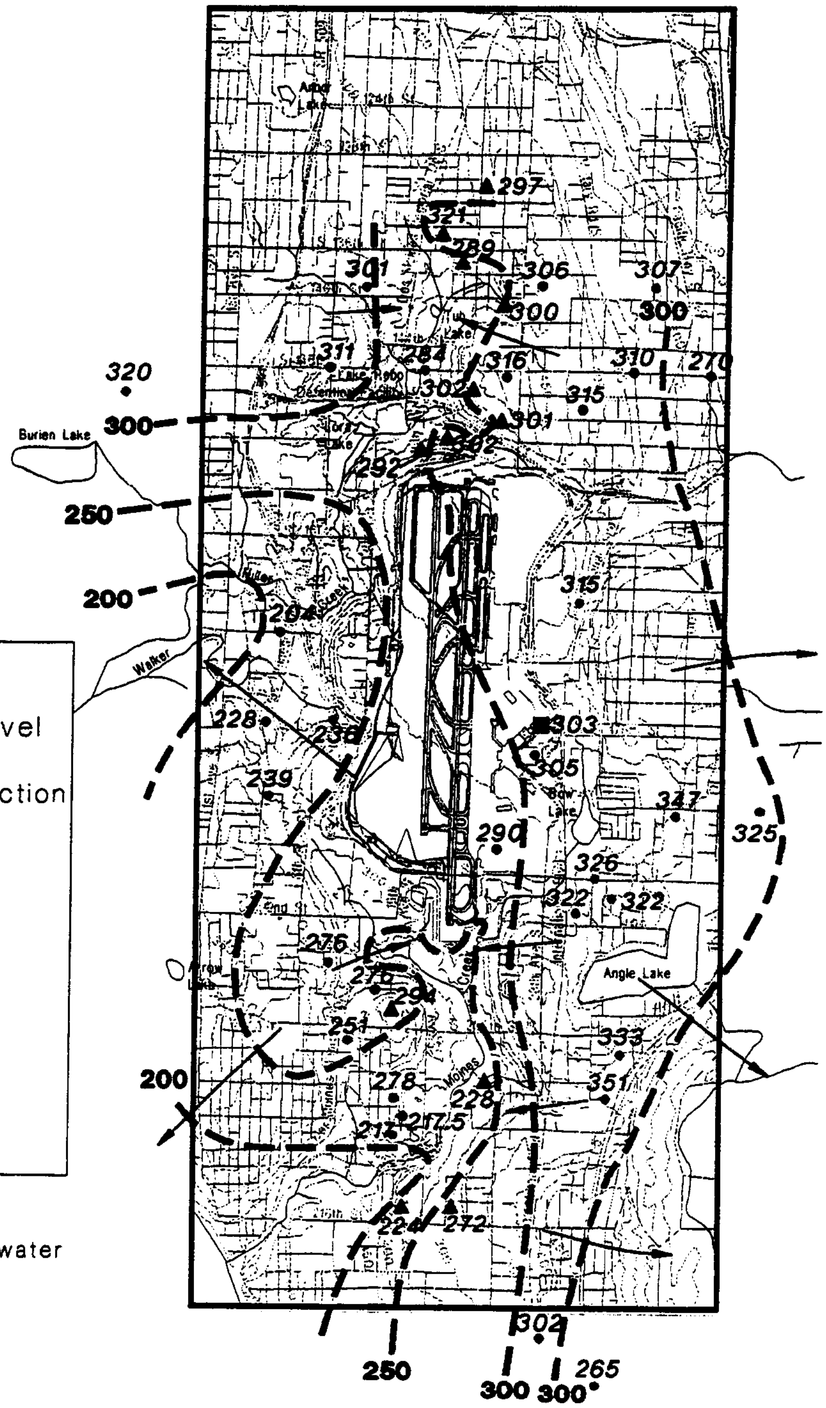
crossec.cdr	14,887.003	BJA	Nov 95			



Legend:

- Generalized Water Level Contour and Inferred Groundwater Flow Direction
- ▲ AGI Piezometers (January 1995)
- • Wells from Previous Investigations (Miscellaneous Dates)
- ■ Converse Well CMW8 (March 1994)

Reference:
Modified from King Co. Groundwater Advisory Committee, 1989.

N

0 2500 5000
Scale in Feet

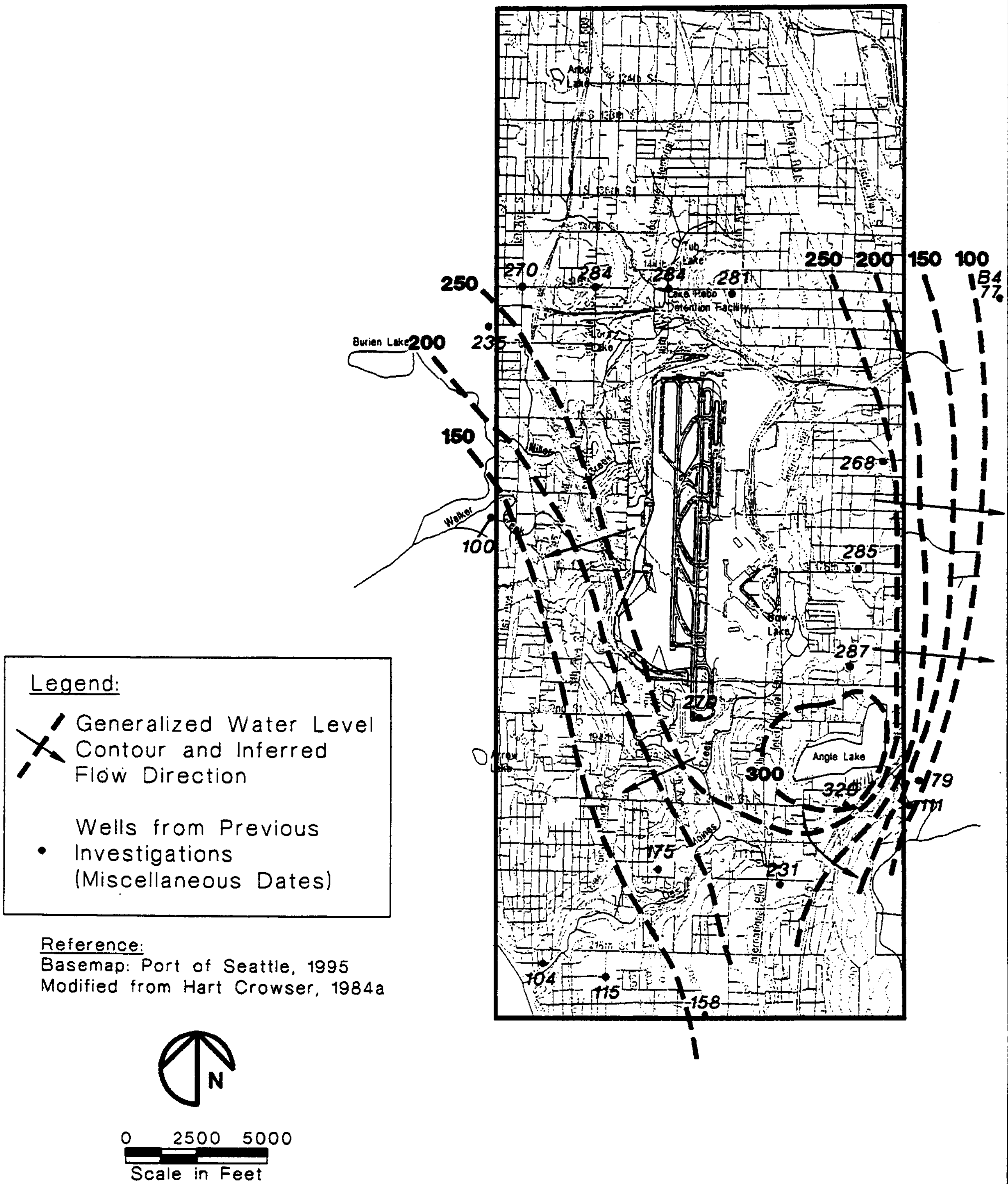
AGI TECHNOLOGIES

Generalized Groundwater Elevations-Shallow (Qva) Aquifer

Shapiro/Sea-Tac EIS
Seatac, Washington

FIGURE **8**

	PROJECT NO.	DRAWN	DATE	APPROVED	REVISED	DATE
wells2.dwg	14,887.003	BJA	Nov 95			



AGI TECHNOLOGIES

Generalized Groundwater Elevations-Intermediate Aquifer

Shapiro/Sea-Tac EIS
Seatac, Washington

FIGURE **9**

points.dwg	PROJECT NO.	DRAWN	DATE	APPROVED	REVISED	DATE
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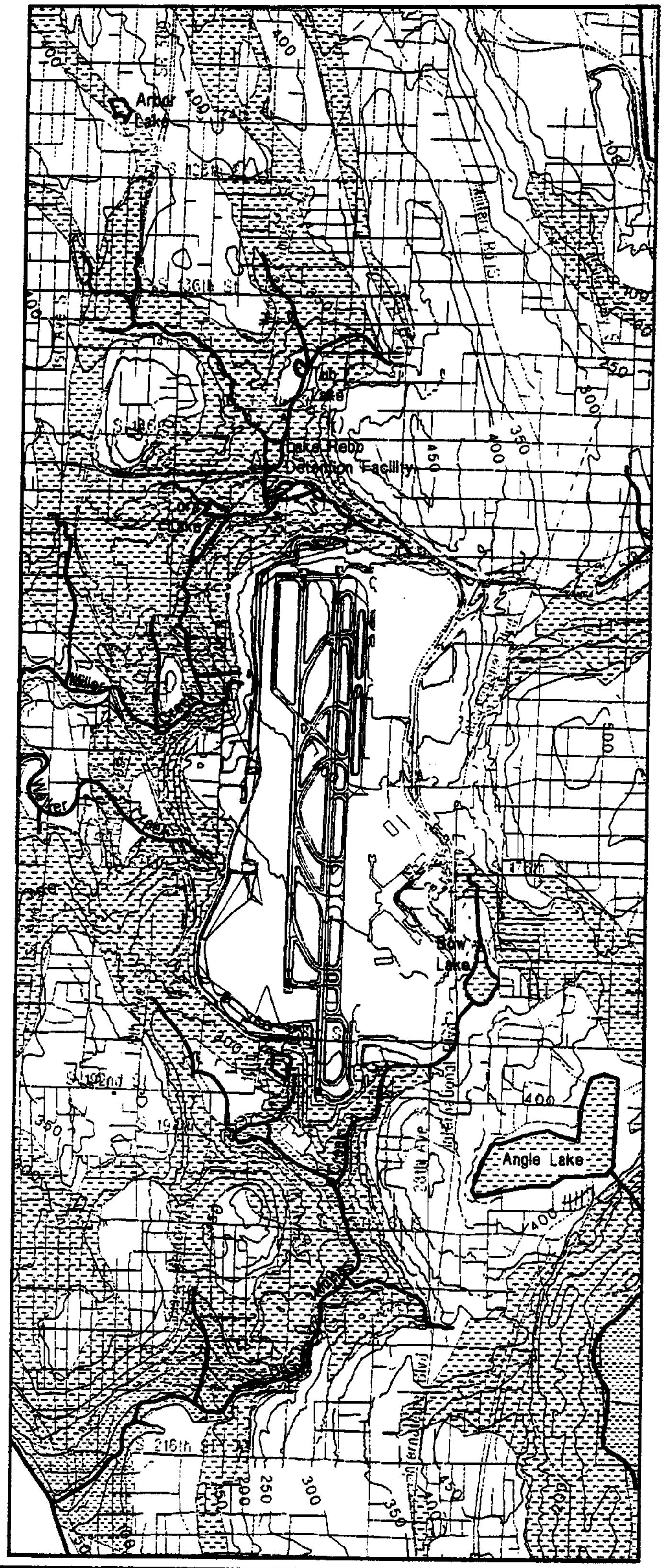


Legend:

Recharge Area

Discharge Area

Reference:
Basemap: Port of Seattle, 1995

N

0 2000 4000
Scale in Feet

AGI TECHNOLOGIES

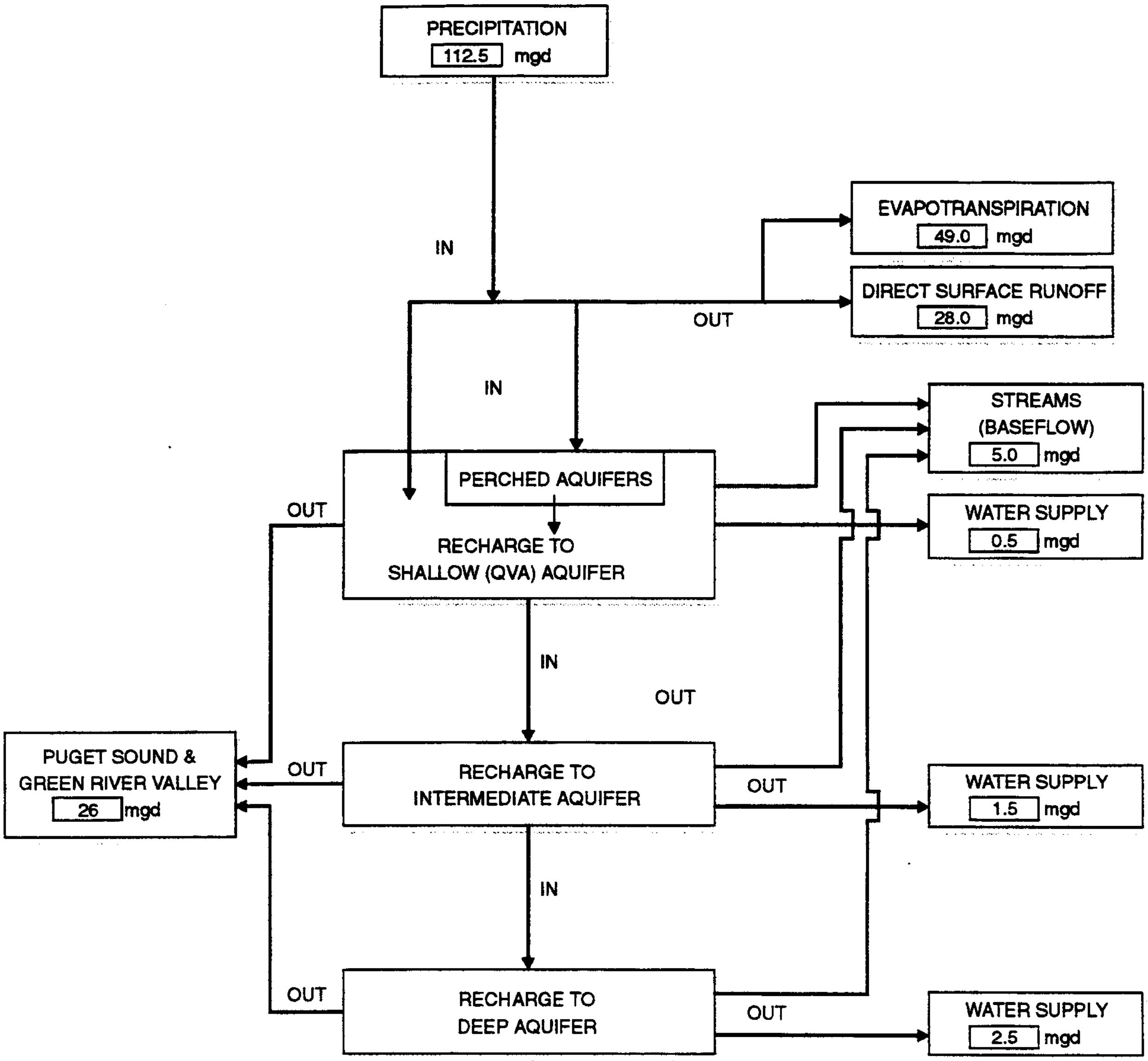
Aquifer Recharge/Discharge - Existing Conditions

Shapiro/Sea-Tac EIS
Seatac, Washington

FIGURE **10**

redis.dwg	PROJECT NO.	DRAWN	DATE	APPROVED	REVISED	DATE
	14,887.003	BJA	Nov 95	[illegible]		

AR 039862



AGI TECHNOLOGIES

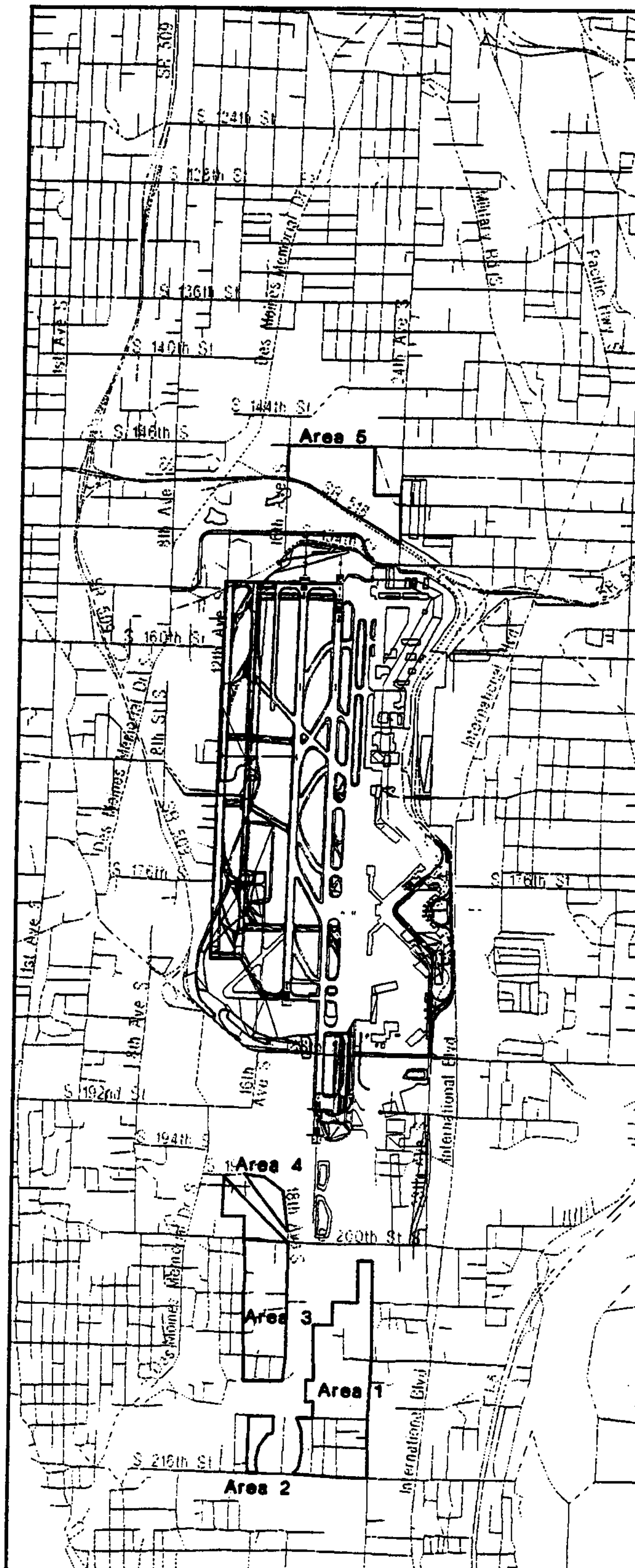
Groundwater Balance - Existing Conditions

Shapiro/Sea-Tac EIS
Seatac, Washington

FIGURE **11**

	PROJECT NO.	DRAWN	DATE	APPROVED	REVISED	DATE
waterbal.cdr	14,887.003	BJA	Nov 95	[signature]		

AR 039863



Legend:

Proposed Future Facilities (Existing Facilities with Proposed Improvements)

Borrow Area

Reference:
Basemap: Port of Seattle, 1995

N

0 2000 4000
Scale in Feet

AGI TECHNOLOGIES

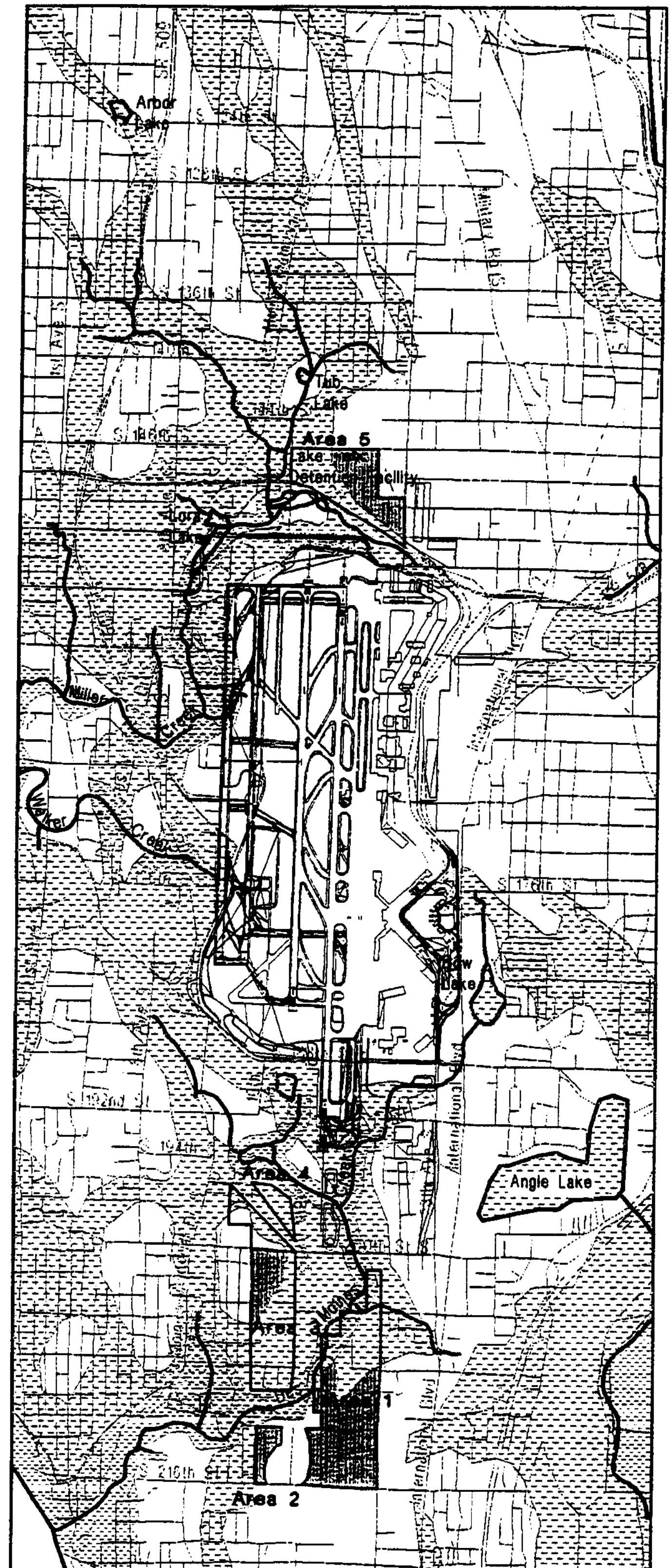
Existing Facilities with Improvements

Shapiro/Sea-Tac EIS
Seatac, Washington

FIGURE **12**

	PROJECT NO.	DRAWN	DATE	APPROVED	REVISED	DATE
Improv.dwg	14,887.003	BJA	Nov 95			

AR 039864



Legend:

- Proposed Future Facilities (Existing Facilities with Proposed Improvements)
- Borrow Area
- Filled Recharge Area
- Recharge Area Created by Till Removal
- Recharge Area
- Discharge Area

Reference:
Basemap: Port of Seattle, 1995

N

0 2000 4000
Scale in Feet

AGI TECHNOLOGIES

Aquifer Recharge/Discharge with Improvements

Shapiro/Sea-Tac EIS
Seatac, Washington

FIGURE **13**

	PROJECT NO.	DRAWN	DATE	APPROVED	REVISED	DATE
redisimp.dwg	14,887.003	BJA	Nov 95			

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AGI
TECHNOLOGIES

APPENDIX A

Boring/Well Logs

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SITEID 472919122182501 LOCAL NUMBER 23N/04E-16D02
LATITUDE 47d29m19s LONGITUDE 122d18m25s
ALTITUDE 365.00 CONST. DATE 03/25/1985
WELL DEPTH 75.00 HOLE DEPTH 75.00
WATER LEVEL 61.00 W.L. DATE 11/13/1986
SCREEN INT. 65.00 - 75.00
DRILLER HOKKAIDO
WELL OWNER SEATTLE WATER DEPT.

INT NO.	INTVL(FT)	DESCRIPTION
1 :	0- 20	GLACIAL TILL
2 :	20- 75	DENSE, DAMP TO WET, BR, F-MED SAND
3 :	75-	DENSE, DAMP, GRAY SILT

SITEID 472919122182502 LOCAL NUMBER 23N/04E-16D3
LATITUDE 47d29m19s LONGITUDE 122d18m25s
ALTITUDE 365.00 CONST. DATE 06/27/1985
WELL DEPTH 297.00 HOLE DEPTH 297.00
WATER LEVEL 7871.00 W.L. DATE 07/18/1985
SCREEN INT. 212.00 - 297.00
DRILLER HOKKAIDO
WELL OWNER SEATTLE WATER DEPT.

INT NO.	INTVL(FT)	DESCRIPTION
1 :	0- 17	BR TO GRAY SILTY,GRAV,SAND(TILL)
2 :	17- 61	BR SAND WITH OCC. GRAVEL
3 :	61- 128	BLUE-GRY SILT AND CL. SILT
4 :	128- 140	BR SL. GRAV, SILTY SAND
5 :	140- 169	BROWN SL SILTY FN-MED SAND WITH GR
6 :	169- 274	BR SANDY GRAVEL WITH COBBLES,WEATHE
7 :	274- 275	BR SILTY SANDY GRAVEL
8 :	275- 297	GRAY SD & GR, CL SILT AT BOTTOM

SITEID 472842122175801 LOCAL NUMBER 23N/04E-16K01
LATITUDE 47d28m42s LONGITUDE 122d17m58s
ALTITUDE 390.00 CONST. DATE 04/09/1985
WELL DEPTH 109.00 HOLE DEPTH 109.00
WATER LEVEL 84.00 W.L. DATE 11/13/1986
SCREEN INT. 98.00 - 108.00
DRILLER HOKKAIDO
WELL OWNER SEATTLE WATER DEPT.

INT NO.	INTVL(FT)	DESCRIPTION
1 :	0- 20	GLACIAL TILL
2 :	20- 109	DENSE, DAMP TO WET, BR, F-MED SD

SITEID 472842122175701 LOCAL NUMBER 23N/04E-16K02
LATITUDE 47d28m42s LONGITUDE 122d17m57s
ALTITUDE 390.00 CONST. DATE 04/09/1985
WELL DEPTH 320.00 HOLE DEPTH 729.00
WATER LEVEL 120.00 W.L. DATE 11/13/1986
SCREEN INT. 220.00 - 320.00
DRILLER HOKKAIDO
WELL OWNER SEATTLE WATER DEPT.

INT NO.	INTVL(FT)	DESCRIPTION
1 :	0- 13	DAMP, GRY&BR, SLIGHTLY GR, SDY SLT
2 :	13- 152	DAMP, BR, F-MED SD W/SOME GR ZONES
3 :	152- 165	WET, BLUE-GRY, VERY FINE SANDY SLT
4 :	165- 185	MOIST, BLUE-GRY, SLIGHTLY F SDY SLT
5 :	185- 199	DAMP,GRY,YELL,VERY SLTY, GR SAND
6 :	199- 330	WET, GRY, SLIGHTLY SLTY TO CLEAN
7 :	330- 363	WET, GRY, GRAVELLY SAND
8 :	363- 438	DAMP, GRAY, SANDY AND FINE SDY SILT
9 :	438- 477	MOIST TO WET, GRAY, SILTY TO CLEAN
10 :	477- 580	WET, GRAY, SANDY GRAVEL W/COBBLE
11 :	580- 602	WET, GRAY, SANDY, COBBLY GR
12 :	602- 619	DAMP, GRAY, SILTY CLY AND CLYEY SLT
13 :	619- 623	SET, GRAY, SLIGHTLY GRAVELLY SAND
14 :	623- 704	DAMP, GRAY, SILTY CLY AND CLYEY SLT
15 :	704- 729	DAMP, WHITE TO LIGHT GRAY SANDSTONE

SITEID 472834122183101 LOCAL NUMBER 23N/04E-16N01
LATITUDE 47d28m34s LONGITUDE 122d18m31s
ALTITUDE 335.00 CONST. DATE 12/10/1987
WELL DEPTH 47.00 HOLE DEPTH 54.50
WATER LEVEL 292.00 W.L. DATE 12/07/1987
SCREEN INT. 42.00 - 47.00
DRILLER GEOBORING
WELL OWNER SEATTLE WATER DEPARTMENT

INT NO.	INTVL(FT)	DESCRIPTION
1 :	0- 7	DAMP, GRAY TO BR, SLTLY SLTY, GR SD
2 :	7- 12	DAMP, GRAY, CLEAN, M-F SAND
3 :	12- 16	GRAVELLY SAND
4 :	16- 35	BROWN SAND
5 :	35- 47	GRAVELLY SAND
6 :	47- 55	VERY DENSE, DAMP, GRAY TO BLUE, CLY

SITEID 472843122190901 LOCAL NUMBER 23N/04E-17K01
LATITUDE 47d28m43s LONGITUDE 122d19m09s
ALTITUDE 320.00 CONST. DATE 08/21/1973
WELL DEPTH 99.00 HOLE DEPTH 110.00
WATER LEVEL 19.00 W.L. DATE 11/21/1984
SCREEN INT. 89.00 - 94.00
DRILLER STATEWIDE DR
WELL OWNER HELLUMS JAMES

INT NO.	INTVL(FT)	DESCRIPTION
1 :	0- 20	SILT, PEAT, BROWN
2 :	20- 25	HARD PAN
3 :	25- 89	SANDY SILT (BROWN)
4 :	89- 99	SAND, BROWN WATER
5 :	99- 110	SILT, PEAT, BROWN GRAY

B10

SITEID 472820122200001 LOCAL NUMBER 23N/04E-19A01
LATITUDE 47d28m20s LONGITUDE 122d20m00s
ALTITUDE 343.60 CONST. DATE 04/23/1982
WELL DEPTH 110.00 HOLE DEPTH 427.50
WATER LEVEL 175.00 W.L. DATE 08/24/1982
SCREEN INT. 80.00 - 100.00
DRILLER PITCHER

INT NO.	INTVL(FT)	DESCRIPTION
1 :	0- 13	GLACIAL TILL
2 :	13- 25	GRNSH-GRY, VERY HARD, CLAYEY SILT
3 :	25- 37	GRAY, VERY DENSE, SILTY SAND
4 :	37- 101	GRAY, VERY DENSE, F-MED SAND
5 :	101- 123	GRAY, VERY DENSE, SILT
6 :	123- 134	GRAY, VERY DENSE FINE SAND
7 :	134- 144	GRAY, VERY DENSE, SILTY SAND
8 :	144- 164	GRAY, VERY DENSE FINE SAND
9 :	164- 189	GRAY, VERY HARD, CLAYEY SILT
10 :	189- 194	GRAY, VERY DENSE, FINE SAND AND SLT
11 :	194- 210	GRAY VERY DENSE CLAYEY SILT
12 :	210- 218	GRAY, VERY DENSE, GRAVELLY SAND
13 :	218- 224	GLACIAL TILL
14 :	224- 244	GRN-GRY, VERY DENSE, F-CRSE SAND
15 :	244- 250	GRAY, V DENSE, HARD, SD & CLY SILT
16 :	250- 298	GRY-BR, VERY DENSE SANDY GRAVEL
17 :	298- 308	GRAY, VERY DENSE FINE SAND
18 :	308- 330	GRAY, VERY HARD, SILTY CLAY
19 :	330- 352	GLACIAL TILL
20 :	352- 359	GRY-BR, VERY DENSE, SAND
21 :	359- 371	GRY, VERY HARD, SILTY CLAY
22 :	371- 374	GRAY, VERY DENSE, FINE SILT AND SD
23 :	374- 428	GRAY, VERY HARD, SILTY CLAY

SITEID	472820122200002	LOCAL NUMBER	23N/04E-19A02
LATITUDE	47d28m20s	LONGITUDE	122d20m00s
ALTITUDE	343.60	CONST. DATE	04/23/1982
WELL DEPTH	320.00	HOLE DEPTH	427.00
WATER LEVEL	72.00	W.L. DATE	07/19/1982
SCREEN INT.	260.00 - 290.00		
DRILLER	PITCHER		

INT NO.	INTVL(FT)	DESCRIPTION
1 :	0- 13	GLACIAL TILL
2 :	13- 25	GRNSH-GRY, VERY HARD, CLAYEY SILT
3 :	25- 37	GRAY, VERY DENSE, SILTY SAND
4 :	37- 101	GRAY, VERY DENSE, F-MED SAND
5 :	101- 123	GRAY, VERY DENSE, SILT
6 :	123- 134	GRAY, VERY DENSE FINE SAND
7 :	134- 144	GRAY, VERY DENSE, SILTY SAND
8 :	144- 164	GRAY, VERY DENSE FINE SAND
9 :	164- 189	GRAY, VERY HARD, CLAYEY SILT
10 :	189- 194	GRAY, VERY DENSE, FINE SAND & SILT
11 :	194- 210	GRAY VERY DENSE CLAYEY SILT
12 :	210- 218	GRAY, VERY DENSE, GRAVELLY SAND
13 :	218- 224	GLACIAL TILL
14 :	224- 244	GRN-GRY, VERY DENSE, F-CRSE SAND
15 :	244- 250	GRAY, V DENSE, HARD, SD & CLY SILT
16 :	250- 298	GRY-BR, VERY DENSE SANDY GRAVEL
17 :	298- 308	GRAY, VERY DENSE FINE SAND
18 :	308- 330	GRAY, VERY HARD, SILTY CLAY
19 :	330- 352	GLACIAL TILL
20 :	352- 359	GRY-BR, VERY DENSE, SAND
21 :	359- 371	GRAY, VERY HARD, SILTY CLAY
22 :	371- 374	GRAY, VERY DENSE, FINE SILT AND SD
23 :	374- 428	GRAY, VERY HARD, SILTY CLAY

SITEID	472822122201901	LOCAL NUMBER	23N/04E-19B01
LATITUDE	47d28m22s	LONGITUDE	122d20m19s
ALTITUDE	375.00	CONST. DATE	03/18/1985
WELL DEPTH	350.00	HOLE DEPTH	362.00
WATER LEVEL	119.00	W.L. DATE	05/20/1985
SCREEN INT.	265.00 - 342.00		
DRILLER	RICHARDSON		
WELL OWNER	KCWD 49		

INT NO.	INTVL(FT)	DESCRIPTION
1 :	0- 26	BROWN SANDY TILL
2 :	26- 48	BROWN SAND W/SOME SILT AND GRAVEL
3 :	48- 56	BROWN GRAVEL WITH SOME SAND
4 :	56- 72	BROWN SAND WITH SOME GRAVEL
5 :	72- 97	BROWN COMPACTED SILT AND FINE SAND
6 :	97- 106	BROWN COMPACTED SILT, SAND & GRAVEL
7 :	106- 109	BROWN SAND WITH SILT AND SAND
8 :	109- 126	BROWN MODERATLY COMPACTED SLT,SD&GR
9 :	126- 145	GRY SILT AND F-SAND W/PEAT & WOOD
10 :	145- 159	GRAY SILTY CLAY
11 :	159- 168	GRAY SILTY CLAY W/GR & SD
12 :	168- 208	GRY TILL COMPACTED SD GR SLT & CLY
13 :	208- 246	GRAY SILT CLAY AND FINE SD W/WOOD
14 :	246- 257	GRY TO BLK SD & GR W/SOME FINE
15 :	257- 263	SAND AND SILT MATRIX
16 :	263- 276	GRY TO BLK SAND AND GR W/GRY CLAY
17 :	276- 278	GRAY SILT
18 :	278- 287	GRAY TO BLK GRAVEL AND SAND
19 :	287- 302	GRY POORLY SORTED SD & GR W/ SLT
20 :	302- 343	GRY GRN AND BLK GR AND MED-CRS SD
21 :	343- 345	GREEN CLAY
22 :	345- 359	GR AND SD W/GRN CLAY & GRY SAND
23 :	359- 362	FINE GRY SD AND CLAY

SITEID	472822122201902	LOCAL NUMBER	23N/04E-19B02
LATITUDE	47d28m22s	LONGITUDE	122d20m19s
ALTITUDE	375.00	CONST. DATE	02/04/1986
WELL DEPTH	354.00	HOLE DEPTH	620.00
WATER LEVEL	120.00	W.L. DATE	07/16/1986
SCREEN INT.	284.00 - 304.00		
DRILLER	RICHARDSON		
WELL OWNER	KCWD 49		

INT NO.	INTVL(FT)	DESCRIPTION
1 :	0- 55	GRAY GLACIAL TILL, SOMEWHAT SANDY
2 :	55- 61	SAND AND GRAVEL WITH CLAY
3 :	61- 65	LOOSE COARSE GRAVEL, DRY
4 :	65- 90	BROWN SILTY SAND
5 :	90- 94	GRAY LOOSE SAND AND GRAVEL
6 :	94- 105	GRAY SAND MUD CLAY WITH SOME GRAVEL
7 :	105- 118	GRAY BROWN SAND AND GR W/CLAY
8 :	118- 120	BROWN SILTY CLAY AND SAND
9 :	120- 135	BROWN SILTY CLAY AND SAND
10 :	135- 162	COMPACTED GRAY SILT
11 :	162- 200	GRAY CLAY AND GRAVEL
12 :	200- 212	COMPACTED GRAY CLAY COBBLES AND SD
13 :	212- 362	GRY SILT AND F-MED SD SOME WOOD
14 :	362- 370	GRAY SANDY SILT W/SOME GRAVEL
15 :	370- 399	GRAY SILTY SAND WITH SOME GRAVEL
16 :	399- 419	DARK GRAY SILT AND CLAY
17 :	419- 426	DK GRAY GRN, SLT WITH PEAT

B8

SITEID 472820122184601 LOCAL NUMBER 23N/04E-20A01
LATITUDE 47d28m20s LONGITUDE 122d18m46s
ALTITUDE 290.40 CONST. DATE 05/06/1982
WELL DEPTH 15.00 HOLE DEPTH 367.00
WATER LEVEL 7.50 W.L. DATE 05/10/1982
SCREEN INT. 10.00 - 15.00
DRILLER PITCHER

INT NO.	INTVL(FT)	DESCRIPTION
1 :	0- 20	YELLWSH-BR, VERY DENSE, SANDY GR
2 :	20- 38	GLACIAL TILL
3 :	38- 44	GRAY, VERY DENSE, F-CRS SAND
4 :	44- 65	GRAY, VERY DENSE F-CRS SILTY SAND
5 :	65- 110	GRAY VERY DENSE, F-CRS SAND
6 :	110- 117	GRNSH-BLK, VERY DENSE GRVL & COBBLE
7 :	117- 123	GRAY, VERY DENSE, SANDY GRAVEL
8 :	123- 128	GRAY, VERY DENSE, SLTY SDY GRAVEL
9 :	128- 133	GRAY, VERY HARD SILT
10 :	133- 140	BROWSH-BLK, VERY DENSE, SILTY SAND
11 :	140- 197	GRAY, VERY DENSE, GRAVEL AND SAND
12 :	197- 224	GRAY, VERY DENSE, SANDY GRAVEL
13 :	224- 244	GRAY, VERY DENSE, SAND
14 :	244- 254	GRAY, VERY DENSE SAND AND SILT
15 :	254- 343	GRAY VERY HARD CLAYEY SILT
16 :	343- 347	GRAY, VERY DENSE SAND
17 :	347- 356	GRAY, VERY HARD, CLAYEY SILT
18 :	356- 367	GRAY VERY DENSE SANDY SILT

SITEID 472820122184603 LOCAL NUMBER 23N/04E-20A03
LATITUDE 47d28m20s LONGITUDE 122d18m46s
ALTITUDE 290.40 CONST. DATE 05/06/1982
WELL DEPTH 365.00 HOLE DEPTH 367.00
WATER LEVEL 40.30 W.L. DATE 07/16/1982
SCREEN INT. 340.00 - 350.00
DRILLER PITCHER

INT NO.	INTVL(FT)	DESCRIPTION
1 :	0- 20	YELLWSH-BRW, VERY DENSE, SANDY GRV
2 :	20- 38	GLACIAL TILL
3 :	38- 44	GRAY, V DENSE, F-COARSE SAND
4 :	44- 65	GRAY, VERY DENSE F-COARSE SLTY SD
5 :	65- 110	GRAY VERY DENSE, F-COARSE SAND
6 :	110- 117	GRNSH BLK, VERY DENSE GR & COBBLES
7 :	117- 123	GRAY, VERY DENSE, SANDY GRAVEL
8 :	123- 128	GRAY, VERY DENSE, SILTY SDY GRAVEL
9 :	128- 133	GRAY, VERY HARD SILTY
10 :	133- 140	BROWSH BLK, VERY DENSE, SILTY SAND
11 :	140- 197	GRAY, VERY DENSE, GRAVEL & SAND
12 :	197- 224	GRAY, VERY DENSE, SANDY GRAVEL
13 :	224- 244	GRAY, VERY DENSE, SAND
14 :	244- 254	GRAY, VERY DENSE SAND AND SILT
15 :	254- 343	GRAY VERY HARD, CLAYEY SILT
16 :	343- 347	GRAY, VERY DENSE SAND
17 :	347- 356	GRAY, VERY HARD, CLAYEY SILT
18 :	356- 367	GRAY VERY DENSE SANDY SILT

SITEID 472820122184602 LOCAL NUMBER 23N/04E-20A02
LATITUDE 47d28m20s LONGITUDE 122d18m46s
ALTITUDE 290.40 CONST. DATE 05/06/1982
WELL DEPTH 195.50 HOLE DEPTH 367.00
WATER LEVEL 6.50 W.L. DATE 05/10/1982
SCREEN INT. 150.00 - 180.00
DRILLER PITCHER

INT NO.	INTVL(FT)	DESCRIPTION
1 :	0- 20	YELLWSH-BR, VERY DENSE, SANDY GRVL
2 :	20- 38	GLACIAL TILL
3 :	38- 44	GRAY, VERY DENSE, F-COARSE SAND
4 :	44- 65	GRAY, VERY DENSE F-COARSE SLTY SD
5 :	65- 110	GRAY VERY DENSE, F-COARSE SAND
6 :	110- 117	GREENISH BLACK, VERY DENSE GR & CBL
7 :	117- 123	GRAY, VERY DENSE, SANDY GRAVEL
8 :	123- 128	GRAY, VERY DENSE, SLTY SDY GRAVEL
9 :	128- 133	GRAY, VERY HARD SILT
10 :	133- 140	BRWNSH BLK, VERY DENSE, SILTY SAND
11 :	140- 197	GRAY, VERY DENSE, GRAVEL AND SAND
12 :	197- 224	GRAY, VERY DENSE, SANDY GRAVEL
13 :	224- 244	GRAY, VERY DENSE, SAND
14 :	244- 254	GRAY, VERY DENSE SAND AND SILT
15 :	254- 343	GRAY VERY HARD, CLAYEY SILT
16 :	343- 347	GRAY, VERY DENSE SAND
17 :	347- 356	GRAY, VERY HARD, CLAYEY SILT
18 :	356- 367	GRAY VERY DENSE SANDY SILT

SITEID 472821122192101 LOCAL NUMBER 23N/04E-20C01
LATITUDE 47d28m21s LONGITUDE 122d19m21s
ALTITUDE 354.80 CONST. DATE 06/07/1982 B9
WELL DEPTH 70.00 HOLE DEPTH 435.00
WATER LEVEL 44.20 W.L. DATE 06/15/1982
SCREEN INT. 35.00 - 50.00
DRILLER PITCHER

INT NO.	INTVL(FT)	DESCRIPTION
1 :	0- 13	YELLWSH-BRW, DENSE, SILTY SANDY GR
2 :	13- 89	YELLWSH-BR, DENSE, F-MED SAND
3 :	89- 130	GRAY, VERY DENSE, SILTY SAND
4 :	130- 149	GRAY, VERY HARD, SILTY CLAY
5 :	149- 153	GRAY, VERY HARD CLAYEY SILT
6 :	153- 165	GRAY, VERY DENSE, GRAVEL AND SAND
7 :	165- 176	GRAY, VERY DENSE, SILTY SAND
8 :	176- 194	GRAY, VERY DENSE GRAVEL AND SAND
9 :	194- 204	GRAY, VERY HARD, CLAYEY SILT
10 :	204- 214	GRAY, VERY DENSE, SAND
11 :	214- 294	GRAY, VERY DENSE GRAVEL AND SAND
12 :	294- 309	GRAY, VERY HARD, CLAYEY SILT
13 :	309- 318	GLACIAL TILL
14 :	318- 323	GRAY, VERY HARD, CLAYEY SILT
15 :	323- 333	GRAY, VERY DENSE, SANDY SILT
16 :	333- 367	GRAY, VERY HARD SILT
17 :	367- 373	GRAY, VERY HARD SILTY CLAY
18 :	373- 393	GRAY, VERY HARD, CLAYEY SILT
19 :	393- 414	GRAY, VERY HARD, SILTY CLAY
20 :	414- 435	GRAY, VERY HARD CLAYEY SILT

SITEID 472821122192102 LOCAL NUMBER 23N/04E-20C02
LATITUDE 47d28m21s LONGITUDE 122d19m21s
ALTITUDE 354.80 CONST. DATE 06/07/1982
WELL DEPTH 289.50 HOLE DEPTH 435.00
WATER LEVEL 73.10 W.L. DATE 06/18/1982
SCREEN INT. 234.00 - 274.00
DRILLER PITCHER

INT NO.	INTVL(FT)	DESCRIPTION
1 :	0- 13	YELLWSH-BR, DENSE, SILTY SANDY GR
2 :	13- 89	YELLWSH-BR, DENSE, F-MED SAND
3 :	89- 130	GRAY, VERY DENSE, SILTY SAND
4 :	130- 149	GRAY, VERY HARD, SILTY CLAY
5 :	149- 153	GRAY, VERY HARD CLAYEY SILT
6 :	153- 165	GRAY, VERY DENSE, GRAVEL AND SAND
7 :	165- 176	GRAY, VERY DENSE, SILTY SAND
8 :	176- 194	GRAY, VERY DENSE GRAVEL AND SAND
9 :	194- 204	GRAY, VERY HARD, CLAYEY SILT
10 :	204- 214	GRAY, VERY DENSE, SAND
11 :	214- 294	GRAY, VERY DENSE GRAVEL AND SAND
12 :	294- 309	GRAY, VERY HARD, CLAYEY SILT
13 :	309- 318	GLACIAL TILL
14 :	318- 323	GRAY, VERY HARD, CLAYEY SILT
15 :	323- 333	GRAY, VERY DENSE, SANDY SILT
16 :	333- 367	GRAY, VERY HARD SILT
17 :	367- 373	GRAY, VERY HARD SILTY CLAY
18 :	373- 393	GRAY, VERY HARD, CLAYEY SILT
19 :	393- 414	GRAY, VERY HARD, SILTY CLAY
20 :	414- 435	GRAY, VERY HARD CLAYEY SILT

SITEID 472821122192103 LOCAL NUMBER 23N/04E-20C03
LATITUDE 47d28m21s LONGITUDE 122d19m21s
ALTITUDE 354.80 CONST. DATE 06/07/1982
WELL DEPTH 341.00 HOLE DEPTH 435.00
WATER LEVEL 83.00 W.L. DATE 05/20/1982
SCREEN INT. 316.00 - 326.00
DRILLER PITCHER

INT NO.	INTVL(FT)	DESCRIPTION
1 :	0- 13	YELLWSH-BR, DENSE, SLTY SDY GRAVEL
2 :	13- 89	YELLWSH-BR, DENSE, F-MED SAND
3 :	89- 130	GRAY, VERY DENSE, SILTY SAND
4 :	130- 149	GRAY, VERY HARD, SILTY CLAY
5 :	149- 153	GRAY, VERY HARD CLAYEY SILT
6 :	153- 165	GRAY, VERY DENSE, GRAVEL AND SAND
7 :	165- 176	GRAY, VERY DENSE, SILTY SAND
8 :	176- 194	GRAY, VERY DENSE GRAVEL AND SAND
9 :	194- 204	GRAY, VERY HARD, CLAYEY SILT
10 :	204- 214	GRAY, VERY DENSE, SAND
11 :	214- 294	GRAY, VERY DENSE GRAVEL AND SAND
12 :	294- 309	GRAY, VERY HARD, CLAYEY SILT
13 :	309- 318	GLACIAL TILL
14 :	318- 323	GRAY, VERY HARD, CLAYEY SILT
15 :	323- 333	GRAY, VERY DENSE, SANDY SILT
16 :	333- 367	GRAY, VERY HARD SILT
17 :	367- 373	GRAY, VERY HARD SILTY CLAY
18 :	373- 393	GRAY, VERY HARD, CLAYEY SILT
19 :	393- 414	GRAY, VERY HARD, SILTY CLAY
20 :	414- 435	GRAY, VERY HARD CLAYEY SILT

SITEID 472821122192104 LOCAL NUMBER 23N/04E-20C04
LATITUDE 47d28m21s LONGITUDE 122d19m21s
ALTITUDE 354.80 CONST. DATE 06/07/1982
WELL DEPTH 435.00 HOLE DEPTH 435.00
WATER LEVEL 84.40 W.L. DATE 05/03/1982
SCREEN INT. 410.00 - 415.00
DRILLER PITCHER

INT NO.	INTVL(FT)	DESCRIPTION
1 :	0- 13	YELLWSH-BR, DENSE, SILTY SNDY GRVL
2 :	13- 89	YELLWSH-BR, DENSE, F-MED SAND
3 :	89- 130	GRAY, VERY DENSE, SILTY SAND
4 :	130- 149	GRAY, VERY HARD, SILTY CLAY
5 :	149- 153	GRAY, VERY HARD CLAYEY SILT
6 :	153- 165	GRAY, VERY DENSE, GRAVEL AND SAND
7 :	165- 176	GRAY, VERY DENSE, SILTY SAND
8 :	176- 194	GRAY, VERY DENSE GRAVEL AND SAND
9 :	194- 204	GRAY, VERY HARD, CLAYEY SILT
10 :	204- 214	GRAY, VERY DENSE, SAND
11 :	214- 294	GRAY, VERY DENSE GRAVEL AND SAND
12 :	294- 309	GRAY, VERY HARD, CLAYEY SILT
13 :	309- 318	GLACIAL TILL
14 :	318- 323	GRAY, VERY HARD, CLAYEY SILT
15 :	323- 333	GRAY, VERY DENSE, SANDY SILT
16 :	333- 367	GRAY, VERY HARD SILT
17 :	367- 373	GRAY, VERY HARD SILTY CLAY
18 :	373- 393	GRAY, VERY HARD, CLAYEY SILT
19 :	393- 414	GRAY, VERY HARD, SILTY CLAY
20 :	414- 435	GRAY, VERY HARD CLAYEY SILT

SITEID 472823122180501 LOCAL NUMBER 23N/04E-21B01
LATITUDE 47d28m23s LONGITUDE 122d18m05s
ALTITUDE 436.80 CONST. DATE 05/25/1982
WELL DEPTH 167.00 HOLE DEPTH 512.00
WATER LEVEL 122.30 W.L. DATE 07/16/1982
SCREEN INT. 137.00 - 147.00
DRILLER

B7

INT NO.	INTVL(FT)	DESCRIPTION
1 :	0- 6	WEATHERED GLACIAL TILL
2 :	6- 22	GLACIAL TILL
3 :	22- 118	GRAY, V DENSE, F-COARSE SAND
4 :	118- 134	GRAY, VERY DENSE GRAVELLY SAND
5 :	134- 141	GRAY, VERY DENSE SAND
6 :	141- 164	GRAY, VERY DENSE SILTY SAND
7 :	164- 179	GRAY, VERY DENSE, SAND AND GRAVEL
8 :	179- 182	GRAY, VERY DENSE SAND
9 :	182- 217	GRAY, VERY DENSE SAND AND SILT
10 :	217- 230	GRAY, VERY DENSE SAND
11 :	230- 286	GRAY VERY DENSE, SILTY GRVL & SAND
12 :	286- 370	GRAY, GRAVEL AND SAND
13 :	370- 400	GRAY, VERY DENSE SAND
14 :	400- 403	GRAY, VERY DENSE SILTY SAND
15 :	403- 413	GRAY, VERY DENSE SAND
16 :	413- 418	GRAY, VERY DENSE SILTY SAND
17 :	418- 437	GRAY, VERY DENSE SAND
18 :	437- 448	GRAY, VERY DENSE SILTY SAND
19 :	448- 453	GRAY, VERY HARD, CLAYEY SILT
20 :	453- 458	GRAY, VERY DENSE, SAND
21 :	458- 473	GRAY, VERY DENSE, SAND AND SILT
22 :	473- 483	GRAY, VERY HARD, SILTY CLAY

SITEID 472820122181401 LOCAL NUMBER 23N/04E-21C03
LATITUDE 47d28m20s LONGITUDE 122d18m14s
ALTITUDE 429.00 CONST. DATE 07/29/1982
WELL DEPTH 337.00 HOLE DEPTH 337.00
WATER LEVEL 149.00 W.L. DATE 08/24/1928
SCREEN INT. 285.00 - 325.00
DRILLER HOKKAIDO
WELL OWNER PORT OF SEATTLE

INT NO.	INTVL(FT)	DESCRIPTION
1 :	0- 28	GLACIAL TILL
2 :	28- 36	GRYBRWN, V DENSE, F-CRS SLTY SAND
3 :	36- 111	GRY BROWN, V DENSE, F-MED SAND
4 :	111- 151	GRY BROWN, V DENSE GRAVELLY SAND
5 :	151- 170	GRY BROWN, VERY DENSE F-CRS SAND
6 :	170- 185	GRAY, VERY HARD, SILT
7 :	185- 226	GRY, V DENSE, SDY GRAVEL W/OCC. ORG
8 :	226- 240	GRY, V DENSE, GRAVELLY SD W/OC.ORG
9 :	240- 244	GRAY, V DENSE SANDY SILT
10 :	244- 274	GRAY, VERY DENSE SANDY GRAVEL
11 :	274- 337	GRAY, VERY DENSE SANDY GRAVEL

SITEID 472810122173701 LOCAL NUMBER 23N/04E-21H07
LATITUDE 47d28m10s LONGITUDE 122d17m37s
ALTITUDE 410.00 CONST. DATE 06/01/1985
WELL DEPTH 107.50 HOLE DEPTH 107.50
WATER LEVEL 95.00 W.L. DATE 07/18/1985
SCREEN INT. 95.00 - 105.00
DRILLER HOKKAIDO
WELL OWNER SEATTLE WATER DEPT.

INT NO.	INTVL(FT)	DESCRIPTION
1 :	0- 9	DAMP, BR, GRAVELLY, SLTY SAND
2 :	9- 62	DAMP, GRAY, GRAVELLY, SILTY SAND
3 :	62- 108	DAMP, BROWN, F-MED. SAND W/GR ZONES

SITEID 472826122162601 LOCAL NUMBER 23N/04E-22A01
LATITUDE 47d28m26s LONGITUDE 122d16m26s
ALTITUDE 285.00 CONST. DATE 05/30/1981
WELL DEPTH 70.00 HOLE DEPTH 71.00
WATER LEVEL 16.00 W.L. DATE 06/04/1981
SCREEN INT. 62.00 - 67.00
DRILLER B&J DRLG
WELL OWNER ELLAFSON, LARRY

INT NO.	INTVL(FT)	DESCRIPTION
1 :	28- 70	WHITE SAND, WATER
2 :	70- 71	BLUE CLAY
3 :	71-	BLUE SILT

SITEID 472822122164901 LOCAL NUMBER 23N/04E-22C01 B5
LATITUDE 47d28m22s LONGITUDE 122d16m49s
ALTITUDE 272.40 CONST. DATE 05/19/1982
WELL DEPTH 58.00 HOLE DEPTH 335.20
WATER LEVEL 2.20 W.L. DATE 05/30/1982
SCREEN INT. 48.00 - 53.00
DRILLER PITCHER

INT NO.	INTVL(FT)	DESCRIPTION
1 :	0- 9	YELLWSH-BRW, V DENSE SLTY GR & SD
2 :	9- 32	GLACIAL TILL
3 :	32- 65	GRAY, VERY DENSE, FINE SAND
4 :	65- 94	GRAY, VERY DENSE, SAND AND SILT
5 :	94- 104	GRAY, VERY HARD SILTY CLAY
6 :	104- 117	GRAY, VERY HARD, SILT
7 :	117- 123	GRAY, VERY HARD SILTY CLAY
8 :	123- 128	GRAY, VERY DENSE, SILT AND SAND
9 :	128- 167	GRAY VERY HARD SANDY, CLAYEY SILT
10 :	167- 175	GRAY, VERY DENSE SANDY SILT
11 :	175- 189	GRAY VERY DENSE SILT AND SAND
12 :	189- 204	GLACIAL TILL
13 :	204- 257	GRAY VERY HARD SILTY CLAY
14 :	257- 295	GRAY, VERY HARD, SILT
15 :	295- 301	GRAY, VERY DENSE SAND AND SILT
16 :	301- 322	GRAY, VERY DENSE, SAND
17 :	322- 327	GRAY, VERY DENSE SAND AND SILT
18 :	327- 335	GLACIAL TILL

SITEID 472822122164902 LOCAL NUMBER 23N/04E-22C02
LATITUDE 47d28m22s LONGITUDE 122d16m49s
ALTITUDE 272.40 CONST. DATE 05/19/1982
WELL DEPTH 200.00 HOLE DEPTH 335.20
WATER LEVEL 17.20 W.L. DATE 05/23/1982
SCREEN INT. 170.00 - 190.00
DRILLER PITCHER

INT NO.	INTVL(FT)	DESCRIPTION
1 :	0- 9	YELLSH-BRW, V-DENSE SLTY GR & SAND
2 :	9- 32	GLACIAL TILL
3 :	32- 65	GRAY, VERY DENSE, FINE SAND
4 :	65- 94	GRAY, VERY DENSE, SAND AND SILT
5 :	94- 104	GRAY, VERY HARD SILTY CLAY
6 :	104- 117	GRAY, VERY HARD, SILT
7 :	117- 123	GRAY, VERY HARD SILTY CLAY
8 :	123- 128	GRAY, VERY DENSE, SILT AND SAND
9 :	128- 167	GRAY VERY HARD SANDY CLAYEY SILT
10 :	167- 175	GRAY, VERY DENSE SANDY SILT
11 :	175- 189	GRAY VERY DENSE SILT AND SAND
12 :	189- 204	GLACIAL TILL
13 :	204- 257	GRAY VERY HARD SILTY CLAY
14 :	257- 295	GRAY, VERY HARD, SILT
15 :	295- 301	GRAY, VERY DENSE SAND AND SILT
16 :	301- 322	GRAY, VERY DENSE, SAND
17 :	322- 327	GRAY, VERY DENSE SAND AND SILT
18 :	327- 335	GLACIAL TILL

SITEID 472822122164903 LOCAL NUMBER 23N/04E-22C03
LATITUDE 47d28m22s LONGITUDE 122d16m49s
ALTITUDE 272.40 CONST. DATE 05/19/1982
WELL DEPTH 335.00 HOLE DEPTH 335.20
WATER LEVEL 99.30 W.L. DATE 07/19/1982
SCREEN INT. 305.00 - 325.00
DRILLER PITCHER

INT NO.	INTVL(FT)	DESCRIPTION
1 :	0- 9	YELLWSH-BR, VERY DENSE SLTY GR & SD
2 :	9- 32	GLACIAL TILL
3 :	32- 65	GRAY, VERY DENSE, FINE SAND
4 :	65- 94	GRAY, VERY DENSE, SAND AND SILT
5 :	94- 104	GRAY, VERY HARD SILTY CLAY
6 :	104- 117	GRAY, VERY HARD, SILT
7 :	117- 123	GRAY, VERY HARD SILTY CLAY
8 :	123- 128	GRAY, VERY DENSE, SILT AND SAND
9 :	128- 167	GRAY VERY HARD SANDY, CLAYEY SILT
10 :	167- 175	GRAY, VERY DENSE SANDY SILT
11 :	175- 189	GRAY VERY DENSE SILT AND SAND
12 :	189- 204	GLACIAL TILL
13 :	204- 257	GRAY VERY HARD SILTY CLAY
14 :	257- 295	GRAY, VERY HARD, SILT
15 :	295- 301	GRAY, VERY DENSE SAND AND SILT
16 :	301- 322	GRAY, VERY DENSE, SAND
17 :	322- 327	GRAY, VERY DENSE SAND AND SILT
18 :	327- 335	GLACIAL TILL

B6

SITEID	472823122172201	LOCAL NUMBER	23N/04E-22D01
LATITUDE	47d28m23s	LONGITUDE	122d17m22s
ALTITUDE	358.20	CONST. DATE	06/02/1982
WELL DEPTH	106.00	HOLE DEPTH	452.50
WATER LEVEL	46.40	W.L. DATE	06/10/1982
DRILLER			

INT NO.	INTVL(FT)	DESCRIPTION
1 :	0- 11	YELLWSH-BRW, DENSE SANDY GRAVEL
2 :	11- 42	YELLWSH-BRW, DENSE SLTY GRVLLY SAND
3 :	42- 75	YELLWSH-BRW, V DENSE, F-MED SAND
4 :	75- 127	BROWNSH GRY V DENSE, F-MED SAND
5 :	127- 141	GRAY; VERY HARD, SILT (LACUSTRINE)
6 :	141- 189	GRAY, VERY HARD, CLAYEY SILT
7 :	189- 254	GRAY, VERY DENSE GRAVEL AND SAND
8 :	254- 262	GRAY, VERY DENSE, SILTY SAND
9 :	262- 269	GRAY, VERY HARD, SILT
10 :	269- 280	GRAY, VERY DENSE, SAND AND SILT
11 :	280- 304	GRAY, VERY DENSE, SAND
12 :	304- 314	GRAY, VERY DENSE SAND AND SILT
13 :	314- 321	GRAY, VERY HARD, CLAYEY SILT
14 :	321- 334	GRAY, VERY DENSE, GRAVEL AND SAND
15 :	334- 339	GRAY, VERY DENSE SILT AND SAND
16 :	339- 344	GRAY, VERY DENSE SAND
17 :	344- 358	GLACIAL TILL
18 :	358- 362	GRAY, VERY HARD SILTY CLAY
19 :	362- 374	GRAY, VERY DENSE GRAVEL AND SAND
20 :	374- 389	GRAY, VERY DENSE GRAVELLY SAND
21 :	389- 431	GRAY, VERY DENSE SANDY GRAVEL
22 :	431- 442	GRAY, VERY DENSE, SAND
23 :	442- 453	GRAY, VERY DENSE SANDY GRAVEL

LATITUDE	47d28m21s	LONGITUDE	122d15m35s
ALTITUDE	192.60	CONST. DATE	06/14/1982
WELL DEPTH	245.00	HOLE DEPTH	253.00
WATER LEVEL	94.70	W.L. DATE	06/24/1982
SCREEN INT.	205.00 - 225.00		
DRILLER	PICTURE		

INT NO.	INTVL(FT)	DESCRIPTION
1 :	0- 12	YELWSH ORNGE, HRD SILTY CLY AND GR
2 :	12- 32	BLUE, HARD, SANDY CLAYEY SILT
3 :	32- 45	BEDROCK (SANDSTONE)
4 :	45- 147	BEDROCK (BASALT)
5 :	147- 253	BEDROCK (SANDSTONE)

SITEID	472821122160101	LOCAL NUMBER	23N/04E-23D01
LATITUDE	47d28m21s	LONGITUDE	122d16m01s
ALTITUDE	163.10	CONST. DATE	06/02/1982
WELL DEPTH	150.00	HOLE DEPTH	220.00
WATER LEVEL	84.90	W.L. DATE	07/19/1982
SCREEN INT.	110.00 - 130.00		
DRILLER	PITCHER		

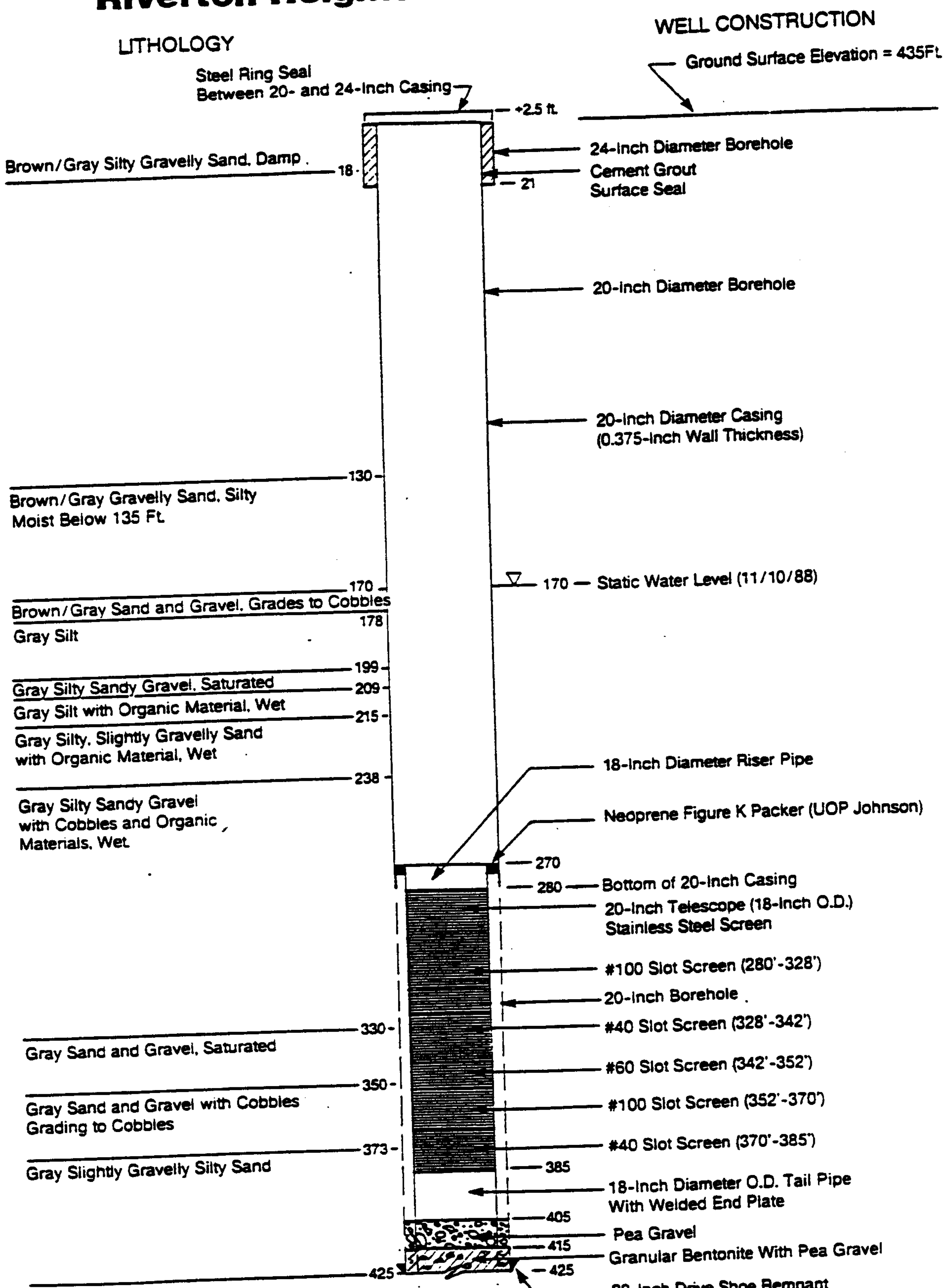
INT NO.	INTVL(FT)	DESCRIPTION
1 :	0- 14	YELLOWISH OR, DENSE SAND AND SILT
2 :	14- 18	GRAY, VERY DENSE, GR SAND AND SILT
3 :	18- 23	GRAY, VERY DENSE, SILT AND SAND
4 :	23- 49	GLACIAL TILL
5 :	49- 106	GRAY, VERY HARD CLAYEY SILT
6 :	106- 112	GRAY, VERY DENSE FINE SAND
7 :	112- 117	GRAY, VERY DENSE SILT
8 :	117- 181	GRAY, VERY DENSE FINE-MED SAND
9 :	181- 197	GRAY, VERY DENSE GRAVEL AND SAND
10 :	197- 204	GRAY, VERY DENSE LAMINATED SD & SLT
11 :	204- 237	WEATHERED BEDROCK

SITEID	472821122160102	LOCAL NUMBER	23N/04E-23D02
LATITUDE	47d28m21s	LONGITUDE	122d16m01s
ALTITUDE	163.10	CONST. DATE	06/02/1982
WELL DEPTH	220.00	HOLE DEPTH	220.00
WATER LEVEL	75.20	W.L. DATE	06/24/1982
SCREEN INT.	180.00 - 200.00		
DRILLER	PITCHER		

INT NO.	INTVL(FT)	DESCRIPTION
1 :	0- 14	YELLOWISH OR, DENSE SAND AND SILT
2 :	14- 18	GRAY, VERY DENSE, GRAVELLY SD & SLT
3 :	18- 23	GRAY, VERY DENSE, SILT AND SAND
4 :	23- 49	GLACIAL TILL
5 :	49- 106	GRAY, VERY HARD CLAYEY SILT
6 :	106- 112	GRAY, VERY DENSE FINE SAND
7 :	112- 117	GRAY, VERY DENSE SILT
8 :	117- 181	GRAY, VERY DENSE FINE-MED SAND
9 :	181- 197	GRAY, VERY DENSE GRAVEL AND SAND
10 :	197- 204	GRAY, VERY DENSE LAMINATED SD & SLT
11 :	204- 237	WEATHERED BEDROCK

SITEID	472734122150601	LOCAL NUMBER	23N/04E-23R01
LATITUDE	47d27m34s	LONGITUDE	122d15m06s
ALTITUDE	23.00	CONST. DATE	01/01/1961
WELL DEPTH	168.00	HOLE DEPTH	0.00
WATER LEVEL	9.17	W.L. DATE	/ /
DRILLER	DAMES & MOOR		
WELL OWNER	VESTEN INC		

Riverton Heights Well No. 2 (RH-2)



Continued
Next Page

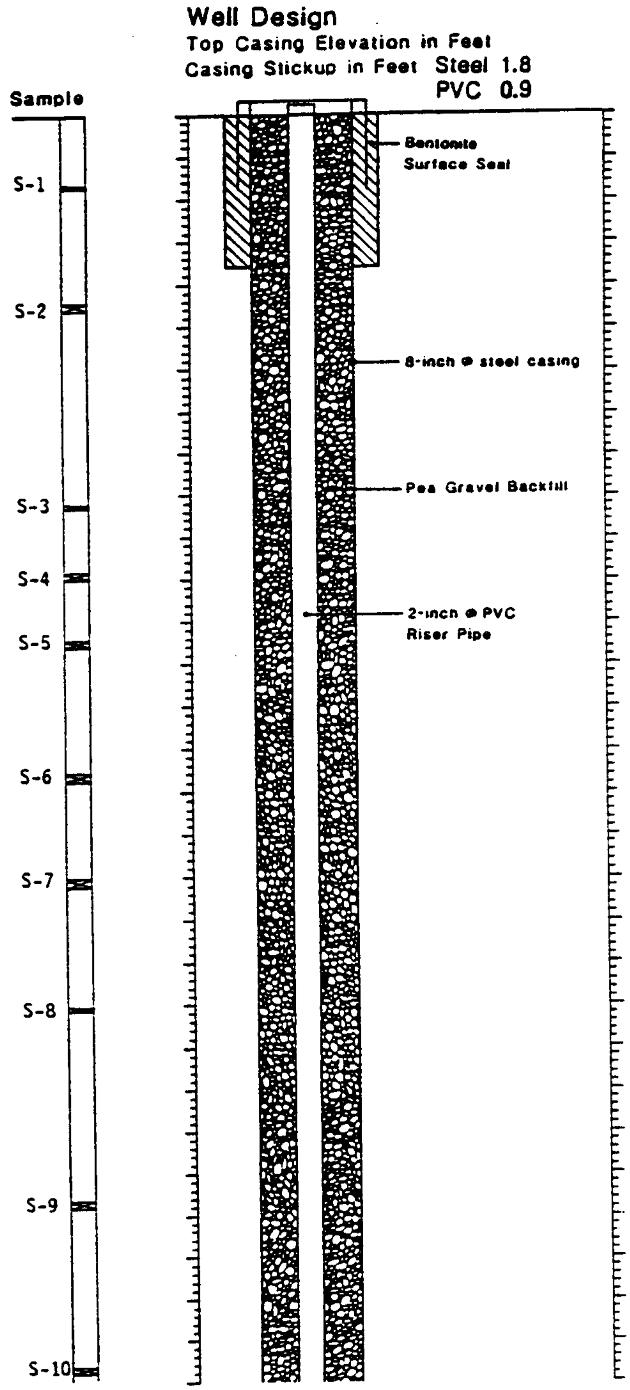
- BOULEVARD PARK -

Boring Log and Construction Data for Well OW-2

Geologic Log

Ground Surface Elevation in Feet

Depth in Feet	Description
0 – 16	Damp, brown to grayish brown, silty, gravelly SAND. (TILL).
16 – 61	Damp to (wet), brown, fine to medium and fine to coarse SAND with some silty zones and occasional gravel.
61 – 128	Damp, bluish-gray SILT and clayey SILT.
128 – 140	Damp, brown, slightly gravelly, silty SAND.

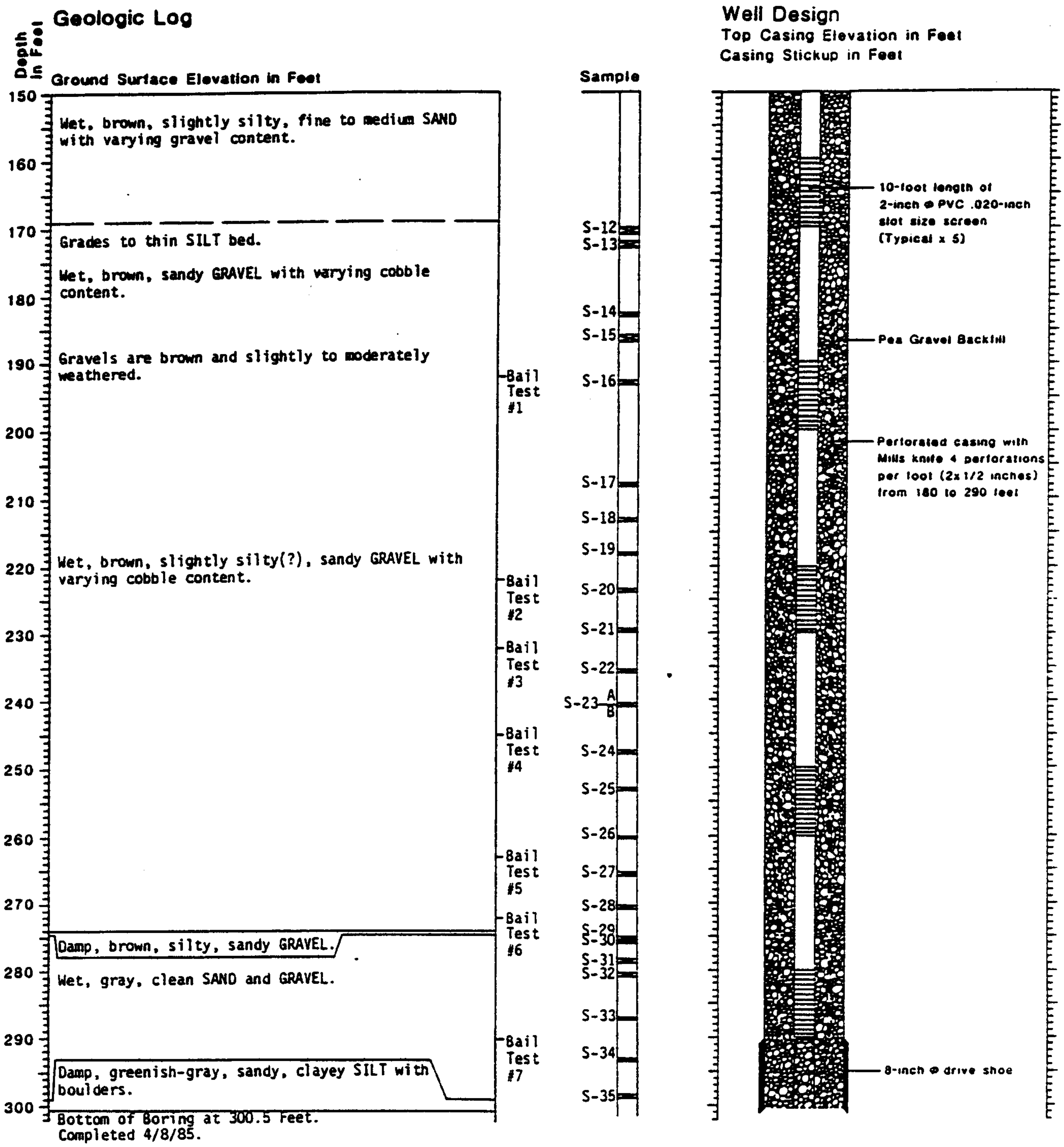


NOTES: 1. Soil descriptions are interpretive and actual changes may be gradual.
2. Water Level ▽ is for date indicated and may vary with time of year.
ATD: At Time of Drilling

J-1441 April 1985
HART-CROWSER & associates, inc.
Sheet 1 of 2 Figure A-2

AR 039876

Boring Log and Construction Data for Well OW-2



NOTES: 1. Soil descriptions are interpretive and actual changes may be gradual.
2. Water Level ∇ is for date indicated and may vary with time of year.
ATD: At Time of Drilling

J-1441 April 1985
HART-CROWSER & associates, inc.
Sheet 2 of 2 Figure A-2

AR 039877

- GLACIER HIGH -

Boring Log and Construction Data for Well GHPW-1

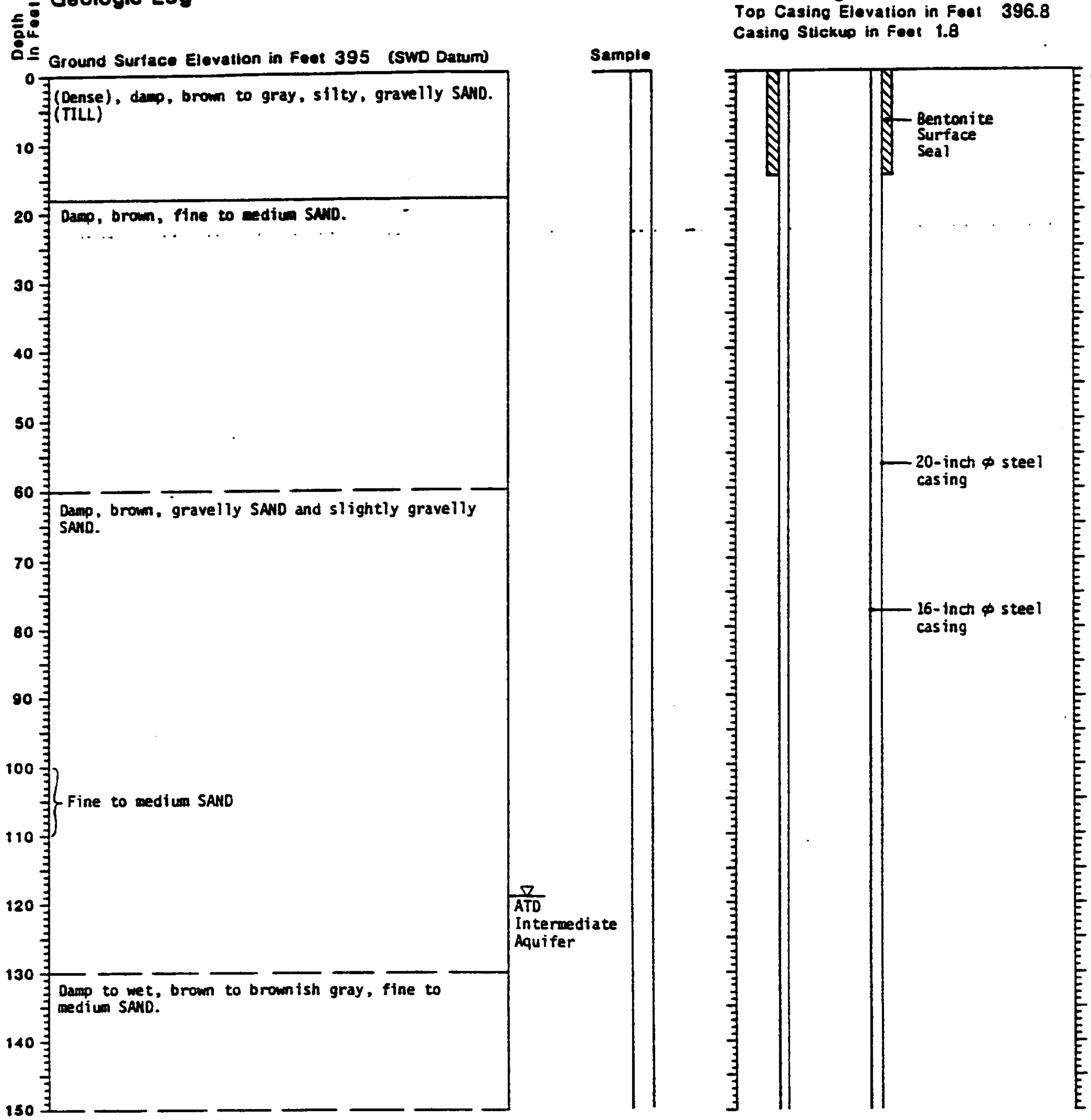
Geologic Log

Ground Surface Elevation in Feet 395 (SWD Datum)

Well Design

Top Casing Elevation in Feet 396.8

Casing Stickup in Feet 1.8



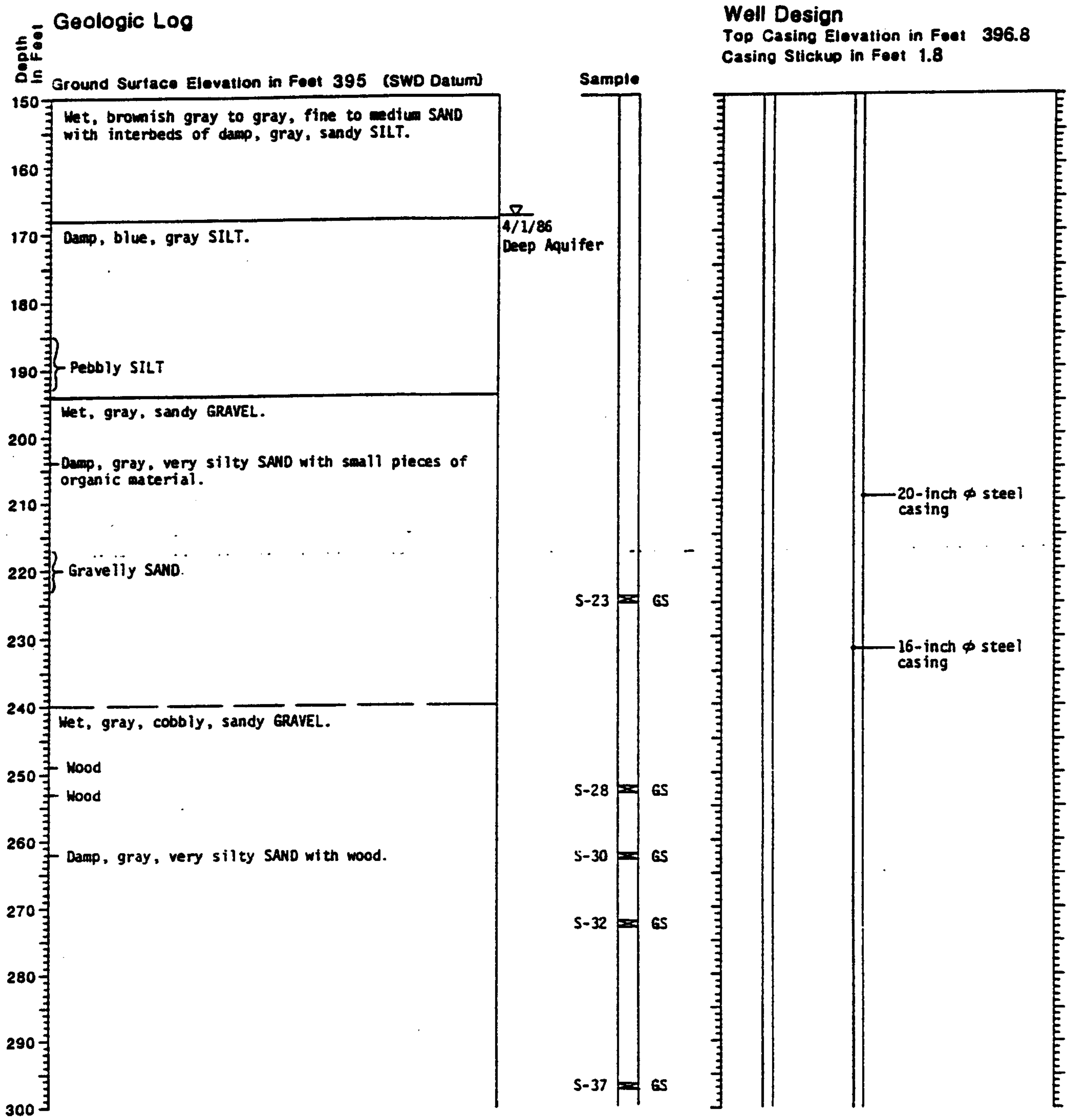
NOTES: 1. Soil descriptions are interpretive and actual changes may be gradual.
2. Water Level ▽ is for date indicated and may vary with time of year.
ATD: At Time of Drilling

J-1441-01 April 1986

HART-CROWSER & associates, inc.

Sheet 1 of 4 Figure 2

Boring Log and Construction Data for Well GHPW-1



NOTES: 1. Soil descriptions are interpretive and actual changes may be gradual.
2. Water Level ▽ is for date indicated and may vary with time of year.
ATD: At Time of Drilling

J-1441-01 April 1986
HART-CROWSER & associates, inc.
Sheet 2 of 4 Figure 2

AR 039879

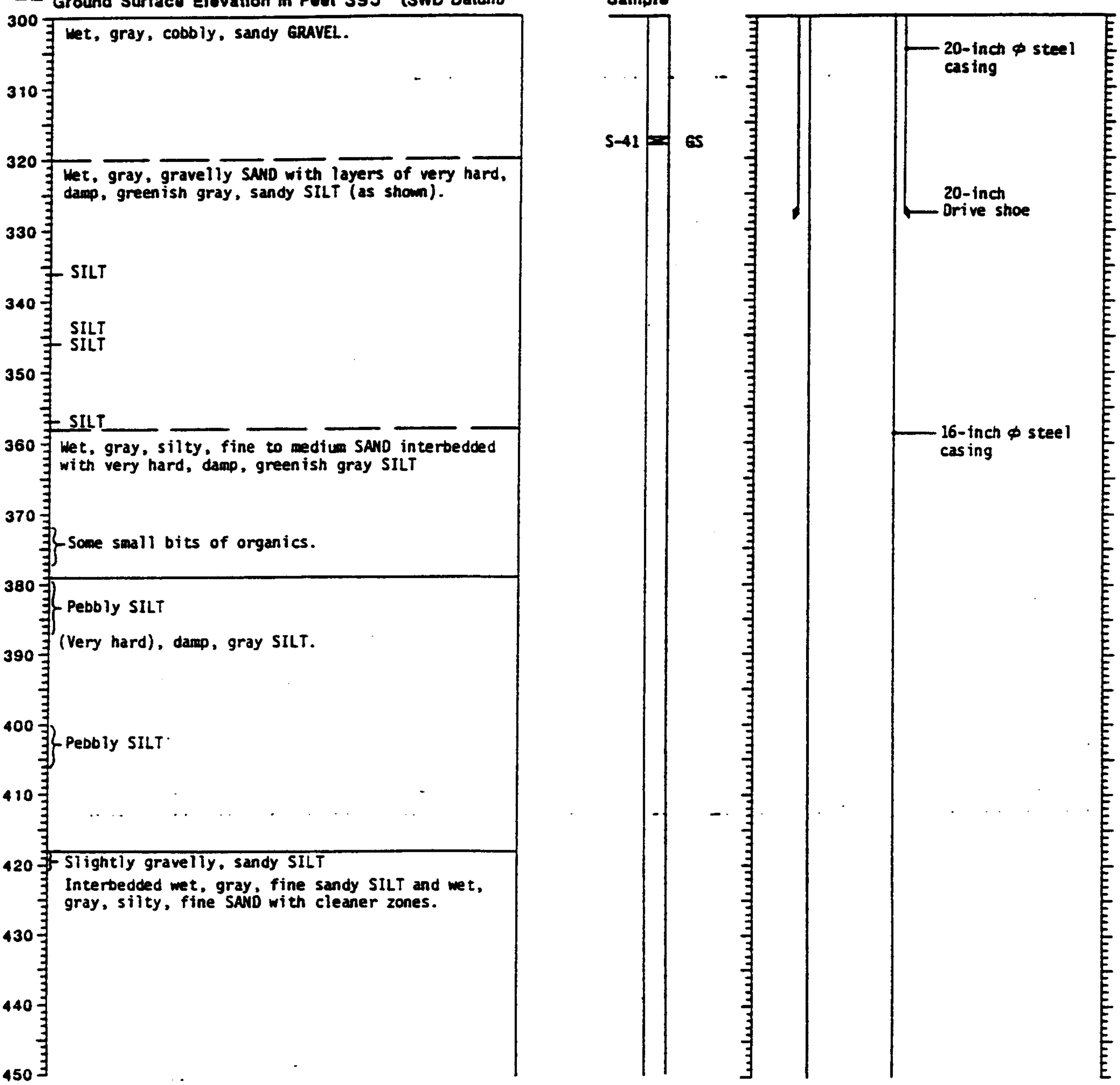
Boring Log and Construction Data for Well GHPW-1

Geologic Log

Ground Surface Elevation in Feet 395 (SWD Datum)

Well Design

Top Casing Elevation in Feet 396.8
Casing Stickup in Feet 1.8



NOTES: 1. Soil descriptions are interpretive and actual changes may be gradual.
2. Water Level ▽ is for date indicated and may vary with time of year.
ATD: At Time of Drilling

J-1441-01 April 1986
HART-CROWSER & associates, inc.
Sheet 3 of 4 Figure 2

Boring Log and Construction Data for Well GHPW-1

Geologic Log

Depth in Feet

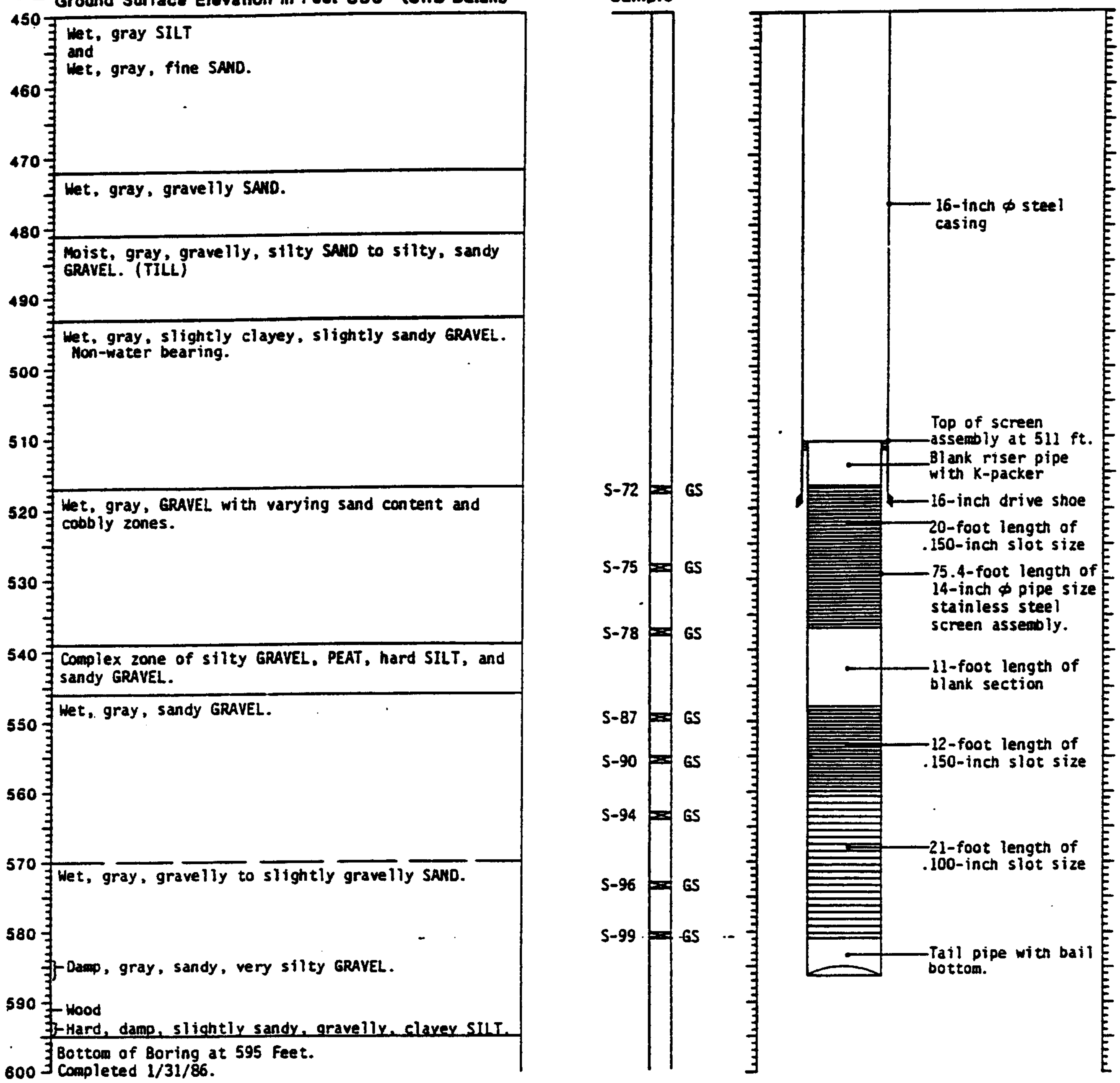
Ground Surface Elevation in Feet 395 (SWD Datum)

Sample

Well Design

Top Casing Elevation in Feet 396.8

Casing Stickup in Feet 1.8



NOTES: 1. Soil descriptions are interpretive and actual changes may be gradual.
2. Water Level ∇ is for date indicated and may vary with time of year.
ATD: At Time of Drilling

J-1441-01 April 1986

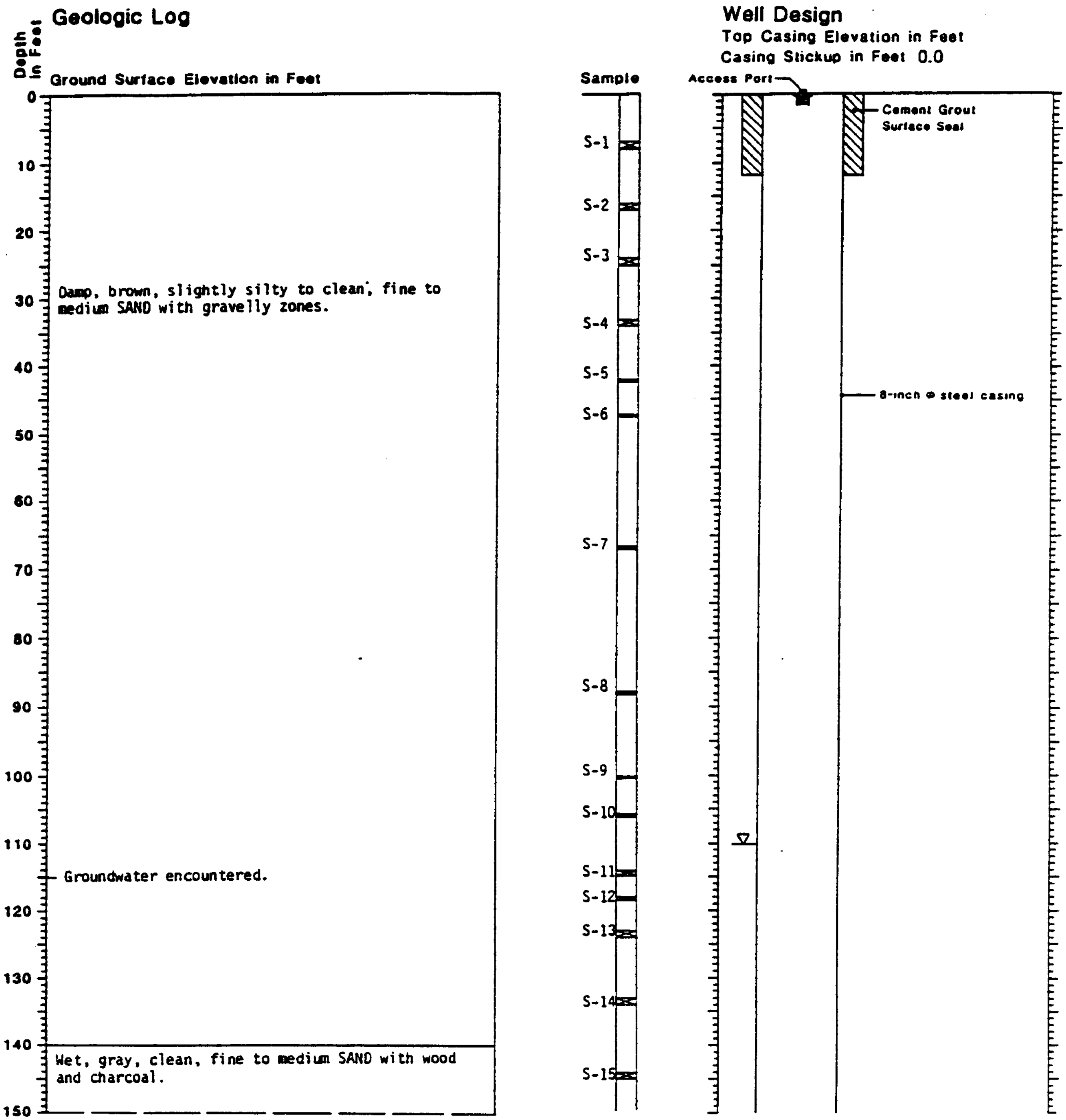
HART-CROWSER & associates, inc.

Sheet 4 of 4 Figure 2

AR 039881

- CRESTVIEW -

Boring Log and Construction Data for Well OW-1

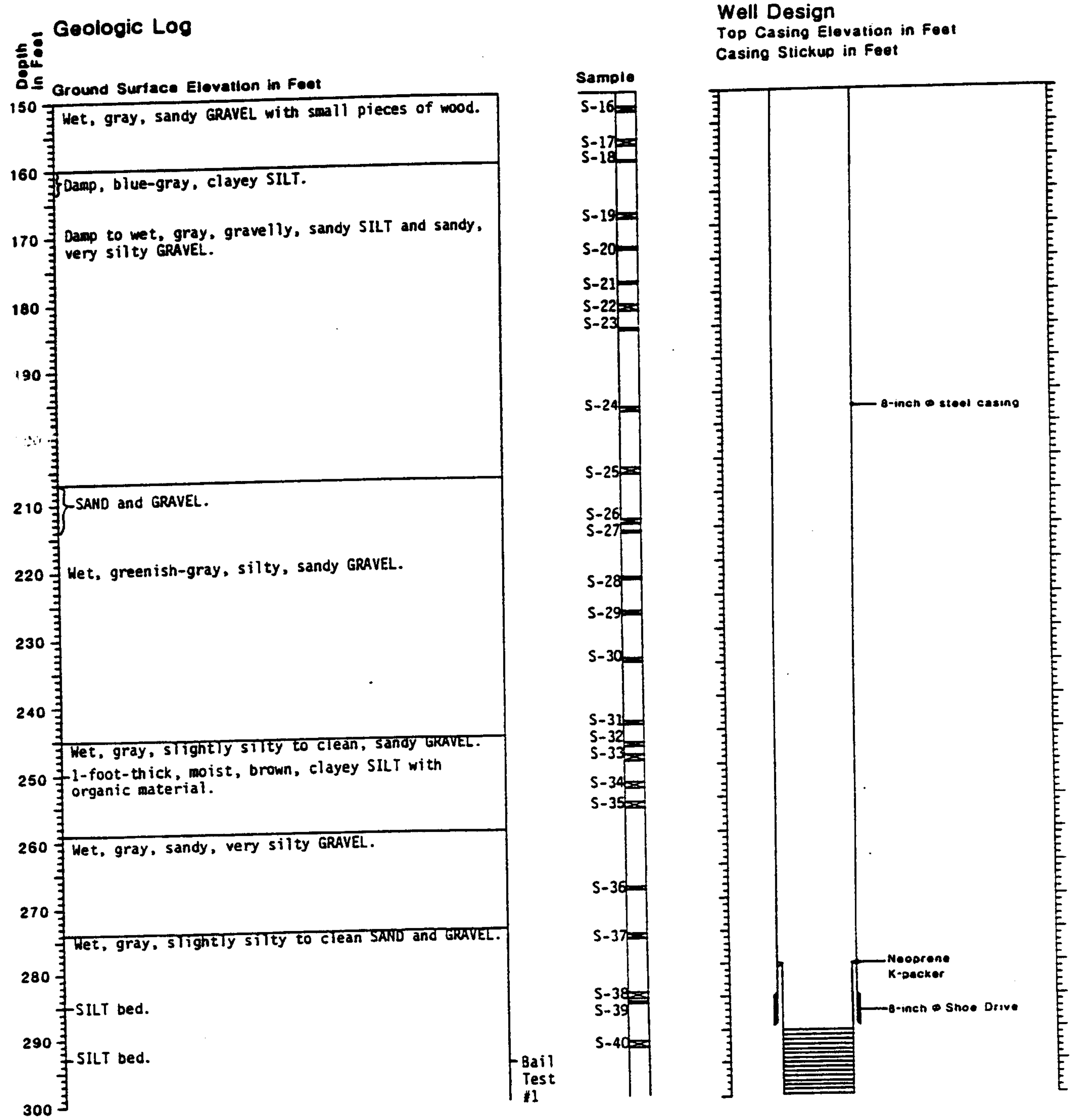


NOTES: 1. Soil descriptions are interpretive and actual changes may be gradual.
2. Water Level ∇ is for date indicated and may vary with time of year.
ATD: At Time of Drilling

J-1441 February 1985
HART-CROWSER & associates, inc.
Sheet 1 of 4 Figure A-1

AR 039882

Boring Log and Construction Data for Well OW-1

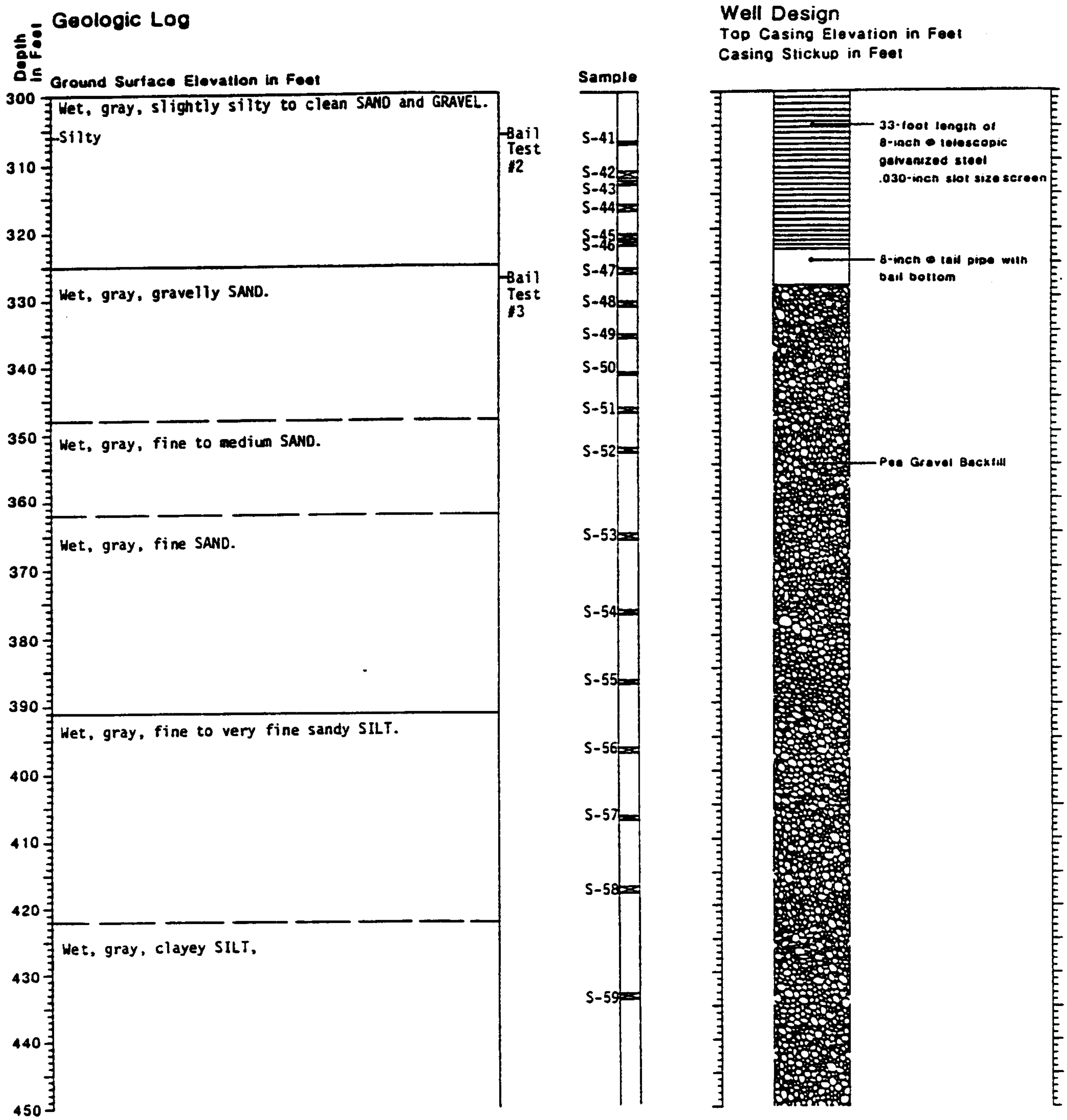


NOTES: 1. Soil descriptions are interpretive and actual changes may be gradual.
2. Water Level ∇ is for date indicated and may vary with time of year.
ATD: At Time of Drilling

J-1441 February 1985
HART-CROWSER & associates, inc.
Sheet 2 of 4 Figure A-1

AR 039883

Boring Log and Construction Data for Well OW-1

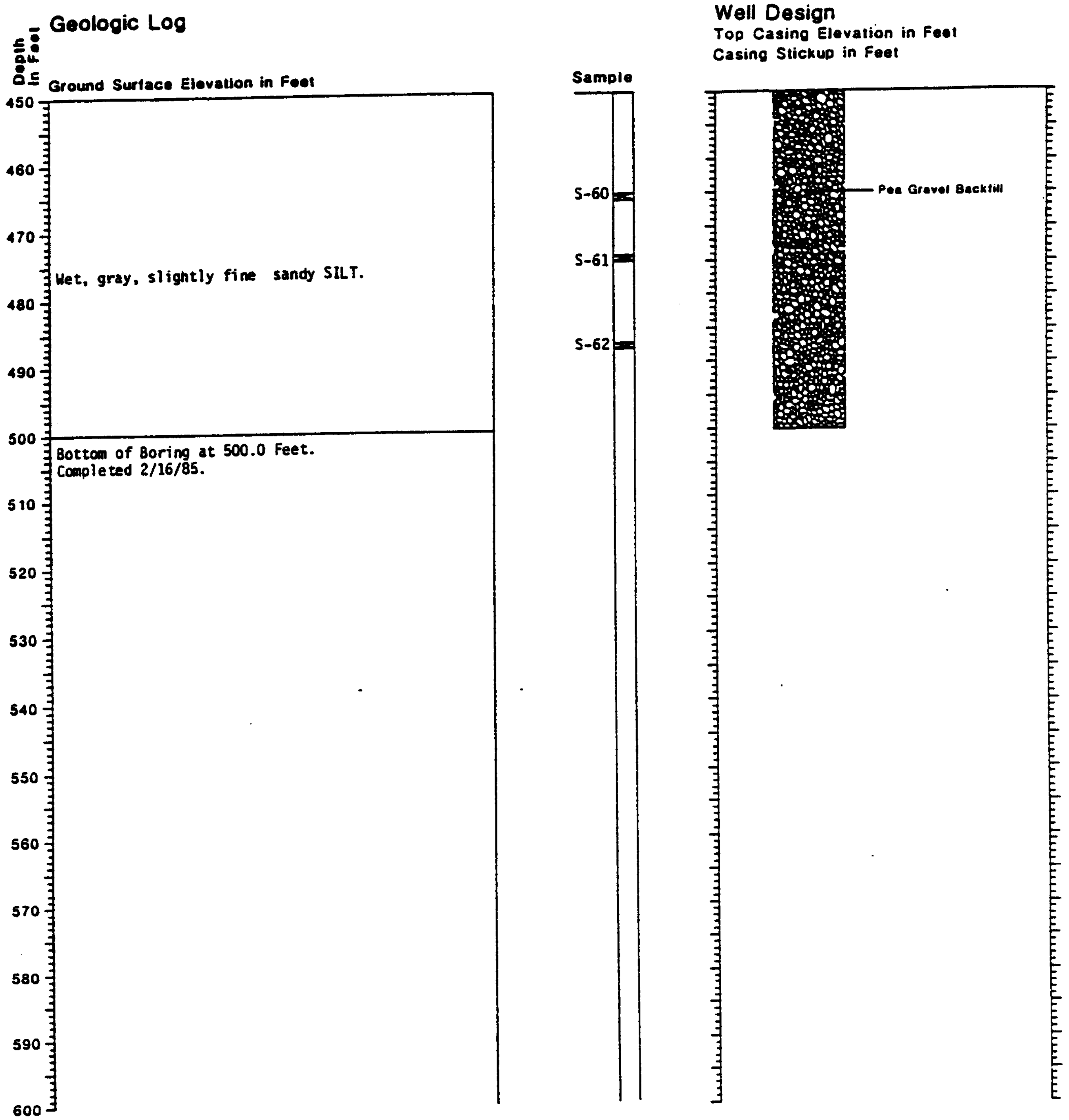


NOTES: 1. Soil descriptions are interpretive and actual changes may be gradual.
2. Water Level ▽ is for date indicated and may vary with time of year.
ATD: At Time of Drilling

J-1441 February 1985
HART-CROWSER & associates, inc.
Sheet 3 of 4 Figure A-1

AR 039884

Boring Log and Construction Data for Well OW-1



NOTES: 1. Soil descriptions are interpretive and actual changes may be gradual.
2. Water Level ∇ is for date indicated and may vary with time of year.
ATD: At Time of Drilling

J-1441 February 1985
HART-CROWSER & associates, inc.
Sheet 4 of 4 Figure A-1

AR 039885

Converse NW

Geologic & Monitoring Well Construction Log

Project Number	Well Number	Sheet
91-35364-06	CMW-8	1 of 7

Project: SeaTac International Airport, Concourse D
Elevation (Top of Well Casing): 392.22
Water Level Elev.: 303.61
Drilling Method: Soil Sampling
Sampler/Driving Weight: Air Rotary

Location: Seatac, Washington
Surface Elevation: 392.78
Start Date: April 5, 1993
Finish Date: April 13, 1993

Depth feet	Well Construction	Other Tests	Blows/6"	OVA (ppm)	Description
0	flush mount steel monument QED Well Wizard 4" Cap concrete annular seal				12" Asphalt Pavement FILL
~8			9 7 13	0	SANDY GRAVELLY SILT; brown, slightly mottled, fine-grained, gravel rounded 1" diameter, medium dense, moist
10	bentonite chip seal				
~18	casing blank, 4" ID Johnson 304 stainless steel		11 40 50/6"	2.6	GLACIAL TILL SANDY SILT WITH GRAVEL; gray, fine to coarse sand, medium to coarse gravel up to 2"; dense, very moist
~23			25 50/3"	2	SILTY SAND WITH GRAVEL; gray-brown, fine to medium, medium to coarse gravel; dense, moist
~28		Ch	20 38 50/5"	2.4	SANDY SILT WITH GRAVEL; gray-brown, slightly mottled rust, fine-grained, fine to coarse gravel; dense, moist
~33			11 20 33	0	(Transitional till to outwash) SILTY SAND WITH GRAVEL; gray-brown, fine to medium sand, fine to medium gravel; dense, moist
~38		Ch	32 50/4"	6	ADVANCE GLACIAL OUTWASH SILTY SAND WITH GRAVEL; gray-brown, fine to medium sand, fine to medium gravel; dense, moist

ST - Sampler Type:
- 2" OD Split Spoon Sampler (SPT)
- Grab Sample
- 3.25" OD Ring Sampler

Lab Tests:
Ch - Chemical Properties
(Sample I.D. Number)
Water Level (Date of Measurement)

Logged by: JJS
Approved by: JJS
Figure No. A-5

AR 039886

Converse NW

Geologic & Monitoring Well Construction Log

Project Number: 91-35364-06 | Well Number: CMW-8 | Sheet 2 of 7

Project: SeaTac International Airport, Concourse D
Elevation (Top of Well Casing): 392.22
Water Level Elev.: 303.61
Drilling Method: Soil Sampling
Sampler/Driving Weight: Air Rotary

Location: Seatac, Washington
Surface Elevation: 392.78
Start Date: April 5, 1993
Finish Date: April 13, 1993

Depth feet	Well Construction	Other Tests	Blows/6"	OVA (ppm)	Description
			7 22 36	0.6	SILTY SAND; brown, fine to medium, little medium to coarse gravel; dense, moist
45					
			7 25 38	0.9	grade no gravel
50	bentonite chip seal				
			10 50/6"	7	grade slightly less silt
55					
		Ch	23 50/6"	12	
60					
			14 50/6"	3	SILTY SAND; brown, fine-grained; dense, moist
65					
	high solids bentonite grout seal		10 25 50/6"	0	grade finer-grained, increasing silt
70					
			5 6 28	0	
75					
			6 27 38	0.2	SAND; brown, fine to medium, little silt; dense, moist

ST - Sampler Type:
- 2" OD Split Spoon Sampler (SPT)
- Grab Sample
- 3.25" OD Ring Sampler

Lab Tests:
Ch - Chemical Properties
(Sample I.D. Number)
Water Level (Date of Measurement)

Logged by: JJS
Approved by: JJS

Figure No. A-5

AR 039887

Converse NW

Geologic & Monitoring Well Construction Log

Project Number	Well Number	Sheet
91-35364-06	CMW-8	3 of 7

Project: SeaTac International Airport, Concourse D
Elevation (Top of Well Casing): 392.22
Water Level Elev.: 303.61
Drilling Method: Soil Sampling
Sampler/Driving Weight: Air Rotary

Location: Seatac, Washington
Surface Elevation: 392.78
Start Date: April 5, 1993
Finish Date: April 13, 1993

Depth feet	Well Construction	Other Tests	Blows/6"	OVA (ppm)	Description
			13 33 50/4"	0	SAND; brown, fine to coarse, trace silt, trace fine gravel; dense, very moist
85					
			30 50/4"	0	SANDY SILT; brown, fine-grained; dense, very moist
90	ATD 4/16/93 5/18/93				
			13 25 50/6"	0.6	SAND; brown, fine to medium, little silt; dense, wet
95					
			32 50/5"	0	grade coarser sand
100	high solids bentonite grout seal				
					driller reports heaving sand conditions beginning at depth 103 feet
105			35 50/6"		SAND; brown, fine to coarse, little silt, trace gravel; dense, wet
			40 120/3"	0.2	SAND; brown, medium to coarse, little silt; dense, wet
			14 75/4"	0	grade slightly coarser-grained, trace fine gravel
110					
			43 75/3"	0	poorly graded, no gravel
			13 16 35	0	
115			50/3"	0	grade coarser sand, trace fine gravel
			8 10 8 9 6	0.2	
			10 13	0.3	GRAVELLY SAND; brown, medium to coarse sand, fine gravel;

ST - Sampler Type:
- 2" OD Split Spoon Sampler (SPT)
- Grab Sample
- 3.25" OD Ring Sampler

Lab Tests:
Ch - Chemical Properties
(Sample I.D. Number)
Water Level (Date of Measurement)

Logged by: JJS
Approved by: JJS
Figure No. A-5

AR 039888

Converse NW

Geologic & Monitoring Well Construction Log

Project Number: 91-35364-06 | Well Number: CMW-8 | Sheet 4 of 7

Project: SeaTac International Airport, Concourse D
Elevation (Top of Well Casing): 392.22
Water Level Elev.: 303.61
Drilling Method: Soil Sampling
Sampler/Driving Weight: Air Rotary

Location: Seatac, Washington
Surface Elevation: 392.78
Start Date: April 5, 1993
Finish Date: April 13, 1993

Depth feet	Well Construction	Other Tests	Blows/6"	OVA (ppm)	Description
			12		medium dense, wet
			4		increasing gravel, well-rounded, 1/4" diameter
			9	0.2	GRAVELLY SAND; brown, medium to coarse sand, fine gravel, 6" thick clean gravel layer; loose, wet
			13		
			22		
			22	0.4	less distinct gravel layers
			12		cobble-size gravel stuck in discharge line at depth 124 feet
			8		
125			4	0.7	
			11		
			50/6"		
			50/0"		no sample collected at depth 127-129 feet due to extreme sand heave conditions, 10' of heave inside drill rods
			20		
			25		
			23	0	cobble clogging discharge line at depth 129 feet
			50/3"		SAND; brown, medium to coarse, trace fine gravel; loose, wet
130			1		
			3		
			8	0.6	SILTY SAND WITH GRAVEL; brown, fine to coarse, fine gravel; dense, wet
			12		change bit to downhole hammer- gravel clogging tricone bit
			14		coarse to cobble-size gravel exiting discharge at 133 feet
			40		
			50/3"		Drill through gravel zone- clean gravel observed exiting discharge between depths 133 and 135 feet
135				0.1	SAND; gray, little gravel, trace silt; wet
	high solids bentonite grout seal				PRE-VASHON INTERGLACIAL GRAVELLY SAND; greenish gray, coarse sand, medium well-rounded gravel; wet
140				0.2	
					wood fragments observed in cuttings, gravel abundant, discharge color change to dark brown, organic-rich zone
145				0	SAND; green-gray, fine to coarse, little gravel, trace silt, wood debris; wet
					abundant gravel 1"-2" diameter exiting discharge
150				0	SAND WITH GRAVEL; green-gray, medium to coarse, medium gravel; wet
	QED Well Wizard Purge Pump Intake				
155				0	

ST - Sampler Type:
- 2" OD Split Spoon Sampler (SPT)
- Grab Sample
- 3.25" OD Ring Sampler

Lab Tests:
- Ch - Chemical Properties
- (Sample I.D. Number)
- Water Level (Date of Measurement)

Logged by: JJS
Approved by: JJS

Figure No. A-5

AR 039889

Converse NW

Geologic & Monitoring Well Construction Log

Project Number	Well Number	Sheet
91-35364-06	CMW-8	5 of 7

Project: SeaTac International Airport, Concourse D
Elevation (Top of Well Casing): 392.22
Water Level Elev.: 303.61
Drilling Method: Soil Sampling
Sampler/Driving Weight: Air Rotary

Location: Seatac, Washington
Surface Elevation: 392.78
Start Date: April 5, 1993
Finish Date: April 13, 1993

Depth feet	Well Construction	Other Tests	ST	Blows/6"	OVA (ppm)	Description
						SAND; green-gray, medium to coarse; wet
						driller reports gravel zone, coarse gravel exiting discharge between 162-165 feet
165					0	SANDY GRAVEL; green-gray, medium, medium to coarse sand, well-rounded; wet CLAYEY GRAVEL; gray, stringer of clay grade back into clean sandy gravel, wood debris driller estimates 20-30 gpm of water out of discharge
170					0	SANDY GRAVEL; very clean, no fines, productive water bearing zone
175					0	
	high solids bentonite grout seal					grade to SILTY SAND WITH GRAVEL; gray, fine to coarse
180					0	SANDY GRAVEL; green-gray, fine to coarse, medium to coarse sand, trace silt; wet decrease in discharge
					0.3	gray silty sand out of discharge line, very fine-grained
185					0	SILTY SAND; gray, fine-grained, white volcanic ash fragments observed in cuttings; wet decrease in water yield < 5 gpm
190					0	
195					0	

ST - Sampler Type:
- 2" OD Split Spoon Sampler (SPT)
- Grab Sample
- 3.25" OD Ring Sampler

Lab Tests:
Ch - Chemical Properties
(Sample I.D. Number)
Water Level (Date of Measurement)

Logged by: JJS
Approved by: JJS
Figure No. A-5

Converse NW

Geologic & Monitoring Well Construction Log

Project Number	Well Number	Sheet
91-35364-06	CMW-8	6 of 7

Project SeaTac International Airport, Concourse D
Elevation (Top of Well Casing) 392.22
Water Level Elev. 303.61
Drilling Method Soil Sampling
Sampler/Driving Weight Air Rotary

Location Seatac, Washington
Surface Elevation 392.78
Start Date April 5, 1993
Finish Date April 13, 1993

Depth feet	Well Construction	Other Tests	ST	Blows/ 6"	OVA (ppm)	Description
205					0	SILTY SAND; gray, fine-grained, wet heavy sand heave conditions encountered
210	high solids bentonite grout seal				0.1	
215					0	
220	8/12 Colorado silica sand pack				0	grade slightly coarser sand
						little coarse gravel observed exiting discharge
225					0.2	SILTY SAND; gray, fine-grained, few coarse gravel, white volcanic ash observed in sample; wet
	stainless steel centralizer					increasing sand grain size, grade less silt
230	well screen, 4" ID Johnson 304 stainless steel, 0.020" slot size				0	SILTY SAND; gray, fine to coarse, wet
						increasing gravel
235					0	SILTY GRAVELLY SAND; gray, fine to coarse sand, fine to medium gravel; wet increase in water discharge, approximately 10 gpm
						color change to green-gray, harder drilling

ST - Sampler Type:
- 2" OD Split Spoon Sampler (SPT)
- Grab Sample
- 3.25" OD Ring Sampler

Lab Tests:
- Ch - Chemical Properties
- (Sample I.D. Number)
- Water Level (Date of Measurement)

Logged by: JJS
Approved by: JJS
Figure No. A-5

Converse NW

Geologic & Monitoring Well Construction Log

Project Number	Well Number	Sheet
91-35364-06	CMW-8	7 of 7

Project: SeaTac International Airport, Concourse D
Elevation (Top of Well Casing): 392.22
Water Level Elev.: 303.61
Drilling Method: Soil Sampling
Sampler/Driving Weight: Air Rotary

Location: Seatac, Washington
Surface Elevation: 392.78
Start Date: April 5, 1993
Finish Date: April 13, 1993

Depth feet	Well Construction	Other Tests	ST	Blows/6"	OVA	Description
					0.1	green-gray, clayey silt clods in sample driller reports harder drilling
245					0	SILTY SAND WITH GRAVEL; green-gray, fine to coarse sand, medium gravel, some clayey silt clods; wet discharge of water approximately 10 gpm
	stainless steel centraliser					
	QED Well Wizard Sample Pump Intake			17	0 0	CLAYEY SILT; olive green, fine-grained, little gravel and fine sand out of discharge CLAYEY SILT; green-gray, very fine-grained; hard, moist
	sediment sump, 4" ID			28		
250	Johnson 304 stainless steel			48		Bottom of boring at depth 248.5 feet Monitoring well installed to depth 249.52 feet Soil sampler driven using 300-pound hammer falling 30-inches
255						
260						
265						
270						
275						

ST - Sampler Type:
- 2" OD Split Spoon Sampler (SPT)
- Grab Sample
- 3.25" OD Ring Sampler

Lab Tests:
Ch - Chemical Properties
(Sample I.D. Number)
Water Level (Date of Measurement)

Logged by: JJS
Approved by: JJS
Figure No. A-5

AR 039892

INT NO.	INTVL(FT)	DESCRIPTION
1 :	0- 58	DIRTY SAND AND SMALL GRAVEL, DRY
2 :	58- 104	DIRTY SAND AND GRAVEL
3 :	104- 113	CLAY, BLUE
4 :	113- 126	GRAVEL & SAND, DIRTY
5 :	126- 197	SANDY BLUE CLAY
6 :	197- 220	HARDPAN, BLUE
7 :	220- 250	GRAVEL WITH CLAY AND SAND
8 :	250- 260	GRAVEL AND BOULDERS
9 :	260- 308	BOULDERS, GRAVEL & SOME CLAY
10 :	308- 350	CLAY, BLUE AND GRAVEL
11 :	350- 380	CLAY, SANDY, BLUE
12 :	380- 401	GRAVEL SAND AND SOME CLAY
13 :	401- 490	SANDY CLAY, BLUE
14 :	490- 537	SANDY CLAY
15 :	537- 569	CLAY SANDY GRAY
16 :	569- 645	CLAY, GREEN & BLUE
17 :	645- 652	SAND, HARD CLAY, CEMENT

B1

SITEID	472539122174701	LOCAL NUMBER	23N/04E-33B01
LATITUDE	47d26m38s	LONGITUDE	122d17m54s
ALTITUDE	364.00	CONST. DATE	10/ /1943
WELL DEPTH	324.00	HOLE DEPTH	396.00
WATER LEVEL	60.00	W.L. DATE	01/01/1943
SCREEN INT.	85.00 - 321.00		
DRILLER	N C JANNSEN		
WELL OWNER	PORT OF SEATTLE		

INT NO.	INTVL(FT)	DESCRIPTION
1 :	0- 32	GRAVEL AND BOULDERS
2 :	32- 45	SAND
3 :	45- 59	SAND AND GRAVEL
4 :	59- 64	SAND
5 :	64- 105	SAND AND GRAVEL, W.B.
6 :	105- 111	BOULDERS
7 :	111- 113	HARDPAN
8 :	113- 137	CLAY
9 :	137- 143	CLAY AND GRAVEL
10 :	143- 224	GRAVEL, SAND, AND CLAY
11 :	224- 247	BLUE CLAY
12 :	247- 290	CLAY WITH GRAVEL
13 :	290- 321	GRAVEL, W.B.
14 :	321- 396	CLAY, BLUE

SITEID	472608122174401	LOCAL NUMBER	23N/04E-33J01
LATITUDE	47d26m05s	LONGITUDE	122d17m28s
ALTITUDE	375.00	CONST. DATE	10/17/1974
WELL DEPTH	61.00	HOLE DEPTH	61.00
WATER LEVEL	44.00	W.L. DATE	10/18/1974
DRILLER	NW PUMP		
WELL OWNER	SMITH, ROBERT		

INT NO.	INTVL(FT)	DESCRIPTION
1 :	0- 3	TOPSOIL
2 :	3- 54	BROWN GLACIAL TILL
3 :	54- 58	BROWN SAND
4 :	58- 61	WATER BEARING SAND AND GRAVEL

SITEID	472633122172401	LOCAL NUMBER	23N/04E-34C02
LATITUDE	47d26m39s	LONGITUDE	122d17m08s
ALTITUDE	395.00	CONST. DATE	12/15/1960
WELL DEPTH	388.00	HOLE DEPTH	388.00
WATER LEVEL	112.00	W.L. DATE	11/01/1961
SCREEN INT.	152.00 - 189.00		
DRILLER			
WELL OWNER	KCWD 75		

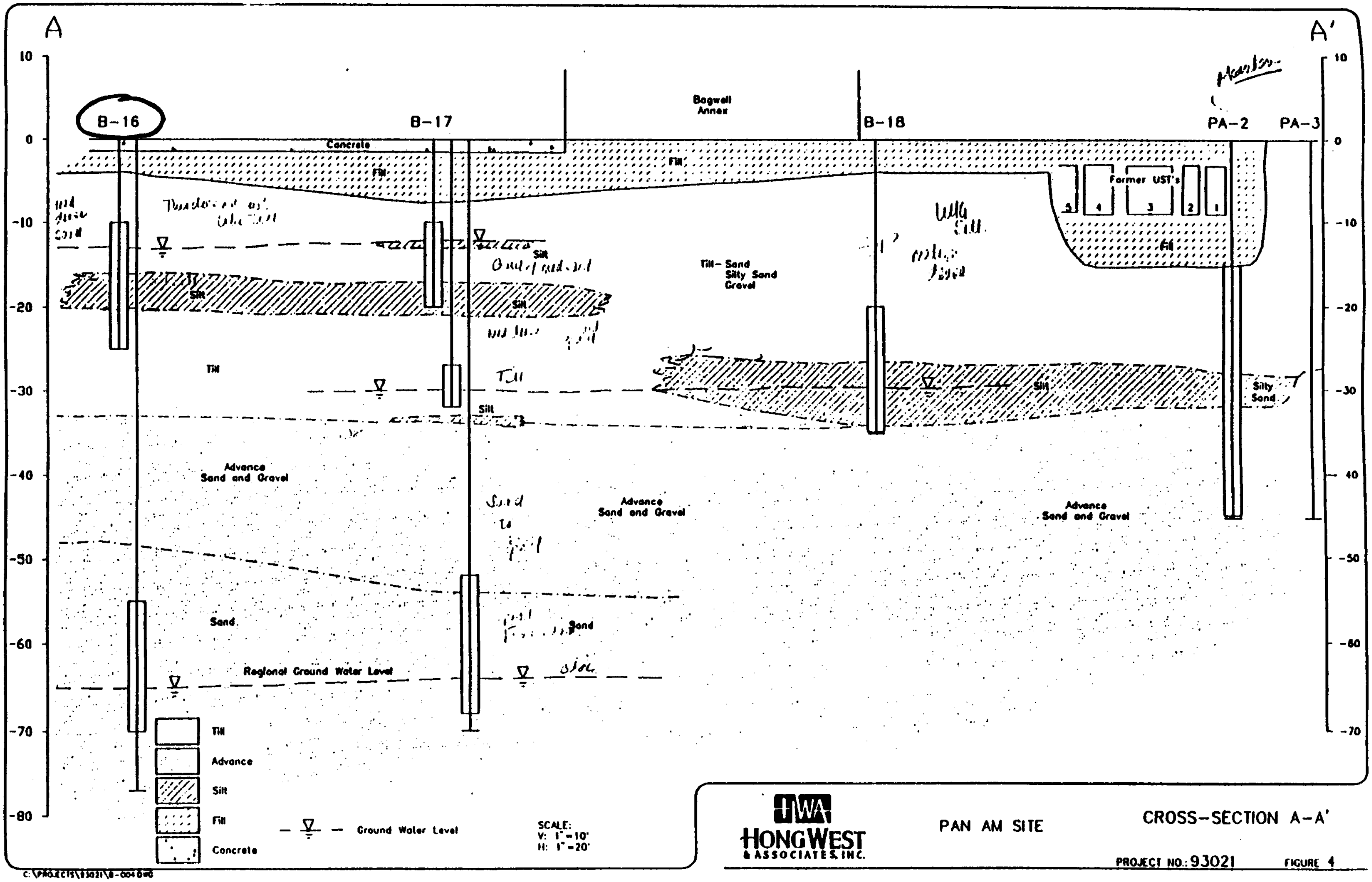
INT NO.	INTVL(FT)	DESCRIPTION
1 :	0- 3	TOPSOIL
2 :	3- 15	CLAY AND GRAVEL
3 :	15- 63	HARDPAN
4 :	63- 67	SAND, GRAVEL AND WATER
5 :	67- 133	CLAY, SAND AND GRAVEL
6 :	133- 139	CLAY, MULTI-COLORED AND PEAT
7 :	139- 151	CLAY, GREEN, SOME SAND AND GRAVEL
8 :	151- 190	WATER, SAND, GRAVEL SPECKS AND CLAY
9 :	190- 238	SAND AND GRAVEL, CEMENTED
10 :	238- 247	CLAY, SAND AND GRAVEL
11 :	247- 388	CLAY, BLUE; SOME SHALE

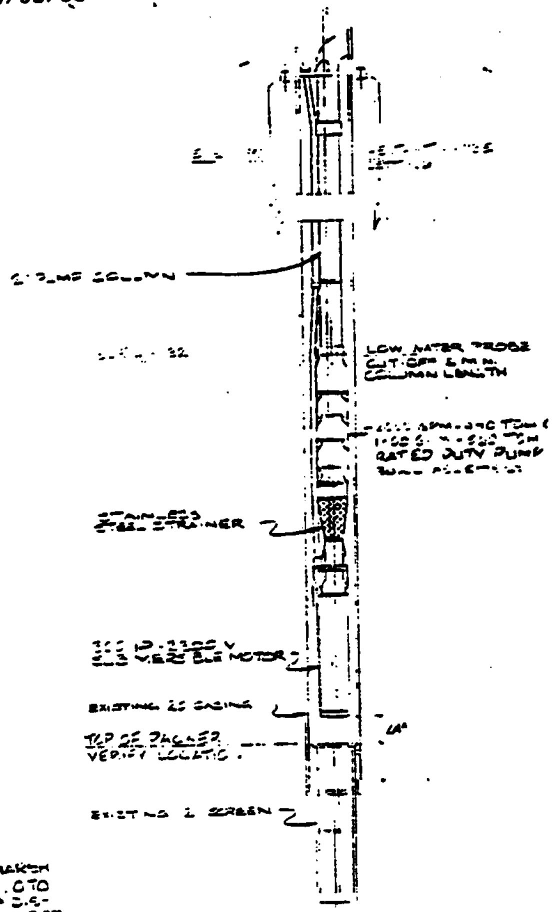
SITEID	472641122171801	LOCAL NUMBER	23N/04E-34D02
LATITUDE	47d26m41s	LONGITUDE	122d17m18s
ALTITUDE	450.00	CONST. DATE	01/16/1961
WELL DEPTH	189.00	HOLE DEPTH	388.00
WATER LEVEL	112.00	W.L. DATE	01/16/1961
SCREEN INT.	152.00 - 189.00		
DRILLER			

INT NO.	INTVL(FT)	DESCRIPTION
1 :	0- 3	TOP SOIL
2 :	3- 15	CLAY AND GRAVEL
3 :	15- 63	HARDPAN-CEMENTED SAND AND GRAVEL
4 :	63- 67	SAND, GRAVEL AND WATER
5 :	67- 133	CLAY, SAND AND GRAVEL
6 :	133- 139	MULTI-COLORED CLAY AND PEAT
7 :	139- 151	GREEN CLAY, SOME SAND AND GRAVEL
8 :	151- 190	WATER, SAND, GR SPECKS AND CLAY
9 :	190- 238	CEMENTED SAND AND GRAVEL
10 :	238- 247	CLAY, SAND AND GRAVEL
11 :	247- 388	BLUE CLAY, SOME SHALE

SITEID	472625122165401	LOCAL NUMBER	23N/04E-34F02
LATITUDE	47d26m25s	LONGITUDE	122d16m54s
ALTITUDE	397.00	CONST. DATE	00/00/1958
WELL DEPTH	245.00	HOLE DEPTH	247.00
WATER LEVEL	109.00	W.L. DATE	08/06/1958
SCREEN INT.	197.00 - 205.00		
DRILLER	GAUDIO		
WELL OWNER	KCWD 75		

INT NO.	INTVL(FT)	DESCRIPTION
1 :	0- 12	TOP SOIL AND CLAY
2 :	12- 32	CLAY, SANDY
3 :	32- 53	HARDPAN
4 :	53- 68	SAND, BROWN, TIGHT


A
A'
B-16
B-17
B-18
PA-2
PA-3
Bagwell Annex
Concrete
Fill
Former UST's
5
4
3
2
1
Till
Silt
Till- Sand Silty Sand Gravel
Silty Sand
Advance Sand and Gravel
Sand
Regional Ground Water Level
10
0
-10
-20
-30
-40
-50
-60
-70
-80
Till
Advance
Silt
Fill
Concrete
Ground Water Level
SCALE:
V: 1" = 10'
H: 1" = 20'
C:\PROJECTS\93021\B-004.DWG
HONGWEST & ASSOCIATES, INC.
PAN AM SITE
CROSS-SECTION A-A'
PROJECT NO.: 93021
FIGURE 4



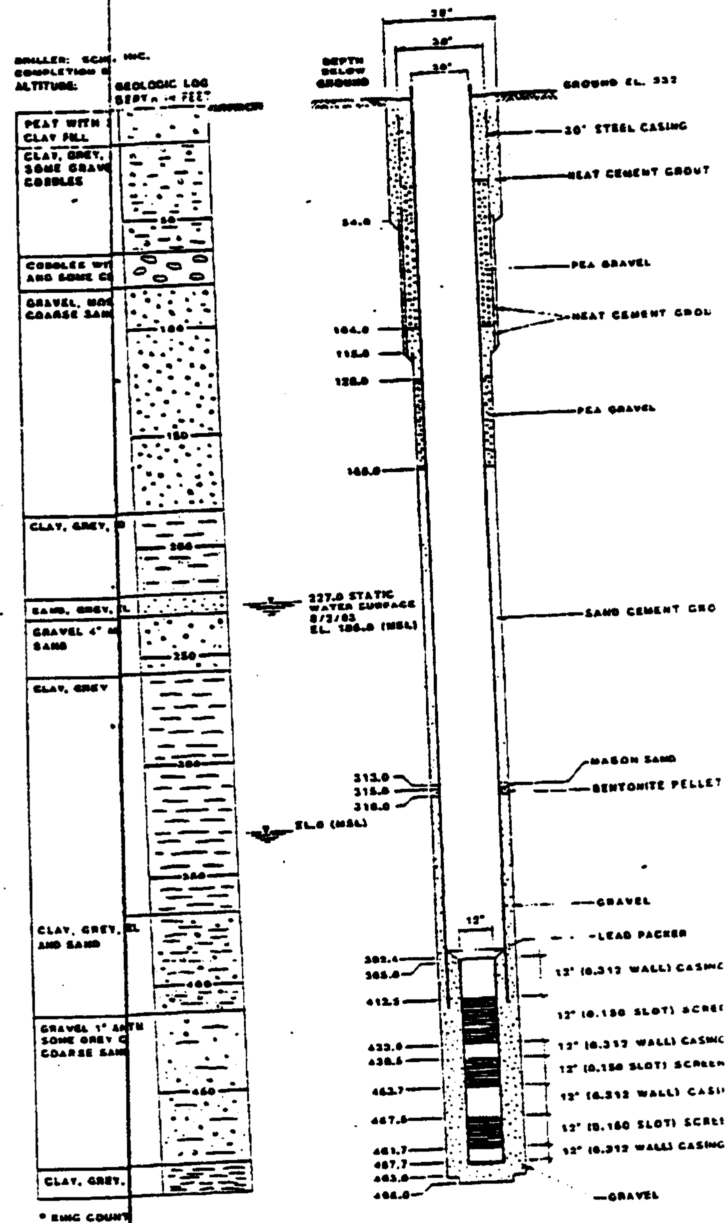
2E GUAGE-MARSH GUAGE #245, 0 TO ...
... 4 1/2" DIA. DIAL, BOT- ...NECTION
...GE COCK
PIGTAIL
...SS TEE W/PLUG
TAP W/1/4" - 125# BRONZE COCK, NO. 266 OR EQUAL

SUBMERSIBLE PUMP (2/4)
NO SCALE

PRESSURE GUAGE (3/4)

...EASE VALVE APCO NO. 55 OR EQUAL
...SHING
...SSURE VACUUM BREAKER & HOSE BIBB
... W/ 3/4" - 125 # BRONZE COCK, ...266 OR EQUAL

SE VALVE (5/4)

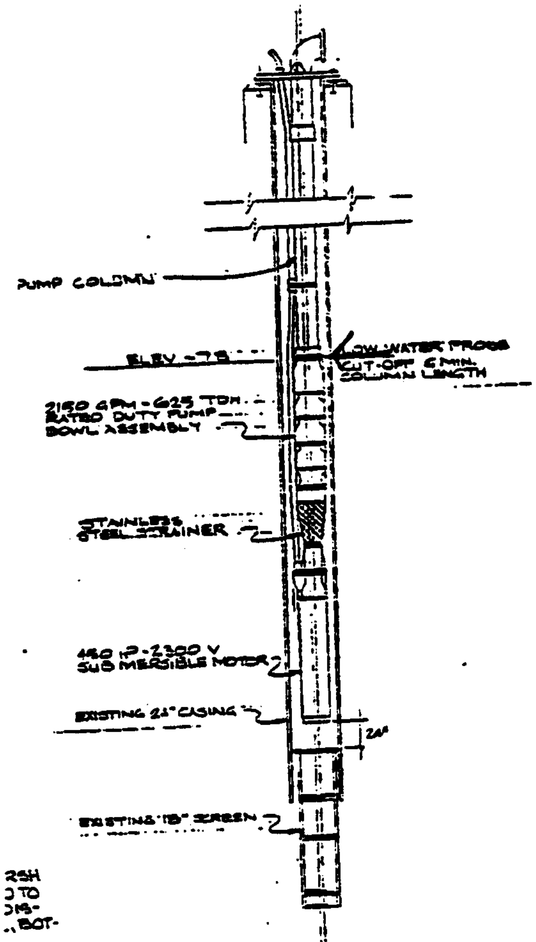


ANGLE LAKE WELL
AS BUILT DIAGRAM AND LOG
GROUND WATER SUPPLY
SE 1/4, SEC 9, T22N, R45E

...ND, COLLIER & WADE-LIVINGSTONE ASSOCIATES, INC.
CONSULTING ENGINEERS
...STONE WAY N SEATTLE WASHINGTON 98103 (206) 632-2664

Water District No. 75, King County
ANGLE LAKE WELL & PUMP STATION PHASE 2
MECHANICAL DETAILS

AR 039895



SUBMERSIBLE PUMP (2/4)
NO SCALE

UG

5" BRONZE COCK,
EQUAL

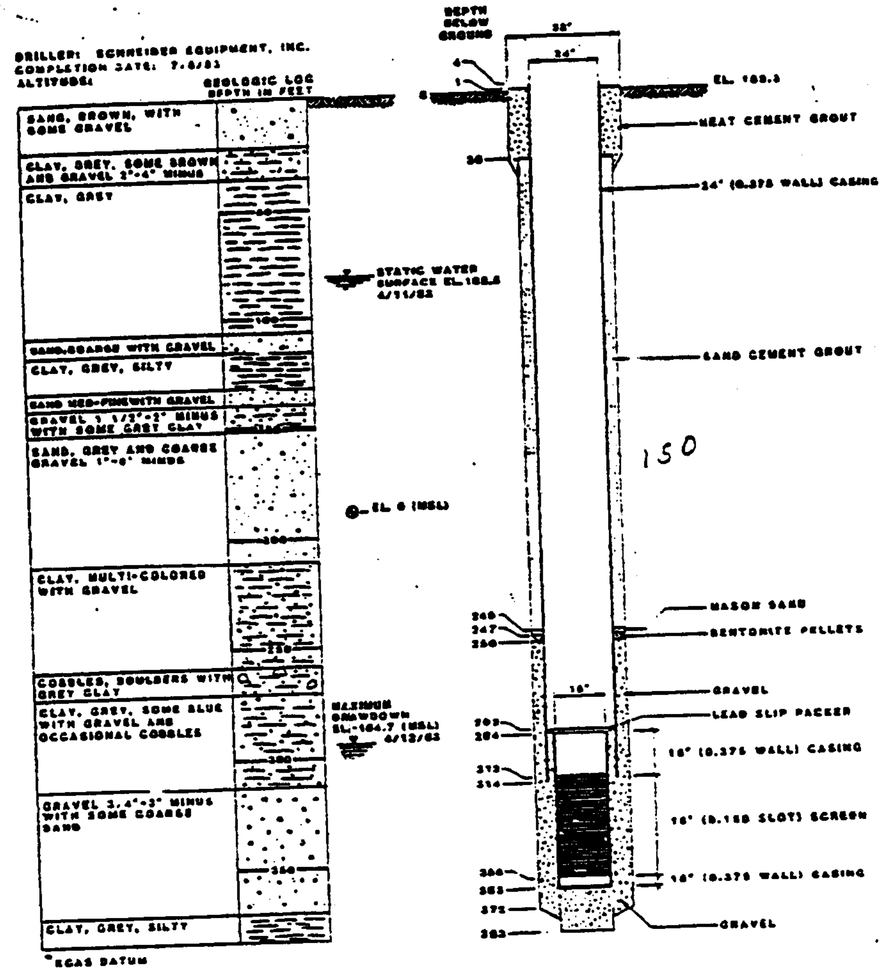
E GUAGE (3/4)

APCO NO. 55 OR EQUAL

UUM BREAKER & HOSE BIBB

BRONZE COCK,
QUAL

/E (5/4)



DES MOINES WELL
AS BUILT DIAGRAM AND LOG
GROUND WATER SUPPLY
NE 1/4, SEC 8, T22N, R4E

)LLIER & WADE-LIVINGSTONE
ISSOCIATES, INC.
ENGINEERS

Water District No. 75, King County
DES MOINES WELL & PUMP STATION
MECHANICAL DETAILS

HCW
KCW
COM

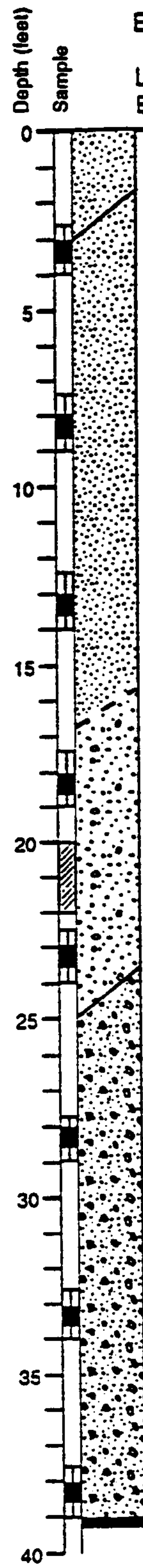
AR 039896

P.O.S. Coordinates: N 3480 E 12,710

Equipment Mobile B-61

Land Surface Elevation 243 feet Date 12/2/94

Laboratory Tests	Moisture Content (%)	Dry Density (pcf)	Blows per Foot
MD	2.5	104	21
MD	13.4	96	16
MD	4.6	99	24
MD,SA	2.9	132	29
COMP			
MD	5.7	144	90
			60
MD,SA	6.8	142	80
MD	4.4	132	81



BROWN SAND (SP) loose, wet; fine to medium grained, with organic material (Recessional Outwash - Unit 1).

GRAY BROWN SAND (SP) medium dense, moist; fine to coarse grained, with a trace of gravel (Recessional Outwash - Unit 1).

Becomes red brown.

GRAY SAND (SW) dense, moist; fine to coarse grained, with gravel and a trace of silt (Recessional Outwash - Unit 2).

Becomes very dense, wet; with fine to medium gravel.

GRAY GRAVEL (GW) very dense, saturated; fine to coarse grained, with sand and a trace of silt (Recessional Outwash - Unit 2).

Becomes brown.

Groundwater encountered at 25.5 feet during drilling. Boring backfilled with bentonite and cuttings on 12/2/94.

AGI TECHNOLOGIES

Log of Area 3 Boring 4

HNTB/Runway Borrow Source Study
SeaTac, Washington

PLATE **A19**

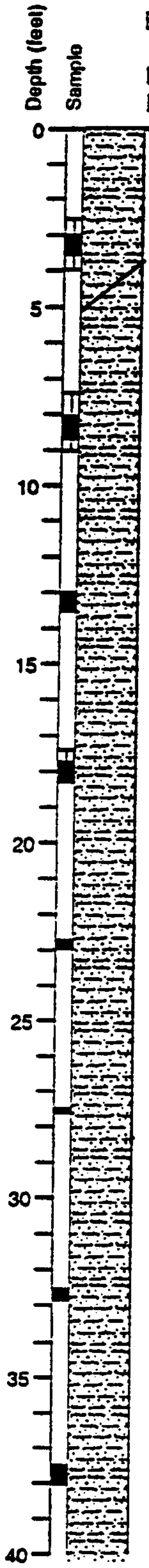
	PROJECT NO.	DRAWN	DATE	APPROVED	REVISED	DATE
H3mw.cdr	14,190.208	ECR	6 December 94			

P.O.S. Coordinates: N 3365 E 14,840

Equipment Mobile B-61

Land Surface Elevation 297 feet Date 12/23/94

Laboratory Tests	Moisture Content (%)	Dry Density (pcf)	Blows per Foot
MD	15.1	119	18
			50/5"
MD	7.7	124	50/3"
			50/4"
			50/1"
M	6.6		50/3"
			50/3"
MD	11.3	122	50/5"



BROWN-GRAY SILTY SAND (SM) medium dense, wet; fine to medium grained, with gravel (Fill).

GRAY SILTY SAND (SM) very dense, moist; fine to coarse grained, with fine gravel (Till - Unit 1).

With some wet interbedded sand zones.

AGI TECHNOLOGIES

Log of Area 1 Boring 8 (0-40')

HNTB/Runway Borrow Source Study

SeaTac, Washington

PLATE **A10a**

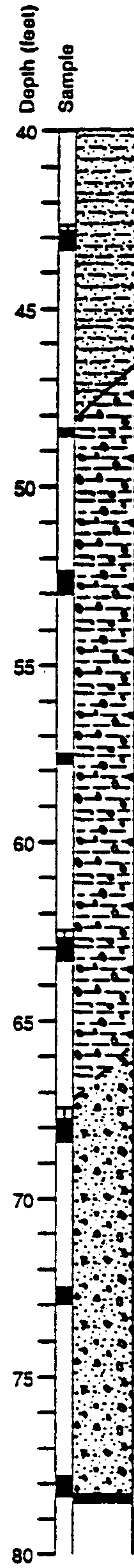
	PROJECT NO.	DRAWN	DATE	APPROVED	REVISED	DATE
H1Bmw.cdr	14,190.208	ECR	6 December 94			

P.O.S. Coordinates: N 3365 E 14,840

Equipment Mobile B-61

Land Surface Elevation 297 feet Date 12/23/94

Laboratory Tests	Moisture Content (%)	Dry Density (pcf)	Blows per Foot
			50/4"
			50/2"
MD	12.3	115	50/5"
			50/3"
			50/2"
MD	10.5	129	50/3"
			50/4"
			50/5"



BROWN SILTY GRAVEL (GM) very dense, wet; fine grained, with sand (Advance Outwash - Unit 3).

GRAY GRAVEL (GP-GM) very dense, wet; fine grained, with silt and sand (Advance Outwash - Unit 3).

Groundwater encountered at 71.5 feet during drilling. Boring backfilled with bentonite and cuttings on 12/23/94.

AGI TECHNOLOGIES

Log of Area 1 Boring 8 (40-78.4')

HNTB/Runway Borrow Source Study
SeaTac, Washington

PLATE **A10b**

	PROJECT NO.	DRAWN	DATE	APPROVED	REVISED	DATE
H1-40.cdr	14,190.208	ECR	6 December 94			

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AGI
TECHNOLOGIES

APPENDIX B

Study Area Water Rights
Washington Department of Ecology

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          RECORDED WATER RIGHTS OF THE DEPARTMENT OF ECOLOGY  REGION  1           PAGE  649      REPORT DATE  5/ 4/95
CONTROL #    SEC  OLD      OLD      OLD      DATE OF    S C A  CNTY  PERMIT    NAME                    SOURCE OF APPROPRIATION TRIBUTARY OF
              #   APPL     PERM     CERT     PRIORITY   T C M        DATE
#OF R                                                          USE     INST   C R S           ANNUAL C R S          IRR   C S PRO-   TIME OF  R R R
PTS P LOC. OF POD/POW  (CHG C#)   PURPOSE OF USE               TYPE     QI    M U U           QA     M U U          AC    M U VISOS  USE      I A C

WATER RESOURCE INVENTORY AREA-  09

TOWNSHIP - 23    RANGE - 04 E

 1    SW4SW4SE4                   IRRIGATION                   C        .7    C                                     68.5              IS

S1-21397C    08                            04/02/974            KING 05/15/975 RAINIER GOLF & C C UNN STR & POND
 1    NE4NE4                      IRRIGATION                   C       1.1    C              140.0                  70.0              IS

G1-22821P    09                            03/23/977  C         KING 10/14/977 CAPERCI JAMES ETUX WELL
 1    SE4SW4                      IRRIGATION                   C      10.0 G                   3.0                   1.2              IS

G1-24822A    09                            04/14/986  R         KING   /  /    SEATTLE CITY OF    WELL
 1    ENTIRE SECTION              DOMESTIC MUNICIPAL           C    4000.0 G

S1*02849C    09 02849   01476   00414   02/19/930               KING 06/05/930 SEATTLE DAHLIA GDN MILL CR *                          DUWAMISH R
 1    L3                          IRRIGATION                   C        .1    C                                      2.5              IS

S1*04133A    09 04133                   07/15/935  R            KING   /  /    RORVIK JACK        UNN SPR                            DUWAMISH R
 1    L-1                         DOMESTIC SINGLE              C       .02    C 2
                                  IRRIGATION                   C       .02    C 2                                    1.0              IS

S1*05610C    09 05610   03458   01879   11/13/941               KING 01/08/942 ROSATTO JOE ET UX  UNN STR                            DUWAMISH R
 1    L1                          IRRIGATION                   C       .01    C                                       .5              IS

S1*02063P    10 02063   00998           04/25/927  C            KING 10/07/927 ROBERTS DANA       GREEN R                            DUWAMISH R
 1    N/A                         DOMESTIC SINGLE              C      40.0    C 2
                                  COMMERCIAL/INDUSTRIAL        C      40.0    C 2

S1*02213P    10 02213   01058           12/14/927  C            KING 02/14/928 ENGLE ALLEN B      DUWAMISH R                         DUWAMISH WTRWAY
 1    NW4                         COMMERCIAL/INDUSTRIAL        C      16.0    C

S1*02483CAL  10 02483A  01255A  00390A  12/23/928               KING 03/29/929 BIGELOW W H        UNN SPRS                           DUWAMISH R
 1    2SW4SW4                     DOMESTIC SINGLE              C       .05    C 2                                                            2 0 0
                                  IRRIGATION                   C       .05    C 2                                    1.75             05011001 2 0 2

S1*02704P    10 02704   01490           09/13/929  C            KING 07/12/930 LITTLE RICHARD F J MILL CR                            DUWAMISH R
 1    BL-6 REPLAT RIVERSIDE TRS   POWER                        N       .04    C 2
                                  IRRIGATION                   C       .04    C 2                                    3.0              04011001

S1*03117P    10 03117   01671           08/29/930  C            KING 04/03/931 BRENNER GEORGE W   MILL CR                            DUWAMISH R
 1    GL-14                       DOMESTIC SINGLE              C       .04    C 2
                                  IRRIGATION                   C       .04    C 2                                    2.0              05011001

S1*04135C    10 04135   02313   05406   07/20/935               KING 10/28/936 WILSON J H         UNN STR                            DUWAMISH R
 1    L-18 BL-9 RIVERTON          DOMESTIC SINGLE              C     .0025C

S1*04742A    10 04742                   02/16/939  R            KING   /  /    POHL ED            MILL CR                            DUWAMISH R
 1    S2 TR-40 RIVERSIDE INT TRS  DOMESTIC SINGLE              C        .1    C 3
                                  FISH PROPAGATION             N        .1    C 3
                                  IRRIGATION                   C        .1    C 3                                    2.0              IS

S1*12332P    10 12332   09310           05/11/953 (C)           KING 12/10/953 CODIGA A           DUWAMISH R                         DUWAMISH WTRWAY
 1    C C LEWIS DLC               IRRIGATION                   C       .49    C                                     50.0     S        04151001
                                  DOMESTIC SINGLE              C       .01    C                                              S

G1-21930C    12                            06/12/974            KING 11/28/975 KING CO WTR D #14  WELL
 1    B 14 P KELSEY CRAIG 5 AC TRSDOMESTIC MUNICIPAL           C     300.0 G             480.0                               RM

G1-21931C    12                            06/12/974            KING 11/28/975 KING CO WTR D #14  WELL
 1    B 14 P KELSEY CRAIG 5 ACRE TDOMESTIC MUNICIPAL           C     100.0 G             160.0                               RM

S1*05220C    13 05220   03140   01772   08/03/940               KING 10/26/940 MATTHIESEN O S     UNN STR                            BLACK R SL
 1    L4 BL20 EARLINGTON ACRE TR  DOMESTIC SINGLE              C       .02    C 2
                                  IRRIGATION                   C       .02    C 2                                    1.5              IS

S1*19954CAL  13 19954A  14671A  09943A  10/31/966               KING 04/06/967 BLACK RIVER QUARRY BLACK R                            DUWAMISH R
 1    L-26 JUNCTION ADD           COMMERCIAL/INDUSTRIAL        C       1.0    C                                              SMD              2 0 0

G1-24891A    14                            08/18/986  R         KING   /  /    TUKWILA CITY OF PK WELL
 1    NE4SW4                      IRRIGATION                   C    1000.0 G

S1*19954CBL  14 19954B  14671B  09943B  10/31/966               KING 04/06/967 BLACK RIVER QUARRY BLACK R                            DUWAMISH R
 1    L-26 JUNCTION ADD           COMMERCIAL/INDUSTRIAL        C       1.0    C                                              SMD              2 0 0

S1-20620A    14                            05/15/973 (R)        KING   /  /    FREIDMAN/TWEET     DUWAMISH R                         DUWAMISH WTRWAY
 1    TR 44 45 46 PL E RV 2 IN NW4IRRIGATION                   C       .02    C 2                                    1.0              IS
                                  STOCK WATERING               C       .02    C 2

S1-23433C    14                            07/11/979            KING 08/31/981 TUKWILA CITY OF    DUWAMISH R                         DUWAMISH WTRWAY
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R = [illegible] APPLICATION
C = Cancelled PERMIT

AR 039903

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CONTROL #   SEC OLD     OLD     OLD     DATE OF   S C A   CNTY  PERMIT   NAME                          SOURCE OF APPROPRIATION TRIBUTARY OF
             #  APPL    PERM    CERT    PRIORITY  T C M         DATE
#OF R
PTS P LOC. OF POD/POW  (CHG C#)  PURPOSE OF USE           USE    INST   C R S      ANNUAL C R S     IRR  C S PRO-   TIME OF  R R R
                                                          TYPE   QI     M U U      QA     M U U     AC   M U VISOS  USE      I A C

WATER RESOURCE INVENTORY AREA-  09
TOWNSHIP - 23    RANGE - 04 E

  1   NW4SE4                       IRRIGATION               C      1.78  C           104.0                           SM      IS

G1-00013C    15 06604   06230              02/04/963        KING 05/27/963 RIVERTON CREST CEM WELL
 1   GL-4                          IRRIGATION               C     150.0 G              30.0              15.0                 05010930

S1*02483CBL  15 02483B  01255B  00390B  12/23/928           KING 03/29/929 BIGELOW W H       UNN SPRS                         DUWAMISH R
 1   2NW4NW4                       DOMESTIC SINGLE          C      .05  C 2                                                           2 0 0
                                   IRRIGATION               C      .05  C 2                               1.75                05011001 2 0 2

S1*03164C    15 03164   01641   00636   09/23/930           KING 03/06/931 DESIMONE G        MILL CR *                        DUWAMISH R
 1   BL-12 RIVERTON PL             IRRIGATION               C      .4   C                                 40.0                IS

S1*04332C    15 04332   02369   01197   12/29/936           KING 03/30/937 TORBERT E S       UNN STR                          DUWAMISH R
 1   L1 BL2 ROBBINS SPR BROOK ADDPOWER                      N      .04  C
                                   IRRIGATION               C      .01  C                                 1.1                 IS

S1*04776C    15 04776   02763   01333   04/08/939           KING 07/27/939 ABBEY E D         UNN SPR                          DUWAMISH R
 1   L6                            DOMESTIC SINGLE          C      .01  C

S1*05283C    15 05283   03203   01681   10/15/940           KING 01/16/941 LOVEGREN F J      UNN STR                          DUWAMISH R
 1   NE4 NW4                       DOMESTIC SINGLE          C      .01  C 2
                                   IRRIGATION               C      .01  C 2                               .5

S1*06036C    15 06036   03848   02043   05/23/944           KING 07/14/944 HINTERBERGER E    UNN STR                          DUWAMISH R
 1   W2 NW4 NW4                    DOMESTIC MULTIPLE        C      .02  C 2
                                   IRRIGATION               C      .02  C 2                               1.8                 IS

S1*06087C    15 06087   04029   02178   07/29/944           KING 03/23/945 MCRAE W           UNN STR                          DUWAMISH R
 1   NW4NW4                        IRRIGATION               C      .01  C                                 .5                  IS

S1*06610C    15 06610   04354   02415   08/21/945           KING 01/30/946 CLOGSTON T L      UNN STR                          DUWAMISH R
 1   GL6                           FISH PROPAGATION         N      .03  C                                          S*

S1*07600C    15 07600   05079   03401   01/18/947           KING 06/12/947 MADDEN G          UNN STR                          DUWAMISH R
 1   NE4                           IRRIGATION               C      .05  C                                 5.0      S          IS

S1*16714C    15 16714   12412   08555   06/08/961           KING 09/01/961 ROSS R E          UNN STR                          DUWAMISH R
 1   L12 BL8 ROBBINS SPR BRK ADD IRRIGATION                 C      .01  C            1.0                  .5       SD         IS

S1-00403C    15 23185   16821           06/21/971           KING 01/19/972 WHITTINGTON ETHEL UNN STR
 1   L 19 20 BL 2 PL MORTIMER PL DOMESTIC SINGLE            C      .01  C            1.0                           SM

G1-24619A    16                         03/07/985           KING   / /      SEATTLE CITY OF  WELL
 1   NW4                           DOMESTIC MUNICIPAL       C    4000.0 G

G1-24620A    16                         03/07/985           KING   / /      SEATTLE CITY OF  WELL
 1   NW4SE4                        DOMESTIC MUNICIPAL       C    4000.0 G

G1-24824A    16                         04/14/986           KING   / /      SEATTLE CITY OF  WELL
 1   NW4SE4                        DOMESTIC MUNICIPAL       C    4000.0 G

G1-24825A    16                         04/14/986           KING   / /      SEATTLE CITY OF  WELL
 1   NW4                           DOMESTIC MUNICIPAL       C    4000.0 G

S1*19083A    17 19083                   06/16/965  R        KING   / /      MCLEOD THOMAS T  UNN STR                          PUGET SOUND
 1   LOT-7 PLAT MCKAY'S ADDITION DOMESTIC SINGLE            C      .01  C

S1*00158A    18 00158                   07/16/918  R        KING   / /      WORTH HENRY      UNN STR                          PUGET SOUND
 1   NW4                           DOMESTIC SINGLE          C      .2   C 2
                                   IRRIGATION               C      .2   C 2                               10.0                IS

G1*00533S    19 00533           00488   05/15/940  Q        KING   / /      KING CO WTR DIST # WELL
 1   NW4SE4NE4                     DOMESTIC MULTIPLE        C     400.0 G           132.0

G1*00534S    19 00534           00489   05/00/944  Q        KING   / /      KING CO WTR DIST # WELL
 1   W2NW4SE4NE4                   DOMESTIC MULTIPLE        C     400.0 G           132.0

G1*00673C    19 00673   00653   00333   12/19/947  Q        KING 04/01/948 KING CO WTR DIST # WELL
 1   W2NW4SE4NE4                   DOMESTIC MULTIPLE        C    1000.0 G           840.0

G1-24532A    19                         08/06/984  R        KING   / /      KCWD #49         WELL
 1   NW4NE4                        DOMESTIC MUNICIPAL       C    3000.0 G

S1-22016C    19                         07/23/974           KING 10/31/975 GWINN HOWARD J    BURIEN LK
 1   L-7 PL LAKEWOOD TERRACE       IRRIGATION               C      .01  C            1.0                  .5       S          IS
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RECORDED WATER RIGHTS OF THE DEPARTMENT OF ECOLOGY REGION 1 PAGE 651 REPORT DATE 5/ 4/95

WATER RESOURCE INVENTORY AREA- 09

TOWNSHIP - 23 RANGE - 04 E

CONTROL #	SEC #	OLD APPL	OLD PERM	OLD CERT	DATE OF PRIORITY	S C A T C H	CNTY	PERMIT DATE	NAME	SOURCE OF APPROPRIATION	TRIBUTARY OF	#OF PTS	R P	LOC. OF POD/POW (CHG C#)	PURPOSE OF USE	USE TYPE	INST QI	C R S H U U	ANNUAL QA	C R S H U U	IRR AC	C S H U	PRO-VISOS	TIME OF USE	R R R I A C
S1-22081C	19				09/09/974		KING	09/15/975	PERRY ROBERT L	BURIEN LK		1		NE4SW4	IRRIGATION	C	.02	C	1.0		.5	S		IS	
S1-22099C	19				09/23/974		KING	08/31/975	CASSIDY THOMAS G	BURIEN LK		1		NE4SW4	IRRIGATION	C	.02	C	1.0		.5	S		IS	
S1-23411C	19				06/20/979		KING	03/31/981	DILLON CARL L	BURIEN LK		1		NW4SW4	IRRIGATION	C	.01	C	.5		.33	S		IS	
S1*02060C	20	02060	00989	00625	04/23/927		KING	09/24/927	BALZARINI L	UNN STR	MILLER CR *	1		SW4SW4SW4	IRRIGATION	C	.2	C			4.75			IS	
S1*03699P	20	03699	01941		08/06/932	C	KING	11/23/932	HALL BARRY B	UNN CR		1		E2SW4SW4SW4	DOMESTIC SINGLE IRRIGATION	C C	.1 .1	C 2 C 2			5.0			04011101	
S1*03763C	20	03763	01972	01051	12/09/932	E	KING	02/06/933	BURNS E	UNN CR		1		SW4 SW4	DOMESTIC SINGLE	C	.02	C					M		
G1*01850C	21	01850	02428	02417	03/03/951		KING	10/27/952	KING CO WTR DIST #	WELL		1		L3 BL2 KNOXS 5 AC GDN TRS	DOMESTIC MULTIPLE	C	350.0	G	560.0				A		
G1*04227C	21	04227	04089	02726	02/23/956		KING	10/05/956	KING CO WTR DIST #	WELLS		2		L3 BL2 KNOX 5 AC GDN TR	DOMESTIC MULTIPLE	C	1425.0	G	448.0	S			AE		
G1-24621A	21				03/07/985		KING	/ /	SEATTLE CITY OF	WELL		1		NE4NW4	DOMESTIC MUNICIPAL	C	4000.0	G							
G1*00230P	22	00230	00361		05/07/946	C	KING	02/06/947	FINCH DAVID R ET U	WELL		1		SW4SW4	DOMESTIC MULTIPLE	C	150.0	G	67.0						
S1*01029A	22	01029			12/15/923	R	KING	/ /	GREENE E F	UNN SPR	WHITE R	1		E2SE4	DOMESTIC MUNICIPAL	C	.5	C							
S1*03119C	22	03119	01635	00635	08/29/930		KING	02/26/931	LEE I W	UNN SPR		1		NE4SW4	IRRIGATION	C	.02	C			2.0			IS	
S1*04367C	22	04367	02397	01016	03/25/937		KING	06/15/937	RASMUSSEN H E	UNN SPRS	UNN STR	1		SUNNYDALE GARDENS ADD DIV 1	DOMESTIC SINGLE IRRIGATION	C C	.05 .05	C 2 C 2			2.12			IS	
S1*04455C	22	04455	02500	02679	08/21/937		KING	12/21/937	ANDROS J	UNN SPRS	DUWAMISH R	1		E2N2NW4SE4	DOMESTIC SINGLE IRRIGATION	C C	.03 .03	C 2 C 2			2.5			IS	
S1*04862C	22	04862	02802	01728	06/02/939		KING	09/15/939	SHARP H E	UNN STR	GILLAM CR *	1		SW4 NW4 SE4	DOMESTIC SINGLE IRRIGATION	C C	.02 .02	C 2 C 2			1.5			IS	
S1*10073C	22	10073	07209	05264	01/09/951		KING	05/07/951	MAXWELL J C	UNN STR	GREEN R	1		L7 BL4 3RD ADDN ADAMS HM TRS	DOMESTIC SINGLE FISH PROPAGATION	C N	.2 .2	C 2 C 2					SD SD		
S1*13085C	22	13085	09799	06337	08/18/954	E	KING	01/07/955	LILLEHEI O	UNN STR	GREEN R	1		S2 L6 BL4 3 ADD ADAMS HM TR	DOMESTIC SINGLE FISH PROPAGATION IRRIGATION	C N C	.01 .01 .01	C 3 C 3 C 3			1.0		S S S	IS	
S1*14752C	22	14752	11056	07641	04/14/958		KING	07/14/958	BENNETT V R	UNN SPRS		1		TR28 SUNNYDALE GARDENS DIV 1	DOMESTIC SINGLE STOCK WATERING	C C	.01 .01	C 2 C 2					SO SO		
S1*17629PAL	22	17629A	12995A		11/23/962	C	KING	03/18/963	ALBERTI F ET AL	UNN SPR	GILLIAM CR	1		SE4 SE4	IRRIGATION	C	.12	C	24.0		12.0		S	IS	2 2 2
S1*07645C	23	07645	05182	03365	02/22/947		KING	08/25/947	SMITH E G	GILLAM CR *	GREEN R	2		TR24 BROOKVALE GARDEN TRS	FIRE PROTECTION IRRIGATION	C C	.02 .02	C 2 C 2			2.0		S S	IS	
S1*07960C	23	07960	05353	03826	07/30/947		KING	11/18/947	EPPS R	GILLIAM CR *	GREEN R	1		L14 CEDAR LODGE	IRRIGATION	C	.015	C			1.5		S	IS	
S1*11370C	23	11370	08296	05742	05/19/952		KING	09/05/952	JORGENSEN G	GREEN R	DUWAMISH R	1		GL-1,2	IRRIGATION	C	.5	C			53.0		S	IS	

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            RECORDED WATER RIGHTS OF THE DEPARTMENT OF ECOLOGY  REGION  1             PAGE  652     REPORT DATE  5/ 4/95
CONTROL #     SEC  OLD      OLD      OLD      DATE OF   S C A   CNTY  PERMIT    NAME                     SOURCE OF APPROPRIATION TRIBUTARY OF
               #   APPL     PERM     CERT     PRIORITY  T C M         DATE
#OF R                                                           USE     INST  C R S       ANNUAL C R S      IRR  C S PRO-    TIME OF  R R R
PTS P LOC. OF POD/POW  (CHG C#)   PURPOSE OF USE                TYPE    QI    M U U       QA     M U U      AC   M U VISOS   USE      I A C

WATER RESOURCE INVENTORY AREA-  09

TOWNSHIP - 23    RANGE - 04 E

S1*12487CAW  23 12487A  09305A  06736A  08/05/953         KING 12/07/953 WATKINS A D          UNN SPRS                         DUWAMISH R
 1   BROOKVALE GARDEN TR-13     DOMESTIC SINGLE           C      .01  C                                              M                 2 0 0
                                FISH PROPAGATION          P      .04  C                                              M                 2 0 0
S1*12487CBW  23 12487B  09305B  06736B  08/05/953         KING 12/07/953 WATKINS A D          UNN STR                          DUWAMISH R
 1   BROOKVALE GARDEN TR-13     DOMESTIC SINGLE           C      .01  C                                              M                 2 0 0
                                FISH PROPAGATION          P      .04  C                                              M                 2 0 0

S1*15025P    23 15025   13004           08/27/958  C      KING 12/08/958 WATANABE S & M       UNN SPR                          DUWAMISH R
 1   TR6 BROOKVALE GARDEN TRS   DOMESTIC SINGLE           C      .01  C
                                IRRIGATION                C      .02  C                   4.0                    2.0      S    04151001

S1*17629PBL  23 17629B  12995B          11/23/962  C      KING 03/18/963 ALBERTI F ET AL      UNN SPR                          GILLIAM CR
 1   TR8 BROOKVALE GARDEN TRS   IRRIGATION                C      .12  C                  24.0                   12.0      S    IS          2 2 2

G1-27288A    24                         08/12/993         KING   /  /    BOEING CO            WELL
 1   NE4SW4                     ENVIRONMENTAL QUALITY     C    100.0 G

S1*04795C    24 04795   02768   01240   04/25/939         KING 08/02/939 ANDERSON H C         GREEN R                          DUWAMISH R
 1   SW4SW4                     IRRIGATION                C      .75  C                                         70.0      S(   IS

S1*11368C    24 11368   08294   05764   05/19/952         KING 09/05/952 NELSEN F             UNN DRN DIT                      BLACK R
 1   SW4NE4                     IRRIGATION                C      .4   C                                         40.0      SD   IS

S1*11369C    24 11369   08295   05741   05/19/952         KING 09/05/952 NIELSEN J            UNN DRN DIT                      BLACK R
 1   SW4NE4                     IRRIGATION                C      .35  C                                         35.0      SD   IS

S1-23815C    24                         03/24/981         KING 04/15/982 ALLEMAN KEN K        GREEN R
 1   GL-10 W/N SW4              IRRIGATION                C      .02  C                   4.0                    1.0      S-   IS

S1*02381C    25 02381   01252   00809   08/10/928         KING 03/14/929 HILL F G             GREEN R                          DUWAMISH R
 1   SW4NW4                     IRRIGATION                C     1.0   C                                         71.0           IS

S1*05951P    25 05951   03786           01/29/944  C      KING 03/24/944 MARTIN ELIZABETH B   GREEN R                          DUWAMISH R
 1   GL-4                       IRRIGATION                C      .4   C                                         30.0      M    04151001

S1*07753C    25 07753   05091   03611   04/12/947         KING 06/20/947 STREULI O            GREEN R                          DUWAMISH R
 1   GL5                        IRRIGATION                C      .6   C                                         60.0      S    IS

S1*04560P    26 04560   02657           07/18/938  C      KING 02/21/939 CLOUGH RUSSELL A     UNN SPRS                         DUWAMISH R
 2   NW4NW4                     DOMESTIC SINGLE           C      .02  C 2
                                IRRIGATION                C      .02  C 2                                        6.4

S1*04561P    26 04561   02658           07/18/938  C      KING 02/21/939 CLOUGH RUSSELL A     UNN SPRS
 2   NW4NW4                     DOMESTIC SINGLE           C      .005 C 2
                                IRRIGATION                C      .005 C 2                                        6.4

S1*04562P    26 04562   02659           07/18/938  C      KING 02/21/939 CLOUGH RUSSELL A     UNN SPRS
 2   NW4NW4                     DOMESTIC SINGLE           C      .05  C 2
                                IRRIGATION                C      .05  C 2                                        6.4

S1*10657C    26 10657   07698   04489   08/27/951         KING 12/10/951 GREENHEAD GUN CLUB   UNN SPR                          GREEN R
 1   L11 BL3 MCMICKEN HT        DOMESTIC SINGLE           C      .01  C

S1*12852C    26 12852   09665   07301   04/05/954         KING 10/01/954 ROBINSON S A         UNN SPRS
 2   NW4NW4                     DOMESTIC SINGLE           C      .01  C                                              M
                                FISH PROPAGATION          N      .03  C                                              M

G1*00109S    27 00109           00069   01/00/927         KING   /  /    SOUTH SEATTLE LAND   WELL
 1   NW4                        DOMESTIC MULTIPLE         C    150.0 G                  244.0

G1*00110S    27 00110           00070   02/07/944         KING   /  /    SOUTH SEATTLE LAND   WELL
 1   NW4                        DOMESTIC MULTIPLE         C    350.0 G                  566.0

G1*00291C    27 00291   00294   00153   06/20/946     W   KING 11/07/946 SOUTH SEATTLE LAND   WELL
 1   SW4                        DOMESTIC MULTIPLE         C    400.0 G                  250.0

G1*00292A    27 00292                   06/20/946  R      KING   /  /    S SEATTLE LAND CO    WELL
 1   SW4NW4                     DOMESTIC MUNICIPAL        C    400.0 G

G1*03450C    27 03450   03228   02181   12/04/953         KING 03/05/954 SOUTH SEATTLE WTR    WELL
 1   L10 BL27 MCMICKEN HTS DIV 2 DOMESTIC MULTIPLE        C    500.0 G 2                740.0     S                  A
                                DOMESTIC MULTIPLE         C    500.0 G 2                 60.0                        A

G1*06179P    27 06179   05816           02/14/962  C      KING 04/27/962 SOUTH SEATTLE WTR    WELL
 1   L19 BL11 MCMICKEN HTS DIV 2 DOMESTIC MULTIPLE        C    800.0 G                 1280.0                        A
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AR 039906

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CONTROL #   SEC  OLD    OLD    OLD   DATE OF    S C A   CNTY  PERMIT    NAME                     SOURCE OF APPROPRIATION TRIBUTARY OF
            #    APPL   PERM   CERT  PRIORITY   T C M         DATE
#OF R                                                   USE    INST  C R S      ANNUAL C R S     IRR  C S PRO-    TIME OF  R R R
PTS P LOC. OF POD/POW  (CHG C#)  PURPOSE OF USE         TYPE   QI    M U U      QA     M U U     AC   M U VISOS   USE      I A C

WATER RESOURCE INVENTORY AREA-  09

TOWNSHIP - 23    RANGE - 04 E

G1-26913A   .27                      02/01/993          KING   /  /     TUKWILLA CITY OF    WELLS 7
7   NW4NE4                    DOMESTIC MUNICIPAL        C     9750.0 G                                   0                     0 0 0

S1*07180P  \.27 07180   04779        05/27/946  C       KING 12/19/946 DELANEY JOSEPH J     UNN SPR                       WHITE R
 1   NE4NE4                   FISH PROPAGATION          N       .005 C                                        M
                              IRRIGATION                C       .005 C                            2.13        M   04151001

G1*05706C    28 05706   05364   03929   08/17/960       KING 10/28/960 WASHINGTON CEMETER WELL
 1   SEC OF WASH MEMORIAL DIV 2   IRRIGATION            C     500.0 G           130.0             65.0        AE  IS

G1*06154A    29 06154                01/16/962  R       KING   /  /     KING CO WATER DIS   WELL
 1   SW4SW4                   DOMESTIC MUNICIPAL        C     300.0 G

S1*00849C   '29 00849   00304   00694   11/09/922       KING 03/28/923 ROSAIA P F / G P     MILLER CR *                   PUGET SOUND
 1   NW4SE4NW4                IRRIGATION                C      .3   C                             23.5            IS

S1*00854P   '29 00854   00333        11/13/922  C       KING 06/28/923 KESSLER MAUD         MILLER CR
 1   SE4NW4                   DOMESTIC SINGLE           C      .2   C 3
                              REC & BEAUTIFICATION      N      .2   C 3
                              IRRIGATION                C      .2   C 3                           10.0            04151001

S1*00907C    29 00907   00332   01300   04/06/923       KING 06/13/923 KINCAID J            MILLER CR *                   PUGET SOUND
 1   N2 NE4 SW4 NW4           REC & BEAUTIFICATION      N      .15  C 2
                              IRRIGATION                C      .15  C 2                           4.0             IS

S1*01205C   '29 01205   00505   00070   11/18/924       KING 04/14/925 ODONNELL ADA         UNN STR                       MILLER CR *
 1   S2 NW4 NW4               DOMESTIC SINGLE           C      .25  C 2
                              IRRIGATION                C      .25  C 2                           3.0             IS

S1*02138C    29 02138   01000   00280   08/16/927       KING 10/18/927 BURTON HENRY ET UX   UNN STR                       MILLER CR *
 1   SW4SE4                   IRRIGATION                C      .1   C                             4.0             IS

S1*02890C   '29 02890   01497   01106   03/24/930       KING 07/25/930 WINTER C M           UNN STR                       MILLER CR *
 1   W2NW4NW4   NW4           IRRIGATION                C      .02  C                             1.0             IS

S1*03594C   '29 03594   01872   01239   01/28/932       KING 04/20/932 EMMANUEL S           MILLER CR *                   PUGET SOUND
 1   NW4NW4                   IRRIGATION                C      .06  C                             3.0             IS

S1*03623P   '29 03623   01901        04/19/932  C       KING 07/02/932 BAKER FREDERIC A     MILLER CR                     PUGET SOUND
 1   NW4NW4                   DOMESTIC SINGLE           C      .1   C 2
                              IRRIGATION                C      .1   C 2                           6.0

S1*03773C   '29 03773   01994   00844   01/03/933       KING 04/10/933 ORCHARD T K          UNN STR                       MILLER CR *
 1   SW4NE4NE4                DOMESTIC SINGLE           C      .06  C 2                                       M
                              IRRIGATION                C      .06  C 2                           3.0         M   IS

S1*04369C    29 04369   02436   04740   04/03/937       KING 07/31/937 GORDON W G           MAYBROOK CR *                 MILLER CR *
 1   N2 E2 S2 SW4 NW4 SW4     DOMESTIC SINGLE           C      .02  C 2
                              IRRIGATION                C      .02  C 2                           1.87            IS

S1*04421C   '29 04421   02449   02660   06/08/937       KING 08/17/937 MAY M M              MAYBROOK CR *                 MILLER CR *
 1   NW4 SW4                  DOMESTIC SINGLE           C      .1   C 4
                              FISH PROPAGATION          N      .1   C 4
                              REC & BEAUTIFICATION      C      .1   C 4
                              IRRIGATION                C      .1   C 4                           2.5             IS

S1*04551CAM '29 04551A  02626A  01811A  06/29/938   *   KING 01/05/939 THOMPSON R E         MAYBROOK CR *                 MILLER CR *
 1   2SW4 NE4 NW4 SW4         DOMESTIC SINGLE           C      .02  C 2                                                        0 0 0
                              IRRIGATION                C      .02  C 2                           2.5                          0 0 2

S1*04551CBM  29 04551B  02626B  01811B  06/29/938   A   KING 01/05/939 FISHER E             MAYBROOK CR *                 MILLER CR *
 1   2E2E2NW4SW4              DOMESTIC SINGLE           C      .01  C 2                                                        0 0 0
                              IRRIGATION                C      .01  C 2                           2.5                          0 0 2

S1*04903C    29 04903   02814   01577   07/17/939       KING 09/29/939 ROULLARD W R         MILLER CR *                   PUGET SOUND
 1   SW4NE4                   IRRIGATION                C      .01  C                             .25             IS

S1*04904C    29 04904   02824   01633   07/17/939       KING 10/09/939 RANDALL D            MILLER CR *                   PUGET SOUND
 1   SE4NW4                   IRRIGATION                C      .01  C                             .5              IS

S1*05145P    29 05145   03207        05/23/940  C       KING 01/17/941 WALLACE W A          MILLER CR                     PUGET SOUND
 1   N2N2S2NW4NE4             IRRIGATION                C      .01  C                             .5          M   04151001

S1*05219P    29 05219   03139        08/01/940  C       KING 10/26/940 KERR WILLIAM         MILLER CR                     PUGET SOUND
 1   S2N2S2NW4NE4             IRRIGATION                C      .03  C                             2.5         M   04151001

S1*05783P    29 05783   03661        01/14/943  C       KING 04/28/943 PHELPS ARCHIE E      MILLER CR                     PUGET SOUND
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AR 039907

CONTROL # / #OF PTS R P LOC. OF POD/POW	SEC #	OLD APPL	OLD PERM (CHG C#)	OLD CERT	DATE OF PRIORITY	S C A T C M	PURPOSE OF USE	USE TYPE	CNTY	PERMIT DATE	INST QI	C R S M U U	NAME	ANNUAL QA	SOURCE OF APPROPRIATION	IRR AC	C S M U / PRO-VISOS	TRIBUTARY OF	TIME OF USE	R R R I A C
WATER RESOURCE INVENTORY AREA- 09																				
TOWNSHIP - 23 RANGE - 04 E																				
1 SW4NW4							DOMESTIC SINGLE	C			.03	C 2					M			
							FISH PROPAGATION	N			.03	C 2					M			
S1*05799A	29	05799			03/04/943	R			KING	/ /			PADDOCK CHARLES R		MILLER CR			PUGET SOUND		
1 SE4NW4							DOMESTIC SINGLE	C			.05	C 2								
							IRRIGATION	C			.05	C 2				2.0			IS	
S1*05991C	29	05991	03812	02212	03/31/944				KING	05/18/944			LLOYD R		MILLER CR *			PUGET SOUND		
1 SW4 NE4							DOMESTIC SINGLE	C			.01	C 2								
							IRRIGATION	C			.01	C 2				1.7			IS	
S1*06355C	29	06355	04091	04438	03/16/945				KING	05/22/945			HUTH A J		UNN SPR			MILLER CR *		
1 SW4 NE4							DOMESTIC SINGLE	C			.01	C								
S1*12460C	29	12460	09278	05958	07/21/953				KING	11/18/953			FISHER ELMER ET UX		MAYBROOK CR *		SD#	MILLER CR *		
1 E2NW4SW4							DOMESTIC SINGLE	C			.01	C								
S1*12791C	29	12791	09495	06259	03/03/954				KING	05/12/954			MCKINNON J A		MAYBROOK CR *		SD	MILLER CR *		
1 SW4NW4SW4							DOMESTIC SINGLE	C			.01	C								
S1*16768C	29	16768	12438	08435	07/07/961				KING	10/09/961			PETERSEN K E		MAYBROOK CR *		SD	MILLER CR *		
1 E2SE4NW4 SW4							FISH PROPAGATION	N			.01	C								
S1-20949C	29				10/02/973				KING	02/28/975			BUTTS BERTHA W		UNN STR		S	MILLER CR *		
1 SW4NE4							DOMESTIC SINGLE	C			.01	C		1.0						
S1-22238A	29				06/03/974	R			KING	/ /			MERCY JOHN A		UNN STR (MAY CR)			PUGET SD		
1 NW4SW4							STOCK WATERING	C			.01	C								
G1*02695C	30	02695	02585	01790	09/02/952				KING	02/06/953			NORMANDY PARK WTR		WELL		AE			
1 NE4SE4							DOMESTIC MULTIPLE	C			250.0	G		400.0						
G1*03057C	30	03057	02876	01639	03/10/953	Q			KING	07/06/953			KING CO WTR DIST #		WELL		S			
1 SW4NW4							DOMESTIC MULTIPLE	C			1000.0	G 2		1104.0			A			
							DOMESTIC MULTIPLE	C			1000.0	G 2		509.0			A			
G1-20523C	30				04/03/973				KING	03/15/974			SOUTHWEST SUB SEW		WELL		TMPR			
1 E2 SW4							COMMERCIAL/INDUSTRIAL	C			100.0	G		160.0						
G1-24687G	30				08/06/985				KING	08/15/986			HOOVER MAHLON R		INFILTRATION SYSTEM					
6 NE4SE4							HEAT EXCHANGE	C			15.0	G 2		1.0						
							IRRIGATION	C			15.0	G 2				.75			IS	
G1-24754C	30				10/30/985				KING	01/16/990			SW SUB SEWER DIST		WELL		RM			
1 E2SW4							COMMERCIAL/INDUSTRIAL	C			33.0	G		17.4						
G1-24755A	30				10/30/985	R			KING	/ /			SOUTHWEST SUB SEWE		WELL					
1 E2SW4							COMMERCIAL/INDUSTRIAL	C			250.0	G								
G1-25411C	30				03/17/989				KING	11/15/989			SW SUB SEWER DIST		WELL		#RM			
1 E2SW4							COMMERCIAL/INDUSTRIAL	C			150.0	G		240.0						
S1*03658C	30	03658	01975	01502	06/20/932				KING	02/15/933			DRACHENBERG F		UNN STR			MILLER CR *		
1 NE4NE4NE4							FISH PROPAGATION	N			.1	C 3					M			
							REC & BEAUTIFICATION	N			.1	C 3					M			
							IRRIGATION	C			.1	C 3				4.0	M		IS	
S1*04479C	30	04479	02529	01103	11/29/937				KING	03/16/938			LOVGREN E		UNN SPRS			MILLER CR *		
1 SW4 SW4 NE4							DOMESTIC SINGLE	C			.02	C 3								
							FIRE PROTECTION	C			.02	C 3								
							IRRIGATION	C			.02	C 3				2.0			IS	
S1*04612C	30	04612	02640	01295	08/30/938				KING	01/23/939			CHESBRO C E		UNN SPR		S	MILLER CR *		
1 W2 NE4 NE4							IRRIGATION	C			.02	C				1.0			IS	
S1*05059C	30	05059	02978	01354	01/26/940	E			KING	03/22/940			RUTOWSKI J J		UNN STR			MILLER CR *		
1 SW4 NE4							DOMESTIC SINGLE	C			.02	C 2								
							IRRIGATION	C			.02	C 2				2.0			IS	
S1*05399C	30	05399	03303	02061	03/29/941				KING	06/02/941			HEAD W L		UNN STR			MILLER CR *		
1 S2NE4NW4NE4							FISH PROPAGATION	N			.01	C 2					M			
							IRRIGATION	C			.01	C 2				.75	M			
S1*06210C	30	06210	04108	02781	10/20/944				KING	06/12/945			KUEHNOEL O A		WALKER CR *		#SF	MILLER CR *		
1 NE4SE4							FISH PROPAGATION	N			.25	C								

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CONTROL #    SEC  OLD      OLD      OLD      DATE OF    S C A   CNTY  PERMIT    NAME                     SOURCE OF APPROPRIATION TRIBUTARY OF
              #   APPL     PERM     CERT     PRIORITY   T C M         DATE
#OF R                                                           USE       INST   C R S          ANNUAL C R S         IRR   C S PRO-    TIME OF   R R R
PTS P LOC. OF POD/POW  (CHG C#)   PURPOSE OF USE                TYPE       QI    M U U          QA     M U U         AC    M U VISOS   USE       I A C

WATER RESOURCE INVENTORY AREA-  09

TOWNSHIP - 23    RANGE - 04 E

S1*06647C   30 06647   04541    03264    09/05/945             KING 07/08/946 HERRING C J ET UX  UNN SPRS                             MILLER CR *
 1   SE4SW4                     DOMESTIC SINGLE                C         .01  C

S1*06828C   30 06828   04478    02492    12/31/945             KING 05/13/946 HUBBERT F A        MILLER CR *                          PUGET SOUND
 1   SW4SW4, L-7 SHORBROOK ADD  IRRIGATION                     C         .01  C                                       1.0     S      IS

S1*10542C   30 10542   07558    04634    07/20/951             KING 10/12/951 THOMAS D           MAYBROOK CR *                        MILLER CR *
 1   SE4NE4SE4                  IRRIGATION                     C         .01  C                                       1.0     SD     IS

S1*11384P   30 11384   08268             05/22/952   C         KING 08/25/952 ANNIBAL ALFRED G   UNN STR
 1   NE4SE4                     DOMESTIC SINGLE                C         .01  C                                               SM

S1*11385C   30 11385   08264    05898    05/22/952             KING 09/25/952 ANNIBAL R J        UNN STR
 1   NE4NE4SE4                  DOMESTIC SINGLE                C         .01  C                                               S

S1*11583CAW 30 11583A  08459A   06012A   08/12/952             KING 11/25/952 PARKER A           MAYBROOK CR *                        MILLER CR *
 1   SE4SE4                     REC & BEAUTIFICATION           N         .11  C                                               SMD              2 0 0
S1*11583CBW 30 11583B  08459B   06012B   08/12/952             KING 11/25/952 PARKER A           SEEPAGE WTR                          PUGET SOUND
 1   SE4SE4                     REC & BEAUTIFICATION           N         .11  C                                               SMD              2 0 0

S1-20116C   30                           05/09/972             KING 02/12/973 WILSON T A         UNN STR
 1   SE4NE4SE4                  IRRIGATION                     C         .01  C              2.0                      1.0     SM     04010830

S1-21479C   30                           04/11/974             KING 05/30/975 DAMMANN GILBERT H  UNN SPR
 1   SE4SE4                     IRRIGATION                     C         .02  C              1.0                       .75    S      IS

S1*04609C   31 04609   02615    01970    08/27/938             KING 12/21/938 REITZE C N         UNN STR                              PUGET SOUND
 1   GL4                        FISH PROPAGATION               N         .1   C 2
                                IRRIGATION                     C         .1   C 2                                     3.0            IS

S1*05398P   31 05398   03305             03/29/941   C         KING 06/02/941 BROWER / MIHALISIN UNN STR                              PUGET SOUND
 1   L-2 BL-6 NORMANDY PK RIVIERADOMESTIC SINGLE               C         .01  C                                               M
                                IRRIGATION                     C         .01  C                                       1.75    M      04151001

S1*06947P   31 06947   04709             03/06/946   C         KING 11/13/946 GARBE FRANK A      UNN STR                              PUGET SOUND
 1   GL-4                       DOMESTIC SINGLE                C         .01  C                                               SLM*
                                FISH PROPAGATION               N         .01  C                                               SLM*
                                IRRIGATION                     C         .02  C                                       3.0     SLM*   04151001

S1*07314C   31 07314   04714    02640    07/12/946             KING 11/13/946 MOORE R B          UNN STR                              PUGET SOUND
 1   GL3                        IRRIGATION                     C         .01  C                                       1.25    S      IS

S1*07336C   31 07336   04926    03092    07/25/946             KING 03/29/947 DIAMOND E L        UNN STR
 1   GL-4                       REC & BEAUTIFICATION           P         .005 C                                               S

S1*08459C   31 08459   06303    03581    06/10/948             KING 03/17/950 ANDERSON A F       UNN DRN DIT                          PUGET SOUND
 1   NORMANDY PK RIVIERA SEC    FISH PROPAGATION               N         .01  C                                               SD

S1*09078C   31 09078   06233    04811    09/12/949             KING 02/17/950 CUNNINGHAM H B ET  UNN STR                              PUGET SOUND
 1   L4 BL5 RIVIERA, NORMANDY PK IRRIGATION                    C         .02  C                                       2.0            IS

S1*12200A   31 12200                     03/27/953   R         KING   /  /    REDDEN EARL        UNN STR                              PUGET SOUND
 1   L-F PLAT OF NORMANDY PARK  FISH PROPAGATION               N         .01  C

S1*17145C   31 17145   12676    10199    02/23/962             KING 05/17/962 NORMANDY PK COM CL MAYBROOK CR *                        MILLER CR
 1   L A RIVIERA SEC NORMANDY PK REC & BEAUTIFICATION          N         .2   C                                               SD

S1*01101C   32 01101   00528    01178    05/23/924             KING 06/19/925 GOULD E            UNN SPR
 1   N2 NW4 NW4                 DOMESTIC SINGLE                C         .1   C 2
                                IRRIGATION                     C         .1   C 2                                    11.0            IS

S1*04203C   32 04203   02308    01922    02/27/936             KING 10/21/936 LENHARD E G        UNN SPR                              PUGET SOUND
 1   S2NW4NW4                   DOMESTIC MULTIPLE              C         .07  C

S1*12981P   32 12981   09738             06/11/954   C         KING 11/19/954 MALONE DONALD H    MAYBROOK CR                          MILLERS CR
 1   S2NE4NW4                   DOMESTIC SINGLE                C         .005 C 2                                             SD
                                FISH PROPAGATION               N         .005 C 2                                             SD

S1*13018C   32 13018   09699    05960    07/13/954             KING 10/20/954 MALONE W R         MAYBROOK CR *                        MILLER CR *
 1   NW4NE4NW4                  DOMESTIC SINGLE                C         .01  C                                               SD

S1*19845C   32 19845   14528    10142    08/24/966             KING 12/08/966 ALEXANDER K M      UNN SPR/STR
 2   NW4SE4                     FISH PROPAGATION               N         .03  C
                                IRRIGATION                     C         .02  C              4.0                      2.0            IS

S1*07994P   33 07994   05340             08/20/947   C         KING 11/18/947 SMITH ROBERT G     BOW LK
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AR 039909

WATER RESOURCE INVENTORY AREA- 09

TOWNSHIP - 23 RANGE - 04 E

CONTROL # / #OF PTS R P LOC. OF POD/POW	SEC #	OLD APPL	OLD PERM (CHG C#)	OLD CERT	DATE OF PRIORITY	S C A T C H	PURPOSE OF USE	USE TYPE	CNTY	PERMIT DATE	INST QI	C R S M U U	NAME	ANNUAL QA	C R S M U U	SOURCE OF APPROPRIATION	IRR AC	C S M U	PRO-VISOS	TRIBUTARY OF / TIME OF USE	R R R I A C
1 NE4SE4							DOMESTIC SINGLE IRRIGATION	C C			.01 .09	C C					10.0		SM SM	04151001	
S1*07996P 1 SE4NE4	33	07996	05343		08/20/947	C	IRRIGATION	C	KING	11/18/947	.1	C	BOYSEN CHRIS			BOW LK	10.0		SLM	04151001	
G1*00082C 1 E2E2SW4SW4	34	00082	00412	00060	01/11/946		DOMESTIC MULTIPLE	C	KING	04/23/947	400.0	G	KING CO WTR DIST #	320.0		WELL					
G1*02736C 1 SE4NE4	34	02736	02513	01445	09/30/952		DOMESTIC SINGLE IRRIGATION	C C	KING	12/19/952	50.0 50.0	G 2 G 2	SCHADER R M	26.0 26.0	2 2	WELL	13.0			IS	
G1*04961C 1 NE4SW4	34	04961	04636	03545	08/14/958		DOMESTIC MULTIPLE	C	KING	11/21/958	400.0	G	KING CO WTR DIST #	640.0		WELL			A		
G1*05781C 1 SW4 SW4 NW4 NE4 NW4	34	05781	05474	04196	11/29/960		DOMESTIC MULTIPLE	C	KING	03/17/961	310.0	G	KING CO WTR DIST #	496.0		WELL			A		
S1*03536A 1 NW4SW4	34	03536			10/21/931	R	IRRIGATION	C	KING	/ /	.33	C	DESIMONE L			BOW LK	160.0			IS	
S1*14823C 1 SE4 SE4	34	14823	11091	07406	05/26/958		DOMESTIC SINGLE POWER	C N	KING	08/26/958	.01 .04	C C	UNITED SERV & UTIL			UNN STR		S S			
S1*20030C 1 S2, GL-2	34	20030	14718	10389	12/28/966		IRRIGATION	C	KING	05/24/967	.02	C	MATELICH G J	3.0		ANGLE LK	1.5	S		GREEN R 04010930	
S1-20322C 1 GL-1	34				10/18/972		IRRIGATION	C	KING	06/01/973	.005	C	BAYNE EDWARD C	.5		ANGLE LK	.5		SLM	GREEN R 05150915	
S1-20848C 1 GL-2	34				08/20/973		IRRIGATION	C	KING	12/16/974	.01	C	STEVENS C HARLOW	1.0		ANGLE LK	.5	S		GREEN R IS	
S1-21162C 1 GOVT LOT 2	34				01/08/974		DOMESTIC SINGLE	C	KING	03/28/975	.02	C	BAHL LORETTA E	1.0		ANGLE LK		S		GREEN R	
S1-21600C 2 GL-1	34				05/06/974		IRRIGATION	C	KING	08/29/975	.04	C	COSGRAVE RONALD ET	4.0		ANGLE LK	2.0	S		GREEN R IS	
S1-22009C 1 GL 2	34				07/12/974		IRRIGATION	C	KING	08/31/975	.02	C	TONSETH ASTRID	1.0		ANGLE LK	.5	S		GREEN R IS	
S1*03687C 1 NW4NE4NW4	35	03687	01963	00714	07/29/932		DOMESTIC SINGLE STOCK WATERING IRRIGATION	C C C	KING	01/16/933	1.0 1.0 1.0	C 3 P C 3 P C 3 P	LISTON M E			UNN SPR	122.0	M M M		IS	
S1*03744C 1 GL-2	35	03744	01978	00756	11/04/932		IRRIGATION	C	KING	02/17/933	2.15	C	MESS F J / W			GREEN R	67.0	M		DUWAMISH R IS	
S1*03750C 1 GL-5	35	03750	01979	00757	11/04/932		IRRIGATION	C	KING	02/17/933	2.15	C	MESS F J / W			GREEN R	70.0	M		DUWAMISH R IS	
S1*05990C 1 GL2	35	05990	03930	02103	03/30/944		IRRIGATION	C	KING	11/15/944	.8	C	SCHOENBACHLER A			GREEN R	80.0	S		DUWAMISH R IS	
S1*05994C 1 SE4 NW4	35	05994	03931	03252	04/04/944		DOMESTIC SINGLE STOCK WATERING	C C	KING	11/15/944	.025 .025	C 2 C 2	SCHOENBACHLER A			UNN STR					
S1*08662C 1 HENRY ADAMS DLC #43	35	08662	05994	04340	12/14/948		IRRIGATION	C	KING	08/05/949	.75	C	BRISCOE MEMORIAL S			GREEN R	100.0	S		DUWAMISH R IS	
S1*10468C 1 HENRY ADAMS DLC	35	10468	07509	04451	07/06/951		IRRIGATION	C	KING	09/21/951	1.0	C	DESIMONE R			GREEN R	100.0	S		DUWAMISH R IS	
G1*03859C 1 ADAMS DLC W2SW4	36	03859	03595	02812	02/01/955		IRRIGATION	C	KING	04/18/955	200.0	G	LOVE W G	120.0	P	WELL	60.0	A		IS	
S1*06428C 1 SW4NE4	36	06428	04159	02423	05/14/945		IRRIGATION	C	KING	07/30/945	.5	C	PILLIE A			SPRING BROOK CR	80.0	S		BLACK R 04151001	

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WATER RESOURCE INVENTORY AREA- 09

TOWNSHIP - 22 RANGE - 04 E

CONTROL # / WOF R PTS P LOC. OF POD/POW	SEC #	OLD APPL	OLD PERM (CHG C#)	OLD CERT	DATE OF PRIORITY	S C A T C M	PURPOSE OF USE	CNTY	PERMIT DATE	USE TYPE	INST QI	C R S M U U	NAME	ANNUAL QA	C R S M U U	SOURCE OF APPROPRIATION	IRR AC	C S M U	PRO-VISOS	TRIBUTARY OF	TIME OF USE	R R R I A C
S1*07193C 1 SW4SW4	01	07193	04600	02605	05/28/946		IRRIGATION	KING	08/22/946	C	.1	C	STANDAERT W			MILL CR M	10.0	S		SPRING BROOK CR	IS	
S1*08924C 1 NW4SW4	01	08924	06077	03721	07/22/949		IRRIGATION	KING	10/20/949	C	.3	C	COSTELLO W F			UNN DRN DIT	30.0	S		SPRING BROOK CR	IS	
S1*11388A 1 SW4SW4	01	11388			05/23/952	R	DOMESTIC SINGLE IRRIGATION	KING	/ /	C C	.2 .2	C 2 C 2	WARREN J B			MILL CR	20.0			GREEN R	IS	
S1*12054C 1 L3 HIWAY HOME GARDEN TRS	01	12054	08942	06839	02/10/953		IRRIGATION	KING	06/03/953	C	.18	C	MIZOGUCHI H	36.0		MILL CR M	18.0	S		SPRING BROOK CR	IS	
G1-25978A 1 GL-7	02				11/16/990	R	IRRIGATION	KING	/ /	C	90.0	G	MINH CHESHENH			WELL	10.0					
S1*02084P 1 SE4SE4	02	02084	00984		05/17/927	C	IRRIGATION	KING	09/20/927	C	1.0	C	MALMO & CO			O'BRIEN CR M	73.93			GREEN R 04011001		
S1*03751C 1 GL-11	02	03751	01980	00758	11/04/932		IRRIGATION	KING	02/17/933	C	2.15	C	MESS F J / W			GREEN R	70.0	M		DUWAMISH R	IS	
S1*06010C 1 SE4SE4	02	06010	03875	02350	04/25/944		IRRIGATION	KING	09/08/944	C	.34	C	BRAND V			UNN DRN DIT	62.0	S		GREEN R	IS	
S1*08307C 1 GL4	02	08307	05611	03190	04/01/948		IRRIGATION	KING	06/04/948	C	1.0	C	AHERN D			GREEN R	104.0	S		DUWAMISH R	IS	
S1*11157C 1 GL7	02	11157	08083	04758	03/17/952		IRRIGATION	KING	06/03/952	C	.25	C	O'CONNELL R			GREEN R	25.0	S		DUWAMISH R	IS	
S1*12300C 1 GL8	02	12300	09301	06078	04/28/953		IRRIGATION	KING	12/01/953	C	.27	C	STROOMER N			GREEN R	35.0		LSD	DUWAMISH R	IS	
G1*05610C 1 SE4NW4SW4	03	05610	05275	03705	05/17/960	E	DOMESTIC MULTIPLE	KING	08/11/960	C	20.0	G	TOMBS S A	13.2		WELL			AN			
G1-21700C 1 NW4 SE4	03				05/23/974		DOMESTIC SINGLE IRRIGATION	KING	09/15/975	C C	15.0 15.0	G 2 G 2	PITTENGER FRED WM	2.0 2.0		WELL	1.0				IS	
S1*03865P 1 L-6	03	03865	02346		07/28/933	C	DOMESTIC SINGLE IRRIGATION	KING	01/13/937	C C	.2 .2	C 2 C 2	BIRKELAND C F			UNN SPR	10.0			WHITE R 05011001		
S1*06666C 1 NW4 SE4	03	06666	04364	02441	09/13/945		DOMESTIC SINGLE STOCK WATERING	KING	02/09/946	C C	.02 .02	C 2 C 2	SUNSKI E			UNN STR						
S1*08589C 1 L6	03	08589	05812	03583	09/17/948		DOMESTIC SINGLE	KING	01/18/949	C	.01	C	BIRKELAND T O			UNN SPR		S		GREEN R		
S1*10514P 1 NW4SE4	03	10514	07805		07/19/951	C	DOMESTIC SINGLE	KING	01/23/952	C	.01	C	ANDERSON CHAS N			UNN STR			MS			
S1*11862C 1 SW4SE4	03	11862	08775	06424	11/19/952		STOCK WATERING IRRIGATION	KING	03/30/953	C C	.01 .14	C C	ZGRAGGEN A			UNN SPR/STR	15.0			GREEN R	IS	
S1*12645C 1 E2NE4SW4	03	12645	09428	05673	11/04/953		DOMESTIC SINGLE	KING	03/01/954	C	.01	C	ZGRAGGEN A			UNN SPR		U		GREEN R		
S1*17927C 1 SW4NW4	03	17927	13153	08890	05/22/963		IRRIGATION	KING	09/05/963	C	.01	C	VINCENZI A J	1.5		ANGLE LK	.75	S		GREEN R	IS	
S1*20683C 1 NW4 NE4 SE4	03	20683	15170	10321	12/26/967		DOMESTIC SINGLE STOCK WATERING	KING	04/22/968	C C	.005 .005	C 2 C 2	STEVENS J D	1.0 1.0	2 2	UNN STR		S S		GREEN R		
S1-00480C 1 GL-4	03	23268			07/30/971		IRRIGATION	KING	01/25/974	C	.02	C	THOMAS J C & S H	1.0		ANGLE LK	.5		SL	GREEN R 04151001		
S1-20001C 1 GL-1 AND SHORELANDS	03				03/01/972		IRRIGATION	KING	08/18/972	C	.02	C	LAYNE BRUCE L	1.0		ANGLE LK	.5		SM	GREEN R 05010930		
S1-20015C	03				03/14/972			KING	12/04/972				CARPENTER J W & C			ANGLE LK				GREEN R		

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WATER RESOURCE INVENTORY AREA- 09

TOWNSHIP - 22 RANGE - 04 E

CONTROL # / #OF PTS R P LOC. OF POD/POW	SEC #	OLD APPL	OLD PERM	OLD CERT (CHG C#)	DATE OF PRIORITY / PURPOSE OF USE	S C A T C M	CNTY / USE TYPE	PERMIT DATE / INST QI	C R S M U U	NAME / ANNUAL QA	C R S M U U / SOURCE OF APPROPRIATION	IRR AC	C S M U	PRO-VISOS	TRIBUTARY OF / TYPE OF USE	R R R I A C
1 GL-4					IRRIGATION		C	.02 C		1.0		.5	SM		05011031	
S1-20147C 1 GL-4	03				05/30/972 IRRIGATION		KING C	01/31/973 .01 C		VINCENZI ALMO J .5	ANGLE LK	.5	SM		GREEN R 05010930	
S1-20290C 1 GL-6	03				09/20/972 IRRIGATION		KING C	05/02/973 .01 C		MOOREHEAD A F & M 2.0	ANGLE LK	1.0	SM		GREEN R 05011001	
S1-20513C 1 L 31 B 4 P SNIVELYS AN LK TR	03				03/30/973 IRRIGATION		KING C	03/29/974 .01 C		BLAKE AMOS E .5	ANGLE LK	.2			GREEN R 04151001	
S1-20546C 1 GL-1	03				04/11/973 IRRIGATION		KING C	05/15/974 .02 C		STIRRAT GEORGE R 3.5	ANGLE LK	1.4	SL		GREEN R 04151001	
S1-20741C 1 GL-1	03				07/06/973 IRRIGATION		KING C	04/30/974 .02 C		WARBERG FRED C R 1.0	ANGEL LK	1.0			GREEN R IS	
S1-21103C 1 GL-5	03				12/12/973 IRRIGATION		KING C	03/28/975 .01 C		WILBERT REYNOLD E 1.0	ANGLE LK	.5	S		GREEN R IS	
S1-21161C 1 GL-5	03				01/08/974 IRRIGATION		KING C	03/28/975 .01 C		CAIN GUY E 1.0	ANGLE LK	.5	S		GREEN R IS	
S1-21186C 1 GL-5	03				01/14/974 IRRIGATION		KING C	03/28/975 .01 C		HAMILTON WILLIAM L 1.0	ANGLE LK	.7	S		GREEN R IS	
S1-21565C 1 GL-6	03				05/02/974 IRRIGATION		KING C	06/30/975 .01 C		TONNEMAKER G E & H 1.0	ANGLE LK	.5	S		GREEN R IS	
S1-21767C 1 L6 B 4 SNIVELYS ANGLE LK TR	03				06/05/974 DOMESTIC SINGLE		KING C	06/30/975 .01 C		JARNIG ANDREW E 1.0	ANGLE LK		S		GREEN R	
S1-21895C 1 GL 1	03				06/26/974 IRRIGATION		KING C	08/29/975 .01 C		HAYNES STANLEY W 1.0	ANGLE LK	.5	S		GREEN R IS	
S1-21986C 1 GL 1	03				07/02/974 IRRIGATION		KING C	10/31/975 .03 C		LOUVIER JAMES I 3.0	ANGLE LK	4.0	S		GREEN R IS	
S1-22321C 1 L 24 B 4 SNIVELYS ANGLE L TR	03				06/27/974 DOMESTIC SINGLE		KING C	11/14/975 .02 C		DEPUE WILLIAM E 1.0	ANGLE LK		S		GREEN R	
S1-22529C 1 GL 5	03				06/18/975 IRRIGATION		KING C	04/30/976 .01 C		SAURWEIN ALBERT C .5	ANGLE LK	.4	S		GREEN R IS	
S1-22562C 1 NE4 SW4	03				08/04/975 DOMESTIC MULTIPLE		KING C	07/15/977 .17 C		ANDERSON C N ET AL 7.0	UNN SPR		U		GREEN R	
S1-22869C 1 L-2 B-4 SNIVELY'S ANGLE LK T	03				05/12/977 IRRIGATION		KING C	11/15/977 .01 C		KENNEDY KEITH J .5	ANGLE LK	.15	S		GREEN R IS	
S1-23560P 1 L-19 BLK-4 SNIVELYS ANGLE TR	03				02/20/980 HEAT EXCHANGE	C	KING N	08/16/982 .056 C		GRIFFIN GARY L	ANGLE LK				GREEN R	
S1-25118C 1 L-1	03				11/06/987 IRRIGATION		KING C	02/15/989 .02 C		ESTES VICTOR G .25	ANGLE LK	.13			IS	
S1-26104P 1 SW4NW4	03				03/13/991 IRRIGATION		KING C	12/15/992 .05 C		YOROZU D S & P J .8	ANGLE LAKE	.4	S		IS	
S1-26793A 1 NW4	03				11/18/992 IRRIGATION		KING C	/ / .05 C		GALVIN J GERALD	ANGLE LK				IS	
G1*00010C 1 NE4NW4NE4	04	00010	00147	00296	08/25/945 DOMESTIC MULTIPLE		KING C	05/28/946 20.0 G		HIGHLINE SCH DIST 25.0	WELL					
G1*01065C 1 SW4SE4NW4	04	01065	01006	02369	02/09/949 DOMESTIC MULTIPLE		KING C	07/05/949 400.0 G		KING CO WTR DIST # 560.0	WELL					
G1*03218C 1 SE4NW4	04	03218	03075	02191	05/14/953 DOMESTIC MULTIPLE		KING C	10/23/953 750.0 G		KING CO WTR DIST # 600.0	WELL					
G1*03843C 1 NE4NW4	04	03843	03757	02376	01/19/955 DOMESTIC MULTIPLE		KING C	08/26/955 350.0 G		KING CO WTR DIST # 560.0	WELL			A		
G1*04120C	04	04120	03910	02735	09/23/955		KING	04/05/956		KING CO WTR DIST #	WELL					

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CONTROL #      SEC  OLD      OLD      OLD      DATE OF    S C A   CNTY  PERMIT     NAME                   SOURCE OF APPROPRIATION TRIBUTARY OF
                #   APPL     PERM     CERT     PRIORITY   T C M         DATE
#OF R                                                                USE      INST   C R S         ANNUAL  C R S          IRR   C S PRO-   TIME OF   R R R
PTS P LOC. OF POD/POW   (CHG C#)  PURPOSE OF USE                     TYPE      QI    M U U         QA      M U U          AC    M U VISOS  USE       I A C

WATER RESOURCE INVENTORY AREA-  09

TOWNSHIP - 22    RANGE - 04 E

 1   TR20/21 HOMESTEAD PARK 5AC  DOMESTIC MULTIPLE          C     1000.0 G            1600.0      S                    A

G1*04999C   ,04 04999   04717    03584   08/29/958                KING 02/04/959 KING CO WTR D #75  WELL
 1  SW4 SW4 SW4                  DOMESTIC MUNICIPAL          C       450.0 G                       S              0    A                 0 0 0

G1*06124P   ,04 06124   05818            12/08/961  C             KING 04/27/962 KING CO WTR DIST 7 WELL
 1  NE4 NE4 NW4 SW4              DOMESTIC MULTIPLE           C     1000.0 G            1600.0      S                    A

S1*03053P   '04 03053   02292            07/23/930  C             KING 08/07/936 HALL WM             UNN STR                         BOW LK
 1  SW4SW4                       DOMESTIC SINGLE             C        .05  C 2                                               M
                                 IRRIGATION                  C        .05  C 2                                   5.0         M     04011001

S1*03054P   ,04 03054   02293            07/23/930  C             KING 08/07/936 HALL HELEN MRS      UNN STR                         BOW LK
 1  SW4SW4                       DOMESTIC SINGLE             C        .05  C 2                                               M
                                 IRRIGATION                  C        .05  C 2                                   5.0         M     04011001

S1*03163C    04 03163   01592    00773   09/22/930                KING 12/30/930 BEVILACQUA A        UNN STR                         PUGET SOUND
 1  NE4SW4SW4                    DOMESTIC SINGLE             C        .1   C 2
                                 IRRIGATION                  C        .1   C 2                                   5.0               IS

S1*05986C    04 05986   03857    04375   03/24/944                KING 08/10/944 AUER M              UNN STR                         PUGET SOUND
 1  SW4 SE4 NW4                  DOMESTIC SINGLE             C        .01  C

S1*07700C   '04 07700   05148    02811   03/19/947                KING 07/31/947 HOLCOMB A V         DESMOINES CR M                  PUGET SOUND
 1  NE4NW4                       IRRIGATION                  C        .02  C                                     1.5         S     IS

S1*08291A   ,04 08291                    03/23/948  R             KING   /  /    ECKMAN G L          DESMOINES CR                    PUGET SOUND
 1  SE4NW4                       IRRIGATION                  C        .2   C                                    20.0               IS

S1*11477A   , 04 11477                   06/24/952  R             KING   /  /    LLOYD MORTON F      DESMOINES CR                    PUGET SOUND
 1  NE4SW4                       IRRIGATION                  C        .1   C                                    10.0               IS

S1-20715C   , 04                         06/21/973                KING 04/30/974 WOOD WAYNE W        ANGLE LK                        GREEN R
 1  GOVT LOT 2                   DOMESTIC SINGLE             C        .02  C 2          1.0   2                              S
                                 FIRE PROTECTION             C        .02  C 2          1.0   2                              S

G1*00763S    06 00763            00600   05/22/944                KING   /  /    FREDRICKSON A P     WELL
 1  NE4NE4                       DOMESTIC SINGLE             C      50.0 G 4           19.5   4
                                 STOCK WATERING              C      50.0 G 4           19.5   4
                                 FIRE PROTECTION             C      50.0 G 4           19.5   4
                                 IRRIGATION                  C      50.0 G 4           19.5   4                 13.0               IS

G1*00944C   '06 00944   00795    00762   07/02/948                KING 08/26/948 FREDRICKSON A P     WELL
 1  NE4NE4                       DOMESTIC SINGLE             C      50.0 G 4           16.5   4
                                 STOCK WATERING              C      50.0 G 4           16.5   4
                                 FIRE PROTECTION             C      50.0 G 4           16.5   4
                                 IRRIGATION                  C      50.0 G 4           16.5   4                 11.0               IS

S1*04767C   '06 04767   02976    03233   03/31/939                KING 03/18/940 FOSS C A            UNN SPR
 1  NW4SE4                       DOMESTIC SINGLE             C        .01  C

S1*04812C    06 04812   02904    01888   05/05/939                KING 12/26/939 FOSS C A            UNN STR
 1  GL3                          DOMESTIC MULTIPLE           C        .01  C 2
                                 STOCK WATERING              C        .01  C 2

S1*03860C C  07 03860   02074    01934A  07/19/933                KING 10/05/933 BENSON H V          UNN STR                         PUGET SOUND
 1  2L2                          DOMESTIC MULTIPLE           C        .12  C

S1*04640C   '07 04640   02631    02181   09/29/938                KING 01/06/939 BENSON H V          UNN SPR                         PUGET SOUND
 1  GL2                          DOMESTIC SINGLE             C        .1   C 2
                                 IRRIGATION                  C        .1   C 2                                   3.0               IS

S1*04934C   '07 04934   02856    01377   08/03/939  E             KING 11/08/939 STONEMAN/BAKER      UNN STR                         PUGET SOUND
 1  L2                           DOMESTIC SINGLE             C        .08  C 2
                                 POWER                       N        .08  C 2

S1*04953C C '07 04953   02877    01934B  08/28/939                KING 12/01/939 BENSON H V          UNN STR                         PUGET SOUND
 1  2L2                          POWER                       N        .15  C

S1*05660P   .07 05660   03644            03/10/942  C             KING 03/17/943 HADLEY HOMER M      UNN STR                         PUGET SOUND
 1  GL-1                         DOMESTIC SINGLE             C        .01  C                                                 M
                                 IRRIGATION                  C        .02  C                                     4.0         M     04151001

S1*23091A    07 23091                    05/17/971  R             KING   /  /    TAYLOR LOUIS G      UNN SPR                         PUGET SOUND
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CONTROL #   SEC  OLD     OLD     OLD     DATE OF   S C A   CNTY  PERMIT   NAME
            #    APPL    PERM    CERT    PRIORITY  T C M         DATE                             SOURCE OF APPROPRIATION TRIBUTARY OF
#OF R                                                      USE    INST   C R S      ANNUAL  C R S      IRR   C S PRO-   TIME OF   R R R
PTS P LOC. OF POD/POW  (CHG C#)  PURPOSE OF USE            TYPE   QI     M U U      QA      M U U      AC    M U VISOS  USE       I A C

WATER RESOURCE INVENTORY AREA-  09

TOWNSHIP - 22   RANGE - 04 E
 1   GOVT LOT 2                 DOMESTIC SINGLE            C       .01  C 2
                                FISH PROPAGATION           C       .01  C 2

S1-20755C    07                         07/16/973          KING 05/15/974 COOK DON W               UNN STR                       PUGET SOUND
 1   GL-3                       DOMESTIC SINGLE            C       .02  C               1.0

S1-21285C    07                         02/25/974          KING 03/28/975 CIEREBIEJ ALBERT         UNN STR                       PUGET SOUND
 1   GL-2                       FISH PROPAGATION           N       .02  C                                         S

G1*00078S    08 00078           00045   05/00/938          KING   /  /    KING CO WTR D #54        WELL
 1   NW4SE4                     DOMESTIC MUNICIPAL         C     150.0 G              244.0

G1*00089C    08 00089   00060   00036   01/17/946          KING 03/21/946 KING CO WTR D #54        WELL
 1   NW4SE4                     DOMESTIC MUNICIPAL         C     300.0 G                                    0                    0 0 0

G1*00751S    08 00751           00597   00/00/905          KING   /  /    WESLEY GARDENS           WELL
 1   NW4SE4                     DOMESTIC GENERAL           C      75.0 G 2             15.0   2
                                IRRIGATION                 C      75.0 G 2             15.0   2        10.0               IS

G1*02001C    08 02001   01797   01677   06/08/951          KING 08/10/951 WESLEY GARDENS           WELL
 1   NW4 SE4                    DOMESTIC MULTIPLE          C     100.0 G 2             28.0                        A
                                IRRIGATION                 C     100.0 G 2             20.0            10.0        AE     IS

G1*03600C    08 03600   03387   02765   05/03/954          KING 08/20/954 KING CO WTR D #54        WELL
 1   SE4 NW4 SE4                DOMESTIC MUNICIPAL         C     250.0 G                               S    0  A             0 0 0

G1*05425C    08 05425   05132   03627   10/26/959          KING 03/18/960 KING CO WTR D #75        WELL
 1   NW4NE4NE4                  DOMESTIC MUNICIPAL         C    1750.0 G                                    0  A             0 0 0

G1*05426C    08 05426   05124   03626   10/26/959          KING 03/07/960 KING CO WTR D #75        WELL
 1   NE4NE4SE4                  DOMESTIC MUNICIPAL         C     500.0 G                                    0  AN            0 0 0

G1*06282A    08 06282                   05/04/962  R       KING   /  /    KING CO WATER DIS#       WELL
 1   SE4SE4                     DOMESTIC MULTIPLE          C    1000.0 G

G1*08089C    08 08089   07559   06076   05/12/966          KING 08/04/966 KING CO WTR D #54        WELL
 1   E2 SE4 NW4 SE4             DOMESTIC MULTIPLE          C    2250.0 G 2            162.0                        RHM
                                DOMESTIC MULTIPLE          C    2250.0 G 2            734.0        S               RHM

G1-20219C    08                         07/17/972          KING 01/31/973 DES MOINES SEWER D       WELL
 1   S2NE4                      COMMERCIAL/INDUSTRIAL      C     100.0 G              161.0                        R

G1-21135A    08                         12/18/973  R       KING   /  /    KING CO WTR DIST 5       WELL
 1   NW4SE4                     DOMESTIC MUNICIPAL         C     250.0 G

G1-21136A    08                         12/18/973  R       KING   /  /    KING CO WTR DIST 5       WELL
 1   NW4SE4                     DOMESTIC MUNICIPAL         C     700.0 G

G1-23253A    08                         10/27/978  R       KING   /  /    DES MOINES SEWER D       WELLS
35   SE4NE4                     DOMESTIC MULTIPLE          C    1250.0 G 2
                                IRRIGATION                 C    1250.0 G 2                              7.0               IS

G1-23881C    08                         07/24/981          KING 05/14/982 KING CO WTR D #54        WELL (#5)
 1   NW4SE4                     DOMESTIC SINGLE            C     500.0 G              360.0                        RM

G1-24214C    08                         01/17/983          KING 09/14/984 KING CO WTR D #75        WELL
 1   NE4NE4                     DOMESTIC MUNICIPAL         C    2500.0 G             1760.0                        M$

G1-26306A    08                         08/29?991          KING   /  /    KING CO WTR D #54        WELL
 1   SE4NW4SE4                  DOMESTIC MUNICIPAL         C     350.0 G

S1-20232A    08                         07/31/972  R       KING   /  /    DES MOINES SEWER D       UNN STR                       PUGET SOUND
 1   N2 S2 NE4                  COMMERCIAL/INDUSTRIAL      C      .222 C              161.3

G1*05423C    09 05423   05122   03624   10/26/959          KING 03/07/960 KING CO WTR D #75        WELL
 1   SW4SE4SW4                  DOMESTIC MUNICIPAL         C     750.0 G                                    0  A             0 0 0

G1*05424C    09 05424   05123   03625   10/26/959          KING 03/07/960 KING CO WTR D #75        WELL
 1   NW4NE4NE4                  DOMESTIC MUNICIPAL         C     750.0 G                                    0  A             0 0 0

G1-24212C    09                         01/17/983          KING 09/14/984 KING CO WTR D #75        WELL
 1   NE4NE4                     DOMESTIC MUNICIPAL         C    2200.0 G             1600.0                        M$

S1*04543P    09 04543   02637           06/16/938  C       KING 01/17/939 BADCON EBER W            UNN STR                       PUGET SOUND
 1   N2NW4NW4                   DOMESTIC SINGLE            C        .1  C 2
                                IRRIGATION                 C        .1  C 2                            20.0                   04151001
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CONTROL #    SEC  OLD     OLD     OLD     DATE OF    S C A  CNTY  PERMIT     NAME                     SOURCE OF APPROPRIATION TRIBUTARY OF
              #   APPL    PERM    CERT    PRIORITY   T C M        DATE
#OF R                                                         USE    INST  C R S      ANNUAL C R S     IRR   C S PRO-   TIME OF  R R R
PTS P LOC. OF POD/POW  (CHG C#)  PURPOSE OF USE               TYPE   QI    M U U      QA     M U U     AC    M U VISOS  USE        I A C

WATER RESOURCE INVENTORY AREA-  09

TOWNSHIP - 22    RANGE - 04 E

S1*05394C    09 05394   03299   01754   03/25/941          KING 05/20/941 STEVICK FRANK ET U UNN SPR
 1   SW4 NW4 NW4                DOMESTIC SINGLE            C        .01  C 2
                                FIRE PROTECTION            C        .01  C 2

S1*14236C    09 14236   10632   07199   02/20/957          KING 05/24/957 OSTERHOUDT D       UNN SPRS
 1   W2 SE4 SW4                 DOMESTIC SINGLE            C        .01  C
                                FISH PROPAGATION           N        .09  C                                            S

G1*01748C    10 01748   01569   00673   12/07/950          KING 03/09/951 LOGAN K            WELL
 1   TR3 VANDEVANTERS 10 AC TR  IRRIGATION                 C       30.0  G          15.0                 7.5       EA     IS

G1-00213C    10 12286                   11/12/971          KING 10/12/972 KENT HIGHLANDS INC WELL
 1   SW4SW4SE4                  DOMESTIC SINGLE            C       15.0  G           1.0

G1-23730BAL  10                         01/06/981  C       KING 07/31/981 LDS CHURCH         WELL
 1   NE4NE4                     IRRIGATION                 C      250.0  G          24.0                48.0              IS        2 2 2

G1-25163C    10                         01/13/988          KING 10/14/988 GREEN JOHN P       WELL
 1   LOT 3                      DOMESTIC MULTIPLE          C       33.0  G           3.5                                  00000000

S1*06536C    10 06536   04246   02564   07/17/945          KING 11/08/945 ADELL F E          GREEN R                               DUWAMISH R
 1   GL2                        IRRIGATION                 C        .69  C                              68.9       S      IS

S1*07249C    10 07249   04706   03487   06/14/946  E       KING 11/06/946 GOOD W             GREEN R                               DUWAMISH R
 1   D A NEELY DLC 37           DOMESTIC SINGLE            C        .3   C 3                                       S
                                STOCK WATERING             C        .3   C 3                                       S
                                IRRIGATION                 C        .3   C 3                            30.0       S      IS

S1*07309PAL  10 07309A  04704A          07/08/946  C       KING 11/06/946 FARM EQUIPM'T& SAL WHITE R                               DUWAMISH R
 1   DAVID A NEELY DLC #37      COMMERCIAL/INDUSTRIAL      C        .05  C                                         SM                4 0 0

S1*07562C    10 07562   05072   02846   12/04/946          KING 06/12/947 WRIGHT C I         GREEN R                               DUWAMISH R
 1   GL-3                       IRRIGATION                 C        .34  C                              34.0       S      IS

S1*12308C    10 12308   09319   05587   04/29/953          KING 12/18/953 DELACRUZ C         GREEN R                               DUWAMISH R
 1   GL-4                       IRRIGATION                 C        .15  C                              15.0       SDL    IS

S1*12420C    10 12420   09280   05565   06/18/953          KING 11/18/953 SHUMATE L E        GREEN R                               DUWAMISH R
 1   GL-3                       IRRIGATION                 C        .1   C                              10.0       LS     IS

S1*16706C    10 16706   12404   08481   06/02/961          KING 08/30/961 KOWING J E         GREEN R                               DUWAMISH R
 1   DAVID A NEELY DLC          DOMESTIC SINGLE            C        .01  C                                         SD

G1-23730BBL  11                         01/06/981  C       KING 07/31/981 LDS CHURCH         WELL
 1   NW4NW4                     IRRIGATION                 C      250.0  G          24.0                48.0              IS        2 2 2

S1*02050P    11 02050   00983           04/16/927  C       KING 09/20/927 MALMO & CO         WHITE R                               DUWAMISH R
 1   SW4NE4NW4                  IRRIGATION                 C       1.5   C                              73.93                  04011001

S1*07309PBL  11 07309B  04704B          07/08/946  C       KING 11/06/946 FARM EQUIPM'T& SAL WHITE R                               DUWAMISH R
 1   DAVID A NEELY DLC #37      COMMERCIAL/INDUSTRIAL      C        .05  C                                         SM                4 0 0

S1*13126P    11 13126   09815           09/15/954  C       KING 01/17/955 BARNETT ALTA M     GREEN R                               DUWAMISH R
 1   GL-5                       IRRIGATION                 C        .1   C                              10.0       SDL     04151001

S1-24083G    11                         05/12/982          KING 01/14/983 KENT VLY FMS (LDS) GREEN R                               DUWAMISH R
 1   NE4NW4                     IRRIGATION                 C       1.1   C          48.0                48.0       S-     IS

G1*04259C    12 04259   03995   02887   03/21/956          KING 06/08/956 KOMOTO J T / G     WELL
 1   SE4NE4                     IRRIGATION                 C       72.0  G          30.0                15.0       AEK    IS

S1*04623CBL  12 04623B  02628B  01214B  09/07/938          KING 01/05/939 OLSON A            MILL CR  *                            SPRING BROOK CR
 1   NE4NW4                     IRRIGATION                 C        .51  C                              34.0                   04151001 2 0 2

S1*05578C    12 05578   03478   02557   09/09/941          KING 01/27/942 EARHART W J        MILL CR                               SPRING BROOK CR
 1   SE4SW4                     IRRIGATION                 C        .22  C                              20.0       S      IS

S1*07341C    12 07341   04774   02747   07/26/946          KING 12/19/946 EARHART W J        MILL CR                               SPRING BROOK CR
 1   SE4SW4                     IRRIGATION                 C        .05  C                              13.0       S      IS

S1*10497C    12 10497   07574   04879   07/16/951          KING 10/18/951 OLSON D A          MILL CR                               SPRING BROOK CR
 1   NE4SW4                     IRRIGATION                 C        .21  C                              21.0       S      IS

G1*04953C    13 04953   04644   03522   08/07/958          KING 12/01/958 HORATH G           WELL
 1   NW4 NW4                    DOMESTIC SINGLE            C       5.0   G 2         5.6  2                        AE
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WATER RESOURCE INVENTORY AREA- 09

TOWNSHIP - 22 RANGE - 04 E

CONTROL # / #OF PTS / R P / LOC. OF POD/POW	SEC #	OLD APPL	OLD PERM (CHG C#)	OLD CERT	DATE OF PRIORITY	S C A / T C M	PURPOSE OF USE	USE TYPE	CNTY	PERMIT DATE	INST QI	C R S / M U U	NAME	ANNUAL QA	C R S / M U U	SOURCE OF APPROPRIATION	IRR AC	C S / M U	PRO-VISOS	TRIBUTARY OF / TIME OF USE	R R R / I A C
							STOCK WATERING	C			5.0	G 2		5.6	2				AE		
S1*09231C 1 NW4NE4	13	09231	06382	03834	11/29/949		IRRIGATION	C	KING	04/13/950	.3	C	LAZZARINI G ET AL			MILL CR	34.0	S		SPRING BROOK CR IS	
S1*09289C 1 NE4NE4	13	09289	06480	04164	12/30/949		IRRIGATION	C	KING	05/31/950	.38	C	BERNASCONI T			UNN DRN DIT	38.0	SD		GREEN R IS	
S1*10216C 1 SE4NE4	13	10216	07349	05305	03/28/951		IRRIGATION	C	KING	07/16/951	.08	C	SHAFF W E			UNN DRN DIT	8.0	SD		GREEN R IS	
S1*11056P 1 NE4SE4	13	11056	08046		02/13/952	C	IRRIGATION	C	KING	05/20/952	.025	C	RADKE RYNHOLD J			MILL CR	2.5	SMLD		GREEN R 04151001	
S1*12504A 1 N2SE4NE4	13	12504			06/25/953	R	DOMESTIC SINGLE IRRIGATION	C C	KING	/ /	.16 .16	C 2 C 2	REAND J			MILL CR	16.0			GREEN R IS	
G1-25102C 3 SW4SE4	14				09/22/987		REC & BEAUTIFICATION	C	KING	12/14/990	450.0	G	KENT COMM LAKES	45.0		WELLS 3			RM	06011031	
S1*07309PCL 1 DAVID A NEELY DLC #37	14	07309C	04704C		07/08/946	C	COMMERCIAL/INDUSTRIAL	C	KING	11/06/946	.05	C	FARM EQUIPM'T& SAL			WHITE R		SH		DUWAMISH R	4 0 0
S1*08308C 2 D A NEELY DLC 37 / GL1	14	08308	05619	03191	04/01/948		IRRIGATION	C	KING	06/09/948	1.0	C	SOAMES H L			GREEN R	102.0	S		DUWAMISH R IS	
G1-00212C 1 NW4NW4NE4	15	12285			11/12/971		DOMESTIC SINGLE	C	KING	10/12/972	15.0	G	KENT HIGHLANDS INC	1.0		WELL					
S1*06911A 1 NW4	15	06911			02/18/946	R	DOMESTIC SINGLE STOCK WATERING IRRIGATION	C C C	KING	/ /	.015 .015 .015	C 3 C 3 C 3	BLECKER W H			UNN SPR	1.0			GREEN R IS	
S1*06912A 1 ENOS COOPER DLC NO 38	15	06912			02/18/946	R	DOMESTIC SINGLE HEAT EXCHANGE STOCK WATERING IRRIGATION	C C C C	KING	/ /	.015 .015 .015 .015	C 4 C 4 C 4 C 4	SMITH CLARENCE ET			UNN SPR	1.0			GREEN R IS	
S1*06971C 1 D A NEELY DLC 37	15	06971	04601	02771	03/14/946		IRRIGATION	C	KING	08/22/946	.42	C	HASHAGEN L G			GREEN R	42.0	S		DUWAMISH R IS	
S1*07063C 1 D A NEELY DLC 37	15	07063	04594	02657	04/20/946		IRRIGATION	C	KING	08/22/946	1.0	C	TAYLOR A P			GREEN R	100.0	S		DUWAMISH R IS	
S1*07247C 1 DAVID A NEELY DLC 37	15	07247	04705	04440	06/14/946		DOMESTIC SINGLE STOCK WATERING IRRIGATION	C C C	KING	11/06/946	.1 .1 .1	C 3 C 3 C 3	CARVER I D			GREEN R	10.0	S S S		PUYALLUP R IS	
S1*07248C 99 DAVID NEELY DLC 37	15	07248	04703	03587	06/14/946		DOMESTIC SINGLE STOCK WATERING IRRIGATION	C C C	KING	11/06/946	1.14 1.14 1.14	C 3 C 3 C 3	DOLAN W E			GREEN R	114.0	S S S		DUWAMISH R IS	
S1*07309PDL 1 DAVID A NEELY DLC #37	15	07309D	04704D		07/08/946	C	COMMERCIAL/INDUSTRIAL	C	KING	11/06/946	.05	C	FARM EQUIPM'T& SAL			WHITE R		SH		DUWAMISH R	4 0 0
S1*07342C 1 ENOS COOPER DLC 38	15	07342	04791	03354	07/26/946		STOCK WATERING FIRE PROTECTION IRRIGATION	C C C	KING	01/07/947	.1 .1 .1	C 3 C 3 C 3	SMITH C A / C S			UNN SPRS	10.0	S S S		GREEN R IS	
S1*07707C 1 E COOPER DLC 38	15	07707	05186	03918	03/22/947		IRRIGATION	C	KING	08/25/947	.15	C	BLECKER W H			UNN STR	15.0	S		GREEN R IS	
S1*16699C 1 NW4SE4NE4	15	16699	12405	09203	05/23/961		COMMERCIAL/INDUSTRIAL	C	KING	08/30/961	2.2	C	KENT HIGHLANDS INC			GREEN R			SDP	DUWAMISH R	
S1*17594P 1 ENOS COOPER DLC 38	15	17594	13030		10/23/962	C	COMMERCIAL/INDUSTRIAL	P	KING	04/17/963	1.0	C	KENT HIGHLANDS INC			UNN STR			PS	GREEN R	
S1-00151C 1 SW4NW4NE4	15	23517			11/12/971		DOMESTIC SINGLE	C	KING	08/28/972	.02	C	KENT HIGHLANDS INC	1.0	M	MORGAN SPR			M	GREEN R	

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WATER RESOURCE INVENTORY AREA- 09

TOWNSHIP - 22 RANGE - 04 E

CONTROL # / #OF PTS / R P / LOC. OF POD/POW	SEC #	OLD APPL	OLD PERM	OLD CERT (CHG C#)	DATE OF PRIORITY	S C A / T C H	PURPOSE OF USE	USE TYPE	CNTY	PERMIT DATE	INST QI / C R S M U U	NAME	ANNUAL QA / C R S M U U	SOURCE OF APPROPRIATION	IRR AC	C S M U / PRO-VISOS	TYPE OF USE / TRIBUTARY OF	R R R / I A C
G1*04579C 1 SW4SW4SW4	16	04579	04336	03073	04/19/957		DOMESTIC MULTIPLE	C	KING	08/21/957	400.0 G	KING CO WTR DIST #	215.0	WELL		A		
G1-25093C 1 LOT 3	16				10/02/987		DOMESTIC SINGLE	C	KING	02/15/989	10.0 G	BEALL ERIC A	.5	WELL				
S1*03148P 1 NE4SW4	16	03148	01595		09/16/930	C	DOMESTIC SINGLE IRRIGATION	C C	KING	12/31/930	.05 C 2 .05 C 2	DALLMAN FRANK E		UNN STR	7.5		PUGET SOUND 04011001	
S1*03490C 1 SW4 SW4	16	03490	01856	01073	08/24/931		DOMESTIC SINGLE IRRIGATION	C C	KING	03/12/932	.2 C 2 .2 C 2	DEAN I H		UNN STR	12.0		PUGET SOUND IS	
S1*03688A 1 NE4NW4	16	03688			07/29/932	R	DOMESTIC SINGLE IRRIGATION	C C	KING	/ /	.5 C 2 .5 C 2	ANDERSON FRED		UNN SPR	40.0		IS	
S1*14650C 1 SE4 NW4	16	14650	10979	07211	01/31/958		DOMESTIC SINGLE STOCK WATERING IRRIGATION	C C C	KING	05/15/958	.01 C 2 .01 C 2 .01 C	WILLITZ V H	2.0	UNN STR	1.0	SD SD SD	PUGET SOUND IS	
G1*00218S 1 SW4SE4	17	00218		00202	00/00/924		DOMESTIC GENERAL IRRIGATION	C C	KING	/ /	30.0 G 2 30.0 G 2	GRAND LODGE F/AM	5.0 2 5.0 2	WELL	15.0	%	IS	
G1*00219S 1 SW4SE4	17	00219		00203	00/00/924	Q	DOMESTIC GENERAL IRRIGATION	C C	KING	/ /	30.0 G 2 30.0 G 2	GRAND LODGE F/AM	5.0 2 5.0 2	WELL	25.0	%	IS	
G1*00220S 1 SW4SE4	17	00220		00204	00/00/926		DOMESTIC GENERAL IRRIGATION	C C	KING	/ /	75.0 G 2 75.0 G 2	GRAND LODGE F/AM	28.0 30.0	WELL	15.0	%	IS	
G1*01712C 1 SE4SW4SE4	17	01712	01591	01199	10/27/950		DOMESTIC MULTIPLE	C	KING	03/23/951	100.0 G 2 2	MOST W GRAND LODGE	81.0	WELL		A		
S1*01297P 1 L-54 DES MOINES TWO-ACER TRS	17	01297	00597		04/08/925	C	REC & BEAUTIFICATION	N	KING	11/19/925	.2 C	RINK EMIL C		UNN CR			PUGET SOUND	
S1*02094P 1 SW4SW4NE4	17	02094	01017		06/08/927	C	DOMESTIC SINGLE IRRIGATION	C C	KING	11/15/927	.05 C 2 .05 C 2	OLSEN OLAF		UNN STR	2.0		PUGET SOUND 05011001	
S1*03555C 1 DES MOINES 2 ACRE TRS	17	03555	01859	00827	11/13/931		IRRIGATION	C	KING	03/12/932	.03 C	ELLINGTON A C		UNN STR	2.0		PUGET SOUND IS	
S1*04125C 1 TR43 DES MOINES TWO ACRE TR	17	04125	02253	01114	06/14/935		DOMESTIC SINGLE POWER IRRIGATION	C N N	KING	02/27/936	.02 C 2 .21 C .02 C 2	HOFFMAN A A		UNN STR	2.0	M M M	PUGET SOUND IS	
S1*04909A 1 GL-2	17	04909			07/20/939	R	IRRIGATION	C	KING	/ /	.03 C	WILHELM JOHN H		UNN STR	2.0		PUGET SOUND IS	
S1*09992C 1 LII DESMOINES 2 AC TRS	17	09992	07205	05348	11/18/950		REC & BEAUTIFICATION	N	KING	05/07/951	.1 C	MOSER ALBERT ET UX		UNN STR		SD	PUGET SOUND	
S1-21875P 1 T 50 P DES MOINES 2 ACRE TRS	17				06/25/974	C	IRRIGATION FISH PROPAGATION	C N	KING	08/16/976	.03 C 2 .03 C 2	NICKELSON FORREST	2.0	UNN STR	1.0	S S	PUGET SOUND IS	
S1*03501A 1 SE4SE4	20	03501			09/02/931	R	DOMESTIC SINGLE	C	KING	/ /	2.0 C	HATCH O C		MCSORLEY CR N			PUGET SOUND	
R1*14620C C 1 E2NW4NW4SW4	21	14620	00218	08314A	12/26/957		REC & BEAUTIFICATION	F	KING	08/15/958	C	MARTINDALE R B	7.0	UNN STR		-#	PUGET SOUND	
S1*08432C 1 SW4 SW4	21	08432	05810	03245	05/29/948		DOMESTIC SINGLE STOCK WATERING	C C	KING	01/18/949	.02 C 2 .02 C 2	GUFFEY C D ET UX		UNN SPR				
S1*14583C C 1 E2NW4NW4SW4	21	14583	11080	08314B	11/18/957		REC & BEAUTIFICATION	N	KING	08/15/958	.5 C	MARTINDALE R B		UNN STR		##	UNN STR	

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