Low Streamflow Analysis and Summer Low Flow Impact Offset Facility Proposal

December 2001

Port of Seattle

Parametrix, Inc.

Volume 1

(Includes Main Text and Appendices B through J)

1308

AR 052659

Low Streamflow Analysis and Summer Low Flow Impact Offset Facility Proposal

Port of Seattle

December 2001

Volume 1

Parametrix, Inc.

(Includes Main Text and Appendices B through J)

AR 052660

LOW STREAMFLOW ANALYSIS AND SUMMER LOW FLOW IMPACT OFFSET FACILITY PROPOSAL

SEATTLE-TACOMA INTERNATIONAL AIRPORT MASTER PLAN UPDATE IMPROVEMENTS

Prepared for

PORT OF SEATTLE
Seattle-Tacoma International Airport
17900 International Boulevard, Suite 402
Seattle, Washington 98188

Prepared by

PARAMETRIX, INC.
5808 Lake Washington Blvd. NE, Suite 200
Kirkland, Washington 98033-7350

Aqua Terra Consultants
6140 Capital Blvd. SE, Suite D
Tumwater, Washington 98501

Earth Tech, Inc.
10800 NE 8th Street, Seventh Floor
Bellevue, Washington 98004

Foster Wheeler Environmental Corporation
12100 NE 195th Street, Suite 200
Bothell, Washington 98011

HNTB
600 108th Avenue NE, Suite 400
Bellevue, Washington 98004

Pacific Groundwater Group
2377 Eastlake Avenue East
Seattle, Washington 98102

December 2001
556-2912-001 (28B)

CERTIFICATE OF ENGINEER

The technical material and data contained in this document were prepared under the supervision and direction of the undersigned, whose seal, as a professional engineer licensed to practice as such, is affixed below.

EXPIRES: 05-12-03

(affix seal here)

Paul S. Fendt, P.E.

TABLE OF CONTENTS

TABLE OF CONTENTS (CONTINUED)

APPENDICES

LIST OF FIGURES

LIST OF TABLES

ACRONYMS AND ABBREVIATIONS

APHA	American Public Health Association
ASTM	American Society for Testing and Materials
BFW	bankfull width
B-IBI	Benthic Index of Biotic Integrity
BMPs	Best Management Practices
BOD	biological oxygen demand
°C	degrees Celsius
cf	cubic feet
cfd	cubic feet per day
cfs	cubic feet per second
CIP	capital improvement project
cm	centimeters
DBH	diameter at breast height (4.5 ft from the ground)
DNR	Department of Natural Resources
DO	dissolved oxygen
Ecology	Washington State Department of Ecology
EPA	U.S. Environmental Protection Agency
ET	evapotranspiration
ft	feet
GIS	geographic information system
GPS	global positioning system
HSPF	Hydrologic Simulation Program – FORTRAN
IWS	Industrial Wastewater System
LWD	large woody debris
m	meter
mg/1	milligrams per liter
mm	millimeter
NEPL	North Employee Parking Lot
NPDES	National Pollutant Discharge Elimination System
NTU	Nephelometric Turbidity Unit
PAM	polyacrylamide
PIT	Pilot Infiltration Test

Port	Port of Seattle
RCU	riparian condition unit
SMP	Stormwater Management Plan
SSHEAR	Salmonid Screening, Habitat Enhancement, and Restoration
STIA	Seattle-Tacoma International Airport
SWPPP	Stormwater Pollution Prevention Plan
UEBEM	Urban Stream Baseline Evaluation Methodology
USFS	United States Forest Service
WDFW	Washington Department of Fish and Wildlife
WDNR	Washington Department of Natural Resources
WFPB	Washington Forest Practices Board

EXECUTIVE SUMMARY

This report presents the analyses performed to estimate the timing and volume of discharges to local receiving streams and wetlands during low-flow periods from Seattle-Tacoma International Airport (STIA) considering improvements defined in the Port of Seattle's Master Plan Update. This report also presents a Flow Impact Offset Facility Plan, which is the Port's proposal to offset impacts to flows in the receiving waters during annual low-streamflow periods, typically experienced in late summer/early fall. The plan is based on a detailed evaluation of the hydrologic impacts of the proposed third runway embankment and associated non-hydrologic impacts (cessation of water use and removal of septic tanks on properties purchased by the Port) on streamflow in Miller, Walker, and Des Moines Creeks. This report is submitted in response to condition I.1 of the Water Quality Certification (#1996-4-02325 [Amended – 1]) issued by the Washington State Department of Ecology (Ecology) on September 21, 2001. The report builds upon previous reports by Earth Tech (December 2000), Pacific Groundwater Group (June 2000, August 2001), and Parametrix (December 2000, July 2001). Earth Tech, Pacific Groundwater Group, Aqua Terra, HNTB, Foster Wheeler, and Parametrix prepared analyses presented in this report, and Hydrocomp contributed technical review of modeling analyses. Ecology was consulted during the development of the plan to ensure that agency concerns are addressed in this report.

Impacts to streamflow in the three streams were evaluated using a suite of modeling tools. The Hydrologic Simulation Program – FORTRAN (HSPF) was used to develop overall stormwater models of STIA (existing conditions and proposed conditions), as described in the *Comprehensive Stormwater Management Plan* (SMP) (Parametrix 2000a, 2001a). These models were also used to evaluate stormwater flows and volumes in the low-flow analysis. The hydrologic properties of the proposed third runway embankment were modeled using a combination of Hydrus and a finite-difference Slice model. Hydrus was used to simulate the movement of water between the root zone and water table in the proposed embankment, and the Slice model was used to simulate the movement of water through the saturated portion of the proposed embankment. Results of the Hydrus and Slice modeling were incorporated back into the HSPF model to estimate the post-construction flows. By comparing these results to the pre-project conditions, the impacts of the proposed embankment on streamflows were determined. Non-hydrologic impacts were then included in the impacts analysis. Statistical analyses of model output, precipitation, and streamflow data for the available period of record predicted a net low-flow impact to be mitigated during the low-flow offset period. The flow offset to be provided is 0.11 cubic feet per second (cfs) in Walker Creek and 0.08 cfs in Des Moines Creek. The project impact in Miller Creek was completely offset by seepage from the third runway embankments.

The Port's proposal to offset impacts to low streamflow is to detain excess stormwater runoff during the winter and release it to the streams during the predicted annual low-streamflow periods. Vault sizes for the volume of water required to offset the predicted impacts were determined by calculating the volume necessary to fulfill the required mitigation during the 92-day mitigation period for each year in the period of record (1949 to 1995), and selecting the year requiring the largest vault volume as the "worst case" scenario. The resulting volumes of stormwater (18.5 acre-ft[1] for Walker Creek and 13.5 acre-ft for Des Moines Creek) were incorporated into supplemental

---

[1] A 19.0 acre-ft vault was used for the concept design.

stormwater vaults in each watershed. These volumes of stormwater will be collected during the rainy season, stored, and discharged during the annual low-flow periods at rates equal to the predicted impact in each stream. Several considerations are proposed to be included in the design of these vaults to allow the management of stormwater discharges to offset the predicted low-flow impacts. Additional considerations in the design and operation of the proposed stormwater vaults to improve the water quality of discharges will also be included. An analysis of the availability of stormwater required to fill the vaults showed that even during the driest years in the period of record, enough water can be collected and stored to offset the impacts to streamflow during the annual low-streamflow period.

Key goals and objectives (performance standards) of the proposed Flow Impact Offset Facility include:

- Provide flow at the rates required to offset the predicted impacts of the proposed embankment for the entire annual low-streamflow period each year (approximately 92 days from late July through the end of October).

- Operate and maintain the facility to maintain water quality during the annual low-streamflow periods.

- Design the facility and its operation, monitoring, and maintenance plan so that an adaptive management strategy can be applied.

As stated in Ecology's *Stormwater Management Manual for Western Washington* (Ecology 2001), the objective of stormwater management is to "control the quantity and quality of stormwater produced by new development and redevelopment such that they comply with water quality standards and contribute to the protection of beneficial uses of the receiving waters." Ecology has determined that stormwater management activities in Washington do not require a water right. Since the Port's proposal to offset flow impacts to the receiving waters consists of stormwater management activities, a water right is not required for the Flow Impact Offset Facility.

1. INTRODUCTION

1.1 PURPOSE

The purpose of this report is to evaluate impacts to streamflows in Miller, Walker, and Des Moines Creeks resulting from construction projects included in the Master Plan Update for Seattle-Tacoma International Airport (STIA), and to propose a Flow Impact Offset Facility to mitigate potential impacts during summer low-streamflow periods. Placement of new impervious surfaces and embankment fill, combined with removal of septic tanks and cessation of existing water uses in the embankment area, will impact the timing and amount of groundwater flows to the streams. While these impacts vary seasonally, they are expected to be most significant during late summer/early fall, when streamflows are typically at their lowest. This document presents the analysis that was completed to determine the impacts (both positive and negative) to streamflows, and to propose a facility and management/operation plan to offset those impacts during the annual low-streamflow periods.

1.2 ORGANIZATION OF REPORT

This report is organized into six sections. Section 1 contains an introduction. Section 2 describes the analysis undertaken to determine the impacts to streamflows in each stream. Surface water modeling, embankment modeling, and the effects of "non-hydrologic" impacts are discussed. The proposal for the Flow Impact Offset Facility is described in Section 3, including discussions of vault sizing, water quality management, performance standards, and a pilot program. Section 4 contains the Operation and Maintenance Plan for the Flow Impact Offset Facility. Section 5 contains the monitoring plan, addressing both operation of the facility and its impacts to the streams. References are listed in Section 6.

Ten appendices containing additional technical information are included. Appendix A is contained in Volume 2, and Appendices B through J are located in Volume 1 behind the main text. Appendix A provides HSPF modeling information and data, including low-flow review of the HSPF model calibration, land use tables, and HSPF input files. The technical report describing the embankment modeling analysis is contained in Appendix B. Appendix C provides information on infiltration into the embankment. Data used in the assessment of the non-hydrologic impacts is provided in Appendix D. Appendix E contains HEC-RAS modeling results and stream cross-section field survey data. Concept drawings of the reserved stormwater system (vaults, routing, discharge locations, etc.) are contained in Appendix F. Appendix G presents additional information on physical habitat monitoring protocol in streams. A memorandum on low streamflow fish behavior is provided in Appendix H. Appendix I contains information on the determination of low-flow quantity impacts and mitigation. The HSPF input files for the low-flow vault sizing are provided in Appendix J.

1.3 RELATIONSHIP TO OTHER DOCUMENTS

This report, which replaces and updates the *Low Streamflow Analysis* prepared by Earth Tech, Inc. in December 2000 (Earth Tech, Inc. 2000) and the *Low Flow Analysis Flow Impact Offset Facility Proposal* prepared by the Port of Seattle in July 2001 (Port of Seattle 2001a), is referred to in

Sections 6.2.1 and 7.7.5 of the *Comprehensive Stormwater Management Plan, Master Plan Update Improvements, Seattle-Tacoma International Airport* (SMP; Parametrix, Inc. 2000a, 2001a).

The Clean Water Act Section 401 water quality certification was issued by the Department of Ecology on August 10, 2001, and amended on September 21, 2001, subsequent to the submittal of the July 2001 Low Flow Analysis/Flow Impact Offset Facility Proposal (Water Quality Certification #1996-02325 [Amended - 1]). The amended certification required the submittal of a revised Low Flow Analysis/Flow Impact Offset Facility Proposal addressing a number of issues listed in Section I of the amended certification. Additional model runs were required to address some of these issues. During the additional modeling, some errors in data handling were detected. While corrections of these errors do not change the modeling approach, the underlying assumptions, or the calibration, they do impact the results of the modeling analysis. Discussions were held between the Port, its consultants, Ecology, and King County to discuss the errors and their resolution, which are summarized below:

1. Different models were used to simulate different parts of the hydrology of the embankment area. This required data to be transferred back and forth between the different models. In one data transfer, a conversion factor (from daily to hourly flows) was inadvertently applied twice. The result was that modeled flow from the embankment was 1/24 of what it should have been. This error was corrected by applying the conversion factor once in the revised modeling.

2. In another data transfer, an incorrect file ("daily AGWO") was used, where another file ("hourly AGWI") should have been used. This error was corrected by transferring the correct file.

3. When the original model was developed, a number of alternatives to model the impervious areas tributary to the filter strips on top of the proposed embankment were considered. With the change implemented in No. 2 above, a more direct way to model this area became possible. In the original modeling, rainfall on the pervious area was "scaled up" to address the impervious area and flow to the filter strips. In the revised modeling, flow to the filter strips will be calculated based on the "AGWI" and "SURO" time series data.

4. In the original modeling, a two-dimensional version of the Hydrus model was used to calculate one-dimensional (vertical) flows through the proposed embankment. Since the revised modeling results in more water flowing through the embankment, a one-dimensional version of Hydrus was used because it is better able to simulate the more varied saturation conditions.

5. In the original modeling, infiltration from infiltration basins was not simulated because it was negligible. In the revised modeling, more water is available to the infiltration basins; therefore, this flow is no longer negligible. The revised modeling will simulate and document this flow, which will be routed to the groundwater component of the HSPF modeling.

6. In the original modeling, all groundwater from pervious areas in the SDS5, SDS6, and SDS7 basins was inadvertently routed to Des Moines Creek in the pre-developed

conditions model. In the post-developed conditions model, groundwater from these areas was correctly routed to Walker Creek. This error was corrected by routing the groundwater in these areas to Walker Creek in the pre-developed conditions model.

An additional revision to the modeling was discussed with Ecology and King County, but was not incorporated into the revised model. This revision involved routing the "seepage to till" component of the embankment flow directly to the stream. The group concluded that the existing approach was a more accurate way to model this flow component.

1.4 PROJECT DESCRIPTION

The Port's proposal is to collect excess stormwater during the rainy season, store it in underground vaults, and release the stored water continuously into each stream during the designated summer low-streamflow period at a rate equivalent to the calculated summer low-streamflow impact to that stream from planned Port projects. The summer low-streamflow impacts in each stream were determined through detailed modeling analyses. The summer low-streamflow periods were determined through statistical analyses of modeled streamflow from the calibrated HSPF models and consultations with biologists on the effects of low-streamflow periods on stream biology.

The facility, as designed, consists of two stormwater vaults (one vault providing water to offset flow impacts in Walker Creek and one vault providing water to Des Moines Creek). Each of these vaults stores stormwater during the rainy season to be released during the summer low-streamflow periods with features that are unique to low-flow vaults. The extra features consist of additional outlets and controls, floating discharge structures to maintain constant discharge rates, varying configurations to manage sediments, and additional water quality management features (ventilation to facilitate aeration, provisions for filtration and mechanical aeration of discharges, and oil/water separation, as appropriate). Generally, water will be collected beginning in January of each year, and discharged from late July through October (with discharges continuing through November depending on the availability of water). Annual facility maintenance will take place in December of each year.

2. LOW STREAMFLOW ANALYSIS

2.1 APPROACH

2.1.1 Introduction

The low-streamflow analysis approach included the determination of the critical low-streamflow periods for each stream, determination of existing streamflow magnitudes (target streamflows), and the determination of impacts to each stream resulting from construction projects in the Master Plan Update for STIA. The evaluations of the summer low-streamflow periods and rates are described in Sections 2.1.2 and 2.1.3. A detailed modeling analysis was used to determine the impacts to streamflows during the summer low-streamflow periods. Modeling tools used include the calibrated Hydrologic Simulation Program – FORTRAN (HSPF; EPA 1997) models for Miller, Walker, and Des Moines Creeks. HSPF model calibration is described in Section 2.2, and detailed HSPF model and calibration information is contained in Appendices A and B (Volumes 2 and 3) of the SMP (Parametrix 2000a, 2001a). The impacts of the proposed third runway embankment were modeled using a combination of Hydrus (Simunek et al. 1999) and Slice models. The embankment modeling is described in Section 2.3, and the complete embankment modeling report (Pacific Groundwater Group 2001) is contained in Appendix B. Non-hydrologic impacts, including cessation of water withdrawals and removal of septic tank discharges, are described in Section 2.4. The total net summer low-streamflow impacts are summarized in Section 2.5.

2.1.2 Determination of Summer Low-Streamflow Period

Determination of the low-streamflow period for each stream was done by analyzing modeled streamflow from the calibrated HSPF model for each stream, which used 1994 (existing) land use conditions. This determination is summarized below, and supporting information is provided in Appendix I.

The 7-day low-flow period for each year (using 1994 flow conditions) in the 47-year period of record (1949 to 1995) for each stream was determined at points of compliance near the airport (200th Street in Des Moines Creek, SR 509 in Miller Creek, and at the outlet of the wetland near Des Moines Memorial Drive in Walker Creek). The 7-day low flow was selected as an indicator of persistent dry season flow. For example, summer low streamflows tend to decrease gradually; therefore, a shorter low-streamflow period is unlikely to result in significantly lower average flows or target flows. In addition, consultation with biologists concluded that summer low flows with durations of less than 2 weeks do not affect the carrying capacity of the streams or cause behavioral changes in salmonids (Appendix H).

The occurrences of the annual 7-day low-flow periods were plotted and a bar graph showing the distribution of the summer low-flow periods by date was developed for each stream. The summer low-streamflow period for each stream was selected to include all the historical 7-day low-flow occurrences.

2.1.3 Existing Summer Low Streamflows

The magnitude of existing summer low streamflow (target streamflow) in each stream was determined through analysis of the 7-day low-flow periods under existing (1994) conditions described above. The annual 7-day low flows for each stream were ranked, and recurrence intervals were determined based on this ranking using a cumulative density function (see Appendix I for supporting information). The 7-day low flow with a 2-year (50 percent) recurrence interval was selected as the streamflow target in each stream. The 2-year, 7-day low flow was selected because the magnitude of the estimated impact to 7-day low flows generally decreases with greater recurrence interval (i.e., the estimated reduction in the 7-day, 2-year-frequency low-flow rate is greater than that for the 7-day, 10-year-frequency low-flow rate). Therefore, providing mitigation equivalent to the 7-day, 2-year-frequency impact will provide mitigation sufficient to mitigate the more extreme summer low-streamflow events. Based on this analysis, the existing summer low streamflows (target streamflows) (7-day, 2-year frequency) were determined to be 0.33 cfs for Des Moines Creek, 0.77 cfs for Walker Creek, and 0.73 cfs for Miller Creek.

2.2 HSPF MODEL CALIBRATION

2.2.1 Overall Model

The computer program HSPF was used to simulate continuous watershed hydrology and to design stormwater detention facilities for the Port's Master Plan Update at STIA. Because the airport encompasses three watersheds, separate HSPF models for Miller, Walker, and Des Moines Creeks were developed. Hydrological modeling using HSPF requires the calibration of many parameters that describe the different hydrologic processes. These processes include:

- Rainfall runoff from pervious and impervious surfaces.
- Infiltration of rainfall to soils.
- Soil moisture accounting.
- Flow of groundwater from soils to streams.
- Loss of groundwater to deep aquifers.

Each of these physical processes is controlled by several parameters. The calibration process adjusts model parameters to achieve a close match between recorded streamflows and simulated streamflows for a period when streamflow data are available. Calibration of the HSPF models used for Miller, Walker, and Des Moines Creek watersheds is described in detail in Appendix B (Volume 3) of the SMP (Parametrix 2000a, 2001a).

2.2.2 Low-Flow Review

The overall HSPF model calibration effort did not focus specifically on low-streamflow periods. The low-flow analysis consisted of review of data from water-years 1991 through 1996, with the low-flow period considered to be June through November. This section summarizes the results of the overall HSPF model calibration for Miller, Walker, and Des Moines Creek watersheds as related to the low-flow analysis. Detailed information on the low-flow calibration review is provided in Appendix A.

2.2.2.1 Miller Creek Low Streamflow

Two streamflow gages located in the Miller Creek watershed were used in the low-streamflow analysis calibration review (Figure 2-1). One of these streamflow gages was located near the mouth of Miller Creek, and the other was located further upstream at the Miller Creek detention facility.

Average simulated and observed streamflows for each 7-day low-flow period during 1991 through 1996 are listed in Table 2-1 for the gage near the mouth and Table 2-2 for the gage at the Miller Creek detention facility. In general, the observed 7-day low flows exceeded the predicted 7-day low flows at both gages, particularly for the gage located at the Miller Creek detention facility.

Table 2-1. Miller Creek at the mouth, 7-day low flows for water-years 1991 through 1996.

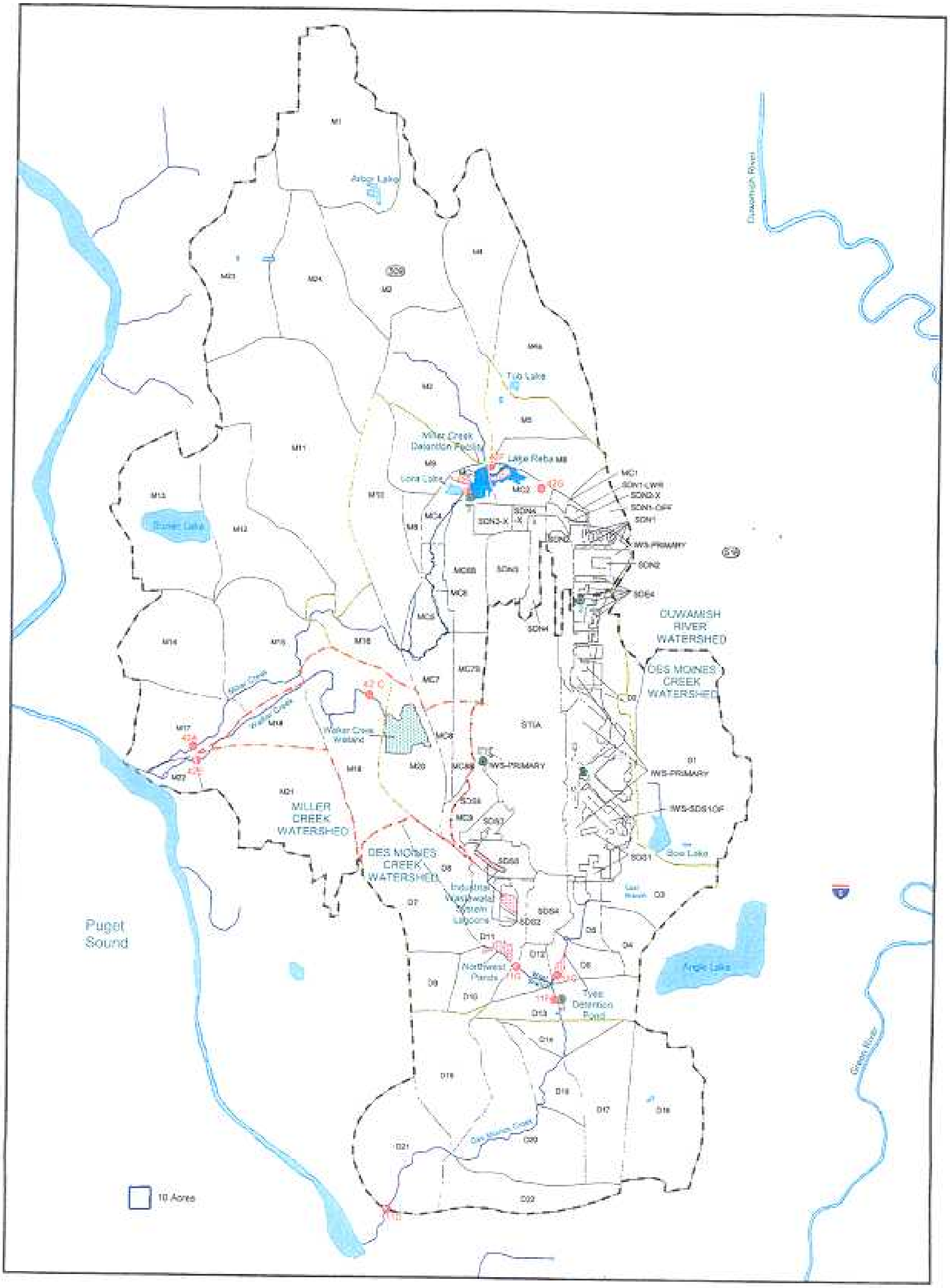
Water-Year	Observed Average Flow (cfs)	Calibrated Average Flow (cfs)	Difference (cfs)
1991	1.348	1.749	-0.401
1992	1.457	1.390	0.067
1993	1.639	1.300	0.339
1994	1.361	1.100	0.261
1995	1.500	1.661	-0.161
1996	2.762	2.138	0.624
Average Difference	**2.517**	**2.335**	**0.182**

Table 2-2. Miller Creek at the detention facility, 7-day low flows for water-years 1991 through 1996.

Water-Year	Observed Average Flow (cfs)	Calibrated Average Flow (cfs)	Difference (cfs)
1991	0.400	0.150	0.250
1992	0.127	0.124	0.004
1993	0.190	0.110	0.080
1994	0.000	0.090	-0.090
1995	0.183	0.137	0.045
1996	0.263	0.189	0.074
Average Difference	**0.291**	**0.200**	**0.091**

2.2.2.2 Walker Creek Low Streamflow

Two streamflow gages located in the Walker Creek watershed were used in the low-streamflow calibration review (see Figure 2-1). One of these streamflow gages was located near the mouth of Walker Creek, and the other was located further upstream near a wetland.



Parametrix, Inc. Sea-Tac Airport Stormwater Management Plan
Source: Roads based on King County data. Water bodies derived from USGS hydrography data. Detention boundaries are approximate.
Note: Subbasin boundaries shown outside of STIA area are for illustration and reference only.
STIA subbasins assume existing (1994) conditions.

N

1000 0 1000 2000 Feet

1:36,000

Roads
Existing (1994) Drainage Subbasins
STIA Area (see note)
Constructed Water Features
IWS Drainage Area
Subwatershed Boundary
Watershed Boundary
Rivers
Water Bodies
Detention Facilities (existing)

Precipitation Gaging Stations:
Type 1 - National Weather Service (Gage relocated 1996)
Type 2 - POS Rainfall Monitoring
Type 3 - King County Rainfall Monitoring

Streamflow
King County Gaging Stations:
42A - Miller Ck @ SW 175th Pl & 12th Ave SW
42B - Miller Ck @ Lake Reba/ROF Outlet
42C - Walker Ck @ 171st Pl
42E - Walker Ck @ 12th Ave SW
42F - Miller Ck @ SR518
42G - Miller Ck @ East Branch
11D - Des Moines Ck near mouth
11F - Des Moines Ck @ Golf Course
11C - Des Moines Ck @ Tyee Pond
11G - Des Moines Ck @ NW Ponds

Figure 2-1
Map of Basins with Gage Locations

Average simulated and observed streamflows for each 7-day low-flow period are listed in Table 2-3 (1993 through 1996) for the gage near the mouth and Table 2-4 (1991 through 1996) for the gage near the wetland. In general, with the exception of 1995, the observed 7-day low flows exceeded the predicted 7-day low flows at both gages.

Table 2-3. Walker Creek at the mouth, 7-day low flows for water-years 1993 through 1996.

Water-Year	Observed Average Flow (cfs)	Calibrated Average Flow (cfs)	Difference (cfs)
1993	1.502	0.923	0.579
1994	0.987	0.833	0.154
1995	0.915	1.077	-0.163
1996	1.719	1.287	0.432
Average Difference	**1.281**	**1.030**	**0.250**

Table 2-4. Walker Creek near wetland, 7-day low flows for water-years 1991 through 1996.

Water-Year	Observed Average Flow (cfs)	Calibrated Average Flow (cfs)	Difference (cfs)
1991	1.208	0.786	0.422
1992	1.098	0.682	0.416
1993	0.800	0.666	0.134
1994	0.670	0.614	0.056
1995	0.256	0.750	-0.494
1996	0.896	0.870	0.026
Average Difference	**0.656**	**0.725**	**-0.069**

2.2.2.3 Des Moines Creek Low Streamflow

Two streamflow gages located in the Des Moines Creek watershed were used in the low-streamflow calibration review (see Figure 2-1). One of these streamflow gages was located near the mouth of Des Moines Creek, and the other gage (11c) was located further upstream.

Average simulated and observed streamflows for each 7-day low-flow period are listed in Table 2-5 (1992 through 1996) for the gage near the mouth and Table 2-6 (1991 through 1996) for gage 11c. In general, the observed 7-day low flows were close to the predicted 7-day low flows at the gage near the mouth, while the observed 7-day low flows at gage 11c exceeded the predicted 7-day low flows.

2.2.2.4 Summary

Low-streamflow analysis calibration review was performed for two gage locations in Miller, Walker, and Des Moines Creeks. Results generally indicated that calibrated low flows at the mouth of each stream were fairly good, while calibrated low flows at the upstream gages typically showed lower flows than observed flows. Groundwater conditions in each of the watersheds are somewhat speculative and may account for these discrepancies at the upstream gage locations.

Table 2-5. Des Moines Creek at the mouth, June through November 7-day low flows for water-years 1992 through 1996.

Water-Year	Observed Average Flow (cfs)	Calibrated Average Flow (cfs)	Difference (cfs)
1992	0.585	0.904	-0.318
1993	1.205	0.900	0.305
1994	0.600	0.700	-0.100
1995	1.284	1.000	0.284
1996	1.268	1.411	-0.144
Average Difference	**1.089**	**1.003**	**0.086**

Table 2-6. Des Moines Creek at gage 11c, June through November 7-day low flows for water-years 1991 through 1996.

Water-Year	Observed Average Flow (cfs)	Calibrated Average Flow (cfs)	Difference (cfs)
1991	0.300	0.100	0.200
1992	0.172	0.090	0.082
1993	0.133	0.100	0.033
1994	0.046	0.100	-0.054
1995	0.300	0.100	0.200
1996	0.301	0.100	0.201
Average Difference	**0.195**	**0.100**	**0.095**

2.3 EMBANKMENT MODELING

This section summarizes the modeling analysis done to estimate impacts of the proposed third runway embankment on streamflows in Miller and Walker Creeks. The complete report is included in Appendix B.

The third runway embankment will be constructed in the Miller and Walker Creek watersheds; therefore, this analysis was not conducted for Des Moines Creek. Impacts to the streamflows in Miller and Walker Creeks from the embankment were estimated to determine the overall impacts of the runway project. The HSPF models alone are not capable of accurately simulating groundwater flows of this type; therefore, additional modeling tools (Hydrus and Slice) were used to simulate flow through the proposed embankment in the Miller and Walker Creek watersheds. The embankment modeling expanded on a previous modeling effort (Pacific Groundwater Group 2000).

The approach used in areas to be covered by the embankment included: (1) calculating the recharge from the HSPF models using regional parameters; (2) modeling the variable saturated vertical flow within the fill using Hydrus; (3) modeling saturated, quasi-horizontal flow at the bottom of the embankment using Slice; (4) integrating the Slice results across the fill embankment; and (5) incorporating the results back into the Miller and Walker Creek HSPF models. This section summarizes steps two through four. Specific tasks included:

- Compiling model input, including:
  - Fill thickness and areal extent.
  - Hydrogeologic data for the fill area.
  - Embankment geometries as represented by three hydrogeologic cross-sections.
- Calculating daily flux into the fill based on recharge estimates.
- Calculating daily flux through the fill using Hydrus models.
- Calculating daily flux through the embankment drain layer and the underlying till using Slice models applied to each basin.

Existing geographic information system (GIS) coverages were used to determine pre-fill topography, "built" (post-construction) topography, and pavement distribution for the third runway. Fill thickness was calculated by subtracting GIS coverages of pre-fill topography from the "built" topography. Thicknesses ranged up to 160 ft, and were discretized into 20-ft sections for the Hydrus model.

Although the Des Moines Creek basin was not included in the analysis (because only a very small amount of runway embankment is in the Des Moines Creek basin), its boundaries were used to define the southern extent of the Walker Creek basin. Impervious areas comprised 36 and 38 percent of the modeled fill areas in Miller and Walker Creek basins, respectively.

Precipitation on the modeled fill area was used to calculate hourly runoff (SURO) from impervious surfaces (runway and taxiways) and hourly infiltration (AGWI) into pervious areas with a generic application of HSPF. Pervious areas were modeled as grass on flat outwash. This approach was selected, with agreement from Ecology and King County, to take advantage of HSPF's superior evapotranspiration (ET) and runoff modeling capabilities. For pervious areas, the generic HSPF model yielded hourly volumes of water that infiltrate beyond the bottom of the root zone (AGWI) and therefore constitute groundwater recharge. That calculation was applied to filter strips and other pervious areas. A separate calculation then estimated the extent to which runoff from impervious surfaces would also infiltrate, or conversely, runoff from, the filter strips. The total amount of infiltration into filter strips (a portion of AGWI and SURO) and other pervious areas (AGWI only) was then used as input to the Hydrus models. Calculated runoff was accounted for but not used in groundwater modeling.

Hydrus simulates the vertical spreading of recharge fronts as they are predicted to move downward through the proposed embankment fill. Hydrus models were set up to simulate a total of 12 vertical profiles of varying thicknesses for the proposed embankment (eight in the Miller Creek watershed and four in the Walker Creek watershed). Model timesteps were optimized by Hydrus, which were typically on the order of 0.1 day. The models were run for water-years 1984 through 1994, with only the last 4 water-years comprising the test period. Hydrus results indicated that substantial lagging and dampening (spreading) of seasonal recharge is likely within the fill, with the amount of lagging and dampening increasing with increasing fill thickness. Discharge at the bottom of the fill is predicted to occur throughout the year. Hydrus output was used as recharge input to the Slice models.

Three finite-difference Slice models were developed to simulate horizontal and vertical groundwater flow within the embankment drain layer and existing soils below the embankment. Slice configurations were based on subsurface data contained in available geotechnical and hydrogeologic reports and from the pre-fill and "built" topography of the third runway area. Slice alignments were located based on the availability of subsurface data describing the range of hydrogeologic and fill conditions in the embankment area. The Slice models were used to accumulate recharge in the shallow water table aquifer and move it downgradient to the Miller Creek or Walker Creek wetlands under the "built" conditions.

Slice 1 is located through the thickest portion of the fill embankment. Slice 2 is located near the northern end of the proposed third runway and represents an intermediate fill thickness. Slices 1 and 2 are both located in the Miller Creek basin. Slice 3 is located in the Walker Creek basin and represents an intermediate fill thickness. Locations and cross-sections of each Slice are provided in Appendix B.

Model results show that the lagtime (seasonal delay) between drain recharge peaks and drain outflow peaks is controlled by the width of fill along the groundwater flowpath represented by a slice, and are also likely influenced by the varying spatial distribution and timing of recharge inflow along each slice.

Groundwater discharge quantities for Miller and Walker Creeks were calculated by multiplying unit-width flow quantities from each representative Slice model by an effective basin length. The effective basin length associated with each slice depends on the length of the basin with characteristics similar to the slice (i.e., thickness and lateral extent). This process integrated the Slice results over the entire length of the embankment.

Estimated annual maximum drain outflows from the fill in the Walker Creek basin for the test period ranged from approximately 1,500 to 3,500 cubic feet per day (cfd). Maximum integrated fill seepage rates from below the embankment in the Walker Creek basin range from approximately 2,200 to 2,400 cfd in the 4-year test period. Estimated annual maximum drain outflows from the fill in the Miller Creek basin for the test period range from approximately 8,000 to 18,000 cfd. Integrated fill seepage rates from below the embankment in the Miller Creek basin range from approximately 7,000 to 16,000 cfd. All results of the embankment modeling analysis are discussed in detail in Appendix B.

2.4 NON-HYDROLOGIC IMPACTS

The following subsections describe non-hydrologic impacts, including cessation of water withdrawals and removal of septic tank discharges. Additional supporting information for the non-hydrologic impacts is provided in Appendix D.

2.4.1 Cessation of Water Withdrawals

Based on assumptions regarding residential and farm property uses of water rights described in the SMP (Parametrix, Inc. 2000a, 2001a), it was concluded that historic irrigation season consumption totaled 0.042 cfs within the Miller Creek buy-out area. Table 2-7 summarizes the withdrawal estimates following consultation with former owners.

Table 2-7. Updated estimate of historic Miller Creek water withdrawals.

Parcel	Last Name	Available Pumping Rate (gpm)	Acres	Months of Use Per Year	Estimated Pumping Rate (gpm)	Updated Usage Estimate (cfs)	Comments from Owner Consultations
068R	Genzale	2.5	4	5	0.52	0.001	4 acres, 2.5 gpm June to mid-October
185R	Berry	5	1	6	1.25	0.003	Less than 1 acre, summer only
244R	Randall	5	0.5	6	1.25	0.003	Only in summer/garden
097R	Smith	20	0.6	4	3.33	0.007	Pump 4 months for orchard, lawn and garden
311R	Rhoton	5	1.7	6	1.25	0.003	Water in summer - unknown quantity
316R	Roullard	0	0.25			0.000	1940-1960 maximum, 1990's no water usage
050R	Eisiminger	0	0.75			0.000	None to very little
246R	Galando	0	3.5			0.000	Unknown - doesn't remember pumping water
093R	Raffo	0				0.000	
055R	Mason	0				0.000	Municipal water
060R	Vacca	0				0.000	Municipal water
061R	Vacca	0				0.000	Municipal water
143R	Brate	0	1			0.000	Water right not used
182R	Illes	0	1			0.000	Water right not used
253R	Kobela	0	0.5			0.000	Water right not used
298R	Warner	0				0.000	Water right not used
302R	Lopez	0				0.000	Water right not used
062R	Scarsella	0	1.2			0.000	Water right not used
142R	Wind of the Willows	0	0.75			0.000	Water right not used
214R	Kamp	20		6	5	0.011	
321R	Beaudin	20		6	5	0.011	
088R	Goodmansen					0.000	
322R	Longridge	4.5		6	1.12	0.003	
TOTAL						0.042	

2.4.2 Removal of Septic Tank Discharges

Many of the residential properties in the buy-out area within Miller and Walker Creek watersheds were served by active septic systems during the pre-project conditions in 1994. These septic systems received water imported from outside of the watershed through water districts and discharged effluent through drain fields that recharge groundwaters that contribute flows to the streams. Within the buy-out area, available records show that there were 41 residences actively served by septic systems in the Walker Creek basin, and there were 236 residences actively served by septic systems in the Miller Creek basin. Table 2-8 summarizes septic system counts for the pre-project condition analysis.

Table 2-8. Active buy-out area septic systems under pre-project conditions.

	Miller Creek	Walker Creek	Total
Residences with septic systems	249	42	291
Inactive systems (served by sewer)	13	1	14
Active septic systems	236	41	277

Based on consultation with water districts serving the buy-out area, it was concluded that winter residential water consumption averaged approximately 975 cf per month, while summer consumption averaged approximately 1,450 cf per month. The flow effectively discharged from each septic system to groundwater was estimated to equal 90 percent of the average winter water consumption, or 878 cf per month. Consistent with the hydrologic modeling of the Walker and Miller Creek basins for the SMP, approximately 30 percent of this recharge would be lost to the deeper aquifer and not available for discharge to the stream; therefore, the effective rate of base flow contribution to a stream from a residential septic system in 1994 was estimated to be 70 percent of the 878-cf-per-month septic-system discharge, or 614 cf per month.

Applying this recharge rate to the 41 active septic systems in Walker Creek produces an average daily contribution to streamflow of 0.0100 cfs. For the 236 active septic systems in Miller Creek, the resulting average daily contribution would be 0.0574 cfs.

2.4.3 Summary of Non-Hydrologic Impacts

For Miller Creek, the combined non-hydrologic impacts to low streamflows from Port projects includes a 0.06-cfs reduction (rounded from 0.0574) from discontinued septic tank discharges, and a 0.04-cfs increase (rounded from 0.042) in low flows due to cessation of water withdrawals. The net non-hydrologic impact for Miller Creek is a 0.02-cfs reduction in low streamflows. For Walker Creek, the non-hydrologic impact to low streamflows from Port projects is a 0.01-cfs reduction from discontinued septic tank discharges.

2.5 SUMMARY OF NET IMPACTS TO CREEKS

2.5.1 Summary of Flow Impacts

The net effects to flow during the summer low-streamflow periods were determined by comparing the modeled streamflow before project construction to modeled streamflow after project construction, with non-hydrologic impacts included as appropriate. Based on the analyses described in Sections 2.1 through 2.4, total net summer low-streamflow impacts that the Port proposes to offset throughout the summer low-streamflow periods are shown in Table 2-9. The net flow impact results are summarized in Sections 2.5.1.1 through 2.5.1.3 for each stream.

Table 2-9. Total net summer low-streamflow impacts.

Stream	Hydrologic Impact (cfs)	Non-Hydrologic Impact (cfs)	Total Net Streamflow Impact (cfs)
Miller Creek	+0.03	-0.02	+0.01
Walker Creek	-0.10	-0.01	-0.11
Des Moines Creek	-0.08	0.00	-0.08

2.5.1.1 Miller Creek Summary

HSPF was used to evaluate the change in low streamflow from 1994 to 2006 conditions. The Miller Creek HSPF modeling information and data, including land use tables and HSPF input files, are provided in Appendix A. Groundwater basin boundaries for Miller Creek were located to allocate the groundwater flow contributions (Appendix A).

In Miller Creek, the analysis of low streamflows needed to account for the effects of discharges from the proposed runway embankment to fully account for future post-project conditions. In areas where embankment is proposed, the quantity of precipitation infiltrating into the embankment was calculated using the 2006 condition HSPF model. The recharge was then input to the Hydrus and Slice models, which simulated the spreading of recharge fronts vertically through the embankment and laterally through the underdrain layer. Output from the Hydrus and Slice models was then input back into the HSPF model to determine the quantity and timing of discharge from the underdrain layer and the effects on contributions to low streamflows in Miller Creek. The embankment fill modeling using the Hydrus and Slice technique is described in Section 2.3, and the complete embankment modeling report (Pacific Groundwater Group 2001) is contained in Appendix B.

To assess the low-streamflow impacts in Miller Creek, the pre- and post-project conditions were modeled for 1991 through 1994. This period was selected as a representative dry period in the precipitation record during which stream gage data is available for Miller Creek. Output from the HSPF model was analyzed to determine the annual 7-day low streamflows for each of the 4 years. To determine the impact between 1994 low streamflows and 2006 flows, the 1994 and 2006 7-day low-flow values were plotted by their probability positions corresponding to the same probability positions of the years 1991 through 1994 in the 1994 pre-project condition (the full period of record [1949 to 1995] was simulated to determine the 50th percentile 7-day low flow). The separation of the 1994 and 2006 plot positions at the 50 percent probability was used as the low-flow impact requiring mitigation. The 1994 condition 50th percentile 2-year, 7-day low streamflow is 0.73 cfs, and the corresponding 2006 condition 50th percentile low streamflow is 0.76 cfs. Therefore, in Miller Creek, the estimated low-streamflow hydrologic impact due to the Port's projects, including effects of discharge from the embankment, is an increase of 0.03 cfs.

Combining the non-hydrologic impact (-0.02 cfs, as described in Section 2.4) with the hydrologic impact results in a total net summer low-streamflow increase of 0.01 cfs for the Miller Creek basin. Since there is not a reduction in low flows, no low-flow mitigation is proposed. However, monitoring and contingency measures described in Section 5 will apply in Miller Creek.

2.5.1.2 Walker Creek Summary

HSPF was used to evaluate the change in low streamflow from 1994 to 2006 conditions. The Walker Creek HSPF modeling information and data, including land use tables and HSPF input files, are provided in Appendix A. Groundwater basin boundaries for Walker Creek were located to allocate the groundwater flow contributions (Appendix A).

In Walker Creek, the analysis of low streamflows needed to account for the effects of discharges from the proposed runway embankment to fully account for future post-project conditions. In areas where embankment is proposed, the quantity of precipitation infiltrating into the embankment was calculated using the 2006 condition HSPF model. The recharge was then input to the Hydrus and Slice models, which simulated the spreading of recharge fronts vertically through the embankment and laterally through the underdrain layer. Output from the Hydrus and Slice models was then input back into the HSPF model to determine the quantity and timing of discharge from the underdrain layer and the effects on contributions to low streamflows in Walker Creek. The embankment fill modeling using the Hydrus and Slice technique is described in Section 2.3, and the complete embankment modeling report (Pacific Groundwater Group 2001) is contained in Appendix B.

To assess site low-streamflow impacts in Walker Creek, the pre- and post-project conditions were modeled for 1991 through 1994. This period was selected as a representative dry period in the precipitation record during which stream gage data is available for Walker Creek. Output from the HSPF model was analyzed to determine the annual 7-day low streamflows for each of the 4 years. To determine the impact between 1994 low streamflows and 2006 flows, the 1994 and 2006 7-day low-flow values were plotted by their probability positions corresponding to the same probability positions of the years 1991 through 1994 in the 1994 pre-project condition (the full period of record [1949 to 1995] was simulated to determine the 50th percentile 7-day low flow). The separation of the 1994 and 2006 plot position at the 50 percent probability was used as the low-flow impact requiring mitigation. The 1994 condition 50th percentile 2-year, 7-day low streamflow is 0.77 cfs, and the corresponding 2006 condition 50th percentile low streamflow is 0.67 cfs. Therefore, in Walker Creek, the estimated low-streamflow impact due to the Port's projects, including the effects from discharge from the embankment, is 0.10 cfs.

The combined hydrologic and non-hydrologic impact to low streamflows is the sum of the 0.10-cfs hydrologic reduction and a 0.01-cfs reduction from discontinued septic system discharges, for a total reduction of 0.11 cfs. This flow rate equates to the magnitude of offset flow that will be provided during the low-streamflow period for Walker Creek.

2.5.1.3 Des Moines Creek Summary

HSPF was used to evaluate the change in low streamflow from 1994 to 2006 conditions. The Des Moines Creek HSPF modeling information and data, including land use tables and HSPF input files, are provided in Appendix A. Groundwater basin boundaries for Des Moines Creek were located to allocate the groundwater flow contributions (Appendix A).

In Des Moines Creek, 2006 land use conditions ("post-project") were modeled for the full 1949 to 1995 period of record. The 7-day low flow for each year was selected and ranked, and the streamflow with a 2-year recurrence interval was determined. In Des Moines Creek, the 2-year post-project summer low streamflow is 0.26 cfs[2]. The impact to streamflow from proposed Port projects is the difference between this flow and the existing pre-project 2-year, 7-day summer low streamflow described above, as determined from the modeled 1994 ("existing") land use conditions (0.33 cfs[2]). The difference between 1994 and 2006 flows is 0.08 cfs[2]. This flow rate is the magnitude of offset that will be provided during the summer low-streamflow period for Des Moines Creek.

2.5.2 Summary of Water Level Impacts

If not mitigated, one impact of reduced streamflow during the summer low-rainfall season would be reduced water depth in the project area streams. To determine the estimated flow depth changes during low-flow periods before and after construction of Master Plan Update projects, a HEC-RAS model was prepared. Detailed HEC-RAS modeling information and associated field survey data are provided in Appendix E.

The HEC-RAS model was used to predict the water depth in the streams at different flow rates. Rating curves (flow rate versus flow depth) were developed for Miller, Walker, and Des Moines Creeks (Figures 2-2, 2-3, and 2-4). These curves were used to predict the water depth for flows before (1994) and after (2006) construction to determine the potential impacts to the stream from flow reduction during low-flow periods (if not mitigated).

The HEC-RAS model was developed using representative surveyed cross-sections from Miller, Walker, and Des Moines Creeks. The sections were repeated in the model at gradually higher elevations (moving downstream to upstream) corresponding to the measured stream profile. Downstream water depths were calculated by the model using the normal depth routine. Flow rates for each stream correspond to the general range of flows from the lowest modeled by the HSPF model to the greatest 7-day low flow during the period of rainfall record. Channel roughness was assumed to range from 0.025 to 0.035 based on observation of channel characteristics.

The estimated average change in water depths between the 1994 and 2006 2-year, 7-day low flows are summarized in Table 2-10. In addition, the corresponding estimated average change in stream widths between the 1994 and 2006 2-year, 7-day low flows are summarized in Table 2-10. The magnitude of these water depth and width changes are graphically illustrated, to scale, in Figure 2-5.

Table 2-10. Changes in average water depths and widths between the 1994 and 2006 2-year, 7-day low flows (not accounting for low flow mitigation).

Creek	Total Net Streamflow Impact (cfs)	Depth		Width	
		Average change (ft)	Average change (mm)	Average change (ft)	Average change (mm)
Miller	+0.01	+0.00	0	+0.02	+6
Walker	-0.11	-0.01	-3	-0.10	-30
Des Moines	-0.08	-0.03	-9	-0.33	-101

[2] Actual values are 0.334 (1994) and 0.257 (2006), for a difference of 0.077, which was rounded to 0.08.

Figure 2-2: Flow Rate Versus Depth Curve for Miller Creek

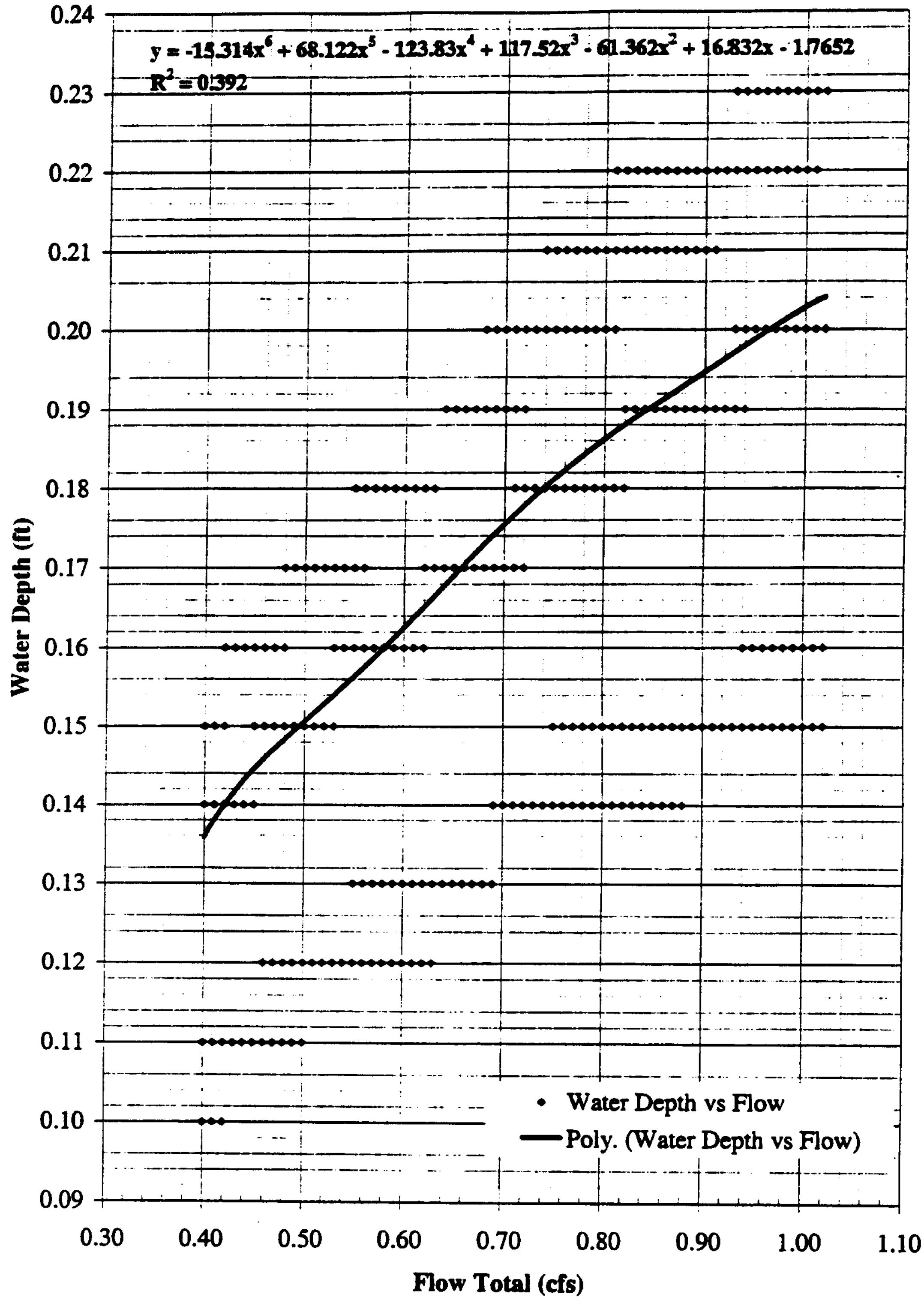


Figure 2-3: Flow Rate Versus Depth Curve for Walker Creek

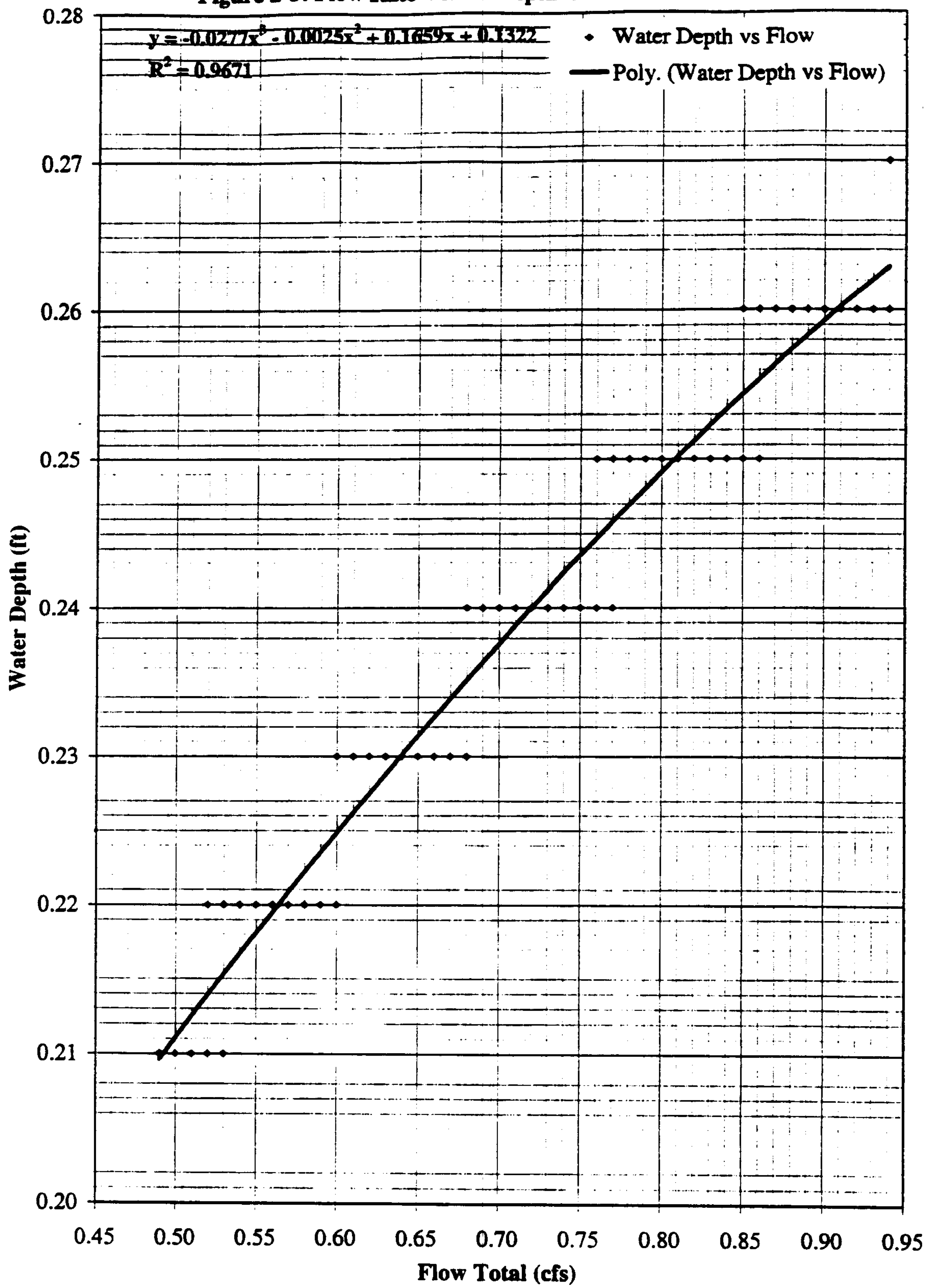
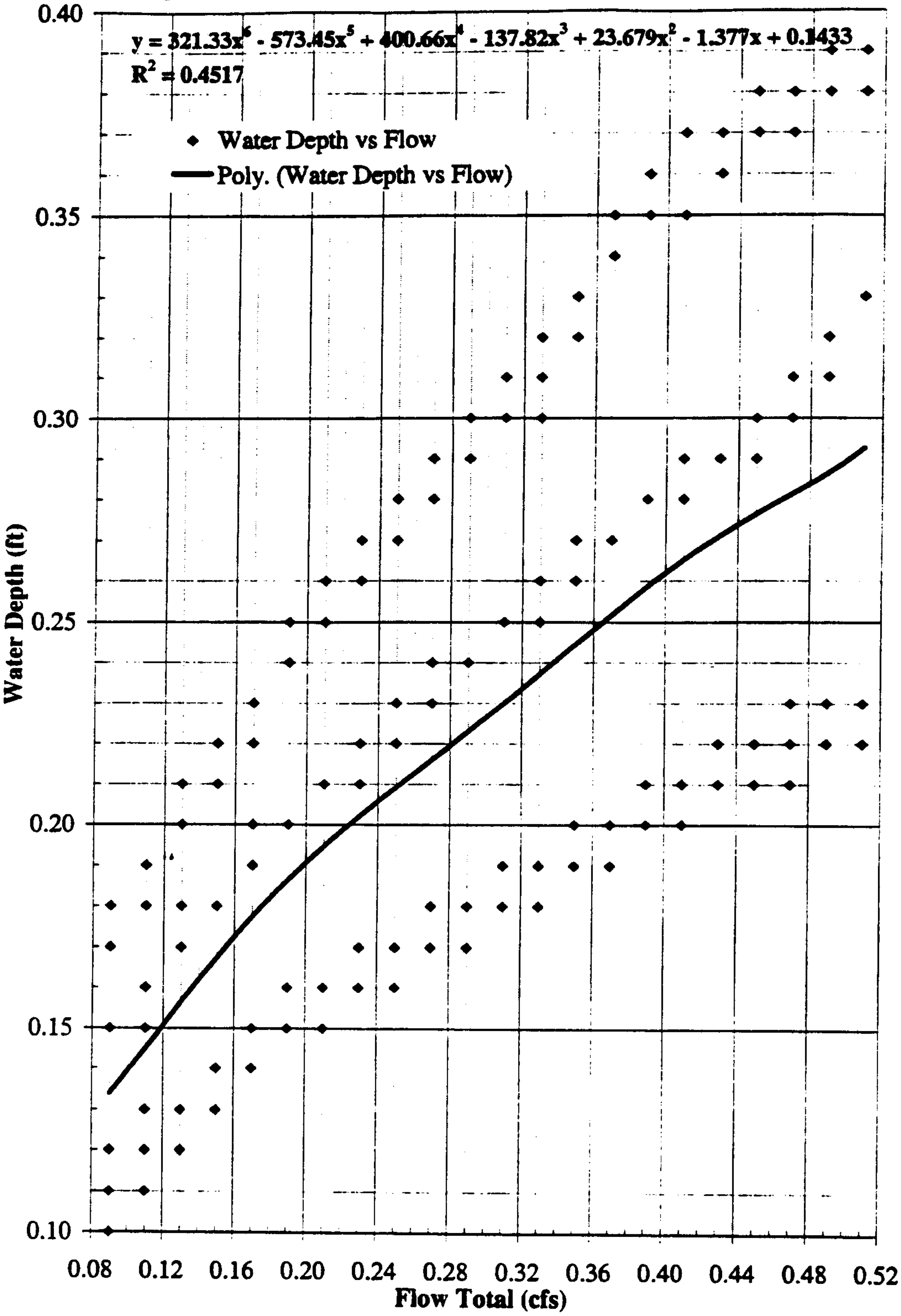


Figure 2-4: Flow Rate Versus Depth Curve for Des Moines Creek



AR 052688

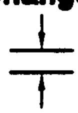
Miller Creek

Change in Channel Low Flow Depth = 0.00 ft (0 mm)

Change in Channel Low Flow Width = +0.02 ft (+6 mm)

Walker Creek

Change in Channel Low Flow Depth = -0.01 ft (-3 mm)

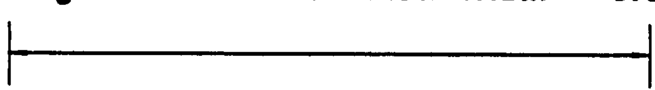


Change in Channel Low Flow Width = -0.10 ft (-30 mm)

Des Moines Creek

Change in Channel Low Flow Depth = -0.03 ft (-9 mm)

Change in Channel Low Flow Width = -0.33 ft (-101 mm)



FILE: K:\CAD\2912\55291201\Task 28\Low flow impacts fig.dwg
DATE: 12/10/01

0 0.5" 1"
DRAWING TO SCALE

Figure 2-5
Changes in Average Water Depths and Widths Between the 1994 and 2006 2-Year, 7-Day Low Flows (Not Accounting for Low-Flow Mitigation)

3. MITIGATION PROPOSAL

3.1 INTRODUCTION OF APPROACH

Hydrologic modeling of the airport drainage areas to determine the potential impacts of Master Plan Update projects, combined with the embankment modeling described in Section 1.3, demonstrate the magnitude of potential low-streamflow impacts due to the construction of Master Plan Update projects. To mitigate these impacts, the Port will collect excess runoff from impervious surfaces during winter storms and reserve that stormwater for discharge during the defined summer low-flow period. This mitigation plan includes the following components:

- Low-flow mitigation performance standards.
- Determination of the season and duration for low-flow mitigation.
- Sizing and location of storage vaults.
- Water quality design aspects.

The proposed mitigation plan is described in the following selections. In addition, a pilot program to test the efficacy of this mitigation approach is described in Section 3.6.

3.2 PERFORMANCE STANDARDS

The overall goal of the Flow Impact Offset Facility is to provide water to Walker and Des Moines Creeks at rates and times equal to the impacts to streamflows calculated by the low-flow analysis. The following measurable performance standards have been developed in order to facilitate meeting this goal:

- To fill the vaults during the rainy season according to the analysis provided in Section 3.3.

- To provide flow at the rates specified in Section 2.5.1 for the entire annual low-flow period each year for each stream (July 24 through October 24 in Des Moines Creek; August 1 through October 31 in Walker Creek).

- To provide flow for additional periods (throughout the month of November) using water remaining in the vaults at the end of the low-flow period.

- To operate the facility in a manner to prevent instream water quality violations caused by operation of the facility.

- To design, operate, and maintain the facility so an adaptive management strategy can be applied.

3.3 WATER QUANTITY – VAULT SIZING ANALYSIS

The vault sizing and vault fill time analyses are summarized below. Additional information and data are provided in Appendices I and J.

3.3.1 Vault Sizing

Vault size was determined by calculating the vault volume necessary to fulfill the required mitigation during the 92-day mitigation period for each stream for each year in the period of record from 1949 to 1995, and selecting the year requiring the largest vault volume as the 'worst case' scenario. The vault size equation returns a daily update of constant mitigation flow accumulation modified by any rainfall recharge. This calculation was repeated for each day in the mitigation period using the previous day's total as a starting point.

The HSPF hydrologic model was used to calculate the rainfall recharge volume generated by runoff from the impervious surface area tributary to the flow mitigation vaults. The intent of the simulation was to account for the reduction in runoff volume due to surface retention and evaporation effects. Flow routing also impacts the timing of the flow to the vaults. The hydrologic parameters, precipitation data, and evaporation data developed for the Des Moines Creek calibration model were used in the impervious surface runoff file. No pervious surfaces were simulated in the model. The HSPF vault sizing input file is included in Appendix J.

The mean, median, minimum, and maximum of the largest vault size necessary within a year were calculated from all years in the period of record from 1949 to 1995. The maximum value was used to determine the size of the storage facility necessary to fulfill the mitigation needs for each stream basin (Table 3-1).

Table 3-1. Summer low flow impact offset maximum vault sizes.

Basin	Vault Size (acre-ft)
Walker Creek	19.0[a]
Des Moines Creek	13.5

[a] Analysis determined 18.5 acre-ft; concept design used 19.0 acre-ft.

3.3.2 Vault Fill Time

The vault fill time calculation records the number of days required to fill a vault to the storage capacity needed on the first day of the mitigation period, for all years in the full record (1949 to 1995) using historical precipitation records and impervious surface areas. Fill time for storage vaults was calculated as the number of days required to fill an empty vault from its close date to the fill limit determined in the vault size calculations. Beginning on the close date and using the previous day's volume as a starting point (zero on the first day), runoff (as calculated by the HSPF recharge model, see Appendix J) was added to the vault. When runoff from storm events filled a vault to the maximum fill volume, the number of days necessary to reach that volume was recorded. The vaults in Des Moines and Walker Creeks were assumed to begin filling on January 2nd.

The mean, median, minimum, and maximum number of days were calculated from the number of days necessary to fill the vault in the period of record from 1949 to 1995 (Table 3-2).

Table 3-2. Low flow vault fill time estimates.

	Estimated Vault Fill Time (days)			
Basin	**Mean**	**Median**	**Minimum**	**Maximum**
Walker Creek	71	60	22	213
Des Moines Creek	11	8	1	38

3.4 WATER QUALITY DESIGN

3.4.1 Introduction

Ecology has defined standards for water quality related to stormwater release, including periods of low flow. Ecology has jurisdiction to monitor and enforce these standards through their National Pollution Discharge Elimination System (NPDES) Permit. These standards include turbidity, dissolved oxygen (DO), temperature, and dissolved metals. The Port's current stormwater design plans for the third runway construction include a stormwater system and operational procedures to provide the storage and managed release of stormwater during low-flow periods. These stormwater storage facilities employ biofiltration strips, catchbasins, detention pond, and vaults to meet current King County water quality requirements. In addition, the facilities are designed to be retrofitted according to the Ecology Stormwater Management Manual (Ecology 2001) if specific water quality concerns are identified during post-construction monitoring. The Port's monitoring and reporting program (see Section 5) is proposed to assess the performance of the facilities, allowing adaptive management to be used in the implementation of additional water quality measures to ensure that standards will continue to be met.

Des Moines, Miller, and Walker Creeks are all assumed to be Class AA (extraordinary) waters (WAC 173-201A-030). As such, the water quality standards discussed in this report are those listed for Class AA water bodies, which are the most stringent standards. Water quality standards for metals are based on toxicity, are independent of the receiving water classification, and are listed in WAC 173-201A-040 (Toxic Substances). Ecology has started the process to potentially revise state water quality standards. The Port will continue to evaluate the proposed changes as part of the final design process and make any needed changes to the facility.

The state water quality standards applicable to the managed release of stormwater to offset flow impacts are discussed below. Specific design features, assumptions, and other information considered in the design of the facility are included. Operational and monitoring proposals are presented in Sections 4 and 5 of this report. References to stormwater vaults refer only to those vaults proposed to detain stormwater to offset impacts to streamflows. Likewise, references to stormwater and stormwater discharges refer only to the managed release of stormwater to offset flow impacts.

All of the stormwater that will be released to offset the impacts during summer low-flow periods will be collected from new and existing airfield areas. The airfield is a highly managed controlled-access area, and generates stormwater that is generally cleaner than typical urban stormwater (Port of Seattle 2000a).

3.4.2 Turbidity

The state water quality standard for turbidity in class AA waters is a two-tiered standard. For receiving water with turbidity less than or equal to 50 NTU (background flow), discharged water may not increase the receiving waters more than 5 NTU over background. For receiving water with turbidity greater than 50 NTU, discharged water may not increase turbidity of the receiving waters more than 10 percent. Turbidity levels in the streams vary between less than 5 NTU to over 1,000 NTU. The lowest turbidity levels in the streams generally occur during low streamflow (base flow) conditions, which correspond to the majority of periods when the stormwater would be released to the streams to offset flow impacts. It is assumed that the releases of stormwater to offset flow impacts would have to meet the 5 NTU standard most, if not all, of the time. To minimize the need to provide constant background level monitoring of the stream above and below the release locations, releases will be limited to 5 NTU or less to ensure compliance at all times.

There are several operational considerations and water quality BMPs in place at the airport to reduce the sediment and turbidity levels in runoff water going into stormwater storage. The Port uses catchbasins, the Industrial Wastewater System (IWS), and biofiltration strips as BMPs on the existing airfield, and the SMP proposes to retrofit the existing airfield with additional sediment trap BMPs in the bottom of each new detention vault facility. The new airfield surface will incorporate similar BMPs to minimize the amount of sediment and suspended solids that could potentially get into the stormwater vaults. The primary BMP consists of the construction of biofiltration strips in the new and existing airfield areas that treat stormwater as it drains directly from impervious areas of runways and taxiways. The Port will also maintain catchbasins to ensure they continue to trap sediments. Filter strips are already in place in the existing Taxiway "C" airfield area that drains to the stormwater vault (SDS3A) located in the Des Moines Creek watershed (see Section 7 in the SMP). In addition, the airfield is a controlled area subject to very low levels of travel by ground vehicles and frequent cleaning and inspection for debris that could be harmful to aircraft. Consequently, the airfield is generally much cleaner than most urban areas that generate stormwater runoff.

There are also operational procedures outlined in the airport's Stormwater Pollution Prevention Plan (SWPPP) that will minimize opportunities for sediment and suspended solids to enter the stormwater vaults. These include:

- Sweeping ramp areas several times per week.
- Annual inspection of catchbasins and cleaning if the depth of sediment equals or exceeds one-third the depth from the bottom of the basin to the invert of the lowest pipe.
- Proper storage and disposal of sediment removed from catchbasins.
- Hydroblasting of runway skid-mark rubber. Water and removed rubber is vacuumed by the same machine, drained, and deposited at the decant station until disposed as solid waste.

All of these BMPs will limit the amount of sediments and suspended solids that enter the stormwater vaults, and therefore will reduce the turbidity of the water stored in the vaults and discharged to the streams.

All of the proposed stormwater vaults, including those associated with the Flow Impact Offset Facility, employ features designed to provide treatment (settling and removal) of suspended solids and turbidity. These features include:

- Dividing the dead storage area (similar to the areas in the vaults where the stormwater detained to offset flow impacts will be held) into several compartments by constructing short walls within the dead storage area of each vault. The compartments provide areas for suspended solids to settle out and be contained. Each compartment's outlet will be configured so that the suspended solids are captured in the compartments during low-flow release periods. Design considerations of this type are typically included in stormwater vaults. Details will be provided at final design of the stormwater vaults.

- The vaults will include an extra 6-inch depth for the first third of the bottom (minimum) to facilitate trapping sediment that reaches the vault.

- The inlets and outlets in the vaults will be configured to minimize disturbance of sediments and floatables within the vaults. This will be done by locating the inlets and outlets within the middle third of the reserved storage depth. Outlets will incorporate a floating design to accomplish this, as well as to maintain a consistent discharge rate.

- Maintenance of the vaults will remove and properly dispose of collected sediments outside of the anticipated low-flow release periods.

- The vaults will be designed to allow installation of additional water quality measures, if needed. Additional water quality features may include filtration of the discharges, oil/water separators, or aeration.

The design of the stormwater vaults, in combination with the operational and monitoring considerations discussed below, will ensure that release of stormwater will not cause violations in the turbidity standards. The Port is currently investigating filtration of stormwater associated with discharges from a landside drainage basin. This research includes determining the effectiveness of several filtration media in treating the stormwater. The results of this study will be completed before final design of the flow offset facilities, and the data will be used to select the filtration method most appropriate to treat the stormwater discharge, if needed.

3.4.3 Temperature

The state water quality standard for temperature in class AA waters is not to raise the temperature of the receiving water to over 16 degrees Celsius (°C). If the baseline temperature of the receiving water is greater than or equal to 16°C, then discharges cannot raise the temperature more than 0.3°C. To date, Ecology has not applied these requirements to stormwater discharges, although they have required temperature monitoring of certain stormwater discharges. Ecology could apply the temperature standard to future stormwater discharges.

The highest annual temperatures in the streams are usually reached during the summer months, which is the period when the Flow Impact Offset Facility is expected to be in operation. Solar radiation is the primary mechanism by which stormwater temperatures increase in detention ponds. Since the stormwater vaults are typically underground structures, there will generally be no direct solar warming. Underground storage provides a constant temperature that will be lower than open storage facilities, more closely matching a native groundwater seep temperature. Water released from the Flow Impact Offset Facility is not expected to increase instream water temperatures. Since the proposed underground stormwater vaults will result in relatively cool water being discharged, no special design considerations are proposed to manage water temperatures in the vaults associated with the Flow Impact Offset Facility.

The Port has begun to collect water temperature data from existing stormwater vaults and in the streams in order to characterize the expected temperatures of the reserved stormwater discharges. Commencing in the summer of 2001, average daily water temperature data is being collected from the NEPL vault and the SDS3A vault located near the south end of the airfield. Data will be collected from June though October of each year from the dead storage area of each vault. These existing vaults were selected because they are similar in size to the proposed stormwater volumes associated with the Flow Impact Offset Facility. The NEPL vault is partially exposed to sunlight (on its west side and top), while the SDS3A vault is completely underground. By collecting temperature data from both vaults, a range of expected temperatures will be established. Temperature data will be collected from the dead storage zone in each vault in order to approximate the vaults associated with the Flow Impact Offset Facility. This data will be compared to stream temperature data also being collected by the Port to characterize any cooling effects of stormwater releases on water temperatures in the streams.

3.4.4 Dissolved Oxygen

The state water quality standard for DO in Class AA waters is 9.5 milligrams per liter (mg/l). Low DO levels in streams during summer low-flow periods is a potential water quality concern. The Flow Impact Offset Facility will be designed and operated in a manner that will not decrease the DO levels in the streams, and under typical conditions, may act to increase DO levels in the streams.

It is anticipated that DO levels in the stormwater vaults should not be significantly reduced while the water is stored. There should be little, if any, biological activity in the vaults that could consume oxygen as a result of the lack of sunlight and the low biological oxygen demand (BOD) typically seen in stormwater runoff from the airfield (Port of Seattle 2000a). The infrequent and short-lived episodes of elevated BOD due to runway de-icing activities are not expected to impact the DO concentrations of the stormwater detained in the Flow Impact Offset Facility because the stormwater associated with these events moves through the stormwater management system in a matter of hours, is replaced with runoff with the low BOD concentrations more typical of airport runoff (Port of Seattle 2000b), and typically happens during the winter months when reserved stormwater releases from the Flow Impact Offset Facility would not take place. In addition, the Port operates BMPs to move snow containing de-icing chemicals (a potential source of BOD) from the airfield to snowmelt areas that drain to the IWS, further reducing the BOD in water that drains to stormwater vaults.

Vents will be included in the stormwater vaults associated with the Flow Impact Offset Facility to allow for the circulation of fresh air. This will help maintain the dissolved oxygen concentration of the stormwater.

An additional design consideration is the positioning of the inlet(s) to the stormwater vaults associated with the Flow Impact Offset Facility. The inlet(s) will be placed as low as possible in the vault (consistent with the inlet placement parameters in the turbidity section above) in order to facilitate flushing of the vault each time there is sufficient rainfall to generate stormwater runoff. Typically, stormwater inlets in vaults are placed at higher elevations within the vault. As a result, water in the lower or dead storage areas may not be circulated and may stagnate. By placing the inlet at a lower elevation, water already in the lower portions of the vault will be displaced by the incoming water and will not have the opportunity to stagnate. Continually replacing the water in the stormwater vaults should benefit the DO levels in the stormwater. Each stormwater vault associated with the Flow Impact Offset Facility will have its inlet position carefully considered during the final design phase, and placed to enhance this circulating effect as much as possible consistent with other requirements.

Passive aeration of stormwater can be achieved through natural turbulence or agitation of the discharges. Steeply sloped pipes with periodic drop structures will be required to move the water from the vault outlets to the stream elevation. An energy-dissipating structure will be required near the release point at stream level to slow the velocity adequately for entering the stream safely, without causing scour or erosion. Both the steeply sloped discharge pipes and the energy-dissipating structures will provide the turbulence or agitation needed to provide passive aeration. Where insufficient fall is available for this natural aeration process, the installation and operation of aeration devices may be necessary. Other vaults are located near the level of the stream discharge elevation such that active aeration measures may be required through the installation of some type of aeration device. Active aeration systems that could be utilized include microbubble diffusers, gas injection, air injection, mechanical aerators, or aeration hoses. Microbubble diffusers consist of a porous ceramic plate (similar to aquarium aeration stones) and a pump to inject air through the plate. Gas and air injection systems inject a controlled amount of gas or air under pressure into the discharge water pipe. Mechanical aerators physically agitate water and allow air to become mixed with the water. Aeration hoses are flexible porous rubber hoses that have air pumped through them similar to the microbubble diffusers. Information on each of these devices is included in Appendix F. Although the selection of the device(s) to be installed will be made during the final design of the Flow Impact Offset Facility, it is likely that the microbubble diffuser will be selected and installed because of its simplicity, effectiveness, cost, and ability to be installed in the discharge pipes. Other attractive features of the microbubble diffuser include low maintenance requirements, the use of a small compressor or pump to provide air instead of the use of compressed gas tanks, and the ability to be automated to function anytime the reserved stormwater discharge valve is open.

3.4.5 Nutrients

There are no water quality standards for nutrients in the current water quality standards. However, nutrients typically found in urban stormwater could be of potential concern. If nutrient-rich stormwater is stored for long periods, exposure to solar radiation can potentially cause algae blooms. However, it is expected that there will be no adverse water quality impacts associated with nutrients in the release of reserved stormwater for the following reasons:

- There is no significant source of nutrients associated with the airfield areas identified as sources of water for the Flow Impact Offset Facility. Primary sources for nutrients in urban stormwater are fertilizers applied to lawns and landscaped areas. However, the grass infield areas of the airfield are not fertilized or irrigated because lush growth could become a wildlife attractant concern. Any landscaped areas to which fertilizers are applied are located near the terminal and drain to stormwater basins that do not contribute flow to the Flow

Impact Offset Facility. The Port's use of fertilizers includes applying the BMPs listed in the airport's SWPPP, which further reduces the amount of fertilizers and nutrients that enter stormwater. With careful management of fertilizer use at the airport, there is no major source of nutrients for the drainage areas that contribute stormwater to the Flow Impact Offset Facility.

- The operation of BMPs on the airfield (biofiltration swales) would reduce the opportunity and concentrations of any nutrients that exist prior to the stormwater entering the vaults.
- Since the vaults are underground facilities, there is no sunlight that would stimulate the growth of algae often associated with elevated nutrient levels.
- Instream residence time for the stormwater discharged from the Flow Impact Offset Facility is only a matter of hours (the time it takes water to flow from the discharge points in the airport vicinity to the streams' discharge points in Puget Sound). Therefore, there will be minimal opportunity for biological activity (algae blooms) in the streams. Such water quality impacts from nutrients are typically associated with lakes and ponds, where long residence time would provide the opportunity for excess algae growth to occur. Since no lakes or ponds occur in the streams between the airport and Puget Sound, this is not an issue.

Given the above, the Port does not propose any monitoring for nutrients in the discharges from the Flow Impact Offset Facility. Through continued implementation of the SWPPP, the BMPs currently in place that manage the use of fertilizers will continue to minimize the opportunities for nutrients to enter stormwater runoff.

3.4.6 Metals

Metals of concern include copper, lead, and zinc. Washington State water quality standards for these metals are based on the dissolved fraction, are dependent on the hardness of the water, and, as with all water quality standards, are applicable to the receiving waters. Chemistry data from existing airfield stormwater discharges (which are typical of the stormwater that would be reserved for release during low-flow periods) have been reported in the annual stormwater monitoring reports. Metal concentrations in these discharges are reported as total recoverable metals, which are not directly comparable to the dissolved fraction listed in the water quality standards. However, this data does serve as an indication of metal concentrations to be expected in the discharges of stormwater from the Flow Impact Offset Facility. Median metals concentrations from airfield stormwater typically range from 0.012 to 0.031 mg/l copper, 0.001 to 0.003 mg/l lead, and 0.020 to 0.051 mg/l zinc (Port of Seattle 2001b). These values were obtained for stormwater sampled at points prior to entering the receiving waters. Additional treatment that occurs in surface waterways prior to entering the receiving waters will result in lower metals concentrations actually entering the streams. In general, these metal concentrations are also less than typical urban runoff, as discussed in the Port's annual stormwater monitoring reports (Port of Seattle 2000a, 2001b). In addition, the Port has conducted whole effluent toxicity testing of stormwater discharges, as required by its NPDES permit (see discussions in the annual monitoring reports). Stormwater associated with airfield subbasins met the performance standards for whole effluent toxicity according to Ecology guidelines. All this information indicates that the Flow Impact Offset Facility can be managed to meet the water quality standards for metals in the receiving waters.

The following items should be considered in the management of the Flow Impact Offset Facility for compliance with state water quality standards:

- A large portion of metals in urban stormwater is attributed to motor vehicle activity. This is illustrated in the annual stormwater monitoring reports, which show higher metal concentrations are associated with the landside basins where motor vehicle activity is concentrated. Since access to the airfield is strictly controlled, motor vehicle activity is kept to a minimum. Therefore, metal concentrations in stormwater runoff are minimized. The airfield basins are the areas that will be providing stormwater to the Flow Impact Offset Facility, and these areas typically have the lowest lead and zinc concentrations of all airport stormwater discharges (copper concentrations are more consistent in all airport stormwater discharges, but are still relatively low in airfield stormwater).

- Data collected by the Port show that a large fraction of the metal concentrations are associated with particulates (i.e., the metal ions are bound to particulate matter). Therefore, the design and management practices proposed to minimize or reduce particulates and turbidity will also reduce total metal concentrations in the stormwater discharges. Biofiltration swales, settling in vaults, and (additional) filtration are all effective in reducing particulates, and therefore total metal concentrations will be reduced as well. Although these BMPs may not be effective in removing dissolved metals, the majority of the metals are bound to particulates and will be removed. The design features proposed for the reserved stormwater vaults (compartmentalized storage, sloping the vault floor away from the stormwater outlets, careful placement of the stormwater inlets and outlets, and the provision for installation of filters) will ensure that the discharge of sediments and metals bound to particles will be minimized.

- The Port is currently investigating filtration of stormwater associated with discharges from a landside basin. This research includes determining the effectiveness of several filtration media in treating the stormwater. The results of this study will be completed before final design of the flow offset facilities, and the data will be used to select the filtration method most appropriate to treat the discharge from the Flow Impact Offset Facility, if needed.

3.5 ADDITIONAL INFORMATION

There are several other considerations relating to the design and operation of the Flow Impact Offset Facility, including the following items:

- The discharge points for the Flow Impact Offset Facility will be the same as the typical ("live") discharge point for each vault or pond they are associated with. This eliminates the need to permit and construct additional discharge points to the streams. The proposed location of each stormwater discharge point for the Flow Impact Offset Facility is illustrated in the drawings in Appendix F.

- All stormwater management facilities, including those associated with the Flow Impact Offset Facility, will be located within the airport's perimeter fencing, thereby controlling access to the facilities and reducing the potential for damage to the facilities from vandalism.

- The Port will operate, inspect, monitor, and maintain the Flow Impact Offset Facility as long as there is an airport at the site. In addition, the Port will provide annual monitoring reports to ensure that the Flow Impact Offset Facility is meeting its performance goals. An adaptive management method will be used to allow for needed adjustments in the operation of the facilities, and to allow for the installation of new management/monitoring technology, if needed.

- As stated in Ecology's *Stormwater Management Manual for Western Washington* (Ecology 2001), the objective of stormwater management is to "control the quantity and quality of stormwater produced by new development and redevelopment such that they comply with water quality standards and contribute to the protection of beneficial uses of the receiving waters." Ecology has determined that stormwater management activities in Washington State do not require a water right. Since the Port's proposal to offset flow impacts to the receiving waters consists of stormwater management activities, a water right is not required for the Flow Impact Offset Facility.

- The Port is incorporating BMPs into the embankment design to ensure infiltration into the embankment rather than the embankment conveyance system. These BMPs include the use of flatter than normal slopes in biofiltration swales, the use of materials (soils) with good infiltration capacities, the incorporation of soil amendments to increase infiltration, managing vegetation to enhance infiltration, and scarifying surfaces to eliminate barriers to infiltration.

- The Port has investigated the potential for conveyance losses to seepage between the discharge points of the reserved vaults and the streams. The portion of conveyance that occurs in unlined ditches or swales occurs in close proximity to the streams, so that any seepage to shallow groundwater is expected to discharge to the streams in a very short time, thereby not impacting the amount of water delivered to the streams. The proposed water quantity monitoring program will provide data to assess this performance characteristic. If losses are detected that are impacting the quantity of water delivered to the streams, actions will be taken to correct the situation, such as conveying the water in pipes to a point where losses will not occur.

- The Port is currently assessing the ability to route the discharges from the Flow Impact Offset Facility into wetlands that are hydraulically connected to the streams. This will be implemented wherever possible in the final design of each reserved stormwater vault. Note that if this is implemented, it may require the construction of additional discharge points (i.e., the reserved stormwater discharge point may have to be separate from the normal ("live") stormwater discharge point to achieve this goal). Analyses indicate that the groundwater hydrology of wetlands hydraulically connected to the streams will be maintained (Parametrix 2001b). To determine if hydrologic conditions in the wetlands are sufficient to maintain the existing vegetation types, the groundwater hydrology of the riparian wetlands adjacent to the Master Plan Update improvements will be monitored for up to 15 years as described in the *Natural Resource Mitigation Plan* (Parametrix 2000b).

3.6 PILOT PROGRAM PROPOSAL

Section I. a) ix) of the Department of Ecology's Water Quality Certification #1996-4-02325 states:

> "The Port shall develop a pilot program to test one reserve stormwater vault for performance. The Port shall include a proposal for a pilot in the revised plan. The pilot shall be completed within three years after receipt of the Section 404 permit from the U. S. Army Corps of Engineers."

The Port proposes to modify the existing "taxiway" vault (SDS3A) in the Des Moines Creek drainage basin as the pilot program for the Flow Impact Offset Facility. The SDS3A vault was selected because most of the vaults proposed as part of the Flow Impact Offset Facility may not be constructed within the time period required in the Water Quality Certification. The SDS3A vault already exists, and can be easily reconfigured to include a reserved stormwater release function. Modification of the discharge structure and the addition of a separate reserved stormwater discharge line would be required.

Because the SDS3A vault already exists, it does not include several of the water quality design features of the proposed vaults, such as ventilation and optimal placement of stormwater inlets. However, this presents the opportunity to utilize the SDS3A vault as a baseline study, i.e., the water quality of the reserved discharge can be tested without the benefit of any of the proposed special design features. If data collected during operation of the pilot program indicates potential water quality problems, then the vault would be reconfigured to include the appropriate features, and additional data would be collected to measure the effectiveness of the features. Examples include:

- The SDS3A vault does not have any special ventilation features to enhance dissolved oxygen (DO) levels of the stored stormwater. Baseline information on DO within the vault and reserved discharges as they enter the stream would be collected. If DO levels are low, additional aeration features (both passive and active) can be added and their effectiveness measured through additional monitoring. The knowledge gained could then be applied to the proposed vaults.

- The SDS3A vault collects stormwater from the airfield (controlled vehicle access area), and employs typical sediment control BMPs (biofiltration swales, settling within the vault). Baseline information on the turbidity of reserved stormwater discharges would be collected, and modification to the vault would be made if turbidity problems are detected. Modifications could include reconfiguring the reserved storage area within the vault to increase its sediment trapping capability, reconfiguring inlets/outlets, or filtration. The effectiveness of these additional features would be measured, and knowledge gained could then be applied to the proposed vaults.

The SDS3A vault will be reconfigured to test the reserved stormwater release concept so that one full year of operational testing and monitoring will be completed within the time period set forth in Section I. a) ix) of the Department of Ecology's Water Quality Certification. After one full year of operation and monitoring, the Port will develop a report describing the operation and its performance. The report will be submitted to Ecology for review. If the SDS3A vault pilot program does not meet any of the performance standards listed in Section 3.2, the report will include an analysis and recommendations to increase performance to the required levels. These recommendations will be implemented in all of the reserved storage vaults, as appropriate.

4. OPERATION AND MAINTENANCE PLAN

4.1 PURPOSE AND SCOPE

4.1.1 Purpose of Plan

The low-flow impact offset vaults were designed to provide long-term detention of runoff for slow release during the summer low-flow period. The purpose of this Operation and Maintenance Plan is to set forth the procedures and schedules that Port maintenance staff will use for operating, inspecting, and maintaining the low-flow vaults. These procedures will be necessary to ensure that stored runoff water is available in adequate quantity and quality for release to the streams during summer low-flow conditions. A well-implemented operations and maintenance plan will also help the Port minimize long-term life cycle costs for the facilities.

4.1.2 Scope of Plan

The Operation and Maintenance Plan addresses the Low Flow Impact Offset Facilities listed below for Walker Creek (SDW2) and Des Moines Creek (SDS3). Detailed design information for each of these vaults is provided in Section 4.2. Facility operation information is contained in Section 4.3. Section 4.4 describes procedures for Port staff to periodically inspect the vaults and examine certain components and potential conditions, such as the accumulation of sediment and debris, clogging of pipes, or structural damage. Section 4.5 provides safety procedures that will be used by Port staff during vault operation, inspection, and maintenance activities.

4.2 FACILITY DESCRIPTIONS

The operation, site layout, and design features of the low-flow vaults are provided below. This information is intended to provide background information to Port staff regarding the operation and maintenance of these facilities.

4.2.1 Facility Design and Operation Concept

Underground vaults will be used to detain stormwater for reserve discharge during the summer low-flow period. Low-flow mitigation storage will be created in vaults adjacent to the SMP detention vaults. Water for low-flow mitigation storage will be captured and stored during the January through July period and released slowly during August through November (see Section 4.3, Facility Operation). In addition to flow control, the vaults will also include water quality treatment components (e.g., trash racks, oil-water separators, filters, etc.), as appropriate for the activities within the areas contributing stormwater to each vault.

4.2.2 Facilities Overview

A total of two low-flow vaults will be used. Locations of the vaults on the airport site are shown in Figure 4-1. Table 4-1 provides a list of the vaults and summarizes their major characteristics, including facility layout and access, hydraulic features, and water quality control and treatment features. Concept drawings of each facility are provided in Appendix F.

4.3 FACILITY OPERATION

4.3.1 System Schedules

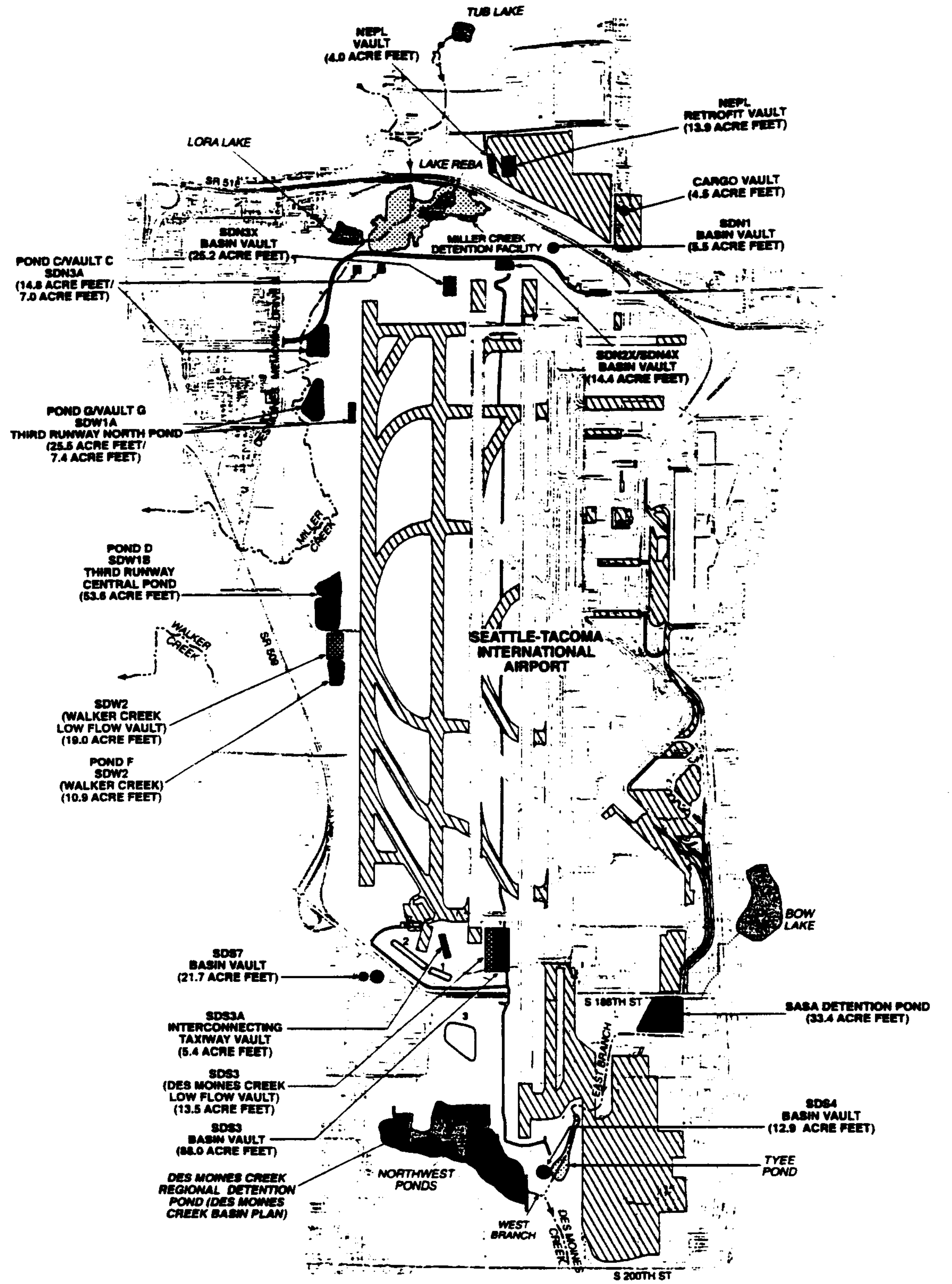
The overall operating schedules for the Walker and Des Moines Creek low-flow vaults are shown in Table 4-2 and in Figures 4-2 and 4-3. The fill rate (water storage) is shown in the figures as linear, but in practice the fill rate is expected to be highly variable depending on the specific vault design, capacity, and rainfall patterns.

If any water remains in the vaults at the end of the summer low-flow period (end of October), the Port shall continue to release the water at the existing rate until the vaults are empty, or until rainfalls occur that cause a significant increase in the base flows of the streams.

Table 4-1. Summary of Low Flow Impact Offset Facilities.

	SDW2	SDS3
General description		
Location	West central side of new runway	North of South 188th Street
System	Walker Creek	Des Moines Creek
Drawing number	C 131	C 141
Type	Underground, rectangular, concrete, single-compartment vault with high-level bypass pipe adjacent to pond F	Underground, rectangular, concrete, with two compartments: low-flow storage and short-term detention
Plan dimensions	Approximately 442 ft x 250 ft	Low-flow storage compartment, approximately 126 ft x 700 ft
Access	Approximately 40 10x10-ft access grates; 1 down ramp	Approximately 6 main access lids
Low-flow offset storage		
Type	Vault dedicated to low-flow offset storage	Low-flow storage compartment as part of overall structure
Volume	19.0 acre-ft[a]	13.5 acre-ft
Maximum water depth	8.0 ft	7.2 ft
Hydraulic features		
Inlet structure	Pipe from MH SDW2-9	Pipe from MH SDS3-592
Outlet structure	Low-level outlet pipe	Low-level outlet pipe
Outlet control	Valve	Valve
Outlet conveyance	Approximate 700-ft pipe	Pipe to MH SDS3-197
Discharge to stream	Adjacent to pond F outfall	SDS3 outfall
Water quality features		
Sediment trap	Sloped vault floor with internal dividing walls	Sloped vault floor with internal dividing walls
Aeration	Passive air flow through grates	Passive air flow through grates
Trash racks	(detail for construction)	(detail for construction)
Filters	Optional sand or filter media filter	Optional sand or filter media filter
Oil-water separators	(detail for construction)	(detail for construction)
Mechanical and Electrical		
Monitoring and alarms	(detail for construction)	(detail for construction)
Lighting	(detail for construction)	(detail for construction)
Washdown	(detail for construction)	(detail for construction)

[a] Analysis determined 18.5 acre-ft; concept design used 19.0 acre-ft.



Sea-Tac Airport Stormwater Management Plan/...

Figure 4-1
Low Flow Offset Facilities Locations

Figure 4-2
Walker Creek Facilities – Annual Schedule

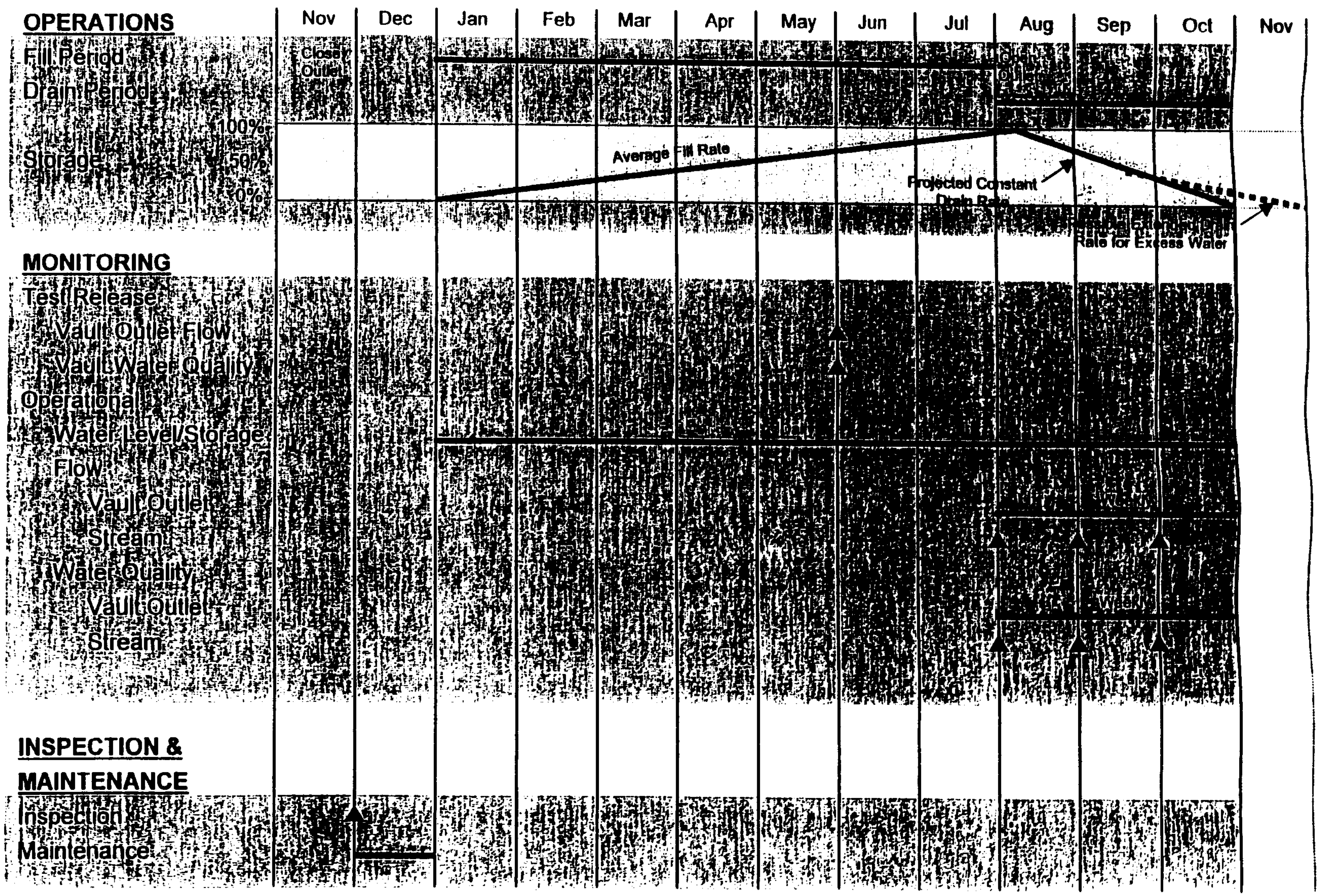


Figure 4-3
Des Moines Creek Facilities – Annual Schedule

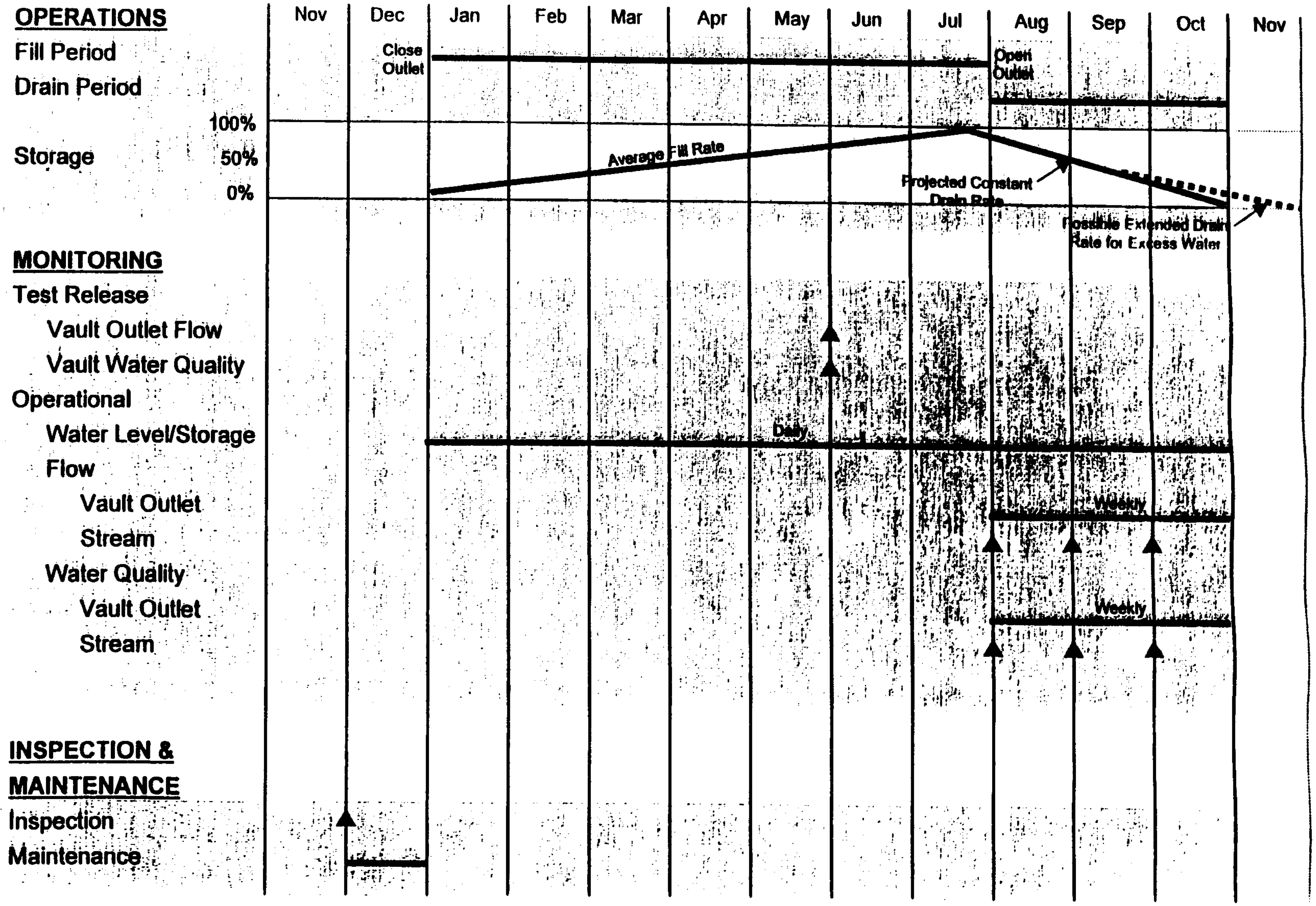


Table 4-2. Summary of Low-Flow Vaults Operating Schedules

	Walker Creek	Des Moines Creek
Start Vault Filling	January 2	January 2
Open Outlet/Start Vault Draining	August 1	July 24
Summer Low-Flow Period Ends	October 31	October 24
Summer Low-Flow Period Release Rate	0.11 cfs	0.08 cfs

4.3.2 Facilitv-Specific Schedules

As operating experience is gained by the Port, the fill and release schedules for the vaults may be adjusted to allow for more effective system operation. Facility-specific schedules will be added to this Operation and Maintenance Plan as they are developed in the future.

4.4 INSPECTION AND MAINTENANCE

The objective of the inspection and maintenance program is to ensure the reliability and consistent performance of the Low Flow Impact Offset Facilities in providing water in sufficient quantity and quality to the streams. In addition, the program will help to extend the life of the facilities and reduce the overall life-cycle costs to the Port.

4.4.1 Procedures

Figure 4-4 conceptually illustrates the inspection and maintenance program. The sample form shown in Figure 4-5 lists typical vault components that will be inspected. An inspection and maintenance record form that is specific to each facility will be developed as final designs are completed.

Inspectors will evaluate their observations with standards to determine if maintenance is required. In many situations, it is expected that maintenance will be performed at the time of inspection. In other situations, when additional staff or equipment is necessary, a work order request will be prepared and the maintenance will be performed at a later date.

4.4.2 Sediment Removal

Sediment is expected to accumulate in the bottom of the facilities below the low-flow outlet. Oil, grease, and other types of debris may also accumulate with the sediment. Regular and proper removal of sediment and debris is critical to ensure that water stored in the vaults will be of satisfactory quality when it is discharged to the streams.

Depending on the facility's design and the quantity of sediment that has accumulated, sediment will be removed with vactor trucks, small front loaders, or manual tools. Washdown water may also be required. Regardless of the methods used, the low-flow outlet will be closed during the sediment removal process to prevent contaminated water from being discharged to the streams. The Port's existing decant facility shall be used for the disposal of all sediment and associated water that is removed from the vault during the sediment removal process.

Figure 4-4
Inspection and Maintenance Process Overview

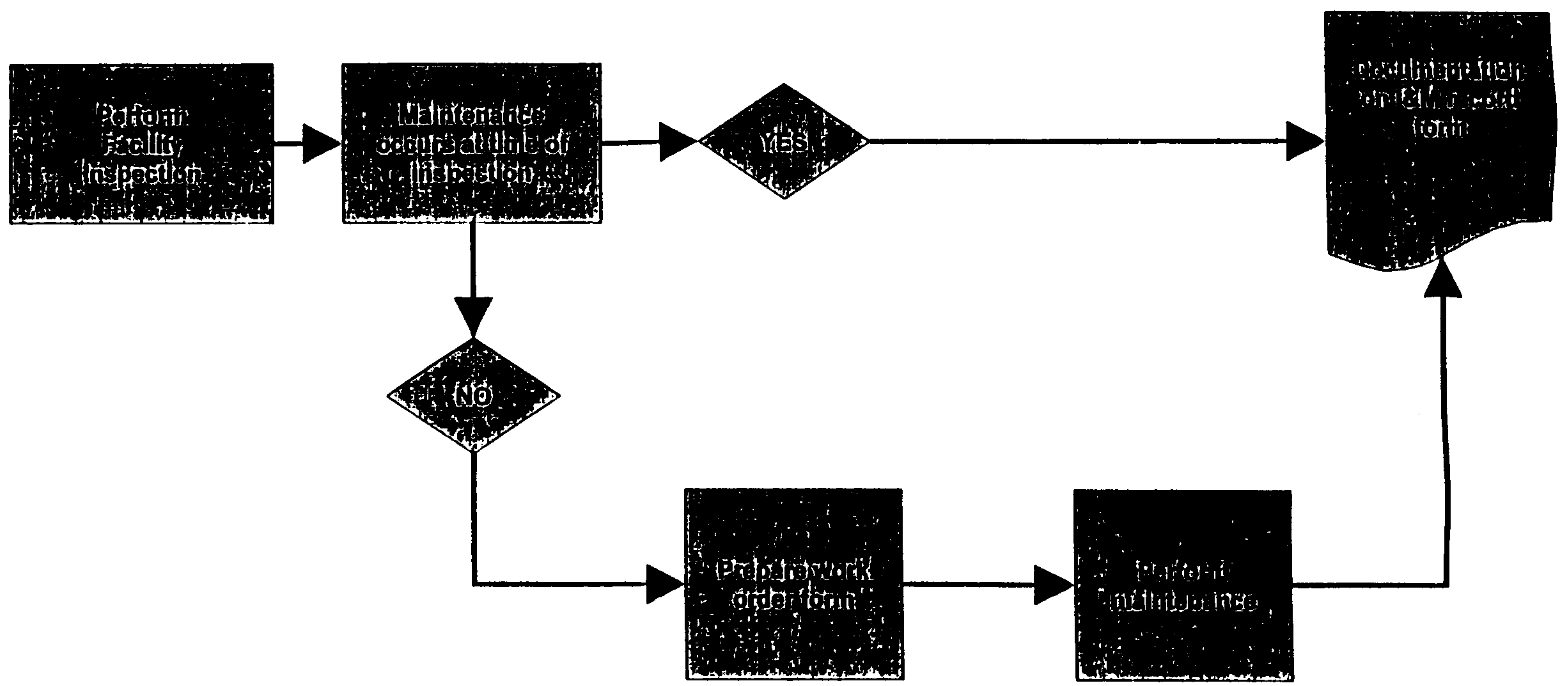


Figure 4-5
Inspection and Maintenance Record

Facility: ____________________

Inspection Date: ____________________

Inspector: ____________________

	Inspection		Maintenance	
Facility Component	**Observed Conditon**	**Required Maintenance**	**Performed By**	**Date**
Access				
Hatches				
Ladders				
Ramps				
Vents				
Hydraulics and Controls				
Outlet pipe				
Outlet valve				
Weir				
Water Quality Treatment				
Trash racks				
Filters				
Oil-water separators				
Sediment Level				
Electrical / Mechanical				
Lights				
Water level instrumentation				
Internal piping				

4.4.3 Schedule

Vault facilities are projected to contain water in varying amounts during the period from January through October for low-flow mitigation purposes. Therefore, in order to conduct inspection and maintenance activities in-the-dry, this work will need to occur during November and December of each year. Specifically, as shown by the schedules in Figures 4-2 and 4-3, inspections will be performed in early November, followed by maintenance activities as necessary through December.

4.4.4 Documentation

An inspection and maintenance record form shall be completed for each inspection at each vault facility.

4.4.5 Reporting

Inspection and maintenance activities shall be summarized in the Port's annual report to Ecology.

4.5 SAFETY

Accumulated sediment, stagnant water conditions, and limited ventilation are typical conditions in vaults and may cause noxious gases to form and accumulate in the vaults. Additional ventilation will be provided in the low-flow vaults. Vault inspection and maintenance procedures must be in compliance with OSHA confined-space entry requirements, which includes clearly marking entrances to confined-space areas.

5. MONITORING PLAN

5.1 WATER QUALITY AND FLOW MONITORING

The Port is proposing a comprehensive monitoring plan for the Flow Impact Offset Facility to ensure that the performance standards are met and that no violations of state water quality standards occur in the receiving waters, and to support an adaptive management strategy. Monitoring consists of three elements: characterization of existing/expected water quality, monitoring of annual test releases from the Flow Impact Offset Facility, and monitoring of the discharges and receiving waters during operation of the facility. Each element is discussed below.

5.1.1 Characterization of Existing/Expected Water Quality

A great deal of water quality data already exists on the Port's stormwater discharges and on the streams. This data has been collected for a variety of purposes, including satisfying the Port's NPDES permit requirements, basin planning activities, and other studies done in the area by the Port and others. The data set includes water quality measurements within the stream systems during the summer periods when the Flow Impact Offset Facility will be scheduled to discharge to the streams. In addition, the Port has started to collect data to characterize the discharges from the Flow Impact Offset Facility. Temperature data is being collected starting in 2001 from the existing NEPL vault and the SDS3A vault in order to characterize the expected temperatures of the Flow Impact Offset Facility. The NEPL vault is partially exposed to sunlight (on its west side and top), while the SDS3A vault is completely underground. By collecting temperature data from both vaults, a range of expected temperatures can be established for each type of vault (buried and partially exposed). Temperature data will be collected from the dead storage zone in each vault in order to approximate the Flow Impact Offset Facility. The Port has collected some instream temperature data beginning in September 2000. Other data that is being collected as part of other Port water quality studies will be used prior to the operation of the Flow Impact Offset Facility to characterize expected water quality within the streams during the summer months (when the facility will be discharging). All of this data will be analyzed and presented in the final design of the facilities associated with the Flow Impact Offset Facility.

5.1.2 Monitoring of Annual Test Releases from the Flow Impact Offset Facility

Each year, prior to the operation of the Flow Impact Offset Facility, the Port proposes to conduct small test discharges from each outlet. The test discharges are intended to confirm the operation of each discharge and to detect and respond to potential problems prior to the annual operation of the Flow Impact Offset Facility. For example, because of the small orifices needed to control discharges to the required rate, a small amount of debris in an orifice could potentially impact the discharge rates. The discharge structures are being designed as floatable structures to maintain a constant discharge rate and minimize the potential to clog with debris or sediment (see Appendix F). Floating debris would be removed at this time to prevent impacts to the annual operation of the facility. Any other problems that may occur within the facility would be detected and corrected at this time.

Water quality sampling of small-volume test discharges is proposed. By conducting this sampling, potential water quality problems can be detected and corrective measures taken prior to scheduled annual releases to the stream systems. Water quality data obtained from the test discharges will be compared to the stream characterization data to determine the potential for water quality violations. If any are indicated, the Port will take corrective action prior to the annual operation of the facility, such as installing portable aerators or additional filtration in the discharges prior to their entry into the streams.

Wherever possible, the Port will install automated dataloggers and/or autosamplers to collect flow data and water quality samples. This will allow the monitoring plan to be flexible if it is determined that samples or data need to be collected more or less frequently than proposed at this time. In addition, it may become possible to automate the operation of the Flow Impact Offset Facility. Valves can be automated to close or open based on signals from dataloggers, and other logic can be programmed into an electronic management system (for example, the valve can be programmed to open only during the low-streamflow period). These systems will be evaluated during final design of the facility.

Water quality sampling of the test discharges will include the following:

- Flow
- Turbidity
- Dissolved Oxygen (DO)
- Temperature
- Metals

5.1.3 Operational Monitoring

The Port is proposing to monitor the operation of the Flow Impact Offset Facility to provide assurance that the facility is achieving its performance goals and not causing any water quality violations in the receiving waters. This will be accomplished by periodic monitoring of both the discharge and receiving waters during the annual operation of the facility, both while the vaults are being filled during the rainy season and while the vaults are discharging through the reserved stormwater outlets. The monitoring proposal for the Flow Impact Offset Facility includes the following monitoring components: water levels within the stormwater vaults, flow, turbidity, DO, temperature, and metals. Additional information on these components is provided below.

5.1.3.1 Water Levels

Water levels within the stormwater vaults will be monitored through installation and operation of a pressure transducer and datalogger in each vault. Average daily water levels will be calculated based on more frequent measurements by the pressure transducer/logger. This data will then be applied to the vault geometry to calculate the volume of water in the stormwater vaults. In addition, vault filling and emptying (average daily water levels) will be monitored throughout the year.

5.1.3.2 Flow

Discharge from each vault will be measured upon opening of the Flow Impact Offset Facility outlets and measured a minimum of weekly throughout annual operation of the facility. In addition, stream gage data will be collected from the King County gages currently active in the Miller, Walker, and Des Moines Creek watersheds in the airport facility and downstream to the mouth of each stream. The Port will coordinate with King County to ensure that data from these gages will continue to be collected in the future.

5.1.3.3 Turbidity

Turbidity data will be taken at discharge points, upstream in receiving waters, and downstream in receiving waters (approximately 100 ft from where the discharges enter the streams). The turbidity measurements will be taken upon opening of Flow Impact Offset Facility outlets and taken a minimum of weekly throughout operation of the facility.

5.1.3.4 Dissolved Oxygen

Dissolved oxygen data will be taken at discharge points and approximately 100 ft downstream from where the discharges enter the streams. The DO measurements will be taken upon opening of Flow Impact Offset Facility outlets and taken a minimum of weekly throughout operation of the facility.

5.1.3.5 Temperature

Water temperature will be measured within the vaults, at discharge points, and in the receiving waters (streams). Temperature measurements within the vaults will be obtained using dataloggers that will provide average daily temperature throughout the year. Instream temperature measurements will be taken at the discharge points, upstream in receiving waters, and approximately 100 ft downstream from where discharges enter the streams. The field temperature measurements will be taken a minimum of weekly upon opening of Flow Impact Offset Facility outlets.

5.1.3.6 Metals

Samples will be analyzed for copper, lead, and zinc. The samples will be obtained from discharge points and receiving waters (approximately 100 ft downstream from where discharges enter the streams). The metals sampling and analysis will occur upon opening of Flow Impact Offset Facility outlets and a minimum of monthly throughout operation of the facility.

5.1.3.7 Schedule

Weekly monitoring of the discharges for the quality parameters (except metals) is proposed as a starting point for monitoring the Flow Impact Offset Facility. Once an adequate volume of data exists, an analysis will be completed on the variability of the water quality parameters, and sampling frequencies can be increased or decreased, as appropriate. Data collected during the pilot program will be included in this analysis. Because the facility will be discharging from a stored volume of water, the water quality of the discharges is not expected to change significantly, until runoff replenishes the vaults. In the event of a significant rainfall event during the operation of the facility (greater than 0.5 inches in a 24-hour period), the Port will conduct additional sampling to ensure that the rainfall did not substantially change the character of the water within the Flow Impact Offset Facility, which could potentially cause a violation of instream water quality standards. Monthly sampling for metals is sufficient because existing data shows that the metals concentrations in stormwater runoff from the airfield is relatively consistent and low compared to stormwater discharges from other urban areas.

5.1.3.8 Locations

Specific monitoring locations, both of the discharges and instream, will be consistent with the requirements of the Section 401 Water Quality Certification and will be precisely located and included in the final design of facilities associated with the Flow Impact Offset Facility. All water quality data will be recorded and reported in an annual monitoring report that will be submitted to Ecology by December 31 of each year. If the monitoring data show that the discharges from the Flow Impact Offset Facility consistently meet water quality standards within the receiving waters, the Port may propose a modified monitoring plan for subsequent operation of the facility. If any water quality problems were encountered during operation of the facilities, the annual report will include a discussion of the immediate actions taken to address the problem and actions taken or proposed to prevent a recurrence of the problem in the future. All sampling and analytical methods used to monitor the Flow Impact Offset Facility will conform to the latest revision of the *Guidelines Establishing Test Procedures for the Analysis of Pollutants* contained in 40 CFR Part 136 or to the latest revision of *Standard Methods for the Examination of Water and Wastewater* (American Public Health Association [APHA] et al. 1998). This will ensure that the monitoring methods for the Flow Impact Offset Facility are consistent with other water quality monitoring done under the NPDES permit for the airport.

5.2 BIOLOGICAL MONITORING

Instream biological monitoring will be performed in Miller, Walker, and Des Moines Creeks to assess the impacts of the Port's Flow Impact Offset Facility. The biological monitoring will consist of Benthic Index of Biotic Integrity (B-IBI) monitoring and physical habitat monitoring. Biological monitoring will occur four times per year and will continue through the fifth year after construction, then annually until completion of a 15-year monitoring period. During the years when monitoring is occurring four times per year, monitoring events will occur in January/February, April/May, June/July, and September/October. If monitoring indicates potential adverse effects, the Port will evaluate potential adaptive management strategies (see Section 5.4, Adaptive Management). The biological monitoring protocols are discussed in the following subsections.

5.2.1 B-IBI Sampling Protocol

5.2.1.1 Approach

A measure of biotic integrity will be used to evaluate the existing and future low-flow conditions of Des Moines, Miller, and Walker Creeks. The B-IBI for Puget Sound Lowlands (Kleindl 1995; Karr and Chu 1997) quantifies the overall biotic condition of a stream based on measured attributes of benthic macroinvertebrates compared to regional distributions. B-IBI scores have been shown to correlate well with levels of urbanization (Fore et al. 1996; Horner et al. 1996). This analysis was designed to analyze invertebrates collected in the fall (Kleindl 1995; Karr and Chu 1997) and will be used to assess the September/October samples. Invertebrates collected during the other monitoring periods will be assessed using several of the same metrics in the B-IBI, coupled with professional judgement, and will be compared to the fall B-IBI score. The protocol described below is from *Biological Monitoring and Assessment: Using Multimetric Indexes Effectively* (Karr and Chu 1997) and will be applied to samples collected throughout the year.

5.2.1.2 Field Equipment

The following field equipment will be used for the B-IBI monitoring:

- 500-micron mesh Surber type sampler
- 500-micron (or smaller) mesh sieve
- Flagged weight to identify sample location
- Ethyl alcohol (95%)
- Two 1-liter squirt bottles for alcohol
- Garden trowel or large spike to disturb substrate
- White bucket or white wash bin to empty sample from Surber
- Large cup with handle to rinse invertebrates off Surber
- Stop watch
- Forceps (tweezers)
- Plastic spatula
- Waterproof ("Rite-in-the-rain") paper
- Pencil, permanent marker (Sharpie), and grease pencil
- 250-ml screw-top jars (three per sample site)
- Ziploc bags

5.2.1.3 Site Selection

Sample sites will be selected that are representative of the larger study areas. This determination will be based on physiographic characteristics, including vegetation, soils, geology, land use, gradient, riparian characteristics, and substrate. For each representative stream reach, a riffle long enough to accommodate three replicate samples will be identified. Ideal sampling locations will consist of rocks 5 to 10 cm in diameter sitting on top of pebbles. Substrates dominated by rocks larger than 50 cm in diameter will be avoided.

To the extent possible, sample sites will not be located directly downstream from anomalies such as culverts, bridges, roads, landslides, or waterfalls (unless these are the conditions that the monitoring program is evaluating). In situations where an anomaly cannot be avoided, sampling will occur at least 50 meters upstream of a bridge and 200 meters downstream of a bridge. The location of each sample site will be recorded.

5.2.1.4 Data Management

During the B-IBI monitoring, site location data and site selection rationale will be recorded onto electronic datasheets. This information can be collected in a field notebook and recorded onto the B-IBI summary sheet later, or entered directly with the field computer.

5.2.1.5 Invertebrate Collection

Three total replicates will be taken from each sample location using the following methodology:

1. Sample within the main flow of the stream. To the extent possible, sample at water depths of 10 to 40 cm. Depending on low-flow conditions, the sampling may need to occur from shallower water depths. Depth, flow, and substrate type should be similar for the three replicate samples collected in the riffle. Begin sampling downstream and proceed upstream for the three replicates.

2. Place the Surber sampler on the selected spot with the opening of the nylon net facing upstream. Brace the frame and hold it firmly on the stream bottom.

3. Lift the larger rocks resting within the frame and brush off crawling or loosely attached organisms so that they drift into the net. After "cleaning" the rocks, inspect for invertebrates and discard from the sampling area.

4. Once the larger rocks are removed, disturb the substrate vigorously with a trowel or large spike for 60 seconds. This disturbance should extend to a depth of about 10 cm to loosen organisms in the interstitial spaces, washing them into the net.

5. Lift the Surber out of the water and tilt the net up and out of the water while keeping the open end upstream. This will help to wash the organisms into the receptacle. Drop a piece of weighted flagging tape to mark the location of the first replicate sample. Do not step on remaining sample areas while walking to the streambank.

6. On the streambank, empty contents of the Surber into large bucket or wash bin. Remove all animals and debris from the Surber sampler.

7. Separate benthic macroinvertebrates from the substrate by stirring the contents of the plastic wash pan. Pour floating organic matter into a 500-μm soil sieve, then transfer into a sampling jar and preserve with ethanol (95 percent). Residual water in the sample will dilute the ethanol to about 70 percent.

8. Repeat rinsing and pouring into the 500-μm soil sieve until all apparent animals are removed from gravel. Add a small amount of water to remaining gravel and set aside for a few moments. Remaining invertebrates will begin to move among the substrate. Use a magnifying glass and tweezers to remove the last animals and place directly into the sample jar.

9. One important note: the density of invertebrates within a riffle can be variable, and there may be times when a sample has low numbers of invertebrates. It is important that a sample have at least 500 individuals (Fore 1999 personal communication). This number will be

estimated in the field by looking at the density of invertebrates in the concentrated sample. If the density appears small, additional combined samples will be necessary.

Archive Sample

Insert a sample label that contains the name of the team, date, location, sample number, and replicate number into the jar. Fill the sample jar to the top with alcohol and seal. Write the location and date on top of the sample lid. Place the jar in a Ziploc bag labeled with the same information.

Collect Replicate Samples

Return to the location of the first sample, walk upstream, and collect another sample of invertebrates. Leave another flagged marker and process the sample as above. Repeat this process once more for a total of three replicate samples from each site location. Each replicate should be labeled (e.g., #1, #2, #3) and archived separately.

Taxonomy

Invertebrates will be identified to the highest possible taxonomic level by a professional invertebrate taxonomist.

5.2.1.6 Reporting

Information obtained from the B-IBI monitoring will be synthesized to evaluate potential impacts associated with operation of the Flow Impact Offset Facility. All B-IBI data will be recorded and reported in the annual monitoring report to be submitted to Ecology by December 31 of each year. If any negative impacts were encountered during operation of the facilities, the annual report will include a discussion of the immediate actions taken to address the problem, and actions taken or proposed to prevent a reoccurrence of the problem in the future.

5.2.2 Physical Habitat Monitoring Protocol

Physical habitat monitoring will be used to evaluate the existing and future low-flow conditions of Miller, Walker, and Des Moines Creeks. Protocols for the physical habitat monitoring are provided in Appendix G.

5.3 FILL MONITORING, INFILTRATION BMPS, AND INFILTRATION CONTINGENCY MEASURES

The hydrogeologic modeling by Hydrus and Slice described in Section 2.3 modeled the movement of precipitation that has infiltrated into the fill embankment. The properties of the fill (e.g., grain size distribution) largely control the amount of water that will infiltrate and water movement through the embankment. Additional factors include the methods of fill placement, final grading, and revegetation. The following section describes the monitoring plan for confirming infiltration properties of the in-place fill.

5.3.1 Existing Fill Quality Control Testing

The embankment construction specification (Specification P-152) establishes that proposed fill sources be tested for acceptance by the Port at least 30 days prior to the proposed use of the fill. Submittal requirements include the following tests, which must all be performed in accordance with American Society for Testing and Materials (ASTM) D 3740 (Minimum Requirements for Agencies Engaged in the Testing and/or Inspection of Soil and Rock as Used in Engineering Design and Construction):

- Sieve analysis and natural moisture content (ASTM C 136)
- Specific gravity (ASTM D 854 or C 127)
- Moisture/density relationship (ASTM D 1557)
- Plasticity index for Group 4 soils (ASTM D 4318)
- Environmental certification report
- Direct shear test for Group 5 soil (ASTM D 3080)

The data must be certified by a licensed geotechnical engineer ensuring that they accurately represent material from the source site. Use of the fill is subject to approval by a Port engineer (Specification P-152-2.1).

The density of in-place fill is tested in "lots" for approval of the lot by a Port engineer (a "lot" is 2000 tons of material in place) in accordance with ASTM D 1556, ASTM D 2167, or ASTM D 2922 (Specification P-152-2.3). In addition, every other lot of Group 1A must be tested by the contractor for fines content in accordance with ASTM C 136.

5.3.2 New Infiltration Capacity Testing Protocol for Fill

In addition to established quality control testing procedures for the fill, tests will be performed to evaluate infiltration capacity. The infiltration capacity measured in the field can be related to infiltration capacity assumptions used in embankment modeling. For modeling, infiltration capacity and hydraulic conductivity were assumed equal and the fill was characterized as a uniform mixture of two media: an inactive gravel fraction, and an active matrix through which unsaturated flow occurred (Pacific Groundwater Group 2001). If macro-pore flow is absent and entrapped air in the soil is minimal during field testing, the following equations define the relationship between bulk infiltration capacity measured in the field and modeled hydraulic conductivity of the fill matrix:

$$Ib = Im(1 - \%G)$$

and

$$Im = Km$$

where
Ib = bulk infiltration capacity measured in the field
Im = matrix infiltration capacity
%G = fraction of the fill that is gravel
Km = saturated hydraulic conductivity of the soil matrix, appropriate as input for modeling variably saturated flow

An important variable in the general water balance of the embankment is the infiltration capacity of the surficial soils. The general water balance is less sensitive to the character of soils buried within the embankment. Therefore, infiltration testing will only be performed when the embankment is nearing completion. It is assumed for purposes of these calculations that no "topsoil" or other distinct surficial layer will be placed on the embankment. If such a layer is decided upon in the future, the timing, locations, and depth of infiltration tests may require alteration from the protocol established below.

Infiltration testing will be performed upon substantial completion of the embankment, including establishment of the various zones (fill types) that will comprise the surface of the embankment. Up to eight locations on top of the new embankment fill will be selected by the Port based on the following criteria:

- Provide geographic coverage of pavement subgrade, pavement support, and common embankment zones of the new fill as shown in Figure 7 of the *Geotechnical Engineering Report, 404 Permit Support, Third Runway Embankment, Sea-Tac International Airport* (Hart Crowser 1999). Testing of the "MSE reinforcing" fill zone will not be performed.

- Remain safely away from air traffic operations.

- Remain safely away from utilities.

- Consider access for water trucks.

At each location, a modified Pilot Infiltration Test (PIT) described in the *Stormwater Management Manual for Western Washington* (Ecology 2001) will be performed. An area of at least 100 ft^2 will be accurately leveled and bermed to allow ponding of imported water (shallow excavations may be used). Turbidity-free water at ambient temperature will be metered into the basin and discharged onto a permeable geotextile to prevent disturbance of the soil surface. Initial ponding may be maintained at substantial depth but not to exceed 1 ft. After at least 17 hours of continuous ponding, the pond depth will be decreased by reduction of discharge to the minimum pond depth necessary to completely cover the basin bottom. The water discharge rate required to maintain a constant minimal ponding depth will be measured. When that water flow rate has not changed substantially over a duration of 1 hour, the test will be terminated. The following equation will be used to calculate bulk infiltration capacity using the test data (in consistent units):

$$Ib = \text{steady water flow rate} / \text{area of basin bottom}$$

For instance, if the steady water flow rate is 25 cf per hour into a basin of 100 ft^2, the infiltration capacity is 0.25 ft per hour (3 inches per hour or 2×10^{-3} cm/sec).

To support interpretation of the infiltration tests, orthogonal photographs of the basin bottoms will be taken with a visible scale. A large volume bulk soil sample will also be collected by digging into the basin bottom. The sample will be retained as a contingency should questions about the test arise. Data collection and reporting guidelines supplied in Ecology's PIT procedures will also be followed.

5.3.3 Fill Infiltration Performance Criterion

The infiltration capacity of the built embankment will be considered substantially lower than that used in modeling if the Km used in modeling (1.35×10^{-4} cm/sec) falls above the upper 95 percent confidence interval of the infiltration test population (the Km values, or a fitted population distribution, calculated from the infiltration test data). This approach will identify field conditions wherein the built embankment has an infiltration capacity substantially less than assumed in modeling.

No similar criterion will be applied to identify conditions wherein the built embankment has a substantially higher infiltration capacity than assumed for modeling. Reasons for this are: (1) the greater concern is building an embankment that infiltrates too little water, and (2) the proposed approach does not require correcting for macro-pore flow that will likely influence the field data.

5.3.4 Fill Infiltration BMPs

BMPs designed to promote infiltration into the embankment are described in the October 26, 2000 HNTB memorandum (Appendix C). The BMPs are limited to use of flatter slopes on the airfield, longer water courses over pervious surfaces, and use of a variety of naturally occurring fill materials. Other measures were deemed inappropriate because of increased risk of instability, construction complexity, and costs, and possible adverse impacts. The three acceptable BMPs are used in the current design of the embankment.

In addition to the three BMPs discussed in the attached memo, a polyacrylamide (PAM) tackifier has been, and will continue to be, used to reduce erosion of the embankment surfaces. A procedure for application of the PAM is attached. PAM has been shown to increase infiltration of irrigation water into soil as a result of stabilization of soil structure. Also, in a partial deviation from Specification P-152, truck traffic will be routed across a minimal area of the embankment upon placement of the final 2 ft of fill. This deviation will not affect the density specification required for engineering acceptance of the constructed fill.

If the measured infiltration capacity of the constructed embankment is substantially lower than used in modeling and anticipated by use of the above BMPs, implementation of contingency measures may be warranted, based on long-term monitoring data as described above.

5.3.5 Fill Infiltration Contingency Measures

Embankment modeling and infiltration testing are only proposed for the third runway fill. Therefore, the contingency measures outlined below are only applicable to the third runway fill.

If the infiltration capacity of the third runway fill is substantially lower than assumed for embankment modeling, the infiltration tests will be rerun after the establishment of vegetation. The post-vegetation tests will be conducted and interpreted in the same fashion as the pre-vegetation tests, except that flat areas will be bermed with soil for use as basins, and excavations will not be used. Vegetation will be maintained within the bermed areas while preparing the basins for testing.

If the post-vegetation infiltration capacity of the third runway fill appears substantially lower than assumed for embankment modeling, long-term monitoring data will be interpreted to allow the Port to adapt water management practices to the as-built condition. This approach is appropriate given the fact that infiltration capacity is only one of many variables involved in determining the as-built water budget, and responding solely to a changed condition in the infiltration capacity could be unnecessary or even misguided given other potential differences between predicted and as-built conditions. Collecting and responding to long-term monitoring data is preferable because it considers the aggregated effects of all factors. Long-term hydrologic and environmental monitoring is discussed in response to Condition I(e). Based on that monitoring, plans will be developed as necessary to respond to adverse conditions not mitigated by existing designs.

5.4 ADAPTIVE MANAGEMENT

The Flow Impact Offset Facility and its Operation and Maintenance Plan are being developed to facilitate an adaptive management strategy. Comprehensive programs are proposed to monitor the facility's performance, and changes to the facility or its operation will be made to meet the performance standards. Monitoring programs will address water quality, water quantity, fill parameters and infiltration performance, impacts to stream biology, and impacts to wetlands. Monitoring programs are discussed in Sections 5.1 and 5.2. Some potential adaptive management strategies are discussed below.

Water quality will be extensively monitored. The discharges from the reserved vaults will be monitored, as well as instream water quality in each stream. In addition, test discharges will be monitored prior to activation of the facility each year. If any instream water quality violations are detected, or if it is determined that the potential to cause an instream water quality violation exists, appropriate action will immediately be taken to correct the situation. Potential contingency actions include unscheduled maintenance of BMPs or the addition of other BMPs (filtration, mechanical aeration, etc.).

Water quantity will be monitored, including vault filling rates, discharge rates, and instream flow at gaging stations. Adaptive management strategies would include the development of modified schedules for vault filling, adjustment of the impervious areas that contribute to filling the reserved vaults, and adjustment of the discharge structures to maintain the target flow.

Tests will be conducted to evaluate infiltration capacity of the embankment fill. The measured infiltration will be compared to the infiltration assumptions used in the low-flow analysis (see Section 5.3). If the assumptions are not being met, potential adaptive management strategies include aeration (perforation) of infiltration surfaces, soil amendments, and regrading surfaces.

Wetlands and stream biology will be monitored during operation of the facility. If impacts are observed, potential adaptive management strategies include revising the operating schedule of the facility to optimize the timing and amount of discharge to the streams.

6. REFERENCES

Abbe, T.B. and D.R. Montgomery. 1996. Large woody debris jams, channel hydraulics and habitat formation in large rivers. Reguiated Rivers: Research & Management 12:201-221.

APHA (American Public Health Association), American Water Works Association, and Water Environmental Federation. 1998. Standard methods for the examination of water and wastewater. 20th edition.

Armantrout, N.B. (compiler). 1998. Glossary of aquatic habitat inventory terminology. American Fisheries Society, Bethesda, Maryland.

Bauer, S.B. and T.A. Burton. 1993. Monitoring protocols to evaluate water quality effects of grazing management on western rangeland streams. U.S. Environmental Protection Agency Region 10, Seattle, Washington.

Bovee, K.D. 1982. A guide to stream habitat analysis using the Instream Incremental Methodology. Instream Flow Information Paper 12, FWS/OBS-28/26, Co-operative Instream Flow Group, U.S. Fish and Wildlife Service, Office of Biological Service.

Collins, B.D., D.R. Montgomery, and A.D. Haas. 2001. Historic changes in the distribution and functions of large woody debris in Puget Lowland rivers. Submitted to Canadian Journal of Fisheries and Aquatic Science.

Earth Tech, Inc. 2000. Low streamflow analysis for Seattle-Tacoma Airport Master Plan Update. Prepared by Earth Tech for the Port of Seattle. Bellevue, Washington.

Ecology (Washington State Department of Ecology). 2001. Stormwater management manual for Western Washington.

EPA (U.S. Environmental Protection Agency). 1997. Hydrological Simulation Program – FORTRAN. Prepared by AQUA TERRA Consultants, Stockton, California. Prepared for Office of Surface Water, U.S. Geological Survey, Reston, Virginia.

Fore, L.S., J.R. Karr, and R. Wisseman. 1996. Assessing invertebrate responses to human activities: Evaluating alternative approaches. Journal of the North American Benthological Society 15(2):212-231.

Fore, L. 1999. Personal communication. Leska Fore – Statistical Design, Seattle, Washington.

Hart Crowser. 1999. Geotechnical engineering report, 404 permit support, third runway embankment, Sea-Tac International Airport. Prepared by Hart Crowser for the Port of Seattle.

Horner, R.R., D.B. Booth, A. Azous, and C.W. May. 1996. Watershed determinants of ecosystem functioning. Proceedings of an Engineering Foundation Conference. American Society of Civil Engineers, Snowbird, Utah.

Karr, J.R. and E.W. Chu. 1997. Biological monitoring and assessment: Using multimetric indexes effectively. University of Washington, Seattle, Washington.

Kleindl, W.J. 1995. A benthic index of biotic integrity for Puget Sound lowland streams, Washington, USA. M.S. Thesis, University of Washington, Seattle, Washington.

Lindsey, A.A., J.D. Barton Jr., and S.R. Miles. 1958. Field efficiencies of forest sampling methods. Ecology 39(3):428-444.

May, C.W., E.B. Welch, R.R. Horner, J.R. Karr, and B.W. Mar. 1997. Quality indices for urbanization effects in Puget Lowland streams. Report prepared for Washington Department of Ecology. Water Resources Series Technical Report No 154.

Pacific Groundwater Group. 2000. Sea-Tac runway fill hydrologic studies report. Prepared by Pacific Groundwater Group for Washington State Department of Ecology. Seattle, Washington.

Pacific Groundwater Group. 2001. Port of Seattle Sea-Tac third runway embankment fill modeling in support of low-streamflow analysis. Prepared by Pacific Groundwater Group for Port of Seattle. Seattle, Washington.

Parametrix, Inc. 2000a. Comprehensive stormwater management plan for Seattle-Tacoma International Airport Master Plan Update improvements. Prepared by Parametrix for the Port of Seattle. Kirkland, Washington.

Parametrix, Inc. 2000b. Natural resource mitigation plan for Seattle-Tacoma International Airport Master Plan Update improvements. Prepared by Parametrix for the Port of Seattle. Kirkland, Washington.

Parametrix, Inc. 2001a. Replacement pages for the comprehensive stormwater management plan for Seattle-Tacoma International Airport Master Plan Update improvements. Prepared by Parametrix for the Port of Seattle. Kirkland, Washington.

Parametrix, Inc. 2001b. Wetland functional assessment and impact analysis for Seattle-Tacoma International Airport Master Plan Update improvements. Prepared by Parametrix for the Port of Seattle. Kirkland, Washington.

Paustian, S.J. (editor) and 13 others. 1992. A channel type users guide for the Tongass National Forest, Southeast Alaska. USDA Forest Service, Alaska Region, R10 Technical Paper 26. 179 pp.

Platts, W.S., W.F. Megahan, and G.W. Minshall. 1983. Methods for evaluating stream, riparian, and biotic conditions. USDA Forest Service General Technical Report INT-GTR-188.

Port of Seattle. 2000a. Annual stormwater monitoring report for Seattle-Tacoma International Airport for the period July 1, 1999 through June 30, 2000.

Port of Seattle. 2000b. Examining the effects of runway deicing on dissolved oxygen in receiving waters: Results of the 1999-2000 winter season, Seattle-Tacoma International Airport. Volume 1.

Port of Seattle. 2001a. Low flow analysis, flow impact offset facility proposal, Seattle-Tacoma International Airport. Seattle, Washington.

Port of Seattle. 2001b. Annual stormwater monitoring report for Seattle-Tacoma International Airport for the period July 1, 2000 through June 30, 2001.

R2 Resources Consultants, CH2M Hill, and Shapiro and Associates. 2000. Tri-County urban issues ESA study: Guidance document. February 2000. Prepared for the Tri-County Urban Issues Advisory Committee, Bellevue, Washington.

Schuett-Hames, D., A. Pleas, L. Bullchild, and S. Hall (eds.). 1994. Ambient monitoring program manual. Timber-Fish-Wildlife, TFW-AM9-94-001. Northwest Indian Fisheries Commission, Olympia, Washington.

Simunek, J., M. Senjna, and M.T. van Genuchten. 1999. Hydrus/Meshgen-2D – Simulating water flow and solute transport in two-dimensional variably saturated media. Version 2.0. U.S. Salinity Laboratory, USDA/ARS. Distributed by International Groundwater Modeling Center.

USFS (United States Forest Service). 1999. Stream inventory handbook: Level I & II. USDA, Region 6, Version 9.9.

Wang, L., T.D. Simonson, and J. Lyons. 1996. Accuracy and precision of selected stream habitat estimates. North American Journal of Fisheries Management 16:340-347.

WDFW (Washington Department of Fish and Wildlife). 2000. Fish passage barrier and surface water diversion screening assessment and prioritization manual. WDFW Habitat Program Environmental Restoration Division: Salmonid Screening, Habitat Enhancement, and Restoration (SSHEAR) Section. Olympia, Washington.

WFPB (Washington Forest Practices Board). 1997. Standard Methodology for Conducting Watershed Analysis under Chapter 222-22 WAC. Version 4.0, November 1997. Washington Department of Natural Resources, Olympia, Washington.

Williams, R.W., R.M. Laramie, and J.J. Ames. 1975. A catalog of Washington streams and salmon utilization. Vol. 1. – Puget Sound. Washington Department of Fish and Wildlife, Olympia, Washington.

Appendix A

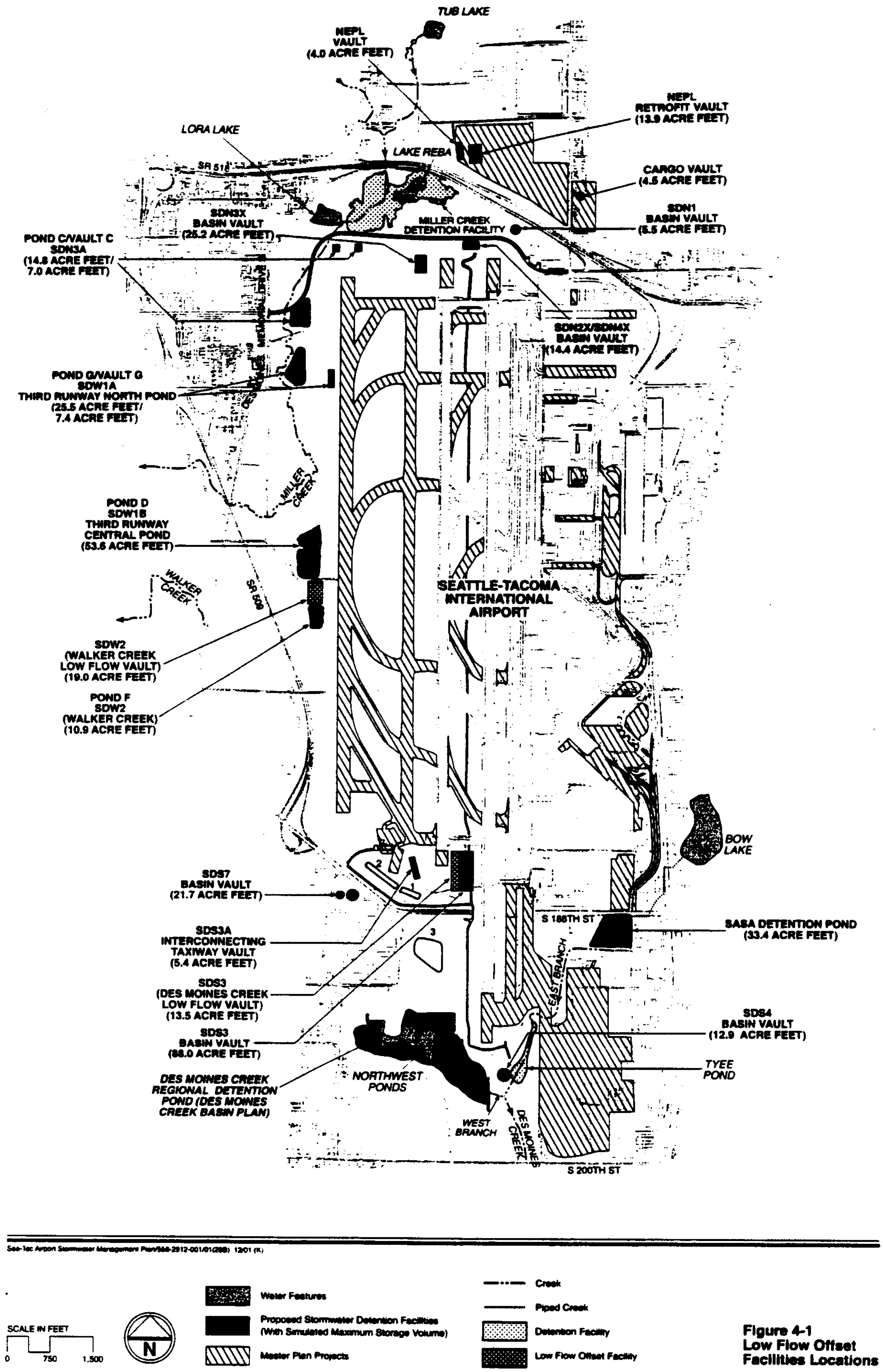
NOTE: **Appendix A–HSPF Modeling Information and Data–is contained in a separate volume.**

Table 4-1. Summary of Low Flow Impact Offset Facilities.

	SDW2	SDS3
General description		
Location	West central side of new runway	North of South 188th Street
System	Walker Creek	Des Moines Creek
Drawing number	C 131	C 141
Type	Underground, rectangular, concrete, single-compartment vault with high-level bypass pipe adjacent to pond F	Underground, rectangular, concrete, with two compartments: low-flow storage and short-term detention
Plan dimensions	Approximately 442 ft x 250 ft	Low-flow storage compartment, approximately 126 ft x 700 ft
Access	Approximately 40 10x10-ft access grates; 1 down ramp	Approximately 6 main access lids
Low-flow offset storage		
Type	Vault dedicated to low-flow offset storage	Low-flow storage compartment as part of overall structure
Volume	19.0 acre-ft[a]	13.5 acre-ft
Maximum water depth	8.0 ft	7.2 ft
Hydraulic features		
Inlet structure	Pipe from MH SDW2-9	Pipe from MH SDS3-592
Outlet structure	Low-level outlet pipe	Low-level outlet pipe
Outlet control	Valve	Valve
Outlet conveyance	Approximate 700-ft pipe	Pipe to MH SDS3-197
Discharge to stream	Adjacent to pond F outfall	SDS3 outfall
Water quality features		
Sediment trap	Sloped vault floor with internal dividing walls	Sloped vault floor with internal dividing walls
Aeration	Passive air flow through grates	Passive air flow through grates
Trash racks	(detail for construction)	(detail for construction)
Filters	Optional sand or filter media filter	Optional sand or filter media filter
Oil-water separators	(detail for construction)	(detail for construction)
Mechanical and Electrical		
Monitoring and alarms	(detail for construction)	(detail for construction)
Lighting	(detail for construction)	(detail for construction)
Washdown	(detail for construction)	(detail for construction)

[a] Analysis determined 18.5 acre-ft; concept design used 19.0 acre-ft.

AR 052727



Sea-Tac Airport Stormwater Management Plan/556-2912-001/01(28B) 12/01 (K)

Figure 4-1
Low Flow Offset Facilities Locations

AR 052728

Figure 4-2
Walker Creek Facilities – Annual Schedule

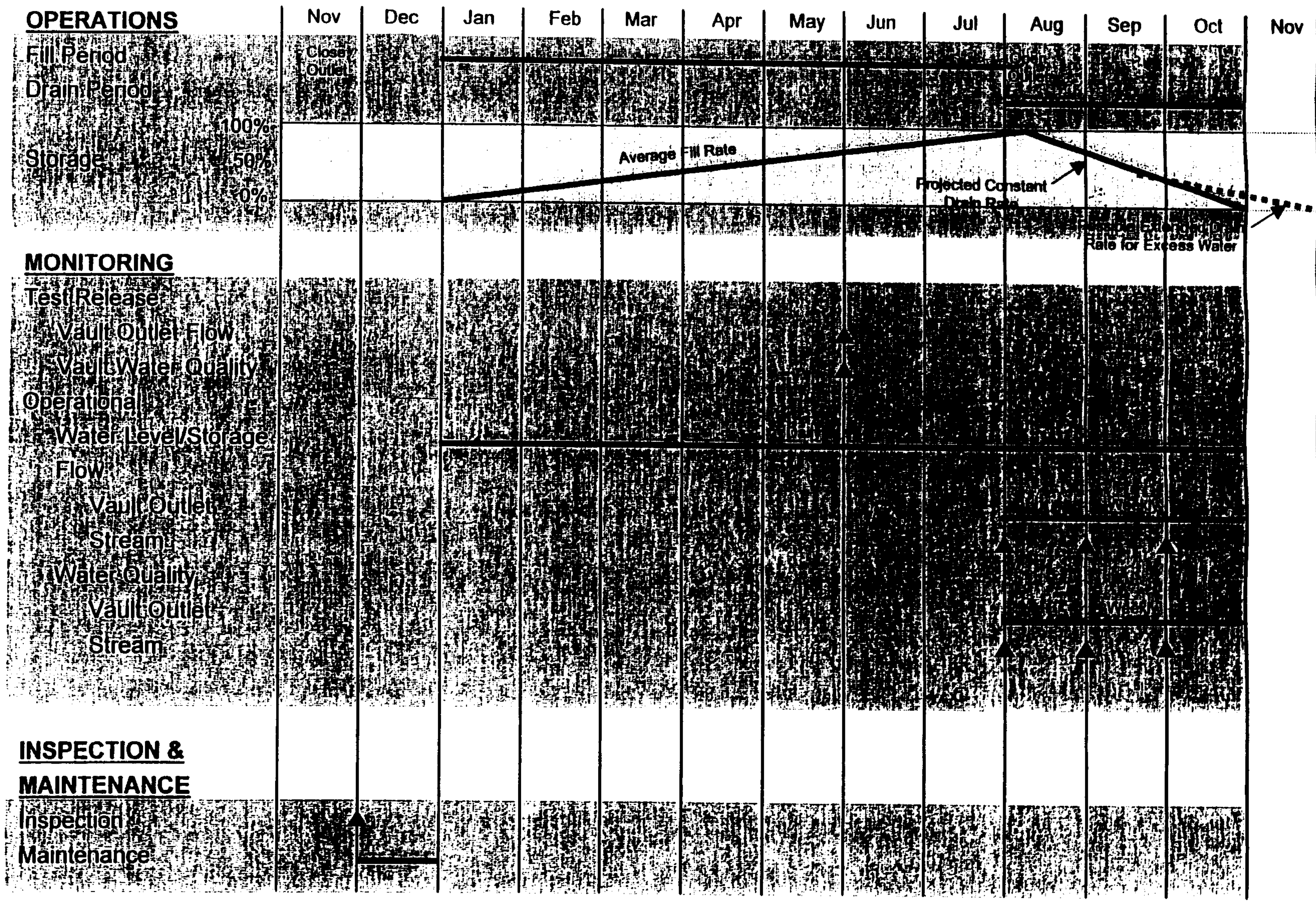
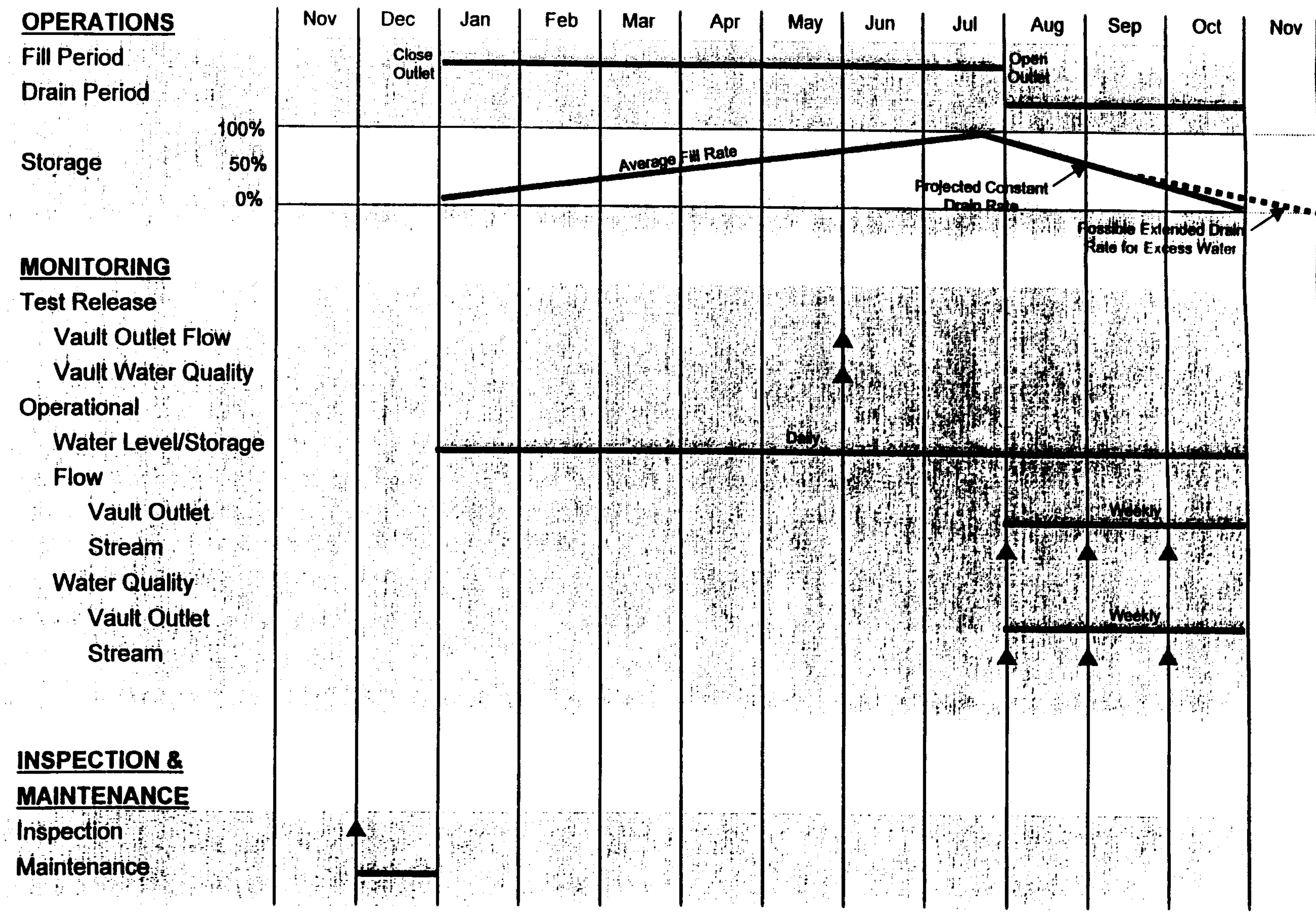


Figure 4-3
Des Moines Creek Facilities – Annual Schedule



AR 052730

Table 4-2. Summary of Low-Flow Vaults Operating Schedules

	Walker Creek	Des Moines Creek
Start Vault Filling	January 2	January 2
Open Outlet/Start Vault Draining	August 1	July 24
Summer Low-Flow Period Ends	October 31	October 24
Summer Low-Flow Period Release Rate	0.11 cfs	0.08 cfs

4.3.2 Facility-Specific Schedules

As operating experience is gained by the Port, the fill and release schedules for the vaults may be adjusted to allow for more effective system operation. Facility-specific schedules will be added to this Operation and Maintenance Plan as they are developed in the future.

4.4 INSPECTION AND MAINTENANCE

The objective of the inspection and maintenance program is to ensure the reliability and consistent performance of the Low Flow Impact Offset Facilities in providing water in sufficient quantity and quality to the streams. In addition, the program will help to extend the life of the facilities and reduce the overall life-cycle costs to the Port.

4.4.1 Procedures

Figure 4-4 conceptually illustrates the inspection and maintenance program. The sample form shown in Figure 4-5 lists typical vault components that will be inspected. An inspection and maintenance record form that is specific to each facility will be developed as final designs are completed.

Inspectors will evaluate their observations with standards to determine if maintenance is required. In many situations, it is expected that maintenance will be performed at the time of inspection. In other situations, when additional staff or equipment is necessary, a work order request will be prepared and the maintenance will be performed at a later date.

4.4.2 Sediment Removal

Sediment is expected to accumulate in the bottom of the facilities below the low-flow outlet. Oil, grease, and other types of debris may also accumulate with the sediment. Regular and proper removal of sediment and debris is critical to ensure that water stored in the vaults will be of satisfactory quality when it is discharged to the streams.

Depending on the facility's design and the quantity of sediment that has accumulated, sediment will be removed with vactor trucks, small front loaders, or manual tools. Washdown water may also be required. Regardless of the methods used, the low-flow outlet will be closed during the sediment removal process to prevent contaminated water from being discharged to the streams. The Port's existing decant facility shall be used for the disposal of all sediment and associated water that is removed from the vault during the sediment removal process.

Figure 4-4
Inspection and Maintenance Process Overview

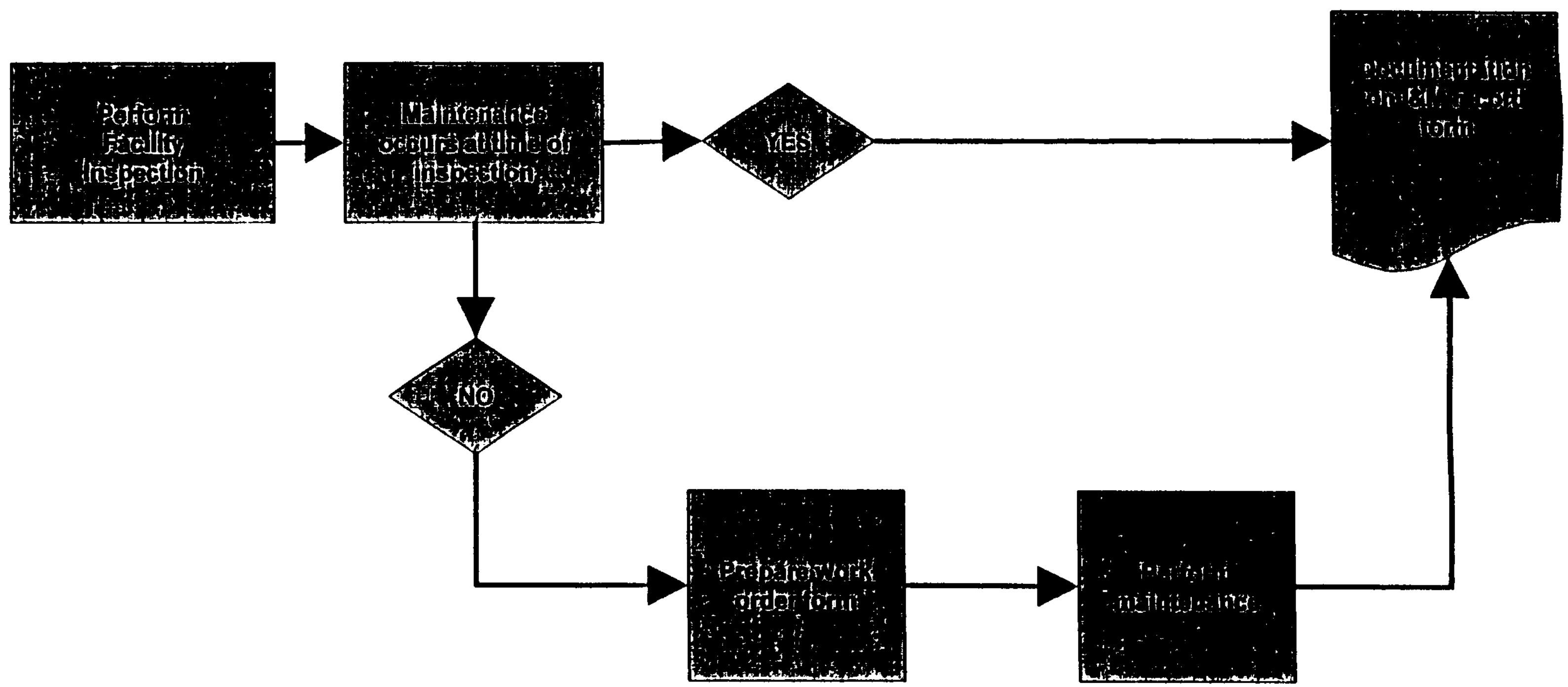


Figure 4-5

Inspection and Maintenance Record

Facility: __________

Inspection Date: __________

Inspector: __________

	Inspection		Maintenance	
Facility Component	**Observed Conditon**	**Required Maintenance**	**Performed By**	**Date**
Access				
Hatches				
Ladders				
Ramps				
Vents				
Hydraulics and Controls				
Outlet pipe				
Outlet valve				
Weir				
Water Quality Treatment				
Trash racks				
Filters				
Oil-water separators				
Sediment Level				
Electrical / Mechanical				
Lights				
Water level instrumentation				
Internal piping				

4.4.3 Schedule

Vault facilities are projected to contain water in varying amounts during the period from January through October for low-flow mitigation purposes. Therefore, in order to conduct inspection and maintenance activities in-the-dry, this work will need to occur during November and December of each year. Specifically, as shown by the schedules in Figures 4-2 and 4-3, inspections will be performed in early November, followed by maintenance activities as necessary through December.

4.4.4 Documentation

An inspection and maintenance record form shall be completed for each inspection at each vault facility.

4.4.5 Reporting

Inspection and maintenance activities shall be summarized in the Port's annual report to Ecology.

4.5 SAFETY

Accumulated sediment, stagnant water conditions, and limited ventilation are typical conditions in vaults and may cause noxious gases to form and accumulate in the vaults. Additional ventilation will be provided in the low-flow vaults. Vault inspection and maintenance procedures must be in compliance with OSHA confined-space entry requirements, which includes clearly marking entrances to confined-space areas.

5. MONITORING PLAN

5.1 WATER QUALITY AND FLOW MONITORING

The Port is proposing a comprehensive monitoring plan for the Flow Impact Offset Facility to ensure that the performance standards are met and that no violations of state water quality standards occur in the receiving waters, and to support an adaptive management strategy. Monitoring consists of three elements: characterization of existing/expected water quality, monitoring of annual test releases from the Flow Impact Offset Facility, and monitoring of the discharges and receiving waters during operation of the facility. Each element is discussed below.

5.1.1 Characterization of Existing/Expected Water Quality

A great deal of water quality data already exists on the Port's stormwater discharges and on the streams. This data has been collected for a variety of purposes, including satisfying the Port's NPDES permit requirements, basin planning activities, and other studies done in the area by the Port and others. The data set includes water quality measurements within the stream systems during the summer periods when the Flow Impact Offset Facility will be scheduled to discharge to the streams. In addition, the Port has started to collect data to characterize the discharges from the Flow Impact Offset Facility. Temperature data is being collected starting in 2001 from the existing NEPL vault and the SDS3A vault in order to characterize the expected temperatures of the Flow Impact Offset Facility. The NEPL vault is partially exposed to sunlight (on its west side and top), while the SDS3A vault is completely underground. By collecting temperature data from both vaults, a range of expected temperatures can be established for each type of vault (buried and partially exposed). Temperature data will be collected from the dead storage zone in each vault in order to approximate the Flow Impact Offset Facility. The Port has collected some instream temperature data beginning in September 2000. Other data that is being collected as part of other Port water quality studies will be used prior to the operation of the Flow Impact Offset Facility to characterize expected water quality within the streams during the summer months (when the facility will be discharging). All of this data will be analyzed and presented in the final design of the facilities associated with the Flow Impact Offset Facility.

5.1.2 Monitoring of Annual Test Releases from the Flow Impact Offset Facility

Each year, prior to the operation of the Flow Impact Offset Facility, the Port proposes to conduct small test discharges from each outlet. The test discharges are intended to confirm the operation of each discharge and to detect and respond to potential problems prior to the annual operation of the Flow Impact Offset Facility. For example, because of the small orifices needed to control discharges to the required rate, a small amount of debris in an orifice could potentially impact the discharge rates. The discharge structures are being designed as floatable structures to maintain a constant discharge rate and minimize the potential to clog with debris or sediment (see Appendix F). Floating debris would be removed at this time to prevent impacts to the annual operation of the facility. Any other problems that may occur within the facility would be detected and corrected at this time.

Water quality sampling of small-volume test discharges is proposed. By conducting this sampling, potential water quality problems can be detected and corrective measures taken prior to scheduled annual releases to the stream systems. Water quality data obtained from the test discharges will be compared to the stream characterization data to determine the potential for water quality violations. If any are indicated, the Port will take corrective action prior to the annual operation of the facility, such as installing portable aerators or additional filtration in the discharges prior to their entry into the streams.

Wherever possible, the Port will install automated dataloggers and/or autosamplers to collect flow data and water quality samples. This will allow the monitoring plan to be flexible if it is determined that samples or data need to be collected more or less frequently than proposed at this time. In addition, it may become possible to automate the operation of the Flow Impact Offset Facility. Valves can be automated to close or open based on signals from dataloggers, and other logic can be programmed into an electronic management system (for example, the valve can be programmed to open only during the low-streamflow period). These systems will be evaluated during final design of the facility.

Water quality sampling of the test discharges will include the following:

- Flow
- Turbidity
- Dissolved Oxygen (DO)
- Temperature
- Metals

5.1.3 <u>Operational Monitoring</u>

The Port is proposing to monitor the operation of the Flow Impact Offset Facility to provide assurance that the facility is achieving its performance goals and not causing any water quality violations in the receiving waters. This will be accomplished by periodic monitoring of both the discharge and receiving waters during the annual operation of the facility, both while the vaults are being filled during the rainy season and while the vaults are discharging through the reserved stormwater outlets. The monitoring proposal for the Flow Impact Offset Facility includes the following monitoring components: water levels within the stormwater vaults, flow, turbidity, DO, temperature, and metals. Additional information on these components is provided below.

5.1.3.1 Water Levels

Water levels within the stormwater vaults will be monitored through installation and operation of a pressure transducer and datalogger in each vault. Average daily water levels will be calculated based on more frequent measurements by the pressure transducer/logger. This data will then be applied to the vault geometry to calculate the volume of water in the stormwater vaults. In addition, vault filling and emptying (average daily water levels) will be monitored throughout the year.

5.1.3.2 Flow

Discharge from each vault will be measured upon opening of the Flow Impact Offset Facility outlets and measured a minimum of weekly throughout annual operation of the facility. In addition, stream gage data will be collected from the King County gages currently active in the Miller, Walker, and Des Moines Creek watersheds in the airport facility and downstream to the mouth of each stream. The Port will coordinate with King County to ensure that data from these gages will continue to be collected in the future.

5.1.3.3 Turbidity

Turbidity data will be taken at discharge points, upstream in receiving waters, and downstream in receiving waters (approximately 100 ft from where the discharges enter the streams). The turbidity measurements will be taken upon opening of Flow Impact Offset Facility outlets and taken a minimum of weekly throughout operation of the facility.

5.1.3.4 Dissolved Oxygen

Dissolved oxygen data will be taken at discharge points and approximately 100 ft downstream from where the discharges enter the streams. The DO measurements will be taken upon opening of Flow Impact Offset Facility outlets and taken a minimum of weekly throughout operation of the facility.

5.1.3.5 Temperature

Water temperature will be measured within the vaults, at discharge points, and in the receiving waters (streams). Temperature measurements within the vaults will be obtained using dataloggers that will provide average daily temperature throughout the year. Instream temperature measurements will be taken at the discharge points, upstream in receiving waters, and approximately 100 ft downstream from where discharges enter the streams. The field temperature measurements will be taken a minimum of weekly upon opening of Flow Impact Offset Facility outlets.

5.1.3.6 Metals

Samples will be analyzed for copper, lead, and zinc. The samples will be obtained from discharge points and receiving waters (approximately 100 ft downstream from where discharges enter the streams). The metals sampling and analysis will occur upon opening of Flow Impact Offset Facility outlets and a minimum of monthly throughout operation of the facility.

5.1.3.7 Schedule

Weekly monitoring of the discharges for the quality parameters (except metals) is proposed as a starting point for monitoring the Flow Impact Offset Facility. Once an adequate volume of data exists, an analysis will be completed on the variability of the water quality parameters, and sampling frequencies can be increased or decreased, as appropriate. Data collected during the pilot program will be included in this analysis. Because the facility will be discharging from a stored volume of water, the water quality of the discharges is not expected to change significantly, until runoff replenishes the vaults. In the event of a significant rainfall event during the operation of the facility (greater than 0.5 inches in a 24-hour period), the Port will conduct additional sampling to ensure that the rainfall did not substantially change the character of the water within the Flow Impact Offset Facility, which could potentially cause a violation of instream water quality standards. Monthly sampling for metals is sufficient because existing data shows that the metals concentrations in stormwater runoff from the airfield is relatively consistent and low compared to stormwater discharges from other urban areas.

5.1.3.8 Locations

Specific monitoring locations, both of the discharges and instream, will be consistent with the requirements of the Section 401 Water Quality Certification and will be precisely located and included in the final design of facilities associated with the Flow Impact Offset Facility. All water quality data will be recorded and reported in an annual monitoring report that will be submitted to Ecology by December 31 of each year. If the monitoring data show that the discharges from the Flow Impact Offset Facility consistently meet water quality standards within the receiving waters, the Port may propose a modified monitoring plan for subsequent operation of the facility. If any water quality problems were encountered during operation of the facilities, the annual report will include a discussion of the immediate actions taken to address the problem and actions taken or proposed to prevent a recurrence of the problem in the future. All sampling and analytical methods used to monitor the Flow Impact Offset Facility will conform to the latest revision of the *Guidelines Establishing Test Procedures for the Analysis of Pollutants* contained in 40 CFR Part 136 or to the latest revision of *Standard Methods for the Examination of Water and Wastewater* (American Public Health Association [APHA] et al. 1998). This will ensure that the monitoring methods for the Flow Impact Offset Facility are consistent with other water quality monitoring done under the NPDES permit for the airport.

5.2 BIOLOGICAL MONITORING

Instream biological monitoring will be performed in Miller, Walker, and Des Moines Creeks to assess the impacts of the Port's Flow Impact Offset Facility. The biological monitoring will consist of Benthic Index of Biotic Integrity (B-IBI) monitoring and physical habitat monitoring. Biological monitoring will occur four times per year and will continue through the fifth year after construction, then annually until completion of a 15-year monitoring period. During the years when monitoring is occurring four times per year, monitoring events will occur in January/February, April/May, June/July, and September/October. If monitoring indicates potential adverse effects, the Port will evaluate potential adaptive management strategies (see Section 5.4, Adaptive Management). The biological monitoring protocols are discussed in the following subsections.

5.2.1 <u>B-IBI Sampling Protocol</u>

5.2.1.1 Approach

A measure of biotic integrity will be used to evaluate the existing and future low-flow conditions of Des Moines, Miller, and Walker Creeks. The B-IBI for Puget Sound Lowlands (Kleindl 1995; Karr and Chu 1997) quantifies the overall biotic condition of a stream based on measured attributes of benthic macroinvertebrates compared to regional distributions. B-IBI scores have been shown to correlate well with levels of urbanization (Fore et al. 1996; Horner et al. 1996). This analysis was designed to analyze invertebrates collected in the fall (Kleindl 1995; Karr and Chu 1997) and will be used to assess the September/October samples. Invertebrates collected during the other monitoring periods will be assessed using several of the same metrics in the B-IBI, coupled with professional judgement, and will be compared to the fall B-IBI score. The protocol described below is from *Biological Monitoring and Assessment: Using Multimetric Indexes Effectively* (Karr and Chu 1997) and will be applied to samples collected throughout the year.

5.2.1.2 Field Equipment

The following field equipment will be used for the B-IBI monitoring:

- 500-micron mesh Surber type sampler
- 500-micron (or smaller) mesh sieve
- Flagged weight to identify sample location
- Ethyl alcohol (95%)
- Two 1-liter squirt bottles for alcohol
- Garden trowel or large spike to disturb substrate
- White bucket or white wash bin to empty sample from Surber
- Large cup with handle to rinse invertebrates off Surber
- Stop watch
- Forceps (tweezers)
- Plastic spatula
- Waterproof ("Rite-in-the-rain") paper
- Pencil, permanent marker (Sharpie), and grease pencil
- 250-ml screw-top jars (three per sample site)
- Ziploc bags

5.2.1.3 Site Selection

Sample sites will be selected that are representative of the larger study areas. This determination will be based on physiographic characteristics, including vegetation, soils, geology, land use, gradient, riparian characteristics, and substrate. For each representative stream reach, a riffle long enough to accommodate three replicate samples will be identified. Ideal sampling locations will consist of rocks 5 to 10 cm in diameter sitting on top of pebbles. Substrates dominated by rocks larger than 50 cm in diameter will be avoided.

To the extent possible, sample sites will not be located directly downstream from anomalies such as culverts, bridges, roads, landslides, or waterfalls (unless these are the conditions that the monitoring program is evaluating). In situations where an anomaly cannot be avoided, sampling will occur at least 50 meters upstream of a bridge and 200 meters downstream of a bridge. The location of each sample site will be recorded.

5.2.1.4 Data Management

During the B-IBI monitoring, site location data and site selection rationale will be recorded onto electronic datasheets. This information can be collected in a field notebook and recorded onto the B-IBI summary sheet later, or entered directly with the field computer.

5.2.1.5 Invertebrate Collection

Three total replicates will be taken from each sample location using the following methodology:

1. Sample within the main flow of the stream. To the extent possible, sample at water depths of 10 to 40 cm. Depending on low-flow conditions, the sampling may need to occur from shallower water depths. Depth, flow, and substrate type should be similar for the three replicate samples collected in the riffle. Begin sampling downstream and proceed upstream for the three replicates.

2. Place the Surber sampler on the selected spot with the opening of the nylon net facing upstream. Brace the frame and hold it firmly on the stream bottom.

3. Lift the larger rocks resting within the frame and brush off crawling or loosely attached organisms so that they drift into the net. After "cleaning" the rocks, inspect for invertebrates and discard from the sampling area.

4. Once the larger rocks are removed, disturb the substrate vigorously with a trowel or large spike for 60 seconds. This disturbance should extend to a depth of about 10 cm to loosen organisms in the interstitial spaces, washing them into the net.

5. Lift the Surber out of the water and tilt the net up and out of the water while keeping the open end upstream. This will help to wash the organisms into the receptacle. Drop a piece of weighted flagging tape to mark the location of the first replicate sample. Do not step on remaining sample areas while walking to the streambank.

6. On the streambank, empty contents of the Surber into large bucket or wash bin. Remove all animals and debris from the Surber sampler.

7. Separate benthic macroinvertebrates from the substrate by stirring the contents of the plastic wash pan. Pour floating organic matter into a 500-μm soil sieve, then transfer into a sampling jar and preserve with ethanol (95 percent). Residual water in the sample will dilute the ethanol to about 70 percent.

8. Repeat rinsing and pouring into the 500-μm soil sieve until all apparent animals are removed from gravel. Add a small amount of water to remaining gravel and set aside for a few moments. Remaining invertebrates will begin to move among the substrate. Use a magnifying glass and tweezers to remove the last animals and place directly into the sample jar.

9. One important note: the density of invertebrates within a riffle can be variable, and there may be times when a sample has low numbers of invertebrates. It is important that a sample have at least 500 individuals (Fore 1999 personal communication). This number will be

estimated in the field by looking at the density of invertebrates in the concentrated sample. If the density appears small, additional combined samples will be necessary.

Archive Sample

Insert a sample label that contains the name of the team, date, location, sample number, and replicate number into the jar. Fill the sample jar to the top with alcohol and seal. Write the location and date on top of the sample lid. Place the jar in a Ziploc bag labeled with the same information.

Collect Replicate Samples

Return to the location of the first sample, walk upstream, and collect another sample of invertebrates. Leave another flagged marker and process the sample as above. Repeat this process once more for a total of three replicate samples from each site location. Each replicate should be labeled (e.g., #1, #2, #3) and archived separately.

Taxonomy

Invertebrates will be identified to the highest possible taxonomic level by a professional invertebrate taxonomist.

5.2.1.6 Reporting

Information obtained from the B-IBI monitoring will be synthesized to evaluate potential impacts associated with operation of the Flow Impact Offset Facility. All B-IBI data will be recorded and reported in the annual monitoring report to be submitted to Ecology by December 31 of each year. If any negative impacts were encountered during operation of the facilities, the annual report will include a discussion of the immediate actions taken to address the problem, and actions taken or proposed to prevent a reoccurrence of the problem in the future.

5.2.2 Physical Habitat Monitoring Protocol

Physical habitat monitoring will be used to evaluate the existing and future low-flow conditions of Miller, Walker, and Des Moines Creeks. Protocols for the physical habitat monitoring are provided in Appendix G.

5.3 FILL MONITORING, INFILTRATION BMPS, AND INFILTRATION CONTINGENCY MEASURES

The hydrogeologic modeling by Hydrus and Slice described in Section 2.3 modeled the movement of precipitation that has infiltrated into the fill embankment. The properties of the fill (e.g., grain size distribution) largely control the amount of water that will infiltrate and water movement through the embankment. Additional factors include the methods of fill placement, final grading, and revegetation. The following section describes the monitoring plan for confirming infiltration properties of the in-place fill.

5.3.1 Existing Fill Quality Control Testing

The embankment construction specification (Specification P-152) establishes that proposed fill sources be tested for acceptance by the Port at least 30 days prior to the proposed use of the fill. Submittal requirements include the following tests, which must all be performed in accordance with American Society for Testing and Materials (ASTM) D 3740 (Minimum Requirements for Agencies Engaged in the Testing and/or Inspection of Soil and Rock as Used in Engineering Design and Construction):

- Sieve analysis and natural moisture content (ASTM C 136)
- Specific gravity (ASTM D 854 or C 127)
- Moisture/density relationship (ASTM D 1557)
- Plasticity index for Group 4 soils (ASTM D 4318)
- Environmental certification report
- Direct shear test for Group 5 soil (ASTM D 3080)

The data must be certified by a licensed geotechnical engineer ensuring that they accurately represent material from the source site. Use of the fill is subject to approval by a Port engineer (Specification P-152-2.1).

The density of in-place fill is tested in "lots" for approval of the lot by a Port engineer (a "lot" is 2000 tons of material in place) in accordance with ASTM D 1556, ASTM D 2167, or ASTM D 2922 (Specification P-152-2.3). In addition, every other lot of Group 1A must be tested by the contractor for fines content in accordance with ASTM C 136.

5.3.2 New Infiltration Capacity Testing Protocol for Fill

In addition to established quality control testing procedures for the fill, tests will be performed to evaluate infiltration capacity. The infiltration capacity measured in the field can be related to infiltration capacity assumptions used in embankment modeling. For modeling, infiltration capacity and hydraulic conductivity were assumed equal and the fill was characterized as a uniform mixture of two media: an inactive gravel fraction, and an active matrix through which unsaturated flow occurred (Pacific Groundwater Group 2001). If macro-pore flow is absent and entrapped air in the soil is minimal during field testing, the following equations define the relationship between bulk infiltration capacity measured in the field and modeled hydraulic conductivity of the fill matrix:

$$Ib = Im(1\text{-}\%G)$$

and

$$Im = Km$$

where

Ib = bulk infiltration capacity measured in the field
Im = matrix infiltration capacity
%G = fraction of the fill that is gravel
Km = saturated hydraulic conductivity of the soil matrix, appropriate as input for modeling variably saturated flow

An important variable in the general water balance of the embankment is the infiltration capacity of the surficial soils. The general water balance is less sensitive to the character of soils buried within the embankment. Therefore, infiltration testing will only be performed when the embankment is nearing completion. It is assumed for purposes of these calculations that no "topsoil" or other distinct surficial layer will be placed on the embankment. If such a layer is decided upon in the future, the timing, locations, and depth of infiltration tests may require alteration from the protocol established below.

Infiltration testing will be performed upon substantial completion of the embankment, including establishment of the various zones (fill types) that will comprise the surface of the embankment. Up to eight locations on top of the new embankment fill will be selected by the Port based on the following criteria:

- Provide geographic coverage of pavement subgrade, pavement support, and common embankment zones of the new fill as shown in Figure 7 of the *Geotechnical Engineering Report, 404 Permit Support, Third Runway Embankment, Sea-Tac International Airport* (Hart Crowser 1999). Testing of the "MSE reinforcing" fill zone will not be performed.

- Remain safely away from air traffic operations.

- Remain safely away from utilities.

- Consider access for water trucks.

At each location, a modified Pilot Infiltration Test (PIT) described in the *Stormwater Management Manual for Western Washington* (Ecology 2001) will be performed. An area of at least 100 ft^2 will be accurately leveled and bermed to allow ponding of imported water (shallow excavations may be used). Turbidity-free water at ambient temperature will be metered into the basin and discharged onto a permeable geotextile to prevent disturbance of the soil surface. Initial ponding may be maintained at substantial depth but not to exceed 1 ft. After at least 17 hours of continuous ponding, the pond depth will be decreased by reduction of discharge to the minimum pond depth necessary to completely cover the basin bottom. The water discharge rate required to maintain a constant minimal ponding depth will be measured. When that water flow rate has not changed substantially over a duration of 1 hour, the test will be terminated. The following equation will be used to calculate bulk infiltration capacity using the test data (in consistent units):

Ib = steady water flow rate / area of basin bottom

For instance, if the steady water flow rate is 25 cf per hour into a basin of 100 ft^2, the infiltration capacity is 0.25 ft per hour (3 inches per hour or 2×10^{-3} cm/sec).

To support interpretation of the infiltration tests, orthogonal photographs of the basin bottoms will be taken with a visible scale. A large volume bulk soil sample will also be collected by digging into the basin bottom. The sample will be retained as a contingency should questions about the test arise. Data collection and reporting guidelines supplied in Ecology's PIT procedures will also be followed.

5.3.3 Fill Infiltration Performance Criterion

The infiltration capacity of the built embankment will be considered substantially lower than that used in modeling if the Km used in modeling (1.35×10^{-4} cm/sec) falls above the upper 95 percent confidence interval of the infiltration test population (the Km values, or a fitted population distribution, calculated from the infiltration test data). This approach will identify field conditions wherein the built embankment has an infiltration capacity substantially less than assumed in modeling.

No similar criterion will be applied to identify conditions wherein the built embankment has a substantially higher infiltration capacity than assumed for modeling. Reasons for this are: (1) the greater concern is building an embankment that infiltrates too little water, and (2) the proposed approach does not require correcting for macro-pore flow that will likely influence the field data.

5.3.4 Fill Infiltration BMPs

BMPs designed to promote infiltration into the embankment are described in the October 26, 2000 HNTB memorandum (Appendix C). The BMPs are limited to use of flatter slopes on the airfield, longer water courses over pervious surfaces, and use of a variety of naturally occurring fill materials. Other measures were deemed inappropriate because of increased risk of instability, construction complexity, and costs, and possible adverse impacts. The three acceptable BMPs are used in the current design of the embankment.

In addition to the three BMPs discussed in the attached memo, a polyacrylamide (PAM) tackifier has been, and will continue to be, used to reduce erosion of the embankment surfaces. A procedure for application of the PAM is attached. PAM has been shown to increase infiltration of irrigation water into soil as a result of stabilization of soil structure. Also, in a partial deviation from Specification P-152, truck traffic will be routed across a minimal area of the embankment upon placement of the final 2 ft of fill. This deviation will not affect the density specification required for engineering acceptance of the constructed fill.

If the measured infiltration capacity of the constructed embankment is substantially lower than used in modeling and anticipated by use of the above BMPs, implementation of contingency measures may be warranted, based on long-term monitoring data as described above.

5.3.5 Fill Infiltration Contingency Measures

Embankment modeling and infiltration testing are only proposed for the third runway fill. Therefore, the contingency measures outlined below are only applicable to the third runway fill.

If the infiltration capacity of the third runway fill is substantially lower than assumed for embankment modeling, the infiltration tests will be rerun after the establishment of vegetation. The post-vegetation tests will be conducted and interpreted in the same fashion as the pre-vegetation tests, except that flat areas will be bermed with soil for use as basins, and excavations will not be used. Vegetation will be maintained within the bermed areas while preparing the basins for testing.

If the post-vegetation infiltration capacity of the third runway fill appears substantially lower than assumed for embankment modeling, long-term monitoring data will be interpreted to allow the Port to adapt water management practices to the as-built condition. This approach is appropriate given the fact that infiltration capacity is only one of many variables involved in determining the as-built water budget, and responding solely to a changed condition in the infiltration capacity could be unnecessary or even misguided given other potential differences between predicted and as-built conditions. Collecting and responding to long-term monitoring data is preferable because it considers the aggregated effects of all factors. Long-term hydrologic and environmental monitoring is discussed in response to Condition I(e). Based on that monitoring, plans will be developed as necessary to respond to adverse conditions not mitigated by existing designs.

5.4 ADAPTIVE MANAGEMENT

The Flow Impact Offset Facility and its Operation and Maintenance Plan are being developed to facilitate an adaptive management strategy. Comprehensive programs are proposed to monitor the facility's performance, and changes to the facility or its operation will be made to meet the performance standards. Monitoring programs will address water quality, water quantity, fill parameters and infiltration performance, impacts to stream biology, and impacts to wetlands. Monitoring programs are discussed in Sections 5.1 and 5.2. Some potential adaptive management strategies are discussed below.

Water quality will be extensively monitored. The discharges from the reserved vaults will be monitored, as well as instream water quality in each stream. In addition, test discharges will be monitored prior to activation of the facility each year. If any instream water quality violations are detected, or if it is determined that the potential to cause an instream water quality violation exists, appropriate action will immediately be taken to correct the situation. Potential contingency actions include unscheduled maintenance of BMPs or the addition of other BMPs (filtration, mechanical aeration, etc.).

Water quantity will be monitored, including vault filling rates, discharge rates, and instream flow at gaging stations. Adaptive management strategies would include the development of modified schedules for vault filling, adjustment of the impervious areas that contribute to filling the reserved vaults, and adjustment of the discharge structures to maintain the target flow.

Tests will be conducted to evaluate infiltration capacity of the embankment fill. The measured infiltration will be compared to the infiltration assumptions used in the low-flow analysis (see Section 5.3). If the assumptions are not being met, potential adaptive management strategies include aeration (perforation) of infiltration surfaces, soil amendments, and regrading surfaces.

Wetlands and stream biology will be monitored during operation of the facility. If impacts are observed, potential adaptive management strategies include revising the operating schedule of the facility to optimize the timing and amount of discharge to the streams.

6. REFERENCES

Abbe, T.B. and D.R. Montgomery. 1996. Large woody debris jams, channel hydraulics and habitat formation in large rivers. Regulated Rivers: Research & Management 12:201-221.

APHA (American Public Health Association), American Water Works Association, and Water Environmental Federation. 1998. Standard methods for the examination of water and wastewater. 20th edition.

Armantrout, N.B. (compiler). 1998. Glossary of aquatic habitat inventory terminology. American Fisheries Society, Bethesda, Maryland.

Bauer, S.B. and T.A. Burton. 1993. Monitoring protocols to evaluate water quality effects of grazing management on western rangeland streams. U.S. Environmental Protection Agency Region 10, Seattle, Washington.

Bovee, K.D. 1982. A guide to stream habitat analysis using the Instream Incremental Methodology. Instream Flow Information Paper 12, FWS/OBS-28/26, Co-operative Instream Flow Group, U.S. Fish and Wildlife Service, Office of Biological Service.

Collins, B.D., D.R. Montgomery, and A.D. Haas. 2001. Historic changes in the distribution and functions of large woody debris in Puget Lowland rivers. Submitted to Canadian Journal of Fisheries and Aquatic Science.

Earth Tech, Inc. 2000. Low streamflow analysis for Seattle-Tacoma Airport Master Plan Update. Prepared by Earth Tech for the Port of Seattle. Bellevue, Washington.

Ecology (Washington State Department of Ecology). 2001. Stormwater management manual for Western Washington.

EPA (U.S. Environmental Protection Agency). 1997. Hydrological Simulation Program – FORTRAN. Prepared by AQUA TERRA Consultants, Stockton, California. Prepared for Office of Surface Water, U.S. Geological Survey, Reston, Virginia.

Fore, L.S., J.R. Karr, and R. Wisseman. 1996. Assessing invertebrate responses to human activities: Evaluating alternative approaches. Journal of the North American Benthological Society 15(2):212-231.

Fore, L. 1999. Personal communication. Leska Fore – Statistical Design, Seattle, Washington.

Hart Crowser. 1999. Geotechnical engineering report, 404 permit support, third runway embankment, Sea-Tac International Airport. Prepared by Hart Crowser for the Port of Seattle.

Horner, R.R., D.B. Booth, A. Azous, and C.W. May. 1996. Watershed determinants of ecosystem functioning. Proceedings of an Engineering Foundation Conference. American Society of Civil Engineers, Snowbird, Utah.

Karr, J.R. and E.W. Chu. 1997. Biological monitoring and assessment: Using multimetric indexes effectively. University of Washington, Seattle, Washington.

Kleindl, W.J. 1995. A benthic index of biotic integrity for Puget Sound lowland streams, Washington, USA. M.S. Thesis, University of Washington, Seattle, Washington.

Lindsey, A.A., J.D. Barton Jr., and S.R. Miles. 1958. Field efficiencies of forest sampling methods. Ecology 39(3):428-444.

May, C.W., E.B. Welch, R.R. Horner, J.R. Karr, and B.W. Mar. 1997. Quality indices for urbanization effects in Puget Lowland streams. Report prepared for Washington Department of Ecology. Water Resources Series Technical Report No 154.

Pacific Groundwater Group. 2000. Sea-Tac runway fill hydrologic studies report. Prepared by Pacific Groundwater Group for Washington State Department of Ecology. Seattle, Washington.

Pacific Groundwater Group. 2001. Port of Seattle Sea-Tac third runway embankment fill modeling in support of low-streamflow analysis. Prepared by Pacific Groundwater Group for Port of Seattle. Seattle, Washington.

Parametrix, Inc. 2000a. Comprehensive stormwater management plan for Seattle-Tacoma International Airport Master Plan Update improvements. Prepared by Parametrix for the Port of Seattle. Kirkland, Washington.

Parametrix, Inc. 2000b. Natural resource mitigation plan for Seattle-Tacoma International Airport Master Plan Update improvements. Prepared by Parametrix for the Port of Seattle. Kirkland, Washington.

Parametrix, Inc. 2001a. Replacement pages for the comprehensive stormwater management plan for Seattle-Tacoma International Airport Master Plan Update improvements. Prepared by Parametrix for the Port of Seattle. Kirkland, Washington.

Parametrix, Inc. 2001b. Wetland functional assessment and impact analysis for Seattle-Tacoma International Airport Master Plan Update improvements. Prepared by Parametrix for the Port of Seattle. Kirkland, Washington.

Paustian, S.J. (editor) and 13 others. 1992. A channel type users guide for the Tongass National Forest, Southeast Alaska. USDA Forest Service, Alaska Region, R10 Technical Paper 26. 179 pp.

Platts, W.S., W.F. Megahan, and G.W. Minshall. 1983. Methods for evaluating stream, riparian, and biotic conditions. USDA Forest Service General Technical Report INT-GTR-188.

Port of Seattle. 2000a. Annual stormwater monitoring report for Seattle-Tacoma International Airport for the period July 1, 1999 through June 30, 2000.

Port of Seattle. 2000b. Examining the effects of runway deicing on dissolved oxygen in receiving waters: Results of the 1999-2000 winter season, Seattle-Tacoma International Airport. Volume 1.

Port of Seattle. 2001a. Low flow analysis, flow impact offset facility proposal, Seattle-Tacoma International Airport. Seattle, Washington.

Port of Seattle. 2001b. Annual stormwater monitoring report for Seattle-Tacoma International Airport for the period July 1, 2000 through June 30, 2001.

R2 Resources Consultants, CH2M Hill, and Shapiro and Associates. 2000. Tri-County urban issues ESA study: Guidance document. February 2000. Prepared for the Tri-County Urban Issues Advisory Committee, Bellevue, Washington.

Schuett-Hames, D., A. Pleas, L. Bullchild, and S. Hall (eds.). 1994. Ambient monitoring program manual. Timber-Fish-Wildlife, TFW-AM9-94-001. Northwest Indian Fisheries Commission, Olympia, Washington.

Simunek, J., M. Senjna, and M.T. van Genuchten. 1999. Hydrus/Meshgen-2D – Simulating water flow and solute transport in two-dimensional variably saturated media. Version 2.0. U.S. Salinity Laboratory, USDA/ARS. Distributed by International Groundwater Modeling Center.

USFS (United States Forest Service). 1999. Stream inventory handbook: Level I & II. USDA, Region 6, Version 9.9.

Wang, L., T.D. Simonson, and J. Lyons. 1996. Accuracy and precision of selected stream habitat estimates. North American Journal of Fisheries Management 16:340-347.

WDFW (Washington Department of Fish and Wildlife). 2000. Fish passage barrier and surface water diversion screening assessment and prioritization manual. WDFW Habitat Program Environmental Restoration Division: Salmonid Screening, Habitat Enhancement, and Restoration (SSHEAR) Section. Olympia, Washington.

WFPB (Washington Forest Practices Board). 1997. Standard Methodology for Conducting Watershed Analysis under Chapter 222-22 WAC. Version 4.0, November 1997. Washington Department of Natural Resources, Olympia, Washington.

Williams, R.W., R.M. Laramie, and J.J. Ames. 1975. A catalog of Washington streams and salmon utilization. Vol. 1. – Puget Sound. Washington Department of Fish and Wildlife, Olympia, Washington.

Appendix A

NOTE: **Appendix A–HSPF Modeling Information and Data–is contained in a separate volume.**

Appendix B

APPENDIX B

EMBANKMENT MODELING REPORT

Pacific Groundwater Group

Port of Seattle
Sea-Tac Third Runway
Embankment Fill Modeling in Support of Low-Streamflow Analysis

November 27, 2001

Pacific Groundwater Group
Seattle, Washington

AR 052753

Port of Seattle
Sea-Tac Third Runway
Embankment Fill Modeling in Support of Low Streamflow Analysis

Prepared for:

Port of Seattle
P.O. Box 68727
Seattle, WA 98168

Prepared by:

Pacific Groundwater Group
2377 Eastlake Avenue East, #200
Seattle, WA 98102
(206) 329-0141
www.pgwg.com

November 27, 2001

JE0105

Table of Contents

Signature Page

This work was performed in part, and reviewed in whole, by the undersigned.

11/27/01

Charles T. Ellingson
Pacific Groundwater Group Principal Hydrogeologist
Oregon Registered Geologist G1128
Idaho Registered Geologist 1008
Certified Groundwater Professional #312 (National Ground Water Association)

List of Tables

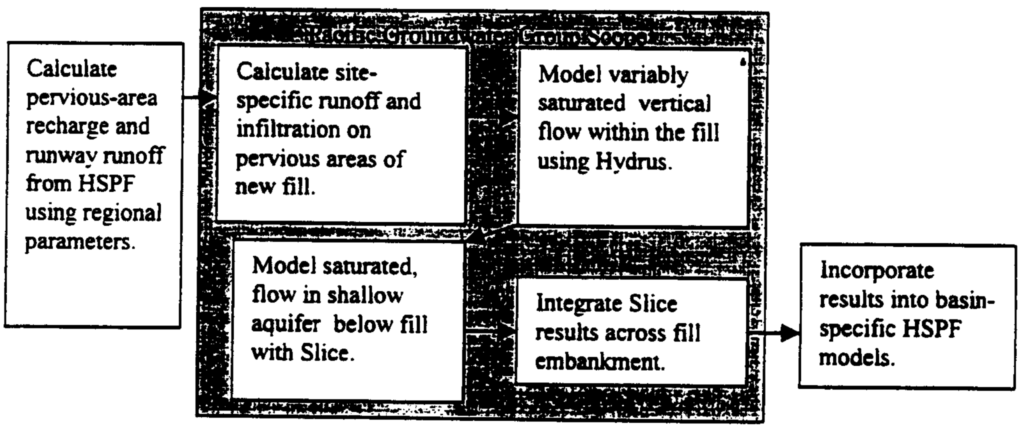
List of Figures

1. Introduction

The Port of Seattle ("the Port") proposes to place a fill embankment in an area west of the existing Sea-Tac Airport complex to build a third runway. Pacific Groundwater work analyzed selected hydrologic impacts for the Department of Ecology in 1999 (Pacific Groundwater Group, 1999). Hydrologic and hydrogeologic studies conducted by Earth Tech, Inc., Parametrix, Inc., Pacific Groundwater Group (PGG) and others then estimated groundwater and low-stream-flow impacts of the proposed fill embankment (Earth Tech, 2000; Pacific Groundwater Group, 2000; and Parametrix, 2001). As part of a more detailed study of low flow impacts to streams near the third runway, the Port contracted Parametrix, Earth Tech and PGG to reevaluate low-stream-flow impacts using a more detailed evaluation of hydrogeologic conditions and fill thickness in the embankment. PGG's role in the more detailed evaluation was to model recharge and redistribution of water within the fill embankment. This is the final report for PGG's portion of that project. The overall project study area includes the Miller Creek and Walker Creek basins, whereas PGG's evaluation was limited to a smaller portion of these basins that are proposed to be underlain by third-runway fill. PGG's evaluation was also limited to post-construction conditions, and did not attempt to simulate existing conditions or use existing conditions for calibration. PGG's study results were used by the HSPF modeling team to evaluate low-stream-flow impacts in the two basins.

1.1 Scope and Approach

PGG's scope of work was authorized by the Port on May 1, 2001. PGG's scope involved reapplication of previously-developed Hydrus and Slice models to post-construction conditions within the proposed embankment as follows:



Input to the modeling process consisted of the following two data sets provided to PGG by Aqua Terra Consultants:

1. direct infiltration from incident precipitation into pervious areas of new fill as calculated by HSPF (model parameter AGWI) for flat outwash

2. runoff from runways and taxiways as calculated by HSPF (model parameter SURO).

Output consisted of the timing and magnitude of runoff from the pervious area, water movement through the shallow aquifer above the till, and downward flow through the till. Output was provided to Aqua Terra and Parametrix Inc. as part of basin-wide simulation of post-construction conditions. The regional HSPF models were modified to allow replacement of regional-scale simulation with local-scale simulation (as described above) in the third runway vicinity. Specifically, Hydrus and Slice models ("Hydrus-Slice") were used instead of the regional HSPF model for the runway fill area, because HSPF was deemed incapable of simulating flow within the embankment. A simulation "test period", consisting of water years 1991 through 1994, was established for Hydrus-Slice modeling in discussions between the Port and the Department of Ecology ("Ecology").

The PGG scope consisted of the following tasks:

- Compile model input using existing information including
  - Fill thickness and extent
  - Hydrogeologic data for the fill area
  - Embankment geometries as represented by three (3) hydrogeologic cross sections
  - Hourly runoff and direct infiltration estimates provided by Aqua Terra Consultants
- Calculate fluxes into the fill based on hourly recharge and runoff estimates
- Calculate daily fluxes through the fill using Hydrus models
- Calculate daily flux through the shallow aquifer at the base of the embankment and the underlying till using Slice models as applied to each basin

Original modeling using the Hydrus-Slice approach was reported on August 8, 2001 (Pacific Groundwater Group, 2001). The modeling reported in this revised report was performed because the original modeling used HSPF parameter AGWO as input instead of the more appropriate parameter AGWI. In addition, the following improvements and changes were made to the revised groundwater modeling:

- PGG adopted the HSPF basin boundary to define the eastern extent of new fill instead of independently-derived boundaries. The independently-derived boundary used in original modeling was similar to the HSPF basin boundary, but not exactly the same. This is a small mathematical change, not a conceptual change.

- PGG included the 1998 fill as third runway fill. Original modeling excluded the 1998 fill because the air-photo-based elevation contours used to calculate fill thickness were flown after placement of the 1998 fill. This change results in a somewhat larger Miller Creek fill area than was originally modeled.

- PGG calculated runoff from pervious areas instead of assuming that all precipitation and runon becomes groundwater recharge. The use of hourly infiltration (AGWI) and runoff (SURO) data from HSPF results in prediction of runoff from filter strips (a portion of the pervious area next to the runways) that simultaneously receive precipitation and runway runoff. This is a more accurate accounting of water performed for the proposed third runway fill area.

- Hydrus 1-D was used to model variably-saturated flow in the fill instead of Hydrus 2-D that was originally used. Hydrus 1-D was required for the revised simulations because it remains stable under the wetter and more variable conditions predicted by the AGWI and SURO model input.

The work was performed, and this report prepared, in accordance with generally accepted hydrogeologic practices, used at this time and in this vicinity, for sole application to the simulation of low-flows under the built condition, and for the sole use of the Port of Seattle. This is in lieu of other warrantees, express or implied.

2. Extent of Fill Modeled by Hydrus-Slice

The modeled fill area (MFA) represents a portion of third runway fill, within the Walker and Miller creek groundwater basins, that would receive precipitation in a post-construction ("built") condition. This area was selected based on discussions with HSPF modelers at the onset of the project. The area was modeled by Hydrus-Slice rather than HSPF for the built condition.

2.1 Geographic Extent of Fill

PGG used existing GIS coverages of pre-fill topography, "built" topography, and third runway pavement distribution to calculate areas for Hydrus-Slice modeling. A graphical approximation of the areas modeled by Hydrus-Slice (and therefore removed from the HSPF model) is shown on **Figure 2-1**. The MFA includes proposed additional runway fill in the Miller and Walker Creek basins minus the steep perimeter slopes along the western and northern edges of the embankment. Steep perimeter slopes were not included in the Hydrus-Slice MFA because surface runoff is assumed to dominate flow in these areas and HSPF is better suited to model these hydrologic conditions. The eastern margin of the MFA is defined by the limit of proposed third runway fill as previously determined by HSPF modelers.

2.2 Thickness of Fill

Fill thickness was calculated by subtracting GIS coverages of pre-fill topography from the "built" topography. A fill thickness of up to 160 feet occurs behind the West Mechanically-Stabilized-Earth (MSE) wall with significantly less fill occurring over most of the third runway area (**Figure 2-1**). For the purpose of Hydrus modeling, fill thickness was descritized into representative values of 10, 20, 30, 50, 70, 90, 110, 130, and 150 feet. Fill thickness in the area of the 1998 fill was approximated and not directly calculated as the difference between two sets of elevations.

2.3 Basin Boundaries and Area Calculations

Groundwater basin boundaries for Miller, Walker and Des Moines Creeks were located for purposes of allocating modeled groundwater flows in the MFA. The groundwater basin boundary of greatest significance in this study is the Miller-Walker divide because these are the receiving basins for groundwater discharge from the fill. A dashed line is drawn on **Figure 2-1** between the Miller and Walker Creek basins. The location of the line is co-incident with the surface water and groundwater basin boundaries used in the HSPF models of 1994 conditions (Parametrix, 2000, Figure B2-2 of Stormwater Management Plan). The Walker-Des Moines groundwater divide is south of the fill area, thus groundwater discharge from the fill will not flow to Des Moines Creek under the current or built condition. The fill areas presented in **Table 2-1** are derived from the basin boundary and model area perimeter shown on **Figure 2-1**. Areas are broken into impervious areas (IA), filter strips (FS), and other pervious areas (OPA). Impervious areas comprised 36 percent and 38 percent of the modeled fill areas in the Miller and Walker Creek basins, respectively.

IA in Walker Creek consists of only the western half of the third runway because runoff from the eastern half will drain to the east and will not flow onto new third runway fill. Runoff from the eastern half of the third runway in Walker Creek was modeled by HSPF.

3. Modeling of Infiltration with Runoff and Evapotranspiration

Precipitation on the MFA was used to calculate hourly runoff (SURO) from impervious surfaces (runway and taxiways) and hourly infiltration (AGWI) into pervious areas with a generic application of HSPF. Pervious areas were modeled as grass on flat outwash. This approach was selected, with agreement from Ecology and King County, to take advantage of HSPF's superior evapotranspiration (ET) and runoff-modeling capabilities. For pervious areas, the generic HSPF model yielded hourly volumes of water that infiltrate beyond the bottom of the root zone (AGWI) and therefore constitute groundwater recharge. That calculation was applied to filter strips and other pervious areas. A separate calculation then estimated the extent to which runoff from impervious surfaces would also infiltrate, or conversely, runoff, from filter strips. The total amount of infiltration into filter strips (a portion of AGWI and SURO) and other pervious areas (AGWI only) was then used as input to the Hydrus models. Calculated runoff was accounted-for but not used in groundwater modeling.

3.1 HSPF Input and Runoff Calculations

Aqua Terra accounted for precipitation, runoff, infiltration, and ET on an hourly basis between 1984 and 1994 using HSPF and regional parameters for grass on outwash soils with land slopes of less than five percent (Joe Brascher, personal communication, May 17, 2001). HSPF model output (AGWI) provided daily estimates of recharge below the root zone considering the effects of runoff and evapotranspiration.

HSPF also calculated hourly volumes of runoff (SURO) from a typical acre of impervious surface. Runoff from impervious surfaces will be routed into "filter strips" that treat the water prior to storage and discharge. The filter strips are part of the pervious surface of the new fill. Therefore, the SURO and AGWI water volumes were added together and compared to the infiltration capacity of the filter strips. Water in excess of the infiltration capacity of the filter strips was considered runoff, and remaining water was considered to infiltrate and become groundwater recharge. For these calculations, areas of impervious surface and filter strips were based on GIS analysis of design data. Flow was assumed uniform over the filter strip, and likely storage of water in surface irregularities was ignored. The infiltration capacity was calculated as the saturated hydraulic conductivity of the fill under a unit hydraulic gradient, over the area of the filter strip. The saturated hydraulic conductivity of the sandy fill matrix was assumed to be 1.35×10^{-4} cm/sec, and no flow was assumed to occur through the portion of the fill occupied by gravel particles, consistent with assumptions throughout PGG's involvement with this project. The total volume of runoff from the filter strips was 28 and 21 percent of the summed AGWI and SURO volumes for Miller and Walker Creek basins, respectively (water years 1991 through 1994 – Table 3-1).

A small amount of runoff was also calculated for "other pervious areas" (pervious areas that are not filter strips and therefore do not receive runoff) because AGWI exceeded the calculated infiltration capacity of other pervious area on occasions. This presumably occurred because of differences between HSPF predictions of runoff from flat outwash, and the runoff-evaluation method applied to the AGWI time series after receipt. The total volume of runoff from the other pervious areas was 6 percent of the AGWI volumes for both basins (water years 1991 through 1994 – Table 3-1).

The Port collected water stage measurements in a sedimentation pond that collected runoff from Phase I (1998) fill of the third runway fill embankment (Parametrix, 2000). The data were collected over about a one-month period in February 1999 and were later used by Parametrix to derive parameters for HSPF modeling of the fill. The interpretation implies a soil infiltration capacity (related to vertical hydraulic conductivity) that is lower than that of regional HSPF parameters for glacial till. The revised runoff calculations summarized above are in much better agreement with observed runoff volumes than the negligible runoff volumes assumed for original modeling reported on August 8, 2001. The observed and predicted runoff volumes are considered to be reasonably consistent although differences in the details may exist for a variety of reasons. As described in Section 4.3, the infiltration volume used in the current modeling could underestimate, and is not likely to over-estimate, actual infiltration. Modeled volumes of groundwater discharge from the fill may therefore be smaller, and are not likely to be larger, than actual discharge. For the purposes of low-flow streamflow assessment, this condition is considered conservative.

3.2 Effective Recharge

Effective recharge (ER) is the average downward groundwater flux over the entire pervious area, just below the root zone. It consists of those portions of AGWI and SURO that infiltrate. As discussed above, the filter strips and other pervious areas receive different amounts of water. In order simplify the analysis, the *average* effective recharge for the entire pervious area was calculated as the summed volume of water infiltrated in those two areas, divided by the total pervious area. Table 3-1 summarizes those water volumes.

4. Modeling of Vertical Flow Through Embankment Fill

Modeling of downward vertical flow through embankment fill describes water movement in the unsaturated or "vadose" zone between the land surface and the proposed drainage layer at the base of the fill. Downward unsaturated flow is the intermediate step between recharge at the land surface and saturated groundwater flow in the shallow aquifer (simulated by the Slice model). An overview of the unsaturated flow modeling completed for this study is presented in the following subsections.

4.1 Summary of Generic Hydrus Model

Vertical flow of effective recharge between the root zone and the water table within the embankment drainage layer was evaluated using the model Hydrus-1D, hereafter called "Hydrus" (Simunek and others, 1999). Hydrus simulates the vertical spreading of recharge fronts as they are predicted to move downward through the proposed embankment fill. Model results describe the lagging and dampening of the recharge pulse for different thicknesses of fill material. Hydrus output was used as recharge input to the Slice models (Section 5).

With the exception of using HSPF-derived recharge input values instead of values derived from average monthly rainfall, the modeling approach used in this study was conceptually identical to the Hydrus simulations completed for the Ecology study (see Appendix C of Pacific Groundwater Group, 2000). Soil characteristics were unchanged. Independent model runs were conducted for the Miller Creek basin using fill thicknesses of 150, 130, 110, 90, 70, 50, 30, and 10 feet. Model runs were conducted for the Walker Creek basin using fill thicknesses of 50, 30, 20, and 10 feet. Hydrus results indicate that substantial lagging and dampening (spreading) of seasonal recharge is likely within the fill, with the amount of lagging and dampening increasing with increased fill thickness. Discharge at the bottom of the fill is predicted to occur throughout the year.

4.2 Characterization of Fill as Soil

The texture of the modeled fill was calculated based on specifications for Phase 1 fill (installed in 1998 and 1999) and proposed embankment composition described by Hart

Crowser (1999). The calculations were also compared to the texture of Phase 1 fill based on soil samples collected by Terra Associates (1998). Details of the characterization of fill texture relative to Hydrus model input is presented in Appendix C of the Ecology study (Pacific Groundwater Group, 2000). Following are summaries of the two types of fill proposed for use in the embankment and designated in this study.

4.2.1 General Fill

Except for Type 1 soils used as fill in limited areas near the MSE walls and runways, the embankment will be comprised of imported material termed "general fill." Average bulk texture for the general fill was estimated to be 55 percent gravel and 45 percent sand-plus-fines matrix. The sand-plus-fines matrix was further estimated to be comprised of an average of 63 percent sand and 37 percent silt; clay was assumed to be absent. Soil-moisture characteristic curves and hydraulic conductivity distributions were developed for the Hydrus runs using Hydrus' version of the U.S. Soil Salinity Laboratory's computer program "Rosetta" based on the grain-size distribution of the matrix.

4.2.2 Type 1 Fill

According to embankment designs presented by Hart Crowser (1999), Type 1 soils are comprised of sand and gravel; they contain virtually no fines. These materials will be used as backfill for the MSE walls and under runways where greater compaction and drainage properties are required. Type 1 soils were assumed to be infinitely permeable and therefore provide immediate delivery of recharge to the underlying drain layer in the Slice models. Type 1 soils were therefore not modeled explicitly using Hydrus although recharge to the drain layer was considered where Type 1 soils existed in modeled areas.

4.3 Representation of Fill in Hydrus

The sand-plus-silt matrix was modeled as an evenly-distributed 45 percent of the general fill and all water flow was assumed to occur within this active matrix. To maintain a water balance while modeling water flow only through the active matrix, effective recharge values were divided by 0.45 and used as the upper boundary condition flux in Hydrus. This matrix-scaled recharge rate used in Hydrus is called the "effective matrix recharge." Logic for using this rate can be understood by considering that any precipitation falling-on, or percolating-into, clusters of gravel particles is likely to be absorbed by the surrounding sand-plus-silt matrix somewhere within the embankment. The gravel fraction of the general fill is therefore treated as inactive. The output at the bottom of the Hydrus model was then multiplied by 0.45 to redistribute flux to the bulk fill body and maintain a long-term water flux equal to the effective recharge rate.

Modeled hydraulic properties for the active fill matrix were generated with Rosetta, based on the percentages of sand and silt summarized in Section 4.2. Rosetta provides estimates of five parameters used to generate the soil moisture characteristic curve; saturated water content, residual water content, "alpha", "N", and "M" (van Genuchten, 1980). Rosetta also provides an estimate of saturated hydraulic conductivity and a factor "L" used to relate the characteristic curve to the unsaturated hydraulic conductivity curve (Mualem, 1976). A default "L" value of 0.5 was assigned by Rosetta in Hydrus, and was used in this analysis. **Table 4-1** presents the hydraulic parameters generated by Rosetta for the general fill matrix. The saturated hydraulic conductivity calculated by Rosetta was 1.35×10^{-4} cm/sec. This value is near the middle of the range presented in Freeze and Cherry (1979) for silty sand. It is near the high end of the reported glacial till range and lower than the clean sand and gravel ranges reported by the same reference.

Although the actual value(s) of hydraulic conductivity are not known for the proposed future embankment, the value calculated by Rosetta is reasonable for the anticipated texture and density of the general fill *matrix*, and is consistent with the active/inactive matrix method of modeling unsaturated flow in the embankment. Experience with testing *saturated* hydraulic conductivity of soils similar in texture to the modeled fill suggests that the Rosetta-calculated value is too low for the bulk (matrix plus gravels) general embankment fill; however, the reason for this discrepancy is the presence of large pores associated with gravels. Large pores associated with gravel deposits dominate saturated flow but can be reasonably assumed inactive under most unsaturated flow conditions because:

- the fill should remain unsaturated except in extreme conditions, and therefore unsaturated flow should predominate,
- large diameter pores associated with gravels will be the first to desaturate as drying occurs,
- over the course of the flow path, water in saturated pores will be absorbed into the finer pores due to matric tension,
- percolation theory (Silliman and Wright, 1988) suggests that continuous paths of finer pores within the matrix will exist throughout the embankment at the modeled texture (it also predicts continuous coarse pore paths which would be predominant in saturated flow),
- it was not feasible for this project to characterize soil moisture retention characteristics of gravels

This representation should be accurate for classical unsaturated flow modeling used by Hydrus and for nearly all other unsaturated flow prediction methods. However, it does not account for the observation that "fingering" of flow can occur in coarse soils under very wet conditions. Fingering occurs when saturation builds-up at one location and then rapidly drains downward through large connected pores in a saturated finger. Such fingering flow will only occur during recharge events when the ground surface, or a subsurface soil zone, becomes saturated. If fingering flow occurs because of a saturated ground surface, this modeling approach will underestimate infiltration. The likelihood of underestimating infiltration has increased relative to the original modeling approach reported on August 8 2001 because of the more variable moisture conditions predicted using hourly precipitation data and the explicit calculation of volumes that will runoff. If fingering flow occurs for substantial distances within the body of the fill, the Hydrus model will overestimate groundwater travel times between ground surface and the water table. The likelihood of overestimating vertical groundwater travel times for the wettest conditions is also somewhat increased relative to the modeling reported on August 8 2001 because of the more variable moisture conditions used in the current assessment.

4.4 Spatial Discretization of Hydrus Models

As described in Section 4.1, Hydrus models were set up to simulate a total of twelve vertical profiles for the proposed fill. Eight different thickness simulations were run for Miller Creek fill and four different thickness simulations were run for Walker Creek fill. Model runs for a given basin differ in fill thickness only. Separate runs were required for the two basins because slightly different IA/PA ratios led to different effective recharge rates.

Nodes representing the land surface were specified flux boundaries. The bottom two nodes were assigned the "water table" boundary condition, which is a constant head boundary equal to elevation head, simulating saturated conditions beneath the embankment fill. Time-series data for flow rates (specific discharge) exiting the bottom of the model domain at the water table boundary nodes were extracted and used as input to the Slice models.

Discretization of the soil profile emphasized detail within the top and bottom six inches of the column to accommodate dramatic changes in recharge and flow. Finer detail within these portions of the soil column improves accuracy in variable flow and water balance calculations as well as improving numerical model performance. Cell size increased in from a minimum of 0.01 cm at the top of the soil profile to about 0.3 inch at a depth of 6 inches. At a depth of 6 inches cells were a constant 6 inches down to 6 inches above the water table, at which point the change in intervals reverted back to 5 percent differences.

4.5 Temporal Discretization

Daily stress periods were used, and daily effective matrix recharge estimates were applied to the top of each model. Model timesteps were automatically optimized by Hydrus, and were typically on the order of 0.10 days. The models were run for water years 1984 through 1994, with only the last four water years comprising the test period. Output from the initial six years was examined visually to assure that residual effects from the initial conditions (uniform moisture) were not present during the 1991-1994 test period.

4.6 Results

Figure 4-1 shows eight daily outflow graphs for the Miller Creek basin fill over the test period. The outflow graphs represent the daily average flow of water to the embankment drain layer (or the water table within the drain) for any one of eight modeled fill thickness intervals. **Figure 4-2** presents comparable results for the Walker Creek fill. Fill thickness intervals correspond with the range of fill geometries occurring in each basin as presented in **Figure 2-1.** Effective recharge into the fill (Hydrus model input) is not shown on these figures because the input is very "spikey" and the lines obscure the model results. Nonetheless, the character of the effective recharge input can be inferred from the 10-foot-thick-fill output, which is only slightly damped and delayed relative to the input.

Figures 4-1 and 4-2 show that the recharge below the root zone is predicted to be lagged and dampened as a function of the thickness of the fill. Lagging causes the arrival of the recharge pulse to be delayed from its introduction at the land surface to its arrival at the bottom of the fill. Dampening causes a reduction in the overall range of flux in the deeper fill. Lagging and dampening both increase with increasing fill thickness and decrease with increasing annual recharge. These effects on the timing of recharge affect the arrival of flow to the top of the slice model (i.e., to the water table in the embankment drainage layer), and ultimately the arrival of baseflow to streams bordering the study area.

The Hydrus models were marginally stable during times of maximum wetness. During some model time steps, saturation was indicated at land surface as would be predicted by the runoff analysis. Hydrus was setup to permanently exclude water that would not enter the land surface at each time step. Water thus excluded was removed from the model and accounted for as a small additional component of runoff (RO3 on Table 3-1). Also, to increase model stability, recharge during one event was artificially lowered, with the removed water accounted as a fourth runoff component (RO4 on Table 3-1). RO3 and RO4 sum to less than 0.3 percent of total water and are insignificant. The runoff time series provided HSPF modelers as a product of this work included all runoff components.

Quality assurance review included comparison of total outflow between runs, and comparison of total inflow to the average total outflow. All model runs had the same total outflow to within 3 percent and 1.6 percent, respectively, for Miller and Walker Creek Hydrus models. For the Miller Creek models, total effective recharge was about 1.4 percent less than the average total outflow, likely as a result of lower storage at the end of the simulation than at the beginning. For the Walker Creek Hydrus models, total effective recharge was about 0.1 percent less than the average total outflow (for the same reason).

Hydrus erroneously predicted zero flux at the bottom boundary in a handfull of time steps. These time steps are apparent on **Figures 4-1 and 4-2.** Review of the time series output and the good mass balance indicates that errors introduced are spurious and not significant.

5. Modeling Saturated Flow Beneath the Embankment Fill

Three simple finite difference slice models were developed to simulate lateral and vertical groundwater flow within the drain layer and existing soils below the embankment. Slice configurations were based on subsurface data described in available geotechnical and hydrogeologic reports and from the pre-fill and "built" topography of the third runway area as supplied by Parametrix and the Port. Slice alignments were located based on the availability of subsurface data and are considered to describe the range of hydrogeologic and fill conditions that exist in the embankment area.

The slice models were used to accumulate recharge in the shallow water table aquifer and move it downgradient to the Miller Creek or Walker Creek wetlands under "built" conditions. Slice 1 was originally developed for the Ecology study (Pacific Groundwater Group, 2000). It was re-applied for this low-flow analysis using daily recharge data for 1984 through 1994 and a more representative runway configuration, but otherwise remained unchanged. Slices 2 and 3 were developed for the low flow analysis using new interpretations of existing hydrogeologic and fill data. The three different versions of the model were constructed to represent a range of conditions that exist within the fill embankment. The slice models are a simplification of subsurface conditions within each hydrogeologic cross section. **Figures 5-1 through 5-3** present simplified cross sections of the slice models used in this study. Slice locations are shown on **Figure 2-1**. Slice 2 was modified slightly from the version reported on August 8 2001 to include the 1998 (Phase 1) fill.

The slice models are based on a quasi-two-dimensional finite-difference formulation of the partial differential equation describing transient groundwater flow through a saturated medium. Model cells were only connected to laterally adjacent neighbors as opposed to overlying or underlying cells – thus the quasi-two-dimensional nature of the model. Each model cell can contain up to three different "soil layers", differing in thickness and hydraulic conductivity. The bottom elevation of each cell is defined by the top of the till layer, and downward flow through the till was simulated. For each cell, the model also specified a uniform specific yield of 30 percent. Recharge for each stress period (day) was derived for each cell from Hydrus output for the appropriate overlying fill thickness. The model assumes unconfined flow (variable transmissivity) under horizontal gradients defined by head differences between adjacent cells. The model was implemented in a Microsoft Excel spreadsheet, using direct (explicit) methods to solve the finite-difference equation. Details of the slice model input and functions are described further in Appendix E of the Ecology study report (Pacific Groundwater Group, 2000).

Downward flow through till was calculated using Darcy's equation, a uniform hydraulic conductivity of $4x10^{-3}$ ft/day ($1.4x10^{-6}$ cm/sec), a uniform thickness of 10 feet, and a model-calculated gradient. To calculate the gradient, the head of groundwater above the till was calculated by the model, and head at the bottom of the till was considered to be one of three values. Groundwater head at the bottom of the till was assumed equal to the elevation of that contact where groundwater in the underlying Qva aquifer was expected to be unconfined (see **Figures 5-1 through 5-3**). This condition prevailed in the eastern portions of Slices 1 and 2, and throughout Slice 3. Groundwater head below the till was considered to be equal to groundwater head above the till where the conceptual model predicted highly confined conditions. This "no vertical flow" condition was actually implemented in the model by assigning a zero hydraulic conductivity to the till where highly confined conditions were expected. That condition prevailed in the western lowland portions of Slices 1 and 2. Groundwater head at the bottom of the till, in locations of intermediate confinement of Qva groundwater, was assigned a value equal to the elevation of the mid-point of the till.

5.1 Cross Section 1 and Slice 1

This cross section is located through the thickest portion of the fill embankment with a fill thickness of up to 160 feet (**Figure 2-1**). A simplified cross section showing Slice 1 is presented in **Figure 5-1**. Slice 1 is located at the same location as the original slice model developed by PGG in the Ecology study. Hydrogeologic conditions were defined by eight subsurface explorations located along the 1,320-foot slice alignment. Fill located behind the West MSE wall was modeled using Slice 1.

The geometry and material types represented in the cross section of **Figure 5-1** were used to construct the Slice 1 model. **Tables 5-1 and 5-2** present Slice 1 model cell parameters. Because the removed portion of the HSPF model does not include the steep slopes of the embankment fill, results from Slice 1 were extracted from the portion east of cell 43 ("active model cells").

5.2 Cross Section 2 and Slice 2

Slice 2 is located through the northern portion of the fill embankment near the northern end of the third runway (**Figure 2-1**). A simplified cross section showing Slice 2 is presented in **Figure 5-2**. The slice is located to represent an intermediate fill thickness of up to 100 feet thick and crosses one taxiway in addition to the third runway. Slice 2 was developed from a generalized hydrogeologic cross section originally created by Hart Crowser through the northern toe of the fill embankment (see Section A-A' of Hart Crowser, 1999a) with supplemental information from more recent borings and shallow test pits (Hart Crowser, 2000a). The slice location is based on availability of suitable subsurface data with seven explorations located near the 1,420-foot slice alignment. Slice 2 represents subsurface conditions for the bulk of Miller Creek embankment fill.

The geometry and material types represented in the cross section of **Figure 5-2** were used to construct the Slice 2 model. **Tables 5-3 and 5-4** present Slice 2 model cell parameters. Because the removed portion of the HSPF model does not include the steep slopes of the embankment fill, results from Slice 2 were extracted from the portion east of cell 38 ("active model cells").

5.3 Cross Section 3 and Slice 3

Slice 3 is located immediately north of the South MSE wall (**Figure 2-1**). A simplified cross section showing Slice 3 is presented in **Figure 5-3**. A fill thickness of up to 40 feet occurs in the western end of this slice. The slice location was chosen through fill of intermediate thickness for the Walker Creek fill and minimal thickness for the Miller

Creek fill. Although this slice does not completely describe the variety of fill thicknesses in Walker Creek basin, the thicker portion of the fill is of small areal extent and does not justify an additional slice model. Slice 3 is partially based on a generalized hydrogeologic cross section originally created by Hart Crowser through the northern end of the South MSE wall study area (see Section E-E' of Hart Crowser, 2000b). The hydrogeologic interpretation for this slice has been modified using geotechnical data (Hart Crowser, 2000a), existing and "built" topography, and available till mapping data (AESI, 1999). Eight subsurface explorations occur along the 625-foot slice alignment.

The geometry and material types represented in the cross section of **Figure 5-3** were used to construct the Slice 3 model. **Tables 5-5 and 5-6** present Slice 3 model cell parameters. Because the removed portion of the HSPF model does not include the steep slopes of the embankment fill, results from Slice 3 were extracted from the portion east of cell 25 ("active model cells").

5.4 Individual Slice Model Results

Figures 5-4 through 5-6 present individual Slice model results for Slices 1 through 3 for water years 1991 through 1994. Results are presented as daily time series plots for three Slice model terms: Qvr/drain outflow flow downward through till, and recharge to the drain layer from the fill. The Qvr/drain outflow term is lateral groundwater flow at the western edge of the fill embankment discharging through the shallow (Qvr) aquifer and the constructed drain layer. The Qvr/drain outflow term is extracted from the western-most "active" cell in the slice, and represents subsurface flow towards downgradient receiving waters. Downward flow through till and recharge to the drain layer from the fill are summed for all active cells in the slice. Downward flow through the till represents vertical drainage to the deeper (Qva) aquifer below the till. Recharge to the drain from the fill is obtained by summing Hydrus output as it varies along the slice due to the varying thickness of overlying fill. Model results represent flow for a one-foot-wide slice of the embankment with units reported in cubic feet per day, per foot of width (ft^2/d or $ft^3/d\text{-}ft$).

Results vary substantially between the slices and indicate that a complex set of factors control the relationship between input (recharge to the drain) and output (Qvr/drain outflow and downward flow through till):

- The timing of recharge to the drain layer is controlled by the type and thickness of fill in the slice. More uniform fill thickness in Slice 3 results in more seasonal variability of recharge to the drain layer compared to Slices 1 and 2.
- Differences in the variability of Qvr/drain outflow shows that the presence of Type 1 fill causes output to be nearly as variable as input on Slice 1 where Type 1 fill exists, and to be rather smooth for the other slices where Type 1 fill is assumed to not exist. Transition of flow from wholly within the moderately-transmissive Qvr during dry and moderate periods, to a combination of the Qvr and the highly-transmissive drain layer during wet periods, may also contribute to this effect at Slice 1. The spikiness of modeled Slice 1 Qvr/drain outflow is likely greater than would actually occur.

- Longer flow-length paths and lower gradients within the Qvr and drain layer should contribute to longer horizontal travel time delays. However, longer flow lengths and steeper gradients in Slices 1 and 2 compare to shorter lengths and gentler gradients in Slice 3. This combination of gradient and flow paths for the two sets of slices causes horizontal travel time delays are more similar between the slices than might otherwise occur.
- Downward flow through the till is seasonal due to changes in aquifer saturation. Downward flow through till is also greater on average than Qvr/drain outflow, and is sensitive to till permeability. Qvr/drain outflow exceed downward flow through till during intense recharge events at Slice 1 (through Type 1 fill), and during some seasonal maxima at Slices 1 and 3.
- Seasonal maxima in Qvr/drain outflow are lagged more in dry years than in wet years (this be more a result of vertical flow delays than lateral flow delays).

Quality assurance review of Slice model results included comparison of total inflow, outflow and change in storage between runs. In all cases, the mass balance error in this comparison was less than one percent.

5.5 Method for Integrating Slice Results Over Entire Fill Areas

Groundwater discharge quantities for Miller and Walker Creeks were calculated by multiplying unit-width flow quantities from representative Slice model output by an effective basin width (EBW). This process integrates the slice model results over the entire basin. The EBW represents an idealized length over which groundwater within the embankment will discharge to the respective downgradient receiving waters. EBWs were measured (or calculated) parallel to the long axis of embankment fill, an orientation perpendicular to the slice models and expected groundwater flow lines. EBWs are associated with each Slice model and depend on the width of the basin with characteristics similar to the slice (i.e., thickness and lateral extent). For instance, the entire Walker Creek basin is best represented only by Slice 3 because the embankment fill in this basin is relatively narrow and has limited thickness variation (typically less than 40 feet thick). Walker Creek is therefore modeled by Slice 3 only and the results are integrated over the basin using a single EBW. In contrast, Miller Creek is represented by a combination of Slices 1, 2, and 3 because of variable fill geometries that occur in this basin (fill thickness ranging up to 160 feet over a variety of fill lengths). **Figure 2-1** presents the approximate segments of the Miller and Walker Creek basins that are represented by each of the Slice models. A summary of effective basin widths is presented in **Table 5-7**.

The derivation of EBWs is discussed in the following sections followed by a summary of the integrated flow results for each basin.

5.6 Effective Basin Width for Walker Creek

The EBW for Walker Creek basin was calculated to maintain a water balance for the modeled fill area (MFA) measured for the basin, where MFA=IA+FS+OPA as defined in Section 2.3. To maintain a water balance, the integrated area of the slice models must equal the MFA of the basin. When this condition is met, effective recharge for the basin should equal the effective recharge of the integrated slice model results. In the Walker Creek Basin, an EBW of 2,084 feet was calculated based on a Slice 3 length of 350 feet and an MFA of 729,547 square feet.

5.7 Effective Basin Width for Miller Creek

The total EBW for Miller Creek basin is comprised of four segments that are represented by Slices 1, 2 and 3 (**Figure 2-1**). Multiple slices were used to describe groundwater flow to Miller Creek because of the variable fill width and fill thickness in this basin. Similar to Walker Creek, the EBW for Miller Creek was adjusted to maintain a water balance for the MFA measured previously for the basin. That is, the Miller Creek basin fill area (and therefore basin recharge area) defined by the calculated total EBW was the same as the MFA used for Hydrus and Slice modeling. Because the average fill length (east-west) is considerably less than the Slice 2 modeled fill length (east-west) used to represent the north and south ends of the basin, the Slice 2 EBW was reduced to achieve the desired MFA.

The EBW for the segment represented by Slice 1 adjacent to the West MSE wall was assigned a value of 1,600 feet based on map measurements (**Figure 2-1**). The fill length over this reach is relatively uniform at approximately 1,000 feet and is close to the 1,050-foot Slice 1 model length. The map-measured length was therefore considered representative for this reach of the basin and the map length was adopted as the EBW.

The Miller Creek basin reach located north of the West MSE wall is represented by Slice 2. The northeastern corner of the runway fill has an irregular shape where the actual fill length (east-west) is less than the Slice 2 model length. The basin reach immediately south of the West MSE wall is also represented by Slice 2. The combined map width of the two Miller Creek reaches represented by Slice 2 is approximately 3,700 feet. However, to maintain a water balance for the basin, the combined EBW for Slice 2 segments was reduced relative to map widths shown on **Figure 2-1**. The combined EBW for Slice 2 segments was adjusted to 2.699 feet to maintain the water balance. By adjusting the Slice 2 EBW in this manner, an MFA of 5.001.390 square feet was calculated which is approximately equal to the GIS-measured MFA of 5,001.205 square feet.

The southern reach of the Miller Creek basin is represented by Slice 3 where the fill is relatively thin and narrow (east-west). The EBW for this reach of Miller Creek was assigned as the map-estimated length 930 feet. The actual fill length (east-west) of 340 feet is closely approximated by the modeled slice width of 350 feet. The map-measured EBW is therefore considered representative for this reach of the basin as mass balance is maintained.

5.8 Integrated Flow Estimates for Walker Creek Fill

Integrated estimates of Qvr/drain outflow and downward flow through till for the Walker Creek fill area for water years 1991 through 1994 are presented in **Figure 5-7**. Also shown is the effective recharge input to the Hydrus model. Thus, Figure 5-7 indicates changes in timing of flows resulting from both vertical and lateral groundwater travel. Integrated flows for Walker Creek are the product of the 2,084-ft EBW discussed in Section 5.6 and the model results for Slice 3 discussed in Section 5.4. **Figure 5-7** shows that the timing and magnitude of Qvr/drain outflow varies seasonally, with maximum flows predicted during spring or early summer and minimum flows predicted during winter. Estimated annual maximum Qvr/drain outflows through the fill range between about 3,500 cubic feet per day (cfd) in water year 1991 with a peak flow predicted in late March, and about 1500 cfd in 1994 with a peak flow predicted in late April. Estimated annual minimum Qvr/drain outflows are predicted to occur between October and December, with some years experiencing a period of no flow from the Qvr/drain. High flows lag behind the onset of recharge season because time is required for unsaturated flow to transport recharge through the embankment fill and because time is required for lateral flow from areas of recharge to the downgradient end of the model.

Integrated till seepage rates for the Walker Creek basin fill increase rapidly in November or December when the downward moving recharge within the embankment reaches the water table. This effect is accentuated in the Walker Creek case because of the narrow range of fill thicknesses. After a long period of nearly constant discharge following the sudden rise, a gradual decline occurs in late summer. Seepage through the till is estimated to occur at maximum annual rates of 2200 to 2400 cfd for the four year period shown in **Figure 5-7**. Downward flow through the till is predicted to occur at some rate over the entire year.

Quality assurance review included comparison of total inflow to total outflow. For Walker Creek, integrated outflow was about 4 percent greater than total effective recharge for the 11-year test period, likely as a result of lower groundwater storage at the end of the simulation than at the beginning, and/or the coarseness of slice model cell resolution which prevented exact replication of the GIS-measured IA and PA.

5.9 Integrated Flow Estimates for Miller Creek Fill

Integrated estimates of Qvr/drain outflow and downward flow through till for the Miller Creek Fill area for water years 1991 through 1994 are presented in **Figure 5-8**. Integrated flows are the sum of the products of the effective basin widths discussed in Section 5.7 and the model results for Slices 1, 2, and 3 presented in Section 5.4. **Figure 5-8** shows relatively constant Qvr/drain outflow rates from the Miller Creek fill embankment, punctuated by spikes during rainstorms, and a seasonal maximum in June and July of the relatively wet year of 1991. The spikiness is to some extent a modeling artifact of the infinite permeability assumed for Type 1 fill. Actual flow rates would likely be steadier. Estimated annual maximum Qvr/drain outflows range from about 18.000 cfd in April of 1991 to about 8,000 cfd in late-July of 1994 following a year of low recharge.

Integrated downward flow through the till for the Miller Creek basin fill is relatively constant, but with a smooth seasonal pattern. Model estimates of flow range from about 16,000 to 7,000 cfd. Maxima are in April to June. Minima are in October and November.

Quality assurance review included comparison of total inflow to total outflow. For Miller Creek, integrated outflow was 3 percent greater than total effective recharge for the 11-year test period, likely as a result of lower groundwater storage at the end of the simulation than at the beginning, and/or coarseness of cell size resolution in the slices which prevented exact replication of the GIS-measured IA and PA.

5.10 Use of Integrated Flow Estimates

Integrated flow estimates for Miller and Walker Creek basins were transmitted to Parametrix and Aqua Terra for use in HSPF models of Miller and Walker Creeks. Time series of total daily discharge (volume per day) from above the till (Qvr/drain outflow), and total daily discharge through the till (downward flow through the till) were provided. In addition, total runoff as an hourly time series was provided. All volumes were for the MFAs within the Miller Creek and Walker Creek basins. Parametrix and Aqua Terra used the flow estimates developed in this modeling study as part of a low-stream-flow impact evaluation.

6. References

Associated Earth Sciences, Inc. (AESI), 1999. Seattle-Tacoma International Airport Ground Water Study – Model Boundary Presentation. Unpublished figures and cross sections prepared for The Port of Seattle dated October 15, 1999.

Brascher, Joe, Aqua Terra, personal communication regarding HSPF-derived recharge data for 1984 through 1994, May 17, 2001.

Earth Tech, 2000, Seattle-Tacoma Airport Master Plan Update Low Streamflow Analysis, December, 2000. Unpublished consulting report prepared for the Port of Seattle.

Freeze R. A. and J.A. Cherry, 1979, Groundwater, Prentice-Hall, Englewood Cliffs, New Jersey

Hart Crowser, Inc., 1999. Subsurface Conditions Data Report 404 Support Third Runway Embankment. Unpublished consulting report prepared for HNTB and The Port of Seattle dated July 1999.

Hart Crowser, Inc., 2000a. Draft Subsurface Conditions Data Report Additional Field Explorations and Advanced Testing, Third Runway Project Sea-Tac International Airport. Unpublished consulting report prepared for HNTB dated September 5, 2000.

Hart Crowser, Inc., 2000b. Draft Subsurface Conditions Data Report South MSE Wall and Adjacent Embankment Third Runway Project Sea-Tac International Airport. Unpublished consulting report prepared for Port of Seattle and HNTB dated April 7, 2000.

Mualem, Y. 1976. A New Model for Predicting the Hydraulic Conductivity of Unsaturated Porous Media, Water Resources Research, 12(3), 513-522.

Pacific Groundwater Group, 2000. Sea-Tac Runway Fill Hydrologic Studies Report, Unpublished consulting report prepared for the Department of Ecology.

Pacific Groundwater Group, 2001a. Memorandum entitled Model Area and Hydrus Results – Draft Interim Deliverables, prepared for Keith Smith, Port of Seattle dated June 25, 2001.

Pacific Groundwater Group, 2001b. Port of Seattle Sea-Tac Third Runway Embankment Fill Modeling, August 8, 2001.

Parametrix, 2000. Comprehensive Stormwater Management Plan, Master Plan Update Improvements, Seattle-Tacoma International Airport, December, 2000.

Parametrix, 2001. Low Flow Analysis, Flow Impact Offset Facility Proposal, Port of Seattle. July, 2001

Simunek, J., Senjna, M., van Genuchten, M. Th., 1999. Hydrus-2D/Meshgen-2D - Simulating Water Flow and Solute Transport in Two-Dimensional Variably Saturated Media, Version 2.0 dated April 1999, U.S. Salinity Laboratory, USDA/ARS. Distributed by International Groundwater Modeling Center.

Silliman S.E., and A.L. Wright. 1988, Stochastic Analysis of Paths of High Hydraulic Conductivity in Porous Media, Water Resources Research, Vol. 24, No. 11.

van Genuchten, M. Th., 1980. A Closed Form Equation for Predicting the Hydraulic Conductivity of Unsaturated Soils. Soil Science Society of America Journal, 44, 892

TABLES

Table 2-1
Summary of Areas Modeled by Hydrus-Slice

	Miller Creek Basin		Walker Creek Basin	
	square feet	acres	square feet	acres
Filter Strip Area (FS)	1,456,854	33.44	353,133	8.11
Other Pervious Fill Area (OPA)	1,746,649	40.10	99,342	2.28
Runway and Taxiway Impervious Area (IA)	1,797,702	41.27	277,072	6.36
Total Modeled Fill Area (MFA) in Basin	5,001,205	114.81	729,547	16.75
IA/total pervious area	0.56		0.61	
FS/PA	0.45		0.78	
IA/total Area	0.36		0.38	

Table 3-1
Summary of Water Volumes

	Water Available to Filer Strip *	Water Available to OPA	Runoff from Filter Strip (RO1)	Runoff from Other Pervious Area (RO2)	Water excluded by Hydrus (RO3)	Water artificially removed from Hydrus to promote stability (RO4)	Total Runoff	Total Infiltration
Miller Creek Modeled Fill Area (ft3)	69,006,366	29,689,341	19,625,881	1,652,948	220,585	0	21,499,415	77,196,293
Miller Creek Modeled Fill Area (percent of total water)	70%	30%	20%	2%	0%	0%	22%	78%
Walker Creek Modeled Fill Area (ft3)	12,821,485	1,688,604	2,650,317	94,013	40,091	8,686	2,793,108	11,716,981
Walker Creek Modeled Fill Area (percent of total water)	88%	12%	18%	1%	0%	0%	19%	81%

AR 052776

Table 4-1
Summary of Hydraulic Parameters Used for Fill Matrix in the Hydrus-2D Model

Sand Fraction of matrix	63%
Silt Fraction of matrix	37%
Clay Fraction of matrix	0
Saturated Volumetric Water Content of matrix	0.25
Residual Volumetric Water Content of matrix	0.02
"alpha" (1/cm)	0.088
"N"	1.35
Saturated Hydraulic Conductivity (cm/sec) of matrix	1.35×10^{-4}

Table 5-1
Slice 1 Model Parameters for Different Cell Types

Model Parameters for Cells Types

	Cell Type 1	Cell Type 2	Cell Type 3
Surficial Soil	removed	removed	removed
Aquifer Materials	fill	outwash stringers	peat & outwash
Land Cover	embankment	embankment	embankment
Wetland/Upland	upland	upland	wetland
Bottom Layer Hydraulic Conductivity (ft/d)	300	6	2.65
Top of Bottom Layer (ft above till)	4	7.5	7.5
Middle Layer Hydraulic Conductivity (ft/d)		300	300
Top of Middle Layer (ft above till)		11.5	11.5
Upper Layer Hydraulic Conductivity (ft/d)			
Top of Upper Layer (ft above till)			
Maximum Saturated Thickness (ft)	4	11.5	11.5
Gradient of Top of Till (ft/ft)	18.75%	18.75%	3.60%
Full Thickness Hydraulic Conductivity (ft/d)	300	108.2608696	106.076087
Maximum Subsurface Flow (cfd)	225	233.4375	43.9155
Maximum Downgradient Flow (cfd)	233.4375	43.9155	124.2
Cell Length (ft)	25	25	25
Specific Yield	0.3	0.3	0.3
Maximum Storage (cubic ft)	30	86.25	86.25
Bottom Layer Storage (cubic ft)	30	56.25	56.25

Model Constants

Till Thickness (ft)	10
Till Permeability Beneath Uplands (ft/d)	0.004
Till Permeability Beneath Wetlands (ft/d)	0
Outwash Permeability (ft/d)	6
Peat Permeability (ft/d)	1
Percent Outwash in Peaty Aquifer	0.33
Peaty Aquifer Permeability (ft/d)	2.65
Drain Material Permeability (ft/d)	300
Till Derived Soil Permeability (ft/d)	4
Outwash Derived Soil Permeability (ft/d)	4
Wetland Surficial Soil Permeability (ft/d)	1
Minimum Saturation Considered for h and T (ft)	0.0001

NOTE: All values are for a vertical slice of 1-foot width.

Time Stepping

user defined model timestep (d)	0.1

AR 052778

Table 5-2
Slice 1 Model Cell Parameters

Cell ID	Distance from Outlet	Top of Till Elevation	Cell Length (ft)	Cell Type	Till Permeability (ft/d)	Head at Bottom of Till	Maximum Subsurface Outflow (cfd)	Specific Yield	Maximum Storage (cf)	Fill Material	Embankment Thickness (ft)	Modeled "Effective" Embankment Thickness (ft)	
1	1137.5	385.0438	25	1	0.004	375.0438	225	0.3	30	Type 2	3	0	
2	1112.5	380.3563	25	1	0.004	370.3563	225	0.3	30	Type 2	7	10	
3	1087.5	375.6688	25	1	0.004	365.6688	225	0.3	30	Type 2	11	10	
4	1062.5	370.9813	25	1	0.004	360.9813	225	0.3	30	Type 2	14	10	
5	1037.5	366.2938	25	1	0.004	356.2938	225	0.3	30	Type 2	19	10	
6	1012.5	361.6063	25	1	0.004	351.6063	225	0.3	30	Type 2	24	-99	taxiway, no recharge
7	987.5	356.9188	25	1	0.004	346.9188	225	0.3	30	Type 2	27	30	
8	962.5	352.2313	25	1	0.004	342.2313	225	0.3	30	Type 2	32	-99	taxiway, no recharge
9	937.5	347.5438	25	1	0.004	337.5438	225	0.3	30	Type 2	35	30	
10	912.5	342.8563	25	1	0.004	332.8563	225	0.3	30	Type 2	40	-99	taxiway, no recharge
11	887.5	338.1688	25	1	0.004	328.1688	225	0.3	30	Type 2	44	50	
12	862.5	333.4813	25	1	0.004	323.4813	225	0.3	30	Type 2	49	-99	taxiway, no recharge
13	837.5	328.7938	25	1	0.004	318.7938	225	0.3	30	Type 2	54	50	
14	812.5	324.1063	25	1	0.004	314.1063	225	0.3	30	Type 2	57	-99	taxiway, no recharge
15	787.5	319.4188	25	1	0.004	309.4188	225	0.3	30	Type 2	60	50	
16	762.5	314.7313	25	2	0.004	304.7313	233.4375	0.3	86.25	Type 2	64	-99	taxiway, no recharge
17	737.5	310.0438	25	2	0.004	300.0438	233.4375	0.3	86.25	Type 2	69	70	
18	712.5	305.3563	25	2	0.004	295.3563	233.4375	0.3	86.25	Type 2	74	70	
19	687.5	300.6688	25	2	0.004	290.6688	233.4375	0.3	86.25	Type 2	78	70	
20	662.5	295.9813	25	2	0.004	285.9813	233.4375	0.3	86.25	Type 2	84	90	
21	637.5	291.2938	25	2	0.004	281.2938	233.4375	0.3	86.25	Type 2	90	90	
22	612.5	286.6063	25	2	0.004	276.6063	233.4375	0.3	86.25	Type 2	96	90	
23	587.5	281.9188	25	2	0.004	271.9188	233.4375	0.3	86.25	Type 2	101	110	
24	562.5	277.2313	25	2	0.004	267.2313	233.4375	0.3	86.25	Type 2	105	110	
25	537.5	272.5438	25	2	0.004	267.5438	233.4375	0.3	86.25	Type 2	111	110	
26	512.5	267.8563	25	2	0.004	262.8563	233.4375	0.3	86.25	Type 2	116	-99	runway, no recharge
27	487.5	263.1688	25	2	0.004	258.1688	233.4375	0.3	86.25	Type 2	120	-99	runway, no recharge
28	462.5	258.4813	25	2	0.004	253.4813	233.4375	0.3	86.25	Type 2	125	-99	runway, no recharge
29	437.5	253.7938	25	2	0.004	248.7938	233.4375	0.3	86.25	Type 2	128	-99	runway, no recharge
30	412.5	249.1063	25	2	0.004	244.1063	233.4375	0.3	86.25	Type 2	132	-99	runway, no recharge
31	387.5	244.4188	25	2	0.004	239.4188	233.4375	0.3	86.25	Type 2	138	-99	runway, no recharge
32	362.5	239.7313	25	2	0.004	234.7313	233.4375	0.3	86.25	Type 2	142	-99	runway, no recharge
33	337.5	235.0438	25	2	0.004	230.0438	43.9155	0.3	86.25	Type 2	147	-99	runway, no recharge
34	312.5	232.25	25	5	0	222.25	43.9155	0.3	86.25	Type 2	148	-99	runway, no recharge
35	287.5	231.35	25	5	0	221.35	43.9155	0.3	86.25	Type 2	148	150	
36	262.5	230.45	25	5	0	220.45	43.9155	0.3	86.25	Type 2	148	150	
37	237.5	229.55	25	5	0	219.55	43.9155	0.3	86.25	Type 2	148	150	
38	212.5	228.65	25	5	0	218.65	43.9155	0.3	86.25	Type 2	148	150	
39	187.5	227.75	25	5	0	217.75	43.9155	0.3	86.25	Type 2	148	150	
40	162.5	226.85	25	5	0	216.85	43.9155	0.3	86.25	Type 1	148	0	
41	137.5	225.95	25	5	0	215.95	43.9155	0.3	86.25	Type 1	146	0	
42	112.5	225.05	25	5	0	215.05	43.9155	0.3	86.25	Type 1	145	0	
43	87.5	224.15	25	5	0	214.15	43.9155	0.3	86.25	Type 1	115	0	not included in mass balance
44	62.5	223.25	25	5	0	213.25	43.9155	0.3	86.25	Type 1	35	0	not included in mass balance
45	37.5	222.35	25	5	0	212.35	43.9155	0.3	86.25	Type 1	7	0	not included in mass balance
46	12.5	221.45	25	5	0	211.45	9999	0.3	86.25	Type 1	0	0	not included in mass balance

AR 052779

Table 5-3
Slice 2 Model Parameters for Different Cell Types

Model Parameters for Cells Types	cells 1-3, 8-9 **Cell Type 1**	cells 4-7 **Cell Type 2**	cells 10-13 **Cell Type 3**	cells 14-28 **Cell Type 4**	cells 29-43 **Cell Type 5**	cells 44-46 **Cell Type 6**
Surficial Soil	removed	removed	removed	removed	removed	removed
Aquifer Materials	outwash stringers	outwash stringers	outwash stringers	outwash stringers	outwash stringers	outwash stringers
Land Cover	embankment	embankment	embankment	embankment	embankment	embankment
Wetland/Upland	upland	upland	upland	upland	upland	upland
Bottom Layer Hydraulic Conductivity (ft/d)	6	6	6	6	6	6
Top of Bottom Layer (ft above till)	39.5	45	28.25	15	15	15
Middle Layer Hydraulic Conductivity (ft/d)	300	300	300	300	300	300
Top of Middle Layer (ft above till)	43.5	49	32.25	19	19	19
Upper Layer Hydraulic Conductivity (ft/d)						
Top of Upper Layer (ft above till)						
Maximum Saturated Thickness (ft)	43.5	49	32.25	19	19	19
Gradient of Top of Till (ft/ft)	0.0908	0.0908	0.0908	0.0908	0.0507	0.0165
Full Thickness Hydraulic Conductivity (ft/d)	33.03448276	30	42.46511628	67.89473684	67.89473684	67.8947368
Maximum Subsurface Flow (cfd)	130.4796	133.476	124.3506	117.132	65.403	21.285
Maximum Downgradient Flow (cfd)	133.476	65.403	21.285	117.132	65.403	21.285
Cell Length (ft)	30	30	30	30	30	30
Specific Yield	0.3	0.3	0.3	0.3	0.3	0.3
Maximum Storage (cubic ft)	391.5	441	290.25	171	171	171
Bottom Layer Storage (cubic ft)	355.5	405	254.25	135	135	135

Model Constants	
Till Thickness (ft)	10
Till Permeability Beneath Uplands (ft/d)	0.004
Till Permeability Beneath Wetlands (ft/d)	0
Outwash Permeability (ft/d)	6
Peat Permeability (ft/d)	1
Percent Outwash in Peaty Aquifer	33%
Peaty Aquifer Permeability (ft/d)	2.65
Drain Material Permeability (ft/d)	300
Till Derived Soil Permeability (ft/d)	4
Outwash Derived Soil Permeability (ft/d)	4
Wetland Surficial Soil Permeability (ft/d)	1
Minimum Saturation Considered for h and T (ft)	0.0001
user defined model timestep (d)	0.1

NOTE: All values are for a vertical slice of 1-foot width.

AR 052780

Table 5-4
Slice 2 Model Cell Parameters

Cell ID	Distance from Outlet	Top of Till Elevation	Cell Length (ft)	Cell Type	Till Permeability (ft/d)	Head at Bottom of Till	Maximum Subsurface Outflow (cfd)	Specific Yield	Maximum Storage (cf)	Fill Material	Embankment Thickness (ft)	Modeled "Effective" Embankment Thickness (ft)	
1	1365	371.9939	30	1	0.004	361.9939	130.4796	0.3	391.5	Type1	0	0	drain only, no overlying fill
2	1335	369.0941	30	1	0.004	359.0941	130.4796	0.3	391.5	Type1	0	0	drain only, no overlying fill
3	1305	366.1944	30	1	0.004	356.1944	130.4796	0.3	391.5	Type 2	0.5432	0	
4	1275	363.2946	30	2	0.004	353.2946	133.476	0.3	441	Type 2	1.3605	0	
5	1245	360.3949	30	2	0.004	350.3949	133.476	0.3	441	Type 2	2.1778	0	
6	1215	357.4951	30	2	0.004	347.4951	133.476	0.3	441	Type 2	9	10	
7	1185	354.5954	30	2	0.004	344.5954	133.476	0.3	441	Type 2	25	-99	taxiway/unspec., no recharge
8	1155	351.6956	30	1	0.004	341.6956	130.4796	0.3	391.5	Type 2	32	30	
9	1125	348.7959	30	1	0.004	338.7959	130.4796	0.3	391.5	Type 2	39	-99	taxiway/unspec., no recharge
10	1095	345.8961	30	3	0.004	335.8961	124.3506	0.3	290.25	Type 2	44	50	
11	1065	342.9964	30	3	0.004	332.9964	124.3506	0.3	290.25	Type 2	49	-99	taxiway/unspec., no recharge
12	1035	340.0966	30	3	0.004	330.0966	124.3506	0.3	290.25	Type 2	51	50	
13	1005	337.1735	30	3	0.004	327.1735	124.3506	0.3	290.25	Type 2	53	-99	taxiway/unspec., no recharge
14	975	334.2466	30	4	0.004	324.2466	117.132	0.3	171	Type 2	54	50	
15	945	331.3197	30	4	0.004	321.3197	117.132	0.3	171	Type 2	55	-99	taxiway/unspec., no recharge
16	915	328.3928	30	4	0.004	318.3928	117.132	0.3	171	Type 2	58	50	
17	885	325.4658	30	4	0.004	315.4658	117.132	0.3	171	Type 2	59	50	
18	855	322.5389	30	4	0.004	312.5389	117.132	0.3	171	Type 2	62.6913	70	
19	825	320.0984	30	4	0.004	310.0984	117.132	0.3	171	Type 2	66.5809	70	
20	795	317.669	30	4	0.004	307.669	117.132	0.3	171	Type 2	70.4705	70	
21	765	315.2396	30	4	0.004	305.2396	117.132	0.3	171	Type 2	74.3601	70	
22	735	312.8102	30	4	0.004	307.8102	117.132	0.3	171	Type 2	77.8707	-99	runway, no recharge
23	705	310.3808	30	4	0.004	305.3808	117.132	0.3	171	Type 2	81.0024	-99	runway, no recharge
24	675	307.9514	30	4	0.004	302.9514	117.132	0.3	171	Type 2	84.1341	-99	runway, no recharge
25	645	305.5219	30	4	0.004	300.5219	117.132	0.3	171	Type 2	86.9	-99	runway, no recharge
26	615	303.0925	30	4	0.004	298.0925	117.132	0.3	171	Type 2	89.3	-99	runway, no recharge
27	585	300.6631	30	4	0.004	295.6631	117.132	0.3	171	Type 2	91.1885	-99	runway, no recharge
28	555	298.4282	30	4	0.004	293.4282	117.132	0.3	171	Type 2	92.2579	-99	runway, no recharge
29	525	296.9078	30	5	0	286.9078	65.403	0.3	171	Type 2	92.7119	-99	runway, no recharge
30	495	295.3875	30	5	0	285.3875	65.403	0.3	171	Type 2	93.1833	90	
31	465	293.8671	30	5	0	283.8671	65.403	0.3	171	Type 2	93.7422	90	
32	435	292.3468	30	5	0	282.3468	65.403	0.3	171	Type 2	94.301	90	
33	405	290.8264	30	5	0	280.8264	65.403	0.3	171	Type 2	94.8599	90	
34	375	289.3061	30	5	0	279.3061	65.403	0.3	171	Type 2	95.1136	90	
35	345	287.7858	30	5	0	277.7858	65.403	0.3	171	Type 2	95.0621	90	
36	315	286.2654	30	5	0	276.2654	65.403	0.3	171	Type 2	95.0105	90	
37	285	284.7451	30	5	0	274.7451	65.403	0.3	171	Type 2	94.9444	90	top of embankment and western edge of area receiving recharge
38	255	283.2247	30	5	0	273.2247	65.403	0.3	171	Type 2	83.3366	-99	no recharge
39	225	281.7044	30	5	0	271.7044	65.403	0.3	171	Type 2	71.7288	-99	no recharge
40	195	280.184	30	5	0	270.184	65.403	0.3	171	Type 2	60.1209	-99	no recharge
41	165	278.6637	30	5	0	268.6637	65.403	0.3	171	Type 2	48.5131	-99	no recharge
42	135	277.1433	30	5	0	267.1433	65.403	0.3	171	Type 2	37.6989	-99	no recharge
43	105	275.623	30	5	0	265.623	65.403	0.3	171	Type 2	27.0434	-99	no recharge
44	75	274.7676	30	6	0	264.7676	21.285	0.3	171	Type 2	16.388	-99	no recharge
45	45	274.2734	30	6	0	264.2734	21.285	0.3	171	Type 2	5.5944	-99	no recharge
46	15	273.7791	30	6	0	263.7791	21.285	0.3	171	Type 2	0	-99	no recharge

Table 5-5
Slice 3 Model Parameters for Different Cell Types

	Cell Type 1	Cell Type 2	Cell Type 3
Surficial Soil	removed	removed	removed
Aquifer Materials	outwash stringers	outwash stringers	outwash stringers
Land Cover	embankment	embankment	embankment
Wetland/Upland	upland	upland	upland
Bottom Layer Hydraulic Conductivity (ft/d)	6	6	6
Top of Bottom Layer (ft above till)	2.5	2.5	4.75
Middle Layer Hydraulic Conductivity (ft/d)	300	300	300
Top of Middle Layer (ft above till)	3	6.5	8.75
Upper Layer Hydraulic Conductivity (ft/d)			
Top of Upper Layer (ft above till)			
Maximum Saturated Thickness (ft)	3	6.5	8.75
Gradient of Top of Till (ft/ft)	0.1711	0.0518	0.0518
Full Thickness Hydraulic Conductivity (ft/d)	55	186.9230769	140.4
Maximum Subsurface Flow (cfd)	28.2315	62.937	63.6363
Maximum Downgradient Flow (cfd)	28.2315	62.937	63.6363
Cell Length (ft)	25	25	25
Specific Yield	0.3	0.3	0.3
Maximum Storage (cubic ft)	22.5	48.75	65.625
Bottom Layer Storage (cubic ft)	18.75	18.75	35.625

Model Constants	
Till Thickness (ft)	10
Till Permeability Beneath Uplands (ft/d)	0.004
Till Permeability Beneath Wetlands (ft/d)	0
Outwash Permeability (ft/d)	6
Peat Permeability (ft/d)	1
Percent Outwash in Peaty Aquifer	0.33
Peaty Aquifer Permeability (ft/d)	2.65
Drain Material Permeability (ft/d)	300
Till Derived Soil Permeability (ft/d)	4
Outwash Derived Soil Permeability (ft/d)	4
Wetland Surficial Soil Permeability (ft/d)	1
Minimum Saturation Considered for h and T (ft)	0.0001

NOTE: All values are for a vertical slice of 1-foot width.

Time Stepping	
user defined model timestep (d)	0.1

AR 052782

FIGURES

Table 5-6
Slice 3 Model Cell Parameters

Cell ID	Distance from Outlet	Top of Till Elevation	Cell Length (ft)	Cell Type	Till Permeability (ft/d)	Head at Bottom of Till	Maximum Subsurface Outflow (cfd)	Specific Yield	Maximum Storage (cf)	Fill Material	Embankment Thickness (ft)	Modeled "Effective" Embankment Thickness (ft)		
1	612.5	368.7677	25	1	0.004	358.7677	28.2315	0.3	22.5	Type 2	0		-99	drain only, no overlying fill, excluded from model via zero recharge
2	587.5	366.3032	25	1	0.004	356.3032	28.2315	0.3	22.5	Type 2	0		-99	drain only, no overlying fill, excluded from model via zero recharge
3	562.5	363.9638	25	2	0.004	353.9638	62.937	0.3	48.75	Type 2	0		-99	drain only, no overlying fill, excluded from model via zero recharge
4	537.5	362.6697	25	2	0.004	352.6697	62.937	0.3	48.75	Type 2	0.8512		-99	excluded from model via zero recharge
5	512.5	361.3756	25	2	0.004	351.3756	62.937	0.3	48.75	Type 2	2.1642		-99	excluded from model via zero recharge
6	487.5	360.0815	25	2	0.004	350.0815	62.937	0.3	48.75	Type 2	3.6315		-99	runway, no recharge
7	462.5	358.7874	25	2	0.004	348.7874	62.937	0.3	48.75	Type 2	5.3445		-99	runway, no recharge
8	437.5	357.4933	25	2	0.004	347.4933	62.937	0.3	48.75	Type 2	7.0575		-99	runway, no recharge
9	412.5	356.1992	25	2	0.004	346.1992	62.937	0.3	48.75	Type 2	8.7706		-99	runway, no recharge
10	387.5	354.9051	25	2	0.004	344.9051	62.937	0.3	48.75	Type 2	10.4836		-99	runway, no recharge
11	362.5	353.611	25	2	0.004	343.611	62.937	0.3	48.75	Type 2	11.8881		-99	runway, no recharge
12	337.5	352.317	25	2	0.004	342.317	62.937	0.3	48.75	Type 2	12.8011		-99	runway, no recharge
13	312.5	351.0229	25	2	0.004	341.0229	62.937	0.3	48.75	Type 2	13.5926		-99	runway, no recharge
14	287.5	349.7288	25	2	0.004	339.7288	62.937	0.3	48.75	Type 2	14.3831		-99	runway, no recharge
15	262.5	348.4347	25	2	0.004	338.4347	62.937	0.3	48.75	Type 2	15.1737		-99	runway, no recharge
16	237.5	347.1406	25	2	0.004	337.1406	62.937	0.3	48.75	Type 2	15.7615		20	
17	212.5	345.8465	25	2	0.004	335.8465	62.937	0.3	48.75	Type 2	16.1106		20	
18	187.5	344.5524	25	2	0.004	334.5524	62.937	0.3	48.75	Type 2	16.5094		20	
19	162.5	343.2583	25	2	0.004	333.2583	62.937	0.3	48.75	Type 2	16.9081		20	
20	137.5	341.9642	25	2	0.004	331.9642	62.937	0.3	48.75	Type 2	17.3068		20	
21	112.5	340.6701	25	2	0.004	330.6701	62.937	0.3	48.75	Type 2	17.7056		20	
22	87.5	339.376	25	2	0.004	329.376	62.937	0.3	48.75	Type 2	18.1308		20	
23	62.5	338.0819	25	3	0.004	328.0819	63.6363	0.3	65.625	Type 2	19.1419		20	
24	37.5	336.7878	25	3	0.004	326.7878	63.6363	0.3	65.625	Type 2	17.3761		20	top of embankment and western edge of area receiving recharge in this cell
25	12.5	335.4937	25	3	0.004	325.4937	63.6363	0.3	65.625	Type 2	6.5615		-99	no recharge

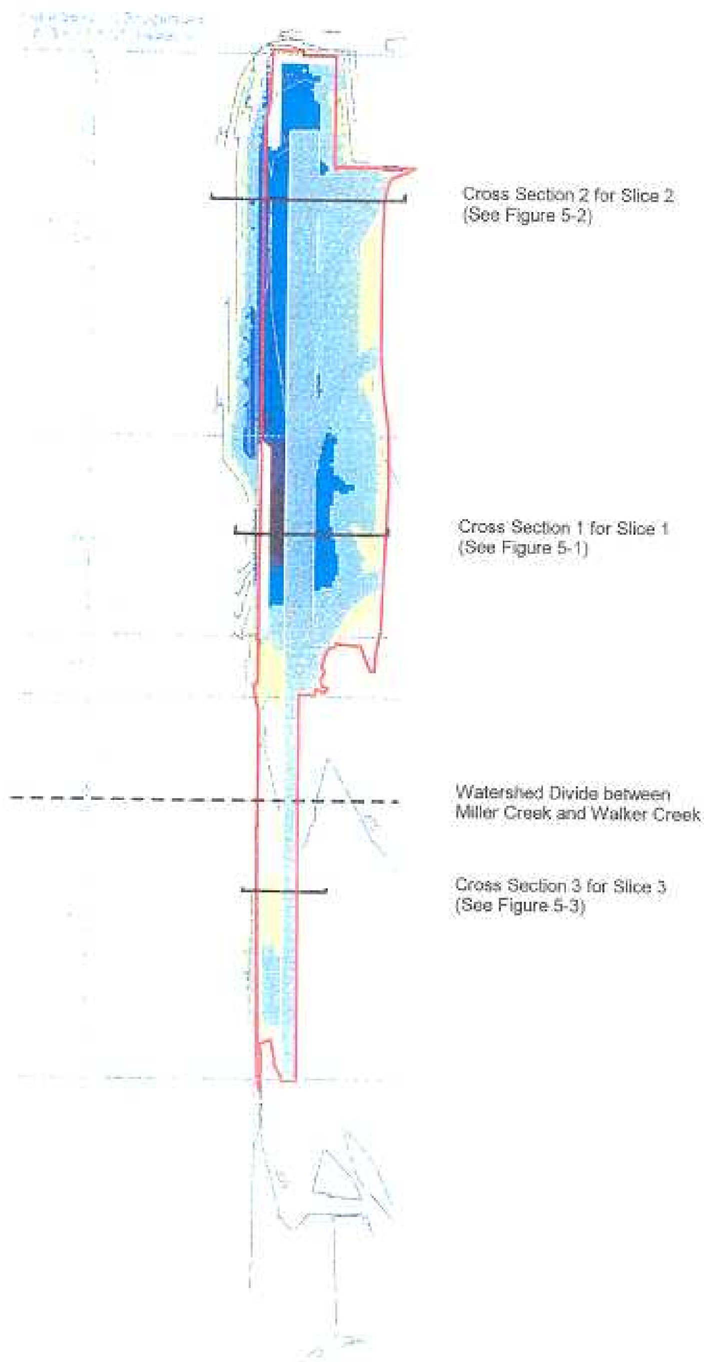
AR 052784

Table 5-7
Summary of Effective Basin Widths for Walker and Miller Creek Flow Estimates

Basin & Slice Representation	Impermeable Area, IA (sf)	Permeable Area, PA= FS+OPA (sf)	Modeled Fill Area (MFA) = IA+PA (sf)	Slice Active Cell Count	Slice Model Cell Length (ft)	Active Slice Length (ASL, ft)	Effective Basin Width (EBW, ft)	Approx. Mapped Basin Width (MBW, ft)	Fraction of EBW
Walker Creek	277,072	452,475	729,547						
Slice 3				14	25	350	2,084	2,300	100.0%
Miller Creek	1,797,702	3,203,503	5,001,205				5,229	6,230	
Slice 1				42	25	1,050	1,600	1,600	30.6%
Slice 2				37	30	1,110	2,699	3,700	51.6%
Slice 3				14	25	350	930	930	17.8%

Note: lengths are measured east-west and widths are measured north-south.

AR 052785



Depth of Fill (feet)

- 0 - 20
- 21 - 40
- 41 - 60
- 61 - 80
- 81 - 100
- 101 - 120
- 121 - 140
- 141 - 160

Approximate Area Modeled by Hydrus and Slice (Clipped from HSPF)*

Impervious Area

"Built" Elevation Contours (25 ft interval)

N

0 1000 Feet

1:12,000

Figure 2-1

Site Features for Hydrus-Slice Modeling

SeaTac Third Runway
Embankment Fill Modeling
JE0105

Pacific Groundwater Group

AR 052786

Figure 4-1 - Hydrus Model Output for Miller Creek Fill - Water Years 1991 - 1994

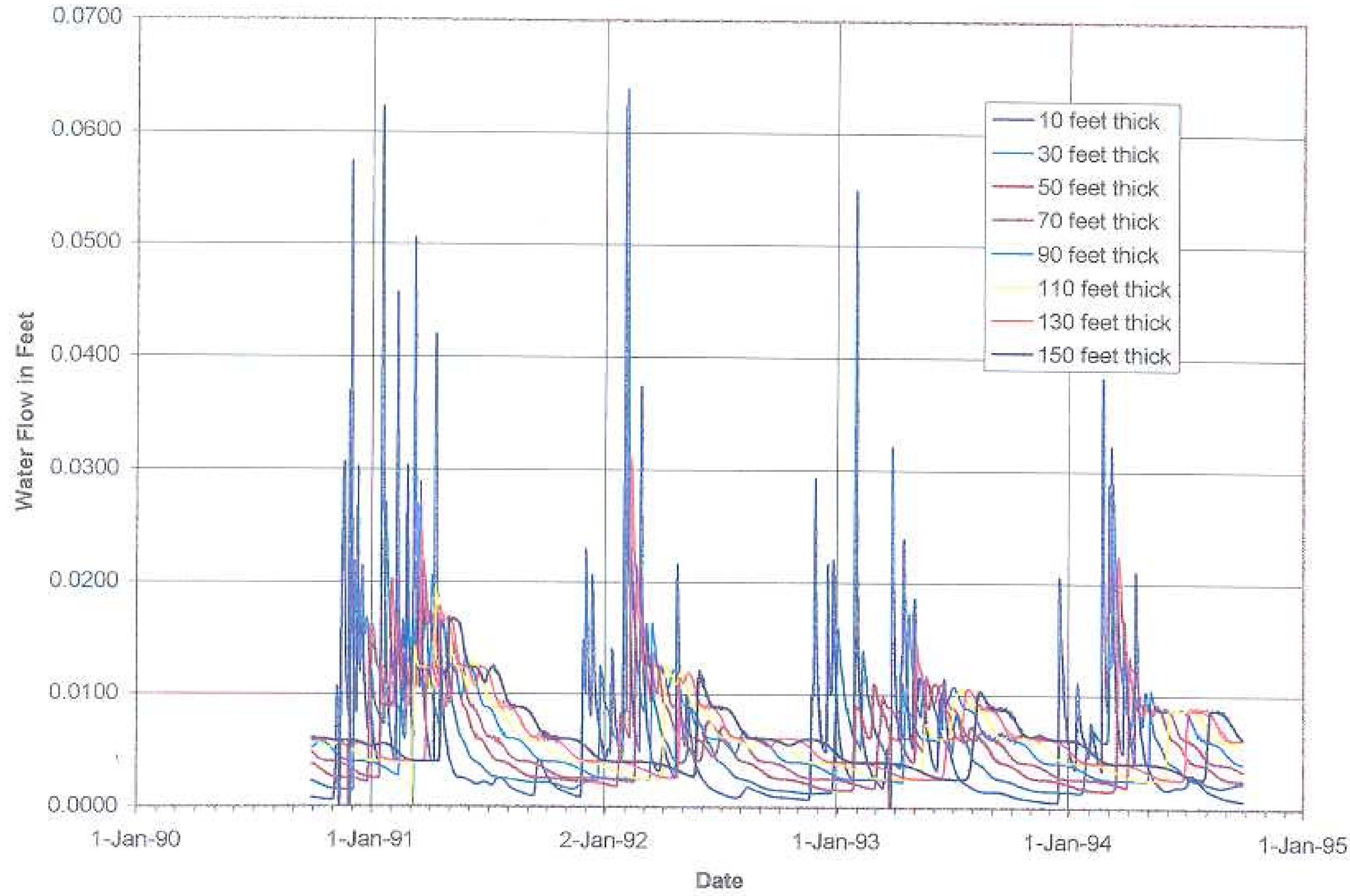
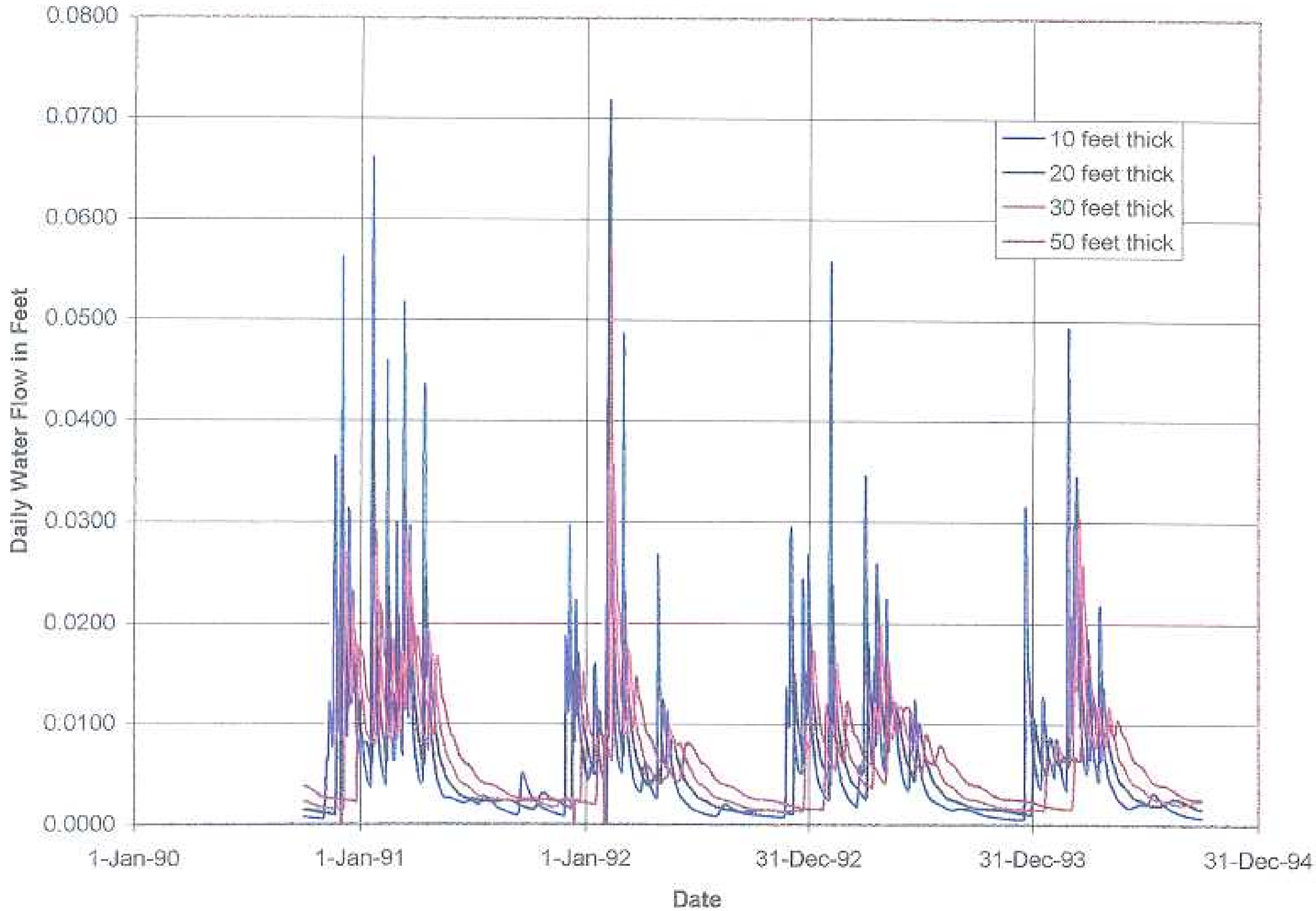
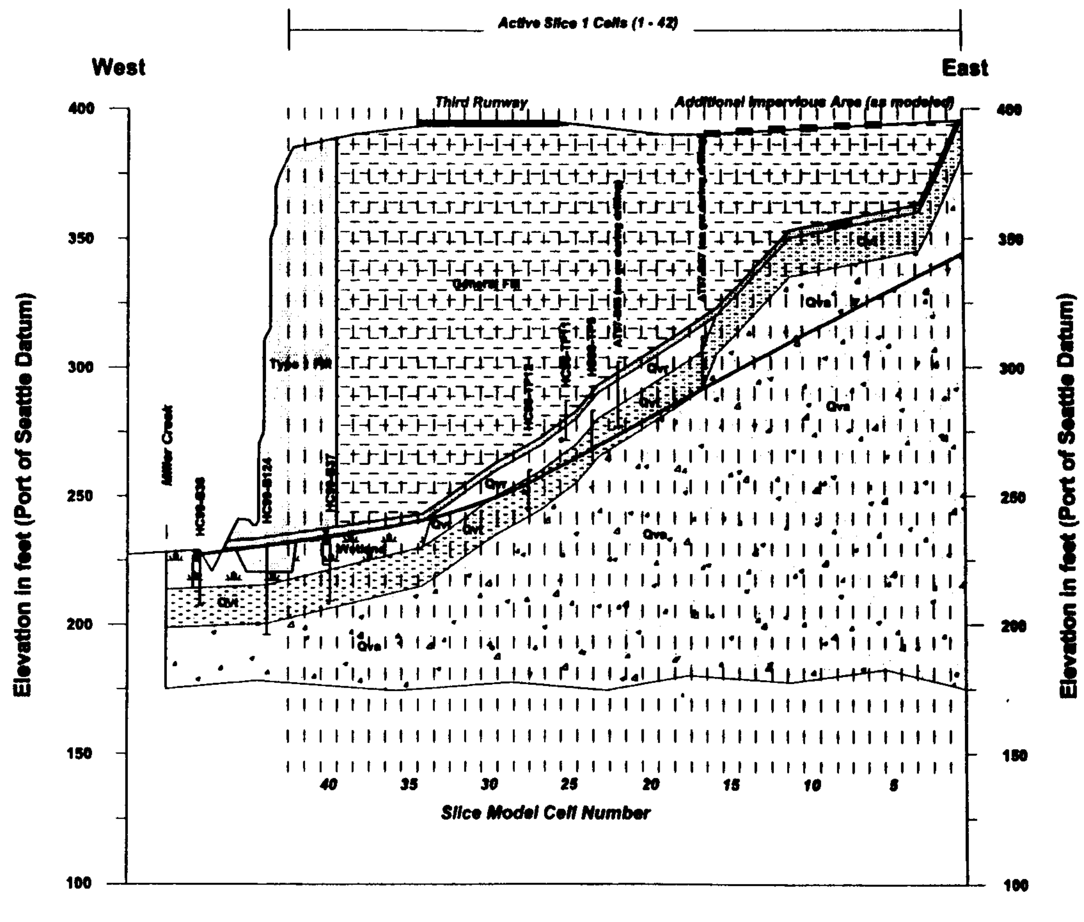


Figure 4-2 - Hydrus Model Output for Walker Creek Fill - Water Years 1991 - 1994





LEGEND

- Groundwater Elevation
- Groundwater Seepage Elevation
- Conceptual Water Table
- General Fill
- Type 1 Fill
- Wetland
- Qvr - Vashon Recessional Outwash
- Qvt - Vashon Till
- Qva - Vashon Advance Outwash
- HC99-B36 — Well with high and low water level and identifier

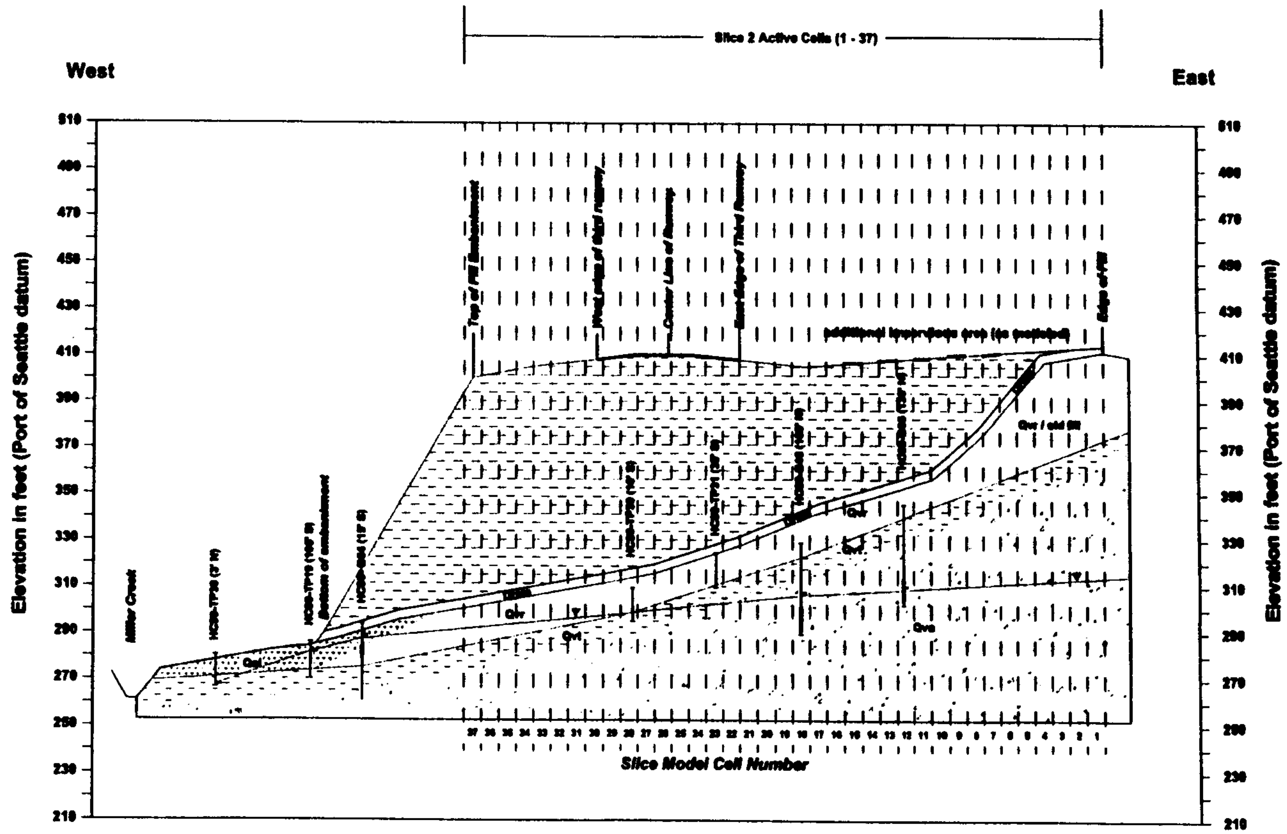
Horizontal Scale in Feet: 0, 100, 200
Vertical Scale in Feet: 0, 25, 50

FIGURE 5-1
Simplified Cross Section for Slice 1

SeaTac Third Runway
Embankment Fill Modeling

Pacific Groundwater Group

AR 052789



LEGEND

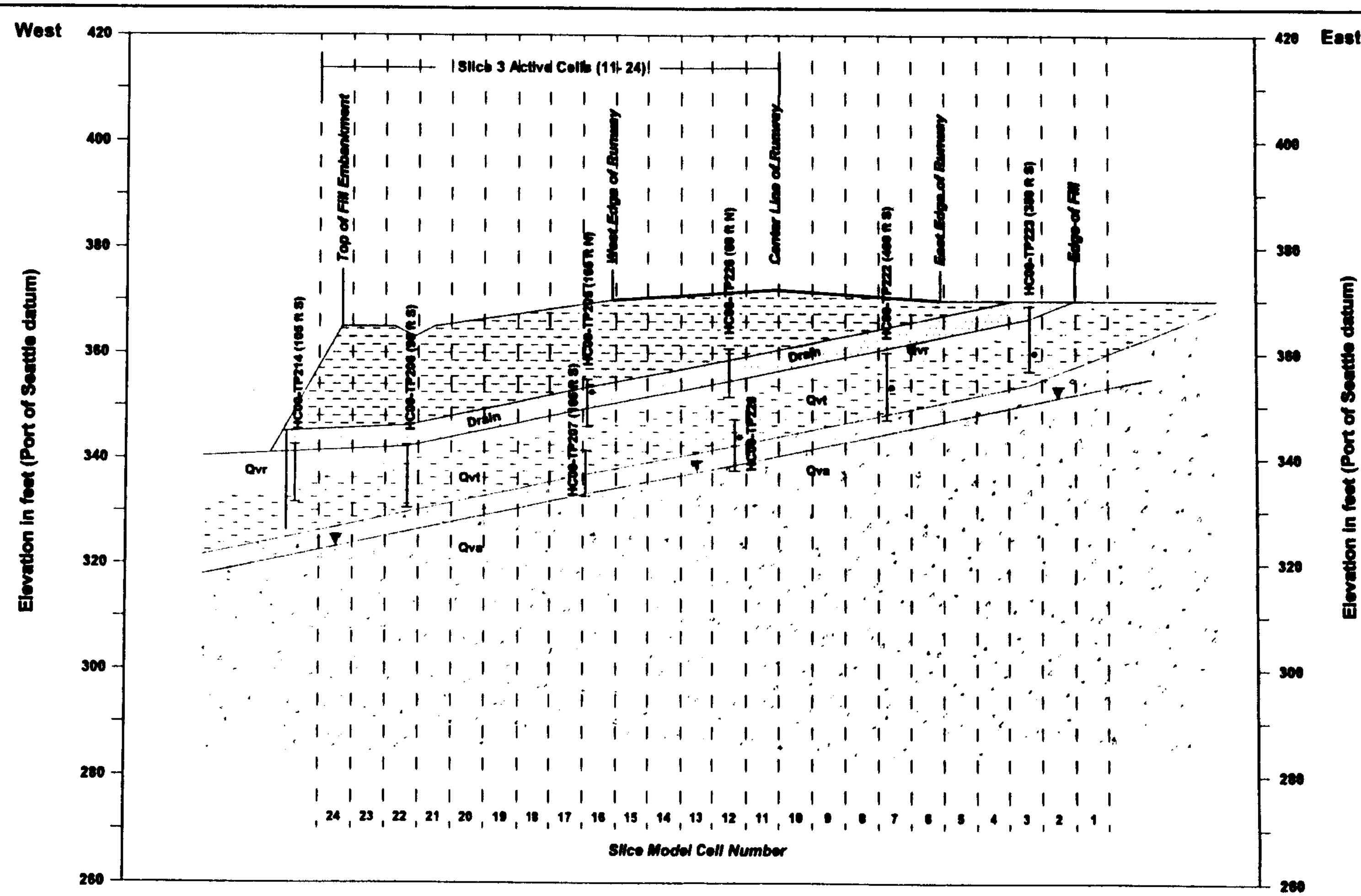
- Groundwater Elevation
- Groundwater Seepage Elevation
- Conceptual Water Table
- General Fill
- Qvr - Vashon Recessional Outwash
- Qvt - Vashon Till
- Qva - Vashon Advance Outwash
- Qal - Recent Alluvium
- Well with high and low water level and identifier

Horizontal Scale in Feet: 0, 100, 200
Vertical Scale in Feet: 0, 25, 50

FIGURE 5-2
Simplified Cross Section for Slice 2

SeaTac Third Runway
Embankment Fill Modeling

Pacific Groundwater Group



LEGEND

- ▼ Groundwater Elevation
- ● Groundwater Seepage Elevation
- Conceptual Water Table
- General Fill
- Qvr - Vashon Recessional Outwash
- Qvt - Vashon Till
- Qva - Vashon Advance Outwash
- Well with high and low water level and identifier

Horizontal Scale in Feet: 0, 40, 80
Vertical Scale in Feet: 0, 10, 20

FIGURE 5-3
Simplified Cross Section for Slice 3

SeaTac Third Runway
Embankment Fill Modeling

Pacific Groundwater Group

Figure 5-4   Slice 1 Model Output for Test Period

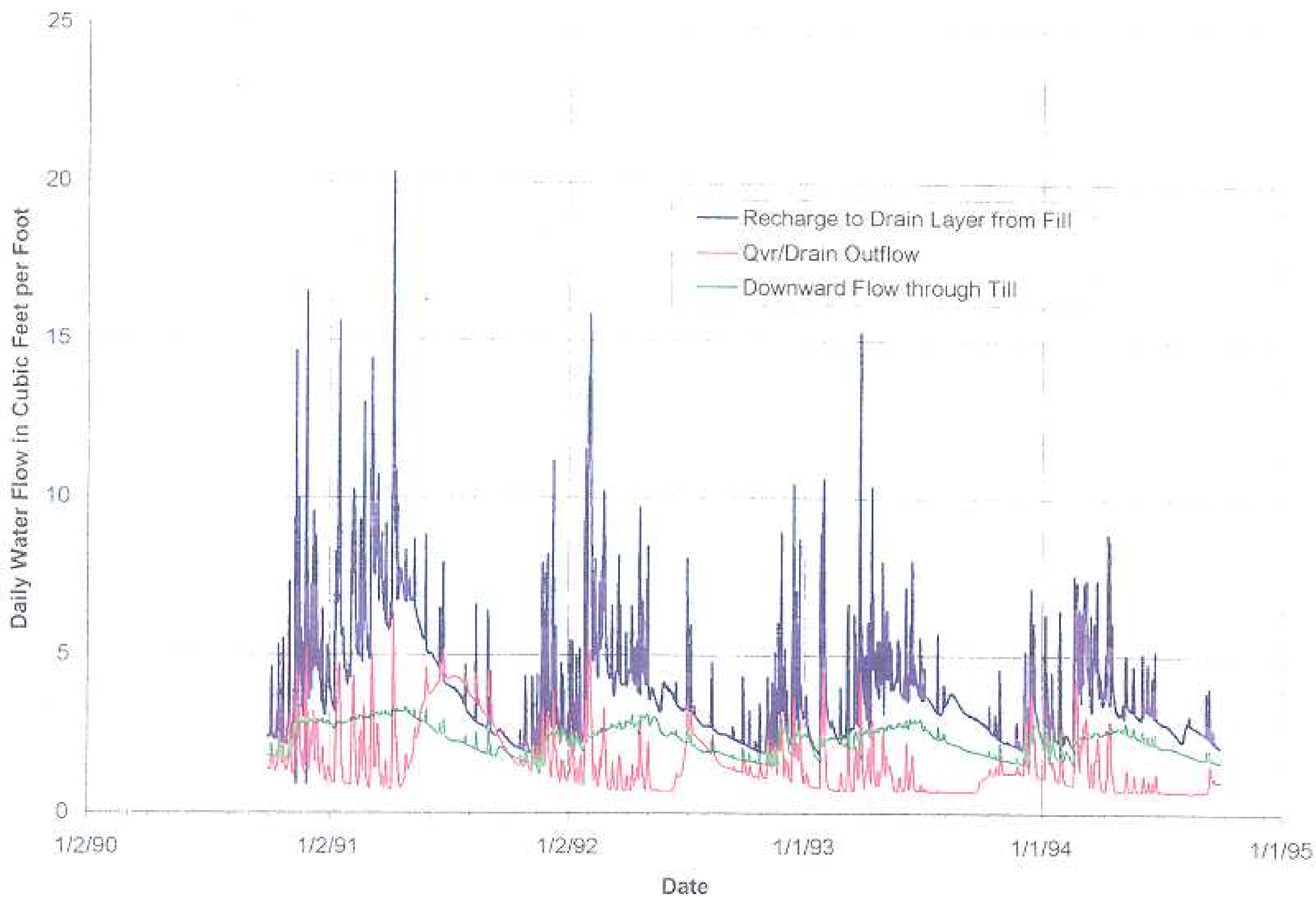


Figure 5-5 - Slice 2 Model Output for Test Period

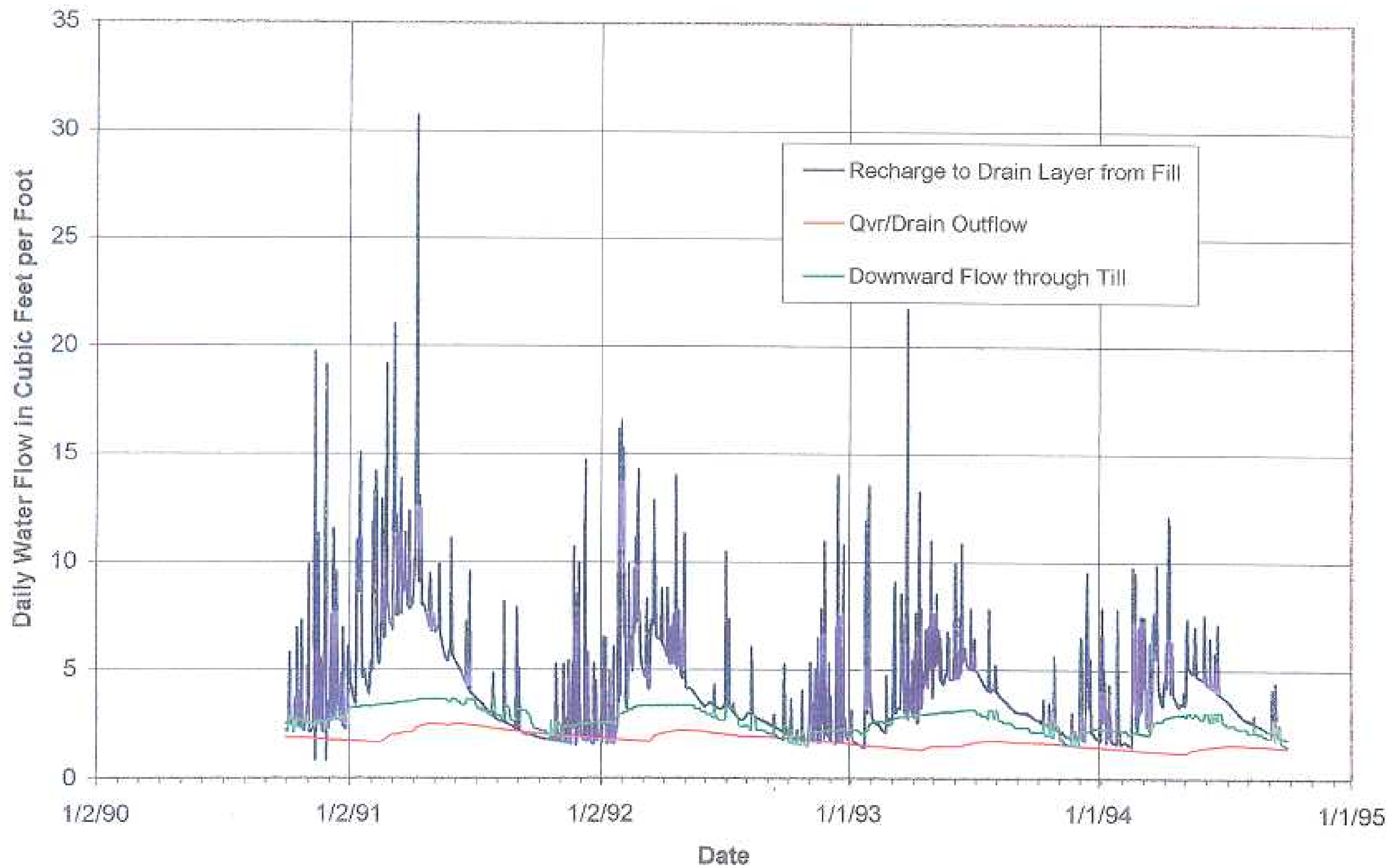


Figure 5-6 - Slice 3 Model Output for Test Period

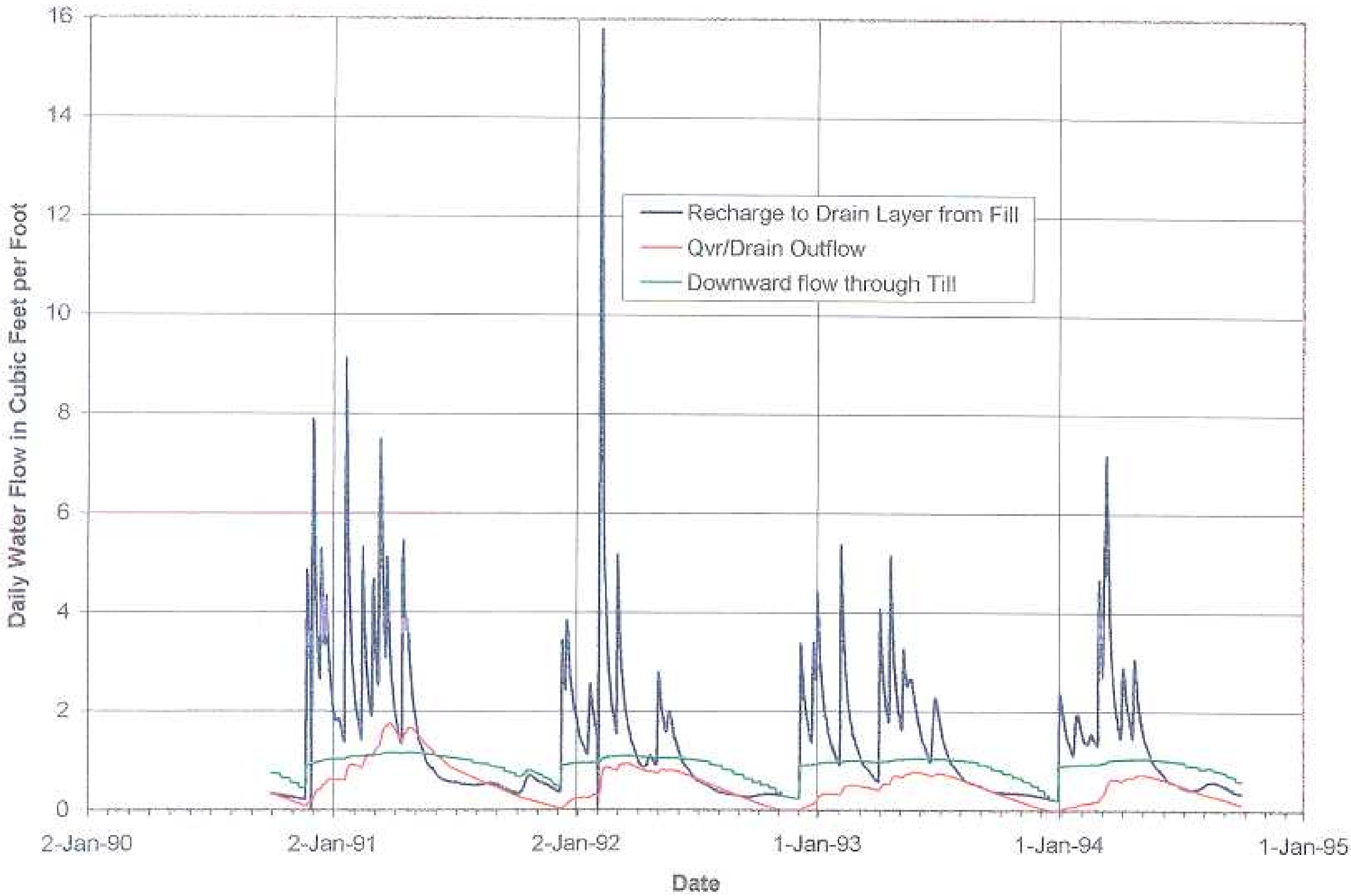
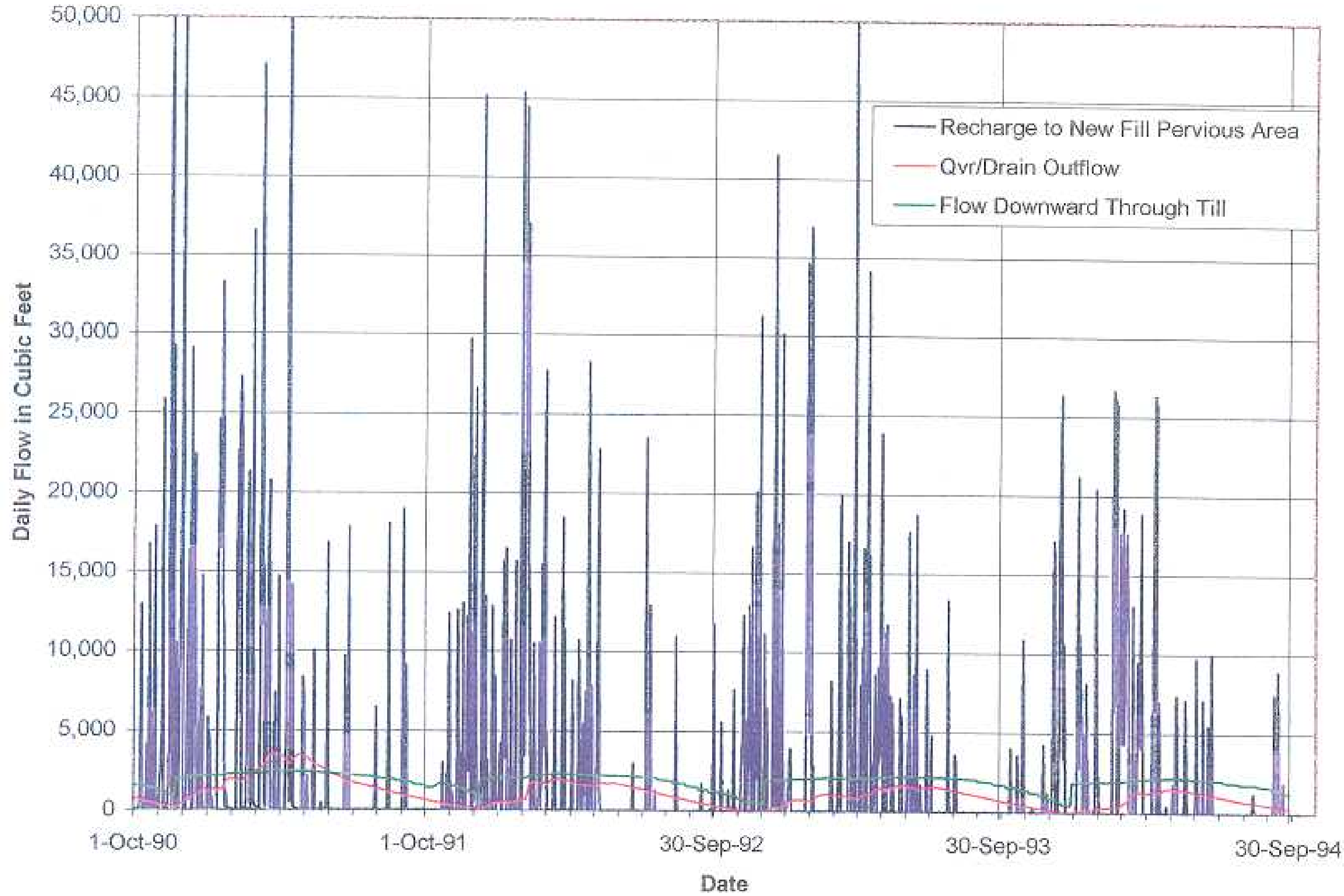
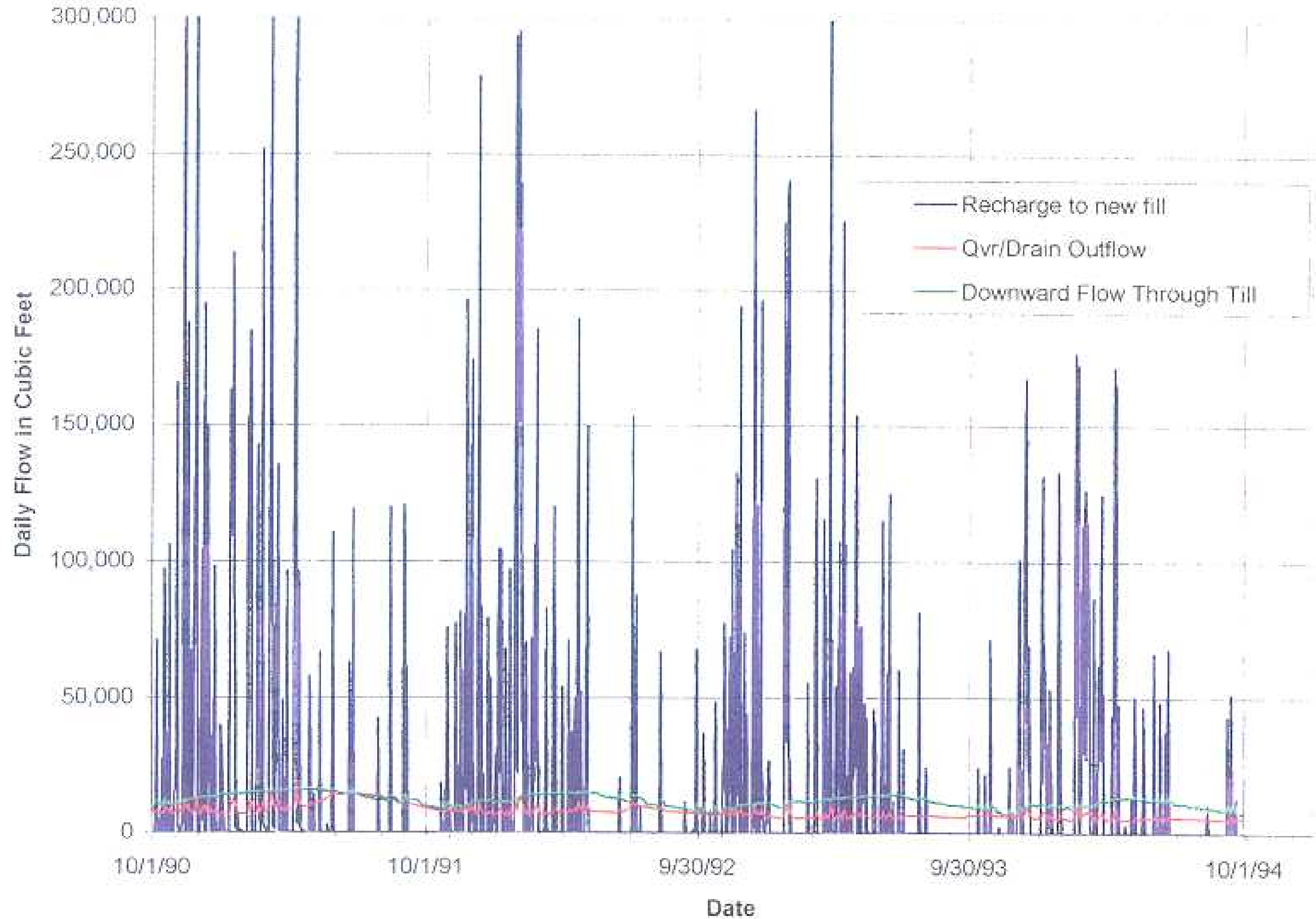


Figure 5-7 - Walker Creek Fill Inflow and Outflow for Test Period



AR 052795

Figure 5-8 - Miller Creek Fill Inflow and Outflow for Test Period



Appendix C

APPENDIX C

EMBANKMENT INFILTRATION MEMORANDUM

HNTB
The HNTB Companies
600 108th Ave., Suite 400, Bellevue, WA 98004
(425) 455-3555 • Fax (425) 453-9179 • Architectural Fax (425) 450-2597

Memorandum

To	Michael Cheyne, PMP Third Runway Program Leader	Date	October 26, 2000
From	Jim Thomson, P.E., HNTB Mike Bailey, P.E., Hart Crowser Michael Kenrick, P.E., Hart Crowser		
Subject	Third Runway Embankment Infiltration		

Summary

Sometime ago, the Third Runway Design Team was asked to consider taking steps toward providing enhanced infiltration within the embankment. Because of the stormwater detention benefit infiltration provides, the team had already reviewed the possibilities of enhanced infiltration and believed the project could provide opportunity in the following ways:

- Use of flatter cross slopes on the airfield providing greater stormwater residence time on pervious surfaces.
- Longer water courses over pervious surfaces prior to storm sewer collection also increasing residence time.
- Use of a variety of naturally occuring fill materials allowing for some infiltration while continuing to provide stability.

Recently, the design team was asked to provide additional infiltration beyond what would occur from the design approach outlined above. We have evaluated alternatives, which would meet both design goals of enhanced infiltration and embankment stability. The design team believes that artificially increasing the amount of infiltration beyond standard design and construction practice for an embankment of this depth would increase the risk of instability, increase construction complexity and costs, and may result in adverse impacts beyond the embankment limits. We believe the benefit, which might be provided through enhanced infiltration, is out-weighed by the increased risks to the embankment.

Embankments that are designed and constructed for storm water retention, reservoirs, etc. are typically built as zoned embankments, with different soil material zones used to control seepage and provide necessary drainage or strength to accommodate the resultant pore pressures. The proposed Third Runway embankment is a type of zoned embankment, but its zones were designed to optimize support of the airfield pavement sections with minimum long term risk. The increased risks resulting from enhanced infiltration are:

- Increased risk of surficial slope stability problems related to seepage
- Increase risk of subgrade liquefaction base stability
- Increased construction complexity
- Long term maintenance issues

A more detailed discussion of the increased risks follows in the next section of this memorandum.

Details of Increased Risk

1. Increased Risk of Surficial Slope Stability Problems Related to Seepage

Side slopes for the proposed embankment are designed to be constructed of readily available soil fill, which can achieve the strength needed with conventional construction methods. The strength necessary for the fill depends on a number of factors, but mainly on the angle of the side slopes, drainage conditions, anticipated seismic loads and foundation conditions. Increasing the amount of water infiltrated into the embankment has the potential to reduce stability by increasing pore pressures. This would have three adverse effects:

- Increased risk of piping and erosion-related instability ("sloughing") of the embankment side slopes due to seepage forces and loss of support where the seep exits the embankment surface;
- Increased soil bulk density due to the added weight of water, which will contribute to the potential for failure of the embankment; and
- Decreased soil strength near the surface of the slope but within the embankment (the effective strength available from soil friction is less than the unsaturated total strength by an amount equal to the increase in pore pressure).

Making a commitment to a specific flow rate and flow timing (during late summer), would require a specific water volume retained. Soil engineering would need to be based on flow rate and not stability.

2. Increased Risk of Subgrade Liquefaction Base Stability

Native soils that provide the foundation for the Third Runway embankment generally consist of a layer of relatively loose to moderately dense sands and interbedded cohesive soils, overlying very dense or hard, glacially overridden soils. Typically there is a layer of groundwater perched on top of the more dense glacial soils, and in some areas this saturated soil zone is subject to significant strength loss during seismic shaking – a process referred to as "liquefaction". The design team has defined some areas where subgrade improvements (i.e., densification or replacement of the native soil) are needed to mitigate liquefaction.

Artificially increasing the amount of infiltration into the embankment would likely lead to an increase in groundwater levels below the embankment, and thus increase the risk and area of potential liquefaction. The extent of this change is difficult to predict and thus an increase in risk would result. (A portion of the additional infiltration is expected to discharge via the underdrain. However, the underdrain is designed to prevent build-up of pore pressures in the fill placed above the drain and will not prevent the water table beneath the embankment from rising to the level of the drain itself; i.e., to the existing ground level).

Potential adverse impacts of liquefaction include reduced embankment stability due to loss of soil shear strength, as well as potential vertical displacement or other ground disturbance (e.g., "sand boils") along the relatively level ground adjacent to the embankment. The potential for liquefaction of native soils adjacent to the embankment already exists, but the risk of occurrence and magnitude would be increased by raising existing groundwater levels, as a direct result of increased infiltration.

3. Increased Construction Complexity and Cost

Specifications for embankment construction to date have included a range of soil fill materials in order to obtain cost competitive bids while supporting airfield pavement sections. Modification of the embankment to increase infiltration would increase complexity of construction and is anticipated to increase construction costs in one or all of the following ways:

- Soil fill used to enhance infiltration would need to be a select material, since the infiltration capacity of sand and gravel decreases rapidly as the percentage of clay and silt increases even moderately. Using bids from the current year for comparison, the cost of the Group 1, non-silty (or "freely draining") soil to enhance infiltration, compared with the more silty Groups 2, 3 and 4 soil used as common embankment fill is about 200 percent more expensive.
- Note that the cost difference presented above does not present the complete picture. Restricting the gradation of the fill material would restrict the number of sources that could supply it, and that along with an increase in the total amount of non-silty soil that needs to be used could possibly increase the unit cost. Further cost increases related to construction management and survey control would also probably occur in the event that placement is required to configure special infiltration zones within the embankment.
- Increased pore pressures within the embankment and liquefaction susceptible subgrade soils would need to be mitigated to achieve the same factor of safety as obtained for the embankment without enhanced infiltration. This mitigation could include use of higher strength embankment material and/or by increased subgrade improvements. Increased costs would result from using higher quality or more highly compacted fill soils; reinforcing the fill; and increasing the area of coverage and/or increasing the density of subgrade improvements within existing areas.

4. Increased Need for Long-term Maintenance and Associated Risks

There are a number of alternatives available that initially appear to provide some opportunity to increase infiltration into the embankment, such as increasing length between catch basins in grassed areas between pavement; infiltration swales; perforated pipes extending from catch basins; a surficial layer of plating sand, etc. All of these approaches are likely to require some degree of maintenance in order to prevent siltation, bacteriological clogging, and/or other problems to provide effective long-term functioning.

Drains in general need to have some means of being cleaned out, and this applies equally to soil zones used to promote infiltration and transmit seepage. There is virtually no way to maintain an infiltration system deep within an embankment. It is also worth noting that once the embankment has been constructed, there will be no way to detect or "unclog" a failed infiltration system deep within the interior of the embankment. Furthermore, a failed system will increase the potential for a stability failure within the embankment.

Appendix D

APPENDIX D

NON-HYDROLOGIC IMPACTS SUPPORT DATA

CERTIFICATE OF ENGINEER

The technical material and data contained in this appendix were prepared under the supervision and direction of the undersigned, whose seal, as a professional engineer licensed to practice as such, is affixed below.

(affix seal here)

Richard L. Schaefer, P.E.

Historic Water Withdrawals from Miller Creek

Documentation

This spreadsheet was created for the purpose of developing a time series representing water withdrawal from Miller Creek due to pumping. This time series is intended to represent conditions prior to the removal of homes in the buyout area.

The worksheet "Annual Time Series" contains the estimated annual water withdrawal from Miller Creek. The total water withdrawal is shaded in yellow in Column B. It is the sum at each hour of the estimated water withdrawal from each parcel contained in Columns C - Y

The time series was constructed using the values and notes presented in Table 2-7. Key notes from Table 2-7 used to construct the time series are listed below:

The quantity of water withdrawn was estimated as follows:

> Available Pumping Rate x Estimated Months of Water Use Per Year x 0.5 (daily pumping duration)
>
> The time series was constructed using the available pumping rate for 12 hours per day (6 am to 6 pm each day).
>
> Estimated months of water use per year was assumed as follows:
>
> 6 Months = April 1 - Sep 30
> 4 Months = June 1 - Sep 30

Summary of Historic Miller Creek Withdrawal Time Series

Date From	Date To	Time From	Time To	Withdrawal (cfs)
1-Jan	31-Mar	12:00 AM	12:00 AM	0.000
1-Apr	31-May	6:00 AM	6:00 PM	0.033
		6:00 PM	6:00 AM	0.000
1-Jun	30-Sep	6:00 AM	6:00 PM	0.042
		6:00 PM	6:00 AM	0.000
1-Oct	16-Oct	6:00 AM	6:00 PM	0.001
		6:00 PM	6:00 AM	0.000
17-Oct	31-Dec	12:00 AM	12:00 AM	0.000

Historic Groundwater Recharge of Imported Water through Septic Systems

Documentation

This spreadsheet was created for the purpose of developing time series representing water recharge from water imported into the buyout area via water distribution systems. Recharge takes two potential forms: 1. recharge from septic systems; 2. recharge from infiltration of irrigation water. These time series is intended to represent conditions prior to the acquisition and removal of homes in the buyout area.

The time series on this worksheet (Recharge from Septic) represents water recharge from septic systems in the buyout area. The recharge to each watershed from septic systems was based on estimated water consumption. Recharge from septic systems is based on winter water use. Additional water use during summer months (above and beyond winter water use) is provided in a separate time series.

The estimated annual water recharge from septic systems in the buyout area to each of the three watersheds is provided below in Columns A - D. The model time series was constructed with an hourly time step. However, the recharge rates shown below reflect estimated daily recharge.

Estimated Recharge Quantity

	Miller Creek	Walker Creek	Des Moines Creek	
Number of Active Septic Tanks	236	41	0	Total of 291 homes were served by septic in Walker and Miller Creek Basins prior to the buy-out. Some of these homes (14) were also served by sewer, and the septic systems were inactive. Based on inventory of septic tanks removed, there were 41 active tanks in the Walker Creek basin buy-out area and 236 in the Miller Creek basin buy-out area (total 277 active tanks, 14 inactive).
Winter Water Use (gallons per home per day)	249	249	249	Winter water use was used to estimate recharge from septic systems. Typical values for winter water use were provided by Water District #20 and Water District #125.
Recharge from Septic Systems (gallons per day)	52,962	9,201	-	Estimated recharge to groundwater within each watershed expressed in gallons per day (number of active tanks multiplied by 90 percent of winter water use rate).
Contribution to streamflow (cfs)	0.0574	0.0100	-	Estimated portion of groundwater recharge available to support streamflows (70 percent of recharge to groundwater).

Appendix E

APPENDIX E

HEC-RAS MODELING INFORMATION AND FIELD SURVEY DATA

Average Change in Flow Depth and Width

By: Angela Wilcox
Checked By: [signature]
December 6, 2001

	Average Change in Flow Depth (ft)	Average Change in Flow Depth (mm)	Average Change in Top Width (ft)	Average Change in Top Width (mm)
Miller Creek	0.00 ft	0 mm	0.02 ft	6 mm
Walker Creek	-0.01 ft	-3 mm	-0.10 ft	-30 mm
Des Moines Creek	-0.03 ft	-9 mm	-0.33 ft	-101 mm

Miller Creek @ SR509

HSPF Modeling
7 Day Low Flows (1949-1996)
Q[illegible] = 0.42 cfs
Q[illegible] = 1.80 cfs
Q[illegible] = 0.01 cfs

HEC-RAS Plan: [illegible] River: Miller Creek Reach: [illegible] Manning's n = [illegible]

River Station	Q Total (cfs)	Minimum Channel Elevation (ft)	Water Surface Elevation (ft)	Flow Depth (ft)	Change in Flow Depth (ft)	Velocity Channel (ft/s)	Flow Area (sq ft)	Top Width (ft)	Change in Top Width (ft)
4	0.40	7.02	7.17	0.15	N/A	1.35	0.30	3.12	N/A
4	0.41	7.02	7.17	0.15	0.00	1.36	0.30	3.14	0.01
4	0.42	7.02	7.18	0.16	0.01	1.37	0.31	3.16	0.02
4	0.43	7.02	7.18	0.16	0.00	1.38	0.31	3.18	0.02
4	0.44	7.02	7.18	0.16	0.00	1.39	0.32	3.19	0.01
4	0.45	7.02	7.18	0.16	0.00	1.40	0.32	3.21	0.02
4	0.46	7.02	7.18	0.16	0.00	1.41	0.33	3.23	0.02
4	0.47	7.02	7.18	0.16	0.00	1.42	0.33	3.24	0.01
4	0.48	7.02	7.18	0.16	0.00	1.43	0.34	3.26	0.02
4	0.49	7.02	7.19	0.17	0.01	1.44	0.34	3.27	0.01
4	0.50	7.02	7.19	0.17	0.00	1.45	0.34	3.29	0.02
4	0.51	7.02	7.19	0.17	0.00	1.46	0.35	3.31	0.02
4	0.52	7.02	7.19	0.17	0.00	1.47	0.35	3.32	0.01
4	0.53	7.02	7.19	0.17	0.00	1.48	0.36	3.33	0.01
4	0.54	7.02	7.19	0.17	0.00	1.49	0.36	3.33	0.00
4	0.55	7.02	7.19	0.17	0.00	1.50	0.37	3.34	0.01
4	0.56	7.02	7.20	0.18	0.01	1.51	0.37	3.34	0.00
4	0.57	7.02	7.20	0.18	0.00	1.52	0.38	3.35	0.01
4	0.58	7.02	7.20	0.18	0.00	1.53	0.38	3.35	0.00
4	0.59	7.02	7.20	0.18	0.00	1.54	0.38	3.36	0.01
4	0.60	7.02	7.20	0.18	0.00	1.55	0.39	3.36	0.00
4	0.61	7.02	7.20	0.18	0.00	1.56	0.39	3.37	0.01
4	0.62	7.02	7.20	0.18	0.00	1.56	0.40	3.37	0.00
4	0.63	7.02	7.20	0.18	0.00	1.57	0.40	3.38	0.01
4	0.64	7.02	7.21	0.19	0.01	1.58	0.40	3.38	0.00
4	0.65	7.02	7.21	0.19	0.00	1.59	0.41	3.38	0.00
4	0.66	7.02	7.21	0.19	0.00	1.60	0.41	3.39	0.0:
4	0.67	7.02	7.21	0.19	0.00	1.61	0.42	3.39	0.00
4	0.68	7.02	7.21	0.19	0.00	1.62	0.42	3.40	0.01
4	0.69	7.02	7.21	0.19	0.00	1.63	0.42	3.40	0.00
4	0.70	7.02	7.21	0.19	0.00	1.64	0.43	3.41	0.01
4	0.71	7.02	7.21	0.19	0.00	1.65	0.43	3.41	0.00
4	0.72	7.02	7.21	0.19	0.00	1.65	0.44	3.42	0.01
4	0.73	7.02	7.22	0.20	0.01	1.66	0.44	3.42	0.00
4	0.74	7.02	7.22	0.20	0.00	1.67	0.44	3.43	0.01
4	0.75	7.02	7.22	0.20	0.00	1.68	0.45	3.43	0.00
4	0.76	7.02	7.22	0.20	0.00	1.69	0.45	3.43	0.00
4	0.77	7.02	7.22	0.20	0.00	1.69	0.45	3.44	0.01
4	0.78	7.02	7.22	0.20	0.00	1.70	0.46	3.44	0.00
4	0.79	7.02	7.22	0.20	0.00	1.71	0.46	3.45	0.01
4	0.80	7.02	7.22	0.20	0.00	1.72	0.47	3.45	0.00
4	0.81	7.02	7.22	0.20	0.00	1.73	0.47	3.46	0.01
4	0.82	7.02	7.23	0.21	0.01	1.73	0.47	3.46	0.00
4	0.83	7.02	7.23	0.21	0.00	1.74	0.48	3.46	0.00
4	0.84	7.02	7.23	0.21	0.00	1.75	0.48	3.47	0.01
4	0.85	7.02	7.23	0.21	0.00	1.76	0.48	3.47	0.00
4	0.86	7.02	7.23	0.21	0.00	1.76	0.49	3.47	0.01
4	0.87	7.02	7.23	0.21	0.00	1.77	0.49	3.48	0.00
4	0.88	7.02	7.23	0.21	0.00	1.78	0.49	3.48	0.01
4	0.89	7.02	7.23	0.21	0.00	1.79	0.50	3.49	0.00
4	0.90	7.02	7.23	0.21	0.00	1.79	0.50	3.49	0.00
4	0.91	7.02	7.23	0.21	0.00	1.80	0.51	3.50	0.01
4	0.92	7.02	7.24	0.22	0.01	1.81	0.51	3.50	0.00
4	0.93	7.02	7.24	0.22	0.00	1.81	0.51	3.51	0.01
4	0.94	7.02	7.24	0.22	0.00	1.82	0.52	3.51	0.00
4	0.95	7.02	7.24	0.22	0.00	1.83	0.52	3.51	0.00
4	0.96	7.02	7.24	0.22	0.00	1.83	0.52	3.52	0.01
4	0.97	7.02	7.24	0.22	0.00	1.84	0.53	3.52	0.00
4	0.98	7.02	7.24	0.22	0.00	1.85	0.53	3.53	0.01
4	0.99	7.02	7.24	0.22	0.00	1.85	0.53	3.53	0.00
4	1.00	7.02	7.24	0.22	0.00	1.86	0.54	3.53	0.00
4	1.01	7.02	7.24	0.22	0.00	1.87	0.54	3.54	0.01
4	1.02	7.02	7.25	0.23	0.01	1.87	0.54	3.54	0.00
3	0.40	6.89	7.04	0.15	N/A	1.36	0.29	3.12	N/A
3	0.41	6.89	7.04	0.15	0.00	1.37	0.30	3.14	0.02
3	0.42	6.89	7.05	0.16	0.01	1.38	0.30	3.15	0.01
3	0.43	6.89	7.05	0.16	0.00	1.39	0.31	3.17	0.02
3	0.44	6.89	7.05	0.16	0.00	1.40	0.31	3.19	0.02
3	0.45	6.89	7.05	0.16	0.00	1.41	0.32	3.20	0.01
3	0.46	6.89	7.05	0.16	0.00	1.42	0.32	3.22	0.02
3	0.47	6.89	7.05	0.16	0.00	1.43	0.33	3.24	0.02
3	0.48	6.89	7.05	0.16	0.00	1.44	0.33	3.25	0.01
3	0.49	6.89	7.06	0.17	0.01	1.45	0.34	3.27	0.02
3	0.50	6.89	7.06	0.17	0.00	1.46	0.34	3.28	0.01
3	0.51	6.89	7.06	0.17	0.00	1.47	0.35	3.30	0.02
3	0.52	6.89	7.06	0.17	0.00	1.48	0.35	3.31	0.01
3	0.53	6.89	7.06	0.17	0.00	1.49	0.36	3.32	0.01
3	0.54	6.89	7.06	0.17	0.00	1.50	0.36	3.33	0.01
3	0.55	6.89	7.06	0.17	0.00	1.51	0.37	3.33	0.00
3	0.56	6.89	7.07	0.18	0.01	1.52	0.37	3.34	0.01
3	0.57	6.89	7.07	0.18	0.00	1.53	0.37	3.34	0.00
3	0.58	6.89	7.07	0.18	0.00	1.54	0.38	3.35	0.01
3	0.59	6.89	7.07	0.18	0.00	1.55	0.38	3.35	0.00
3	0.60	6.89	7.07	0.18	0.00	1.55	0.39	3.36	0.01
3	0.61	6.89	7.07	0.18	0.00	1.56	0.39	3.36	0.00
3	0.62	6.89	7.07	0.18	0.00	1.57	0.39	3.37	0.01
3	0.63	6.89	7.07	0.18	0.00	1.58	0.40	3.37	0.00
3	0.64	6.89	7.08	0.19	0.01	1.59	0.40	3.38	0.01
3	0.65	6.89	7.08	0.19	0.00	1.60	0.41	3.38	0.00
3	0.66	6.89	7.08	0.19	0.00	1.61	0.41	3.39	0.01
3	0.67	6.89	7.08	0.19	0.00	1.62	0.41	3.39	0.00
3	0.68	6.89	7.08	0.19	0.00	1.63	0.42	3.40	0.01
3	0.69	6.89	7.08	0.19	0.00	1.64	0.42	3.40	0.00
3	0.70	6.89	7.08	0.19	0.00	1.64	0.43	3.41	0.01
3	0.71	6.89	7.08	0.19	0.00	1.65	0.43	3.41	0.00
3	0.72	6.89	7.08	0.19	0.00	1.66	0.43	3.41	0.00
3	0.73	6.89	7.09	0.20	0.01	1.67	0.44	3.42	0.01
3	0.74	6.89	7.09	0.20	0.00	1.68	0.44	3.42	0.00
3	0.75	6.89	7.09	0.20	0.00	1.69	0.44	3.43	0.01
3	0.76	6.89	7.09	0.20	0.00	1.69	0.45	3.43	0.00
3	0.77	6.89	7.09	0.20	0.00	1.70	0.45	3.44	0.01
3	0.78	6.89	7.09	0.20	0.00	1.71	0.46	3.44	0.00
3	0.79	6.89	7.09	0.20	0.00	1.72	0.46	3.45	0.01
3	0.80	6.89	7.09	0.20	0.00	1.73	0.46	3.45	0.00
3	0.81	6.89	7.09	0.20	0.00	1.73	0.47	3.45	0.00
3	0.82	6.89	7.10	0.21	0.01	1.74	0.47	3.46	0.01
3	0.83	6.89	7.10	0.21	0.00	1.75	0.47	3.46	0.00
3	0.84	6.89	7.10	0.21	0.00	1.76	0.48	3.47	0.01
3	0.85	6.89	7.10	0.21	0.00	1.76	0.48	3.47	0.00
3	0.86	6.89	7.10	0.21	0.00	1.77	0.49	3.47	0.00
3	0.87	6.89	7.10	0.21	0.00	1.78	0.49	3.48	0.01
3	0.88	6.89	7.10	0.21	0.00	1.79	0.49	3.48	0.00
3	0.89	6.89	7.10	0.21	0.00	1.79	0.50	3.49	0.01
3	0.90	6.89	7.10	0.21	0.00	1.80	0.50	3.49	0.00
3	0.91	6.89	7.10	0.21	0.00	1.81	0.50	3.50	0.01
3	0.92	6.89	7.11	0.22	0.01	1.81	0.51	3.50	0.00
3	0.93	6.89	7.11	0.22	0.00	1.82	0.51	3.50	0.00
3	0.94	6.89	7.11	0.22	0.00	1.83	0.51	3.51	0.01
3	0.95	6.89	7.11	0.22	0.00	1.84	0.52	3.51	0.00
3	0.96	6.89	7.11	0.22	0.00	1.84	0.52	3.52	0.01
3	0.97	6.89	7.11	0.22	0.00	1.85	0.52	3.52	0.00
3	0.98	6.89	7.11	0.22	0.00	1.86	0.53	3.52	0.00
3	0.99	6.89	7.11	0.22	0.00	1.86	0.53	3.53	0.01
3	1.00	6.89	7.11	0.22	0.00	1.87	0.54	3.53	0.00
3	1.01	6.89	7.11	0.22	0.00	1.88	0.54	3.54	0.01
3	1.02	6.89	7.12	0.23	0.01	1.88	0.54	3.54	0.00

River Station	Q Total (cfs)	Minimum Channel Elevation (ft)	Water Surface Elevation (ft)	Flow Depth (ft)	Change in Flow Depth (ft)	Velocity Channel (ft/s)	Flow Area (sq ft)	Top Width (ft)	Change in Top Width (ft)
2	0.40	6.76	6.81	0.15	N/A	1.37	0.29	3.11	N/A
2	0.41	6.76	6.81	0.15	0.00	1.38	0.30	3.13	0.02
2	0.42	6.76	6.82	0.16	0.01	1.39	0.30	3.15	0.02
2	0.43	6.76	6.82	0.16	0.00	1.40	0.31	3.16	0.01
2	0.44	6.76	6.82	0.16	0.00	1.41	0.31	3.18	0.02
2	0.45	6.76	6.82	0.16	0.00	1.42	0.32	3.20	0.02
2	0.46	6.76	6.82	0.16	0.00	1.43	0.32	3.21	0.01
2	0.47	6.76	6.82	0.16	0.00	1.44	0.33	3.23	0.02
2	0.48	6.76	6.82	0.16	0.00	1.45	0.33	3.25	0.02
2	0.49	6.76	6.83	0.17	0.01	1.46	0.34	3.26	0.01
2	0.50	6.76	6.83	0.17	0.00	1.47	0.34	3.28	0.02
2	0.51	6.76	6.83	0.17	0.00	1.48	0.34	3.29	0.01
2	0.52	6.76	6.83	0.17	0.00	1.49	0.35	3.31	0.02
2	0.53	6.76	6.83	0.17	0.00	1.50	0.35	3.32	0.01
2	0.54	6.76	6.83	0.17	0.00	1.50	0.36	3.33	0.01
2	0.55	6.76	6.83	0.17	0.00	1.52	0.36	3.33	0.00
2	0.56	6.76	6.84	0.18	0.01	1.52	0.37	3.34	0.01
2	0.57	6.76	6.84	0.18	0.00	1.53	0.37	3.34	0.00
2	0.58	6.76	6.84	0.18	0.00	1.54	0.38	3.35	0.01
2	0.59	6.76	6.84	0.18	0.00	1.55	0.38	3.35	0.00
2	0.60	6.76	6.84	0.18	0.00	1.56	0.38	3.36	0.01
2	0.61	6.76	6.84	0.18	0.00	1.57	0.39	3.36	0.00
2	0.62	6.76	6.84	0.18	0.00	1.58	0.39	3.37	0.01
2	0.63	6.76	6.84	0.18	0.00	1.59	0.40	3.37	0.00
2	0.64	6.76	6.85	0.19	0.01	1.60	0.40	3.37	0.00
2	0.65	6.76	6.85	0.19	0.00	1.61	0.40	3.38	0.01
2	0.66	6.76	6.85	0.19	0.00	1.62	0.41	3.38	0.00
2	0.67	6.76	6.85	0.19	0.00	1.63	0.41	3.39	0.01
2	0.68	6.76	6.85	0.19	0.00	1.64	0.42	3.39	0.00
2	0.69	6.76	6.85	0.19	0.00	1.64	0.42	3.40	0.01
2	0.70	6.76	6.85	0.19	0.00	1.65	0.42	3.40	0.00
2	0.71	6.76	6.85	0.19	0.00	1.66	0.43	3.41	0.01
2	0.72	6.76	6.85	0.19	0.00	1.67	0.43	3.41	0.00
2	0.73	6.76	6.86	0.20	0.01	1.68	0.43	3.42	0.01
2	0.74	6.76	6.86	0.20	0.00	1.69	0.44	3.42	0.00
2	0.75	6.76	6.86	0.20	0.00	1.70	0.44	3.43	0.01
2	0.76	6.76	6.86	0.20	0.00	1.70	0.45	3.43	0.00
2	0.77	6.76	6.86	0.20	0.00	1.71	0.45	3.43	0.00
2	0.78	6.76	6.86	0.20	0.00	1.72	0.45	3.44	0.01
2	0.79	6.76	6.86	0.20	0.00	1.73	0.46	3.44	0.00
2	0.80	6.76	6.86	0.20	0.00	1.73	0.46	3.45	0.01
2	0.81	6.76	6.86	0.20	0.00	1.74	0.46	3.45	0.00
2	0.82	6.76	6.87	0.21	0.01	1.75	0.47	3.46	0.01
2	0.83	6.76	6.87	0.21	0.00	1.76	0.47	3.46	0.00
2	0.84	6.76	6.87	0.21	0.00	1.77	0.48	3.46	0.00
2	0.85	6.76	6.87	0.21	0.00	1.77	0.48	3.47	0.01
2	0.86	6.76	6.87	0.21	0.00	1.78	0.48	3.47	0.00
2	0.87	6.76	6.87	0.21	0.00	1.79	0.49	3.48	0.01
2	0.88	6.76	6.87	0.21	0.00	1.79	0.49	3.48	0.00
2	0.89	6.76	6.87	0.21	0.00	1.80	0.49	3.48	0.00
2	0.90	6.76	6.87	0.21	0.00	1.81	0.50	3.49	0.01
2	0.91	6.76	6.88	0.22	0.01	1.82	0.50	3.49	0.00
2	0.92	6.76	6.88	0.22	0.00	1.82	0.50	3.50	0.01
2	0.93	6.76	6.88	0.22	0.00	1.83	0.51	3.50	0.00
2	0.94	6.76	6.88	0.22	0.00	1.84	0.51	3.51	0.01
2	0.95	6.76	6.88	0.22	0.00	1.84	0.52	3.51	0.00
2	0.96	6.76	6.88	0.22	0.00	1.85	0.52	3.51	0.00
2	0.97	6.76	6.88	0.22	0.00	1.86	0.52	3.52	0.01
2	0.98	6.76	6.88	0.22	0.00	1.86	0.53	3.52	0.00
2	0.99	6.76	6.88	0.22	0.00	1.87	0.53	3.53	0.01
2	1.00	6.76	6.88	0.22	0.00	1.88	0.53	3.53	0.00
2	1.01	6.76	6.89	0.23	0.01	1.88	0.54	3.53	0.00
2	1.02	6.76	6.89	0.23	0.00	1.89	0.54	3.54	0.01
1	0.40	6.63	6.78	0.15	N/A	1.38	0.29	3.11	N/A
1	0.41	6.63	6.78	0.15	0.00	1.39	0.29	3.12	0.01
1	0.42	6.63	6.79	0.16	0.01	1.40	0.30	3.14	0.02
1	0.43	6.63	6.79	0.16	0.00	1.41	0.30	3.16	0.02
1	0.44	6.63	6.79	0.16	0.00	1.42	0.31	3.17	0.01
1	0.45	6.63	6.79	0.16	0.00	1.43	0.31	3.19	0.02
1	0.46	6.63	6.79	0.16	0.00	1.44	0.32	3.21	0.02
1	0.47	6.63	6.79	0.16	0.00	1.45	0.32	3.22	0.01
1	0.48	6.63	6.80	0.17	0.01	1.46	0.33	3.24	0.02
1	0.49	6.63	6.80	0.17	0.00	1.47	0.33	3.25	0.01
1	0.50	6.63	6.80	0.17	0.00	1.48	0.34	3.27	0.02
1	0.51	6.63	6.80	0.17	0.00	1.49	0.34	3.28	0.01
1	0.52	6.63	6.80	0.17	0.00	1.50	0.35	3.30	0.02
1	0.53	6.63	6.80	0.17	0.00	1.51	0.35	3.31	0.01
1	0.54	6.63	6.80	0.17	0.00	1.51	0.36	3.32	0.01
1	0.55	6.63	6.81	0.18	0.01	1.52	0.36	3.33	0.01
1	0.56	6.63	6.81	0.18	0.00	1.53	0.37	3.33	0.00
1	0.57	6.63	6.81	0.18	0.00	1.54	0.37	3.34	0.01
1	0.58	6.63	6.81	0.18	0.00	1.55	0.37	3.34	0.00
1	0.59	6.63	6.81	0.18	0.00	1.56	0.38	3.35	0.01
1	0.60	6.63	6.81	0.18	0.00	1.57	0.38	3.35	0.00
1	0.61	6.63	6.81	0.18	0.00	1.58	0.38	3.36	0.01
1	0.62	6.63	6.81	0.18	0.00	1.59	0.39	3.36	0.00
1	0.63	6.63	6.81	0.18	0.00	1.60	0.39	3.37	0.01
1	0.64	6.63	6.82	0.19	0.01	1.61	0.40	3.37	0.00
1	0.65	6.63	6.82	0.19	0.00	1.62	0.40	3.38	0.01
1	0.66	6.63	6.82	0.19	0.00	1.63	0.41	3.38	0.00
1	0.67	6.63	6.82	0.19	0.00	1.64	0.41	3.39	0.01
1	0.68	6.63	6.82	0.19	0.00	1.64	0.41	3.39	0.00
1	0.69	6.63	6.82	0.19	0.00	1.65	0.42	3.40	0.01
1	0.70	6.63	6.82	0.19	0.00	1.66	0.42	3.40	0.00
1	0.71	6.63	6.82	0.19	0.00	1.67	0.42	3.40	0.00
1	0.72	6.63	6.83	0.20	0.01	1.68	0.43	3.41	0.01
1	0.73	6.63	6.83	0.20	0.00	1.69	0.43	3.41	0.00
1	0.74	6.63	6.83	0.20	0.00	1.70	0.44	3.42	0.01
1	0.75	6.63	6.83	0.20	0.00	1.70	0.44	3.42	0.00
1	0.76	6.63	6.83	0.20	0.00	1.71	0.44	3.43	0.01
1	0.77	6.63	6.83	0.20	0.00	1.72	0.45	3.43	0.00
1	0.78	6.63	6.83	0.20	0.00	1.73	0.45	3.44	0.01
1	0.79	6.63	6.83	0.20	0.00	1.74	0.46	3.44	0.00
1	0.80	6.63	6.83	0.20	0.00	1.74	0.46	3.44	0.00
1	0.81	6.63	6.84	0.21	0.01	1.75	0.46	3.45	0.01
1	0.82	6.63	6.84	0.21	0.00	1.76	0.47	3.45	0.00
1	0.83	6.63	6.84	0.21	0.00	1.77	0.47	3.46	0.01
1	0.84	6.63	6.84	0.21	0.00	1.77	0.47	3.46	0.00
1	0.85	6.63	6.84	0.21	0.00	1.78	0.48	3.47	0.01
1	0.86	6.63	6.84	0.21	0.00	1.79	0.48	3.47	0.00
1	0.87	6.63	6.84	0.21	0.00	1.80	0.48	3.47	0.00
1	0.88	6.63	6.84	0.21	0.00	1.80	0.49	3.48	0.01
1	0.89	6.63	6.84	0.21	0.00	1.81	0.49	3.48	0.00
1	0.90	6.63	6.84	0.21	0.00	1.82	0.50	3.49	0.01
1	0.91	6.63	6.85	0.22	0.01	1.82	0.50	3.49	0.00
1	0.92	6.63	6.85	0.22	0.00	1.83	0.50	3.49	0.00
1	0.93	6.63	6.85	0.22	0.00	1.84	0.51	3.50	0.01
1	0.94	6.63	6.85	0.22	0.00	1.85	0.51	3.50	0.00
1	0.95	6.63	6.85	0.22	0.00	1.85	0.51	3.51	0.01
1	0.96	6.63	6.85	0.22	0.00	1.86	0.52	3.51	0.00
1	0.97	6.63	6.85	0.22	0.00	1.87	0.52	3.51	0.00
1	0.98	6.63	6.85	0.22	0.00	1.87	0.52	3.52	0.01
1	0.99	6.63	6.85	0.22	0.00	1.88	0.53	3.52	0.00
1	1.00	6.63	6.85	0.22	0.00	1.88	0.53	3.53	0.01
1	1.01	6.63	6.86	0.23	0.01	1.89	0.53	3.53	0.00
1	1.02	6.63	6.86	0.23	0.00	1.90	0.54	3.53	0.00

Average Change in depth = 0.00 ft
0 mm

Average Change in width = 0.01 ft
3 mm

Miller Creek @ SR509

HSPF modeling
7 Day Low Flows (1949-1996)
$Q_{low\ min}$ = 0.42 cfs
$Q_{low\ max}$ = 1.00 cfs
$Q_{change\ in\ table}$ = 0.01 cfs

HEC-RAS Plan: "M-2 S=1.70%" River: Miller Creek Reach: M-2 Mannings n = 0.035

River Station	Q Total (cfs)	Minimum Channel Elevation (ft)	Water Surface Elevation (ft)	Flow Depth (ft)	Change in Flow Depth (ft)	Velocity Channel (ft/s)	Flow Area (sq ft)	Top Width (ft)	Change in Top Width (ft)
4	0.40	7.56	7.66	0.10	N/A	1.31	0.30	4.61	N/A
4	0.41	7.56	7.67	0.11	0.01	1.29	0.32	4.64	0.03
4	0.42	7.56	7.67	0.11	0.00	1.30	0.32	4.65	0.01
4	0.43	7.56	7.67	0.11	0.00	1.31	0.33	4.66	0.01
4	0.44	7.56	7.67	0.11	0.00	1.33	0.33	4.66	0.00
4	0.45	7.56	7.67	0.11	0.00	1.34	0.34	4.67	0.01
4	0.46	7.56	7.67	0.11	0.00	1.35	0.34	4.68	0.01
4	0.47	7.56	7.67	0.11	0.00	1.36	0.35	4.69	0.01
4	0.48	7.56	7.67	0.11	0.00	1.37	0.35	4.70	0.01
4	0.49	7.56	7.67	0.11	0.00	1.38	0.36	4.71	0.01
4	0.50	7.56	7.68	0.12	0.01	1.37	0.37	4.73	0.02
4	0.51	7.56	7.68	0.12	0.00	1.37	0.37	4.74	0.01
4	0.52	7.56	7.68	0.12	0.00	1.38	0.38	4.74	0.00
4	0.53	7.56	7.68	0.12	0.00	1.39	0.38	4.75	0.01
4	0.54	7.56	7.68	0.12	0.00	1.40	0.39	4.76	0.01
4	0.55	7.56	7.68	0.12	0.00	1.41	0.39	4.77	0.01
4	0.56	7.56	7.68	0.12	0.00	1.42	0.39	4.78	0.01
4	0.57	7.56	7.68	0.12	0.00	1.43	0.40	4.78	0.00
4	0.58	7.56	7.68	0.12	0.00	1.44	0.40	4.79	0.01
4	0.59	7.56	7.69	0.13	0.01	1.46	0.41	4.80	0.01
4	0.60	7.56	7.69	0.13	0.00	1.47	0.41	4.80	0.00
4	0.61	7.56	7.68	0.12	-0.01	1.51	0.40	4.79	-0.01
4	0.62	7.56	7.69	0.13	0.01	1.52	0.41	4.80	0.01
4	0.63	7.56	7.69	0.13	0.00	1.53	0.41	4.81	0.01
4	0.64	7.56	7.69	0.13	0.00	1.54	0.42	4.82	0.01
4	0.65	7.56	7.69	0.13	0.00	1.55	0.42	4.82	0.00
4	0.66	7.56	7.69	0.13	0.00	1.56	0.42	4.83	0.01
4	0.67	7.56	7.69	0.13	0.00	1.56	0.43	4.84	0.01
4	0.68	7.56	7.69	0.13	0.00	1.57	0.43	4.85	0.01
4	0.69	7.56	7.70	0.14	0.01	1.50	0.46	4.89	0.04
4	0.70	7.56	7.70	0.14	0.00	1.51	0.46	4.90	0.01
4	0.71	7.56	7.70	0.14	0.00	1.51	0.47	4.91	0.01
4	0.72	7.56	7.70	0.14	0.00	1.52	0.47	4.92	0.01
4	0.73	7.56	7.70	0.14	0.00	1.53	0.48	4.92	0.00
4	0.74	7.56	7.70	0.14	0.00	1.54	0.48	4.93	0.01
4	0.75	7.56	7.70	0.14	0.00	1.54	0.49	4.94	0.01
4	0.76	7.56	7.70	0.14	0.00	1.55	0.49	4.94	0.00
4	0.77	7.56	7.70	0.14	0.00	1.56	0.49	4.95	0.01
4	0.78	7.56	7.70	0.14	0.00	1.57	0.50	4.95	0.00
4	0.79	7.56	7.70	0.14	0.00	1.58	0.50	4.96	0.01
4	0.80	7.56	7.71	0.15	0.01	1.59	0.50	4.97	0.01
4	0.81	7.56	7.71	0.15	0.00	1.60	0.51	4.97	0.00
4	0.82	7.56	7.70	0.14	-0.01	1.68	0.49	4.94	-0.03
4	0.83	7.56	7.70	0.14	0.00	1.69	0.49	4.95	0.01
4	0.84	7.56	7.70	0.14	0.00	1.69	0.50	4.95	0.00
4	0.85	7.56	7.70	0.14	0.00	1.70	0.50	4.96	0.01
4	0.86	7.56	7.71	0.15	0.01	1.71	0.50	4.97	0.01
4	0.87	7.56	7.71	0.15	0.00	1.71	0.51	4.97	0.00
4	0.88	7.56	7.71	0.15	0.00	1.72	0.51	4.98	0.01
4	0.89	7.56	7.71	0.15	0.00	1.73	0.51	4.99	0.01
4	0.90	7.56	7.71	0.15	0.00	1.74	0.52	4.99	0.00
4	0.91	7.56	7.71	0.15	0.00	1.74	0.52	5.00	0.01
4	0.92	7.56	7.71	0.15	0.00	1.75	0.53	5.00	0.00
4	0.93	7.56	7.71	0.15	0.00	1.76	0.53	5.01	0.01
4	0.94	7.56	7.71	0.15	0.00	1.76	0.53	5.02	0.01
4	0.95	7.56	7.71	0.15	0.00	1.77	0.54	5.02	0.00
4	0.96	7.56	7.71	0.15	0.00	1.78	0.54	5.03	0.01
4	0.97	7.56	7.71	0.15	0.00	1.78	0.54	5.03	0.00
4	0.98	7.56	7.71	0.15	0.00	1.79	0.55	5.04	0.01
4	0.99	7.56	7.71	0.15	0.00	1.80	0.55	5.05	0.01
4	1.00	7.56	7.72	0.16	0.01	1.80	0.56	5.05	0.00
4	1.01	7.56	7.72	0.16	0.00	1.81	0.56	5.06	0.01
4	1.02	7.56	7.72	0.16	0.00	1.81	0.56	5.06	0.00
3	0.40	7.38	7.49	0.11	N/A	1.27	0.32	4.63	N/A
3	0.41	7.38	7.49	0.11	0.00	1.30	0.32	4.64	0.01
3	0.42	7.38	7.49	0.11	0.00	1.31	0.32	4.64	0.00
3	0.43	7.38	7.49	0.11	0.00	1.32	0.33	4.65	0.01
3	0.44	7.38	7.49	0.11	0.00	1.33	0.33	4.66	0.01
3	0.45	7.38	7.49	0.11	0.00	1.34	0.34	4.67	0.01
3	0.46	7.38	7.50	0.12	0.01	1.35	0.34	4.68	0.01
3	0.47	7.38	7.50	0.12	0.00	1.36	0.34	4.69	0.01
3	0.48	7.38	7.50	0.12	0.00	1.37	0.35	4.70	0.01
3	0.49	7.38	7.50	0.12	0.00	1.38	0.35	4.70	0.00
3	0.50	7.38	7.50	0.12	0.00	1.37	0.37	4.73	0.03
3	0.51	7.38	7.50	0.12	0.00	1.37	0.37	4.74	0.01
3	0.52	7.38	7.50	0.12	0.00	1.38	0.38	4.74	0.00
3	0.53	7.38	7.50	0.12	0.00	1.39	0.38	4.75	0.01
3	0.54	7.38	7.50	0.12	0.00	1.40	0.39	4.76	0.01
3	0.55	7.38	7.51	0.13	0.01	1.41	0.39	4.77	0.01
3	0.56	7.38	7.51	0.13	0.00	1.42	0.39	4.78	0.01
3	0.57	7.38	7.51	0.13	0.00	1.43	0.40	4.78	0.00
3	0.58	7.38	7.51	0.13	0.00	1.44	0.40	4.79	0.01
3	0.59	7.38	7.51	0.13	0.00	1.46	0.41	4.80	0.01
3	0.60	7.38	7.51	0.13	0.00	1.47	0.41	4.80	0.00
3	0.61	7.38	7.51	0.13	0.00	1.51	0.40	4.79	-0.01
3	0.62	7.38	7.51	0.13	0.00	1.52	0.41	4.80	0.01
3	0.63	7.38	7.51	0.13	0.00	1.53	0.41	4.81	0.01
3	0.64	7.38	7.51	0.13	0.00	1.54	0.42	4.82	0.01
3	0.65	7.38	7.51	0.13	0.00	1.55	0.42	4.82	0.00
3	0.66	7.38	7.51	0.13	0.00	1.55	0.42	4.83	0.01
3	0.67	7.38	7.51	0.13	0.00	1.56	0.43	4.84	0.01
3	0.68	7.38	7.51	0.13	0.00	1.57	0.43	4.85	0.01
3	0.69	7.38	7.52	0.14	0.01	1.50	0.46	4.89	0.04
3	0.70	7.38	7.52	0.14	0.00	1.51	0.46	4.90	0.01
3	0.71	7.38	7.52	0.14	0.00	1.51	0.47	4.91	0.01
3	0.72	7.38	7.52	0.14	0.00	1.52	0.47	4.92	0.01
3	0.73	7.38	7.52	0.14	0.00	1.53	0.48	4.92	0.00
3	0.74	7.38	7.52	0.14	0.00	1.54	0.48	4.93	0.01
3	0.75	7.38	7.53	0.15	0.01	1.54	0.49	4.94	0.01
3	0.76	7.38	7.53	0.15	0.00	1.55	0.49	4.94	0.00
3	0.77	7.38	7.53	0.15	0.00	1.56	0.49	4.95	0.01
3	0.78	7.38	7.53	0.15	0.00	1.57	0.50	4.95	0.00
3	0.79	7.38	7.53	0.15	0.00	1.58	0.50	4.96	0.01
3	0.80	7.38	7.53	0.15	0.00	1.59	0.50	4.97	0.01
3	0.81	7.38	7.53	0.15	0.00	1.60	0.51	4.97	0.00
3	0.82	7.38	7.53	0.15	0.00	1.68	0.49	4.94	-0.03
3	0.83	7.38	7.53	0.15	0.00	1.69	0.49	4.95	0.01
3	0.84	7.38	7.53	0.15	0.00	1.69	0.50	4.95	0.00
3	0.85	7.38	7.53	0.15	0.00	1.70	0.50	4.96	0.01
3	0.86	7.38	7.53	0.15	0.00	1.71	0.50	4.97	0.01
3	0.87	7.38	7.53	0.15	0.00	1.71	0.51	4.97	0.00
3	0.88	7.38	7.53	0.15	0.00	1.72	0.51	4.98	0.01
3	0.89	7.38	7.53	0.15	0.00	1.73	0.51	4.99	0.01
3	0.90	7.38	7.53	0.15	0.00	1.74	0.52	4.99	0.00
3	0.91	7.38	7.53	0.15	0.00	1.74	0.52	5.00	0.01
3	0.92	7.38	7.53	0.15	0.00	1.75	0.53	5.00	0.00
3	0.93	7.38	7.53	0.15	0.00	1.76	0.53	5.01	0.01
3	0.94	7.38	7.54	0.16	0.01	1.76	0.53	5.02	0.01
3	0.95	7.38	7.54	0.16	0.00	1.77	0.54	5.02	0.00
3	0.96	7.38	7.54	0.16	0.00	1.78	0.54	5.03	0.01
3	0.97	7.38	7.54	0.16	0.00	1.78	0.54	5.03	0.00
3	0.98	7.38	7.54	0.16	0.00	1.79	0.55	5.04	0.01
3	0.99	7.38	7.54	0.16	0.00	1.80	0.55	5.05	0.01
3	1.00	7.38	7.54	0.16	0.00	1.80	0.56	5.05	0.00
3	1.01	7.38	7.54	0.16	0.00	1.81	0.56	5.06	0.01
3	1.02	7.38	7.54	0.16	0.00	1.81	0.56	5.06	0.00

River Station	Q Total (cfs)	Minimum Channel Elevation (ft)	Water Surface Elevation (ft)	Flow Depth (ft)	Change in Flow Depth (ft)	Velocity Channel (ft/s)	Flow Area (sq ft)	Top Width (ft)	Change in Top Width (ft)
2	0.40	7.21	7.31	0.10	N/A	1.29	0.31	4.63	N/A
2	0.41	7.21	7.31	0.10	0.00	1.30	0.32	4.63	0.00
2	0.42	7.21	7.31	0.10	0.00	1.31	0.32	4.64	0.01
2	0.43	7.21	7.32	0.11	0.01	1.32	0.32	4.65	0.01
2	0.44	7.21	7.32	0.11	0.00	1.34	0.33	4.66	0.01
2	0.45	7.21	7.32	0.11	0.00	1.35	0.33	4.67	0.01
2	0.46	7.21	7.32	0.11	0.00	1.36	0.34	4.68	0.01
2	0.47	7.21	7.32	0.11	0.00	1.37	0.34	4.68	0.00
2	0.48	7.21	7.32	0.11	0.00	1.38	0.35	4.69	0.01
2	0.49	7.21	7.32	0.11	0.00	1.39	0.35	4.70	0.01
2	0.50	7.21	7.32	0.11	0.00	1.37	0.37	4.73	0.03
2	0.51	7.21	7.33	0.12	0.01	1.37	0.37	4.74	0.01
2	0.52	7.21	7.33	0.12	0.00	1.38	0.38	4.74	0.00
2	0.53	7.21	7.33	0.12	0.00	1.39	0.38	4.75	0.01
2	0.54	7.21	7.33	0.12	0.00	1.40	0.39	4.76	0.01
2	0.55	7.21	7.33	0.12	0.00	1.41	0.39	4.77	0.01
2	0.56	7.21	7.33	0.12	0.00	1.42	0.39	4.78	0.01
2	0.57	7.21	7.33	0.12	0.00	1.43	0.40	4.78	0.00
2	0.58	7.21	7.33	0.12	0.00	1.44	0.40	4.79	0.01
2	0.59	7.21	7.33	0.12	0.00	1.46	0.41	4.80	0.01
2	0.60	7.21	7.33	0.12	0.00	1.47	0.41	4.80	0.00
2	0.61	7.21	7.33	0.12	0.00	1.51	0.40	4.79	-0.01
2	0.62	7.21	7.33	0.12	0.00	1.52	0.41	4.80	0.01
2	0.63	7.21	7.33	0.12	0.00	1.53	0.41	4.81	0.01
2	0.64	7.21	7.34	0.13	0.01	1.54	0.42	4.82	0.01
2	0.65	7.21	7.34	0.13	0.00	1.55	0.42	4.82	0.00
2	0.66	7.21	7.34	0.13	0.00	1.55	0.42	4.83	0.01
2	0.67	7.21	7.34	0.13	0.00	1.56	0.43	4.84	0.01
2	0.68	7.21	7.34	0.13	0.00	1.57	0.43	4.85	0.01
2	0.69	7.21	7.34	0.13	0.00	1.50	0.46	4.89	0.04
2	0.70	7.21	7.35	0.14	0.01	1.51	0.46	4.90	0.01
2	0.71	7.21	7.35	0.14	0.00	1.51	0.47	4.91	0.01
2	0.72	7.21	7.35	0.14	0.00	1.52	0.47	4.92	0.01
2	0.73	7.21	7.35	0.14	0.00	1.53	0.48	4.92	0.00
2	0.74	7.21	7.35	0.14	0.00	1.54	0.48	4.93	0.01
2	0.75	7.21	7.35	0.14	0.00	1.54	0.49	4.94	0.01
2	0.76	7.21	7.35	0.14	0.00	1.55	0.49	4.94	0.00
2	0.77	7.21	7.35	0.14	0.00	1.56	0.49	4.95	0.01
2	0.78	7.21	7.35	0.14	0.00	1.57	0.50	4.95	0.00
2	0.79	7.21	7.35	0.14	0.00	1.58	0.50	4.96	0.01
2	0.80	7.21	7.35	0.14	0.00	1.59	0.50	4.97	0.01
2	0.81	7.21	7.35	0.14	0.00	1.60	0.51	4.97	0.00
2	0.82	7.21	7.35	0.14	0.00	1.68	0.49	4.94	-0.03
2	0.83	7.21	7.35	0.14	0.00	1.69	0.49	4.95	0.01
2	0.84	7.21	7.35	0.14	0.00	1.69	0.50	4.95	0.00
2	0.85	7.21	7.35	0.14	0.00	1.70	0.50	4.96	0.01
2	0.86	7.21	7.35	0.14	0.00	1.71	0.50	4.97	0.01
2	0.87	7.21	7.35	0.14	0.00	1.71	0.51	4.97	0.00
2	0.88	7.21	7.35	0.14	0.00	1.72	0.51	4.98	0.01
2	0.89	7.21	7.36	0.15	0.01	1.73	0.51	4.99	0.01
2	0.90	7.21	7.36	0.15	0.00	1.74	0.52	4.99	0.00
2	0.91	7.21	7.36	0.15	0.00	1.74	0.52	5.00	0.01
2	0.92	7.21	7.36	0.15	0.00	1.75	0.53	5.00	0.00
2	0.93	7.21	7.36	0.15	0.00	1.76	0.53	5.01	0.01
2	0.94	7.21	7.36	0.15	0.00	1.76	0.53	5.02	0.01
2	0.95	7.21	7.36	0.15	0.00	1.77	0.54	5.02	0.00
2	0.96	7.21	7.36	0.15	0.00	1.78	0.54	5.03	0.01
2	0.97	7.21	7.36	0.15	0.00	1.78	0.54	5.03	0.00
2	0.98	7.21	7.36	0.15	0.00	1.79	0.55	5.04	0.01
2	0.99	7.21	7.36	0.15	0.00	1.80	0.55	5.05	0.01
2	1.00	7.21	7.36	0.15	0.00	1.80	0.56	5.05	0.00
2	1.01	7.21	7.36	0.15	0.00	1.81	0.56	5.06	0.01
2	1.02	7.21	7.36	0.15	0.00	1.81	0.56	5.06	0.00
1	0.40	7.03	7.14	0.11	N/A	1.30	0.31	4.62	N/A
1	0.41	7.03	7.14	0.11	0.00	1.31	0.31	4.63	0.01
1	0.42	7.03	7.14	0.11	0.00	1.32	0.32	4.64	0.01
1	0.43	7.03	7.14	0.11	0.00	1.33	0.32	4.65	0.01
1	0.44	7.03	7.14	0.11	0.00	1.34	0.33	4.66	0.01
1	0.45	7.03	7.14	0.11	0.00	1.35	0.33	4.67	0.01
1	0.46	7.03	7.14	0.11	0.00	1.36	0.34	4.67	0.00
1	0.47	7.03	7.14	0.11	0.00	1.37	0.34	4.68	0.01
1	0.48	7.03	7.14	0.11	0.00	1.38	0.35	4.69	0.01
1	0.49	7.03	7.15	0.12	0.01	1.39	0.35	4.70	0.01
1	0.50	7.03	7.15	0.12	0.00	1.37	0.37	4.73	0.03
1	0.51	7.03	7.15	0.12	0.00	1.37	0.37	4.74	0.01
1	0.52	7.03	7.15	0.12	0.00	1.38	0.38	4.74	0.00
1	0.53	7.03	7.15	0.12	0.00	1.39	0.38	4.75	0.01
1	0.54	7.03	7.15	0.12	0.00	1.40	0.39	4.76	0.01
1	0.55	7.03	7.15	0.12	0.00	1.41	0.39	4.77	0.01
1	0.56	7.03	7.15	0.12	0.00	1.42	0.39	4.78	0.01
1	0.57	7.03	7.16	0.13	0.01	1.43	0.40	4.78	0.00
1	0.58	7.03	7.16	0.13	0.00	1.44	0.40	4.79	0.01
1	0.59	7.03	7.16	0.13	0.00	1.45	0.41	4.80	0.01
1	0.60	7.03	7.16	0.13	0.00	1.47	0.41	4.80	0.00
1	0.61	7.03	7.16	0.13	0.00	1.51	0.40	4.79	-0.01
1	0.62	7.03	7.16	0.13	0.00	1.52	0.41	4.80	0.01
1	0.63	7.03	7.16	0.13	0.00	1.53	0.41	4.81	0.01
1	0.64	7.03	7.16	0.13	0.00	1.54	0.42	4.82	0.01
1	0.65	7.03	7.16	0.13	0.00	1.55	0.42	4.82	0.00
1	0.66	7.03	7.16	0.13	0.00	1.55	0.42	4.83	0.01
1	0.67	7.03	7.16	0.13	0.00	1.56	0.43	4.84	0.01
1	0.68	7.03	7.16	0.13	0.00	1.57	0.43	4.85	0.01
1	0.69	7.03	7.17	0.14	0.01	1.50	0.46	4.89	0.04
1	0.70	7.03	7.17	0.14	0.00	1.51	0.46	4.90	0.01
1	0.71	7.03	7.17	0.14	0.00	1.51	0.47	4.91	0.01
1	0.72	7.03	7.17	0.14	0.00	1.52	0.47	4.92	0.01
1	0.73	7.03	7.17	0.14	0.00	1.53	0.48	4.92	0.00
1	0.74	7.03	7.17	0.14	0.00	1.54	0.48	4.93	0.01
1	0.75	7.03	7.17	0.14	0.00	1.54	0.49	4.94	0.01
1	0.76	7.03	7.17	0.14	0.00	1.55	0.49	4.94	0.00
1	0.77	7.03	7.18	0.15	0.01	1.56	0.49	4.95	0.01
1	0.78	7.03	7.18	0.15	0.00	1.57	0.50	4.95	0.00
1	0.79	7.03	7.18	0.15	0.00	1.58	0.50	4.96	0.01
1	0.80	7.03	7.18	0.15	0.00	1.59	0.50	4.97	0.01
1	0.81	7.03	7.18	0.15	0.00	1.60	0.51	4.97	0.00
1	0.82	7.03	7.17	0.14	-0.01	1.68	0.49	4.94	-0.03
1	0.83	7.03	7.17	0.14	0.00	1.69	0.49	4.95	0.01
1	0.84	7.03	7.18	0.15	0.01	1.69	0.50	4.95	0.00
1	0.85	7.03	7.18	0.15	0.00	1.70	0.50	4.96	0.01
1	0.86	7.03	7.18	0.15	0.00	1.71	0.50	4.97	0.01
1	0.87	7.03	7.18	0.15	0.00	1.71	0.51	4.97	0.00
1	0.88	7.03	7.18	0.15	0.00	1.72	0.51	4.98	0.01
1	0.89	7.03	7.18	0.15	0.00	1.73	0.51	4.99	0.01
1	0.90	7.03	7.18	0.15	0.00	1.74	0.52	4.99	0.00
1	0.91	7.03	7.18	0.15	0.00	1.74	0.52	5.00	0.01
1	0.92	7.03	7.18	0.15	0.00	1.75	0.53	5.00	0.00
1	0.93	7.03	7.18	0.15	0.00	1.76	0.53	5.01	0.01
1	0.94	7.03	7.18	0.15	0.00	1.76	0.53	5.02	0.01
1	0.95	7.03	7.18	0.15	0.00	1.77	0.54	5.02	0.00
1	0.96	7.03	7.18	0.15	0.00	1.78	0.54	5.03	0.01
1	0.97	7.03	7.19	0.16	0.01	1.78	0.54	5.03	0.00
1	0.98	7.03	7.19	0.16	0.00	1.79	0.55	5.04	0.01
1	0.99	7.03	7.19	0.16	0.00	1.80	0.55	5.05	0.01
1	1.00	7.03	7.19	0.16	0.00	1.80	0.56	5.05	0.00
1	1.01	7.03	7.19	0.16	0.00	1.81	0.56	5.06	0.01
1	1.02	7.03	7.19	0.16	0.00	1.81	0.56	5.06	0.00

Average Change in depth = 0.00 ft
0 mm

Average Change in width = 0.01 ft
3 mm

Miller Creek @ SR509

HSPF modeling
7 Day Low Flows (1949-1996)

$Q_{low\ min}$ = 0.42 cfs
$Q_{low\ max}$ = 1.00 cfs
$Q_{change\ in\ size}$ = 0.01 cfs

HEC-RAS Plan: "M-3 [illegible]" River: Miller Creek Reach: M-3 Mannings n = 0.0[illegible]

River Station	Q Total (cfs)	Minimum Channel Elevation (ft)	Water Surface Elevation (ft)	Flow Depth (ft)	Change in Flow Depth (ft)	Velocity Channel (ft/s)	Flow Area (sq ft)	Top Width (ft)	Change in Top Width (ft)
4	0.40	5.77	5.92	0.15	N/A	1.14	0.35	3.80	N/A
4	0.41	5.77	5.92	0.15	0.00	1.15	0.35	3.82	0.02
4	0.42	5.77	5.93	0.16	0.01	1.16	0.36	3.84	0.02
4	0.43	5.77	5.93	0.16	0.00	1.16	0.37	3.86	0.02
4	0.44	5.77	5.93	0.16	0.00	1.17	0.37	3.88	0.02
4	0.45	5.77	5.93	0.16	0.00	1.18	0.38	3.89	0.01
4	0.46	5.77	5.93	0.16	0.00	1.19	0.38	3.91	0.02
4	0.47	5.77	5.93	0.16	0.00	1.20	0.39	3.93	0.02
4	0.48	5.77	5.93	0.16	0.00	1.21	0.40	3.94	0.01
4	0.49	5.77	5.94	0.17	0.01	1.22	0.40	3.96	0.02
4	0.50	5.77	5.94	0.17	0.00	1.22	0.41	3.98	0.02
4	0.51	5.77	5.94	0.17	0.00	1.23	0.41	3.99	0.01
4	0.52	5.77	5.94	0.17	0.00	1.24	0.42	4.01	0.02
4	0.53	5.77	5.94	0.17	0.00	1.25	0.42	4.03	0.02
4	0.54	5.77	5.94	0.17	0.00	1.26	0.43	4.04	0.01
4	0.55	5.77	5.94	0.17	0.00	1.26	0.44	4.06	0.02
4	0.56	5.77	5.95	0.18	0.01	1.27	0.44	4.07	0.01
4	0.57	5.77	5.95	0.18	0.00	1.28	0.45	4.09	0.02
4	0.58	5.77	5.95	0.18	0.00	1.29	0.46	4.10	0.01
4	0.59	5.77	5.95	0.18	0.00	1.29	0.46	4.12	0.02
4	0.60	5.77	5.95	0.18	0.00	1.30	0.46	4.14	0.02
4	0.61	5.77	5.95	0.18	0.00	1.31	0.47	4.21	0.07
4	0.62	5.77	5.95	0.18	0.00	1.31	0.47	4.29	0.08
4	0.63	5.77	5.95	0.18	0.00	1.32	0.48	4.38	0.09
4	0.64	5.77	5.96	0.19	0.01	1.30	0.49	4.54	0.16
4	0.65	5.77	5.96	0.19	0.00	1.30	0.50	4.67	0.13
4	0.66	5.77	5.96	0.19	0.00	1.29	0.51	4.80	0.13
4	0.67	5.77	5.96	0.19	0.00	1.28	0.52	4.93	0.13
4	0.68	5.77	5.97	0.20	0.01	1.28	0.53	5.05	0.12
4	0.69	5.77	5.97	0.20	0.00	1.27	0.54	5.16	0.11
4	0.70	5.77	5.97	0.20	0.00	1.27	0.55	5.26	0.10
4	0.71	5.77	5.97	0.20	0.00	1.27	0.56	5.36	0.10
4	0.72	5.77	5.97	0.20	0.00	1.27	0.57	5.46	0.10
4	0.73	5.77	5.97	0.20	0.00	1.26	0.58	5.55	0.09
4	0.74	5.77	5.98	0.21	0.01	1.26	0.59	5.65	0.10
4	0.75	5.77	5.98	0.21	0.00	1.26	0.60	5.73	0.08
4	0.76	5.77	5.98	0.21	0.00	1.26	0.60	5.82	0.09
4	0.77	5.77	5.98	0.21	0.00	1.26	0.61	5.90	0.08
4	0.78	5.77	5.98	0.21	0.00	1.26	0.62	5.93	0.03
4	0.79	5.77	5.98	0.21	0.00	1.26	0.63	5.96	0.03
4	0.80	5.77	5.98	0.21	0.00	1.26	0.64	5.98	0.02
4	0.81	5.77	5.99	0.22	0.01	1.26	0.64	6.00	0.02
4	0.82	5.77	5.99	0.22	0.00	1.27	0.65	6.03	0.03
4	0.83	5.77	5.99	0.22	0.00	1.27	0.66	6.04	0.01
4	0.84	5.77	5.99	0.22	0.00	1.28	0.66	6.06	0.02
4	0.85	5.77	5.99	0.22	0.00	1.28	0.66	6.08	0.02
4	0.86	5.77	5.99	0.22	0.00	1.29	0.67	6.10	0.02
4	0.87	5.77	5.99	0.22	0.00	1.29	0.67	6.12	0.02
4	0.88	5.77	5.99	0.22	0.00	1.30	0.68	6.14	0.02
4	0.89	5.77	5.99	0.22	0.00	1.30	0.69	6.16	0.02
4	0.90	5.77	5.99	0.22	0.00	1.30	0.69	6.18	0.02
4	0.91	5.77	5.99	0.22	0.00	1.31	0.70	6.20	0.02
4	0.92	5.77	5.99	0.22	0.00	1.31	0.70	6.22	0.02
4	0.93	5.77	6.00	0.23	0.01	1.32	0.71	6.24	0.02
4	0.94	5.77	6.00	0.23	0.00	1.32	0.71	6.26	0.02
4	0.95	5.77	6.00	0.23	0.00	1.33	0.72	6.28	0.02
4	0.96	5.77	6.00	0.23	0.00	1.33	0.72	6.29	0.01
4	0.97	5.77	6.00	0.23	0.00	1.33	0.73	6.31	0.02
4	0.98	5.77	6.00	0.23	0.00	1.34	0.73	6.33	0.02
4	0.99	5.77	6.00	0.23	0.00	1.34	0.74	6.37	0.04
4	1.00	5.77	6.00	0.23	0.00	1.35	0.74	6.40	0.03
4	1.01	5.77	6.00	0.23	0.00	1.35	0.75	6.44	0.04
4	1.02	5.77	6.00	0.23	0.00	1.35	0.75	6.48	0.04
3	0.40	5.67	5.82	0.15	N/A	1.15	0.35	3.79	N/A
3	0.41	5.67	5.82	0.15	0.00	1.16	0.35	3.81	0.02
3	0.42	5.67	5.83	0.16	0.01	1.17	0.36	3.83	0.02
3	0.43	5.67	5.83	0.16	0.00	1.18	0.36	3.84	0.01
3	0.44	5.67	5.83	0.16	0.00	1.19	0.37	3.86	0.02
3	0.45	5.67	5.83	0.16	0.00	1.20	0.38	3.88	0.02
3	0.46	5.67	5.83	0.16	0.00	1.21	0.38	3.90	0.02
3	0.47	5.67	5.83	0.16	0.00	1.21	0.39	3.91	0.01
3	0.48	5.67	5.83	0.16	0.00	1.22	0.39	3.93	0.02
3	0.49	5.67	5.84	0.17	0.01	1.23	0.40	3.95	0.02
3	0.50	5.67	5.84	0.17	0.00	1.24	0.40	3.96	0.01
3	0.51	5.67	5.84	0.17	0.00	1.25	0.41	3.98	0.02
3	0.52	5.67	5.84	0.17	0.00	1.26	0.41	4.00	0.02
3	0.53	5.67	5.84	0.17	0.00	1.26	0.42	4.01	0.01
3	0.54	5.67	5.84	0.17	0.00	1.27	0.42	4.03	0.02
3	0.55	5.67	5.84	0.17	0.00	1.28	0.43	4.04	0.01
3	0.56	5.67	5.84	0.17	0.00	1.29	0.44	4.06	0.02
3	0.57	5.67	5.85	0.18	0.01	1.29	0.44	4.07	0.01
3	0.58	5.67	5.85	0.18	0.00	1.30	0.45	4.09	0.02
3	0.59	5.67	5.85	0.18	0.00	1.31	0.45	4.11	0.02
3	0.60	5.67	5.85	0.18	0.00	1.31	0.46	4.12	0.01
3	0.61	5.67	5.85	0.18	0.00	1.32	0.46	4.14	0.02
3	0.62	5.67	5.85	0.18	0.00	1.33	0.47	4.22	0.08
3	0.63	5.67	5.85	0.18	0.00	1.33	0.47	4.31	0.09
3	0.64	5.67	5.86	0.19	0.01	1.32	0.49	4.47	0.16
3	0.65	5.67	5.86	0.19	0.00	1.31	0.50	4.60	0.13
3	0.66	5.67	5.86	0.19	0.00	1.30	0.51	4.73	0.13
3	0.67	5.67	5.86	0.19	0.00	1.30	0.52	4.85	0.12
3	0.68	5.67	5.87	0.20	0.01	1.29	0.53	4.97	0.12
3	0.69	5.67	5.87	0.20	0.00	1.29	0.54	5.08	0.11
3	0.70	5.67	5.87	0.20	0.00	1.29	0.54	5.19	0.11
3	0.71	5.67	5.87	0.20	0.00	1.28	0.55	5.29	0.10
3	0.72	5.67	5.87	0.20	0.00	1.28	0.56	5.39	0.10
3	0.73	5.67	5.87	0.20	0.00	1.28	0.57	5.48	0.09
3	0.74	5.67	5.88	0.21	0.01	1.28	0.58	5.57	0.09
3	0.75	5.67	5.88	0.21	0.00	1.27	0.59	5.66	0.09
3	0.76	5.67	5.88	0.21	0.00	1.27	0.60	5.75	0.09
3	0.77	5.67	5.88	0.21	0.00	1.27	0.60	5.83	0.08
3	0.78	5.67	5.88	0.21	0.00	1.27	0.61	5.90	0.07
3	0.79	5.67	5.88	0.21	0.00	1.27	0.62	5.93	0.03
3	0.80	5.67	5.88	0.21	0.00	1.27	0.63	5.96	0.03
3	0.81	5.67	5.88	0.21	0.00	1.28	0.63	5.98	0.02
3	0.82	5.67	5.89	0.22	0.01	1.28	0.64	6.00	0.02
3	0.83	5.67	5.89	0.22	0.00	1.29	0.64	6.02	0.02
3	0.84	5.67	5.89	0.22	0.00	1.29	0.65	6.04	0.02
3	0.85	5.67	5.89	0.22	0.00	1.30	0.66	6.06	0.02
3	0.86	5.67	5.89	0.22	0.00	1.30	0.66	6.08	0.02
3	0.87	5.67	5.89	0.22	0.00	1.31	0.67	6.10	0.02
3	0.88	5.67	5.89	0.22	0.00	1.31	0.67	6.12	0.02
3	0.89	5.67	5.89	0.22	0.00	1.31	0.68	6.14	0.02
3	0.90	5.67	5.89	0.22	0.00	1.32	0.68	6.15	0.01
3	0.91	5.67	5.89	0.22	0.00	1.32	0.69	6.17	0.02
3	0.92	5.67	5.89	0.22	0.00	1.33	0.69	6.19	0.02
3	0.93	5.67	5.90	0.23	0.01	1.33	0.70	6.21	0.02
3	0.94	5.67	5.90	0.23	0.00	1.34	0.70	6.23	0.02
3	0.95	5.67	5.90	0.23	0.00	1.34	0.71	6.25	0.02
3	0.96	5.67	5.90	0.23	0.00	1.34	0.71	6.27	0.02
3	0.97	5.67	5.90	0.23	0.00	1.35	0.72	6.28	0.02
3	0.98	5.67	5.90	0.23	0.00	1.35	0.72	6.30	0.01
3	0.99	5.67	5.90	0.23	0.00	1.36	0.73	6.32	0.02
3	1.00	5.67	5.90	0.23	0.00	1.36	0.74	6.35	0.03
3	1.01	5.67	5.90	0.23	0.00	1.36	0.74	6.39	0.04
3	1.02	5.67	5.90	0.23	0.00	1.37	0.75	6.42	0.03
2	0.40	5.57	5.72	0.15	N/A	1.17	0.34	3.78	N/A
2	0.41	5.57	5.72	0.15	0.00	1.18	0.35	3.79	0.01
2	0.42	5.57	5.73	0.16	0.01	1.19	0.35	3.81	0.02
2	0.43	5.57	5.73	0.16	0.00	1.20	0.36	3.83	0.02
2	0.44	5.57	5.73	0.16	0.00	1.20	0.37	3.85	0.02
2	0.45	5.57	5.73	0.16	0.00	1.21	0.37	3.86	0.01
2	0.46	5.57	5.73	0.16	0.00	1.22	0.38	3.88	0.02
2	0.47	5.57	5.73	0.16	0.00	1.23	0.38	3.90	0.02
2	0.48	5.57	5.73	0.16	0.00	1.24	0.39	3.91	0.01
2	0.49	5.57	5.74	0.17	0.01	1.25	0.39	3.93	0.02
2	0.50	5.57	5.74	0.17	0.00	1.25	0.40	3.95	0.02
2	0.51	5.57	5.74	0.17	0.00	1.26	0.40	3.97	0.02
2	0.52	5.57	5.74	0.17	0.00	1.27	0.41	3.98	0.01
2	0.53	5.57	5.74	0.17	0.00	1.28	0.41	4.00	0.02
2	0.54	5.57	5.74	0.17	0.00	1.29	0.42	4.01	0.01
2	0.55	5.57	5.74	0.17	0.00	1.29	0.43	4.03	0.02
2	0.56	5.57	5.74	0.17	0.00	1.30	0.43	4.04	0.01
2	0.57	5.57	5.75	0.18	0.01	1.31	0.44	4.06	0.02
2	0.58	5.57	5.75	0.18	0.00	1.32	0.44	4.08	0.02
2	0.59	5.57	5.75	0.18	0.00	1.32	0.45	4.09	0.01
2	0.60	5.57	5.75	0.18	0.00	1.33	0.45	4.11	0.02
2	0.61	5.57	5.75	0.18	0.00	1.34	0.46	4.12	0.01
2	0.62	5.57	5.75	0.18	0.00	1.34	0.46	4.15	0.03
2	0.63	5.57	5.75	0.18	0.00	1.35	0.47	4.24	0.09
2	0.64	5.57	5.76	0.19	0.01	1.33	0.48	4.39	0.15
2	0.65	5.57	5.76	0.19	0.00	1.33	0.49	4.53	0.14
2	0.66	5.57	5.76	0.19	0.00	1.32	0.49	4.66	0.13
2	0.67	5.57	5.76	0.19	0.00	1.31	0.51	4.78	0.12
2	0.68	5.57	5.77	0.20	0.01	1.31	0.52	4.90	0.12
2	0.69	5.57	5.77	0.20	0.00	1.30	0.53	5.01	0.11
2	0.70	5.57	5.77	0.20	0.00	1.30	0.54	5.12	0.11
2	0.71	5.57	5.77	0.20	0.00	1.30	0.55	5.22	0.10
2	0.72	5.57	5.77	0.20	0.00	1.30	0.56	5.32	0.10
2	0.73	5.57	5.77	0.20	0.00	1.29	0.56	5.41	0.09
2	0.74	5.57	5.78	0.21	0.01	1.29	0.57	5.50	0.09
2	0.75	5.57	5.78	0.21	0.00	1.29	0.58	5.59	0.09
2	0.76	5.57	5.78	0.21	0.00	1.29	0.59	5.68	0.09
2	0.77	5.57	5.78	0.21	0.00	1.29	0.60	5.76	0.08
2	0.78	5.57	5.78	0.21	0.00	1.29	0.61	5.84	0.08
2	0.79	5.57	5.78	0.21	0.00	1.29	0.61	5.90	0.06
2	0.80	5.57	5.78	0.21	0.00	1.29	0.62	5.93	0.03
2	0.81	5.57	5.78	0.21	0.00	1.29	0.63	5.95	0.02
2	0.82	5.57	5.79	0.22	0.01	1.30	0.63	5.97	0.02
2	0.83	5.57	5.79	0.22	0.00	1.30	0.64	5.99	0.02
2	0.84	5.57	5.79	0.22	0.00	1.31	0.64	6.01	0.02
2	0.85	5.57	5.79	0.22	0.00	1.31	0.65	6.03	0.02
2	0.86	5.57	5.79	0.22	0.00	1.32	0.65	6.05	0.02
2	0.87	5.57	5.79	0.22	0.00	1.32	0.66	6.07	0.02
2	0.88	5.57	5.79	0.22	0.00	1.32	0.66	6.09	0.02
2	0.89	5.57	5.79	0.22	0.00	1.33	0.67	6.11	0.02
2	0.90	5.57	5.79	0.22	0.00	1.33	0.68	6.13	0.02
2	0.91	5.57	5.79	0.22	0.00	1.34	0.68	6.15	0.02
2	0.92	5.57	5.79	0.22	0.00	1.34	0.69	6.17	0.02
2	0.93	5.57	5.80	0.23	0.01	1.35	0.69	6.18	0.01
2	0.94	5.57	5.80	0.23	0.00	1.35	0.70	6.20	0.02
2	0.95	5.57	5.80	0.23	0.00	1.35	0.70	6.22	0.02
2	0.96	5.57	5.80	0.23	0.00	1.36	0.71	6.24	0.02
2	0.97	5.57	5.80	0.23	0.00	1.36	0.71	6.26	0.02
2	0.98	5.57	5.80	0.23	0.00	1.37	0.72	6.28	0.02
2	0.99	5.57	5.80	0.23	0.00	1.37	0.72	6.29	0.01
2	1.00	5.57	5.80	0.23	0.00	1.37	0.73	6.31	0.02
2	1.01	5.57	5.80	0.23	0.00	1.38	0.73	6.33	0.02
2	1.02	5.57	5.80	0.23	0.00	1.38	0.74	6.37	0.04
1	0.40	5.47	5.62	0.15	N/A	1.18	0.34	3.78	N/A
1	0.41	5.47	5.62	0.15	0.00	1.19	0.34	3.78	0.02
1	0.42	5.47	5.62	0.15	0.00	1.20	0.35	3.80	0.02
1	0.43	5.47	5.63	0.16	0.01	1.21	0.36	3.81	0.01
1	0.44	5.47	5.63	0.16	0.00	1.22	0.36	3.83	0.02
1	0.45	5.47	5.63	0.16	0.00	1.23	0.37	3.85	0.02
1	0.46	5.47	5.63	0.16	0.00	1.24	0.37	3.87	0.02
1	0.47	5.47	5.63	0.16	0.00	1.25	0.38	3.88	0.01
1	0.48	5.47	5.63	0.16	0.00	1.25	0.38	3.90	0.02
1	0.49	5.47	5.64	0.17	0.01	1.26	0.39	3.92	0.02
1	0.50	5.47	5.64	0.17	0.00	1.27	0.39	3.93	0.01
1	0.51	5.47	5.64	0.17	0.00	1.28	0.40	3.95	0.02
1	0.52	5.47	5.64	0.17	0.00	1.29	0.40	3.97	0.02
1	0.53	5.47	5.64	0.17	0.00	1.29	0.41	3.98	0.01
1	0.54	5.47	5.64	0.17	0.00	1.30	0.42	4.00	0.02
1	0.55	5.47	5.64	0.17	0.00	1.31	0.42	4.01	0.01
1	0.56	5.47	5.64	0.17	0.00	1.32	0.43	4.03	0.02
1	0.57	5.47	5.65	0.18	0.01	1.32	0.43	4.05	0.02
1	0.58	5.47	5.65	0.18	0.00	1.33	0.44	4.06	0.01
1	0.59	5.47	5.65	0.18	0.00	1.34	0.44	4.08	0.02
1	0.60	5.47	5.65	0.18	0.00	1.34	0.45	4.09	0.01
1	0.61	5.47	5.65	0.18	0.00	1.35	0.45	4.11	0.02
1	0.62	5.47	5.65	0.18	0.00	1.36	0.46	4.12	0.01
1	0.63	5.47	5.65	0.18	0.00	1.36	0.46	4.17	0.05
1	0.64	5.47	5.66	0.19	0.01	1.35	0.47	4.32	0.15
1	0.65	5.47	5.66	0.19	0.00	1.34	0.48	4.46	0.14
1	0.66	5.47	5.66	0.19	0.00	1.33	0.49	4.59	0.13
1	0.67	5.47	5.66	0.19	0.00	1.33	0.50	4.71	0.12
1	0.68	5.47	5.66	0.19	0.00	1.32	0.51	4.83	0.12
1	0.69	5.47	5.67	0.20	0.01	1.32	0.52	4.94	0.11
1	0.70	5.47	5.67	0.20	0.00	1.32	0.53	5.05	0.11
1	0.71	5.47	5.67	0.20	0.00	1.31	0.54	5.15	0.10
1	0.72	5.47	5.67	0.20	0.00	1.31	0.55	5.24	0.09
1	0.73	5.47	5.67	0.20	0.00	1.31	0.56	5.34	0.10
1	0.74	5.47	5.68	0.21	0.01	1.31	0.57	5.43	0.09
1	0.75	5.47	5.68	0.21	0.00	1.31	0.57	5.52	0.09
1	0.76	5.47	5.68	0.21	0.00	1.30	0.58	5.60	0.08
1	0.77	5.47	5.68	0.21	0.00	1.30	0.59	5.69	0.09
1	0.78	5.47	5.68	0.21	0.00	1.30	0.60	5.77	0.08
1	0.79	5.47	5.68	0.21	0.00	1.30	0.61	5.85	0.08
1	0.80	5.47	5.68	0.21	0.00	1.30	0.61	5.90	0.05
1	0.81	5.47	5.68	0.21	0.00	1.31	0.62	5.92	0.02
1	0.82	5.47	5.69	0.22	0.01	1.31	0.62	5.94	0.02
1	0.83	5.47	5.69	0.22	0.00	1.32	0.63	5.96	0.02
1	0.84	5.47	5.69	0.22	0.00	1.32	0.64	5.98	0.02
1	0.85	5.47	5.69	0.22	0.00	1.33	0.64	6.00	0.02
1	0.86	5.47	5.69	0.22	0.00	1.33	0.65	6.02	0.02
1	0.87	5.47	5.69	0.22	0.00	1.34	0.65	6.04	0.02
1	0.88	5.47	5.69	0.22	0.00	1.34	0.66	6.06	0.02
1	0.89	5.47	5.69	0.22	0.00	1.34	0.66	6.08	0.02
1	0.90	5.47	5.69	0.22	0.00	1.35	0.67	6.10	0.02
1	0.91	5.47	5.69	0.22	0.00	1.35	0.67	6.12	0.02
1	0.92	5.47	5.69	0.22	0.00	1.36	0.68	6.14	0.02
1	0.93	5.47	5.69	0.22	0.00	1.36	0.68	6.16	0.02
1	0.94	5.47	5.70	0.23	0.01	1.37	0.69	6.18	0.02
1	0.95	5.47	5.70	0.23	0.00	1.37	0.69	6.19	0.01
1	0.96	5.47	5.70	0.23	0.00	1.37	0.70	6.21	0.02
1	0.97	5.47	5.70	0.23	0.00	1.38	0.70	6.23	0.02
1	0.98	5.47	5.70	0.23	0.00	1.38	0.71	6.25	0.02
1	0.99	5.47	5.70	0.23	0.00	1.38	0.71	6.27	0.02
1	1.00	5.47	5.70	0.23	0.00	1.39	0.72	6.29	0.02
1	1.01	5.47	5.70	0.23	0.00	1.39	0.72	6.30	0.01
1	1.02	5.47	5.70	0.23	0.00	1.40	0.73	6.32	0.02

Average Change in depth = 0.00 ft
0 mm

Average Change in width = 0.04 ft
12 mm

Parametrix
Port of Seattle
554-2912-000

Checked By [signature] December 6, 200[illegible]

Miller Creek @ SR509

HSPF modeling
7 Day Low Flows (1948-1999)
$Q_{...}$ = 0.42 cfs
$Q_{...}$ = 1.80 cfs
$Q_{...}$ = 0.01 cfs

HEC-RAS Plan: "M-4 S=1.00%" River: Miller Creek Reach: M-4 Manning's n = 0.035

River Station	Q Total (cfs)	Minimum Channel Elevation (ft)	Water Surface Elevation (ft)	Flow Depth (ft)	Change in Flow Depth (ft)	Velocity Channel (ft/s)	Flow Area (sq ft)	Top Width (ft)	Change in Top Width (ft)
4	0.40	6.57	6.71	0.14	N/A	1.13	0.35	4.33	N/A
4	0.41	6.57	6.71	0.14	0.00	1.15	0.36	4.35	0.02
4	0.42	6.57	6.71	0.14	0.00	1.16	0.38	4.36	0.01
4	0.43	6.57	6.71	0.14	0.00	1.13	0.38	4.43	0.07
4	0.44	6.57	6.71	0.14	0.00	1.17	0.38	4.41	-0.02
4	0.45	6.57	6.71	0.14	0.00	1.18	0.38	4.43	0.02
4	0.46	6.57	6.72	0.15	0.01	1.19	0.39	4.45	0.02
4	0.47	6.57	6.72	0.15	0.00	1.20	0.39	4.47	0.02
4	0.48	6.57	6.72	0.15	0.00	1.20	0.40	4.49	0.02
4	0.49	6.57	6.72	0.15	0.00	1.21	0.40	4.51	0.02
4	0.50	6.57	6.72	0.15	0.00	1.22	0.41	4.53	0.02
4	0.51	6.57	6.72	0.15	0.00	1.23	0.41	4.55	0.02
4	0.52	6.57	6.72	0.15	0.00	1.24	0.42	4.57	0.02
4	0.53	6.57	6.72	0.15	0.00	1.24	0.43	4.59	0.02
4	0.54	6.57	6.73	0.16	0.01	1.25	0.43	4.60	0.01
4	0.55	6.57	6.73	0.16	0.00	1.26	0.44	4.62	0.02
4	0.56	6.57	6.73	0.16	0.00	1.27	0.44	4.64	0.02
4	0.57	6.57	6.73	0.16	0.00	1.27	0.45	4.66	0.02
4	0.58	6.57	6.73	0.16	0.00	1.28	0.45	4.68	0.02
4	0.59	6.57	6.73	0.16	0.00	1.29	0.46	4.70	0.02
4	0.60	6.57	6.73	0.16	0.00	1.29	0.46	4.71	0.01
4	0.61	6.57	6.73	0.16	0.00	1.30	0.47	4.73	0.02
4	0.62	6.57	6.73	0.16	0.00	1.31	0.47	4.75	0.02
4	0.63	6.57	6.74	0.17	0.01	1.31	0.48	4.77	0.02
4	0.64	6.57	6.74	0.17	0.00	1.32	0.48	4.78	0.01
4	0.65	6.57	6.74	0.17	0.00	1.33	0.49	4.80	0.02
4	0.66	6.57	6.74	0.17	0.00	1.33	0.50	4.82	0.02
4	0.67	6.57	6.74	0.17	0.00	1.34	0.50	4.83	0.01
4	0.68	6.57	6.74	0.17	0.00	1.35	0.51	4.85	0.02
4	0.69	6.57	6.74	0.17	0.00	1.35	0.51	4.86	0.01
4	0.70	6.57	6.74	0.17	0.00	1.36	0.52	4.87	0.01
4	0.71	6.57	6.74	0.17	0.00	1.37	0.52	4.88	0.01
4	0.72	6.57	6.74	0.17	0.00	1.37	0.52	4.89	0.01
4	0.73	6.57	6.75	0.18	0.01	1.38	0.53	4.90	0.01
4	0.74	6.57	6.75	0.18	0.00	1.39	0.53	4.91	0.01
4	0.75	6.57	6.75	0.18	0.00	1.39	0.54	4.92	0.01
4	0.76	6.57	6.75	0.18	0.00	1.40	0.54	4.93	0.01
4	0.77	6.57	6.75	0.18	0.00	1.40	0.55	4.94	0.01
4	0.78	6.57	6.75	0.18	0.00	1.41	0.55	4.95	0.01
4	0.79	6.57	6.75	0.18	0.00	1.42	0.56	4.96	0.01
4	0.80	6.57	6.75	0.18	0.00	1.42	0.56	4.97	0.01
4	0.81	6.57	6.75	0.18	0.00	1.43	0.57	4.98	0.01
4	0.82	6.57	6.75	0.18	0.00	1.43	0.57	4.99	0.01
4	0.83	6.57	6.76	0.19	0.01	1.44	0.58	5.00	0.01
4	0.84	6.57	6.76	0.19	0.00	1.45	0.58	5.01	0.01
4	0.85	6.57	6.76	0.19	0.00	1.46	0.59	5.02	0.01
4	0.86	6.57	6.76	0.19	0.00	1.46	0.59	5.03	0.01
4	0.87	6.57	6.76	0.19	0.00	1.46	0.59	5.04	0.01
4	0.88	6.57	6.76	0.19	0.00	1.47	0.60	5.05	0.01
4	0.89	6.57	6.76	0.19	0.00	1.47	0.60	5.06	0.01
4	0.90	6.57	6.76	0.19	0.00	1.48	0.61	5.06	0.00
4	0.91	6.57	6.76	0.19	0.00	1.49	0.61	5.07	0.01
4	0.92	6.57	6.76	0.19	0.00	1.49	0.62	5.07	0.00
4	0.93	6.57	6.76	0.19	0.00	1.50	0.62	5.08	0.01
4	0.94	6.57	6.76	0.19	0.00	1.50	0.62	5.08	0.00
4	0.95	6.57	6.77	0.20	0.01	1.51	0.63	5.09	0.01
4	0.96	6.57	6.77	0.20	0.00	1.52	0.63	5.10	0.01
4	0.97	6.57	6.77	0.20	0.00	1.52	0.64	5.10	0.00
4	0.98	6.57	6.77	0.20	0.00	1.53	0.64	5.11	0.01
4	0.99	6.57	6.77	0.20	0.00	1.53	0.65	5.11	0.00
4	1.00	6.57	6.77	0.20	0.00	1.54	0.65	5.12	0.01
4	1.01	6.57	6.77	0.20	0.00	1.54	0.65	5.12	0.00
4	1.02	6.57	6.77	0.20	0.00	1.55	0.66	5.13	0.01
3	0.40	6.46	6.60	0.14	N/A	1.16	0.34	4.28	N/A
3	0.41	6.46	6.60	0.14	0.00	1.18	0.35	4.31	0.03
3	0.42	6.46	6.60	0.14	0.00	1.19	0.35	4.33	0.02
3	0.43	6.46	6.60	0.14	0.00	1.25	0.34	4.30	-0.03
3	0.44	6.46	6.60	0.14	0.00	1.18	0.37	4.40	0.10
3	0.45	6.46	6.60	0.14	0.00	1.19	0.38	4.42	0.02
3	0.46	6.46	6.61	0.15	0.01	1.19	0.39	4.44	0.02
3	0.47	6.46	6.61	0.15	0.00	1.20	0.39	4.46	0.02
3	0.48	6.46	6.61	0.15	0.00	1.21	0.40	4.48	0.02
3	0.49	6.46	6.61	0.15	0.00	1.22	0.40	4.50	0.02
3	0.50	6.46	6.61	0.15	0.00	1.23	0.41	4.52	0.02
3	0.51	6.46	6.61	0.15	0.00	1.24	0.41	4.54	0.02
3	0.52	6.46	6.61	0.15	0.00	1.24	0.42	4.56	0.02
3	0.53	6.46	6.61	0.15	0.00	1.25	0.42	4.58	0.02
3	0.54	6.46	6.62	0.16	0.01	1.26	0.43	4.60	0.02
3	0.55	6.46	6.62	0.16	0.00	1.26	0.43	4.62	0.02
3	0.56	6.46	6.62	0.16	0.00	1.27	0.44	4.64	0.02
3	0.57	6.46	6.62	0.16	0.00	1.28	0.45	4.65	0.02
3	0.58	6.46	6.62	0.16	0.00	1.29	0.45	4.67	0.02
3	0.59	6.46	6.62	0.16	0.00	1.29	0.46	4.69	0.02
3	0.60	6.46	6.62	0.16	0.00	1.30	0.46	4.71	0.02
3	0.61	6.46	6.62	0.16	0.00	1.31	0.47	4.72	0.01
3	0.62	6.46	6.62	0.16	0.00	1.31	0.47	4.74	0.02
3	0.63	6.46	6.63	0.17	0.01	1.32	0.48	4.76	0.02
3	0.64	6.46	6.63	0.17	0.00	1.33	0.48	4.78	0.02
3	0.65	6.46	6.63	0.17	0.00	1.33	0.49	4.79	0.01
3	0.66	6.46	6.63	0.17	0.00	1.34	0.49	4.81	0.02
3	0.67	6.46	6.63	0.17	0.00	1.35	0.50	4.83	0.02
3	0.68	6.46	6.63	0.17	0.00	1.35	0.50	4.84	0.01
3	0.69	6.46	6.63	0.17	0.00	1.36	0.51	4.85	0.01
3	0.70	6.46	6.63	0.17	0.00	1.36	0.51	4.86	0.01
3	0.71	6.46	6.63	0.17	0.00	1.37	0.52	4.87	0.01
3	0.72	6.46	6.64	0.18	0.01	1.38	0.52	4.88	0.01
3	0.73	6.46	6.64	0.18	0.00	1.38	0.53	4.89	0.01
3	0.74	6.46	6.64	0.18	0.00	1.39	0.53	4.90	0.01
3	0.75	6.46	6.64	0.18	0.00	1.40	0.54	4.92	0.02
3	0.76	6.46	6.64	0.18	0.00	1.40	0.54	4.93	0.01
3	0.77	6.46	6.64	0.18	0.00	1.41	0.55	4.94	0.01
3	0.78	6.46	6.64	0.18	0.00	1.42	0.55	4.95	0.01
3	0.79	6.46	6.64	0.18	0.00	1.42	0.56	4.96	0.01
3	0.80	6.46	6.64	0.18	0.00	1.43	0.56	4.97	0.01
3	0.81	6.46	6.64	0.18	0.00	1.43	0.56	4.98	0.01
3	0.82	6.46	6.64	0.18	0.00	1.44	0.57	4.99	0.01
3	0.83	6.46	6.65	0.19	0.01	1.45	0.57	5.00	0.01
3	0.84	6.46	6.65	0.19	0.00	1.45	0.58	5.00	0.00
3	0.85	6.46	6.65	0.19	0.00	1.46	0.58	5.01	0.01
3	0.86	6.46	6.65	0.19	0.00	1.46	0.59	5.02	0.01
3	0.87	6.46	6.65	0.19	0.00	1.47	0.59	5.03	0.01
3	0.88	6.46	6.65	0.19	0.00	1.47	0.60	5.04	0.01
3	0.89	6.46	6.65	0.19	0.00	1.48	0.60	5.05	0.01
3	0.90	6.46	6.65	0.19	0.00	1.49	0.61	5.06	0.01
3	0.91	6.46	6.65	0.19	0.00	1.49	0.61	5.06	0.00
3	0.92	6.46	6.65	0.19	0.00	1.50	0.61	5.07	0.01
3	0.93	6.46	6.65	0.19	0.00	1.50	0.62	5.08	0.01
3	0.94	6.46	6.66	0.20	0.01	1.51	0.62	5.08	0.00
3	0.95	6.46	6.66	0.20	0.00	1.52	0.63	5.09	0.01
3	0.96	6.46	6.66	0.20	0.00	1.52	0.63	5.09	0.00
3	0.97	6.46	6.66	0.20	0.00	1.53	0.64	5.10	0.01
3	0.98	6.46	6.66	0.20	0.00	1.53	0.64	5.10	0.00
3	0.99	6.46	6.66	0.20	0.00	1.54	0.64	5.11	0.01
3	1.00	6.46	6.66	0.20	0.00	1.54	0.65	5.11	0.00
3	1.01	6.46	6.66	0.20	0.00	1.55	0.65	5.12	0.01
3	1.02	6.46	6.66	0.20	0.00	1.55	0.66	5.13	0.01
2	0.40	6.35	6.49	0.14	N/A	1.10	0.36	4.37	N/A
2	0.41	6.35	6.49	0.14	0.00	1.12	0.37	4.38	0.01
2	0.42	6.35	6.49	0.14	0.00	1.14	0.37	4.39	0.01
2	0.43	6.35	6.49	0.14	0.00	1.15	0.37	4.40	0.01
2	0.44	6.35	6.49	0.14	0.00	1.16	0.37	4.40	0.00
2	0.45	6.35	6.50	0.15	0.01	1.18	0.38	4.42	0.02
2	0.46	6.35	6.50	0.15	0.00	1.20	0.38	4.44	0.02
2	0.47	6.35	6.50	0.15	0.00	1.21	0.39	4.46	0.02
2	0.48	6.35	6.50	0.15	0.00	1.22	0.39	4.48	0.02
2	0.49	6.35	6.50	0.15	0.00	1.22	0.40	4.50	0.02
2	0.50	6.35	6.50	0.15	0.00	1.23	0.41	4.52	0.02
2	0.51	6.35	6.50	0.15	0.00	1.24	0.41	4.53	0.01
2	0.52	6.35	6.50	0.15	0.00	1.25	0.42	4.55	0.02
2	0.53	6.35	6.50	0.15	0.00	1.26	0.42	4.57	0.02
2	0.54	6.35	6.51	0.16	0.01	1.26	0.43	4.59	0.02
2	0.55	6.35	6.51	0.16	0.00	1.27	0.43	4.61	0.02
2	0.56	6.35	6.51	0.16	0.00	1.28	0.44	4.63	0.02
2	0.57	6.35	6.51	0.16	0.00	1.28	0.44	4.65	0.02
2	0.58	6.35	6.51	0.16	0.00	1.29	0.45	4.66	0.01
2	0.59	6.35	6.51	0.16	0.00	1.30	0.45	4.68	0.02
2	0.60	6.35	6.51	0.16	0.00	1.31	0.46	4.70	0.02
2	0.61	6.35	6.51	0.16	0.00	1.31	0.46	4.72	0.02
2	0.62	6.35	6.52	0.17	0.01	1.32	0.47	4.73	0.01
2	0.63	6.35	6.52	0.17	0.00	1.33	0.48	4.75	0.02
2	0.64	6.35	6.52	0.17	0.00	1.33	0.48	4.77	0.02
2	0.65	6.35	6.52	0.17	0.00	1.34	0.49	4.79	0.02
2	0.66	6.35	6.52	0.17	0.00	1.34	0.49	4.80	0.01
2	0.67	6.35	6.52	0.17	0.00	1.35	0.50	4.82	0.02
2	0.68	6.35	6.52	0.17	0.00	1.36	0.50	4.84	0.02
2	0.69	6.35	6.52	0.17	0.00	1.36	0.51	4.85	0.01
2	0.70	6.35	6.52	0.17	0.00	1.37	0.51	4.86	0.01
2	0.71	6.35	6.52	0.17	0.00	1.38	0.52	4.87	0.01
2	0.72	6.35	6.53	0.18	0.01	1.38	0.52	4.88	0.01
2	0.73	6.35	6.53	0.18	0.00	1.39	0.53	4.89	0.01
2	0.74	6.35	6.53	0.18	0.00	1.40	0.53	4.90	0.01
2	0.75	6.35	6.53	0.18	0.00	1.40	0.53	4.91	0.01
2	0.76	6.35	6.53	0.18	0.00	1.41	0.54	4.92	0.01
2	0.77	6.35	6.53	0.18	0.00	1.42	0.54	4.93	0.01
2	0.78	6.35	6.53	0.18	0.00	1.42	0.55	4.94	0.01
2	0.79	6.35	6.53	0.18	0.00	1.43	0.55	4.95	0.01
2	0.80	6.35	6.53	0.18	0.00	1.43	0.56	4.96	0.01
2	0.81	6.35	6.53	0.18	0.00	1.44	0.56	4.97	0.01
2	0.82	6.35	6.54	0.19	0.01	1.45	0.57	4.98	0.01
2	0.83	6.35	6.54	0.19	0.00	1.45	0.57	4.99	0.01
2	0.84	6.35	6.54	0.19	0.00	1.46	0.58	5.00	0.01
2	0.85	6.35	6.54	0.19	0.00	1.46	0.58	5.01	0.01
2	0.86	6.35	6.54	0.19	0.00	1.47	0.58	5.02	0.01
2	0.87	6.35	6.54	0.19	0.00	1.47	0.59	5.03	0.01
2	0.88	6.35	6.54	0.19	0.00	1.48	0.59	5.04	0.01
2	0.89	6.35	6.54	0.19	0.00	1.49	0.60	5.05	0.01
2	0.90	6.35	6.54	0.19	0.00	1.49	0.60	5.06	0.01
2	0.91	6.35	6.54	0.19	0.00	1.50	0.61	5.06	0.00
2	0.92	6.35	6.54	0.19	0.00	1.50	0.61	5.07	0.01
2	0.93	6.35	6.54	0.19	0.00	1.51	0.62	5.07	0.00
2	0.94	6.35	6.55	0.20	0.01	1.52	0.62	5.08	0.01
2	0.95	6.35	6.55	0.20	0.00	1.52	0.62	5.08	0.00
2	0.96	6.35	6.55	0.20	0.00	1.53	0.63	5.09	0.01
2	0.97	6.35	6.55	0.20	0.00	1.53	0.63	5.09	0.00
2	0.98	6.35	6.55	0.20	0.00	1.54	0.64	5.10	0.01
2	0.99	6.35	6.55	0.20	0.00	1.54	0.64	5.11	0.01
2	1.00	6.35	6.55	0.20	0.00	1.55	0.65	5.11	0.00
2	1.01	6.35	6.55	0.20	0.00	1.55	0.65	5.12	0.01
2	1.02	6.35	6.55	0.20	0.00	1.56	0.65	5.12	0.00
1	0.40	6.24	6.38	0.14	N/A	1.15	0.35	4.31	N/A
1	0.41	6.24	6.38	0.14	0.00	1.16	0.35	4.33	0.02
1	0.42	6.24	6.38	0.14	0.00	1.17	0.36	4.35	0.02
1	0.43	6.24	6.38	0.14	0.00	1.18	0.36	4.37	0.02
1	0.44	6.24	6.38	0.14	0.00	1.19	0.37	4.39	0.02
1	0.45	6.24	6.39	0.15	0.01	1.20	0.38	4.41	0.02
1	0.46	6.24	6.39	0.15	0.00	1.21	0.38	4.43	0.02
1	0.47	6.24	6.39	0.15	0.00	1.22	0.39	4.45	0.02
1	0.48	6.24	6.39	0.15	0.00	1.22	0.39	4.47	0.02
1	0.49	6.24	6.39	0.15	0.00	1.23	0.40	4.49	0.02
1	0.50	6.24	6.39	0.15	0.00	1.24	0.40	4.51	0.02
1	0.51	6.24	6.39	0.15	0.00	1.25	0.41	4.53	0.02
1	0.52	6.24	6.39	0.15	0.00	1.25	0.41	4.55	0.02
1	0.53	6.24	6.40	0.16	0.01	1.26	0.42	4.57	0.02
1	0.54	6.24	6.40	0.16	0.00	1.27	0.43	4.58	0.01
1	0.55	6.24	6.40	0.16	0.00	1.28	0.43	4.60	0.02
1	0.56	6.24	6.40	0.16	0.00	1.29	0.44	4.62	0.02
1	0.57	6.24	6.40	0.16	0.00	1.29	0.44	4.64	0.02
1	0.58	6.24	6.40	0.16	0.00	1.30	0.45	4.66	0.02
1	0.59	6.24	6.40	0.16	0.00	1.30	0.45	4.68	0.02
1	0.60	6.24	6.40	0.16	0.00	1.31	0.46	4.69	0.01
1	0.61	6.24	6.40	0.16	0.00	1.32	0.46	4.71	0.02
1	0.62	6.24	6.41	0.17	0.01	1.32	0.47	4.73	0.02
1	0.63	6.24	6.41	0.17	0.00	1.33	0.47	4.75	0.02
1	0.64	6.24	6.41	0.17	0.00	1.34	0.48	4.76	0.01
1	0.65	6.24	6.41	0.17	0.00	1.34	0.48	4.78	0.02
1	0.66	6.24	6.41	0.17	0.00	1.35	0.49	4.80	0.02
1	0.67	6.24	6.41	0.17	0.00	1.36	0.49	4.81	0.01
1	0.68	6.24	6.41	0.17	0.00	1.36	0.50	4.83	0.02
1	0.69	6.24	6.41	0.17	0.00	1.37	0.50	4.84	0.01
1	0.70	6.24	6.41	0.17	0.00	1.38	0.51	4.85	0.01
1	0.71	6.24	6.42	0.18	0.01	1.38	0.51	4.86	0.01
1	0.72	6.24	6.42	0.18	0.00	1.39	0.52	4.88	0.02
1	0.73	6.24	6.42	0.18	0.00	1.40	0.52	4.89	0.01
1	0.74	6.24	6.42	0.18	0.00	1.40	0.53	4.90	0.01
1	0.75	6.24	6.42	0.18	0.00	1.41	0.53	4.91	0.01
1	0.76	6.24	6.42	0.18	0.00	1.42	0.54	4.92	0.01
1	0.77	6.24	6.42	0.18	0.00	1.42	0.54	4.93	0.01
1	0.78	6.24	6.42	0.18	0.00	1.43	0.55	4.94	0.01
1	0.79	6.24	6.42	0.18	0.00	1.43	0.55	4.95	0.01
1	0.80	6.24	6.42	0.18	0.00	1.44	0.56	4.96	0.01
1	0.81	6.24	6.42	0.18	0.00	1.45	0.56	4.97	0.01
1	0.82	6.24	6.43	0.19	0.01	1.45	0.57	4.98	0.01
1	0.83	6.24	6.43	0.19	0.00	1.46	0.57	4.99	0.01
1	0.84	6.24	6.43	0.19	0.00	1.46	0.57	5.00	0.01
1	0.85	6.24	6.43	0.19	0.00	1.47	0.58	5.01	0.01
1	0.86	6.24	6.43	0.19	0.00	1.47	0.58	5.01	0.00
1	0.87	6.24	6.43	0.19	0.00	1.48	0.59	5.02	0.01
1	0.88	6.24	6.43	0.19	0.00	1.49	0.59	5.03	0.01
1	0.89	6.24	6.43	0.19	0.00	1.49	0.60	5.04	0.01
1	0.90	6.24	6.43	0.19	0.00	1.50	0.60	5.05	0.01
1	0.91	6.24	6.43	0.19	0.00	1.50	0.61	5.06	0.01
1	0.92	6.24	6.43	0.19	0.00	1.51	0.61	5.06	0.00
1	0.93	6.24	6.44	0.20	0.01	1.52	0.61	5.07	0.01
1	0.94	6.24	6.44	0.20	0.00	1.52	0.62	5.07	0.00
1	0.95	6.24	6.44	0.20	0.00	1.53	0.62	5.08	0.01
1	0.96	6.24	6.44	0.20	0.00	1.53	0.63	5.09	0.01
1	0.97	6.24	6.44	0.20	0.00	1.54	0.63	5.09	0.00
1	0.98	6.24	6.44	0.20	0.00	1.54	0.63	5.10	0.01
1	0.99	6.24	6.44	0.20	0.00	1.55	0.64	5.10	0.00
1	1.00	6.24	6.44	0.20	0.00	1.56	0.64	5.11	0.01
1	1.01	6.24	6.44	0.20	0.00	1.56	0.65	5.11	0.00
1	1.02	6.24	6.44	0.20	0.00	1.57	0.65	5.12	0.01

Average Change in depth = 0.00 ft
0 mm

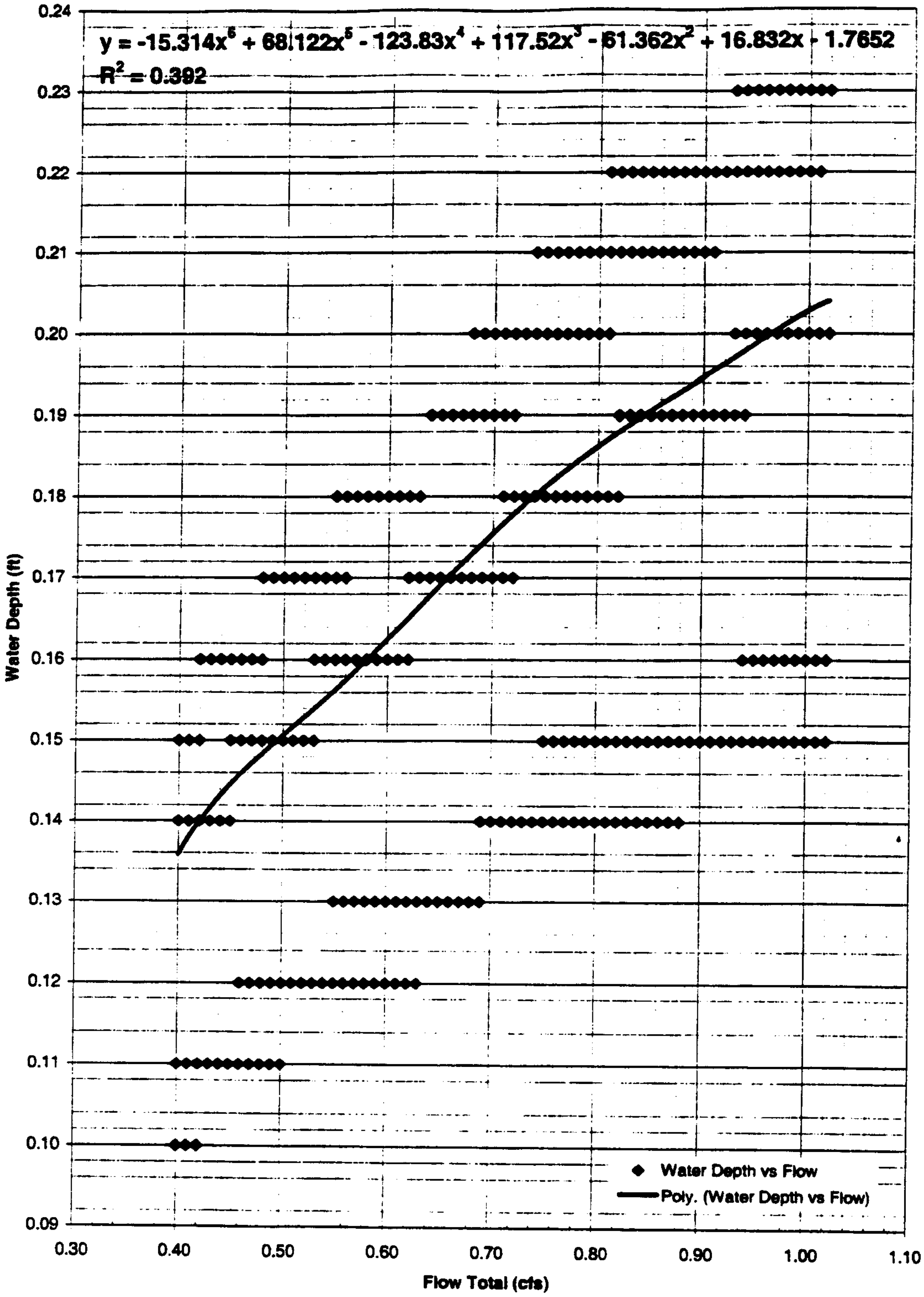
Average Change in width = 0.01 ft
3 mm

Miller Creek Average Change in Depth for $Q_{...}$ = 0.00 ft (0 mm)
Miller Creek Average Change in Width for $Q_{...}$ = 0.02 ft (6 mm)

Parametrix Inc.
Port of Seattle
554-2912-28B

By: Angela Wilcox
Checked By: [signature]
December 5, 2001

Miller Creek

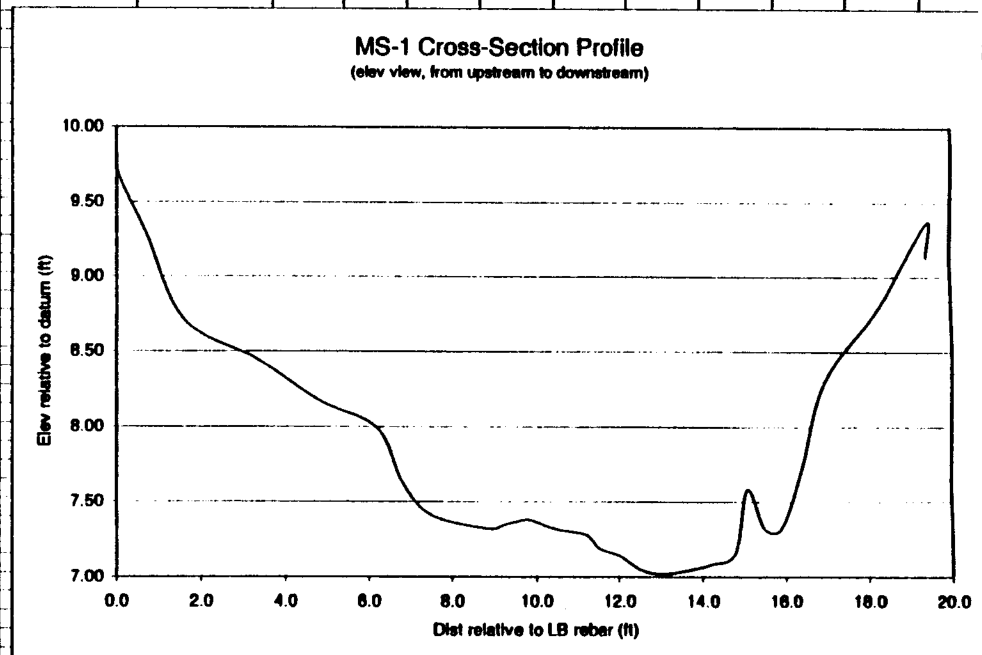


K:\working\2912\2912(28B)\HecRas Values.xlsMiller Creek Q vs H2O Depth

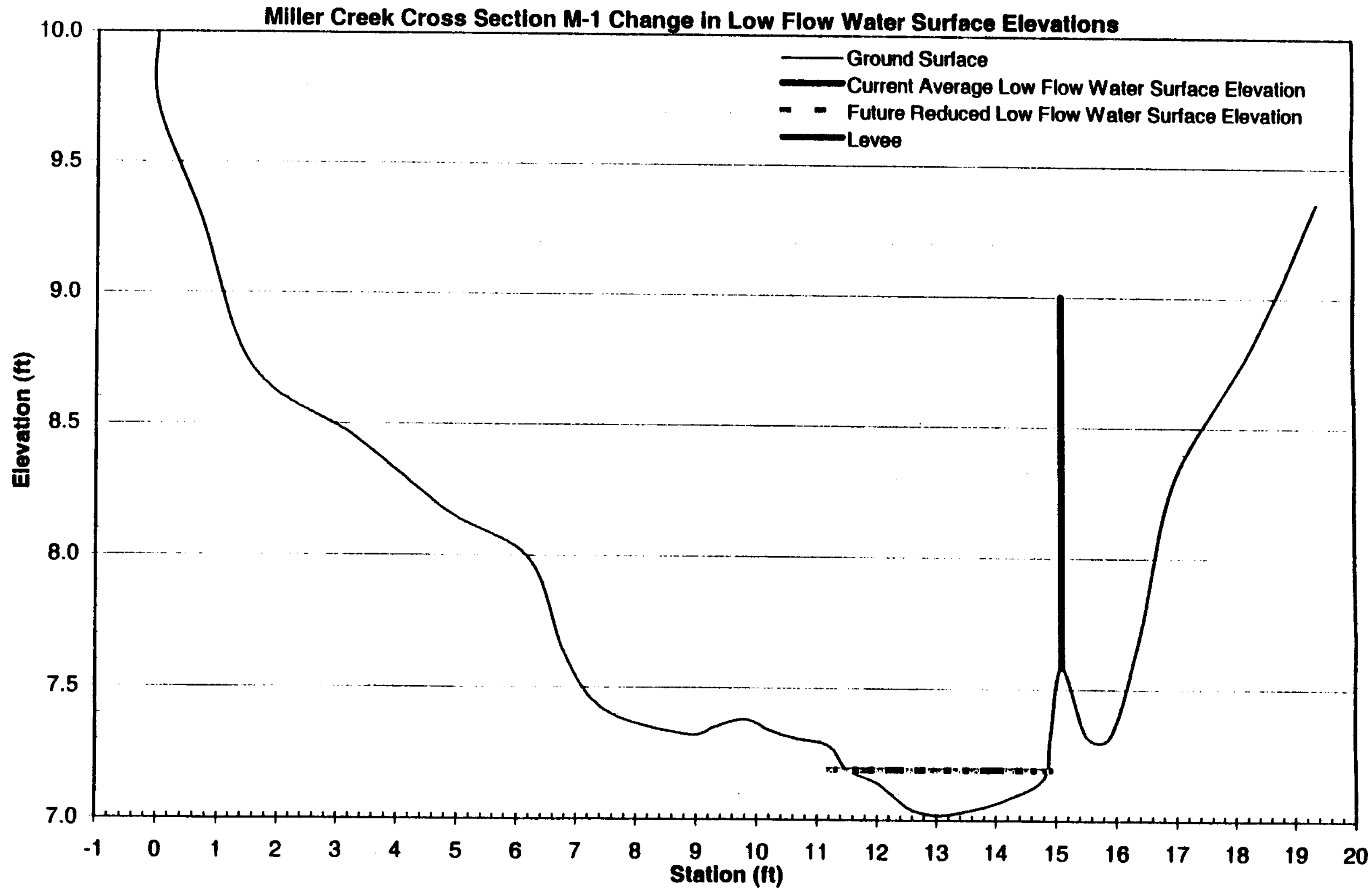
Summer low flow assessment: cross section data					
3rd Runway Project					
Creek:	Miller				
Cross-section # :	MS-1				
Date Surveyed:	8/10/2001				
Field Crew:	HW, RF	Stadia:	HW		
Date Entered:	8/23/2001	Notes:	RF		
Entered By:	HW				
Vert Dist from level to datum:		19.73	feet		

Definitions:	RB - right bank, looking d/s	BFW est (ft) =	10.5	(to nearest 0.5 ft)
	LB - left bank, looking d/s	WW (ft) =	4.2	
	OHWM - ordinary high water m	Ave H20 depth (ft) =	0.168889	
	EOW - edge of water	Max H20 depth (ft) =	0.29	
	SS - substrate			
	BFW - bank full width			
	WW - wetted width			
Conventions:	measurements begin on left bank			
	datum defined at 10 feet below top of LB rebar			

RAW DATA			Final Values		
Description	dist (ft)	height (ft)	dist (ft)	elev (ft)	H20 depth (ft)
top LB rebar	0.7	9.73	0.00	10.00	
base LB rebar	0.7	10.01	0.00	9.72	
	1.4	10.44	0.70	9.29	
	2.3	11.02	1.60	8.71	
	4.0	11.28	3.30	8.45	
	5.6	11.57	4.90	8.16	
	6.9	11.74	6.20	7.99	
OHWM	7.5	12.10	6.80	7.63	
	8.2	12.32	7.50	7.41	
	9.6	12.41	8.90	7.32	
	10.0	12.38	9.30	7.35	
	10.5	12.35	9.80	7.38	
	10.9	12.39	10.20	7.34	
EOW	11.3	12.42	10.60	7.31	0.00
ss	11.9	12.45	11.20	7.28	0.03
ss	12.2	12.54	11.50	7.19	0.12
ss	12.7	12.59	12.00	7.14	0.17
ss	13.2	12.68	12.50	7.05	0.26
thalweg	13.7	12.71	13.00	7.02	0.29
ss	14.3	12.69	13.60	7.04	0.27
ss	14.9	12.65	14.20	7.08	0.23
EOW; LB side of cobble	15.5	12.57	14.80	7.16	0.15
top of cobble	15.8	12.15	15.10	7.58	
RB side of cobble	16.2	12.41	15.50	7.32	
	16.6	12.41	15.90	7.32	
OHWM	17.1	12.03	16.40	7.70	
	17.7	11.42	17.00	8.31	
	19.0	10.92	18.30	8.81	
top RB rebar	20.1	10.37	19.40	9.36	
base RB rebar	20.1	10.60	19.40	9.13	



AR 052815


Miller Creek Cross Section M-1 Change in Low Flow Water Surface Elevations
Ground Surface
Current Average Low Flow Water Surface Elevation
Future Reduced Low Flow Water Surface Elevation
Levee
Elevation (ft)
10.0
9.5
9.0
8.5
8.0
7.5
7.0
Station (ft)
-1
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20

Summer low flow assessment: cross section data
3rd Runway Project

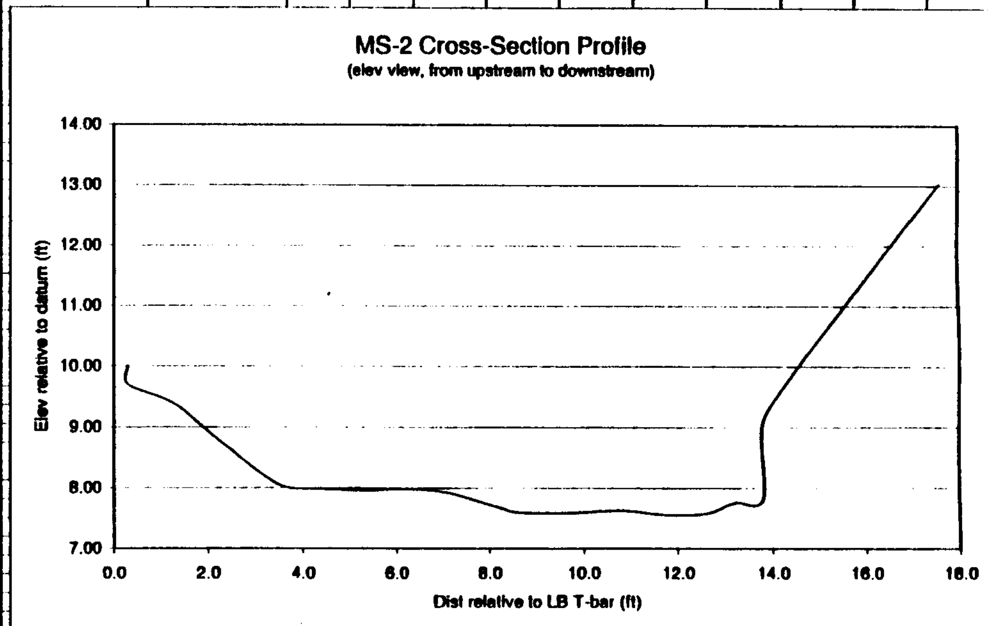
Creek:	Miller		
Cross-section # :	MS-2		
Date Surveyed:	8/10/2001		
Field Crew:	HW, RF	Stadia:	HW
Date Entered:	8/23/2001	Notes:	RF
Entered By:	HW		
Vert Dist from level to datum:	16.52	feet	

Definitions:

RB - right bank, looking d/s	BFW est (ft) =	11.5	(to nearest 0.5 ft)
LB - left bank, looking d/s	WW (ft) =	8.4	
OHWM - ordinary high water m	Ave H20 depth (ft) =	0.105	
EOW - edge of water	Max H20 depth (ft) =	0.39	
SS - substrate			
BFW - bank full width			
WW - wetted width			

Conventions: measurements begin on left bank
datum defined at 10 feet below top of LB datum rebar

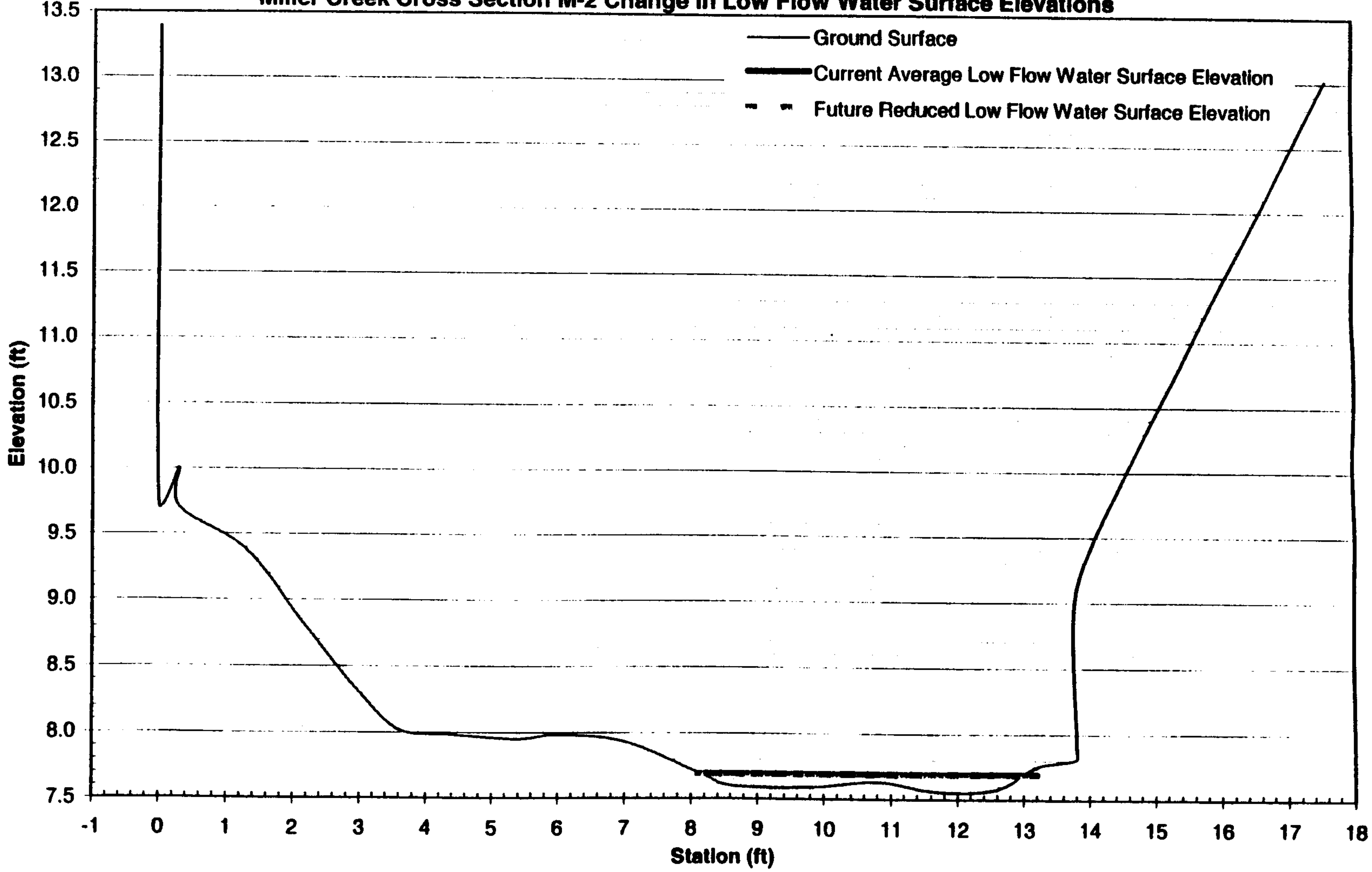
RAW DATA			Final Values		
Description	dist (ft)	height (ft)	dist (ft)	elev (ft)	H20 depth (ft)
top LB Tbar	1.6	3.13	0.00	13.39	
base LB Tbar	1.6	6.79	0.00	9.73	
top LB datum rebar	1.9	6.52	0.30	10.00	
base LB datum rebar	1.9	6.82	0.30	9.70	
	2.9	7.14	1.30	9.38	
	3.7	7.66	2.10	8.86	
OHWM	4.2	7.98	2.60	8.54	
	4.6	8.22	3.00	8.30	
	5.2	8.50	3.60	8.02	
	6.0	8.54	4.40	7.98	
EOW	7.0	8.57	5.40	7.95	0.00
ss	7.6	8.54	6.00	7.98	-0.03
ss	8.6	8.59	7.00	7.93	0.02
ss	9.7	8.82	8.10	7.70	0.25
ss	10.2	8.92	8.60	7.60	0.35
thalweg	11.4	8.93	9.80	7.59	0.36
ss	12.4	8.89	10.80	7.63	0.32
ss	13.3	8.96	11.70	7.56	0.39
ss	14.2	8.94	12.60	7.58	0.37
ss	14.8	8.77	13.20	7.75	0.20
EOW	15.4	8.71	13.80	7.81	0.14
OHWM	15.4	7.46	13.80	9.06	-1.11
	16.0	6.70	14.40	9.82	
base RB Tbar	19.2	3.50	17.60	13.02	
top RB Tbar	19.2	-0.40	17.60	16.92	



AR 052817

By: Ange... Wilcox
Checked By:
December 6, 2001

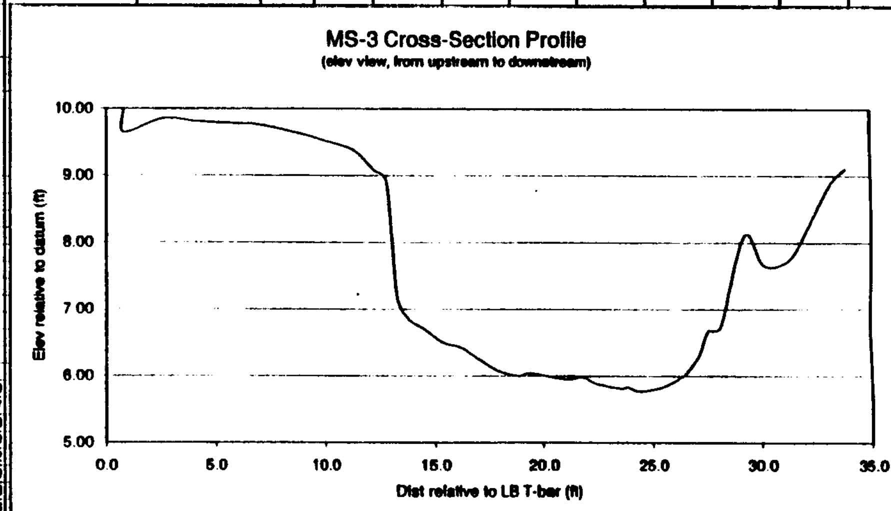
Miller Creek Cross Section M-2 Change in Low Flow Water Surface Elevations



K:\working\2912\2912(28B)\miller.xlsM-2 Water Surface

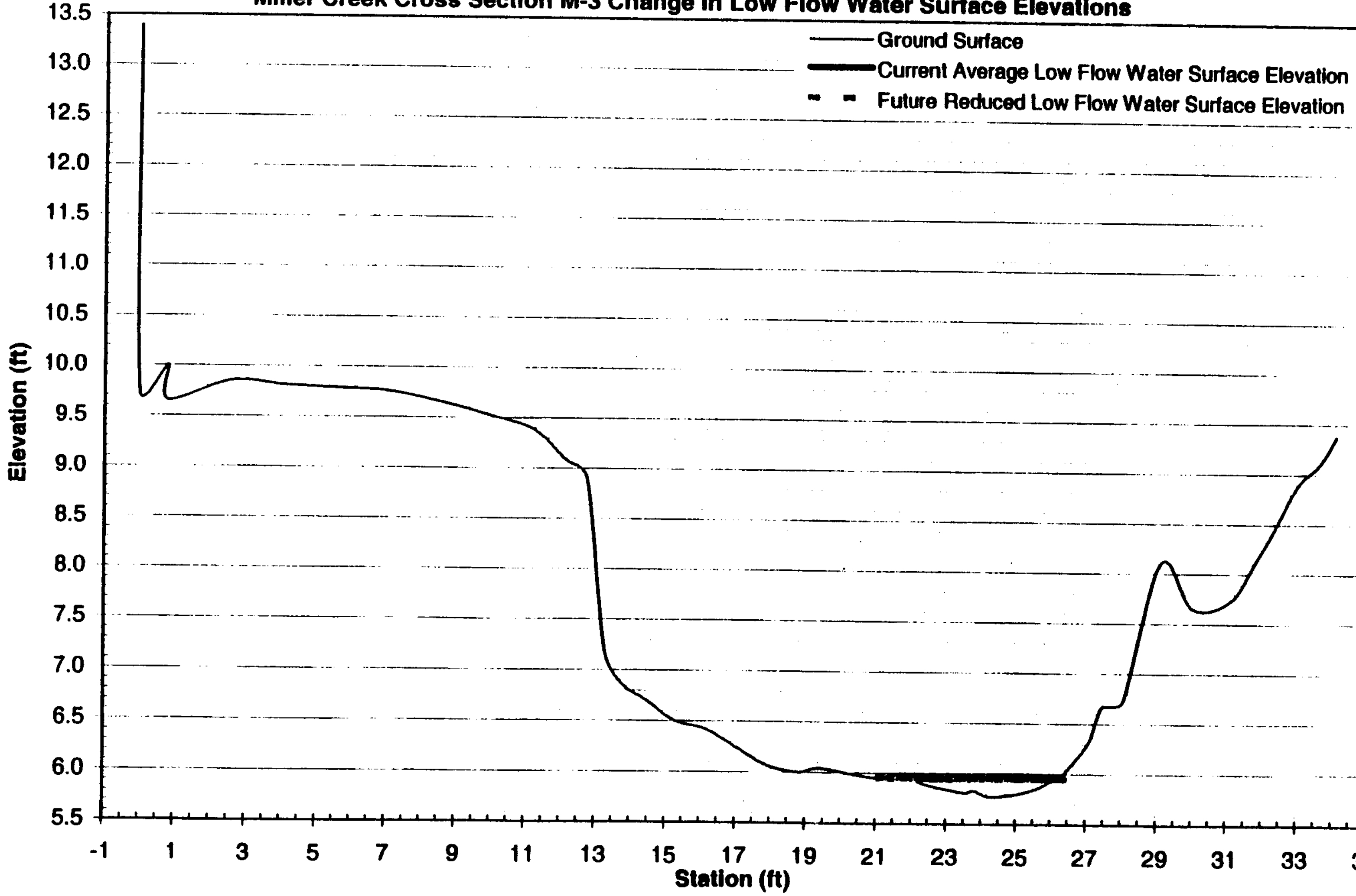
Summer low flow assessment: cross section data									
3rd Runway Project									
				Definitions:	RB - right bank, looking d/s	BFW est (ft) =	13.5	(to nearest 0.5 ft)	
Creek:	**Miller**				LB - left bank, looking d/s	WW (ft) =	8.5		
Cross-section #	MS-3				OHWM - ordinary high water mark	Ave H20 depth (ft) =	0.1508		
Date Surveyed	8/10/2001				EOW - edge of water	Max H20 depth (ft) =	0.3		
Field Crew:	HW, RF	Stadia	RF		SS - substrate				
Date Entered	8/24/2001	Notes	HW		BFW - bank full width				
Entered By	HW				WW - wetted width				
				Conventions:	measurements begin on left bank				
Vert Dist from level to datum:		14.70	feet		datum defined at 10 feet below top of LB datum rebar				

RAW DATA			Final Values		
Description	**dist (ft)**	**height (ft)**	**dist (ft)**	**elev (ft)**	**H20 depth (ft)**
top LB Tbar	1.8	1.31	0.00	13.39	
base LB Tbar	1.8	4.98	0.00	9.72	
top LB datum rebar	2.6	4.70	0.80	10.00	
base LB datum rebar	2.6	5.05	0.80	9.65	
	4.4	4.85	2.60	9.85	
	5.9	4.89	4.10	9.81	
	7.6	4.92	5.80	9.78	
	8.8	4.94	7.00	9.76	
	10.4	5.05	8.60	9.65	
	11.8	5.18	10.00	9.52	
	13.1	5.32	11.30	9.38	
	14.0	5.62	12.20	9.08	
top of vertical bank	14.6	5.80	12.80	8.90	
bottom of bank	15.1	7.51	13.30	7.19	
OHWM	15.6	7.84	13.80	6.86	
	16.3	8.00	14.50	6.70	
	17.1	8.20	15.30	6.50	
	18.0	8.28	16.20	6.42	
	18.9	8.47	17.10	6.23	
EOW	19.7	8.63	17.90	6.07	0.00
ss	20.6	8.70	18.80	6.00	0.07
ss	21.2	8.66	19.40	6.04	0.03
ss	22.2	8.72	20.40	5.98	0.09
ss	22.9	8.75	21.10	5.95	0.12
ss	23.6	8.72	21.80	5.98	0.09
ss	24.2	8.81	22.40	5.89	0.18
ss	25.3	8.89	23.50	5.81	0.26
ss	25.6	8.87	23.80	5.83	0.24
thalweg	26.0	8.93	24.20	5.77	0.30
ss	26.6	8.92	24.80	5.78	0.29
ss	27.4	8.85	25.60	5.85	0.22
EOW	28.2	8.70	26.40	6.00	0.07
	28.3	8.39	26.50	6.04	
OHWM	29.3	8.03	27.10	6.31	
LB side of boulder	29.9	7.97	27.50	6.67	
top of boulder	31.0	6.60	28.10	6.73	
RB side of boulder	31.9	7.05	29.20	8.10	
	33.0	6.97	30.10	7.65	
	33.8	6.53	31.20	7.73	
	34.9	5.84	32.00	8.17	
	35.6	5.60	33.10	8.86	
base RB Tbar	36.1	5.33	33.80	9.10	
top RB Tbar	36.1	1.58	34.30	9.37	



AR 052819

Miller Creek Cross Section M-3 Change in Low Flow Water Surface Elevations



K:\working\2912\2912(28B)\miller.xlsM-3 Water Surface

Summer low flow assessment: cross section data
3rd Runway Project

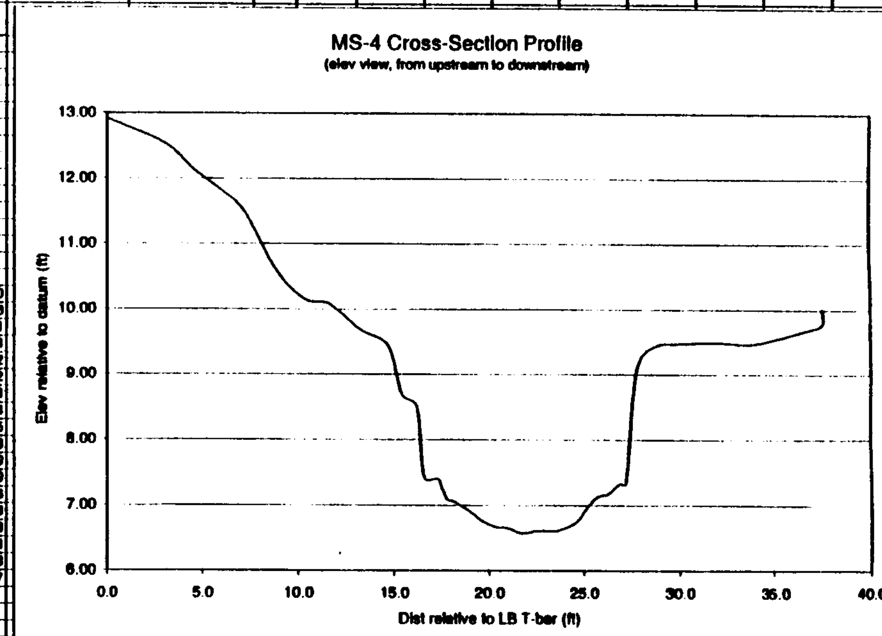
Creek:	Miller		
Cross-section # :	MS-4		
Date Surveyed:	8/10/2001		
Field Crew:	HW, RF	Stadia:	HW
Date Entered:	8/24/2001	Notes:	RF
Entered By:	HW		
Vert Dist from level to datum:	14.74	feet	

Definitions:
RB - right bank, looking d/s
LB - left bank, looking d/s
OHWM - ordinary high water mark
EOW - edge of water
SS - substrate
BFW - bank full width
WW - wetted width

BFW est (ft) =	11.5	(to nearest 0.5 ft)
WW (ft) =	9.6	
Ave H20 depth (ft) =	0.454	
Max H20 depth (ft) =	0.83	

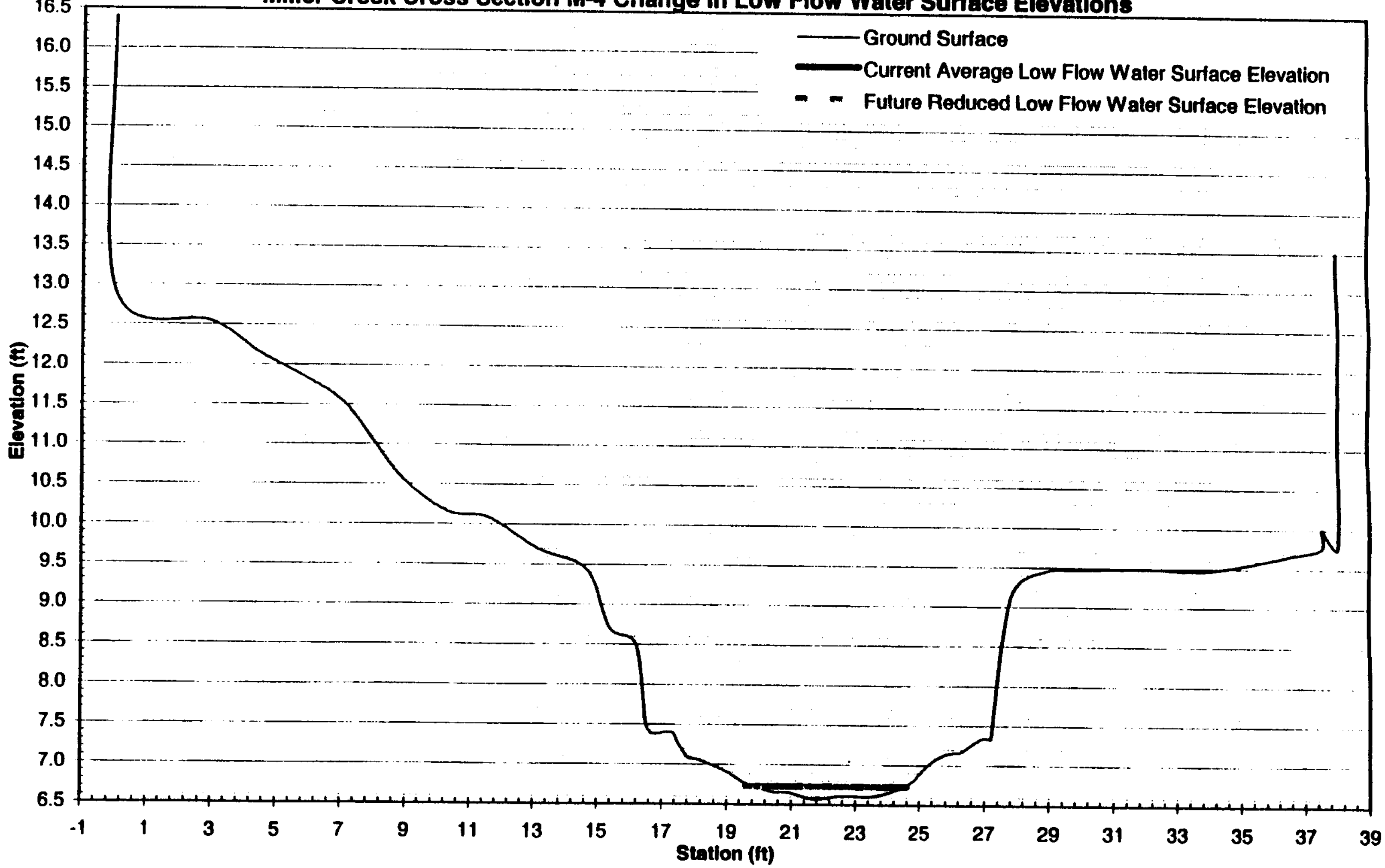
Conventions:
measurements begin on left bank
datum defined at 10 feet below top of RB datum rebar (LB too soft)

	RAW DATA		Final Values		
Description	**dist (ft)**	**height (ft)**	**dist (ft)**	**elev (ft)**	**H20 depth (ft)**
top LB Tbar	2.0	-1.66	0.00	16.40	
base LB Tbar	2.0	1.82	0.00	12.92	
(datum rebar on RB)	5.0	2.20	3.00	12.54	
	6.5	2.59	4.50	12.15	
	7.9	2.90	5.90	11.84	
	9.2	3.25	7.20	11.49	
	10.8	4.12	8.80	10.62	
	12.3	4.58	10.30	10.16	
	13.6	4.66	11.60	10.08	
	15.2	5.05	13.20	9.69	
	16.7	5.31	14.70	9.43	
	17.4	6.04	15.40	8.70	
OHWM	18.2	6.25	16.20	8.49	
	18.5	7.24	16.50	7.50	
	18.7	7.36	16.70	7.38	
EOW	19.3	7.34	17.30	7.40	0.00
ss	19.5	7.47	17.50	7.27	0.13
ss	19.8	7.65	17.80	7.09	0.31
ss	20.1	7.68	18.10	7.06	0.34
ss	20.6	7.76	18.60	6.98	0.42
ss	21.1	7.86	19.10	6.88	0.52
ss	21.6	7.98	19.60	6.76	0.64
ss	22.4	8.08	20.40	6.66	0.74
ss	22.9	8.09	20.90	6.65	0.75
thalweg	23.7	8.17	21.70	6.57	0.83
ss	24.6	8.13	22.60	6.61	0.79
ss	25.6	8.13	23.60	6.61	0.79
ss	26.6	8.00	24.60	6.74	0.66
ss	27.2	7.77	25.20	6.97	0.43
ss	27.7	7.62	25.70	7.12	0.28
ss	28.1	7.58	26.10	7.16	0.24
ss	28.3	7.57	26.30	7.17	0.23
EOW	28.9	7.41	26.90	7.33	0.07
edge of concrete rip-rap	29.2	7.41	27.20	7.33	
OHWM	29.6	6.12	27.60	8.62	
top edge of concrete rip-ra	30.0	5.50	28.00	9.24	
	31.0	5.29	29.00	9.45	
	32.0	5.27	30.00	9.47	
	34.0	5.25	32.00	9.49	
	36.0	5.27	34.00	9.47	
	38.5	5.08	36.50	9.66	
base RB datum rebar	39.5	4.98	37.50	9.76	
top RB datum rebar	39.5	4.74	37.50	10.00	
base RB Tbar	40.0	4.98	38.00	9.76	
top RB Tbar	40.0	1.24	38.00	13.50	



AR 052821

Miller Creek Cross Section M-4 Change in Low Flow Water Surface Elevations



K:\working\2912\2912(28B)\miller.xlsM-4 Water Surface

Walker Creek @ SR509 HSPF modeling

7 Day Low Flows (1949-1995)

$Q_{low\ min}$ = 0.60 cfs

$Q_{low\ max}$ = 0.94 cfs

$Q_{change\ in\ state}$ = -0.11 cfs

Mannings n = 0.035

HEC-RAS Plan: "W-1 S=1.4% River: Walker Creek Reach: W-1

River Station	Q Total (cfs)	Minimum Channel Elevation (ft)	Water Surface Elevation (ft)	Flow Depth (ft)	Change in Flow Depth (ft)	Velocity Channel (ft/s)	Flow Area (sq ft)	Top Width (ft)	Change in Top Width (ft)
4	0.49	11.89	12.10	0.21	N/A	1.51	0.32	3.05	N/A
4	0.50	11.89	12.10	0.21	N/A	1.52	0.33	3.07	N/A
4	0.51	11.89	12.10	0.21	N/A	1.53	0.33	3.08	N/A
4	0.52	11.89	12.11	0.22	N/A	1.54	0.34	3.09	N/A
4	0.53	11.89	12.11	0.22	N/A	1.55	0.34	3.10	N/A
4	0.54	11.89	12.11	0.22	N/A	1.56	0.35	3.12	N/A
4	0.55	11.89	12.11	0.22	N/A	1.57	0.35	3.13	N/A
4	0.56	11.89	12.11	0.22	N/A	1.58	0.35	3.14	N/A
4	0.57	11.89	12.11	0.22	N/A	1.59	0.36	3.15	N/A
4	0.58	11.89	12.11	0.22	N/A	1.60	0.36	3.16	N/A
4	0.59	11.89	12.11	0.22	N/A	1.61	0.37	3.17	N/A
4	0.60	11.89	12.12	0.23	0.02	1.62	0.37	3.18	0.12
4	0.61	11.89	12.12	0.23	N/A	1.63	0.37	3.19	N/A
4	0.62	11.89	12.12	0.23	N/A	1.64	0.38	3.20	N/A
4	0.63	11.89	12.12	0.23	N/A	1.65	0.38	3.21	N/A
4	0.64	11.89	12.12	0.23	N/A	1.65	0.39	3.22	N/A
4	0.65	11.89	12.12	0.23	N/A	1.66	0.39	3.22	N/A
4	0.66	11.89	12.12	0.23	N/A	1.67	0.40	3.23	N/A
4	0.67	11.89	12.12	0.23	N/A	1.68	0.40	3.24	N/A
4	0.68	11.89	12.13	0.24	N/A	1.69	0.40	3.25	N/A
4	0.69	11.89	12.13	0.24	N/A	1.70	0.41	3.26	N/A
4	0.70	11.89	12.13	0.24	N/A	1.70	0.41	3.27	N/A
4	0.71	11.89	12.13	0.24	0.01	1.71	0.41	3.28	0.10
4	0.72	11.89	12.13	0.24	N/A	1.72	0.42	3.29	N/A
4	0.73	11.89	12.13	0.24	N/A	1.73	0.42	3.30	N/A
4	0.74	11.89	12.13	0.24	N/A	1.73	0.43	3.31	N/A
4	0.75	11.89	12.13	0.24	N/A	1.74	0.43	3.32	N/A
4	0.76	11.89	12.14	0.25	N/A	1.75	0.43	3.33	N/A
4	0.77	11.89	12.14	0.25	N/A	1.76	0.44	3.33	N/A
4	0.78	11.89	12.14	0.25	N/A	1.76	0.44	3.34	N/A
4	0.79	11.89	12.14	0.25	N/A	1.77	0.45	3.35	N/A
4	0.80	11.89	12.14	0.25	N/A	1.78	0.45	3.36	N/A
4	0.81	11.89	12.14	0.25	N/A	1.79	0.45	3.37	N/A
4	0.82	11.89	12.14	0.25	0.01	1.79	0.46	3.38	0.10
4	0.83	11.89	12.14	0.25	N/A	1.80	0.46	3.39	N/A
4	0.84	11.89	12.14	0.25	N/A	1.81	0.46	3.39	N/A
4	0.85	11.89	12.15	0.26	N/A	1.81	0.47	3.40	N/A
4	0.86	11.89	12.15	0.26	N/A	1.82	0.47	3.41	N/A
4	0.87	11.89	12.15	0.26	N/A	1.83	0.48	3.42	N/A
4	0.88	11.89	12.15	0.26	N/A	1.83	0.48	3.43	N/A
4	0.89	11.89	12.15	0.26	N/A	1.84	0.48	3.44	N/A
4	0.90	11.89	12.15	0.26	N/A	1.85	0.49	3.44	N/A
4	0.91	11.89	12.15	0.26	N/A	1.85	0.49	3.45	N/A
4	0.92	11.89	12.15	0.26	N/A	1.86	0.49	3.46	N/A
4	0.93	11.89	12.15	0.26	0.01	1.87	0.50	3.47	0.09
4	0.94	11.89	12.16	0.27	N/A	1.87	0.50	3.48	N/A
3	0.49	11.75	11.96	0.21	N/A	1.52	0.32	3.06	N/A
3	0.50	11.75	11.96	0.21	N/A	1.53	0.33	3.07	N/A
3	0.51	11.75	11.96	0.21	N/A	1.54	0.33	3.08	N/A
3	0.52	11.75	11.96	0.21	N/A	1.55	0.33	3.09	N/A
3	0.53	11.75	11.97	0.22	N/A	1.56	0.34	3.10	N/A
3	0.54	11.75	11.97	0.22	N/A	1.57	0.34	3.11	N/A
3	0.55	11.75	11.97	0.22	N/A	1.58	0.35	3.12	N/A
3	0.56	11.75	11.97	0.22	N/A	1.59	0.35	3.13	N/A
3	0.57	11.75	11.97	0.22	N/A	1.60	0.36	3.14	N/A
3	0.58	11.75	11.97	0.22	N/A	1.61	0.36	3.15	N/A
3	0.59	11.75	11.97	0.22	N/A	1.62	0.36	3.16	N/A
3	0.60	11.75	11.98	0.23	0.02	1.63	0.37	3.17	0.11
3	0.61	11.75	11.98	0.23	N/A	1.64	0.37	3.18	N/A
3	0.62	11.75	11.98	0.23	N/A	1.65	0.38	3.19	N/A
3	0.63	11.75	11.98	0.23	N/A	1.66	0.38	3.20	N/A
3	0.64	11.75	11.98	0.23	N/A	1.66	0.38	3.21	N/A
3	0.65	11.75	11.98	0.23	N/A	1.67	0.39	3.22	N/A
3	0.66	11.75	11.98	0.23	N/A	1.68	0.39	3.23	N/A
3	0.67	11.75	11.98	0.23	N/A	1.69	0.40	3.24	N/A
3	0.68	11.75	11.99	0.24	N/A	1.70	0.40	3.25	N/A
3	0.69	11.75	11.99	0.24	N/A	1.70	0.40	3.26	N/A
3	0.70	11.75	11.99	0.24	N/A	1.71	0.41	3.27	N/A
3	0.71	11.75	11.99	0.24	0.01	1.72	0.41	3.28	0.11
3	0.72	11.75	11.99	0.24	N/A	1.73	0.42	3.28	N/A
3	0.73	11.75	11.99	0.24	N/A	1.74	0.42	3.29	N/A
3	0.74	11.75	11.99	0.24	N/A	1.74	0.42	3.30	N/A
3	0.75	11.75	11.99	0.24	N/A	1.75	0.43	3.31	N/A
3	0.76	11.75	11.99	0.24	N/A	1.76	0.43	3.32	N/A
3	0.77	11.75	12.00	0.25	N/A	1.77	0.44	3.33	N/A
3	0.78	11.75	12.00	0.25	N/A	1.77	0.44	3.34	N/A
3	0.79	11.75	12.00	0.25	N/A	1.78	0.44	3.35	N/A
3	0.80	11.75	12.00	0.25	N/A	1.79	0.45	3.35	N/A
3	0.81	11.75	12.00	0.25	N/A	1.80	0.45	3.36	N/A
3	0.82	11.75	12.00	0.25	0.01	1.80	0.45	3.37	0.09
3	0.83	11.75	12.00	0.25	N/A	1.81	0.46	3.38	N/A
3	0.84	11.75	12.00	0.25	N/A	1.82	0.46	3.39	N/A
3	0.85	11.75	12.00	0.25	N/A	1.82	0.47	3.40	N/A
3	0.86	11.75	12.01	0.26	N/A	1.83	0.47	3.41	N/A
3	0.87	11.75	12.01	0.26	N/A	1.84	0.47	3.41	N/A
3	0.88	11.75	12.01	0.26	N/A	1.84	0.48	3.42	N/A
3	0.89	11.75	12.01	0.26	N/A	1.85	0.48	3.43	N/A
3	0.90	11.75	12.01	0.26	N/A	1.86	0.48	3.44	N/A
3	0.91	11.75	12.01	0.26	N/A	1.86	0.49	3.45	N/A
3	0.92	11.75	12.01	0.26	N/A	1.87	0.49	3.46	N/A
3	0.93	11.75	12.01	0.26	0.01	1.88	0.50	3.46	0.09
3	0.94	11.75	12.01	0.26	N/A	1.88	0.50	3.47	N/A

HEC-RAS Plan: "W-1 S=1.4% River: Walker Creek Reach: W-1

River Station	Q Total (cfs)	Minimum Channel Elevation (ft)	Water Surface Elevation (ft)	Flow Depth (ft)	Change in Flow Depth (ft)	Velocity Channel (ft/s)	Flow Area (sq ft)	Top Width (ft)	Change in Top Width (ft)
2	0.49	11.61	11.82	0.21	N/A	1.53	0.32	3.05	N/A
2	0.50	11.61	11.82	0.21	N/A	1.54	0.32	3.06	N/A
2	0.51	11.61	11.82	0.21	N/A	1.55	0.33	3.07	N/A
2	0.52	11.61	11.82	0.21	N/A	1.56	0.33	3.08	N/A
2	0.53	11.61	11.83	0.22	N/A	1.57	0.34	3.09	N/A
2	0.54	11.61	11.83	0.22	N/A	1.58	0.34	3.10	N/A
2	0.55	11.61	11.83	0.22	N/A	1.59	0.35	3.11	N/A
2	0.56	11.61	11.83	0.22	N/A	1.60	0.35	3.13	N/A
2	0.57	11.61	11.83	0.22	N/A	1.61	0.35	3.14	N/A
2	0.58	11.61	11.83	0.22	N/A	1.62	0.36	3.15	N/A
2	0.59	11.61	11.83	0.22	N/A	1.63	0.36	3.16	N/A
2	0.60	11.61	11.83	0.22	0.01	1.64	0.37	3.17	0.12
2	0.61	11.61	11.84	0.23	N/A	1.65	0.37	3.18	N/A
2	0.62	11.61	11.84	0.23	N/A	1.66	0.37	3.18	N/A
2	0.63	11.61	11.84	0.23	N/A	1.66	0.38	3.19	N/A
2	0.64	11.61	11.84	0.23	N/A	1.67	0.38	3.20	N/A
2	0.65	11.61	11.84	0.23	N/A	1.68	0.39	3.21	N/A
2	0.66	11.61	11.84	0.23	N/A	1.69	0.39	3.22	N/A
2	0.67	11.61	11.84	0.23	N/A	1.70	0.39	3.23	N/A
2	0.68	11.61	11.84	0.23	N/A	1.71	0.40	3.24	N/A
2	0.69	11.61	11.85	0.24	N/A	1.71	0.40	3.25	N/A
2	0.70	11.61	11.85	0.24	N/A	1.72	0.41	3.26	N/A
2	0.71	11.61	11.85	0.24	0.02	1.73	0.41	3.27	0.10
2	0.72	11.61	11.85	0.24	N/A	1.74	0.41	3.28	N/A
2	0.73	11.61	11.85	0.24	N/A	1.75	0.42	3.29	N/A
2	0.74	11.61	11.85	0.24	N/A	1.75	0.42	3.30	N/A
2	0.75	11.61	11.85	0.24	N/A	1.76	0.43	3.31	N/A
2	0.76	11.61	11.85	0.24	N/A	1.77	0.43	3.31	N/A
2	0.77	11.61	11.86	0.25	N/A	1.78	0.43	3.32	N/A
2	0.78	11.61	11.86	0.25	N/A	1.78	0.44	3.33	N/A
2	0.79	11.61	11.86	0.25	N/A	1.79	0.44	3.34	N/A
2	0.80	11.61	11.86	0.25	N/A	1.80	0.44	3.35	N/A
2	0.81	11.61	11.86	0.25	N/A	1.81	0.45	3.36	N/A
2	0.82	11.61	11.86	0.25	0.01	1.81	0.46	3.37	0.10
2	0.83	11.61	11.86	0.25	N/A	1.82	0.46	3.38	N/A
2	0.84	11.61	11.86	0.25	N/A	1.83	0.46	3.38	N/A
2	0.85	11.61	11.86	0.25	N/A	1.83	0.46	3.39	N/A
2	0.86	11.61	11.87	0.26	N/A	1.84	0.47	3.40	N/A
2	0.87	11.61	11.87	0.26	N/A	1.85	0.47	3.41	N/A
2	0.88	11.61	11.87	0.26	N/A	1.85	0.47	3.42	N/A
2	0.89	11.61	11.87	0.26	N/A	1.86	0.48	3.43	N/A
2	0.90	11.61	11.87	0.26	N/A	1.87	0.48	3.43	N/A
2	0.91	11.61	11.87	0.26	N/A	1.87	0.49	3.44	N/A
2	0.92	11.61	11.87	0.26	N/A	1.88	0.49	3.45	N/A
2	0.93	11.61	11.87	0.26	0.01	1.89	0.49	3.46	0.09
2	0.94	11.61	11.87	0.26	N/A	1.89	0.50	3.47	N/A
1	0.49	11.47	11.68	0.21	N/A	1.54	0.32	3.05	N/A
1	0.50	11.47	11.68	0.21	N/A	1.55	0.32	3.06	N/A
1	0.51	11.47	11.68	0.21	N/A	1.56	0.33	3.07	N/A
1	0.52	11.47	11.68	0.21	N/A	1.57	0.33	3.08	N/A
1	0.53	11.47	11.68	0.21	N/A	1.58	0.33	3.09	N/A
1	0.54	11.47	11.69	0.22	N/A	1.59	0.34	3.10	N/A
1	0.55	11.47	11.69	0.22	N/A	1.60	0.34	3.11	N/A
1	0.56	11.47	11.69	0.22	N/A	1.61	0.35	3.12	N/A
1	0.57	11.47	11.69	0.22	N/A	1.62	0.35	3.13	N/A
1	0.58	11.47	11.69	0.22	N/A	1.63	0.36	3.14	N/A
1	0.59	11.47	11.69	0.22	N/A	1.64	0.36	3.15	N/A
1	0.60	11.47	11.69	0.22	0.01	1.65	0.36	3.16	0.11
1	0.61	11.47	11.70	0.23	N/A	1.66	0.37	3.17	N/A
1	0.62	11.47	11.70	0.23	N/A	1.67	0.37	3.18	N/A
1	0.63	11.47	11.70	0.23	N/A	1.67	0.38	3.19	N/A
1	0.64	11.47	11.70	0.23	N/A	1.68	0.38	3.20	N/A
1	0.65	11.47	11.70	0.23	N/A	1.69	0.38	3.21	N/A
1	0.66	11.47	11.70	0.23	N/A	1.70	0.39	3.22	N/A
1	0.67	11.47	11.70	0.23	N/A	1.71	0.39	3.23	N/A
1	0.68	11.47	11.70	0.23	N/A	1.72	0.40	3.24	N/A
1	0.69	11.47	11.71	0.24	N/A	1.72	0.40	3.25	N/A
1	0.70	11.47	11.71	0.24	N/A	1.73	0.40	3.26	N/A
1	0.71	11.47	11.71	0.24	0.02	1.74	0.41	3.26	0.10
1	0.72	11.47	11.71	0.24	N/A	1.75	0.41	3.27	N/A
1	0.73	11.47	11.71	0.24	N/A	1.76	0.42	3.28	N/A
1	0.74	11.47	11.71	0.24	N/A	1.76	0.42	3.29	N/A
1	0.75	11.47	11.71	0.24	N/A	1.77	0.42	3.30	N/A
1	0.76	11.47	11.71	0.24	N/A	1.78	0.43	3.31	N/A
1	0.77	11.47	11.71	0.24	N/A	1.79	0.43	3.32	N/A
1	0.78	11.47	11.72	0.25	N/A	1.79	0.44	3.33	N/A
1	0.79	11.47	11.72	0.25	N/A	1.80	0.44	3.34	N/A
1	0.80	11.47	11.72	0.25	N/A	1.81	0.44	3.34	N/A
1	0.81	11.47	11.72	0.25	N/A	1.81	0.45	3.35	N/A
1	0.82	11.47	11.72	0.25	0.01	1.82	0.45	3.36	0.10
1	0.83	11.47	11.72	0.25	N/A	1.83	0.45	3.37	N/A
1	0.84	11.47	11.72	0.25	N/A	1.84	0.46	3.38	N/A
1	0.85	11.47	11.72	0.25	N/A	1.84	0.46	3.39	N/A
1	0.86	11.47	11.72	0.25	N/A	1.85	0.47	3.40	N/A
1	0.87	11.47	11.73	0.26	N/A	1.86	0.47	3.40	N/A
1	0.88	11.47	11.73	0.26	N/A	1.86	0.47	3.41	N/A
1	0.89	11.47	11.73	0.26	N/A	1.87	0.48	3.42	N/A
1	0.90	11.47	11.73	0.26	N/A	1.88	0.48	3.43	N/A
1	0.91	11.47	11.73	0.26	N/A	1.88	0.48	3.44	N/A
1	0.92	11.47	11.73	0.26	N/A	1.89	0.49	3.44	N/A
1	0.93	11.47	11.73	0.26	0.01	1.89	0.49	3.45	0.09
1	0.94	11.47	11.73	0.26	N/A	1.90	0.49	3.46	N/A

Average Change in depth = 0.01 ft
3 mm

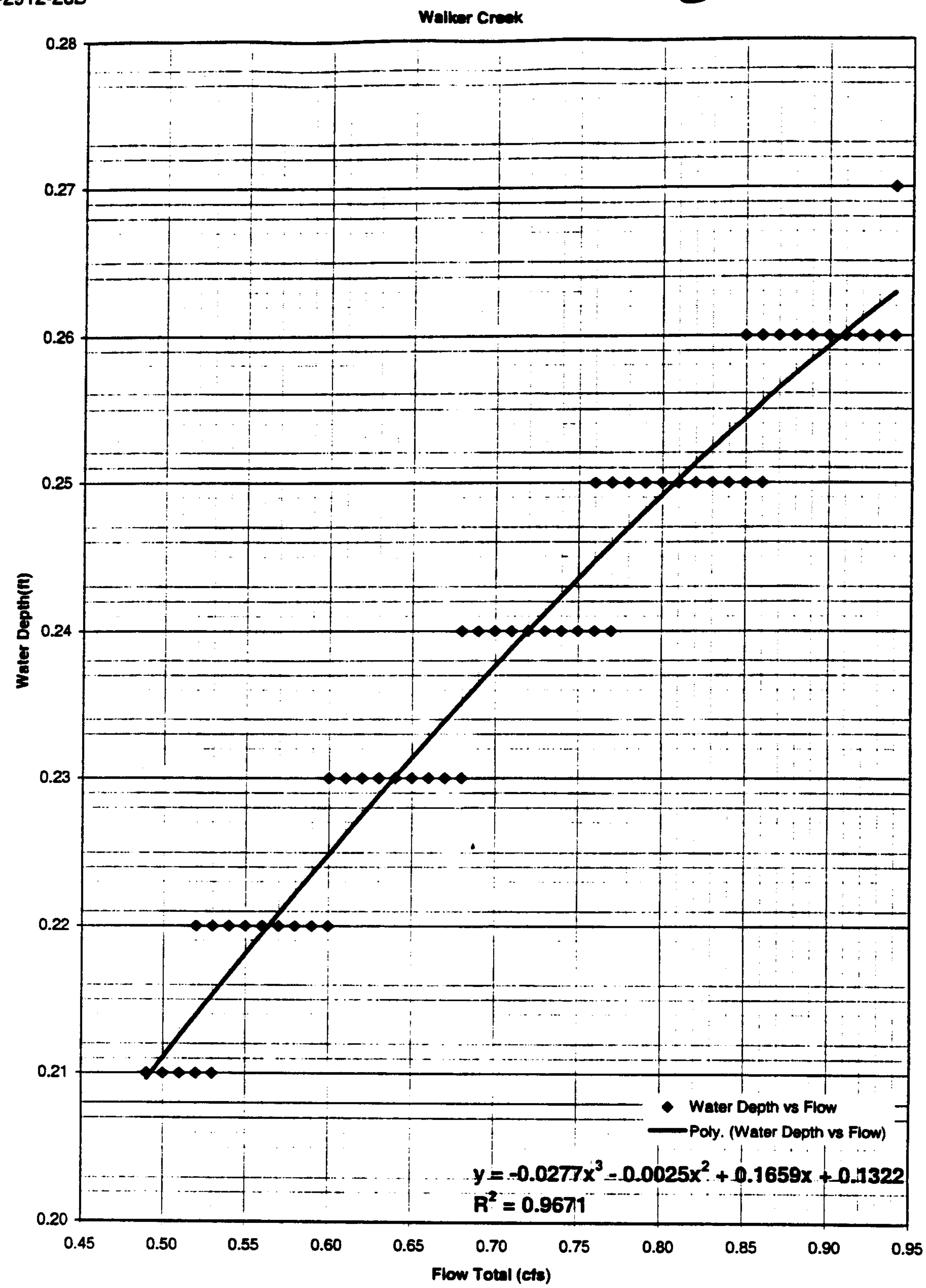
Average Change in width = 0.10 ft
30 mm

Parametrix Inc.
Port of Seattle
554-2912-28B

By: Angela Wilcox

Checked By: [signature]

December 5, 2001



K:working\2912\2912(28B)\HecRas Values.xlsWalker Creek Q vs H2O Depth

Summer low flow assessment: cross section data
3rd Runway Project

Creek:	Walker			
Cross-section # :	d/s of culvert at Des Moines Mem Dr, north of S 171st			
Date Surveyed:	8/10/2001			
Field Crew:	HW, RF	Stadia:	HW	
Date Entered:	8/24/2001	Notes:	RF	
Entered By:	HW			
Vert Dist from level to datum:		23.15	feet	

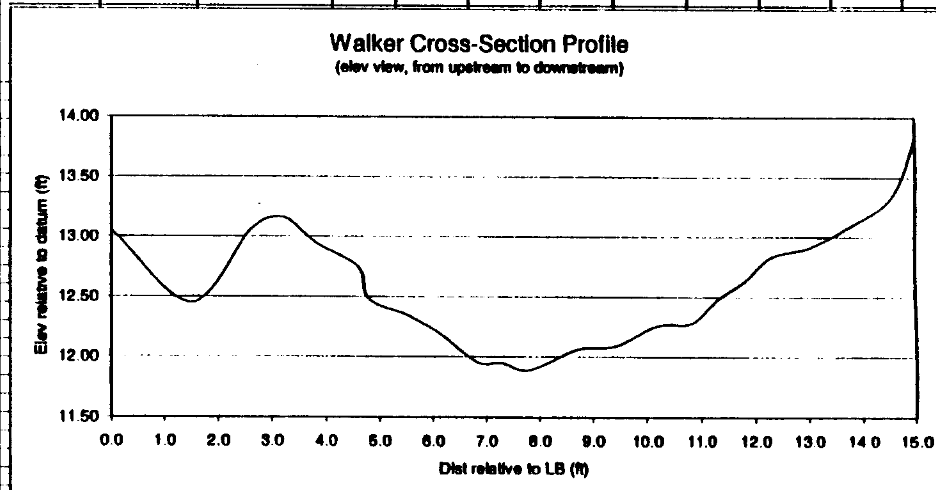
Definitions:

- RB - right bank, looking d/s
- LB - left bank, looking d/s
- OHWM - ordinary high water mark
- EOW - edge of water
- SS - substrate
- BFW - bank full width
- WW - wetted width

BFW est (ft) =	10.5	(to nearest 0.5 ft)
WW (ft) =	6.5	
Ave H20 depth (ft) =	0.30	
Max H20 depth (ft) =	0.59	

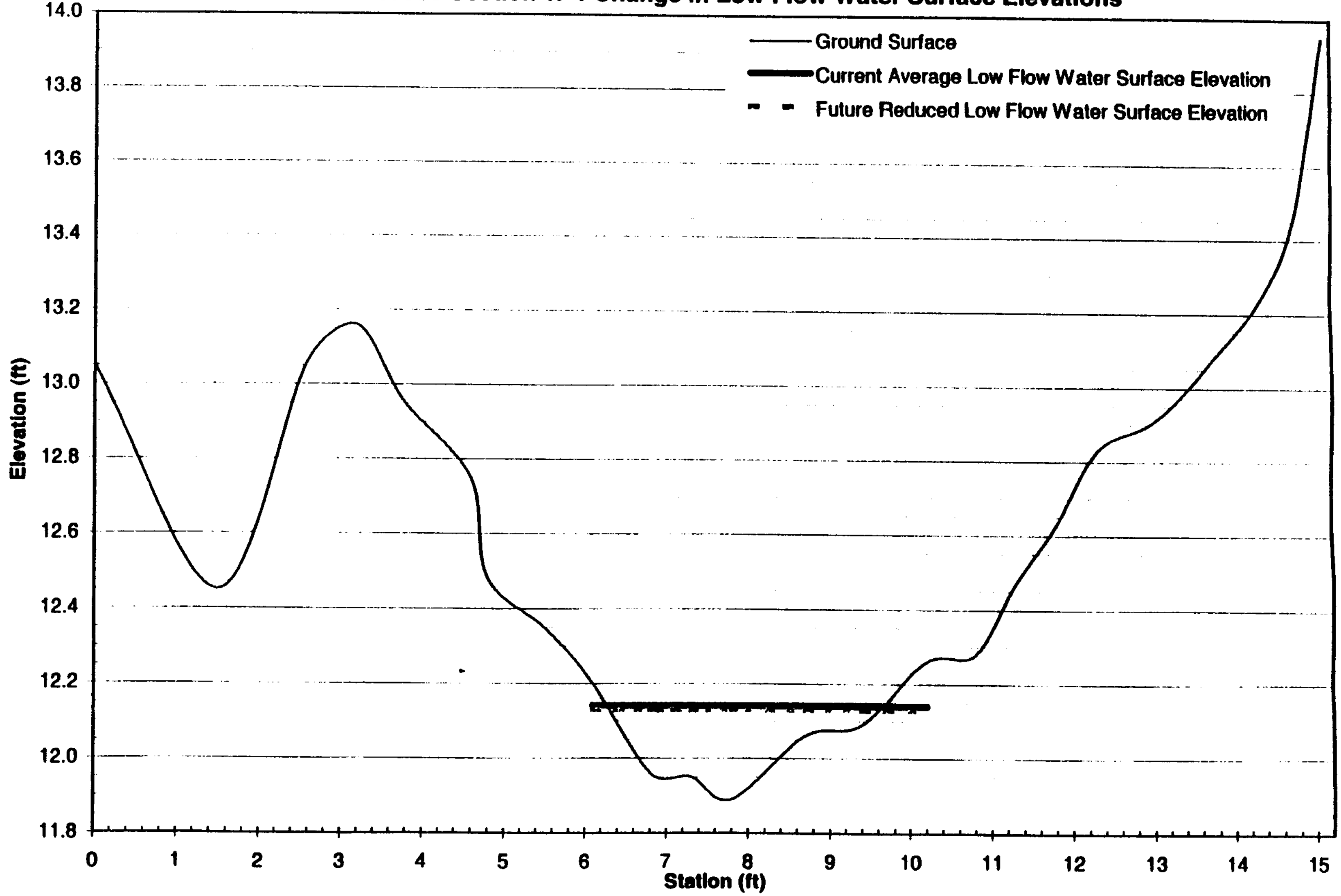
Conventions: measurements begin on left bank
datum defined at 10 feet below painted benchmark on Des Moines Mem Dr (no permanent rebar due to property access)

	RAW DATA		Final Values		
Description	**dist (ft)**	**height (ft)**	**dist (ft)**	**elev (ft)**	**H20 depth (ft)**
painted benchmark	n/a	13.15	n/a	10.00	
LB (no permanent rebar)	2.1	10.10	0.00	13.05	
	3.6	10.70	1.50	12.45	
	4.7	10.09	2.60	13.06	
OHWM	5.3	9.99	3.20	13.16	
	5.9	10.20	3.80	12.95	
	6.7	10.40	4.60	12.75	
EOW	6.9	10.67	4.80	12.48	0.00
ss	7.6	10.80	5.50	12.35	0.13
ss	8.2	10.95	6.10	12.20	0.28
ss	8.9	11.19	6.80	11.96	0.52
ss	9.4	11.20	7.30	11.95	0.53
thalweg	9.9	11.26	7.80	11.89	0.59
ss	10.8	11.09	8.70	12.06	0.42
ss	11.5	11.06	9.40	12.09	0.39
ss	12.3	10.89	10.20	12.26	0.22
ss	12.9	10.87	10.80	12.28	0.20
EOW	13.4	10.68	11.30	12.47	0.01
	13.9	10.52	11.80	12.63	
	14.4	10.32	12.30	12.83	
	15.1	10.24	13.00	12.91	
OHWM	15.8	10.08	13.70	13.07	
	16.7	9.79	14.60	13.36	
RB (no permanent rebar)	17.2	9.20	15.10	13.95	



AR 052825

Walker Creek Cross Section W-1 Change in Low Flow Water Surface Elevations



Start of 7-Day Low Flows with Average Flow Rates

Date	No Fill inflow 1994 HSPF Walker Creek Wetland at POC
17-Oct-49	0.66
13-Sep-50	0.83
11-Sep-51	0.78
15-Nov-52	0.65
5-Sep-53	0.76
30-Sep-54	0.87
23-Aug-55	0.83
2-Sep-56	0.85
2-Sep-57	0.80
10-Sep-58	0.70
2-Aug-59	0.85
20-Sep-60	0.83
4-Sep-61	0.80
23-Aug-62	0.79
6-Sep-63	0.74
8-Aug-64	0.90
24-Aug-65	0.78
25-Aug-66	0.77
15-Aug-67	0.75
28-Jun-68	0.94
26-Jul-69	0.82
2-Sep-70	0.76
10-Jul-71	0.88
25-Jul-72	0.94
24-Jul-73	0.74
22-Aug-74	0.77
18-Jun-75	0.79
15-Oct-76	0.73
19-Jun-77	0.66
26-Jun-78	0.78
6-Aug-79	0.63
14-Aug-80	0.68
8-Jul-81	0.70
23-Jul-82	0.75
1-Aug-83	0.90
21-Jul-84	0.77
27-Jul-85	0.68
3-Aug-86	0.66
16-Aug-87	0.64
18-Jul-88	0.65
13-Jul-89	0.69
3-Jul-90	0.71
3-Aug-91	0.76
26-Jul-92	0.67
11-Aug-93	0.65
18-Jul-94	0.60
18-Jun-95	0.73

Statistical Ranking of Average 7-Day Low Flows
Period of Record: 1949-1995

Date	Average 7-Day Lows Ordered	Rank	Rank/N+1	Return Frequency
1994	0.60	1	0.02	2.1
1979	0.63	2	0.04	4.2
1987	0.64	3	0.06	6.3
1952	0.65	4	0.08	8.3
1993	0.65	5	0.10	10.4
1988	0.65	6	0.13	12.5
1986	0.66	7	0.15	14.6
1949	0.66	8	0.17	16.7
1977	0.66	9	0.19	18.8
1992	0.67	10	0.21	20.8
1985	0.68	11	0.23	22.9
1980	0.68	12	0.25	25.0
1989	0.69	13	0.27	27.1
1958	0.70	14	0.29	29.2
1981	0.70	15	0.31	31.3
1990	0.71	16	0.33	33.3
1976	0.73	17	0.35	35.4
1995	0.73	18	0.38	37.5
1963	0.74	19	0.40	39.6
1973	0.74	20	0.42	41.7
1982	0.75	21	0.44	43.8
1967	0.75	22	0.46	45.8
1970	0.76	23	0.48	47.9
1953	0.76	24	0.50	50.0
1991	0.76	25	0.52	52.1
1966	0.77	26	0.54	54.2
1974	0.77	27	0.56	56.3
1984	0.77	28	0.58	58.3
1951	0.78	29	0.60	60.4
1965	0.78	29	0.60	60.4
1978	0.78	31	0.65	64.6
1962	0.79	32	0.67	66.7
1975	0.79	33	0.69	68.8
1961	0.80	34	0.71	70.8
1957	0.80	35	0.73	72.9
1969	0.82	36	0.75	75.0
1960	0.83	37	0.77	77.1
1950	0.83	38	0.79	79.2
1955	0.83	39	0.81	81.3
1959	0.85	40	0.83	83.3
1956	0.85	41	0.85	85.4
1954	0.87	42	0.88	87.5
1971	0.88	43	0.90	89.6
1964	0.90	44	0.92	91.7
1983	0.90	44	0.92	91.7
1972	0.94	46	0.96	95.8
1968	0.94	47	0.98	97.9

Des Moines Creek @ SR509 — HSPF modeling
7 Day Low Flows (1949-1995)
$Q_{low\ min}$ = 0.17 cfs
$Q_{low\ max}$ = 0.51 cfs
$Q_{Change\ in\ ...}$ = -0.06 cfs

HEC-RAS Plan: D-19=0.37% n=0.035 River: Des Moines Reach: D-1

River Station	Q Total (cfs)	Minimum Channel Elevation (ft)	Water Surface Elevation (ft)	Flow Depth (ft)	Change in Flow Depth (ft)	Velocity Channel (ft/s)	Flow Area (sq ft)	Top Width (ft)	Change in Top Width (ft)
4	0.09	5.28	5.43	0.15	N/A	0.72	0.12	1.42	N/A
4	0.11	5.28	5.44	0.16	N/A	0.73	0.15	1.47	N/A
4	0.13	5.28	5.46	0.18	N/A	0.78	0.17	1.51	N/A
4	0.15	5.28	5.46	0.18	N/A	0.85	0.18	1.53	N/A
4	0.17	5.28	5.48	0.20	0.05	0.86	0.20	1.57	0.15
4	0.19	5.28	5.48	0.20	N/A	0.85	0.20	1.57	N/A
4	0.21	5.28	5.49	0.21	N/A	0.98	0.21	1.60	N/A
4	0.23	5.28	5.49	0.21	N/A	1.01	0.23	1.62	N/A
4	0.25	5.28	5.50	0.22	0.02	1.03	0.24	1.65	0.08
4	0.27	5.28	5.51	0.23	N/A	1.06	0.26	1.67	N/A
4	0.29	5.28	5.52	0.24	N/A	1.08	0.27	1.70	N/A
4	0.31	5.28	5.53	0.25	N/A	1.10	0.28	1.72	N/A
4	0.33	5.28	5.53	0.25	0.03	1.12	0.29	1.74	0.09
4	0.35	5.28	5.54	0.26	N/A	1.14	0.31	1.76	N/A
4	0.37	5.28	5.55	0.27	N/A	1.16	0.32	1.79	N/A
4	0.39	5.28	5.56	0.28	N/A	1.17	0.33	1.81	N/A
4	0.41	5.28	5.56	0.28	0.03	1.19	0.34	1.83	0.09
4	0.43	5.28	5.57	0.29	N/A	1.21	0.36	1.85	N/A
4	0.45	5.28	5.57	0.29	N/A	1.22	0.37	1.86	N/A
4	0.47	5.28	5.58	0.30	N/A	1.24	0.38	1.88	N/A
4	0.49	5.28	5.59	0.31	0.03	1.21	0.41	1.98	0.16
4	0.51	5.28	5.61	0.33	N/A	1.18	0.43	2.22	N/A
3	0.09	5.24	5.39	0.15	N/A	0.69	0.13	1.43	N/A
3	0.11	5.24	5.40	0.16	N/A	0.76	0.15	1.46	N/A
3	0.13	5.24	5.42	0.18	N/A	0.75	0.17	1.52	N/A
3	0.15	5.24	5.42	0.18	N/A	0.90	0.17	1.51	N/A
3	0.17	5.24	5.44	0.20	0.05	0.85	0.20	1.57	0.14
3	0.19	5.24	5.44	0.20	N/A	0.94	0.20	1.58	N/A
3	0.21	5.24	5.45	0.21	N/A	0.97	0.22	1.60	N/A
3	0.23	5.24	5.46	0.22	N/A	0.99	0.23	1.63	N/A
3	0.25	5.24	5.47	0.23	0.03	1.02	0.25	1.66	0.09
3	0.27	5.24	5.48	0.24	N/A	1.04	0.26	1.68	N/A
3	0.29	5.24	5.48	0.24	N/A	1.06	0.27	1.70	N/A
3	0.31	5.24	5.49	0.25	N/A	1.09	0.29	1.73	N/A
3	0.33	5.24	5.50	0.26	0.03	1.11	0.30	1.75	0.09
3	0.35	5.24	5.51	0.27	N/A	1.12	0.31	1.77	N/A
3	0.37	5.24	5.51	0.27	N/A	1.14	0.32	1.79	N/A
3	0.39	5.24	5.52	0.28	N/A	1.16	0.34	1.81	N/A
3	0.41	5.24	5.53	0.29	0.03	1.18	0.35	1.83	0.08
3	0.43	5.24	5.53	0.29	N/A	1.19	0.36	1.85	N/A
3	0.45	5.24	5.54	0.30	N/A	1.21	0.37	1.87	N/A
3	0.47	5.24	5.55	0.31	N/A	1.23	0.38	1.89	N/A
3	0.49	5.24	5.56	0.32	0.03	1.19	0.41	2.04	0.21
3	0.51	5.24	5.57	0.33	N/A	1.17	0.44	2.26	N/A
2	0.09	5.21	5.36	0.15	N/A	0.67	0.13	1.44	N/A
2	0.11	5.21	5.36	0.15	N/A	0.78	0.14	1.45	N/A
2	0.13	5.21	5.38	0.17	N/A	0.77	0.17	1.51	N/A
2	0.15	5.21	5.39	0.18	N/A	0.87	0.17	1.52	N/A
2	0.17	5.21	5.41	0.20	0.05	0.83	0.20	1.58	0.14
2	0.19	5.21	5.41	0.20	N/A	0.82	0.21	1.58	N/A
2	0.21	5.21	5.42	0.21	N/A	0.95	0.22	1.61	N/A
2	0.23	5.21	5.43	0.22	N/A	0.98	0.24	1.64	N/A
2	0.25	5.21	5.43	0.22	0.02	1.00	0.25	1.66	0.08
2	0.27	5.21	5.44	0.23	N/A	1.03	0.26	1.69	N/A
2	0.29	5.21	5.45	0.24	N/A	1.05	0.28	1.71	N/A
2	0.31	5.21	5.46	0.25	N/A	1.07	0.29	1.73	N/A
2	0.33	5.21	5.46	0.25	0.03	1.09	0.30	1.76	0.10
2	0.35	5.21	5.47	0.26	N/A	1.11	0.32	1.78	N/A
2	0.37	5.21	5.48	0.27	N/A	1.13	0.33	1.80	N/A
2	0.39	5.21	5.49	0.28	N/A	1.15	0.34	1.82	N/A
2	0.41	5.21	5.49	0.28	0.03	1.16	0.35	1.84	0.08
2	0.43	5.21	5.50	0.29	N/A	1.18	0.36	1.86	N/A
2	0.45	5.21	5.51	0.30	N/A	1.20	0.38	1.88	N/A
2	0.47	5.21	5.51	0.30	N/A	1.21	0.39	1.90	N/A
2	0.49	5.21	5.53	0.32	0.04	1.18	0.41	2.08	0.24
2	0.51	5.21	5.54	0.33	N/A	1.16	0.44	2.30	N/A
1	0.09	5.17	5.32	0.15	N/A	0.71	0.13	1.43	N/A
1	0.11	5.17	5.33	0.16	N/A	0.76	0.15	1.46	N/A
1	0.13	5.17	5.34	0.17	N/A	0.80	0.16	1.50	N/A
1	0.15	5.17	5.35	0.18	N/A	0.84	0.18	1.53	N/A
1	0.17	5.17	5.36	0.19	0.04	0.87	0.19	1.56	0.13
1	0.19	5.17	5.37	0.20	N/A	0.90	0.21	1.59	N/A
1	0.21	5.17	5.38	0.21	N/A	0.93	0.22	1.62	N/A
1	0.23	5.17	5.39	0.22	N/A	0.96	0.24	1.64	N/A
1	0.25	5.17	5.40	0.23	0.04	0.99	0.25	1.67	0.11
1	0.27	5.17	5.41	0.24	N/A	1.01	0.27	1.69	N/A
1	0.29	5.17	5.41	0.24	N/A	1.03	0.28	1.72	N/A
1	0.31	5.17	5.42	0.25	N/A	1.06	0.29	1.74	N/A
1	0.33	5.17	5.43	0.26	0.03	1.08	0.31	1.76	0.09
1	0.35	5.17	5.44	0.27	N/A	1.10	0.32	1.78	N/A
1	0.37	5.17	5.44	0.27	N/A	1.11	0.33	1.81	N/A
1	0.39	5.17	5.45	0.28	N/A	1.13	0.34	1.83	N/A
1	0.41	5.17	5.46	0.29	0.03	1.15	0.36	1.85	0.09
1	0.43	5.17	5.46	0.29	N/A	1.17	0.37	1.87	N/A
1	0.45	5.17	5.47	0.30	N/A	1.18	0.38	1.89	N/A
1	0.47	5.17	5.48	0.31	N/A	1.20	0.39	1.90	N/A
1	0.49	5.17	5.49	0.32	0.03	1.17	0.42	2.12	0.27
1	0.51	5.17	5.50	0.33	N/A	1.14	0.45	2.34	N/A

HEC-RAS Plan: D-19=0.37% n=0.035 River: Des Moines Reach: D-1

River Station	Q Total (cfs)	Minimum Channel Elevation (ft)	Water Surface Elevation (ft)	Flow Depth (ft)	Change in Flow Depth (ft)	Velocity Channel (ft/s)	Flow Area (sq ft)	Top Width (ft)	Change in Top Width (ft)
4	0.09	5.28	5.45	0.17	N/A	0.55	0.16	1.50	N/A
4	0.11	5.28	5.47	0.19	N/A	0.59	0.19	1.54	N/A
4	0.13	5.28	5.49	0.21	N/A	0.59	0.22	1.61	N/A
4	0.15	5.28	5.50	0.22	N/A	0.62	0.24	1.65	N/A
4	0.17	5.28	5.51	0.23	0.06	0.65	0.26	1.68	0.18
4	0.19	5.28	5.53	0.25	N/A	0.68	0.28	1.72	N/A
4	0.21	5.28	5.54	0.26	N/A	0.70	0.30	1.75	N/A
4	0.23	5.28	5.55	0.27	N/A	0.72	0.32	1.78	N/A
4	0.25	5.28	5.56	0.28	0.05	0.74	0.34	1.81	0.13
4	0.27	5.28	5.57	0.29	N/A	0.76	0.35	1.84	N/A
4	0.29	5.28	5.58	0.30	N/A	0.78	0.37	1.87	N/A
4	0.31	5.28	5.59	0.31	N/A	0.80	0.39	1.90	N/A
4	0.33	5.28	5.60	0.32	0.04	0.81	0.41	2.00	0.19
4	0.35	5.28	5.61	0.33	N/A	0.80	0.44	2.29	N/A
4	0.37	5.28	5.63	0.35	N/A	0.77	0.48	2.59	N/A
4	0.39	5.28	5.64	0.36	N/A	0.76	0.51	2.66	N/A
4	0.41	5.28	5.65	0.37	0.06	0.78	0.53	2.67	0.67
4	0.43	5.28	5.65	0.37	N/A	0.79	0.54	2.67	N/A
4	0.45	5.28	5.66	0.38	N/A	0.80	0.56	2.68	N/A
4	0.47	5.28	5.66	0.38	N/A	0.82	0.58	2.68	N/A
4	0.49	5.28	5.67	0.39	0.02	0.83	0.59	2.69	0.02
4	0.51	5.28	5.67	0.39	N/A	0.84	0.60	2.69	N/A
3	0.09	5.24	5.42	0.18	N/A	0.53	0.17	1.51	N/A
3	0.11	5.24	5.43	0.19	N/A	0.61	0.18	1.53	N/A
3	0.13	5.24	5.45	0.21	N/A	0.61	0.21	1.60	N/A
3	0.15	5.24	5.46	0.22	N/A	0.64	0.24	1.64	N/A
3	0.17	5.24	5.47	0.23	0.05	0.67	0.26	1.67	0.16
3	0.19	5.24	5.49	0.25	N/A	0.69	0.28	1.71	N/A
3	0.21	5.24	5.50	0.26	N/A	0.71	0.29	1.74	N/A
3	0.23	5.24	5.51	0.27	N/A	0.74	0.31	1.77	N/A
3	0.25	5.24	5.52	0.28	0.05	0.76	0.33	1.80	0.13
3	0.27	5.24	5.53	0.29	N/A	0.77	0.36	1.83	N/A
3	0.29	5.24	5.54	0.30	N/A	0.79	0.37	1.86	N/A
3	0.31	5.24	5.55	0.31	N/A	0.81	0.38	1.89	N/A
3	0.33	5.24	5.56	0.31	0.03	0.82	0.40	1.94	0.14
3	0.35	5.24	5.57	0.33	N/A	0.81	0.43	2.23	N/A
3	0.37	5.24	5.59	0.35	N/A	0.79	0.47	2.53	N/A
3	0.39	5.24	5.60	0.36	N/A	0.77	0.50	2.66	N/A
3	0.41	5.24	5.61	0.37	0.06	0.79	0.52	2.66	0.72
3	0.43	5.24	5.61	0.37	N/A	0.80	0.54	2.67	N/A
3	0.45	5.24	5.62	0.38	N/A	0.82	0.55	2.67	N/A
3	0.47	5.24	5.62	0.38	N/A	0.83	0.57	2.68	N/A
3	0.49	5.24	5.63	0.39	0.02	0.84	0.58	2.69	0.03
3	0.51	5.24	5.63	0.39	N/A	0.86	0.60	2.69	N/A
2	0.09	5.21	5.38	0.17	N/A	0.56	0.16	1.50	N/A
2	0.11	5.21	5.39	0.18	N/A	0.63	0.18	1.52	N/A
2	0.13	5.21	5.41	0.20	N/A	0.62	0.21	1.59	N/A
2	0.15	5.21	5.42	0.21	N/A	0.65	0.23	1.63	N/A
2	0.17	5.21	5.43	0.22	0.05	0.68	0.25	1.66	0.16
2	0.19	5.21	5.45	0.24	N/A	0.70	0.27	1.70	N/A
2	0.21	5.21	5.46	0.25	N/A	0.73	0.29	1.73	N/A
2	0.23	5.21	5.47	0.26	N/A	0.75	0.31	1.76	N/A
2	0.25	5.21	5.48	0.27	0.05	0.77	0.33	1.79	0.13
2	0.27	5.21	5.49	0.28	N/A	0.79	0.34	1.82	N/A
2	0.29	5.21	5.50	0.29	N/A	0.81	0.36	1.85	N/A
2	0.31	5.21	5.51	0.30	N/A	0.82	0.38	1.88	N/A
2	0.33	5.21	5.51	0.30	0.03	0.84	0.39	1.91	0.12
2	0.35	5.21	5.53	0.32	N/A	0.82	0.43	2.17	N/A
2	0.37	5.21	5.55	0.34	N/A	0.80	0.46	2.47	N/A
2	0.39	5.21	5.56	0.35	N/A	0.79	0.50	2.65	N/A
2	0.41	5.21	5.56	0.35	0.05	0.80	0.51	2.66	0.75
2	0.43	5.21	5.57	0.36	N/A	0.82	0.53	2.66	N/A
2	0.45	5.21	5.58	0.37	N/A	0.83	0.54	2.67	N/A
2	0.47	5.21	5.58	0.37	N/A	0.84	0.56	2.68	N/A
2	0.49	5.21	5.59	0.38	0.03	0.86	0.57	2.68	0.02
2	0.51	5.21	5.59	0.38	N/A	0.87	0.59	2.69	N/A
1	0.09	5.17	5.34	0.17	N/A	0.56	0.16	1.49	N/A
1	0.11	5.17	5.35	0.18	N/A	0.60	0.18	1.54	N/A
1	0.13	5.17	5.37	0.20	N/A	0.64	0.20	1.58	N/A
1	0.15	5.17	5.38	0.21	N/A	0.67	0.22	1.62	N/A
1	0.17	5.17	5.39	0.22	0.05	0.69	0.24	1.65	0.16
1	0.19	5.17	5.41	0.24	N/A	0.72	0.26	1.69	N/A
1	0.21	5.17	5.42	0.25	N/A	0.74	0.28	1.72	N/A
1	0.23	5.17	5.43	0.26	N/A	0.76	0.30	1.75	N/A
1	0.25	5.17	5.44	0.27	0.05	0.78	0.32	1.78	0.13
1	0.27	5.17	5.45	0.28	N/A	0.80	0.34	1.81	N/A
1	0.29	5.17	5.46	0.29	N/A	0.82	0.35	1.84	N/A
1	0.31	5.17	5.47	0.30	N/A	0.83	0.37	1.87	N/A
1	0.33	5.17	5.47	0.30	0.03	0.85	0.39	1.90	0.12
1	0.35	5.17	5.49	0.32	N/A	0.84	0.42	2.11	N/A
1	0.37	5.17	5.51	0.34	N/A	0.81	0.46	2.41	N/A
1	0.39	5.17	5.52	0.35	N/A	0.80	0.49	2.64	N/A
1	0.41	5.17	5.52	0.35	0.05	0.82	0.50	2.66	0.76
1	0.43	5.17	5.53	0.36	N/A	0.83	0.52	2.66	N/A
1	0.45	5.17	5.54	0.37	N/A	0.84	0.53	2.67	N/A
1	0.47	5.17	5.54	0.37	N/A	0.86	0.55	2.67	N/A
1	0.49	5.17	5.55	0.38	0.03	0.87	0.56	2.68	0.02
1	0.51	5.17	5.55	0.38	N/A	0.88	0.58	2.68	N/A

Average Change in depth = 0.04 ft   Average Change in width = 0.18 ft

Des Moines Creek @ SR509 HSPF modeling

7 Day Low Flows (1949-1995)

$Q_{low\ min}$ = 0.17 cfs

$Q_{low\ max}$ = 0.51 cfs

$Q_{Change\ in\ 2000}$ = -0.05 cfs

HEC-RAS Plan: "D-2 S=0.1% n=0.060 River: Des Moines Reach: D-2

River Station	Q Total (cfs)	Minimum Channel Elevation (ft)	Water Surface Elevation (ft)	Flow Depth (ft)	Change in Flow Depth (ft)	Velocity Channel (ft/s)	Flow Area (sq ft)	Top Width (ft)	Change in Top Width (ft)
4	0.09	7.77	7.87	0.10	N/A	0.29	0.31	4.41	N/A
4	0.11	7.77	7.88	0.11	N/A	0.31	0.36	4.57	N/A
4	0.13	7.77	7.89	0.12	N/A	0.32	0.41	4.86	N/A
4	0.15	7.77	7.90	0.13	N/A	0.33	0.45	5.09	N/A
4	0.17	7.77	7.91	0.14	0.04	0.35	0.49	5.22	0.81
4	0.19	7.77	7.92	0.15	N/A	0.36	0.53	5.34	N/A
4	0.21	7.77	7.92	0.15	N/A	0.37	0.57	5.45	N/A
4	0.23	7.77	7.93	0.16	N/A	0.38	0.61	5.56	N/A
4	0.25	7.77	7.94	0.17	0.03	0.39	0.64	5.66	0.44
4	0.27	7.77	7.94	0.17	N/A	0.40	0.68	6.43	N/A
4	0.29	7.77	7.95	0.18	N/A	0.41	0.71	6.50	N/A
4	0.31	7.77	7.95	0.18	N/A	0.42	0.75	6.55	N/A
4	0.33	7.77	7.96	0.19	0.02	0.43	0.78	6.61	0.95
4	0.35	7.77	7.96	0.19	N/A	0.44	0.81	6.67	N/A
4	0.37	7.77	7.97	0.20	N/A	0.45	0.84	6.72	N/A
4	0.39	7.77	7.97	0.20	N/A	0.46	0.88	6.76	N/A
4	0.41	7.77	7.98	0.21	0.02	0.47	0.91	6.81	0.20
4	0.43	7.77	7.98	0.21	N/A	0.47	0.94	6.85	N/A
4	0.45	7.77	7.99	0.22	N/A	0.48	0.97	6.89	N/A
4	0.47	7.77	7.99	0.22	N/A	0.49	1.00	6.93	N/A
4	0.49	7.77	7.99	0.22	0.01	0.50	1.02	6.97	0.16
4	0.51	7.77	8.00	0.23	N/A	0.51	1.05	7.01	N/A
3	0.09	7.76	7.86	0.10	N/A	0.29	0.31	4.43	N/A
3	0.11	7.76	7.87	0.11	N/A	0.30	0.36	4.61	N/A
3	0.13	7.76	7.88	0.12	N/A	0.32	0.41	4.90	N/A
3	0.15	7.76	7.89	0.13	N/A	0.33	0.46	5.12	N/A
3	0.17	7.76	7.90	0.14	0.04	0.34	0.50	5.24	0.81
3	0.19	7.76	7.91	0.15	N/A	0.35	0.54	5.36	N/A
3	0.21	7.76	7.92	0.16	N/A	0.36	0.58	5.46	N/A
3	0.23	7.76	7.92	0.16	N/A	0.37	0.62	5.56	N/A
3	0.25	7.76	7.93	0.17	0.03	0.38	0.65	5.66	0.44
3	0.27	7.76	7.93	0.17	N/A	0.40	0.69	6.45	N/A
3	0.29	7.76	7.94	0.18	N/A	0.41	0.72	6.51	N/A
3	0.31	7.76	7.95	0.19	N/A	0.42	0.76	6.57	N/A
3	0.33	7.76	7.95	0.19	0.02	0.42	0.79	6.63	0.95
3	0.35	7.76	7.96	0.20	N/A	0.43	0.82	6.68	N/A
3	0.37	7.76	7.96	0.20	N/A	0.44	0.86	6.74	N/A
3	0.39	7.76	7.96	0.20	N/A	0.45	0.89	6.78	N/A
3	0.41	7.76	7.97	0.21	0.02	0.46	0.92	6.82	0.19
3	0.43	7.76	7.97	0.21	N/A	0.47	0.95	6.86	N/A
3	0.45	7.76	7.98	0.22	N/A	0.48	0.98	6.91	N/A
3	0.47	7.76	7.98	0.22	N/A	0.49	1.01	6.95	N/A
3	0.49	7.76	7.99	0.23	0.02	0.49	1.03	6.99	0.17
3	0.51	7.76	7.99	0.23	N/A	0.50	1.06	7.03	N/A
2	0.09	7.75	7.85	0.10	N/A	0.28	0.32	4.44	N/A
2	0.11	7.75	7.87	0.12	N/A	0.30	0.37	4.65	N/A
2	0.13	7.75	7.88	0.13	N/A	0.31	0.42	4.95	N/A
2	0.15	7.75	7.88	0.13	N/A	0.32	0.46	5.14	N/A
2	0.17	7.75	7.89	0.14	0.04	0.34	0.51	5.27	0.83
2	0.19	7.75	7.90	0.15	N/A	0.35	0.55	5.39	N/A
2	0.21	7.75	7.91	0.16	N/A	0.36	0.59	5.50	N/A
2	0.23	7.75	7.91	0.16	N/A	0.37	0.62	5.61	N/A
2	0.25	7.75	7.92	0.17	0.03	0.38	0.66	6.41	1.14
2	0.27	7.75	7.93	0.18	N/A	0.39	0.70	6.47	N/A
2	0.29	7.75	7.93	0.18	N/A	0.40	0.73	6.53	N/A
2	0.31	7.75	7.94	0.19	N/A	0.41	0.77	6.59	N/A
2	0.33	7.75	7.94	0.19	0.02	0.42	0.80	6.65	0.24
2	0.35	7.75	7.95	0.20	N/A	0.43	0.83	6.70	N/A
2	0.37	7.75	7.95	0.20	N/A	0.44	0.87	6.75	N/A
2	0.39	7.75	7.96	0.21	N/A	0.45	0.90	6.79	N/A
2	0.41	7.75	7.96	0.21	0.02	0.46	0.93	6.84	0.19
2	0.43	7.75	7.97	0.22	N/A	0.46	0.96	6.88	N/A
2	0.45	7.75	7.97	0.22	N/A	0.47	0.99	6.92	N/A
2	0.47	7.75	7.97	0.22	N/A	0.48	1.02	6.96	N/A
2	0.49	7.75	7.98	0.23	0.02	0.49	1.05	7.00	0.16
2	0.51	7.75	7.98	0.23	N/A	0.50	1.07	7.04	N/A
1	0.09	7.74	7.85	0.11	N/A	0.27	0.33	4.46	N/A
1	0.11	7.74	7.86	0.12	N/A	0.29	0.38	4.70	N/A
1	0.13	7.74	7.87	0.13	N/A	0.30	0.43	4.99	N/A
1	0.15	7.74	7.88	0.14	N/A	0.32	0.47	5.16	N/A
1	0.17	7.74	7.88	0.14	0.03	0.33	0.51	5.29	0.83
1	0.19	7.74	7.89	0.15	N/A	0.34	0.56	5.41	N/A
1	0.21	7.74	7.90	0.16	N/A	0.35	0.59	5.52	N/A
1	0.23	7.74	7.91	0.17	N/A	0.36	0.63	5.63	N/A
1	0.25	7.74	7.91	0.17	0.03	0.37	0.67	6.42	1.13
1	0.27	7.74	7.92	0.18	N/A	0.39	0.71	6.49	N/A
1	0.29	7.74	7.92	0.18	N/A	0.40	0.74	6.55	N/A
1	0.31	7.74	7.93	0.19	N/A	0.41	0.78	6.61	N/A
1	0.33	7.74	7.93	0.19	0.02	0.42	0.81	6.66	0.24
1	0.35	7.74	7.94	0.20	N/A	0.42	0.84	6.72	N/A
1	0.37	7.74	7.94	0.20	N/A	0.43	0.88	6.76	N/A
1	0.39	7.74	7.95	0.21	N/A	0.44	0.91	6.81	N/A
1	0.41	7.74	7.95	0.21	0.02	0.45	0.94	6.85	0.19
1	0.43	7.74	7.96	0.22	N/A	0.46	0.97	6.89	N/A
1	0.45	7.74	7.96	0.22	N/A	0.47	1.00	6.94	N/A
1	0.47	7.74	7.97	0.23	N/A	0.48	1.03	6.98	N/A
1	0.49	7.74	7.97	0.23	0.02	0.48	1.06	7.02	0.17
1	0.51	7.74	7.97	0.23	N/A	0.49	1.09	7.05	N/A

Average Change in depth = 0.03 ft Average Change in width = 0.51 ft

Des Moines Creek @ SR509 — HSPF modeling
7 Day Low Flows (1949-1996)

$Q_{low\ min}$ = 0.17 cfs
$Q_{low\ max}$ = 0.51 cfs
$Q_{Change\ in\ [illegible]}$ = -0.06 cfs

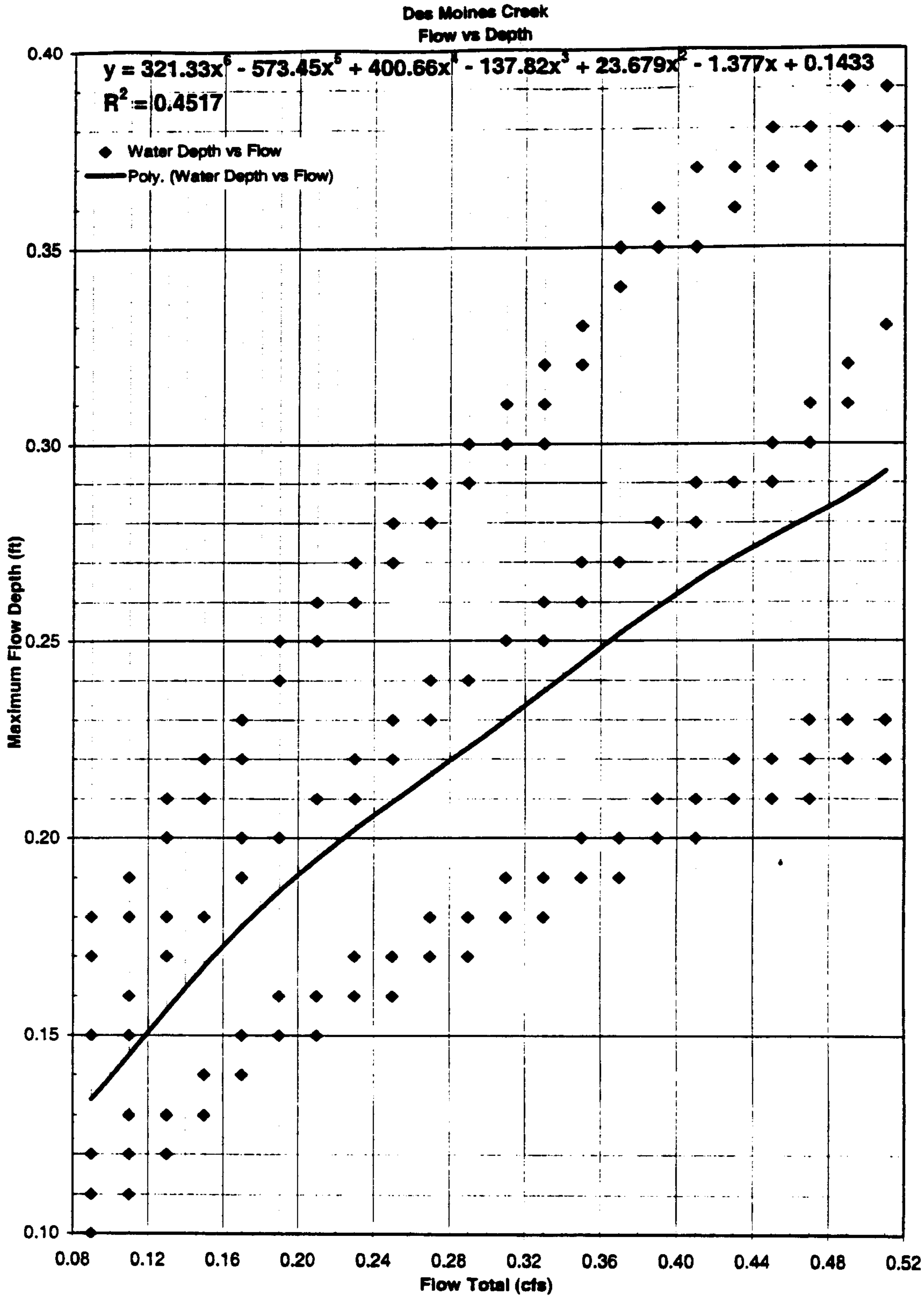
HEC-RAS Plan: "D-3 S=0.37% n = 0.035 River: Des Moines Reach: D-3

River Station	Q Total (cfs)	Minimum Channel Elevation (ft)	Water Surface Elevation (ft)	Flow Depth (ft)	Change in Flow Depth (ft)	Velocity Channel (ft/s)	Flow Area (sq ft)	Top Width (ft)	Change in Top Width (ft)
4	0.09	5.90	6.01	0.11	N/A	0.58	0.15	2.42	N/A
4	0.11	5.90	6.02	0.12	N/A	0.62	0.18	2.55	N/A
4	0.13	5.90	6.03	0.13	N/A	0.64	0.20	2.67	N/A
4	0.15	5.90	6.03	0.13	N/A	0.70	0.22	2.73	N/A
4	0.17	5.90	6.05	0.15	0.04	0.66	0.28	2.82	0.80
4	0.19	5.90	6.05	0.15	N/A	0.73	0.26	2.93	N/A
4	0.21	5.90	6.06	0.16	N/A	0.75	0.28	3.02	N/A
4	0.23	5.90	6.06	0.16	N/A	0.77	0.30	3.10	N/A
4	0.25	5.90	6.07	0.17	0.02	0.79	0.32	3.17	0.25
4	0.27	5.90	6.07	0.17	N/A	0.80	0.34	3.18	N/A
4	0.29	5.90	6.07	0.17	N/A	0.86	0.33	3.23	N/A
4	0.31	5.90	6.08	0.18	N/A	0.88	0.35	3.29	N/A
4	0.33	5.90	6.08	0.18	0.01	0.90	0.36	3.36	0.19
4	0.35	5.90	6.09	0.19	N/A	0.92	0.38	3.42	N/A
4	0.37	5.90	6.09	0.19	N/A	0.93	0.40	3.46	N/A
4	0.39	5.90	6.10	0.20	N/A	0.94	0.41	3.54	N/A
4	0.41	5.90	6.10	0.20	0.02	0.95	0.43	3.60	0.24
4	0.43	5.90	6.11	0.21	N/A	0.97	0.45	3.65	N/A
4	0.45	5.90	6.11	0.21	N/A	0.98	0.46	3.71	N/A
4	0.47	5.90	6.11	0.21	N/A	0.99	0.48	3.76	N/A
4	0.49	5.90	6.12	0.22	0.02	1.00	0.49	3.81	0.21
4	0.51	5.90	6.12	0.22	N/A	1.01	0.50	3.85	N/A
3	0.09	5.86	5.98	0.12	N/A	0.54	0.17	2.49	N/A
3	0.11	5.86	5.99	0.13	N/A	0.59	0.19	2.58	N/A
3	0.13	5.86	5.99	0.13	N/A	0.69	0.19	2.60	N/A
3	0.15	5.86	6.00	0.14	N/A	0.66	0.23	2.78	N/A
3	0.17	5.86	6.01	0.15	0.03	0.70	0.24	2.86	0.37
3	0.19	5.86	6.02	0.16	N/A	0.71	0.27	2.97	N/A
3	0.21	5.86	6.01	0.15	N/A	0.79	0.26	2.95	N/A
3	0.23	5.86	6.03	0.17	N/A	0.74	0.31	3.14	N/A
3	0.25	5.86	6.03	0.17	0.02	0.83	0.30	3.10	0.24
3	0.27	5.86	6.04	0.18	N/A	0.78	0.35	3.29	N/A
3	0.29	5.86	6.04	0.18	N/A	0.85	0.34	3.26	N/A
3	0.31	5.86	6.04	0.18	N/A	0.87	0.36	3.33	N/A
3	0.33	5.86	6.05	0.19	0.02	0.88	0.37	3.39	0.29
3	0.35	5.86	6.05	0.19	N/A	0.90	0.39	3.45	N/A
3	0.37	5.86	6.06	0.20	N/A	0.91	0.41	3.51	N/A
3	0.39	5.86	6.06	0.20	N/A	0.92	0.42	3.57	N/A
3	0.41	5.86	6.07	0.21	0.02	0.93	0.44	3.63	0.24
3	0.43	5.86	6.07	0.21	N/A	0.95	0.45	3.69	N/A
3	0.45	5.86	6.08	0.22	N/A	0.96	0.47	3.74	N/A
3	0.47	5.86	6.08	0.22	N/A	0.97	0.49	3.79	N/A
3	0.49	5.86	6.08	0.22	0.01	0.98	0.50	3.84	0.21
3	0.51	5.86	6.09	0.23	N/A	0.99	0.51	3.87	N/A
2	0.09	5.83	5.93	0.10	N/A	0.63	0.14	2.36	N/A
2	0.11	5.83	5.94	0.11	N/A	0.66	0.17	2.49	N/A
2	0.13	5.83	5.95	0.12	N/A	0.67	0.19	2.63	N/A
2	0.15	5.83	5.97	0.14	N/A	0.62	0.24	2.84	N/A
2	0.17	5.83	5.97	0.14	0.04	0.74	0.23	2.80	0.44
2	0.19	5.83	5.98	0.15	N/A	0.68	0.28	3.01	N/A
2	0.21	5.83	5.98	0.15	N/A	0.77	0.27	2.99	N/A
2	0.23	5.83	5.99	0.16	N/A	0.72	0.32	3.18	N/A
2	0.25	5.83	5.99	0.16	0.02	0.80	0.31	3.14	0.34
2	0.27	5.83	6.01	0.18	N/A	0.76	0.36	3.33	N/A
2	0.29	5.83	6.00	0.17	N/A	0.83	0.35	3.29	N/A
2	0.31	5.83	6.01	0.18	N/A	0.85	0.37	3.36	N/A
2	0.33	5.83	6.01	0.18	0.02	0.86	0.38	3.43	0.29
2	0.35	5.83	6.02	0.19	N/A	0.88	0.40	3.49	N/A
2	0.37	5.83	6.02	0.19	N/A	0.89	0.42	3.55	N/A
2	0.39	5.83	6.03	0.20	N/A	0.90	0.43	3.61	N/A
2	0.41	5.83	6.03	0.20	0.02	0.91	0.45	3.66	0.23
2	0.43	5.83	6.04	0.21	N/A	0.93	0.46	3.72	N/A
2	0.45	5.83	6.04	0.21	N/A	0.94	0.48	3.77	N/A
2	0.47	5.83	6.05	0.22	N/A	0.95	0.50	3.83	N/A
2	0.49	5.83	6.05	0.22	0.02	0.96	0.51	3.86	0.20
2	0.51	5.83	6.05	0.22	N/A	0.97	0.52	3.90	N/A
1	0.09	5.79	5.90	0.11	N/A	0.58	0.16	2.43	N/A
1	0.11	5.79	5.91	0.12	N/A	0.61	0.18	2.55	N/A
1	0.13	5.79	5.92	0.13	N/A	0.64	0.20	2.66	N/A
1	0.15	5.79	5.93	0.14	N/A	0.67	0.22	2.76	N/A
1	0.17	5.79	5.93	0.14	0.03	0.70	0.24	2.86	0.43
1	0.19	5.79	5.94	0.15	N/A	0.72	0.26	2.95	N/A
1	0.21	5.79	5.95	0.16	N/A	0.74	0.28	3.03	N/A
1	0.23	5.79	5.95	0.16	N/A	0.76	0.30	3.11	N/A
1	0.25	5.79	5.96	0.17	0.03	0.78	0.32	3.18	0.32
1	0.27	5.79	5.96	0.17	N/A	0.80	0.34	3.26	N/A
1	0.29	5.79	5.97	0.18	N/A	0.81	0.36	3.33	N/A
1	0.31	5.79	5.97	0.18	N/A	0.83	0.37	3.39	N/A
1	0.33	5.79	5.98	0.19	0.02	0.84	0.39	3.46	0.28
1	0.35	5.79	5.98	0.19	N/A	0.86	0.41	3.52	N/A
1	0.37	5.79	5.99	0.20	N/A	0.87	0.43	3.58	N/A
1	0.39	5.79	5.99	0.20	N/A	0.88	0.44	3.64	N/A
1	0.41	5.79	6.00	0.21	0.02	0.89	0.46	3.70	0.24
1	0.43	5.79	6.00	0.21	N/A	0.91	0.47	3.75	N/A
1	0.45	5.79	6.01	0.22	N/A	0.92	0.49	3.81	N/A
1	0.47	5.79	6.01	0.22	N/A	0.93	0.51	3.85	N/A
1	0.49	5.79	6.01	0.22	0.01	0.94	0.52	3.89	0.19
1	0.51	5.79	6.02	0.23	N/A	0.95	0.53	3.92	N/A
		Average Change in depth =			0.02 ft	Average Change in width =			0.29 ft

Des Moines Creek Average Change in Depth = 0.03 ft (9 mm)
Des Moines Creek Average Change in Width = 0.33 ft (101 mm)

Parametrix Inc.
Port of Seattle
554-2912-28B

By: Angela Wilcox
Checked By: [signature]
December 5, 2001

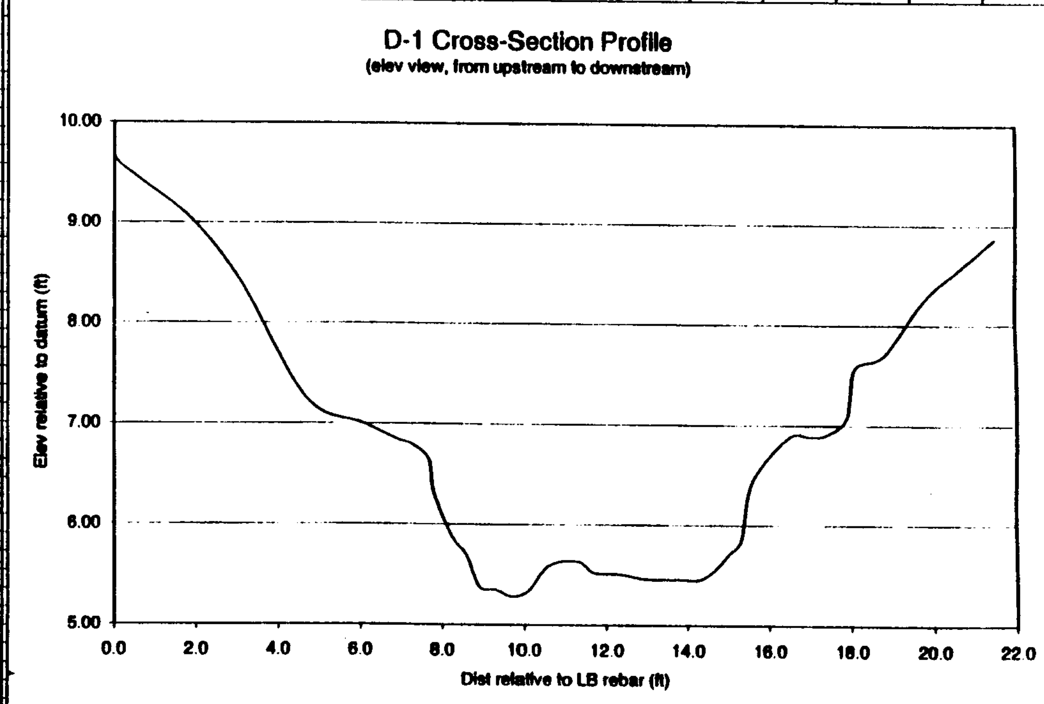


K:\working\2912\2912(28B)\HecRas Values.xlsDes Moines Q vs H2O Depth

AR 052831

Summer low flow assessment: cross section data								
3rd Runway Project								
			Definitions:	RB - right bank, looking d/s	BFW est (ft) =	8	(to nearest 0.5 ft)	
Creek:	Des Moines @ golf course			LB - left bank, looking d/s	WW (ft) =	7.1		
Cross-section # :	D-1; glide, u/s of weirs within golf course, d/s			OHWM - ordinary high water mark	Ave H20 depth (ft) =	0.36		
Date Surveyed:	8/15/2001			EOW - edge of water	Max H20 depth (ft) =	0.62		
Field Crew:	HW, RF	Stadia:	HW	SS - substrate				
Date Entered:	8/24/2001	Notes:	RF	BFW - bank full width				
Entered By:	HW			WW - wetted width				
			Conventions:	measurements begin on left bank				
Vert Dist from level to datum:		12.55	feet	datum defined at 10 feet below top of LB rebar				

Description	RAW DATA dist (ft)	height (ft)	Final Values dist (ft)	elev (ft)	H20 depth (ft)
top LB Tbar	2.0	-0.77	0.00	13.32	
base LB Tbar	2.0	2.89	0.00	9.66	
top LB datum rebar	2.0	2.55	0.00	10.00	
base LB datum rebar	2.0	2.89	0.00	9.66	
	2.7	3.14	0.70	9.41	
	3.9	3.52	1.90	9.03	
	5.1	4.16	3.10	8.39	
	6.7	5.30	4.70	7.25	
	8.1	5.55	6.10	7.00	
	8.9	5.70	6.90	6.85	
	9.3	5.76	7.30	6.79	
OHWM	9.7	5.91	7.70	6.64	
	9.8	6.23	7.80	6.32	
EOW	10.2	6.65	8.20	5.90	0.00
ss	10.6	6.87	8.60	5.68	0.22
ss	10.9	7.17	8.90	5.38	0.52
ss	11.3	7.20	9.30	5.35	0.55
thalweg	11.7	7.27	9.70	5.28	0.62
ss	12.1	7.21	10.10	5.34	0.56
ss	12.6	6.96	10.60	5.59	0.31
ss	13.3	6.92	11.30	5.63	0.27
ss	13.7	7.03	11.70	5.52	0.38
ss	14.3	7.04	12.30	5.51	0.39
ss	15.0	7.09	13.00	5.46	0.44
ss	15.7	7.09	13.70	5.46	0.44
ss	16.3	7.09	14.30	5.46	0.44
ss	16.7	6.98	14.70	5.57	0.33
ss	17.0	6.84	15.00	5.71	0.19
EOW	17.3	6.70	15.30	5.85	0.05
	17.5	6.22	15.50	6.33	
OHWM	17.6	5.98	15.60	6.57	
	18.5	5.66	16.50	6.89	
	19.0	5.66	17.00	6.89	
	19.4	5.64	17.40	6.91	
	19.9	5.47	17.90	7.08	
	20.1	4.99	18.10	7.56	
	20.8	4.85	18.80	7.70	
	21.8	4.30	19.80	8.25	
	22.6	4.01	20.60	8.54	
base RB Tbar	23.5	3.69	21.50	8.86	
top RB Tbar	23.5	0.84	21.50	11.71	



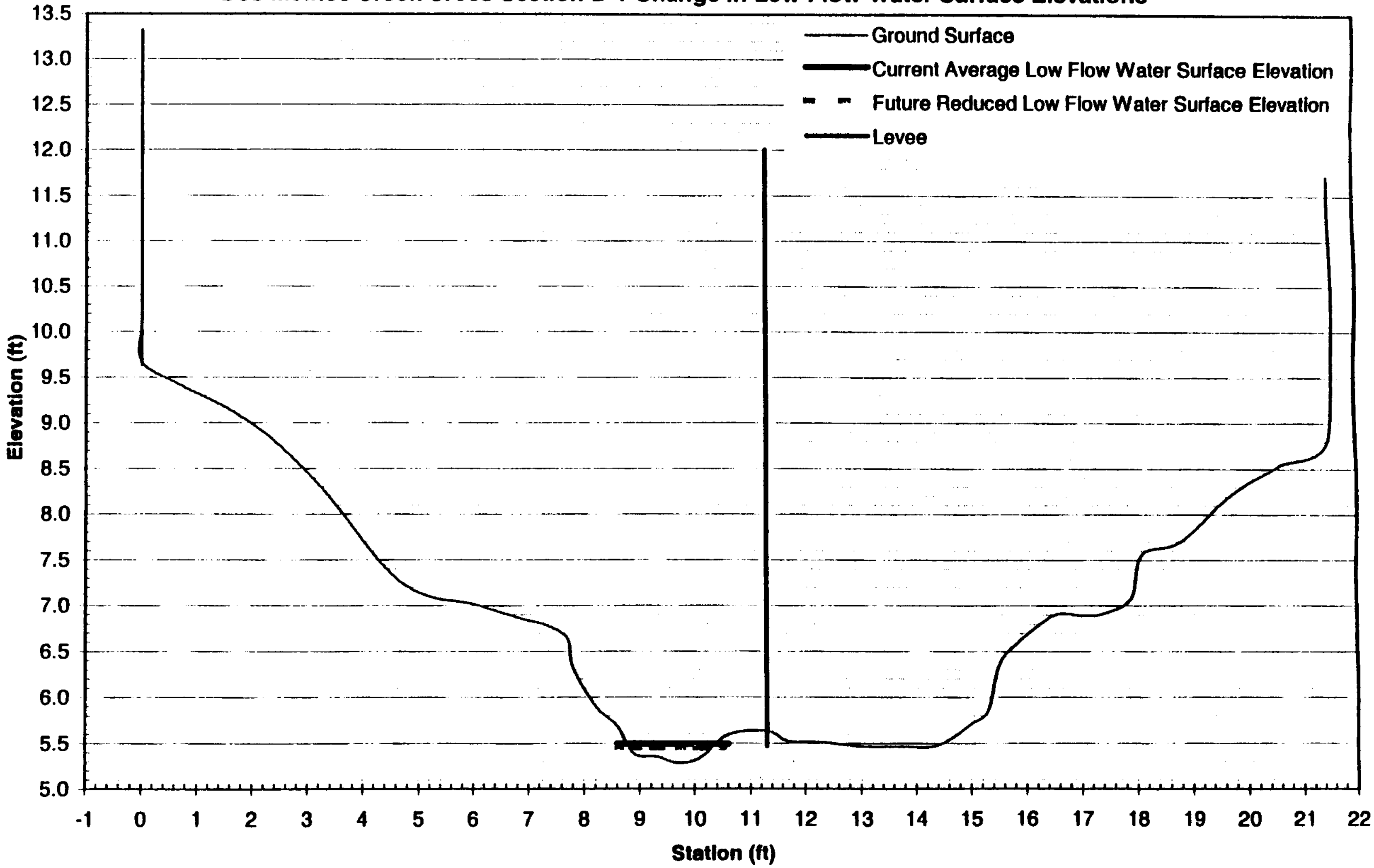
AR 052832

Parame... Inc.
Port of Seattle
554-2912-28B

Checked By: [signature]

By: Ange... Wilcox
December 6, 2001

Des Moines Creek Cross Section D-1 Change in Low Flow Water Surface Elevations



K:\working\2912\2912(28B)\des moines.xlsD-1 Water Surface

Summer low flow assessment: cross section data
3rd Runway Project

Creek:	Des Moines @ golf course		
Cross-section # :	D-2; riffle d/s of pool and u/s of glide backwatered by		
Date Surveyed:	8/15/2001		
Field Crew:	HW, RF	Stadia:	RF
Date Entered:	8/24/2001	Notes:	HW
Entered By:	HW		

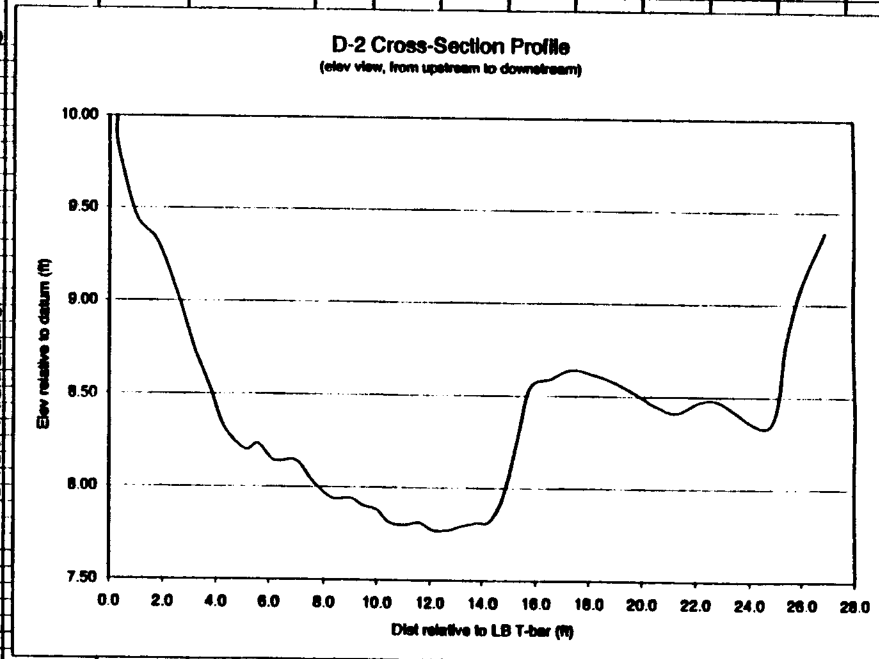
Definitions:
RB - right bank, looking d/s
LB - left bank, looking d/s
OHWM - ordinary high water mark
EOW - edge of water
SS - substrate
BFW - bank full width
WW - wetted width

BFW est (ft) =	12	(to nearest 0.5 ft)
WW (ft) =	5.8	
Ave H20 depth (ft) =	0.10	
Max H20 depth (ft) =	0.17	

Conventions: measurements begin on left bank
datum defined at 10 feet below top of LB rebar

Vert Dist from level to datum: 15.04 feet

	RAW DATA		Final Values		
Description	dist (ft)	height (ft)	dist (ft)	elev (ft)	H20 depth (ft)
top LB Tbar	3.1	1.51	0.00	13.53	
base LB Tbar	3.1	5.12	0.00	9.92	
top LB datum rebar	3.4	5.04	0.30	10.00	
base LB datum rebar	3.4	5.19	0.30	9.85	
	4.1	5.58	1.00	9.46	
	4.9	5.72	1.80	9.32	
	5.7	6.02	2.60	9.02	
OHWM	6.3	6.29	3.20	8.75	
	6.9	6.51	3.80	8.53	
	7.4	6.72	4.30	8.32	
	8.2	6.84	5.10	8.20	
	8.7	6.81	5.60	8.23	
	9.3	6.90	6.20	8.14	
	10.1	6.90	7.00	8.14	
	10.7	7.01	7.60	8.03	
	11.4	7.10	8.30	7.94	
EOW	12.1	7.10	9.00	7.94	0.00
ss	12.6	7.14	9.50	7.90	0.04
ss	13.1	7.16	10.00	7.88	0.06
ss	13.6	7.23	10.50	7.81	0.13
ss	14.2	7.24	11.10	7.80	0.14
ss	14.7	7.23	11.60	7.81	0.13
thalweg	15.2	7.27	12.10	7.77	0.17
ss	15.8	7.27	12.70	7.77	0.17
ss	16.2	7.25	13.10	7.79	0.15
ss	16.9	7.23	13.80	7.81	0.13
ss	17.4	7.22	14.30	7.82	0.12
EOW	17.9	7.07	14.80	7.97	-0.03
OHWM	18.4	6.79	15.30	8.25	
	18.9	6.50	15.80	8.54	
	19.7	6.45	16.60	8.59	
	20.5	6.4	17.40	8.64	
	21.4	6.43	18.30	8.61	
	22.0	6.46	18.90	8.58	
	22.7	6.51	19.60	8.53	
	23.6	6.59	20.50	8.45	
	24.4	6.63	21.30	8.41	
	25.3	6.57	22.20	8.47	
	26.0	6.57	22.90	8.47	
	27.9	6.70	24.60	8.34	
	28.6	6.23	25.50	8.81	
	29.2	5.93	26.10	9.11	
base RB Tbar	30.0	5.65	26.90	9.39	
top RB Tbar	30.0	2.42	26.90	12.62	



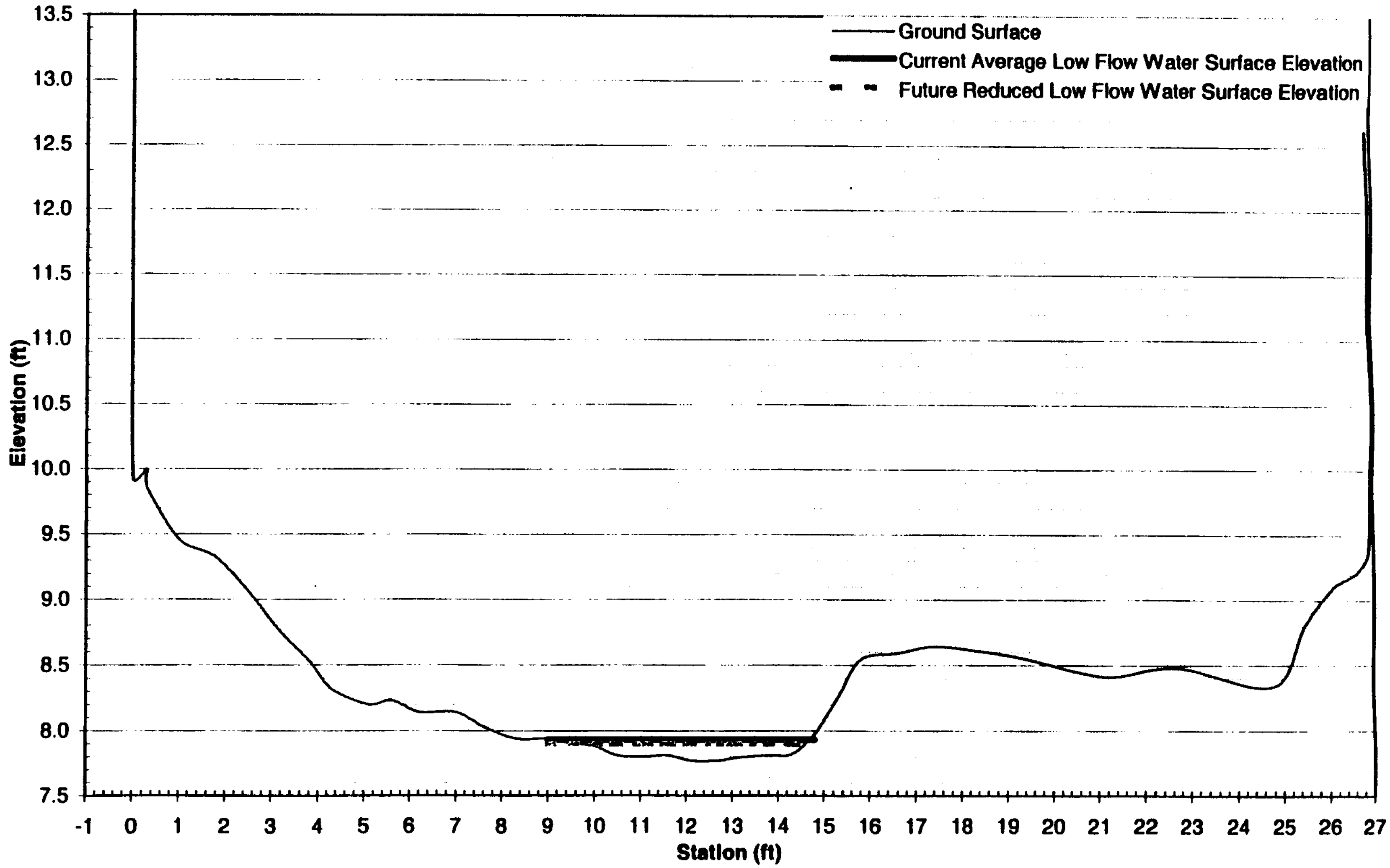
AR 052834

Parame... Inc.
Port of Seattle
554-2912-28B

Des Moines Creek ...w Flow Analysis

By: Ange... Wilcox
Checked By:
December 6, 2001

Des Moines Creek Cross Section D-2 Change in Low Flow Water Surface Elevations

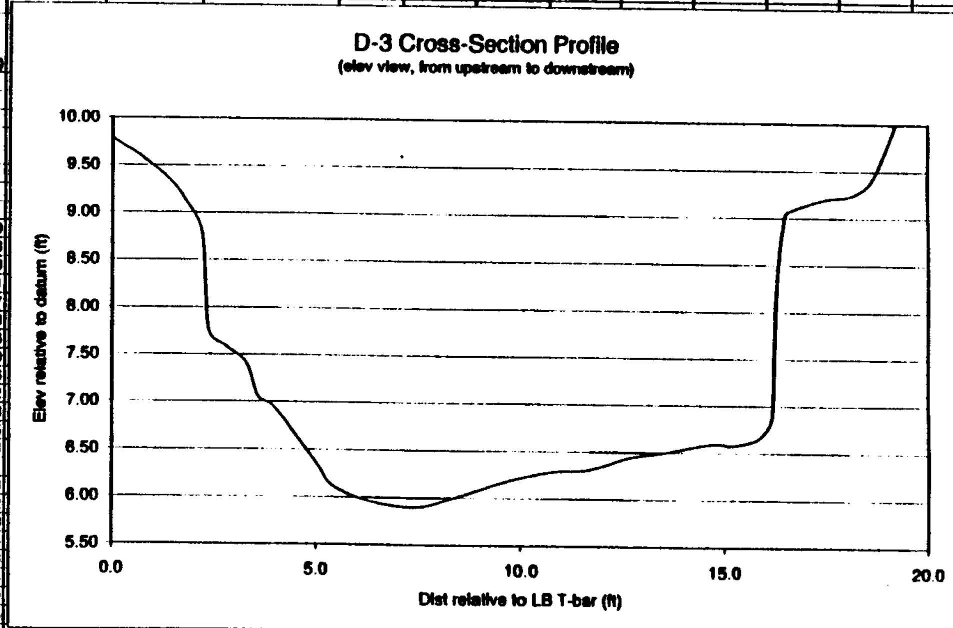


K:\working\2912\2912(28B)\D-2 Water Surface Chart 1D-2 Water Surface Chart 1

AR 052835

Summer low flow assessment: cross section data								
3rd Runway Project								
				Definitions:	RB - right bank, looking d/s			
Creek:	**Des Moines @ golf course**				LB - left bank, looking d/s	BFW est (ft) =	14.5	(to nearest 0.5 ft)
Cross-section # :	D-3; glide/pool u/s of most d/s weir within golf course;				OHWM - ordinary high water mark	WW (ft) =	14.0	
Date Surveyed:	8/15/2001				EOW - edge of water	Ave H20 depth (ft) =	1.46	
Field Crew:	HW, RF	Stadia:	HW		SS - substrate	Max H20 depth (ft) =	2.32	
Date Entered:	8/24/2001	Notes:	RF		BFW - bank full width			
Entered By:	HW				WW - wetted width			
				Conventions:	measurements begin on left bank			
Vert Dist from level to datum:		12.98	feet		datum defined at 10 feet below top of LB rebar			

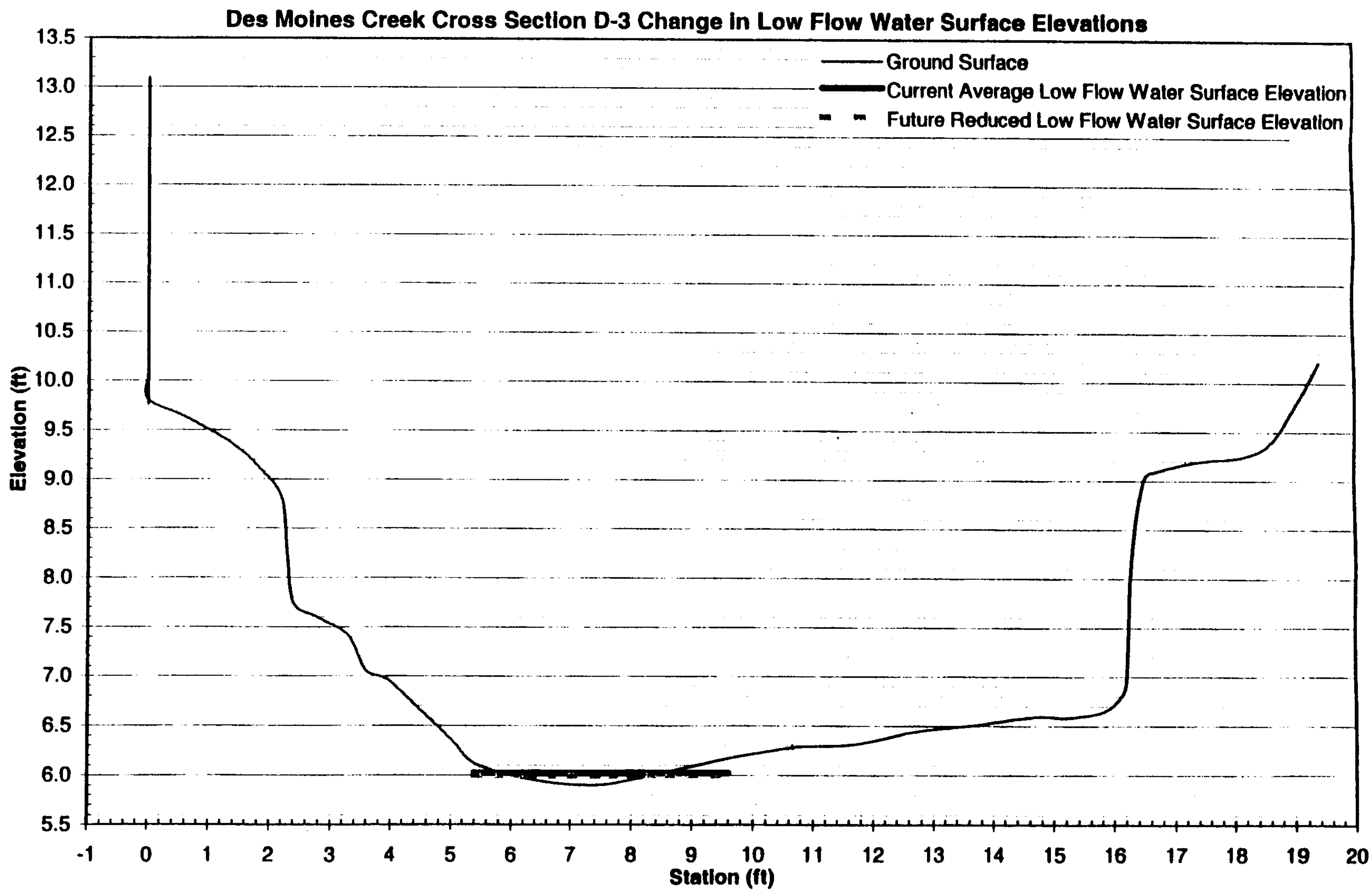
	RAW DATA		**Final Values**		
Description	**dist (ft)**	**height (ft)**	**dist (ft)**	**elev (ft)**	**H20 depth (ft)**
top LB Tbar	2.1	-0.10	0.00	13.08	
base LB Tbar	2.1	3.20	0.00	9.78	
top LB datum rebar	2.1	2.98	0.00	10.00	
base LB datum rebar	2.1	3.18	0.00	9.80	
	2.8	3.38	0.70	9.60	
	3.5	3.63	1.40	9.35	
OHWM	3.9	3.85	1.80	9.13	
	4.3	4.17	2.20	8.81	
EOW	4.4	4.76	2.30	8.22	0.00
ss	4.5	5.24	2.40	7.74	0.48
ss	4.9	5.39	2.80	7.59	0.63
ss	5.4	5.57	3.30	7.41	0.81
ss	5.7	5.93	3.60	7.05	1.17
ss	6.1	6.04	4.00	6.94	1.28
ss	7.1	6.62	5.00	6.36	1.86
ss	7.5	6.86	5.40	6.12	2.10
ss	8.4	7.02	6.30	5.96	2.26
thalweg	9.5	7.08	7.40	5.90	2.32
ss	10.4	6.99	8.30	5.99	2.23
ss	11.7	6.81	9.60	6.17	2.05
ss	12.8	6.70	10.70	6.28	1.94
ss	13.8	6.67	11.70	6.31	1.91
ss	14.8	6.54	12.70	6.44	1.78
ss	15.7	6.48	13.60	6.50	1.72
ss	16.8	6.39	14.70	6.59	1.63
ss	17.3	6.40	15.20	6.58	1.64
ss	17.9	6.34	15.80	6.64	1.58
ss	18.2	6.20	16.10	6.78	1.44
ss	18.3	6.05	16.20	6.93	1.29
EOW	18.4	4.71	16.30	8.27	-0.05
OHWM	18.6	3.96	16.50	9.02	
	18.8	3.89	16.70	9.09	
	19.5	3.79	17.40	9.19	
	20.3	3.73	18.20	9.25	
	20.8	3.53	18.70	9.45	
top of root	21.5	2.77	19.40	10.21	
no RB Tbar, dense roots					
xsec from LB to balze on u/s side tree					



AR 052836

Paramet... Inc.
Port of Seattle
554-2912-28B

Checked By: [signature]
By: Ange... Wilcox
December 6, 2001



K:\working\2912\2912(28B)\D-3 Water Surface Chart 1D-3 Water Surface Chart 1

Start of 7-Day Low Flows
with Average Flow Rates

	Date		1994 HSPF Des Moines Creek at 200th St. / Flow cfs Average 7-Day Low Flow
1949	Sep	7	0.18
1950	Sep	17	0.40
1951	Aug	20	0.35
1952	Oct	13	0.21
1953	Sep	15	0.35
1954	Aug	7	0.48
1955	Sep	6	0.34
1956	Sep	3	0.43
1957	Sep	20	0.32
1958	Sep	2	0.27
1959	Aug	24	0.38
1960	Aug	7	0.39
1961	Aug	23	0.40
1962	Sep	2	0.33
1963	Sep	27	0.36
1964	Aug	31	0.47
1965	Aug	3	0.38
1966	Aug	20	0.32
1967	Aug	25	0.33
1968	Aug	6	0.47
1969	Sep	6	0.38
1970	Aug	27	0.33
1971	Aug	14	0.41
1972	Oct	18	0.51
1973	Sep	12	0.27
1974	Oct	13	0.31
1975	Aug	11	0.33
1976	Oct	17	0.34
1977	Aug	16	0.17
1978	Oct	16	0.41
1979	Aug	7	0.22
1980	Aug	23	0.33
1981	Sep	12	0.28
1982	Aug	6	0.41
1983	Oct	10	0.45
1984	Aug	29	0.36
1985	Aug	30	0.25
1986	Sep	10	0.26
1987	Sep	7	0.29
1988	Sep	11	0.25
1989	Oct	3	0.35
1990	Sep	25	0.31
1991	Oct	9	0.33
1992	Sep	1	0.31
1993	Sep	29	0.27
1994	Aug	26	0.22
1995	Sep	20	0.35

Statistical Ranking of Average 7-Day Low Flows
Period of Record: 1949 - 1995

Year	Average 7-Day Lows Ordered	Rank	Rank/(47+1)	Return Frequency
1977	0.17	1	0.02	2.1
1949	0.18	2	0.04	4.2
1952	0.21	3	0.06	6.3
1994	0.22	4	0.08	8.3
1979	0.22	5	0.10	10.4
1988	0.25	6	0.13	12.5
1985	0.25	7	0.15	14.6
1986	0.26	8	0.17	16.7
1993	0.27	9	0.19	18.8
1973	0.27	10	0.21	20.8
1958	0.27	11	0.23	22.9
1981	0.28	12	0.25	25.0
1987	0.29	13	0.27	27.1
1990	0.31	14	0.29	29.2
1974	0.31	15	0.31	31.3
1992	0.31	16	0.33	33.3
1966	0.32	17	0.35	35.4
1957	0.32	18	0.38	37.5
1970	0.33	19	0.40	39.6
1975	0.33	20	0.42	41.7
1962	0.33	21	0.44	43.8
1980	0.33	22	0.46	45.8
1991	0.33	22	0.46	45.8
1967	0.33	24	0.50	50.0
1976	0.34	25	0.52	52.1
1955	0.34	26	0.54	54.2
1951	0.35	27	0.56	56.3
1995	0.35	27	0.56	56.3
1953	0.35	29	0.60	60.4
1989	0.35	30	0.63	62.5
1984	0.36	31	0.65	64.6
1963	0.36	32	0.67	66.7
1965	0.38	33	0.69	68.8
1969	0.38	34	0.71	70.8
1959	0.38	35	0.73	72.9
1960	0.39	36	0.75	75.0
1961	0.40	37	0.77	77.1
1950	0.40	38	0.79	79.2
1971	0.41	39	0.81	81.3
1978	0.41	40	0.83	83.3
1982	0.41	41	0.85	85.4
1956	0.43	42	0.88	87.5
1983	0.45	43	0.90	89.6
1964	0.47	44	0.92	91.7
1968	0.47	44	0.92	91.7
1954	0.48	46	0.96	95.8
1972	0.51	47	0.98	97.9

Rank = Numerical position of ordered average 7-day low flow values with the driest year equal to one.
N = 47

Appendix F

APPENDIX F

RESERVE STORMWATER RELEASE STORAGE FACILITIES
CONCEPT DRAWINGS

Seattle Tacoma International Airport

Low Flow Analysis
Flow Impact Offset Facility Proposal

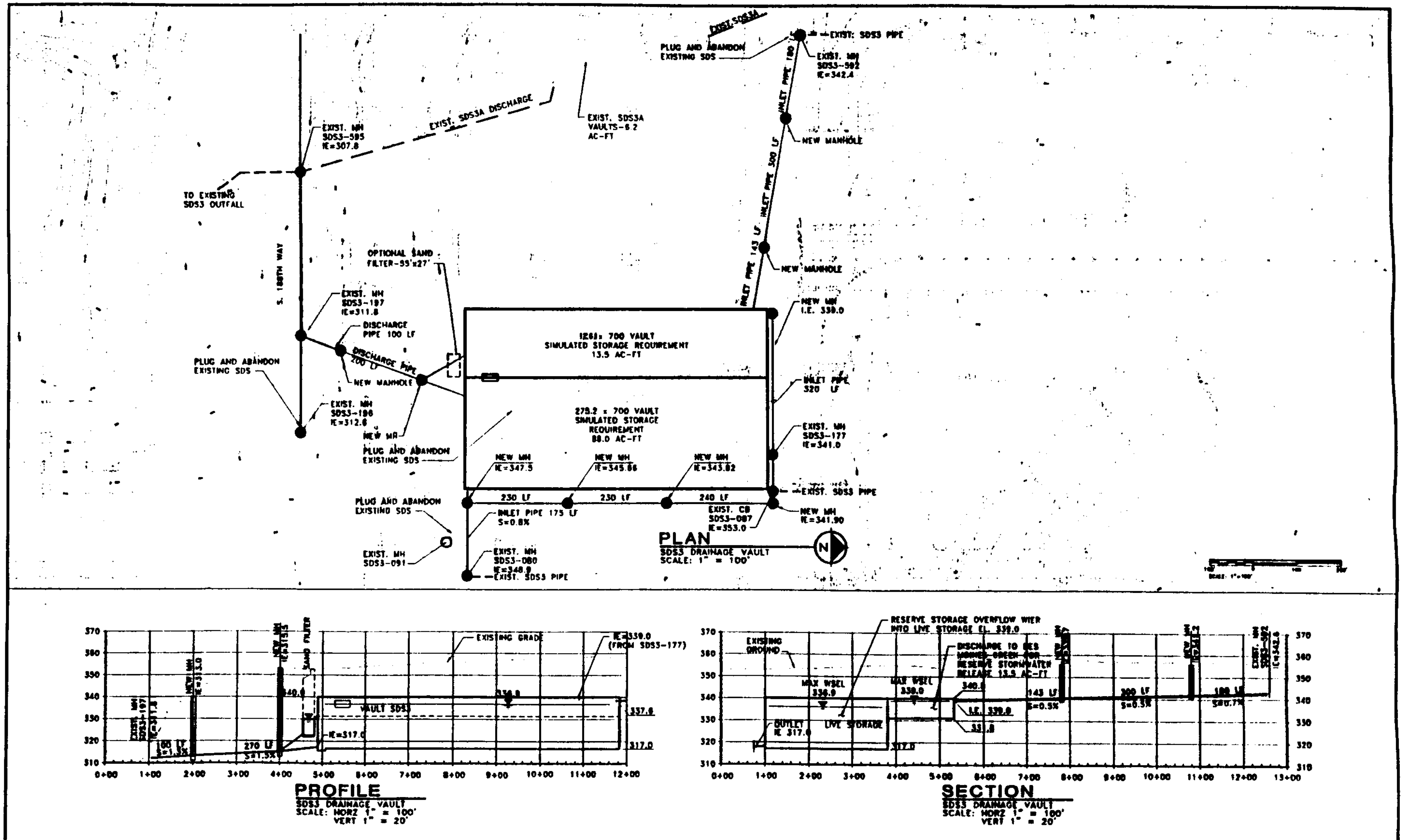
RESERVE STORMWATER RELEASE STORAGE FACILITIES
CONCEPT DRAWINGS

Prepared By

HNTB

Checked By

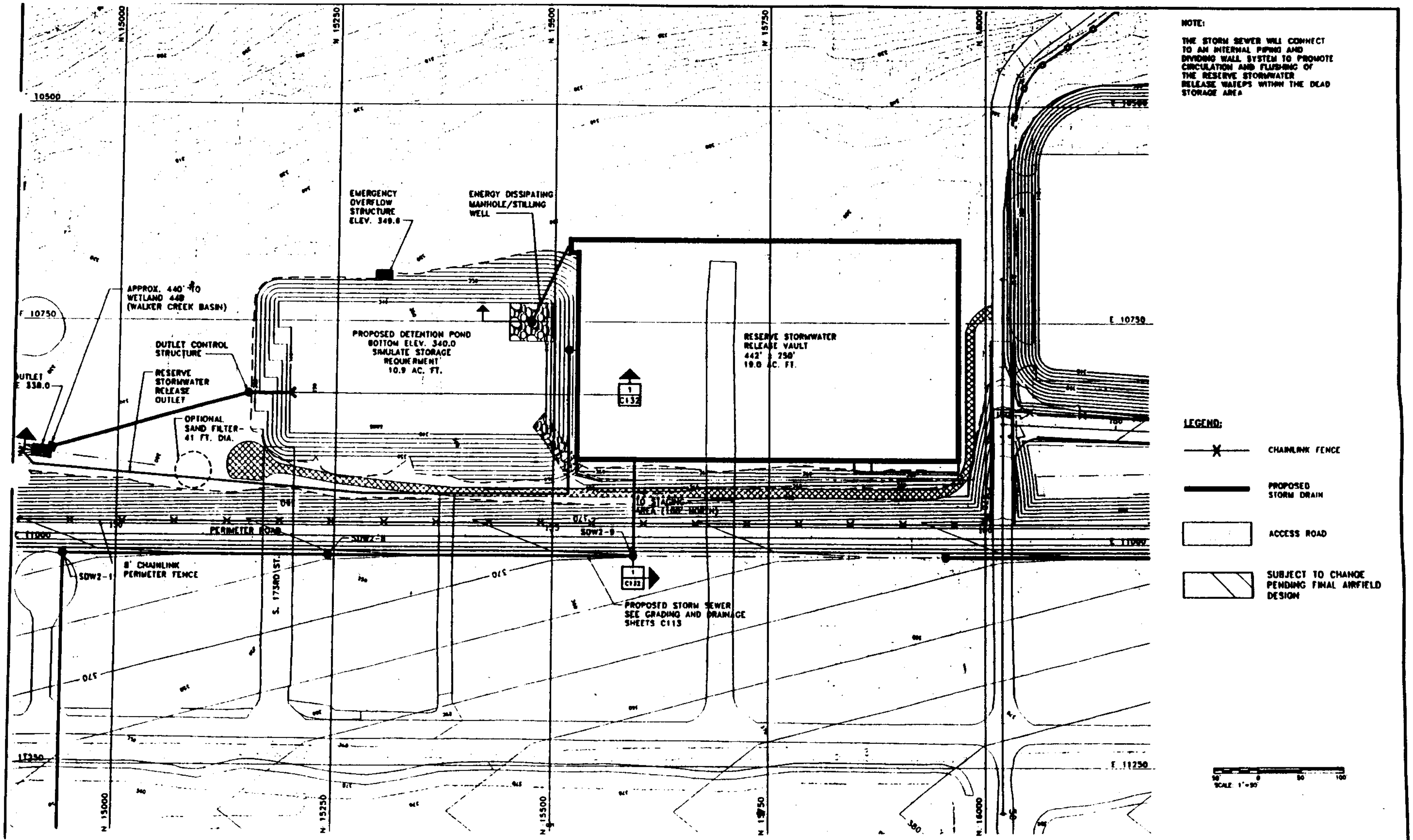
Alan D. Black P.E.



Port of Seattle
SEA-TAC INTERNATIONAL AIRPORT
PROJECT: THIRD RUNWAY - EMBANKMENT CONSTRUCTION
SHEET TITLE: SDS3, SDS3A AND SDS5 BASIN VAULT / PLAN AND PROFILE

DEC. 5, 2001
EXHIBIT C141

AR 052842



PLAN
POND F PLAN
SDW2 BASIN POND
SCALE: 1" = 50'

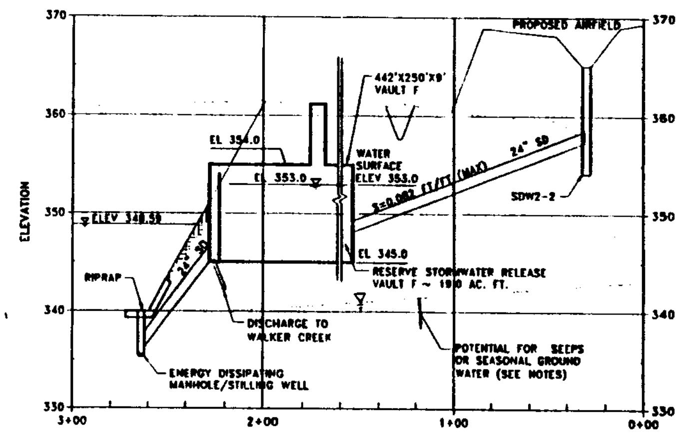
Port of Seattle
SEA-TAC INTERNATIONAL AIRPORT

PROJECT: THIRD RUNWAY - EMBANKMENT CONSTRUCTION

SHEET TITLE: POND F PLAN
SDW2 BASIN POND

DEC. 5, 2001

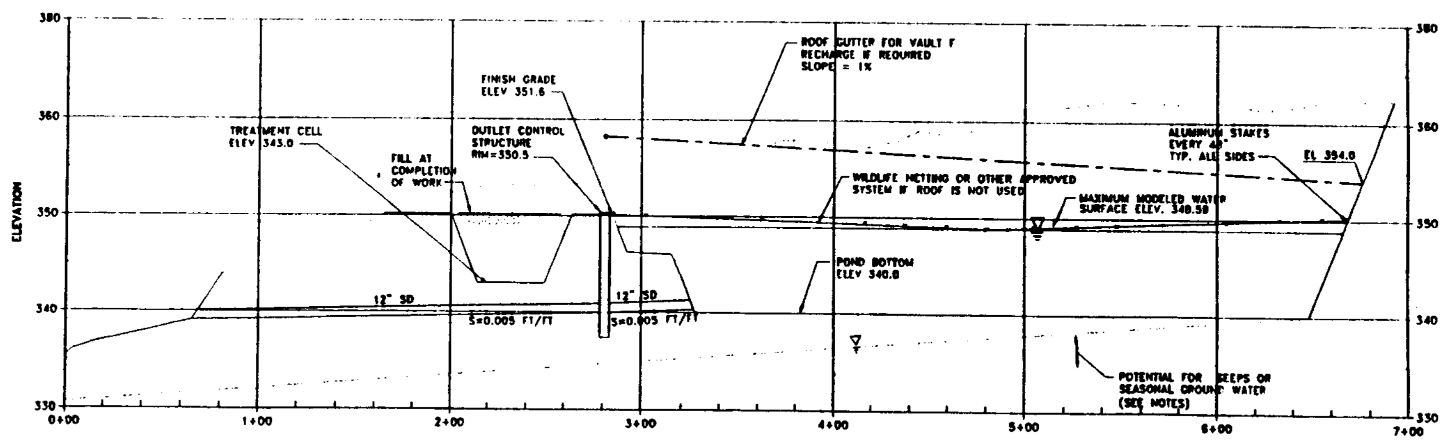
EXHIBIT_ C131



PROFILE 2 / C131
STORM DRAIN AND RESERVE STORMWATER RELEASE VAULT PROFILE
SCALE: HORZ 1" = 30'
VERT 1" = 6'

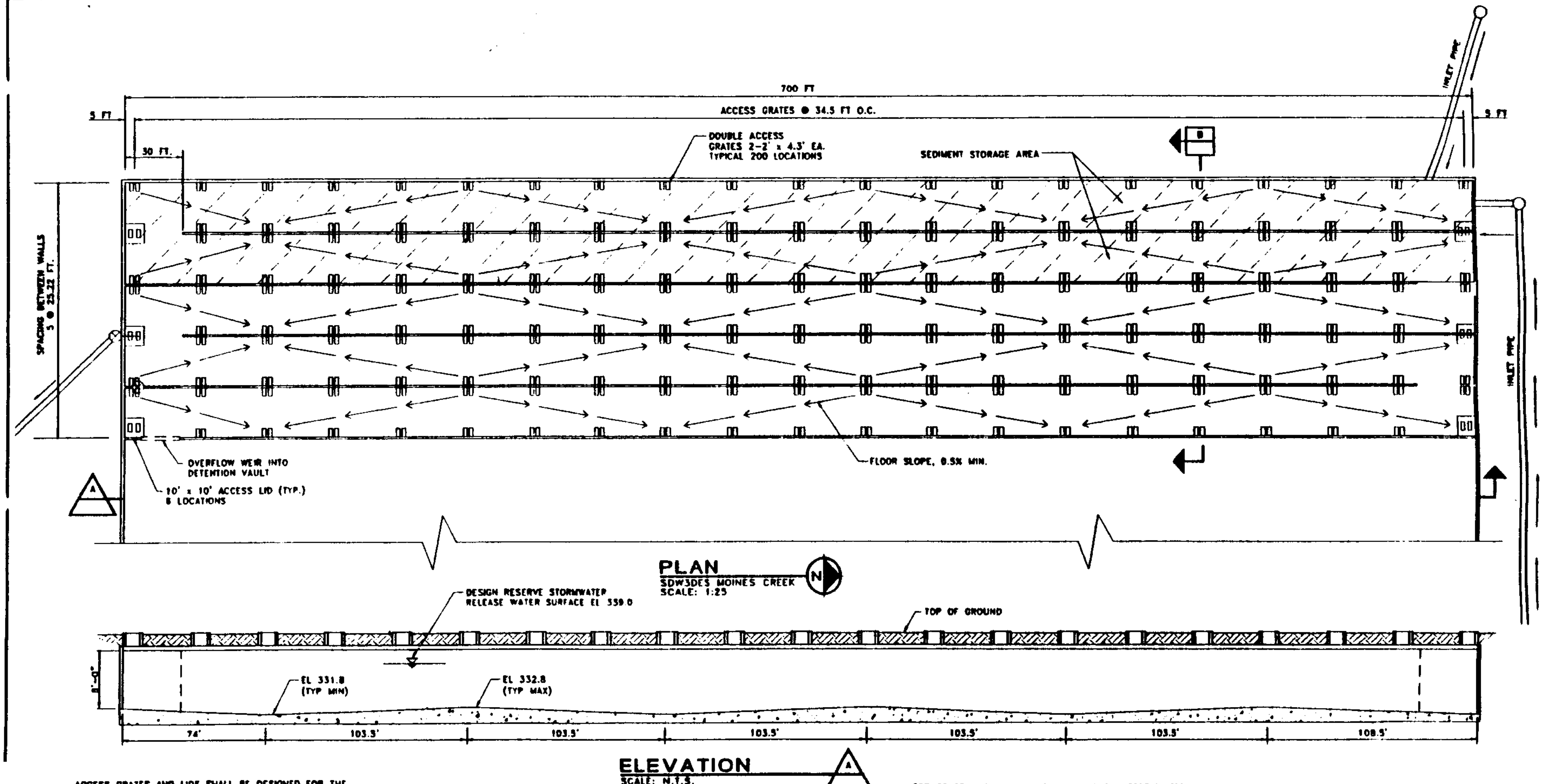
NOTES:

1. GROUND WATER ELEVATIONS ARE APPROXIMATE BASED ON AVAILABLE GEOTECHNICAL INVESTIGATIONS AND HYDROGEOLOGIC ELEVATION WILL BE INCLUDED AS PART OF THE FINAL DESIGN ANALYSIS.
2. FINAL POND CONFIGURATION MAY VARY TO MAINTAIN STORM WATER STORAGE ABOVE THE OBSERVED GROUND WATER.



PROFILE 1 / C131
POND F PROFILE
SDW-2 BASIN POND
SCALE: HORZ 1" = 30'
VERT 1" = 6'

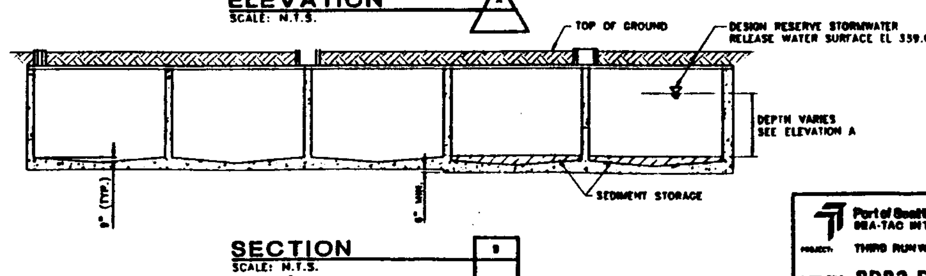
Port of Seattle
SEA-TAC INTERNATIONAL AIRPORT
PROJECT: THIRD RUNWAY - EMBANKMENT CONSTRUCTION
SHEET TITLE: **POND F PROFILE SDW2 BASIN POND**
DEC. 5, 2001
EXHIBIT_C132



ACCESS GRATES AND LIDS SHALL BE DESIGNED FOR THE FOLLOWING LOADINGS.

1. MANHOLE COVERS, INLETS AND FRAMES FOR 100,000-LB. WHEEL LOADS WITH 250 PSI TIRE PRESSURE.
2. FOR SPANS OF 2 FEET OR LESS IN THE LEAST DIRECTION, A UNIFORM LIVE LOAD OF 250 PSI.
3. FOR SPANS BETWEEN 2 FEET AND 10 FEET IN THE LEAST DIRECTION, A UNIFORM LIVE LOAD VARYING BETWEEN 250 PSI AND 50 PSI, IN INVERSE PROPORTION TO THE SPAN LENGTH.
4. BRAKING LOADS OF 0.7G FOR PORTIONS OF THE STRUCTURE SUBJECT TO DIRECT WHEEL LOADS.
5. SOIL PRESSURE SHALL BE LIMITED TO 2.5 KSF.

THE CONTRACTOR SHALL SUBMIT SHOP DRAWINGS AND STRUCTURAL CALCULATIONS STAMPED BY A STRUCTURAL ENGINEER LICENSED TO PRACTICE IN THE STATE OF WASHINGTON.



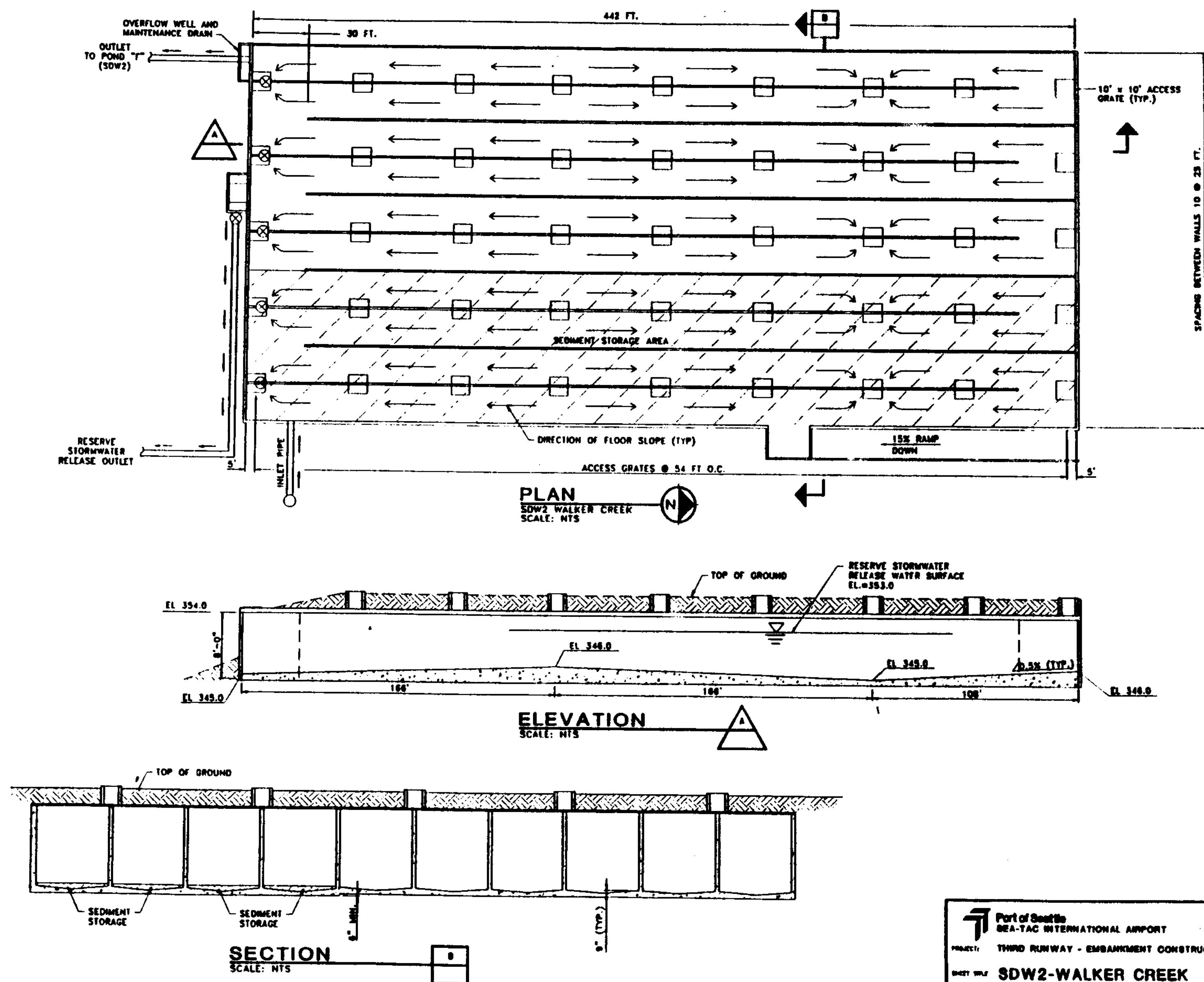
Port of Seattle
SEA-TAC INTERNATIONAL AIRPORT

PROJECT: THIRD RUNWAY - EMBANKMENT CONSTRUCTION

SHEET TITLE: SDS3-DES MOINES CREEK
RESERVE STORMWATER RELEASE VAULT

DEC. 5, 2001

EXHIBIT



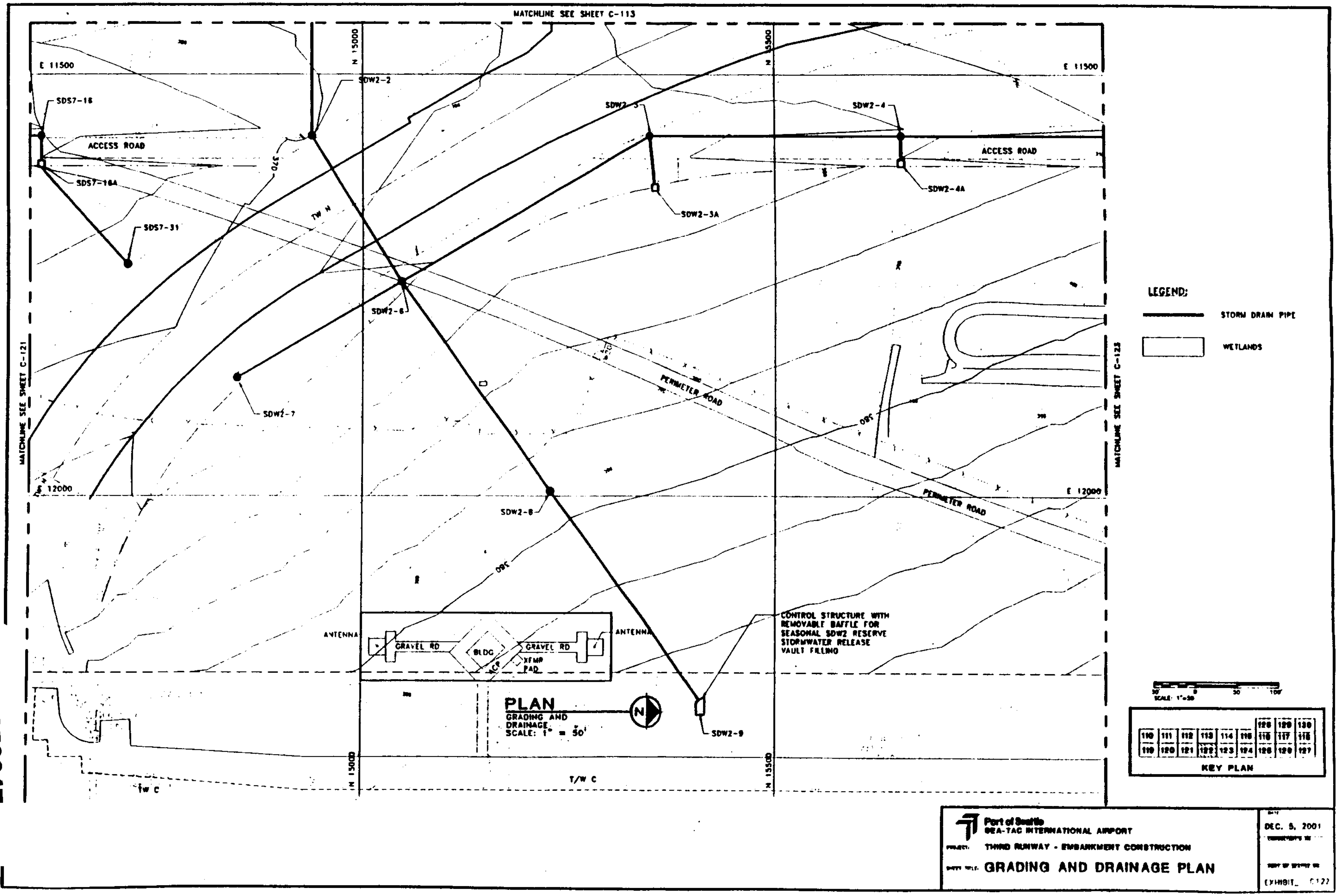
Port of Seattle
SEA-TAC INTERNATIONAL AIRPORT

PROJECT: THIRD RUNWAY - EMBANKMENT CONSTRUCTION

SHEET TITLE: **SDW2-WALKER CREEK RESERVE STORMWATER RELEASE VAULT**

DEC. 5, 2001

EXHIBIT SDW2

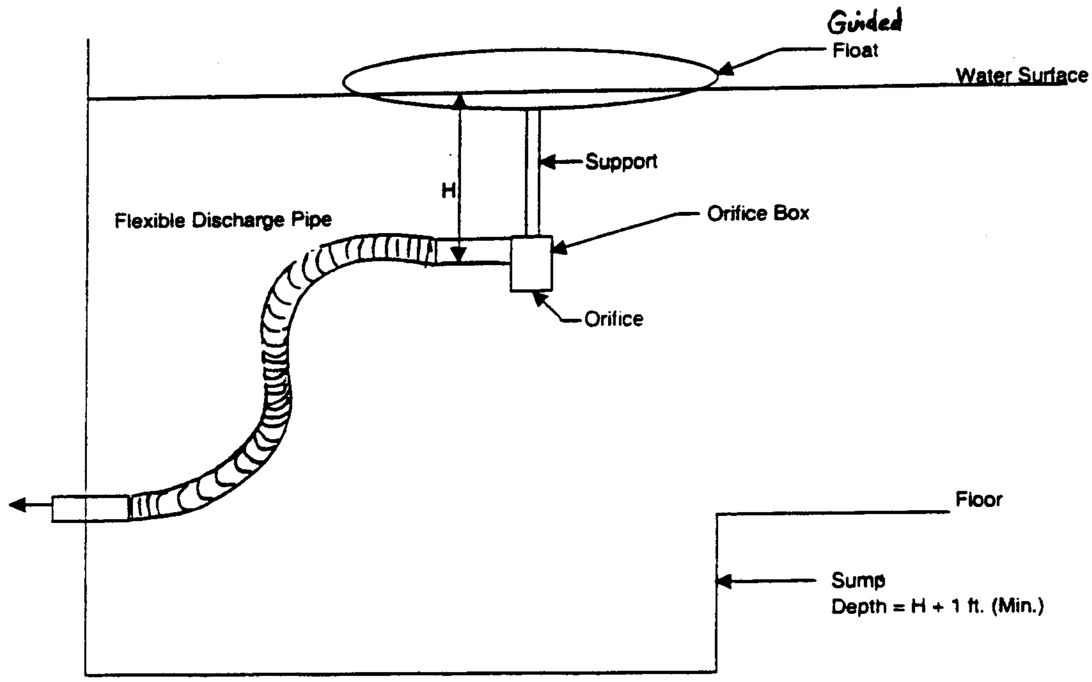

MATCHLINE SEE SHEET C-113
MATCHLINE SEE SHEET C-121
MATCHLINE SEE SHEET C-125
E 11500
E 12000
N 15000
N 15500
SDS7-16
SDS7-16A
SDS7-31
SDW2-2
SDW2-3
SDW2-3A
SDW2-4
SDW2-4A
SDW2-6
SDW2-7
SDW2-8
SDW2-9
ACCESS ROAD
PERIMETER ROAD
TW N
T/W C
370
380
CONTROL STRUCTURE WITH REMOVABLE BAFFLE FOR SEASONAL SDW2 RESERVE STORMWATER RELEASE VAULT FILLING
ANTENNA
GRAVEL RD
BLDG
XFMR PAD
PLAN
GRADING AND DRAINAGE
SCALE: 1" = 50'
LEGEND:
STORM DRAIN PIPE
WETLANDS
KEY PLAN
Port of Seattle
SEA-TAC INTERNATIONAL AIRPORT
THIRD RUNWAY - EMBANKMENT CONSTRUCTION
GRADING AND DRAINAGE PLAN
DEC. 5, 2001

AR 052847

Orifice Sizing Calculation

Seattle-Tacoma International Airport
Low Flow Analysis
Flow Impact Offset Facility Proposal

		SDW2	SDS3
Given: Facility		SDW2	SDS3
Maximum Discharge (cfs)		0.11	0.08
		2"	1 3/4"
Design Orifice	Dia.	2	1.75
	Cd	0.62	0.62
	A	0.0218	0.0167
	H	1.00	1.00
	Q	0.11	0.08



Appendix G

APPENDIX G

PHYSICAL HABITAT SURVEY AND MONITORING PROTOCOL FOR WADABLE STREAMS

PHYSICAL HABITAT SURVEY AND MONITORING PROTOCOL FOR WADABLE STREAMS

RATIONALE

These protocols were designed based on the Tri-County Urban Stream Baseline Evaluation Methodology (UEBEM) (R2 Resources Consultants et al. 2000). The protocols were designed to provide year to year comparisons of several habitat attributes.

REACH SELECTION AND DELINEATION

A physical habitat survey will be conducted in 100 percent of Miller Creek in the buyout area. Additional surveys will be conducted in approximately 25 percent of the total length of each reach type (palustrine, floodplain, alluvial plain, large contained, moderate gradient mixed control, moderate gradient contained, and high gradient contained [Paustian et al. 1992]) within Des Moines, Walker, and the remainder of Miller Creek, depending on site access. All surveys will be conducted during the low-flow period of the year.

REACH UNIT LENGTH

To facilitate the development regulation appropriate to aquatic ecosystem conditions within the Port of Seattle (Port), a standard survey reach length of approximately 30 bankfull channel widths will be used. Bankfull width (BFW) measured at the beginning of each unit reach will be used to calculate the reach unit length. Lengths of less than 30 channel widths will only be measured if the reach type changes before a length of 30 channel widths. If there is a significant change in the stream system and/or channel characteristic (e.g., landform, floodplain width, stream gradient, channel form, adjacent land use, and major confluence), the reach will end at this point and a new reach assessment will begin. Reach assessments will begin at the downstream end of each reach.

FIELD EQUIPMENT

The following equipment will be used for the physical habitat monitoring:

- Field computer
- Stadia rod or wading stick (feet)
- Measuring tape
- Hip chain (feet)
- Flagging tape
- Thump tally
- Digital camera
- Abney level
- Off-channel habitat qualitative assessment forms (Attachment A)
- Culvert assessment data forms (Attachment B)
- Global positioning system (GPS) unit

FIELD COMPUTERS AND FILE MANAGEMENT

During the survey, data will be entered into a spreadsheet database contained on a Juniper Systems Allegro™ Field PC. Detailed operating instructions for both hardware and software are contained in the Allegro Field PC owner's manual, available to all field personnel. The following section describes the procedure each survey team should follow to ensure all data are stored in a useful and organized format.

Activate the Field PC by pressing the On/Off button (as long as the batteries remain charged, the field computers will revert to suspended mode when turned "off" or not used for a predetermined amount of time). Once activated, most of the subsequent functions are easily achieved using the touch screen. If for any reason during the survey the touch screen becomes inoperable, most necessary functions can be accessed using the keypad in much the same way as on a desktop PC.

At the beginning of each reach unit, open (double-click) the shortcut to **Str_Datasheet1.1.pt**, the main database file. The file contains six worksheets: one header sheet containing the information about the reach to be surveyed, five sheets for habitat parameter data entry, and a compilation sheet that organizes data from each of the previous sheets into a single spreadsheet (for data management purposes only). Before entering any data, use the ***Save As*** command in the ***File*** menu to save the file as the designated reach identification number. Make sure the file saves to the C drive, as this is the solid-state hard drive that stores data in the event power is lost. A backup copy of the blank spreadsheet is located in **C_MyDocs** in case the original is saved over.

Once the file is saved as the reach identification number, check to make sure the caps lock is engaged and begin filling all known reach information into the spaces provided in the header sheet. Begin surveying the stream, switching back and forth between habitat parameter sheets by tapping on the tab at the bottom of the screen and filling in appropriate information. Save the file periodically to minimize potential loss of data in the event of a computer lockup. At no time should data be entered into the compilation sheet (while the sheet is protected, some data entries are still possible). If data are entered inadvertently into the compilation spreadsheet, use the ***Undo*** function under the ***Edit*** pull-down menu to remove entries (deleting the entry may also delete equations built into the sheet). At the end of the reach, fill in all remaining blanks in the header sheet and perform a final save before closing the file.

Completed reach files should be transferred to an office computer after each day of survey and checked for invalid or missing data. Any anomalies should be recorded and communicated to the data manager.

GENERAL PROCEDURE

<u>Comment Field</u>

There may be times when this protocol does not fully capture a situation encountered during a survey. Comment fields are included as part of each spreadsheet in the database and are intended as a means to document instances when a measurement or classification of a habitat parameter is not completely clear. When these situations occur, surveyors are encouraged to make comments based on their best professional judgment. Record a brief explanation of the decision in the comment field associated with the parameter in question.

Station

At the start of each reach, tie off and zero the hip chain. Record a station (in yards) for each piece of information gathered in the reach. The station designation provides an organizational record for data entry into an extensive field computer database. While the hip-chain station reading is fairly arbitrary on a subbasin scale, it allows the physical habitat information recorded to be analyzed, if need be, on a site-specific level. The station designation also provides the opportunity for quality control surveys.

Protocol for Dry Channels

Channels that are dry at the time of the survey will be surveyed for BFW and wood and bank instability. If dry channels have standing water in pools and these pools meet the survey criteria, they will also be recorded.

HEADER INFORMATION

Purpose: Header information, like all data collected with this protocol, is linked to a database tab within the data sheet. These database tabs facilitate downloading data into Microsoft Access. From there, the data can be organized, checked for quality, and imported into various analysis packages such as Excel and Analytica.

Procedure: The header information is arranged to organize the reach data. At the start of each reach, obtain latitude and longitude from the GPS unit and record. Load additional information into the appropriate areas. An information box is available under the comment space that will automatically calculate, after the initial BFW is measured, the minimum pool depth and size, large woody debris (LWD) length and width, and the general locations of additional BFW measurements (Figure G-1).

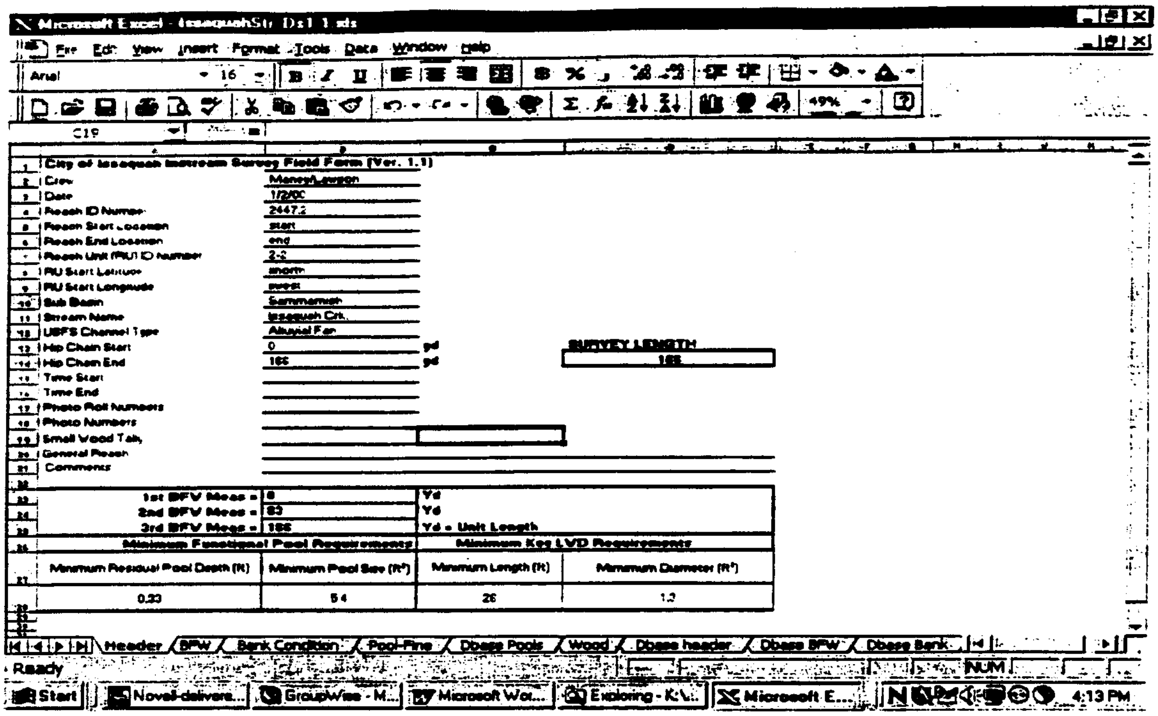
HABITAT PARAMETERS

Bankfull Width

Purpose: BFW is the primary measure of channel size and is used to determine the minimum size of functioning pools and woody debris along the reach (explained below), as well as the reach unit length.

Definition: BFW is the width of a stream channel at the point where over-bank flow begins during a flood event. In entrenched channels with disconnected or undeveloped floodplains, bankfull indicators may include: the top of deposited bedload (gravel bars), stain lines, the lower limit of perennial vegetation, moss or lichen, a change in slope or particle size on the streambank, and undercut banks (USFS 1999).

Figure G-1. **Example Data Entry for Reach Unit Header Sheet**



Procedure: For each 166-yard (roughly 500 ft long) reach, three BFW measurements will be made. Measure BFW at the crest of the first riffle, at the crest of the riffles nearest a distance of 83 yards upstream, and at the crest of the last riffle nearest a distance of 166 yards upstream. Straight, low-gradient riffles with uniform banks are best for identifying bankfull stage and therefore BFW. Locate bankfull stage by using any of the above indicators on at least one of the streambanks. Measure the width of the channel at the indicated point and record it in the handheld computer database (Figure G-2).

BANK CONDITIONS

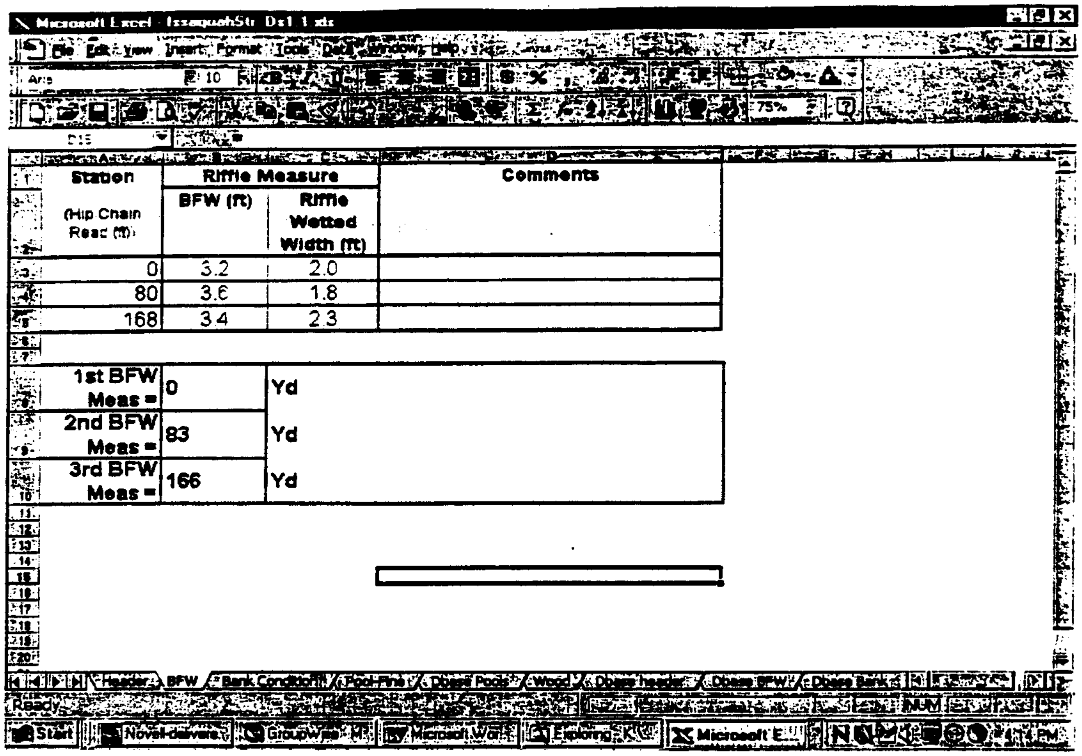
Purpose: To assess channel stability and response to watershed conditions. This protocol will follow the definitions used by Bauer and Burton (1993):

Definitions:

- **Bank Stability:** Defined by the American Fisheries Society (Armantrout 1998) as the resistance of a bank to erosion.
- **Bank Instability:** Banks are considered stable unless they show indications of any of the following features at or above bankfull (this list is for reference only, surveyors are not expected to record the instability type):
  - **Breakdown:** obvious blocks of bank broken away and lying adjacent to the bank breakage.

AR 052854

Figure G-2. Example Data Entry for Start, Midpoint, and End BFW Measurements



Station (Hip Chain Read (ft))	Riffle Measure		Comments
	BFW (ft)	Riffle Wetted Width (ft)	
0	3.2	2.0	
80	3.6	1.8	
168	3.4	2.3	

1st BFW Meas =	0	Yd
2nd BFW Meas =	83	Yd
3rd BFW Meas =	166	Yd

- **Slumping or False Bank**: bank has obviously slipped down, cracks may or may not be obvious, but the slump feature is obvious.
- **Fracture**: a crack is visibly obvious on the bank indicating that the block of bank is about to slump or move into the stream.
- **Vertical & Eroding**: The bank is mostly uncovered as defined below *and* the bank angle is steeper than 80° from the horizontal.
  - Perennial vegetation ground cover < 50 percent.
  - Roots of vegetation cover < 50 percent of the bank.
  - Rocks of cobble size or larger protect <50 percent of the bank surfaces.
  - Logs of ≥10-cm diameter protect < 50 percent of the bank surfaces.

- **Bank Hydro-Modification:** For hydro-modified banks, record the type of modification and the material composition of the toe of the feature (at and below the bankfull elevation). Seven categories of hydro-modification are listed below:
  - **DI: Dike/Levee/Berm**
  - **RE: Revetment**
  - **BU: Bulkhead**
  - **BR: Bridge Footing**
  - **BE: Beaver Dam**

- DA: **Dam**
- CU: **Culvert**

To capture the extent of beaver dams in the system. we have included them as a category distinct from human-created dams. All dams (beaver or human) that are connected bank-to-bank and impound water, as well as any abandoned dams that are encountered, will be noted.

The five categories of material composition are listed below:

- **RI:** **Riprap** – bank material > 10 inches (256 cm) in diameter.
- **RU:** **Rubble** – bank material < 10 inches (256 cm) in diameter will be considered rubble.
- **ST:** **Structural** – other material such as wood (other then LWD), concrete, and gabion.
- **EA:** **Earth** – includes artificially placed soil as well as other "natural" toe materials.
- **BE:** **Beaver Dam** – material that was placed by beavers (used only for beaver dam hydro-modification).

Procedure: Stream bank instability and hydro-modification will be continuously measured along both banks. When a portion of bank that meets the above criteria is encountered, identify whether it is on the right or left bank (facing downstream) and record the hip-chain reading in the field computer database. Continue with the survey collecting data on any and all other required stream features. When the end point of the bank feature is reached, record the hip-chain reading in the database. The length of the feature will be calculated automatically. In instances when the feature is small and more easily measured with a stadia rod or tape, do so and enter the length in the end point column. If the channel is braided, then measure bank features along the banks furthest to the right and left only. For beaver dams that extend from bank-to-bank, enter a "B" in the bank column, enter "Beaver Dam" in the hydro-modification column, measure the downstream height and width of the dam, and place those measurements in the comments field. Finally, measure the length of the hydrologic impoundment (Figure G-3).

WOOD STRUCTURE FREQUENCY (ADAPTED FROM WFPB 1997)

Purpose: To measure the type and amount of wood providing habitat complexity and hydraulic roughness.

Definitions: Wood structures are classified into three categories (woody debris, stumps, and jams) using the following definitions:

- **Key Large Woody Debris (LWD)** – defined as downed wood that intercepts bankfull flow in a substantial fashion and is large enough to influence the formation of habitats (USFS 1999). To be counted as key LWD, a piece of wood must meet the minimum criteria listed in Table G-1, which are based on the average BFW for the reach surveyed. To qualify, a piece of wood must have a minimum length of greater than 26 ft (for BFW of 0 to 16.4 ft). Additionally, the diameter of the wood must be greater than 1.3 ft (again for BFW of 0 to 16.4 ft). Wood that spans the bankfull channel and touches just above bankfull on both sides is counted.

Figure G-3. Example Data Entry for Stream Bank Condition

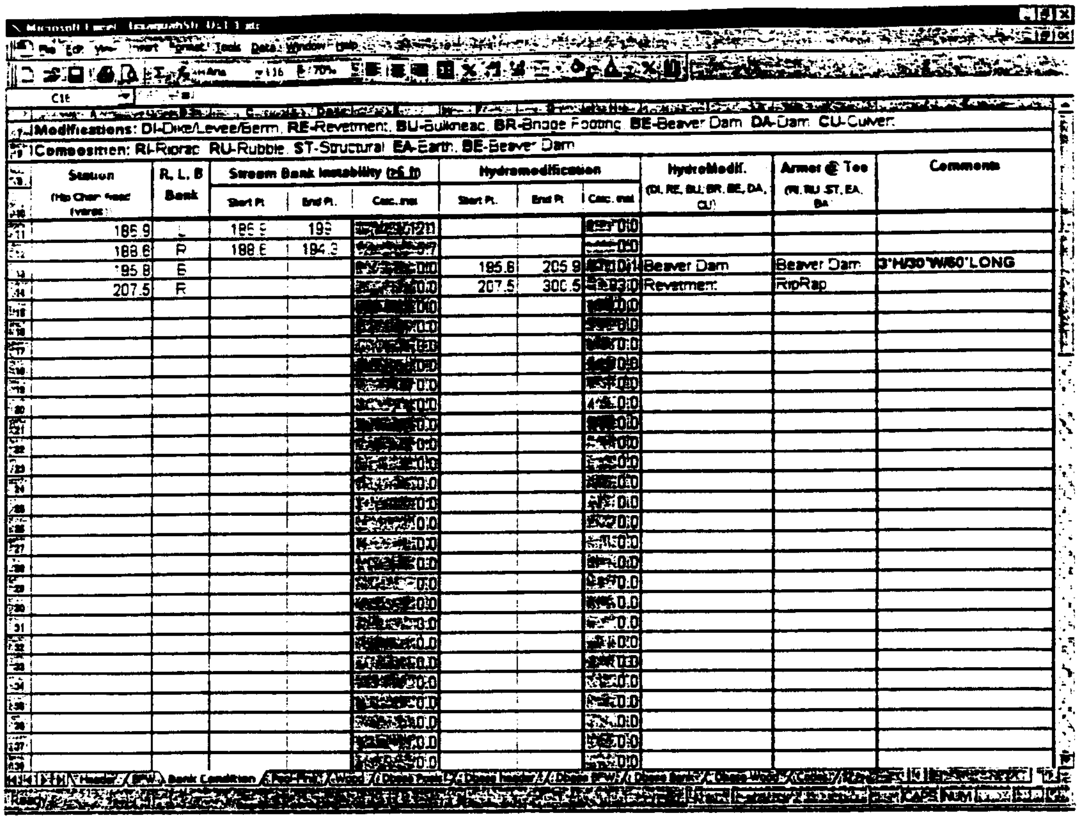


Table G-1. Minimum size to qualify LWD as a key piece (WFPB 1997).

Bankfull Width		Diameter		Length	
Meters	Feet	Meters	Feet	Meters	Feet
0 – 5	0 – 15	0.40	1.3	8	26
6 – 10	15 – 30	0.55	1.8	10	33
11 – 15	30 – 45	0.65	2.1	18	60
16 – 20	45 – 60	0.70	2.3	24	79

- **Stump** – A rootwad with a diameter greater than or equal to 3 ft and a length and/or bole diameter less than the minimum LWD criteria. The rootwad or attached bole must significantly intercept bankfull flow.
- **Small Wood** – If wood is more than 6 ft long and greater than 4 inches in diameter at the narrowest end, then the wood is tallied with a hand counter and recorded on the header page at the end of the reach.

In addition to LWD dimensions, wood debris is further characterized by collecting data on rootwad presence, wood type, decay class, and association with a jam. These attributes are defined as:

- **Rootwad Presence** – for a rootwad to be counted on a piece of woody debris, the rootwad diameter must be at least 3 ft.
- **Wood Type** – Deciduous (D), evergreen/conifer (C), or unknown (U). A decay class of 5 "old" (see below) automatically enters a U into the proper field.
- **Decay Class** – characterizes each piece based on the condition of the wood from natural decay. Table G-2 lists the criteria for three decay classes: "recent" (1), "intermediate" (3), and "old" (5).

Table G-2. Decay class criteria (Collins et al. 2001; Schuett-Hames et al. 1994).

Decay Class	Bark	Twigs	Texture	Shape	Wood Color
1	Intact	Varies	Intact	Round	Original Color
3	Trace	Absent	Smooth	Round	Darkening
5	Absent	Absent	Abrasion	Round/Oval	Dark

- **Jam** – Three or more touching pieces of woody debris and/or stumps (defined above) together producing a single structure significantly intercepting bankfull flow.

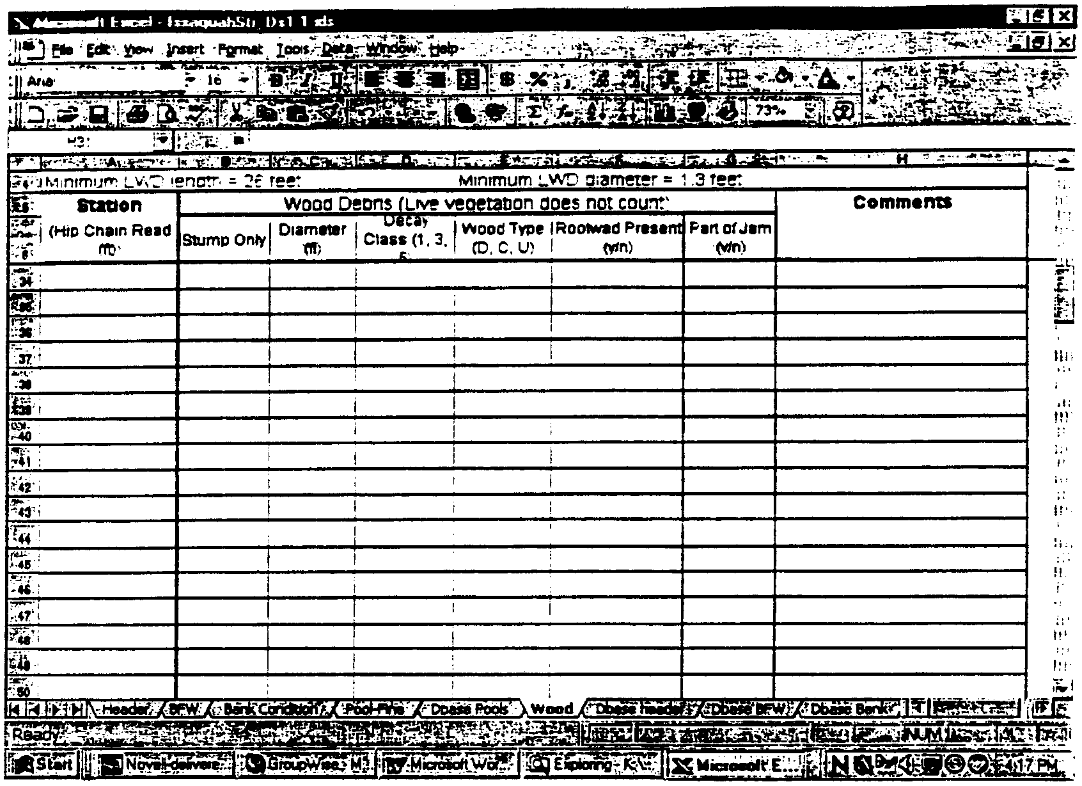
Procedure: Determine minimum length and diameter of key large woody debris based on bankfull width at the starting point of the reach. Measure the diameter of the key woody debris wood at the minimum required length and record. Also record the general station of all wood debris (including stumps) using the hip-chain, wood type, decay class, rootwad presence or absence, and jam association (jam or single piece). Decay class and wood type information are not required for stumps. Tally and record all small wood that meets the minimum size criteria as defined above (Figure G-4).

Comments for wood structure may include but are not limited to general descriptions about stream conditions caused by wood or lack of it and potential for future wood recruitment. Notations concerning small wood that does not meet minimum criteria can also be entered.

RIPARIAN AREA

Purpose: Riparian vegetation influences the productivity and habitat characteristics of a stream reach. This protocol characterizes riparian vegetation following the Washington Department of Natural Resources (WDNR) standard methodology for assessing riparian vegetation along streams using aerial photographs combined with field verification (WFPB 1997).

Figure G-4. Example Data Entry for Wood Structure



Definition:

- **Riparian Area** – 100 ft on either side of bankfull edge (ordinary high water mark) of the stream.

Procedure: The WDNR method examines and verifies a riparian zone 100 ft on each side of the stream and classifies the riparian condition units (RCUs) into categories depending on the trunk diameter, canopy density, and vegetation composition of the trees in the zone (Tables G-3, G-4, and G-5).

Vegetation on each bank will be assessed using photos. The riparian corridor will be categorized using the variables in Tables G-3, G-4, and G-5. For example, a riparian zone on the left bank with a typical stand of 20-year-old alder would get HMD (for hardwood, medium, dense). If the right bank was a mature, mixed-deciduous forest with at least 30 percent conifer understory beginning to accede to the canopy, it would probably get MLD (for mixed large dense). Observers should interpret the riparian canopy as it would appear from an aerial photograph. Before going out in the field, at least one observer will practice delineating RCUs using aerial photographs and a stereoscope. Before making riparian calls in the field, each observer will also practice visually estimating the diameter classes of trees (diameter at breast height [dbh], or 4.5 ft from the ground) and checking the visual estimates with a diameter tape.

Table G-3. Riparian vegetation types for King County stream surveys.

Type	Code	Description
Conifer dominated	C	Forested, more than 70% of trees are conifer
Hardwood dominated	H	Forested, more than 70% of the trees are hardwood
Mixed	M	Forested, no dominance greater than 70%
Shrub	S	Dominated by woody stemmed vegetation that does not reach > 40 ft at maturity, e.g., willows (*Salix*), dogwood (*Cornus*), and salmonberry (*Rubus*).
Grass or cleared	G	Pasture, row crops, maintained rights-of-way, orchards, parkland, landscaped areas, vacant fields, marshes, and wetlands not in open water.
Urban	U	Greater than 70% of RCU is paved or built-up. Includes roads, levees, railroads, and bridges.

Table G-4. Size classifications for riparian trees.

Type	Code	Description
Small	S	Dominant trees in the RCU: DBH between 3" and 12"
Medium	M	Dominant trees in the RCU: DBH between 12" and 20"
Large	L	Dominant trees in the RCU: DBH greater than 20"
Not applicable	X	Value applied to the shrub, grass, and urban classes

Table G-5. Density classes for riparian trees.

Type	Code	Description
Dense	D	More than 1/3 of the RCU is covered by trees
Sparse	S	Less than 1/3 of the RCU is covered by trees
Not applicable	X	Value applied to the shrub, grass, and urban classes

POOLS, RIFFLES, AND SUBSTRATE

Purpose: To characterize the stream longitudinal profile as a measurement of fish habitat, and to quantify substrate conditions in potential spawning locations as an assessment of the risk to eggs and juveniles from entombment, oxygen depletion, gill abrasion, and foraging difficulty.

Definitions:

- **Pool** – a section of stream channel where water is impounded within a closed topographical depression (Abbe and Montgomery 1996).
- **Riffle** – defined by the American Fisheries Society (Armantrout 1998) as: "…characterized by small hydrologic jumps of rough bed material, causing small riffles, waves, and eddies…"

- **Substrate** (bed load) – defined by the American Fisheries Society (Armantrout 1998) as a general term that refers to the sediment moved by a stream at the bottom.

Procedure: Data are loaded in the **Pools_Fines tab** of the computer (Figure G-5). Pool parameters will be recorded for pools meeting the BFW, residual depth, and surface area criteria described in Table G-6.

Figure G-5. Example Field Computer Data Entry for Pools, Riffles, and Substrate

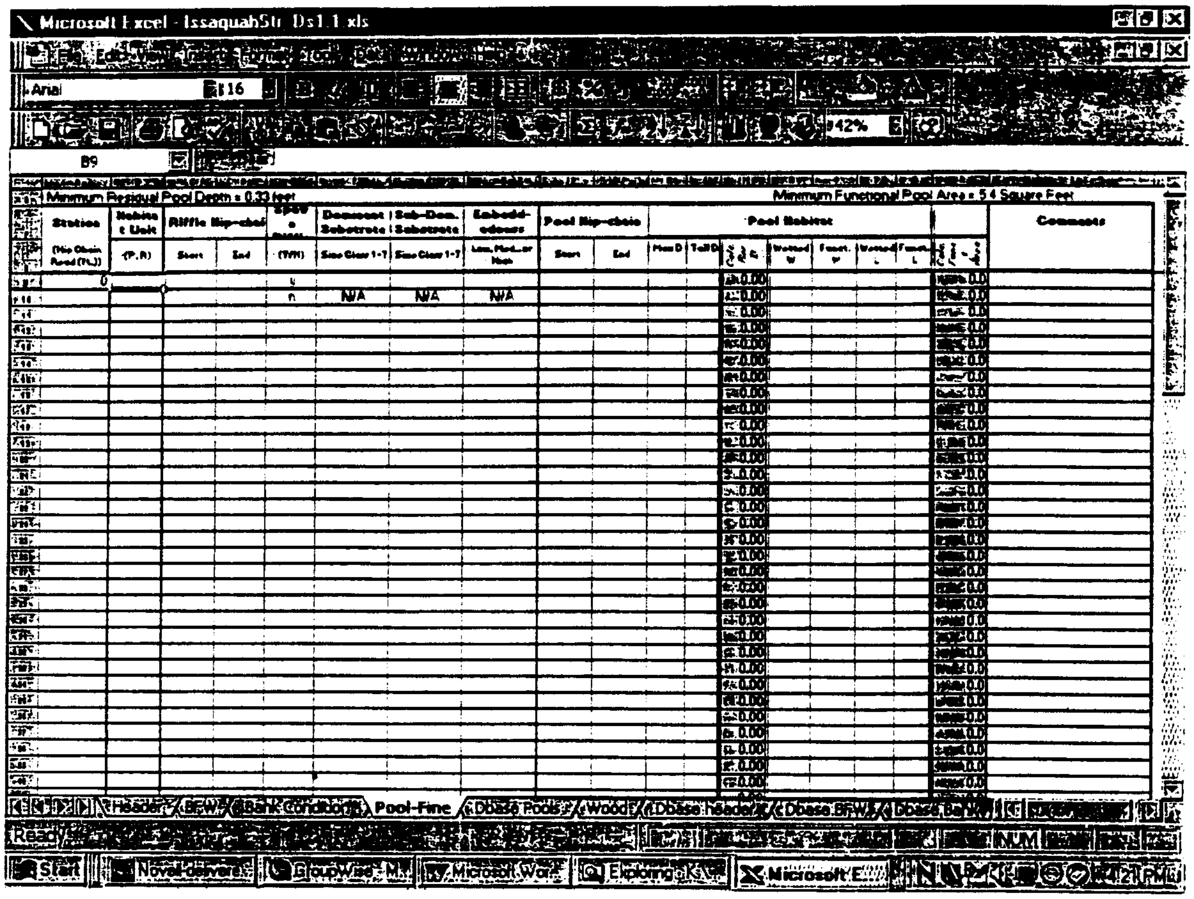


Table G-6. Minimum pool size requirements.

Bank Full Width (ft)	Area (ft^2)	Residual Pool Depth (ft)
0 – 8	5.4 (0.5 m^2)	0.33 (0.10 m)
8 – 16	10.8 (1.0 m^2)	0.66 (0.20 m)
16 – 33	21.5 (2.0 m^2)	0.82 (0.25 m)
33 – 49	32.3 (3.0 m^2)	0.98 (0.30 m)
49 – 66	43.1 (4.0 m^2)	1.15 (0.35 m)
>66	0.2 x BFW	0.0968 x BFW $^{0.4608}$

Based on: Schuett-Hames et al. 1994.

When a pool is encountered, the following will be done:

1. Measure the maximum pool depth and tailout depth using a stadia or wading rod.
2. Calculate the residual pool depth (maximum depth minus pool tailout) manually with a calculator or automatically by entering the depth values into the appropriate database fields.
3. Maximum pool depths of more than 6.0 ft may be entered into the spreadsheet as 6.0 with "over 6 ft" entered in the comment field.
4. If the calculated residual depth value falls within the criteria in Table G-6, measure the mean wetted width and length of the pool, and the mean *functional* width and length. The functional area is the area of the pool most likely to be used by adult salmonids for holding, and is defined by a minimum depth from Table G-6 or the pool tailout depth, whichever is greater. This definition captures the deeper areas of the pool and excludes the shallow margins as the pool tapers toward the banks.
5. If the functional area meets the area requirements in Table G-6, the pool is of acceptable size. If it does not, remove the entered measurements from the record and continue surveying.
6. When two or more pools occur in sequence, they should be split and measured separately whenever there is a clear division (tailout) between them.

Calculate the *functional* pool surface area (length x width) manually with a calculator or automatically by entering the functional pool length and width values into the field computer database. If the calculated area falls within the criteria for the BFW (see Table G-6), enter all of the remaining required information for the pool unit into the field computer database.

When a riffle is encountered, the survey team will do the following and enter data in the *Pools_Fines* tab of the computer (see Figure G-5):

1. Enter "R" in the "Habitat Unit" column.
2. If "R" is entered, the "Riffle Hip-chain" start measurement will automatically load.
3. In the "Riffle End" column, enter the hip-chain location of the end of the riffle.
4. In the "Spawning Potential (Y/N)" column, enter the appropriate response based on best professional judgement.

If a spawning riffle is present, an assessment of substrate condition will be performed. The surface substrate composition provides an indication of the habitat quality for salmon spawning. A visual estimation can provide identification of potential spawning areas. Care must be taken in identifying the dominant/subdominant substrate, particularly in the correct classification of cobble and boulders. This will be aided by the use of a small ruler while in the field.

AR 052862

If there is spawning potential, enter the dominant and subdominant substrate present in the riffle/pool tailout. There are seven numerical choices, as follows (Bovee 1982):

1 = Bedrock
2 = Silt/organic (<2mm)
3 = Sand (2 - 4mm)
4 = Small gravel (4 - 25mm)
5 = Large gravel (25 - 74 mm)
6 = Cobble (74 - 300 mm)
7 = Boulder (>300mm)

Embeddedness (the percent that interstitial spaces are filled with small grain particles) will also be measured in all riffles that potentially support spawning. Embeddedness is also used as a measure of fine sediment concentrations in the substrate (May et al. 1997). Percent embeddedness is measured based on visual estimation. Enter one of the following classes into the computer for each potential spawning riffle.

L = **Low:** Gravel, pebble, cobble, and boulder particles have < 20 percent of their surface covered by fine (sand, silt, clay) particles.

M = **Medium:** Gravel, pebble, cobble, and boulder particles have 20 to 40 percent of their surface covered by fine (sand, silt, clay) particles.

H = **High:** Gravel, pebble, cobble, and boulder particles have > 40 percent of their surface covered by fine (sand, silt, clay) particles.

SECONDARY CHANNEL HABITAT

Purpose: To quantify habitat in secondary channels and identify significant off-channel features.

Definition: Secondary channels are defined as channels that are separated from the main channel by a stable island and contain the smaller portion of the total flow. A stable island in a forested stream is defined by the United States Forest Service (USFS 1999) as supporting woody vegetation (excluding willows that do not meet the tree definition), which is estimated to be at least 5 years old (and covers at least 50 percent of the island surface). Off-channel habitats include marshes, ponds, and oxbow lakes that are outside the bankfull channel.

Procedure: Identify whether or not a potential secondary channel feature is separated from the main channel by a stable island. If the feature is not separated by a stable island, then lump it in with the main channel measurements. If the feature is located outside the bankfull channel, then describe the off-channel feature in the comments.

Side channels will be evaluated using the qualitative habitat assessment sheet (Attachment A). No measurements will be taken, but the location (reach number, hip-chain distance, bank location - RB or LB) will be recorded on the sheet, with a brief description of any significant features, such as amount of flow in channel. Determine whether the secondary channel within the bankfull channel is dry, connected at one end (channel type SC1), or connected at both ends (channel type SC2) at the time of the survey, and record the corresponding code on the survey form. No data entry is required for secondary channel measurements.

FISH PASSAGE BARRIERS

Purpose: During field investigations, the teams may encounter potential fish blockages. In these areas. the team will perform a rapid passage assessment based on the Washington Department of Fish and Wildlife's (WDFW) Level A approach for culverts and non-culvert blockages (e.g. dams, bedrock-dominated shallow glides, cascades, etc) (WDFW 2000). Assessing potential fish barriers will help provide a list of potential capital improvement projects (CIPs) and restoration projects.

Definition:

- **Fish Barrier** – defined by the American Fisheries Society (Armantrout 1998) as: any physical, physiographic, chemical, or biological obstacle to migration or dispersal of aquatic organisms. For this assessment, only physical barriers will be examined.

Procedure: During the survey, data will be entered onto hard copy datasheets (Attachment B). The surveyors will use the WDFW Level A assessment to establish a fish passage database and provide repair recommendations. The information will be loaded into an electronic database that can be used for later Level B assessments. Level B assessments require instrument survey and hydrologic analysis. The assessment team will not perform Level B assessment during this project.

When a culvert is encountered, the assessment team will perform a WDFW Level A culvert assessment. The Level A assessment is relatively simple and is explained in the dichotomous key below. The key will determine if the culvert is *a barrier*, *not a barrier*, or *unknown*. If the determination leads to an *unknown* status, the assessment team will use their professional judgment to determine the extent of a potential blockage and will recommend that future Level B assessments occur on the culvert.

Prior to conducting this assessment, each team should download and print the WDFW manual from the WDFW website (www.wa.gov/wdfw/hab/engineer/fishbarr.htm [PDF format]). Several portions of this protocol are taken directly from the WDFW approach, and their manual provides additional details and clarification.

<u>Level A Barrier Analysis (WDFW 2000)</u>

A. Is there natural streambed material throughout the culvert?
   a. If yes, is the culvert width (span) at least 75 percent of the average streambed toe width at the second riffle downstream of the culvert (representative riffle)?
      i. If yes, the culvert *is not a barrier* and additional measurements are not required.
      ii. In no, go to B.
   b. If no, is there an outfall > 0.24 m?
      i If yes, the culvert is a barrier and additional measurements are not required.
      ii If no, is the culvert slope > 1 percent?
         1. If yes, the culvert *is a barrier* and additional measurements are not required.
         2. In no, go to B.

B. *Is there a grade break in the culvert?*

a. If yes, then the barrier status is *unknown* and a Level B analysis is not possible.

b. If no, then go to C.

C. Is the culvert tidally influenced or is there a large pond or wetland downstream of the culvert making it difficult or impossible to obtain the downstream control cross-section information?

a. If yes, then the barrier status is *unknown* and a Level B analysis is not possible.

b. If no, go to D.

D. Barrier status is *unknown* and a future Level B analysis will be required.

Grade breaks occur in cases where culverts have been extended and the new section is installed at a different elevation or slope than the old culvert. This can also occur when a section of culvert settles or a joint fails. In cases where the slope of any portion of the culvert exceeds 1 percent or the drop inside the culvert exceeds 0.24 m, then it can be categorized as a barrier. If the slope does not exceed 1 percent or the drop does not exceed 0.24 m, of if these parameters cannot be measured, then the barrier status of the culvert is unknown and a higher level of analysis is required.

DATA ENTRY FOR FIELD CULVERT DATASHEET

The field datasheet requires the team to collect a suite of location and structural information that will later be used for a culvert database and for future analysis. The header information of the datasheet provides location information. It is important that the culvert is located by street crossing or by GPS. Once the location is acquired, all of the additional information required for the WDFW database can be extracted from GIS databases.

Culvert structural information is self-explanatory from the datasheet. This information is important for the WDFW database and for future analysis.

Measurements Required in the Field

1. Measure the length of the culvert in meters.
2. Assess if natural streambed is present *throughout* the culvert.
3. Measure the horizontal span of the culvert at the downstream side.
4. Measure the average streambed toe width at the second riffle downstream of the culvert. The streambed toe is defined by WDFW as the bottom of each bank, and in some cases can be below the wetted surface elevation.
5. Measure the outfall drop from the top of the water in the culvert to the top of the water downstream of the culvert to the nearest 0.01 m.

6. Measure the slope of the culvert from the culvert upstream invert elevation to the culvert downstream invert elevation in percentage ((USIE-DSIE)/Length*100 = Slope). This can be done with an Abney level, or a bubble level and two wading/stadia rods. The WDFW manual states that clinometers are not acceptable for slope measurements.

Photographs

All culverts that receive an *unknown* or *barrier* status should have a photograph. These photographs will help the teams later determine the significance of each blockage and provide an eventual CIP needs list. Keep track of photograph and roll numbers on the datasheet.

FISHWAY AND DAM BLOCKAGES

Below is a brief description of fishway and dam blockages summarized from the WDFW manual. Again, the field teams should familiarize themselves with the WDFW manual. The datasheets will also be useful for describing non-culvert barriers found in the field. These datasheets, like the qualitative datasheets, will help the field teams develop and document the rational for their professional judgment and determination of CIP lists.

- **Fishways** – A fishway is any human-made structure that facilitates the passage of fish through or over a barrier. As fishways frequently fail or are poorly designed, WDFW recommends that fishways be assessed as dams.
- **Dams** – A dam is any human-made structure that results in an abrupt change in water surface elevation. WDFW states that a water surface difference greater than 0.24 m is a block to chum and greater than 0.30 m is a block to all other fish. Dams with standpipes are always barriers.

Photographs

All dams or fishways that receive an *unknown* or *barrier* status should be photographed. These photographs will help the teams later determine the significance of each blockage. Record photograph and roll numbers on the datasheet.

AVAILABLE RESOURCES

The WDFW web site mentioned above provides useful information. Other resources include:

- A Catalog of Washington Streams and Salmon Utilization (Williams et. al. 1975)
- Tri-County salmon information web site (http://www.salmoninfo.org/)
- Forest Service Fish Xing web site (http://www.stream.fs.fed.us/fishxing/index.html)

REFERENCES

Abbe, T.B. and D.R. Montgomery. 1996. Large woody debris jams, channel hydraulics and habitat formation in large rivers. Regulated Rivers: Research & Management, Vol. 12, 201-221.

Armantrout, N.B. (compiler). 1998. Glossary of aquatic habitat inventory terminology. American Fisheries Society, Bethesda, Maryland.

Bauer, S.B. and T.A. Burton. 1993. Monitoring protocols to evaluate water quality effects of grazing management on western rangeland streams. U.S. Environmental Protection Agency Region 10, Seattle, Washington.

Bovee, K.D. 1982. A guide to stream habitat analysis using the Instream Incremental Methodology, Instream Flow Information Paper 12, FWS/OBS-28/26, Co-operative Instream Flow Group, US Fish and Wildlife Service, Office of Biological Service.

Collins, B.D., D.R. Montgomery, and A.D. Haas. 2001. Historic changes in the distribution and functions of large woody debris in Puget Lowland rivers, submitted to Canadian Journal of Fisheries and Aquatic Science.

Lindsey, A.A., J.D. Barton Jr., and S.R. Miles. 1958. Field efficiencies of forest sampling methods. Ecology 39(3):428-444.

May, C.W., E.B. Welch, R.R. Horner, J.R. Karr, and B.W. Mar. 1997. Quality indices for urbanization effects in Puget Lowland streams. Report prepared for Washington Department of Ecology. Water Resources Series Technical Report No 154.

Paustian, S.J. (editor) and 13 others. 1992. A channel type users guide for the Tongass National Forest, Southeast Alaska. USDA Forest Service, Alaska Region, R10 Technical Paper 26. 179 pp.

Platts, W.S., W.F. Megahan, and G.W. Minshall. 1983. Methods for evaluating stream, riparian, and biotic conditions. USDA Forest Service General Technical Report INT-GTR-188.

R2 Resources Consultants, CH2M Hill, and Shapiro and Associates. 2000. Tri-County urban issues ESA study: Guidance document. February 2000. Prepared for the Tri-County Urban Issues Advisory Committee, Bellevue, Washington.

Schuett-Hames, D., A. Pleas, L. Bullchild, and S. Hall (eds.). 1994. Ambient monitoring program manual. Timber-Fish-Wildlife, TFW-AM9-94-001. Northwest Indian Fisheries Commission, Olympia, Washington.

USFS (United States Forest Service). 1999. Stream inventory handbook: Level I & II. USDA, Region 6, Version 9.9.

Wang, L., T.D. Simonson, and J. Lyons. 1996. Accuracy and precision of selected stream habitat estimates. North American Journal of Fisheries Management 16:340-347.

WDFW (Washington Department of Fish and Wildlife). 2000. Fish passage barrier and surface water diversion screening assessment and prioritization manual. WDFW Habitat Program Environmental Restoration Division: Salmonid Screening, Habitat Enhancement, and Restoration (SSHEAR) Section. Olympia, Washington.

WFPB (Washington Forest Practices Board). 1997. Standard Methodology for Conducting Watershed Analysis under Chapter 222-22 WAC. Version 4.0, November 1997. Washington Department of Natural Resources. Olympia. Washington.

Williams, R.W., R.M. Laramie, and J.J. Ames. 1975. A catalog of Washington Streams and Salmon Utilization. Vol. 1. – Puget Sound. Wash. Dept. Fish, Olympia, Washington.

ATTACHMENT A

QUALITATIVE DATASHEET

Port of Seattle Qualitative Assessment Field Form

Date:	Team Name:
Sub Basin:	Stream Name:
Rosgen Class:	Reach ID Number:
Site number:	Lat.: Long:
Sample Location:	Above Culvert (y/n)?
Photo Roll:	Photo Numbers:

Limiting Factors	**Good (1)**	**Fair (2)**	**Poor (3)**	**Yes (Y)**	**No (N)**
Habitat Trend:					
Subjective Habitat Rating					
Improving Habitat					
Deteriorating Habitat					
Are the Following Limiting Factors for Habitat?					
Unstable banks					
Hydro-modifications					
Lack of Shade					
Eutrophication					
Flashy Hydrology					
Turbidity					
Lack of Undercut banks					
Habitat Ratings					
Spawning Areas					
Pool Abundance					
Pool Quality					
Riffle abundance					
Aquatic Invertebrate Quality					
Bank Cover (e.g.Brush and Roots)					
Riparian Cover					
Large Woody Debris					
Embeddedness					
Dominant/Subdominant Substrate (in mm) Check Box	Silt/Clay/ Organic (<0.059)	Sand (0.06-1)	Small Gravel (.25-1.25)	Large Gravel (1.25 -2.5)	Cobble/ Boulder (>2.5)
Dominant					
Subdominant					
Approximate % Grade:		**Comments:**			

AR 052870

ATTACHMENT B

FISH PASSAGE/CULVERT ASSESSMENT DATASHEET

Port of Seattle Fish Passage/Culvert Assessment Field Form

Date	Team Name:
Sub Basin:	Stream Name:
Rosgen Class	Reach ID Number:
Photo Roll:	Photo Numbers:

Feature Type

Culvert	Fishway	Dam	Gravity Diversion	Pump Diversion	Other (describe)

Feature Location:

Lat:	Long:

Culvert Previously Assessed (Y/N)?		If yes then stop, if no continue.

Culvert Shape

Round (RND)	Box (BOX)	Bottomless Arch (ARCH)	Squash (SQSH)	Ellipse (ELL)	Other (OTH) describe:

Culvert Material

Precast concrete (PCC)	Cast in Place Concrete (CPC)	Corrugated Steel (CST)	Smooth Steel (SST)	Corrugated Aluminum (CAL)	Structural Plate Steel (SPS)	Structural Plate Aluminum (SPA)
Plastic (PVC)	Timber (TMB)	Masonry (MRY)	Other (OTH) describe:			

Culvert Assessment

1. Culvert length in Meters
2. Streambed material throughout the length of Culvert (y/n)?

If 2 is Yes, measure the following:

A. Culvert span in meters -

B. Streambed toe width of second riffle down stream from culvert in meters -
If riffle not available, culvert status is *unknown*.

C. A/B * 100 = %

If C is ≥ 75% then culvert status is *not a barrier*, otherwise culvert is *a barrier*.

Culvert Status

Barrier	*Not a Barrier*	*Unknown*

If 2 is No, measure the following:

A. Outfall Drop in meters (water surface to water surface) -
If A is > 0.24 meters culvert is *a barrier*, if not go to B.

B. Culvert slope measured from invert to invert in percentage - %
If B is ≥ 1% culvert is *a barrier*, if not culvert status is unknown.

Culvert Status

Barrier	*Not a Barrier*	*Unknown*

Professional opinion of culverts with *unknown* status, general repair recommendations, general comments:

Appendix H

APPENDIX H

LOW STREAMFLOW FISH BEHAVIOR MEMORANDUM

MEMORANDUM

to:	Paul Fendt	July 20, 2001
from:	Don Weitkamp	556 2912 001 1 28
re:	Low Stream Flow Fish Behavior and Stream Characteristics	

The following are some thoughts on the issues raised in the e-mail message from Kelly Whiting to Ann Kenny of July 2, 2001 which we discussed at our meeting with the agencies.

1. Migrations of juvenile and adult salmonids appear to be stimulated/regulated by a variety of biological and physical factors of which flow is one. Young fish generally require growth to a certain size range before migration will occur. The physiological processes (smoltification) that ready them for migration also depend of a sequence of events that appears to be triggered by a combination of temperature, photoperiod, and phase of the moon that stimulate hormonal mediated physiological changes. Once these fish are prepared to migrate a substantial change in flow will often trigger the initiation of migration. However, flow increases alone are not likely to initiate a process that depends on many factors.

   Likewise the migrations of adult salmonids are commonly the result of a variety of factors. Adults commonly do not approach streams or prepare to move into headwaters until specific times apparently regulated by photoperiod, temperature, potentially food supply, etc. When ready to migrate the adults are commonly stimulated by freshet conditions that involve both a flow increase and runoff from riparian areas. The chemical cues in the runoff appear to play some role in triggering the migrations. The relationship to flow is far from certain. Sometimes minor increases in flow will stimulate migrations, sometimes minor increases are ignored, and sometimes migrations occur in the absence of flow increases. A minor flow supplementation during normal low flow periods is not likely to provide a trigger for biological processes that would not normally occur during that time period.

2. Severe drought conditions are generally a habitat-limiting factor that can severely limit the carry capacity of a stream. In most Puget Sound lowland streams the low flow conditions of late July to mid-September determine the minimum habitat available to support the resident fish populations including juvenile salmon and trout. Prolonged low flows of several weeks to months during this period are commonly the factor that establishes the carrying capacity of a stream.

   Protection or restoration of stream flows during the late July through September period will maintain the habitat that sustains and controls fish populations remaining within the stream through out the year. Stream flow supplementation during this period can have a substantial influence on the abundance of resident and anadromous salmonids. Providing flow outside this late summer low flow period is unlikely to provide an increase in the fish population that can be sustained within the stream. Additional habitat provided by flow increases preceding the limiting low flow period is unlikely to provide an increase in the fish population following the low flow period. The potential effects of providing additional habitat outside the limiting flow period would likely be negated by the subsequent low flows. Maintaining existing flow conditions during the common low flow period will ensure that habitat does not become more of a limiting factor than it is under existing conditions.

3. Water quality can be a critical factor in determining salmonid habitat. However, sudden changes of a moderate degree are naturally common in small streams. Freshet conditions (storm events) can naturally change temperature and chemical parameters within hours, depending on the nature of the storm event, the drainage basin, stream characteristics and ambient conditions. Generally decreasing temperatures have little immediate effect on salmonids other than reduced activity for a brief period. Decreasing temperatures rapidly within the range of a few degrees can be a benefit if temperatures are near the upper end of the range of acceptable temperatures or greater. Decreases in DO appear to have little effect on behavior when they remain within a range acceptable for survival and growth. The relatively small amount of water provided during low flow mitigation together with the proposed oxygenation techniques is likely to maintain adequate DO conditions.

Appendix I

AR 052877

APPENDIX I

DETERMINATION OF LOW FLOW QUANTITY IMPACTS AND MITIGATION

MILLER CREEK

7-DAY LOW FLOW OCCURRENCES IN MILLER CREEK (1994)

Start of 7-Day Low Flows with Average Flow Rates

	Date		1994 Miller Creek at SR509 Flow / cfs
1949	Sep	7	0.59
1950	Sep	17	0.88
1951	Sep	17	0.79
1952	Nov	23	0.53
1953	Sep	15	0.75
1954	Oct	3	0.87
1955	Sep	6	0.83
1956	Sep	3	0.87
1957	Sep	20	0.78
1958	Sep	29	0.63
1959	Aug	24	0.88
1960	Sep	29	0.84
1961	Sep	29	0.83
1962	Sep	3	0.73
1963	Sep	27	0.71
1964	Oct	25	0.88
1965	Sep	27	0.78
1966	Sep	3	0.78
1967	Sep	22	0.73
1968	Aug	7	0.97
1969	Sep	6	0.82
1970	Aug	27	0.72
1971	Aug	14	0.92
1972	Sep	11	1.01
1973	Sep	12	0.65
1974	Oct	13	0.72
1975	Aug	11	0.78
1976	Dec	10	0.69
1977	Aug	16	0.53
1978	Aug	17	0.80
1979	Oct	7	0.54
1980	Oct	17	0.66
1981	Sep	12	0.69
1982	Sep	17	0.81
1983	Oct	10	0.90
1984	Oct	1	0.78
1985	Sep	29	0.62
1986	Oct	18	0.59
1987	Oct	24	0.58
1988	Sep	11	0.60
1989	Oct	3	0.67
1990	Sep	25	0.71
1991	Oct	9	0.79
1992	Sep	16	0.65
1993	Nov	9	0.58
1994	Oct	6	0.50
1995	Sep	20	0.76

Statistical Ranking of Average 7-Day Low Flows
Period of Record: 1949 - 1995

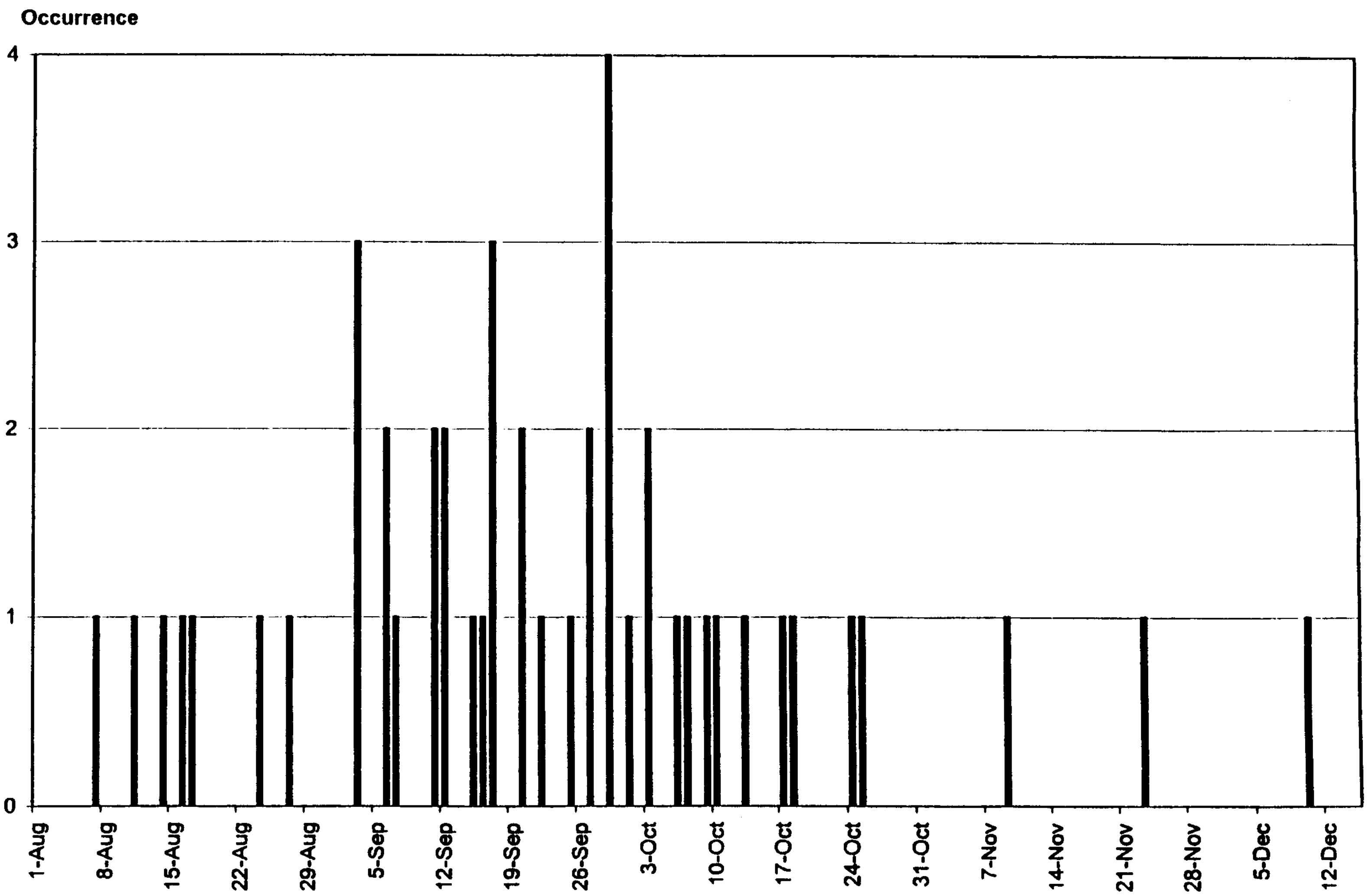
Year	Average 7-Day Lows Ordered	Rank	Rank/(N+1)	Return Frequency
1994	0.50	1	0.02	2.08
1952	0.53	2	0.04	4.17
1977	0.53	3	0.06	6.25
1979	0.54	4	0.08	8.33
1987	0.58	5	0.10	10.42
1993	0.58	6	0.13	12.50
1949	0.59	7	0.15	14.58
1986	0.59	8	0.17	16.67
1988	0.60	9	0.19	18.75
1985	0.62	10	0.21	20.83
1958	0.63	11	0.23	22.92
1973	0.65	12	0.25	25.00
1992	0.65	13	0.27	27.08
1980	0.66	14	0.29	29.17
1989	0.67	15	0.31	31.25
1976	0.69	16	0.33	33.33
1981	0.69	16	0.33	33.33
1963	0.71	18	0.38	37.50
1990	0.71	18	0.38	37.50
1974	0.72	20	0.42	41.67
1970	0.72	21	0.44	43.75
1962	0.73	22	0.46	45.83
1967	0.73	23	0.48	47.92
1953	0.75	24	0.50	50.00
1995	0.76	25	0.52	52.08
1966	0.78	26	0.54	54.17
1957	0.78	27	0.56	56.25
1975	0.78	27	0.56	56.25
1965	0.78	29	0.60	60.42
1984	0.78	29	0.60	60.42
1951	0.79	31	0.65	64.58
1991	0.79	32	0.67	66.67
1978	0.80	33	0.69	68.75
1982	0.81	34	0.71	70.83
1969	0.82	35	0.73	72.92
1961	0.83	36	0.75	75.00
1955	0.83	37	0.77	77.08
1960	0.84	38	0.79	79.17
1956	0.87	39	0.81	81.25
1954	0.87	40	0.83	83.33
1950	0.88	41	0.85	85.42
1964	0.88	41	0.85	85.42
1959	0.88	43	0.90	89.58
1983	0.90	44	0.92	91.67
1971	0.92	45	0.94	93.75
1968	0.97	46	0.96	95.83
1972	1.01	47	0.98	97.92

Rank = Numerocal Position of ordered low flow data with driest year equal to one.

N = 47

BAR GRAPH LOW FLOW OCCURRENCES IN MILLER CREEK (1994)

Low Flow Occurrences in Miller Creek, 1949-1995 (1994 HSPF)



7-DAY LOW FLOW OCCURRENCES IN MILLER CREEK (1991-1994)

Start of 7-Day Low Flows with
Average Flow Rates

	Date		1994 Miller Creek at SR509 Flow / cfs
1991	Oct	9	0.79
1992	Sep	16	0.65
1993	Nov	9	0.58
1994	Sep	24	0.54

Statistical Ranking of Average 7-Day Low Flows
Period of Record: 1949 - 1995

Date	Average 7-Day Lows Ordered	Rank	Rank/(N+1)	Return Frequency
1994	0.54	1	0.20	20.0
1993	0.58	2	0.40	40.0
1992	0.65	3	0.60	60.0
1991	0.79	4	0.80	80.0

Rank = Numerical Position of ordered low flow data
with driest year equal to one.
N = 4

CALCULATION OF 50% RETURN FREQUENCY FOR MILLER CREEK

	Date		1994 Miller Creek at Hwy 509 Flow / cfs
1991	Oct	9	0.79
1992	Sep	16	0.65
1993	Nov	9	0.56
1994	Sep	24	0.54

	Date		2006 Miller Creek at Hwy 509	2006 -1994
1991	Oct	9	0.82	0.03
1992	Sep	16	0.68	0.03
1993	Nov	9	0.63	0.05
1994	Aug	26	0.58	0.04

RANKED	Year (1994 HSPF)	1994	2006	2006-1994	Non Hydrologic	Net Impact
	1994	0.54	0.58	0.04	-0.02	0.02
	1993	0.56	0.63	0.05	-0.02	0.03
	1992	0.65	0.68	0.03	-0.02	0.01
	1991	0.79	0.82	0.03	-0.02	0.01

	50th Return Frequency 1994	50th Return Frequency 2006	Mitigation Value 2006 - 1994
2 yrs only	0.7349	0.763	0.028
all 4 yrs	0.7322	0.762	0.030

Return Frequency		modeled 1994	modeled 2006	modeled 2006-1994
2.08	1994	0.54	0.58	0.04
12.50	1993	0.56	0.63	0.05
27.08	1992	0.65	0.68	0.03
66.67	1991 .	0.79	0.82	0.03

50th Return Frequency	1994 slope	2006 slope	1994 intercept	2006 intercept	1994 rf = 50	2006 rf = 50
all 4 years	0.0039	0.0037	0.53	0.58	0.73	0.762
91 and 92 only	0.0036	0.0035	0.56	0.59	0.73	0.763

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.997736053
R Square	0.995477231
Adjusted R Squa	0.993215847
Standard Error	0.00922213
Observations	4

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	0.037438585	0.037438585	440.206993	0.002263947
Residual	2	0.000170095	8.50477E-05		
Total	3	0.037608681			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	0.534917591	0.006870667	77.85525951	0.000164936	0.505355474	0.564479707	0.50535547	0.56447971
X Variable 1	0.0039459	0.000188069	20.98111038	0.002263947	0.003136703	0.004755097	0.0031367	0.0047551

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.998691931
R Square	0.997385573
Adjusted R Sq	0.996078359
Standard Error	0.006525423
Observations	4

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	0.03248882	0.03248882	762.9859383	0.001308069
Residual	2	8.51623E-05	4.25812E-05		
Total	3	0.032573982			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	0.578199727	0.004861568	118.9327615	7.06869E-05	0.557282073	0.599117381	0.5572821	0.5991174
X Variable 1	0.003675812	0.000133075	27.6222001	0.001308069	0.003103238	0.004248386	0.0031032	0.0042484

COMPARISON OF 7-DAY LOW FLOW BY YEAR

Comparison of 7-Day Low Flow Values by Year
for Miller Creek

	Date		1994 Miller Creek at SR509 Flow / cfs		Date		2006 Miller Creek at SR509 Flow / cfs	-1994
1991	Oct	9	0.79	1991	Oct	9	0.82	0.03
1992	Sep	16	0.65	1992	Sep	16	0.68	0.03
1993	Nov	9	0.58	1993	Nov	9	0.63	0.05
1994	Sep	24	0.54	1994	Aug	26	0.58	0.04

WALKER CREEK

7-DAY LOW FLOW OCCURRENCES IN WALKER CREEK (1994)

BAR GRAPH LOW FLOW OCCURRENCES IN WALKER CREEK (1994)

7-DAY LOW FLOW OCCURRENCES IN WALKER CREEK (1991-1994)

CALCULATION OF 50% RETURN FREQUENCY FOR WALKER CREEK

SUMMARY OF LOW STREAM FLOW MITIGATION VAULT STORAGE AND FILLING

PLOTTED MINIMUM VOLUME IN WALKER CREEK VAULT AUG 1 - 0CT 31, 1949-1995

HISTOGRAM VAULT VOLUME REMAINING ON OCT 31, 1949-1995

7-DAY LOW FLOW OCCURRENCES IN WALKER CREEK (1994)

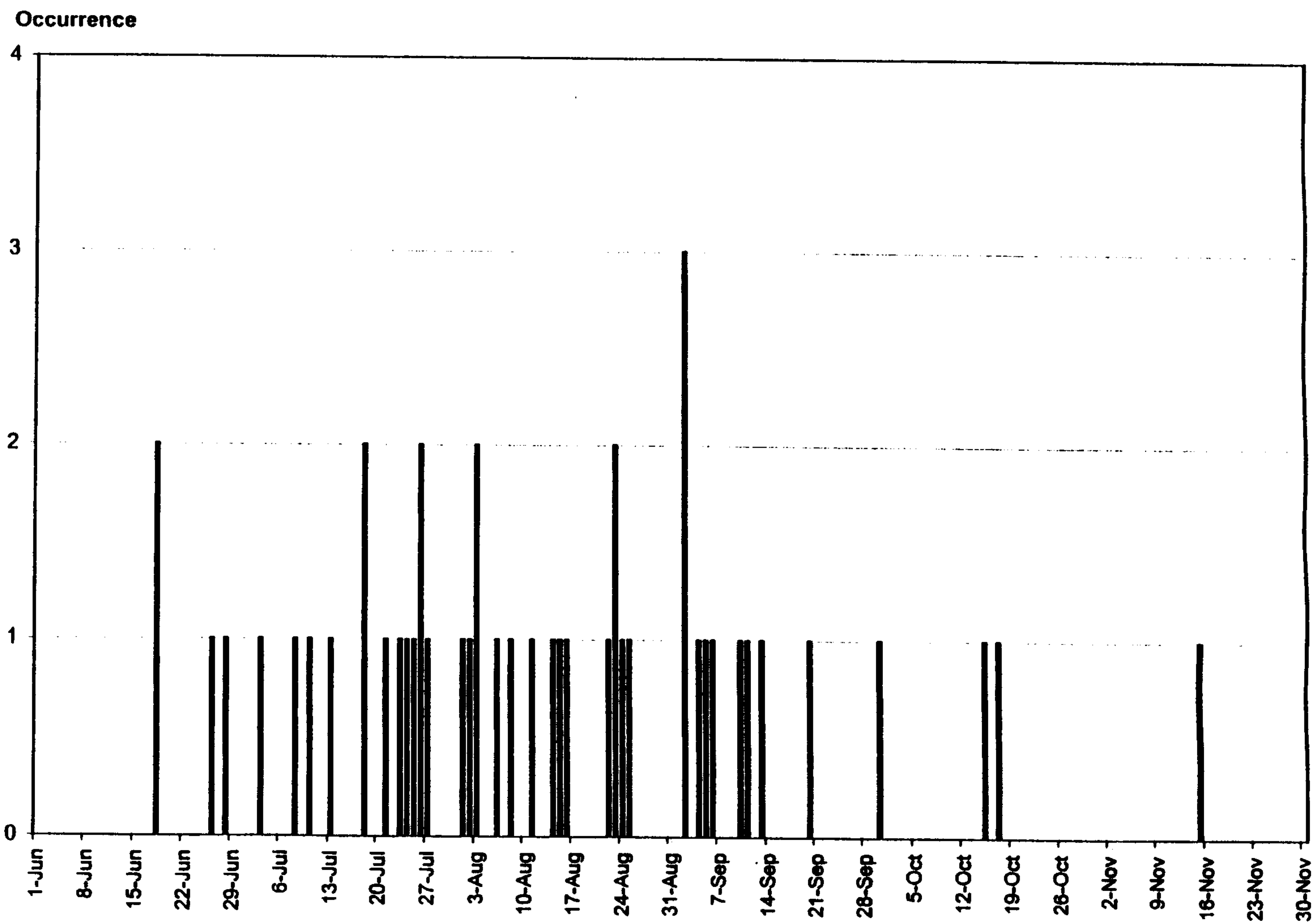
Start of 7-Day Low Flows with Average Flow Rates				Statistical Ranking of Average 7-Day Low Flows Period of Record: 1949-1995				
	Date		1994 HSPF Walker Creek at POC	Date	Average 7-Day Lows Ordered	Rank	Rank/N+1	Return Frequency
1949	Oct	17	0.66	1994	0.60	1	0.02	2.1
1950	Sep	13	0.83	1979	0.63	2	0.04	4.2
1951	Sep	11	0.78	1987	0.64	3	0.06	6.3
1952	Nov	15	0.65	1952	0.65	4	0.08	8.3
1953	Sep	5	0.76	1993	0.65	5	0.10	10.4
1954	Sep	30	0.87	1988	0.65	6	0.13	12.5
1955	Aug	23	0.83	1986	0.66	7	0.15	14.6
1956	Sep	2	0.85	1949	0.66	8	0.17	16.7
1957	Sep	2	0.80	1977	0.66	9	0.19	18.8
1958	Sep	10	0.70	1992	0.67	10	0.21	20.8
1959	Aug	2	0.85	1985	0.68	11	0.23	22.9
1960	Sep	20	0.83	1980	0.68	12	0.25	25.0
1961	Sep	4	0.80	1989	0.69	13	0.27	27.1
1962	Aug	23	0.79	1958	0.70	14	0.29	29.2
1963	Sep	6	0.74	1981	0.70	15	0.31	31.3
1964	Aug	8	0.90	1990	0.71	16	0.33	33.3
1965	Aug	24	0.78	1976	0.73	17	0.35	35.4
1966	Aug	25	0.77	1995	0.73	18	0.38	37.5
1967	Aug	15	0.75	1963	0.74	19	0.40	39.6
1968	Jun	28	0.94	1973	0.74	20	0.42	41.7
1969	Jul	26	0.82	1982	0.75	21	0.44	43.8
1970	Sep	2	0.76	1967	0.75	22	0.46	45.8
1971	Jul	10	0.88	1970	0.76	23	0.48	47.9
1972	Jul	25	0.94	1953	0.76	24	0.50	50.0
1973	Jul	24	0.74	1991	0.76	25	0.52	52.1
1974	Aug	22	0.77	1966	0.77	26	0.54	54.2
1975	Jun	18	0.79	1974	0.77	27	0.56	56.3
1976	Oct	15	0.73	1984	0.77	28	0.58	58.3
1977	Jun	19	0.66	1951	0.78	29	0.60	60.4
1978	Jun	26	0.78	1965	0.78	29	0.60	60.4
1979	Aug	6	0.63	1978	0.78	31	0.65	64.6
1980	Aug	14	0.68	1962	0.79	32	0.67	66.7
1981	Jul	8	0.70	1975	0.79	33	0.69	68.8
1982	Jul	23	0.75	1961	0.80	34	0.71	70.8
1983	Aug	1	0.90	1957	0.80	35	0.73	72.9
1984	Jul	21	0.77	1969	0.82	36	0.75	75.0
1985	Jul	27	0.68	1960	0.83	37	0.77	77.1
1986	Aug	3	0.66	1950	0.83	38	0.79	79.2
1987	Aug	16	0.64	1955	0.83	39	0.81	81.3
1988	Jul	18	0.65	1959	0.85	40	0.83	83.3
1989	Jul	13	0.69	1956	0.85	41	0.85	85.4
1990	Jul	3	0.71	1954	0.87	42	0.88	87.5
1991	Aug	3	0.76	1971	0.88	43	0.90	89.6
1992	Jul	26	0.67	1964	0.90	44	0.92	91.7
1993	Aug	11	0.65	1983	0.90	44	0.92	91.7
1994	Jul	18	0.60	1972	0.94	46	0.96	95.8
1995	Jun	18	0.73	1968	0.94	47	0.98	97.9

Rank = Numerical position of ordered low flow data with the driest year equal to one.

N = 47

BAR GRAPH LOW FLOW OCCURRENCES IN WALKER CREEK (1994)

7-Day Low Flow Occurrences in Walker Creek, 1949-1995 (1994 HSPF)



7-DAY LOW FLOW OCCURRENCES IN WALKER CREEK (1991-1994)

Start of 7-Day Low Flows with
Average Flow Rates

	Date		1994 Walker Creek at POC
1991	Oct	9	0.77
1992	Oct	22	0.67
1993	Nov	9	0.65
1994	Sep	24	0.64

Statistical Ranking of Average 7-Day Low Flows
Period of Record: 1991-1994

Date	Average 7-Day Lows Ordered	Rank	Rank/N+1	Return Frequency
1994	0.64	1	0.2	20
1993	0.65	2	0.4	40
1992	0.67	3	0.6	60
1991	0.77	4	0.8	80

Rank = Numerical position of ordered low flow data with the driest year equal to one.
N = 4

CALCULATION OF 50% RETURN FREQUENCY FOR WALKER CREEK

Calculation of 50% Return Frequency

Date Yr	Mnth	7 day low flow
1991	Oct	0.77
1992	Oct	0.67
1993	Nov	0.65
1994	Sep	0.64

Date	7 day low flow	Rank	Rank/4+1	Return Frequency	Slope	Y intercep	7 day low at 50% RF
24-Sep-94	0.64	1	0.2	20	0.0022	0.576	0.68
9-Nov-93	0.65	2	0.4	40			
22-Oct-92	0.67	3	0.6	60			
9-Oct-91	0.77	4	0.8	80			

Date Yr	Mnth	7 day low flow
1991	Oct	0.67
1992	Oct	0.59
1993	Nov	0.57
1994	Sep	0.55

Date	7 day low flow	Rank	Rank/4+1	Return Frequency	Slope	Y intercep	7 day low at 50% RF
24-Sep-94	0.55	1	0.2	20			
9-Nov-93	0.57	2	0.4	40	0.0027	0.448	0.58
22-Oct-92	0.59	3	0.6	60			
9-Oct-91	0.67	4	0.8	80			

Mitigation value calculated using difference in 80% return frequency (RF)
0.10

Mitigation value calculated using difference in 50% return frequency (RF)
0.10

SUMMARY OF LOW STREAM FLOW MITIGATION VAULT STORAGE AND FILLING

Reserve Storage Vaults for Walker Creek

Vault sizes (dead storage in acre ft) required for 92-day release of 0.11 cfs (1949 - 1995).

	SDS3a
Mean	12.79
Median	12.83
Max	18.41
Min	5.40

Contributing Drainage Areas		**Impervious Area**
Subbasin	**Vault A**	**Acre**
SDS3A	SDS3a-LF	14.6
SDW2		11.5
SUM		26.1

Fill time for 18.5 acre foot volume / Days to fill starting on January 2.

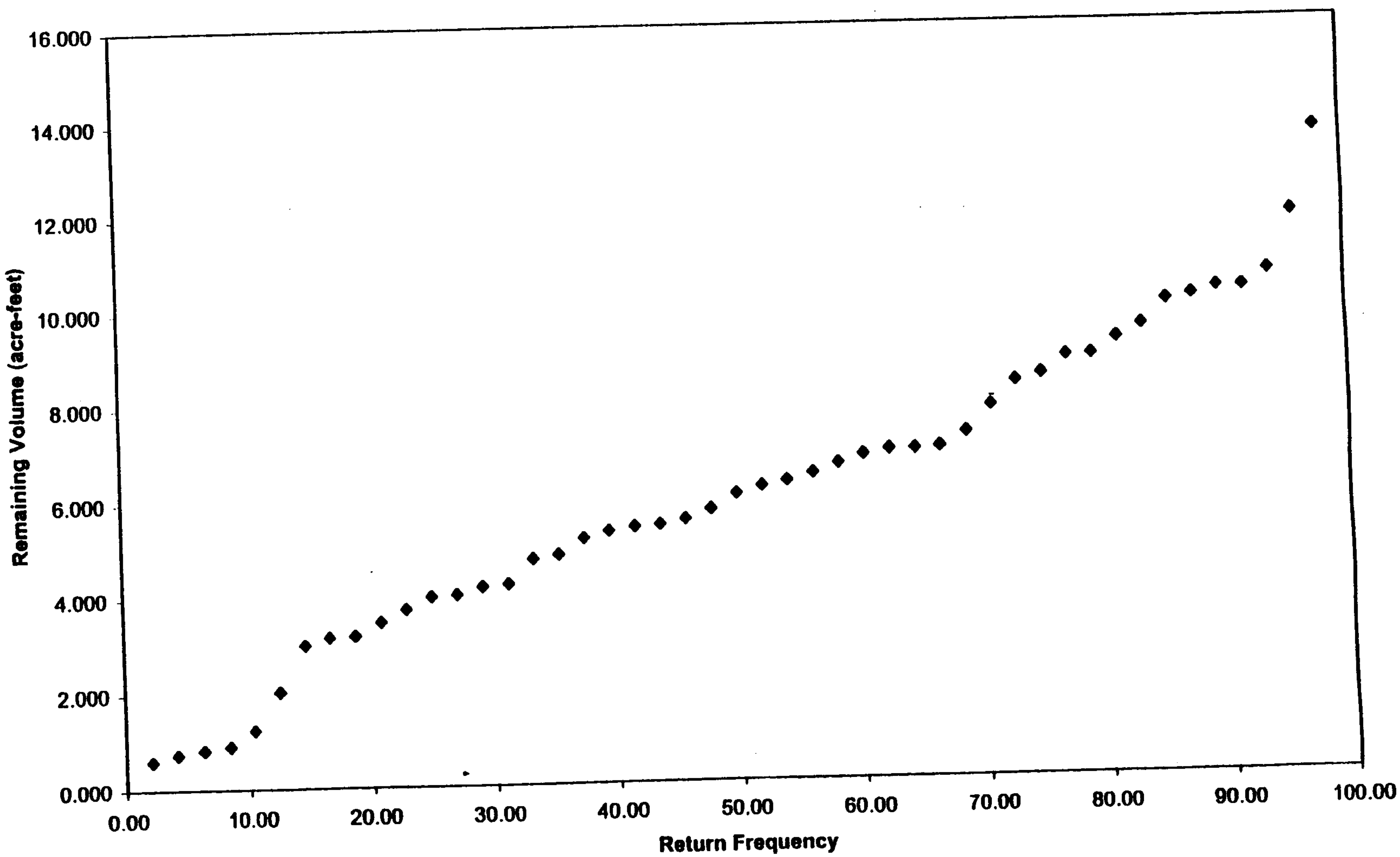
Mean	71
Median	60
Max	213
Min	22

Remaining volume in vaults on Oct 31

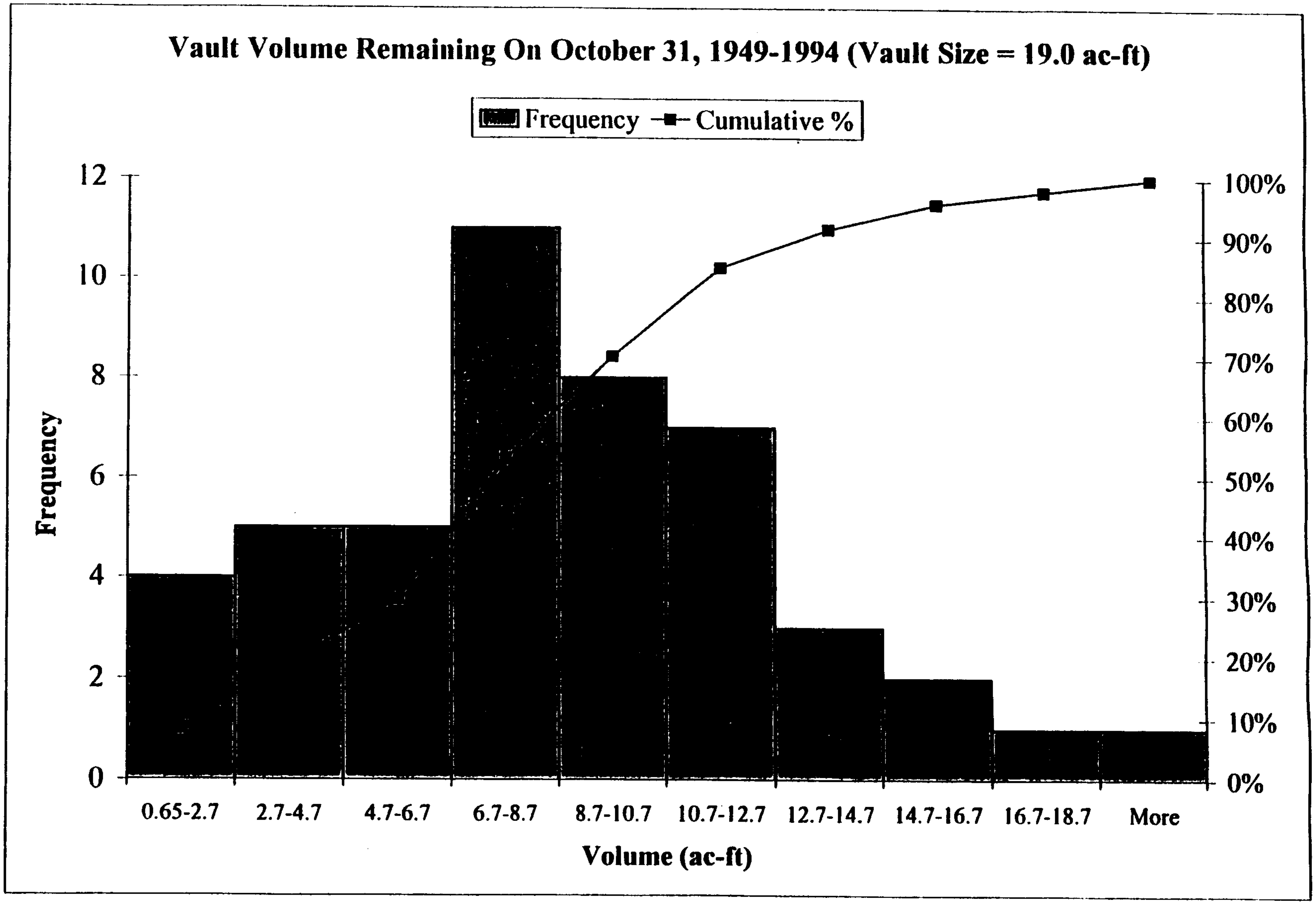
	Volume	Remaining
	ac ft	Days
Mean	8.49	77.19
Median	8.05	73.19
Max	18.68	169.84
Min	0.65	5.94

PLOTTED MINIMUM VOLUME IN WALKER CREEK VAULT AUG 1 - 0CT 31, 1949-1995

Minimum Volume in Walker Creek Vault from Aug 1 - Oct 31 (1949 - 1995)



HISTOGRAM VAULT VOLUME REMAINING ON OCT 31, 1949-1995


Vault Volume Remaining On October 31, 1949-1994 (Vault Size = 19.0 ac-ft)
Frequency
Cumulative %
Frequency
0
2
4
6
8
10
12
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
0.65-2.7
2.7-4.7
4.7-6.7
6.7-8.7
8.7-10.7
10.7-12.7
12.7-14.7
14.7-16.7
16.7-18.7
More
Volume (ac-ft)

DES MOINES CREEK

7-DAY LOW FLOW OCCURRENCES IN DES MOINES CREEK (1994)

Start of 7-Day Low Flows with Average Flow Rates			1994 HSPF Des Moines Creek at 200th St. / Flow cfs
	Date		Average 7-Day Low Flow
1949	Sep	7	0.18
1950	Sep	17	0.40
1951	Aug	20	0.35
1952	Oct	13	0.21
1953	Sep	15	0.35
1954	Aug	7	0.48
1955	Sep	6	0.34
1956	Sep	3	0.43
1957	Sep	20	0.32
1958	Sep	2	0.27
1959	Aug	24	0.38
1960	Aug	7	0.39
1961	Aug	23	0.40
1962	Sep	2	0.33
1963	Sep	27	0.36
1964	Aug	31	0.47
1965	Aug	3	0.38
1966	Aug	20	0.32
1967	Aug	25	0.33
1968	Aug	6	0.47
1969	Sep	6	0.38
1970	Aug	27	0.33
1971	Aug	14	0.41
1972	Oct	18	0.51
1973	Sep	12	0.27
1974	Oct	13	0.31
1975	Aug	11	0.33
1976	Oct	17	0.34
1977	Aug	16	0.17
1978	Oct	16	0.41
1979	Aug	7	0.22
1980	Aug	23	0.33
1981	Sep	12	0.28
1982	Aug	6	0.41
1983	Oct	10	0.45
1984	Aug	29	0.36
1985	Aug	30	0.25
1986	Sep	10	0.26
1987	Sep	7	0.29
1988	Sep	11	0.25
1989	Oct	3	0.35
1990	Sep	25	0.31
1991	Oct	9	0.33
1992	Sep	1	0.31
1993	Sep	29	0.27
1994	Aug	26	0.22
1995	Sep	20	0.35

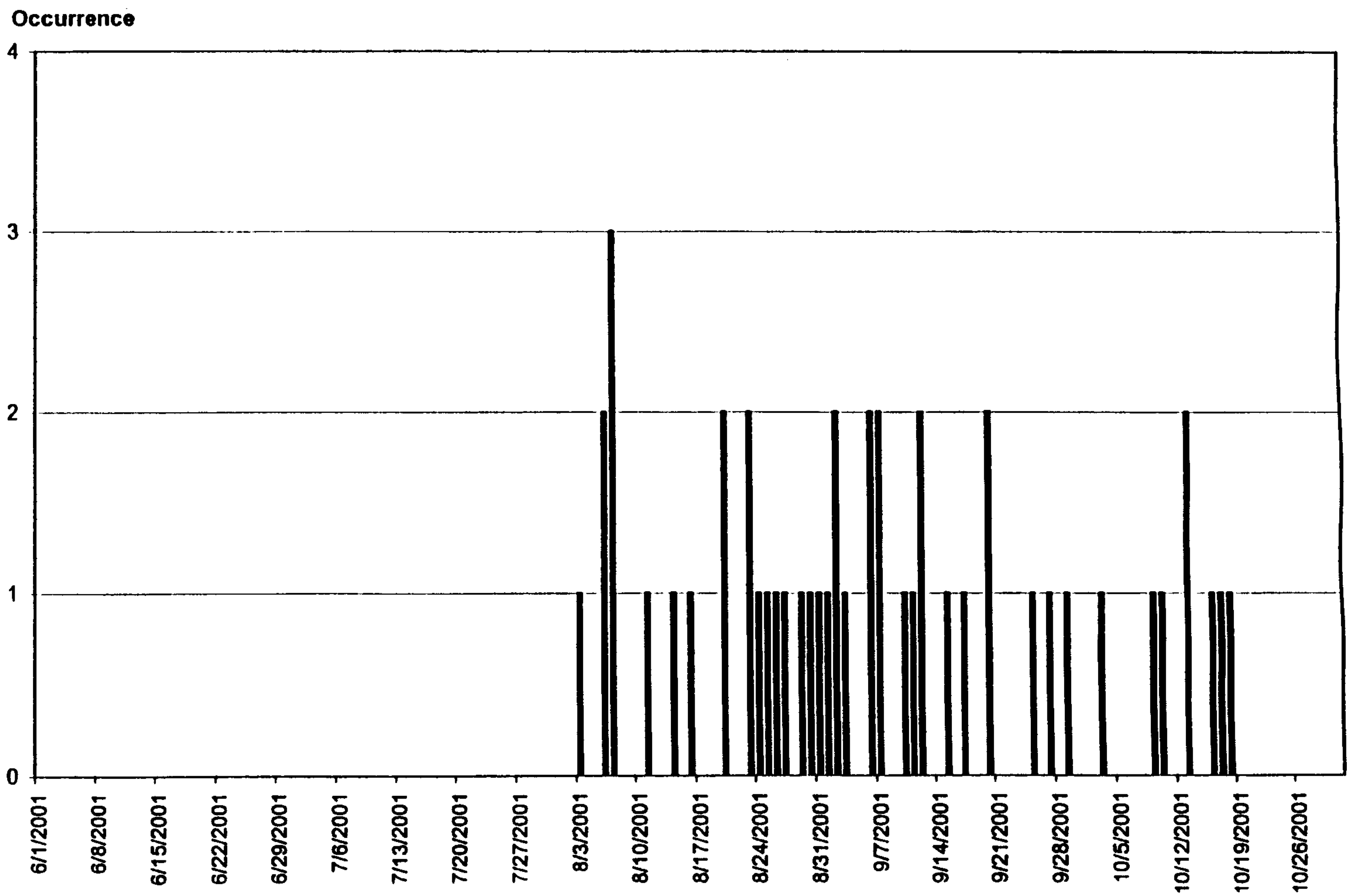
Statistical Ranking of Average 7-Day Low Flows
Period of Record: 1949 - 1995

Year	Average 7-Day Lows Ordered	Rank	Rank/(47+1)	Return Frequency
1977	0.17	1	0.02	2.1
1949	0.18	2	0.04	4.2
1952	0.21	3	0.06	6.3
1994	0.22	4	0.08	8.3
1979	0.22	5	0.10	10.4
1988	0.25	6	0.13	12.5
1985	0.25	7	0.15	14.6
1986	0.26	8	0.17	16.7
1993	0.27	9	0.19	18.8
1973	0.27	10	0.21	20.8
1958	0.27	11	0.23	22.9
1981	0.28	12	0.25	25.0
1987	0.29	13	0.27	27.1
1990	0.31	14	0.29	29.2
1974	0.31	15	0.31	31.3
1992	0.31	16	0.33	33.3
1966	0.32	17	0.35	35.4
1957	0.32	18	0.38	37.5
1970	0.33	19	0.40	39.6
1975	0.33	20	0.42	41.7
1962	0.33	21	0.44	43.8
1980	0.33	22	0.46	45.8
1991	0.33	22	0.46	45.8
1967	0.33	24	0.50	50.0
1976	0.34	25	0.52	52.1
1955	0.34	26	0.54	54.2
1951	0.35	27	0.56	56.3
1995	0.35	27	0.56	56.3
1953	0.35	29	0.60	60.4
1989	0.35	30	0.63	62.5
1984	0.36	31	0.65	64.6
1963	0.36	32	0.67	66.7
1965	0.38	33	0.69	68.8
1969	0.38	34	0.71	70.8
1959	0.38	35	0.73	72.9
1960	0.39	36	0.75	75.0
1961	0.40	37	0.77	77.1
1950	0.40	38	0.79	79.2
1971	0.41	39	0.81	81.3
1978	0.41	40	0.83	83.3
1982	0.41	41	0.85	85.4
1956	0.43	42	0.88	87.5
1983	0.45	43	0.90	89.6
1964	0.47	44	0.92	91.7
1968	0.47	44	0.92	91.7
1954	0.48	46	0.96	95.8
1972	0.51	47	0.98	97.9

Rank = Numerical position of ordered average 7-day low flow values with the driest year equal to one.
N = 47

BAR GRAPH LOW FLOW OCCURRENCES IN DES MOINES CREEK (1994)

7-Day Low Flow Occurrences in Des Moines Creek, 1949-1995 (1994 HSPF)



7-DAY LOW FLOW OCCURRENCES IN DES MOINES CREEK (2006)

Start of 7-Day Low Flows
with Average Flow Rates

	Date		2006 HSPF Des Moines Creek at 200th St. / Flow cfs Average 7-Day Low Flow
1949	Sep	7	0.14
1950	Sep	17	0.33
1951	Aug	20	0.25
1952	Oct	13	0.15
1953	Sep	15	0.29
1954	Aug	7	0.38
1955	Sep	6	0.26
1956	Sep	3	0.36
1957	Sep	20	0.25
1958	Sep	2	0.20
1959	Aug	24	0.29
1960	Aug	7	0.29
1961	Aug	23	0.31
1962	Sep	3	0.28
1963	Sep	27	0.31
1964	Aug	31	0.40
1965	Aug	3	0.30
1966	Aug	20	0.24
1967	Aug	25	0.24
1968	Aug	7	0.38
1969	Sep	6	0.29
1970	Jul	18	0.25
1971	Aug	14	0.31
1972	Aug	8	0.42
1973	Sep	11	0.20
1974	Oct	13	0.23
1975	Aug	11	0.25
1976	Oct	17	0.27
1977	Aug	16	0.12
1978	Jul	9	0.34
1979	Aug	7	0.17
1980	Aug	23	0.26
1981	Sep	12	0.21
1982	Aug	6	0.33
1983	Oct	10	0.41
1984	Aug	29	0.27
1985	Aug	30	0.20
1986	Sep	6	0.19
1987	Sep	6	0.22
1988	Sep	11	0.19
1989	Aug	7	0.30
1990	Sep	25	0.24
1991	Oct	9	0.26
1992	Sep	16	0.25
1993	Sep	29	0.20
1994	Aug	26	0.16
1995	Sep	20	0.30

Statistical Ranking of Average 7-Day Low Flows
Period of Record: 1949 - 1995

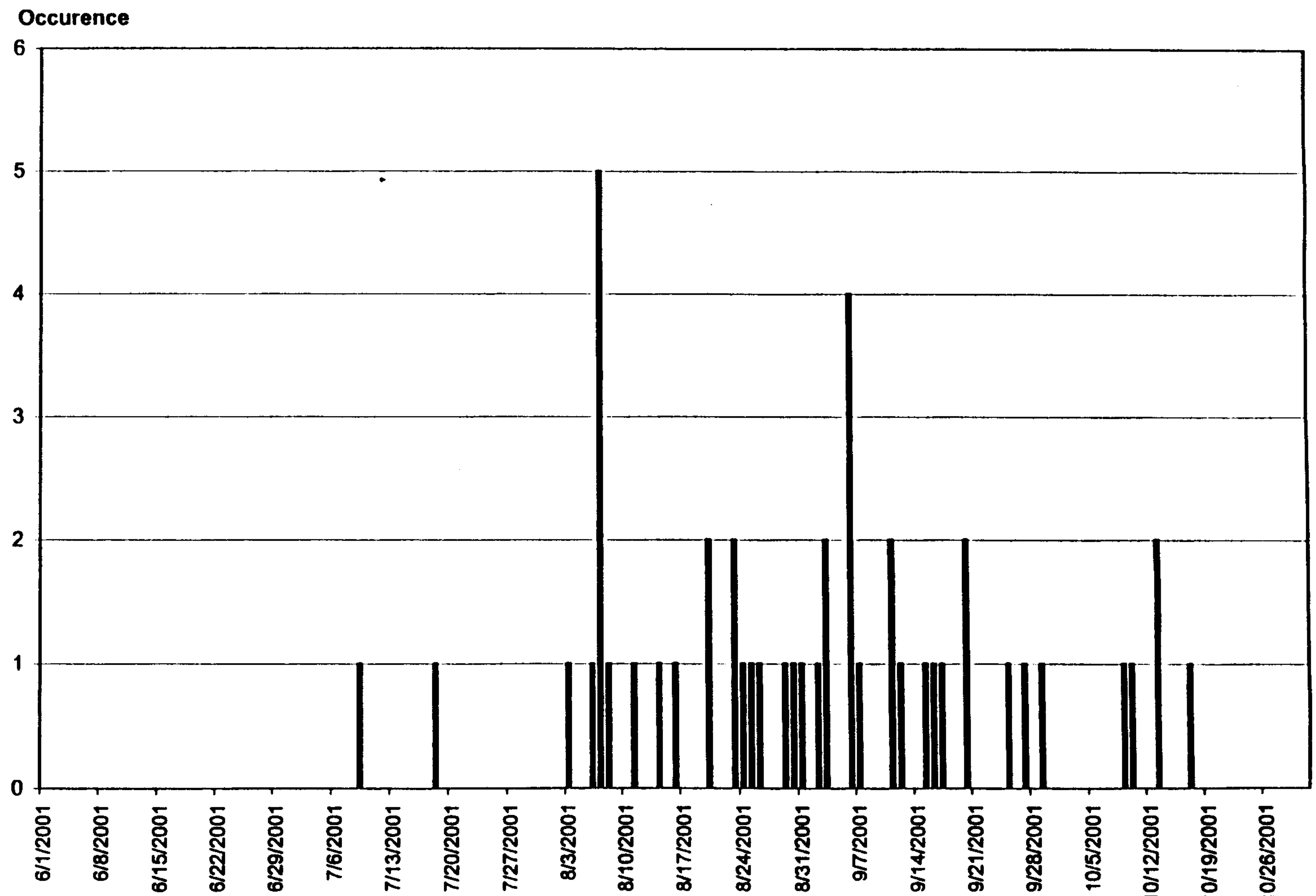
Year	Average 7-Day Lows Ordered	Rank	Rank/(47+1)	Return Frequency
1977	0.12	1	0.02	2.1
1949	0.14	2	0.04	4.2
1952	0.15	3	0.06	6.3
1994	0.16	4	0.08	8.3
1979	0.17	5	0.10	10.4
1988	0.19	6	0.13	12.5
1986	0.19	7	0.15	14.6
1958	0.20	8	0.17	16.7
1985	0.20	8	0.17	16.7
1993	0.20	8	0.17	16.7
1973	0.20	11	0.23	22.9
1981	0.21	12	0.25	25.0
1987	0.22	13	0.27	27.1
1974	0.23	14	0.29	29.2
1990	0.24	15	0.31	31.3
1966	0.24	16	0.33	33.3
1967	0.24	17	0.35	35.4
1992	0.25	18	0.38	37.5
1975	0.25	19	0.40	39.6
1957	0.25	20	0.42	41.7
1951	0.25	21	0.44	43.8
1970	0.25	21	0.44	43.8
1991	0.26	23	0.48	47.9
1955	0.26	24	0.50	50.0
1980	0.26	24	0.50	50.0
1976	0.27	26	0.54	54.2
1984	0.27	26	0.54	54.2
1962	0.28	28	0.58	58.3
1959	0.29	29	0.60	60.4
1953	0.29	30	0.63	62.5
1960	0.29	31	0.65	64.6
1969	0.29	32	0.67	66.7
1995	0.30	33	0.69	68.8
1965	0.30	34	0.71	70.8
1989	0.30	35	0.73	72.9
1961	0.31	36	0.75	75.0
1963	0.31	37	0.77	77.1
1971	0.31	38	0.79	79.2
1950	0.33	39	0.81	81.3
1982	0.33	40	0.83	83.3
1978	0.34	41	0.85	85.4
1956	0.36	42	0.88	87.5
1968	0.38	43	0.90	89.6
1954	0.38	44	0.92	91.7
1964	0.40	45	0.94	93.8
1983	0.41	46	0.96	95.8
1972	0.42	47	0.98	97.9

Rank = Numerical position of ordered average 7-day low flow values with the driest year equal to one.
N = 47

AR 052911

BAR GRAPH LOW FLOW OCCURRENCES IN DES MOINES CREEK (2006)

7-Day Low Flow Occurrences in Des Moines Creek, 1949-1995 (2006 HSPF)



LOW FLOW OCCURRENCES IN DES MOINES CREEK (WITH MITIGATION)

Start of 7-Day Low Flows with Average Flow Rates			2006 HSPF Des Moines Creek at 200th St. / Flow cfs Average 7-Day Low Flow
	Date		Jul24-Oct24 Release 0.08
1949	Sep	7	0.22
1950	Sep	17	0.41
1951	Aug	20	0.33
1952	Oct	13	0.23
1953	Sep	15	0.37
1954	Aug	7	0.46
1955	Sep	6	0.34
1956	Sep	3	0.44
1957	Sep	20	0.33
1958	Sep	2	0.28
1959	Aug	24	0.37
1960	Aug	7	0.37
1961	Aug	23	0.39
1962	Sep	3	0.36
1963	Sep	27	0.39
1964	Aug	31	0.48
1965	Jul	13	0.36
1966	Aug	20	0.32
1967	Aug	25	0.32
1968	Aug	7	0.46
1969	Sep	6	0.37
1970	Jul	17	0.26
1971	Aug	14	0.39
1972	Aug	8	0.50
1973	Sep	11	0.28
1974	Oct	13	0.31
1975	Aug	11	0.33
1976	Nov	30	0.34
1977	Aug	16	0.20
1978	Jul	9	0.34
1979	Jun	23	0.23
1980	Aug	23	0.34
1981	Sep	12	0.29
1982	Jun	19	0.37
1983	Oct	10	0.49
1984	Aug	29	0.35
1985	Jul	17	0.24
1986	Sep	6	0.27
1987	Oct	24	0.27
1988	Sep	11	0.27
1989	Aug	7	0.38
1990	Sep	25	0.32
1991	Oct	9	0.34
1992	Sep	16	0.33
1993	Oct	29	0.28
1994	Jul	17	0.24
1995	Sep	20	0.38

Statistical Ranking of Average 7-Day Low Flows

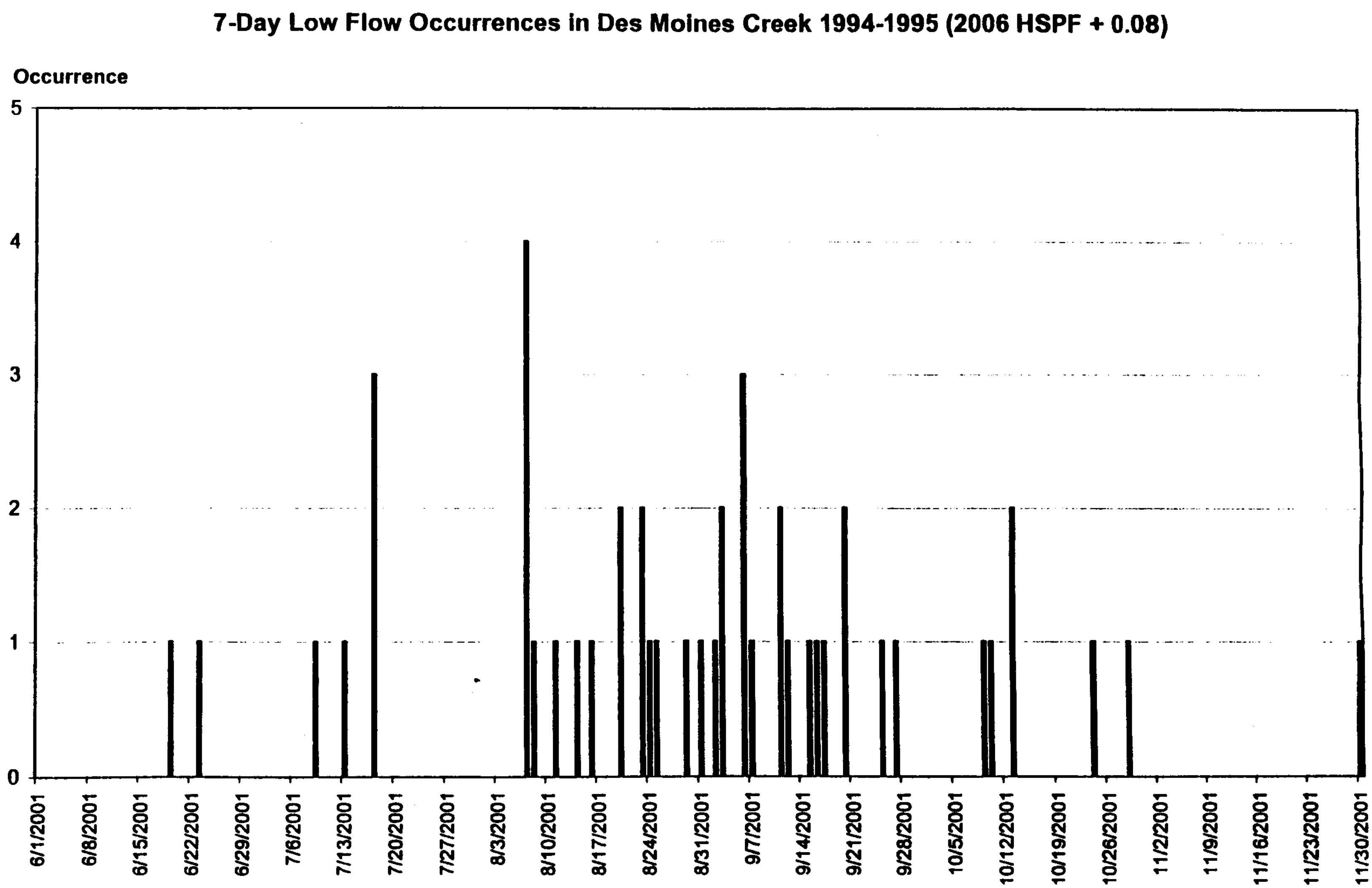
Period of Record: 1949 - 1995

Year	Average 7-Day Lows Ordered	Rank	Rank/(47+1)	Return Frequency
1977	0.20	1	0.02	2.1
1949	0.22	2	0.04	4.2
1979	0.23	3	0.06	6.3
1952	0.23	4	0.08	8.3
1994	0.24	5	0.10	10.4
1985	0.24	6	0.13	12.5
1970	0.26	7	0.15	14.6
1988	0.27	8	0.17	16.7
1987	0.27	9	0.19	18.8
1986	0.27	10	0.21	20.8
1958	0.28	11	0.23	22.9
1993	0.28	11	0.23	22.9
1973	0.28	13	0.27	27.1
1981	0.29	14	0.29	29.2
1974	0.31	15	0.31	31.3
1990	0.32	16	0.33	33.3
1966	0.32	17	0.35	35.4
1967	0.32	18	0.38	37.5
1992	0.33	19	0.40	39.6
1975	0.33	20	0.42	41.7
1957	0.33	21	0.44	43.8
1951	0.33	22	0.46	45.8
1991	0.34	23	0.48	47.9
1955	0.34	24	0.50	50.0
1976	0.34	24	0.50	50.0
1978	0.34	24	0.50	50.0
1980	0.34	24	0.50	50.0
1984	0.35	28	0.58	58.3
1962	0.36	29	0.60	60.4
1965	0.36	29	0.60	60.4
1959	0.37	31	0.65	64.6
1982	0.37	31	0.65	64.6
1953	0.37	33	0.69	68.8
1960	0.37	34	0.71	70.8
1969	0.37	35	0.73	72.9
1995	0.38	36	0.75	75.0
1989	0.38	37	0.77	77.1
1961	0.39	38	0.79	79.2
1963	0.39	39	0.81	81.3
1971	0.39	40	0.83	83.3
1950	0.41	41	0.85	85.4
1956	0.44	42	0.88	87.5
1968	0.46	43	0.90	89.6
1954	0.46	44	0.92	91.7
1964	0.48	45	0.94	93.8
1983	0.49	46	0.96	95.8
1972	0.50	47	0.98	97.9

Rank = Numerical position of ordered average 7-day low flow values with the driest year equal to one.

N = 47

BAR GRAPH LOW FLOW OCCURRENCES IN DES MOINES CREEK (WITH MITIGATION)



7-Day Low Flow Occurrences in Des Moines Creek 1994-1995 (2006 HSPF + 0.08)
Occurrence
5
4
3
2
1
0
6/1/2001
6/8/2001
6/15/2001
6/22/2001
6/29/2001
7/6/2001
7/13/2001
7/20/2001
7/27/2001
8/3/2001
8/10/2001
8/17/2001
8/24/2001
8/31/2001
9/7/2001
9/14/2001
9/21/2001
9/28/2001
10/5/2001
10/12/2001
10/19/2001
10/26/2001
11/2/2001
11/9/2001
11/16/2001
11/23/2001
11/30/2001

SUMMARY OF LOW STREAM FLOW MITIGATION VAULT STORAGE AND FILLING

Reserve Storage Vaults for Des Moines Creek

Vault sizes (dead storage in acre ft) required for 92-day release of 0.08 cfs (1949 - 1995).

	SDS3
Mean	5.86
Median	5.40
Max	13.47
Min	3.17

Contributing Drainage Areas

Subbasin	Vault	Area
SDS3	SDS3-LF	195.9

Fill time for 13.5 acre foot volume / Days to fill starting on January 2.

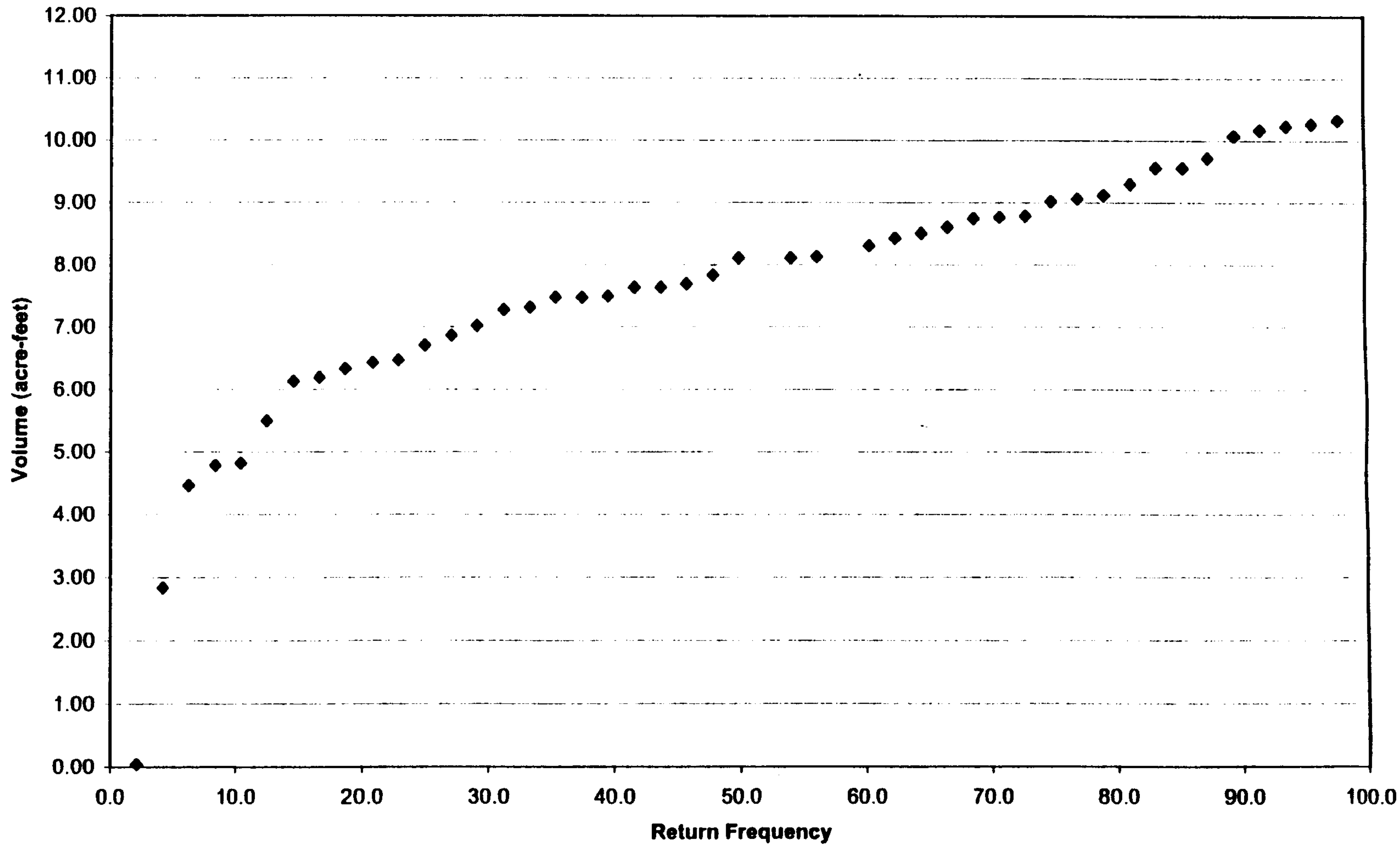
Mean	11
Median	8
Max	38
Min	1

Remaining volume in vaults on October 24

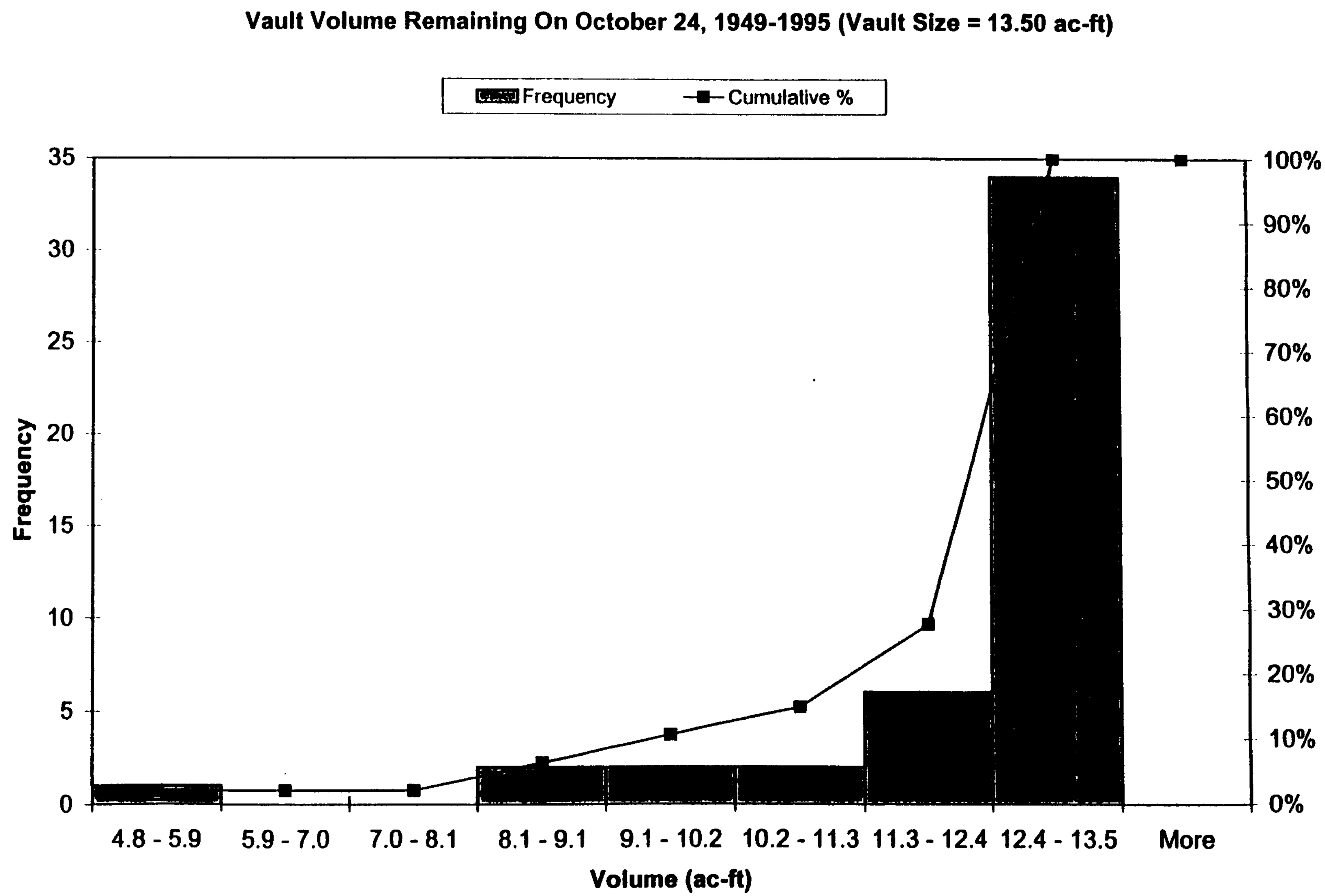
	Volume ac ft	Remaining Days
Mean	12.51	79
Median	13.20	83
Max	13.50	85
Min	4.79	30

PLOTTED MINIMUM VOLUME IN DES MOINES VAULT JUL 24-0CT 24, 1949-1995

Minimum Volume in Des Moines Vault Jul 24-Oct 24, 1949-1995



HISTOGRAM VAULT VOLUME REMAINING ON OCT 24, 1949-1995


Vault Volume Remaining On October 24, 1949-1995 (Vault Size = 13.50 ac-ft)
Frequency
Cumulative %
35
30
25
20
15
10
5
0
Frequency
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
4.8 - 5.9
5.9 - 7.0
7.0 - 8.1
8.1 - 9.1
9.1 - 10.2
10.2 - 11.3
11.3 - 12.4
12.4 - 13.5
More
Volume (ac-ft)

Appendix J

APPENDIX J

HSPF INPUT FILES FOR LOW FLOW VAULT SIZING

```
RUN
GLOBAL
  ***  FILE: IMPFILL.INP
  ***  Based on calibration file for Des Moines Creek
  ***  HSPF Model of runoff from impervious surface
  SEATAC AIRPORT HSPF MODEL
  START       1948/10/01 00:00  END    1996/09/30 24:00
  RUN INTERP OUTPUT LEVEL    4
  RESUME     0 RUN     1
END GLOBAL

FILES
MESSU       24    C:\HSPF\IMPLOW.MES
WDM         25    C:\HSPF\IMPLOW.WDM
END FILES

OPN SEQUENCE
    INGRP              INDELT 01:00
      PERLND      16
      PERLND      26
      PERLND      34
      PERLND      44
      PERLND      54
      IMPLND      14
      COPY        20
      COPY        30
      COPY        40
    END INGRP
END OPN SEQUENCE

PERLND
  GEN-INFO
    <PLS >       Name           NBLKS   Unit-systems   Printer                    ***
    # -  #                               User  t-series Engl Metr                 ***
                                               in  out                            ***
   16       TFM- TILL FOR MOD       1     1    1    1   60    0
   26       TGM- TILL GR MOD        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   54    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   54    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   54    0    0    0    0    0    0    0    0    0
  END PWAT-PARM1

  PWAT-PARM2
    <PLS > ***
    # -  # ***FOREST      LZSN    INFILT      LSUR     SLSUR     KVARY     AGWRC
   16                   4.5000    0.2000    200.00    0.1000    0.5000    0.9960
   26                   4.5000    0.0750    400.00    0.1000    0.5000    0.9960
   34                   5.0000    2.0000    200.00    0.0500    0.3000    0.9960
```

```
                                     implow
    44                    5.0000     0.8000     200.00     0.0500     0.3000     0.9960
    54                    4.0000     2.0000     200.00     0.0010     0.5000     0.9960
  END PWAT-PARM2
  PWAT-PARM3
    <PLS >***
    # -  #*** PETMAX     PETMIN     INFEXP     INFILD     DEEPFR     BASETP     AGWETP
    16                               2.0000     2.0000      0.55       0.00        0.0
    26                               2.0000     2.0000      0.55       0.00        0.0
    34                               2.0000     2.0000      0.55       0.00        0.0
    44                               2.0000     2.0000      0.55       0.00        0.0
    54                               10.000     2.0000      0.55       0.00        0.7
  END PWAT-PARM3
  PWAT-PARM4
                                                                           ***
    <PLS >
    # -  #      CEPSC      UZSN       NSUR      INTFW        IRC     LZETP***
    16         0.2000     0.5000     0.3500     3.000     0.5000     0.7000
    26         0.1000     0.2500     0.2500     3.000     0.5000     0.2500
    34         0.2000     0.5000     0.3500     0.000     0.7000     0.7000
    44         0.1000     0.5000     0.2500     0.000     0.7000     0.2500
    54         0.2000     3.0000     0.5000     1.000     0.7000     0.8000
  END PWAT-PARM4

  PWAT-STATE1
    <PLS >  PWATER state variables***
    # -  #***   CEPS      SURS        UZS       IFWS        LZS       AGWS       GWVS
    16          0.078       0.     0.0010         0.      0.075      0.267      0.026
    26          0.051       0.     0.0350         0.      1.928      0.680      0.049
    34          0.078       0.     0.0010         0.      0.090      0.676      0.038
    44          0.051       0.     0.0040         0.      1.127      0.614      0.152
    54          0.051       0.     0.3330         0.      0.622      0.000      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          500.0    0.0100     0.1000     0.100
  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

 COPY
   TIMESERIES
   Copy-opn                                                                  ***
     # -  #  NPT  NMN                                                        ***
     1   60         1
   END TIMESERIES
 END COPY

 EXT SOURCES
<-Volume-> <Member> SsysSgap<--Mult-->Tran <-Target vols> <-Grp> <-Member->  ***
<Name>   # <Name> # tem strg<-factor->strg <Name>   #   #        <Name> # #  ***
WDM      1 EVAP     ENGLZERO    0.8        PERLND  14  54 EXTNL  PETINP
WDM      1 EVAP     ENGLZERO    0.8        IMPLND  14     EXTNL  PETINP
WDM      2 PREC     ENGLZERO               PERLND  14  54 EXTNL  PREC
WDM      2 PREC     ENGLZERO               IMPLND  14     EXTNL  PREC
END EXT SOURCES

EXT TARGETS
<-Volume-> <-Grp> <-Member-><--Mult-->Tran <-Volume-> <Member> Tsys Tgap Amd ***
<Name>   #        <Name> # #<-factor->strg <Name>   # <Name>    tem strg strg***
*******************************************************************************
*** Multiplication Factor of 12.1 applied for unit conversion
*** from acre-ft/hr to cfs
*******************************************************************************
*** Des Moines Creek Impervious Surface
*******************************************************************************
COPY    20 OUTPUT MEAN   1    12.1         WDM    20 FLOW     ENGL       REPL
*******************************************************************************
*** Walker Creek Impervious Surface
*******************************************************************************
COPY    30 OUTPUT MEAN   1    12.1         WDM    30 FLOW     ENGL       REPL
*******************************************************************************
*** Miller Creek Impervious Surface
*******************************************************************************
COPY    40 OUTPUT MEAN   1    12.1         WDM    40 FLOW     ENGL       REPL
*******************************************************************************
END EXT TARGETS
                                                                             ***
NETWORK
***        <MEMBER> SSYSSGAP<--MULT-->TRAN <-TARGET VOLS>       <-MEMBER->
<NAME>   # <NAME>    TEM STRG<-FACTOR->STRG <NAME>   #   # <-GRP> <NAME> # # ***
*******************************************************************************
*** Multiplication Factor of 0.08333 applied to total area for unit conversion
*** from inches to feet
*******************************************************************************
*** Des Moines Creek Impervious Surface
*** 199.17 ac EIA for SDS-3 minus 3.27 ac area unable to plumb
*** Result is 195.90 ac impervious surface
*******************************************************************************
IMPLND  14 IWATER SURO          16.325      COPY    20      INPUT  MEAN   1
*******************************************************************************
*** Walker Creek Impervious Surface
*******************************************************************************
IMPLND  14 IWATER SURO           1.383      COPY    30      INPUT  MEAN   1
```

```
*********************************************************************************
*** Miller Creek Impervious Surface
*********************************************************************************
IMPLND  14 IWATER SURO          2.191      COPY    40      INPUT  MEAN   1
*********************************************************************************
END NETWORK

END RUN
```

Low Streamflow Analysis and Summer Low Flow Impact Offset Facility Proposal

December 2001

Port of Seattle

Parametrix, Inc.

Volume 2

Appendix A

Low Streamflow Analysis and Summer Low Flow Impact Offset Facility Proposal

Port of Seattle

December 2001

Volume 2

Parametrix, Inc.

Appendix A

AR 052931

APPENDIX A

HSPF MODELING INFORMATION AND DATA

CONTENTS

- HSPF Model Low Flow Calibration Review
- Land Use Tables (Surface Water Subbasins, Contiguous Groundwater Subbasins, and Non-Contiguous Groundwater Subbasins) for Miller, Walker, and Des Moines Creek Watersheds
- HSPF Input Files (1994 and 2006 Conditions) for Miller, Walker, and Des Moines Creek Watersheds
- HSPF Non-Contiguous Groundwater Information

HSPF MODEL LOW FLOW CALIBRATION REVIEW

SEATTLE-TACOMA INTERNATIONAL AIRPORT
MASTER PLAN UPDATE IMPROVEMENTS

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

1. INTRODUCTION

The computer program HSPF was used to simulate continuous watershed hydrology and to design stormwater detention facilities for Port of Seattle's Master Plan Update at Seattle-Tacoma International Airport (STIA). The HSPF modeling and calibration are described in detail in the *Comprehensive Stormwater Management Plan* (SMP) (Parametrix, Inc. 2000, 2001). The overall HSPF model calibration effort did not specifically focus on the low-streamflow period, which is considered to be June through November. This appendix provides detailed information on the HSPF model calibration as related to the low-flow analysis for the Miller, Walker, and Des Moines Creek watersheds.

2. MILLER CREEK LOW STREAMFLOW

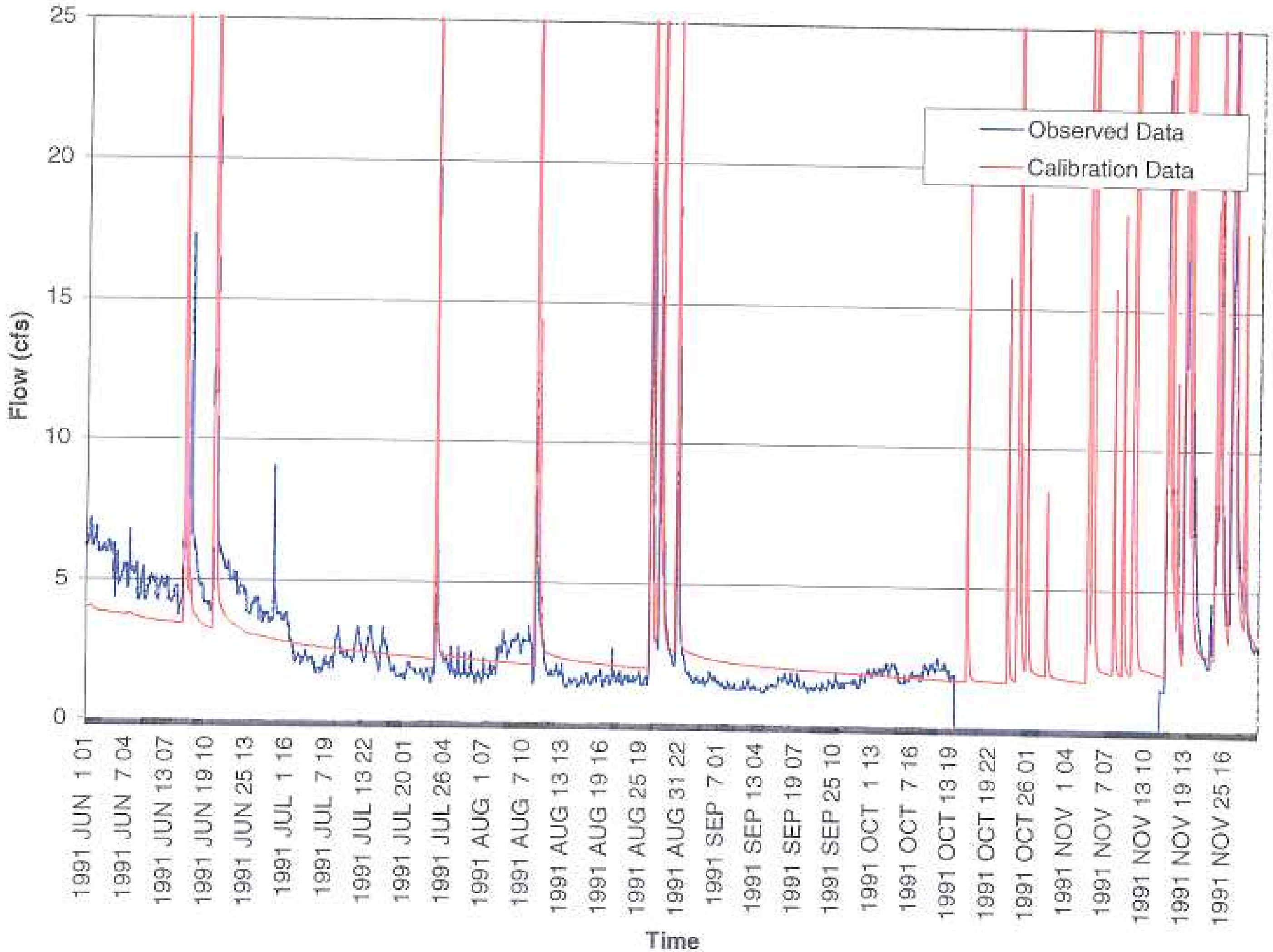
Two streamflow gages located in the Miller Creek watershed were used in the low-streamflow calibration review (see Figure 2-1 in the main text for gage locations). One of the streamflow gages was located near the mouth of Miller Creek, and the other was located further upstream at the Miller Creek detention facility. Data for the streamflow gages were collected by the King County Department of Natural Resources (DNR). The analysis period covers water-years 1991 through 1996. The modeling team selected this period because it appeared to contain the most reliable data. However, the observed data from these water-years contain several gaps. The dates of the missing data are listed in Table B2-1 (Appendix B, Volume 3 of the SMP).

2.1 MILLER CREEK AT THE MOUTH

The streamflow gage was down for 4 months during water-year 1995. Examination of the recorded data after a gage malfunction in December and January of water-year 1995 indicated possible disruption in the reliability of the recorded data for the months of January through May. In June of 1995, the gage again malfunctioned. This malfunction lasted until the middle of October 1995. These chronic problems during water-year 1995 call into question the overall reliability of the gaged streamflow data for this water-year.

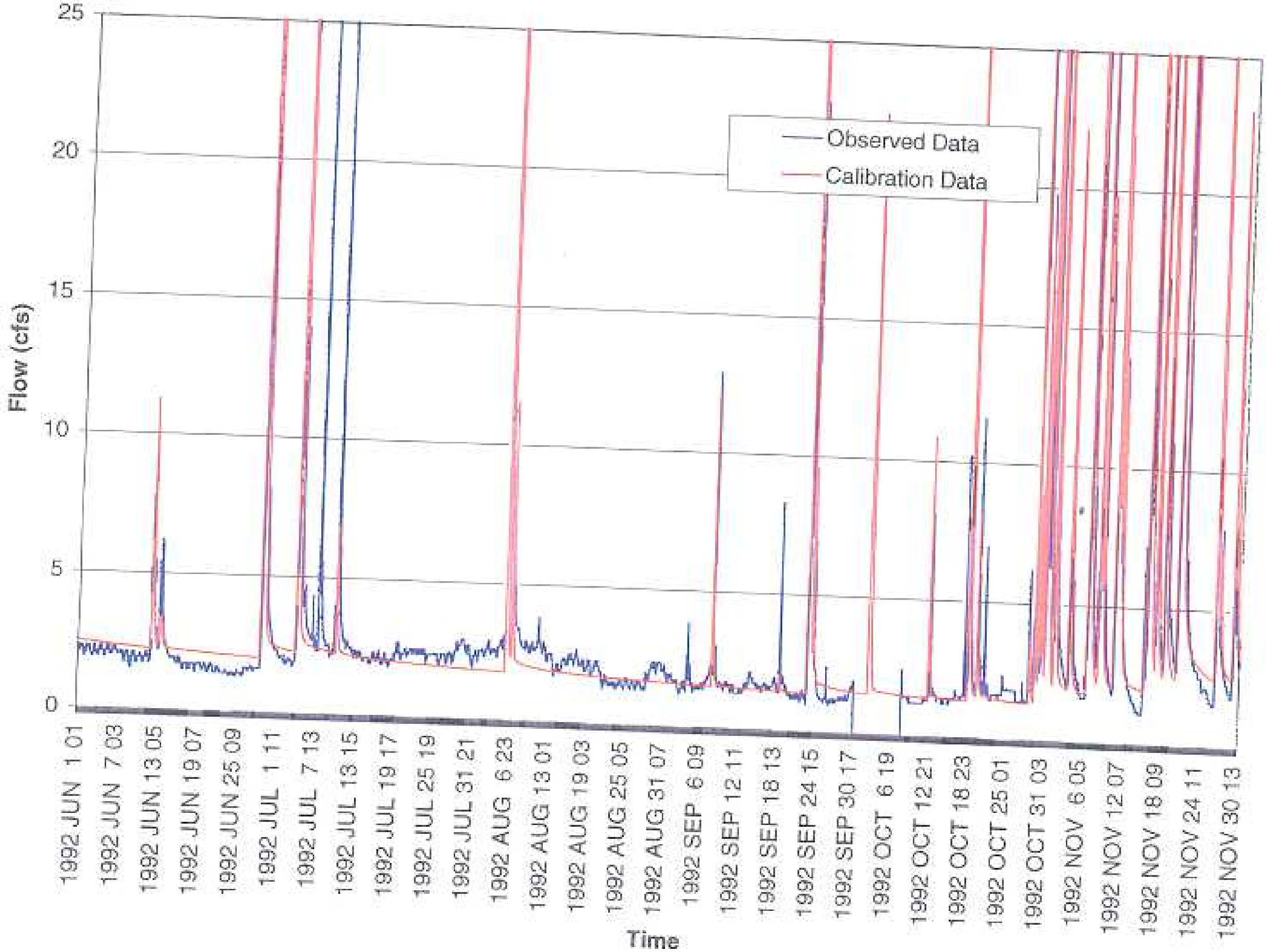
Observed and calibrated low flows for the gage near the mouth of Miller Creek are shown in Figures 2-1 through 2-6. Average simulated and observed streamflows for each low-flow period are listed in Table 2-1. Average simulated and observed streamflows for each 7-day low-flow period are listed in Table 2-2. The 7-day low-flow period for each observed water-year did not occur during the same 7-day period as the simulated low-flow period. Water-years 1991, 1992, 1994, and 1995 all have gaps missing from the observed data. Water-year 1994 appears to have a shift in the rating curve. Close inspection of the month of September shows a dramatic shift in the observed base flow conditions. Between September 4th and September 11th, two flood events occurred. The base flow entering these events was about 1.4 cubic feet per sencond (cfs). After the events, the base flow increased to approximately 2.5 cfs and stayed at or near this level the rest of the low-flow period. The 7-day low flow for water-year 1994 concluded on September 3rd. This was the earliest 7-day low-flow period of the 6 years of data, with the exception of 1996. The low-flow analysis period ended September 30th, 1996. This abrupt jump in observed base flows was not matched by simulated base flows. The cause of the jump in base flow has not been determined, nor is it known if this impacted later water-years.

Figure 2-1. Miller Creek at the Mouth Observed vs. Calibrated Low Flow 1991



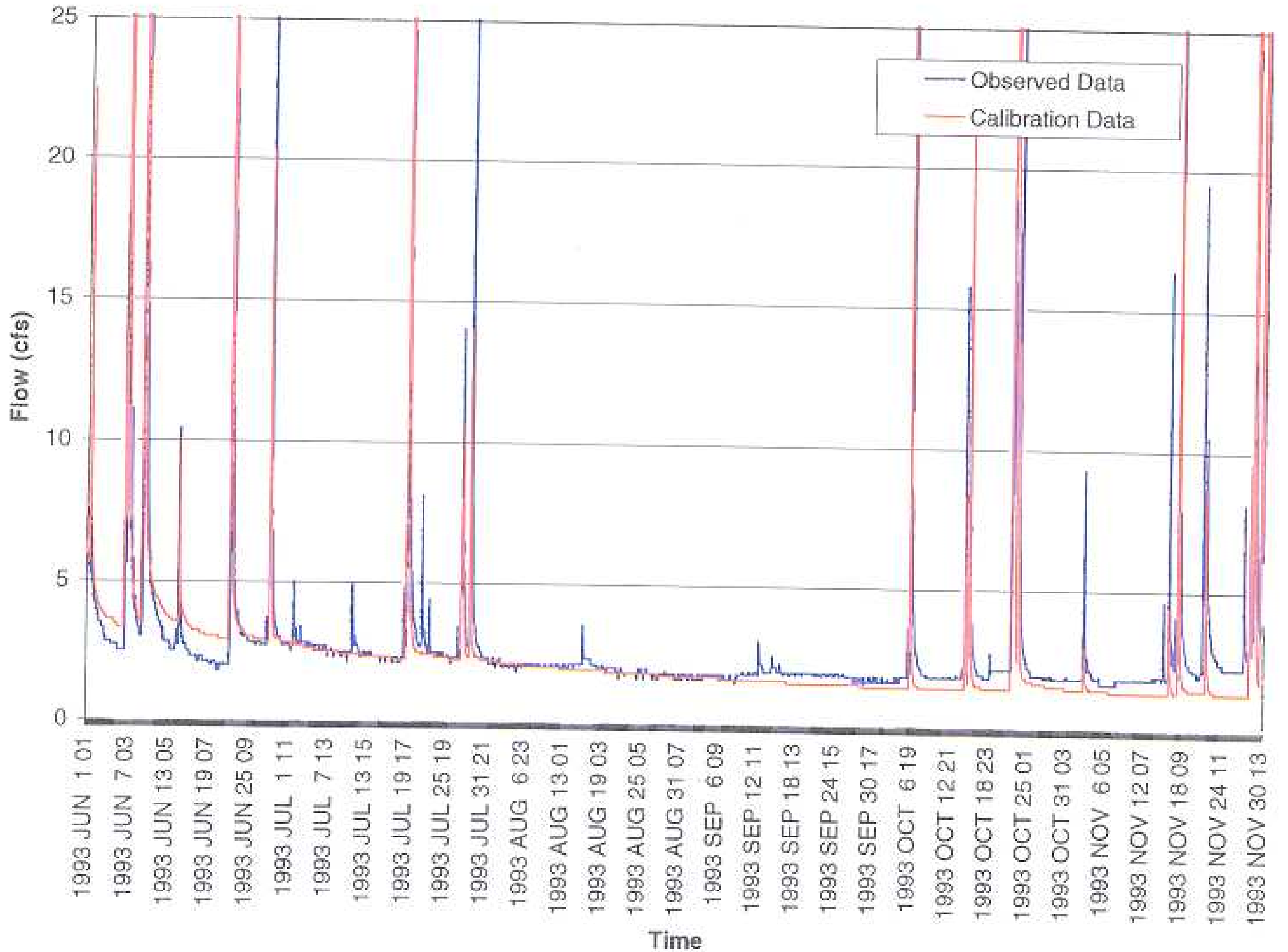
AR 052939

Figure 2-2. Miller Creek at the Mouth Observed vs. Calibrated Low Flow 1992



AR 052940

Figure 2-3. Miller Creek at the Mouth Observed vs. Calibrated Low Flow 1993



AR 052941

Figure 2-4. Miller Creek at the Mouth Observed vs. Calibrated Low Flow 1994

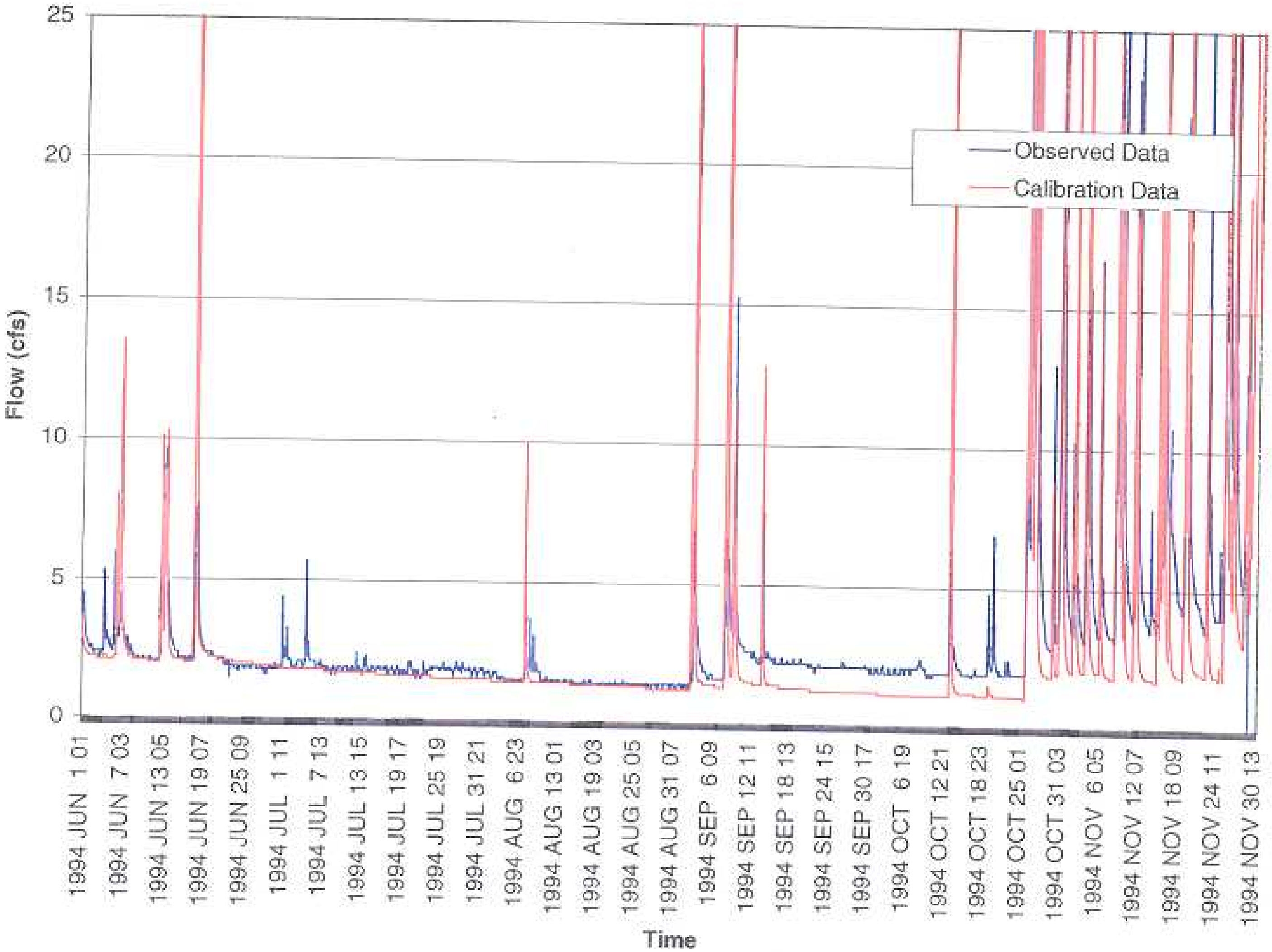
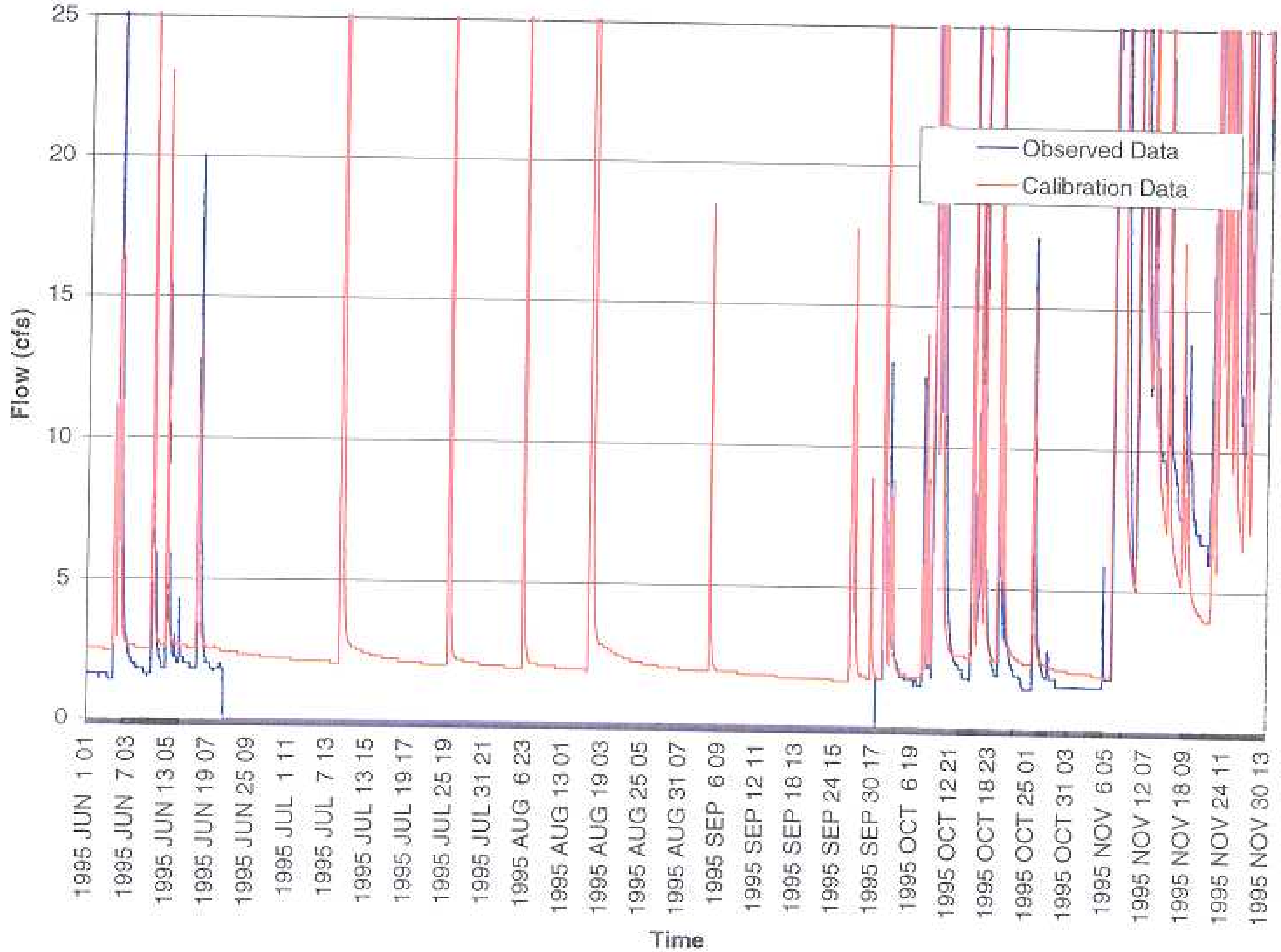
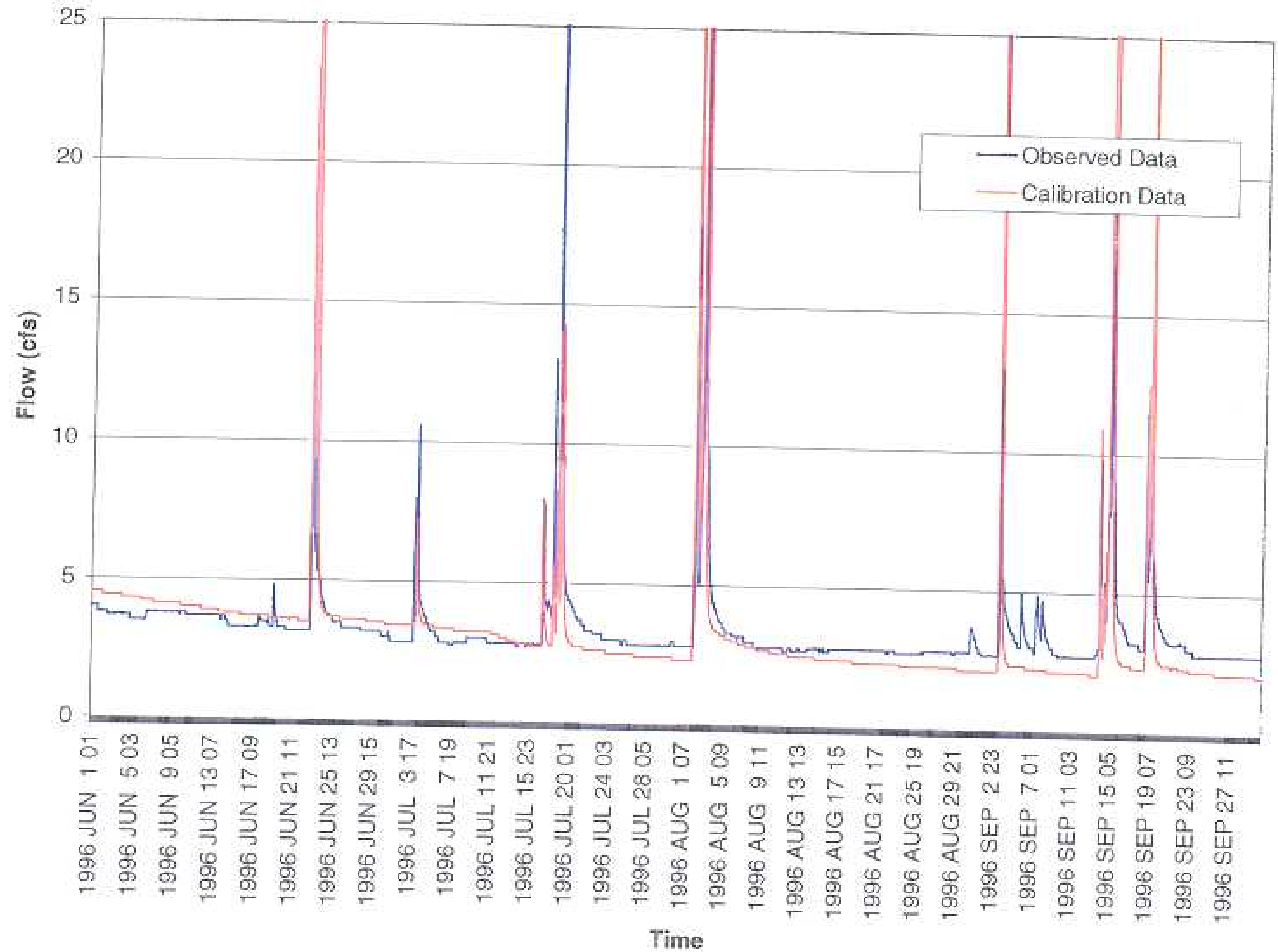


Figure 2-5. Miller Creek at the Mouth Observed vs. Calibrated Low Flow 1995



AR 052943

Figure 2-6. Miller Creek at the Mouth Observed vs. Calibrated Low Flow 1996



AR 052944

Table 2-1. Miller Creek at the mouth, June through November low-flow average flows for water-years 1991 through 1996.

Water-Year	Observed Average Flow (cfs)	Calibrated Average Flow (cfs)	Difference (cfs)
1991	3.429	3.756	-0.327
1992	3.034	3.387	-0.354
1993	2.914	2.792	0.122
1994	3.865	3.001	0.864
1995	10.433	9.775	0.658
1996	3.607	3.537	0.070
Average Difference	**6.820**	**6.562**	**0.258**

Table 2-2. Miller Creek at the mouth, 7-day low flows for water-years 1991 through 1996.

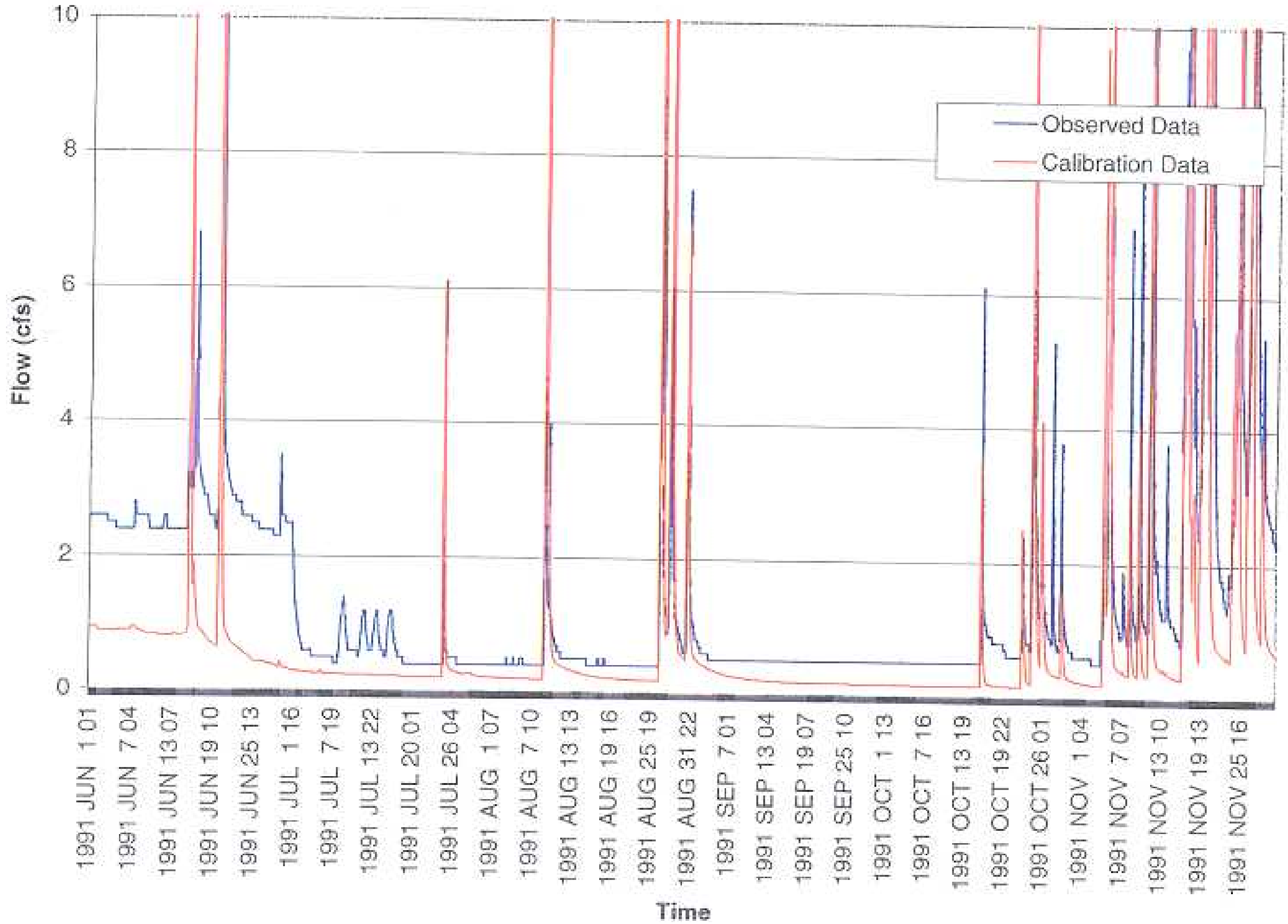
Water-Year	Observed Average Flow (cfs)	Calibrated Average Flow (cfs)	Difference (cfs)
1991	1.348	1.749	-0.401
1992	1.457	1.390	0.067
1993	1.639	1.300	0.339
1994	1.361	1.100	0.261
1995	1.500	1.661	-0.161
1996	2.762	2.138	0.624
Average Difference	**2.517**	**2.335**	**0.182**

2.2 MILLER CREEK AT THE DETENTION FACILITY

Observed and calibrated low flows at the Miller Creek detention facility are shown in Figures 2-7 through 2-12. Average simulated and observed streamflows for each low-flow period are listed in Table 2-3. Average simulated and observed streamflows for each 7-day low-flow period are listed in Table 2-4. The 7-day low-flow period for each observed water-year did not occur during the same 7-day period as the simulated low-flow period. Water-years 1993 and 1994 have gaps missing from the observed data, and in 1994, it is difficult to determine when there is a gage malfunction and when the stream goes dry.

In June 1991, the observed base flow suddenly dropped from about 2.5 cfs to 0.8 cfs. This is probably due to a change in the gage or the rating curve. At the end of September 1992, the gage malfunctioned. Prior to the malfunction, the observed base flow was about 1 cfs; after the gage was repaired, the base flow was about 0.1 cfs. This change in the basic behavior of the observed base flow is not matched by the simulated streamflow. For these reasons, water-years 1991 and 1992 were not used to determine the accuracy of the simulated low-flow data. Following this period, the simulated average streamflows are within 0.25 cfs of the observed average streamflows and the simulated 7-day low flows are within 0.09 cfs of the observed 7-day low flows. The general shape and magnitude of the simulated low flows is slightly lower than that of the observed low flows. This is due to the simulated routing of groundwater from some subbasins upstream of the Miller Creek detention facility. In an effort to match overall volumes at the Miller Creek detention facility, some of the groundwater upstream of the Miller Creek detention facility was routed to the Vacca Farm area. While this assumption improved the accuracy of the overall HSPF modeling, it is possible that some of this groundwater does in fact contribute to streamflow at the Miller Creek detention facility. This is not an issue for this analysis since the point of compliance for the low-flow study is downstream of Vacca Farm (therefore, all of the contributing groundwater was included).

Figure 2-7. Miller Creek at the Miller Creek Detention Facility Observed vs. Calibrated Low Flow 1991



AR 052947

Figure 2-8. Miller Creek at the Miller Creek Detention Facility Observed vs. Calibrated Low Flow 1992

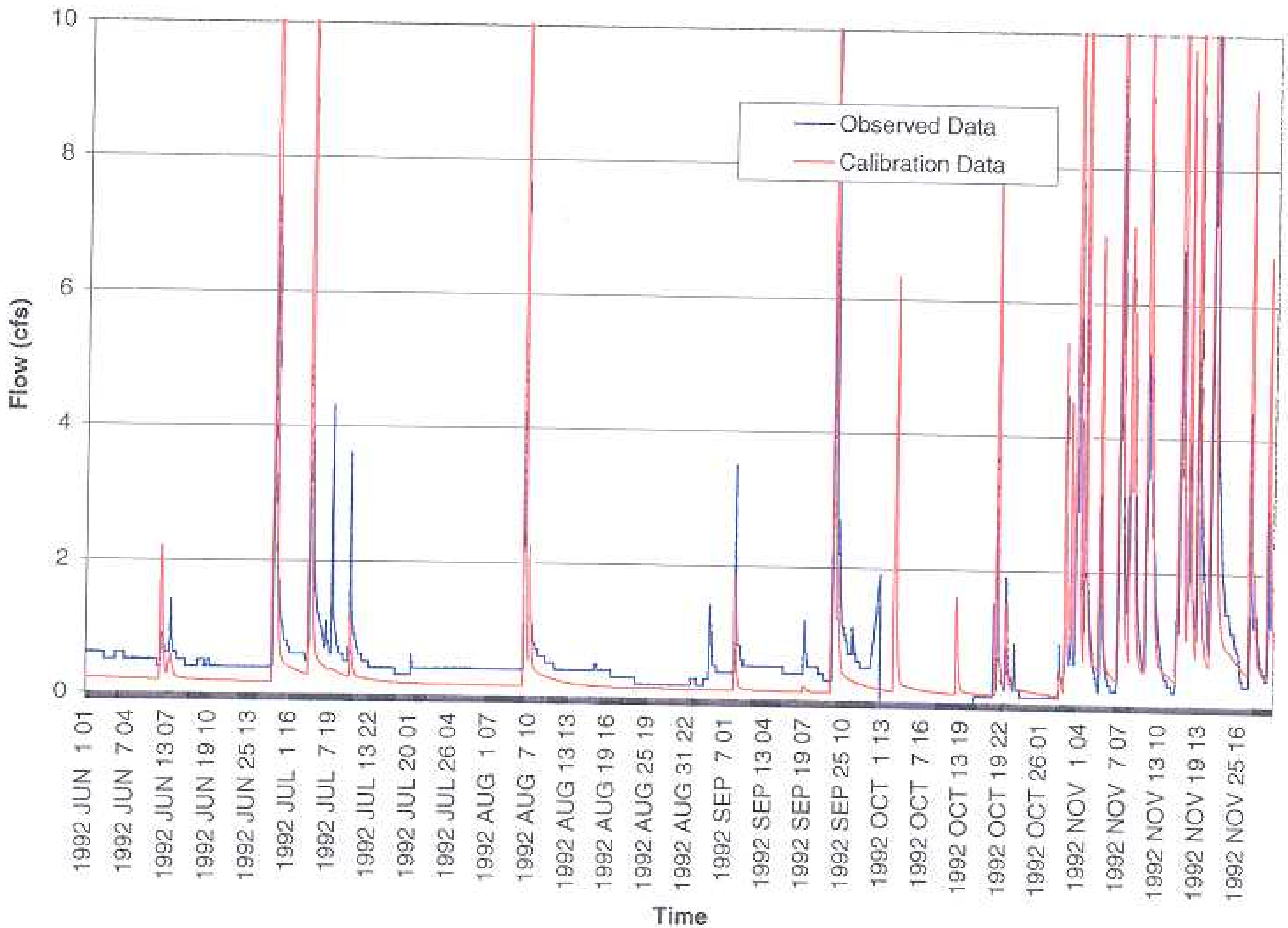
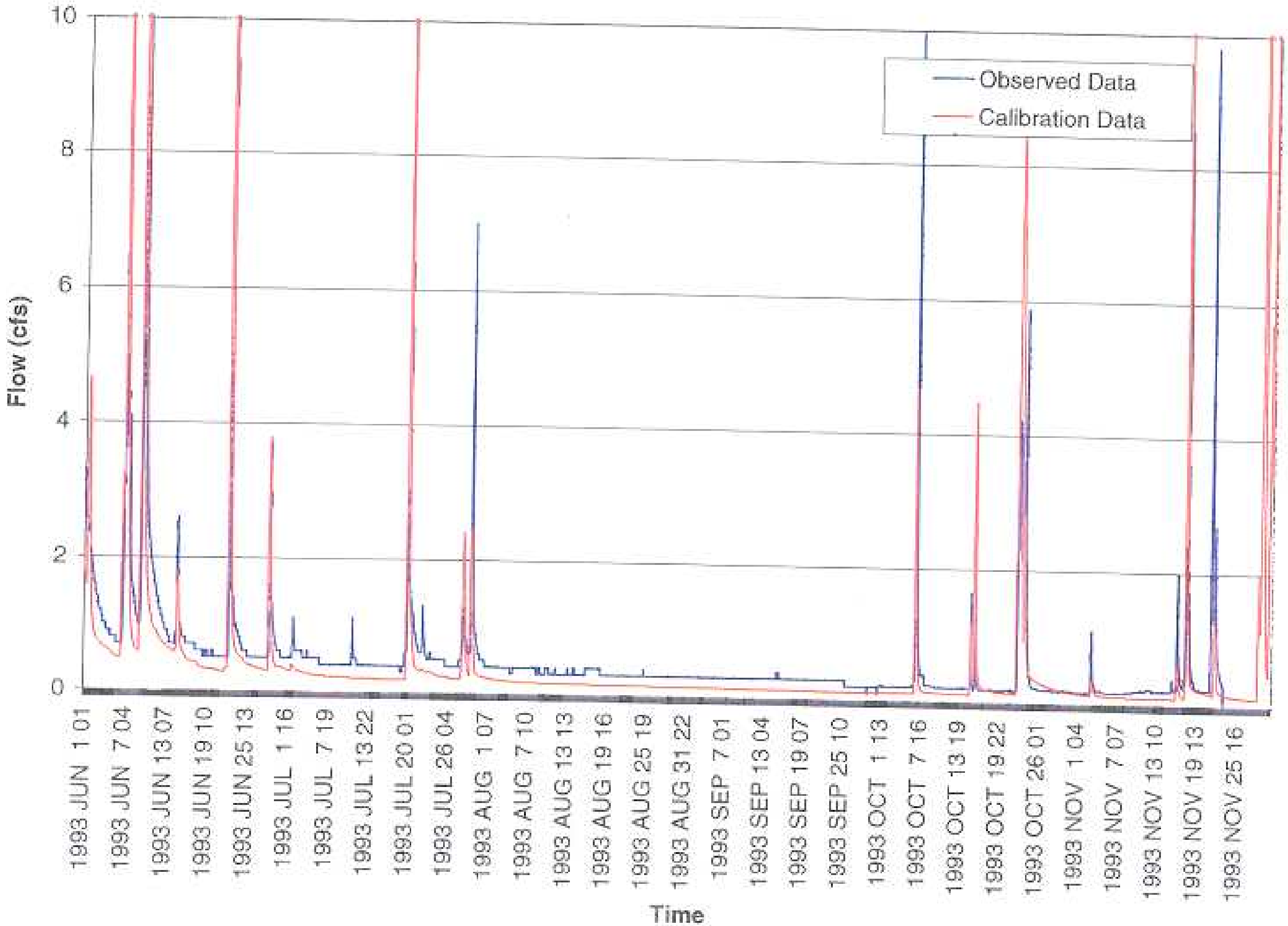
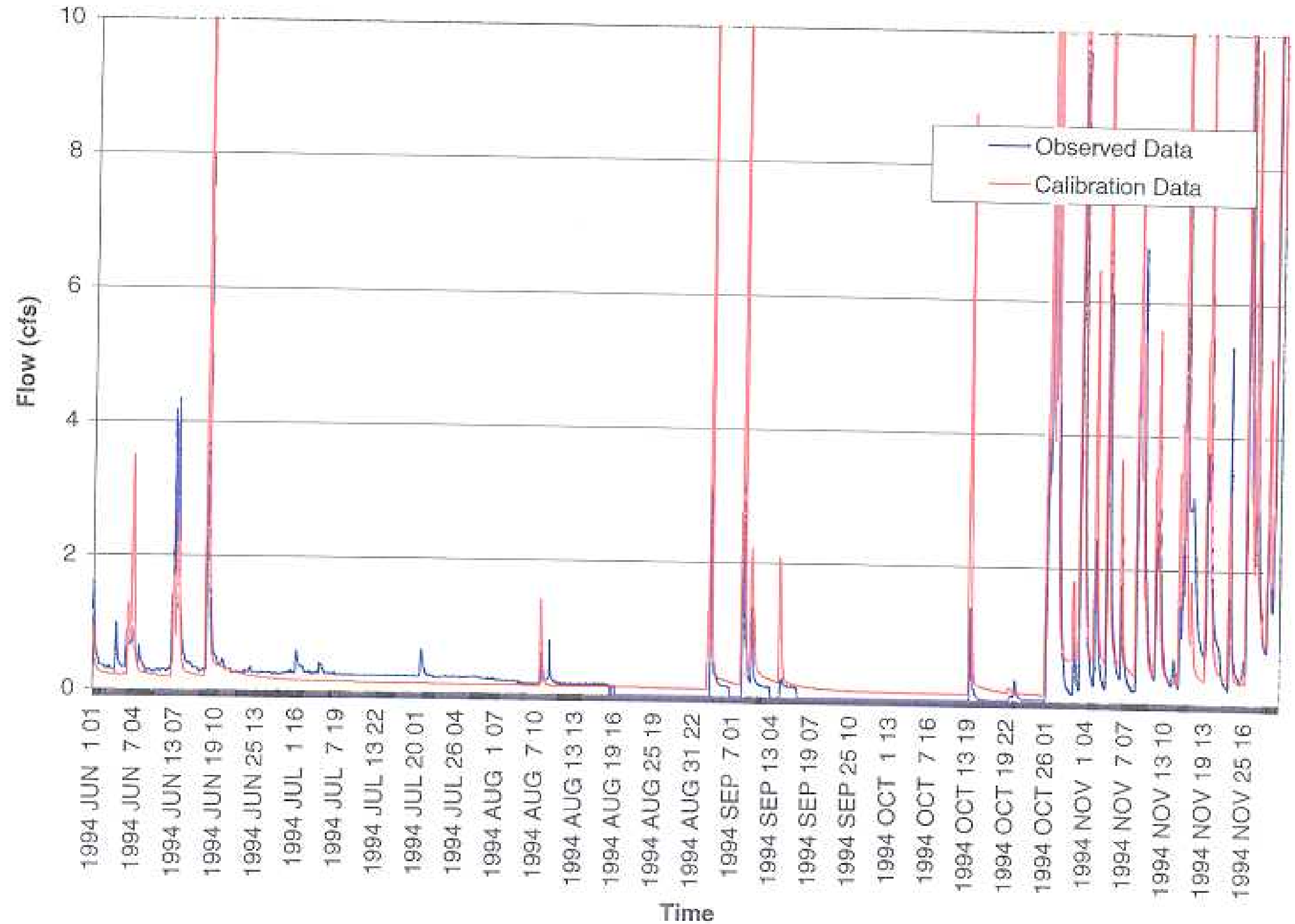


Figure 2-9. Miller Creek at the Miller Creek Detention Facility Observed vs. Calibrated Low Flow 1993



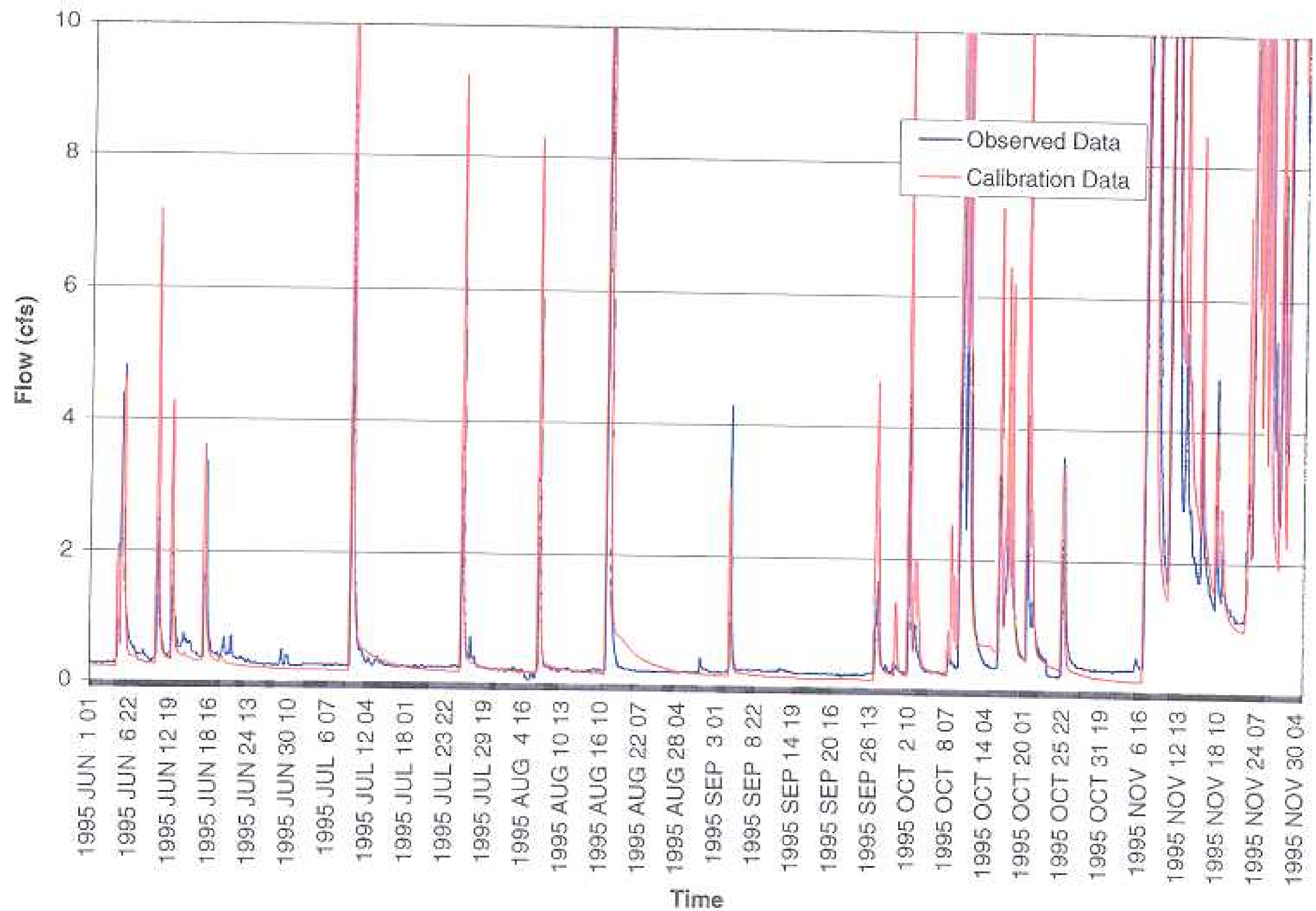
AR 052949

Figure 2-10. Miller Creek at the Miller Creek Detention Facility Observed vs. Calibrated Low Flow 1994



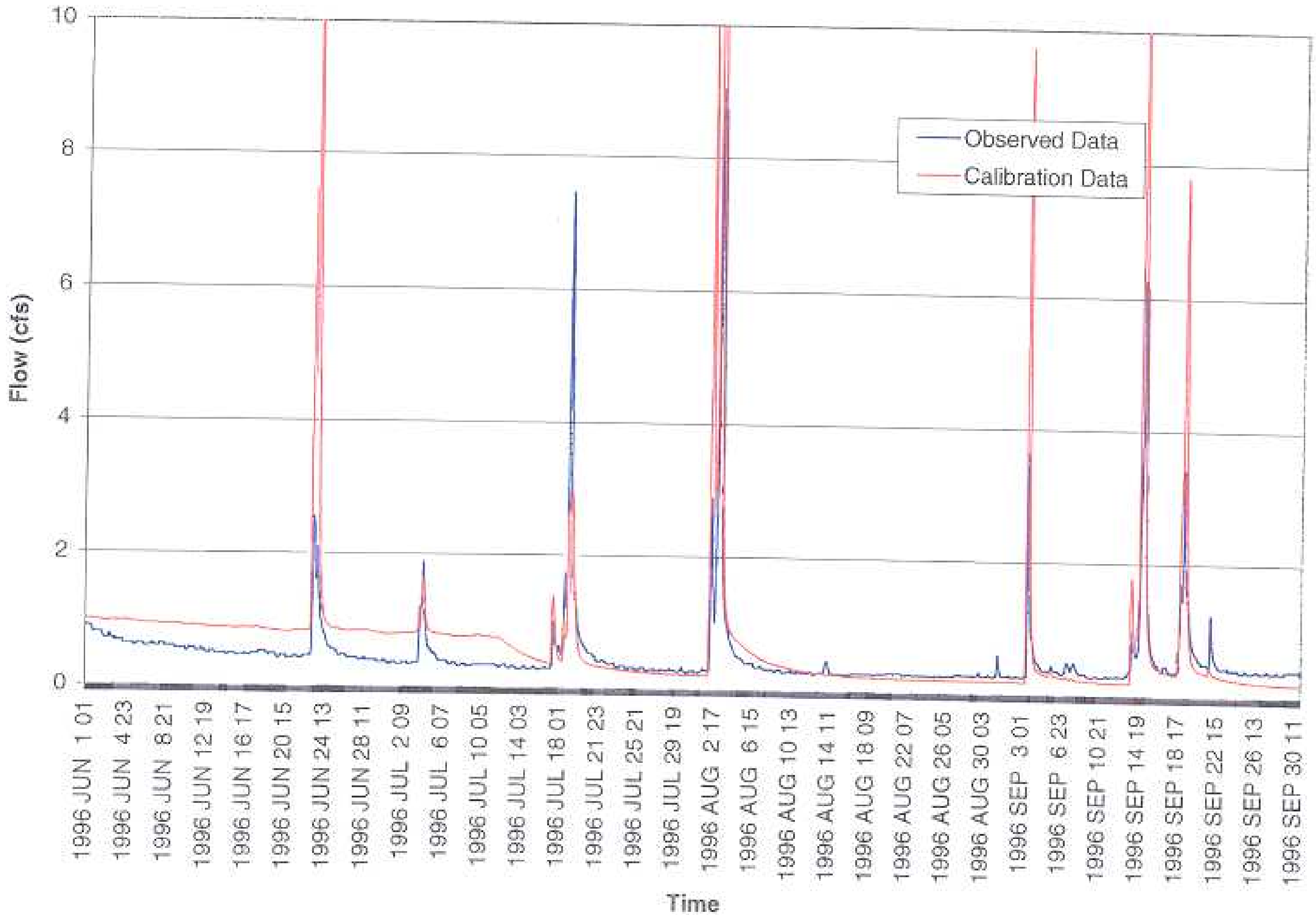
AR 052950

Figure 2-11. Miller Creek at the Miller Creek Detention Facility Observed vs. Calibrated Low Flow 1995



AR 052951

Figure 2-12. Miller Creek at the Miller Creek Detention Facility Observed vs. Calibrated Low Flow 1996



AR 052952

Table 2-3. Miller Creek at the Miller Creek detention facility, June through November low-flow average flows for water-years 1991 through 1996.

Water-Year	Observed Average Flow (cfs)	Calibrated Average Flow (cfs)	Difference (cfs)
1991	1.556	0.887	0.670
1992	0.860	0.873	-0.013
1993	0.577	0.467	0.109
1994	0.900	1.132	-0.232
1995	1.598	1.813	-0.215
1996	0.522	0.753	-0.231
Average Difference	**1.503**	**1.481**	**0.022**

Table 2-4. Miller Creek at the Miller Creek detention facility, 7-day low flows for water-years 1991 through 1996.

Water-Year	Observed Average Flow (cfs)	Calibrated Average Flow (cfs)	Difference (cfs)
1991	0.400	0.150	0.250
1992	0.127	0.124	0.004
1993	0.190	0.110	0.080
1994	0.000	0.090	-0.090
1995	0.183	0.137	0.045
1996	0.263	0.189	0.074
Average Difference	**0.291**	**0.200**	**0.091**

3. WALKER CREEK LOW STREAMFLOW

Two streamflow gages located in the Walker Creek watershed were used in the low-streamflow calibration review (see Figure 2-1 in the main text for gage locations). One of the streamflow gages was located near the mouth of Walker Creek, and the other was located further upstream near a wetland. Data for the streamflow gages were collected by King County DNR. The analysis period covers water-years 1993 through 1996. The modeling team selected this period because it appeared to contain the most reliable data. However, the observed data from these water-years still contain several gaps. The dates of the missing data are listed in Table B2-2 (Appendix B, Volume 3 of the SMP).

3.1 WALKER CREEK AT THE MOUTH

Observed and calibrated low flows for Walker Creek at the mouth are shown in Figures 3-1 through 3-4. Average simulated and observed streamflows for each low-flow period are listed in Table 3-1. Average simulated and observed streamflows for each 7-day low-flow period are listed in Table 3-2. The 7-day low-flow period for each observed water-year did not occur during the same 7-day period as the simulated low-flow period. Water-years 1994 and 1996 have gaps missing from the observed data, and water-year 1995 has some odd behavior in the months of August through October. The observed base flow on August 16th was 1.4 cfs. On August 17th, a flood event occurred with a maximum flow of 22.5 cfs. On August 18th, the event ended and flows dropped back down to base flows. However, the new base flow was 0.9 cfs, which was a drop of 0.5 cfs relative to the previous base flow. The base flow remained relatively flat until a flood event occurred on October 9th. When this event was over, the base flow jumped up to 1.9 cfs. The sharp decrease and subsequent increase in base flow was not matched by simulated data. The cause of these changes is not known.

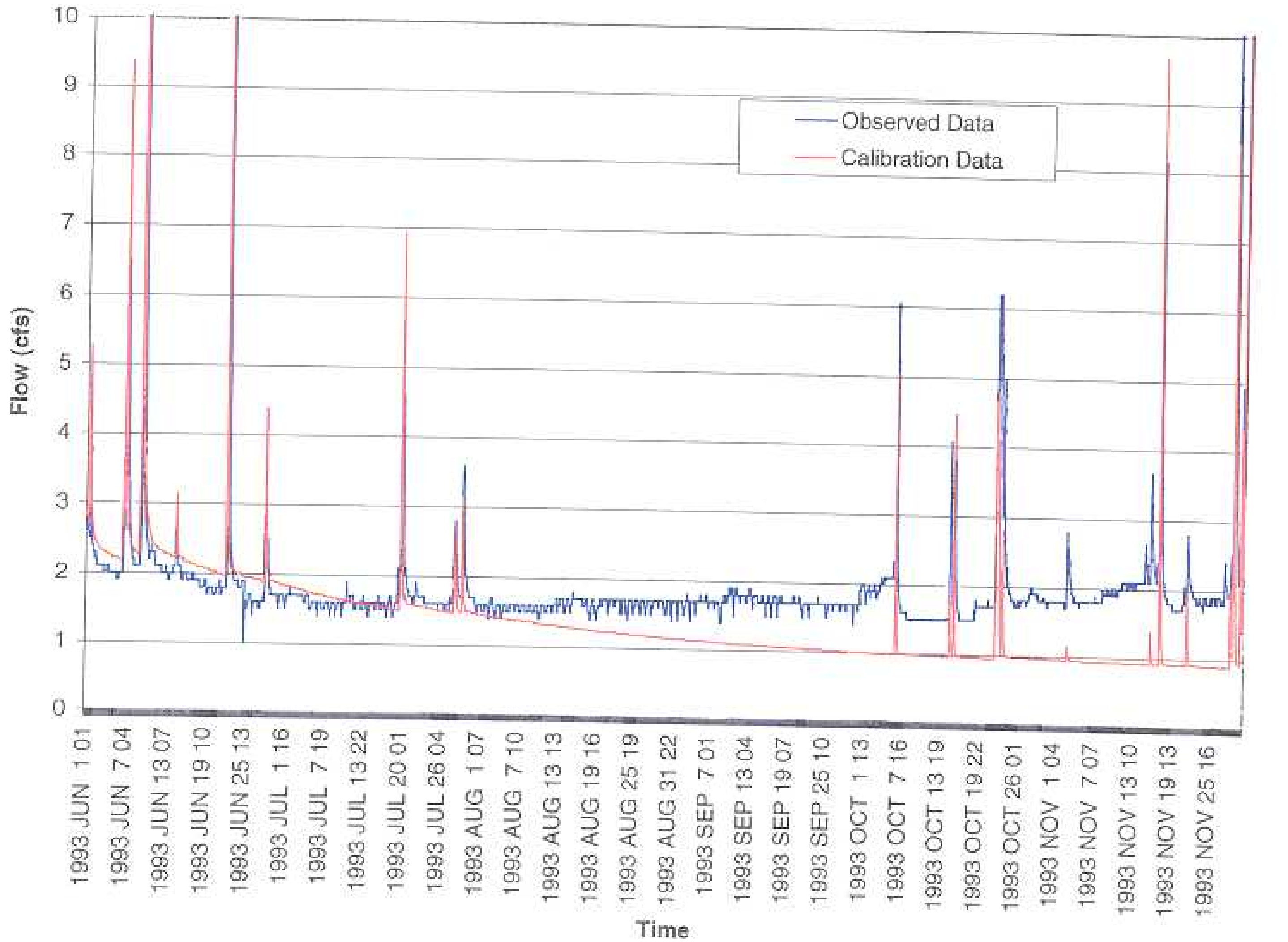
Table 3-1. Walker Creek at the mouth, June through November low-flow average flows for water-years 1993 through 1996.

Water-Year	Observed Average Flow (cfs)	Calibrated Average Flow (cfs)	Difference (cfs)
1993	1.879	1.442	0.437
1994	1.584	1.283	0.301
1995	2.318	1.937	0.380
1996	2.034	1.723	0.310
Average Difference	**1.953**	**1.596**	**0.357**

Table 3-2. Walker Creek at the mouth, 7-day low flows for water-years 1993 through 1996.

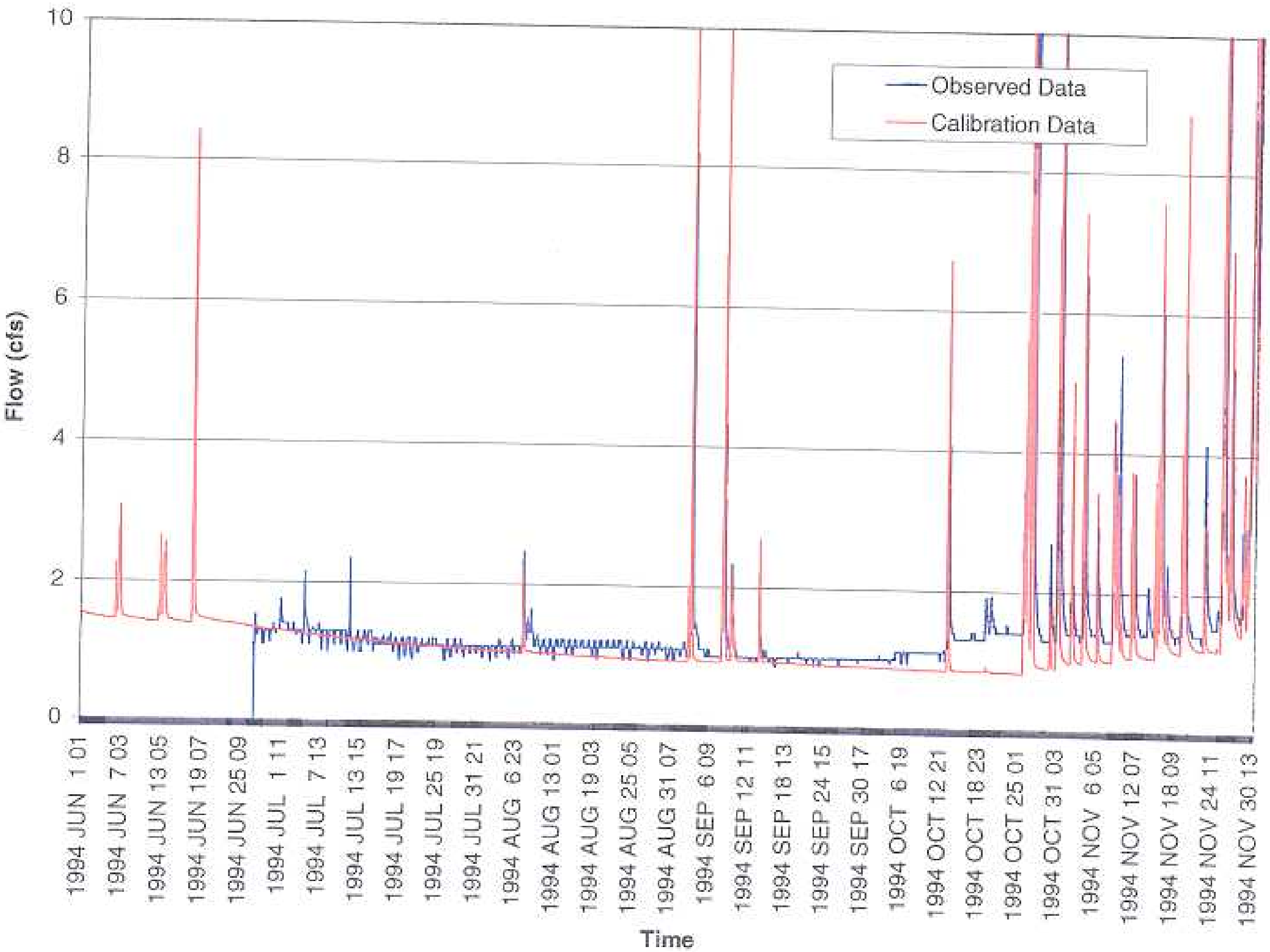
Water-Year	Observed Average Flow (cfs)	Calibrated Average Flow (cfs)	Difference (cfs)
1993	1.502	0.923	0.579
1994	0.987	0.833	0.154
1995	0.915	1.077	-0.163
1996	1.719	1.287	0.432
Average Difference	**1.281**	**1.030**	**0.250**

Figure 3-1. Walker Creek at the Mouth Observed vs. Calibrated Low Flow 1993



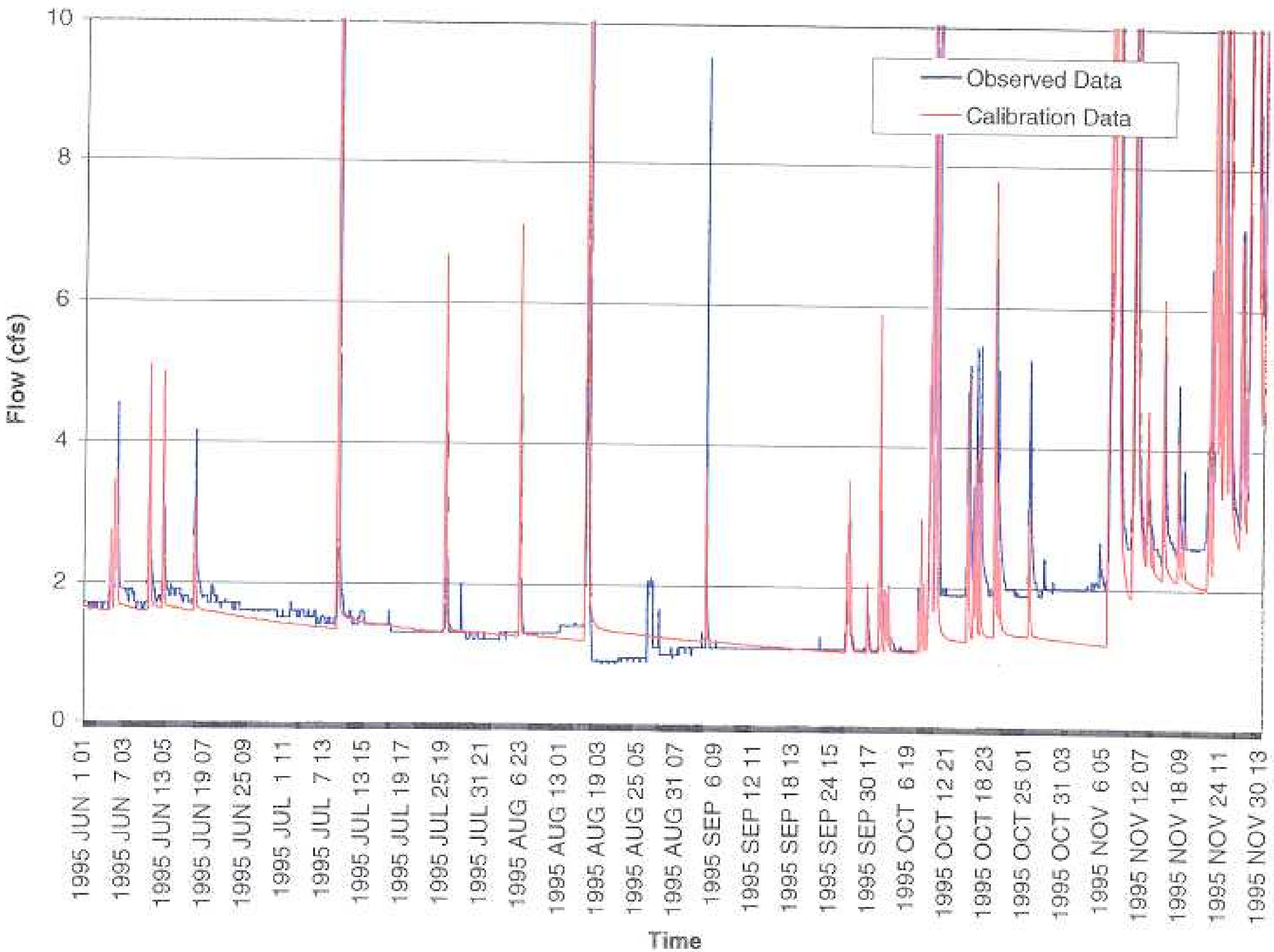
AR 052955

Figure 3-2. Walker Creek at the Mouth Observed vs. Calibrated Low Flow 1994



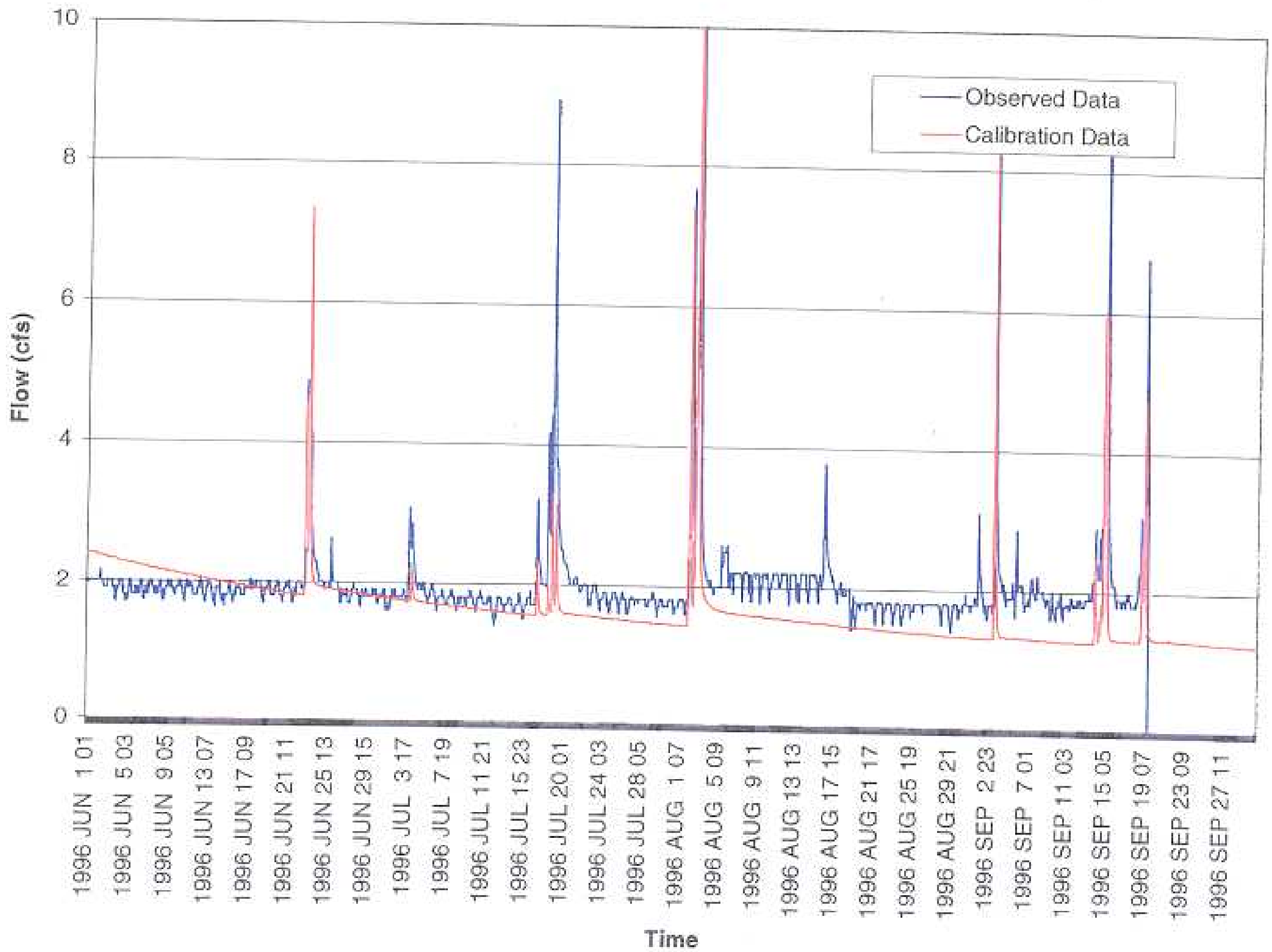
AR 052956

Figure 3-3. Walker Creek at the Mouth Observed vs. Calibrated Low Flow 1995



AR 052957

Figure 3-4. Walker Creek at the Mouth Observed vs. Calibrated Low Flow 1996



AR 052958

3.2 WALKER CREEK NEAR THE WETLAND

Observed and calibrated low flows for Walker Creek near the wetland are shown in Figures 3-5 through 3-10. Average simulated and observed streamflows for each low-flow period are listed in Table 3-3. Average simulated and observed streamflows for each 7-day low-flow period are listed in Table 3-4. The 7-day low-flow period for each observed water-year did not occur during the same 7-day period as the simulated low-flow period. Water-year 1994 had a small gap missing from the observed data.

Table 3-3. Walker Creek near wetland, June through November low-flow average flows for water-years 1991 through 1996.

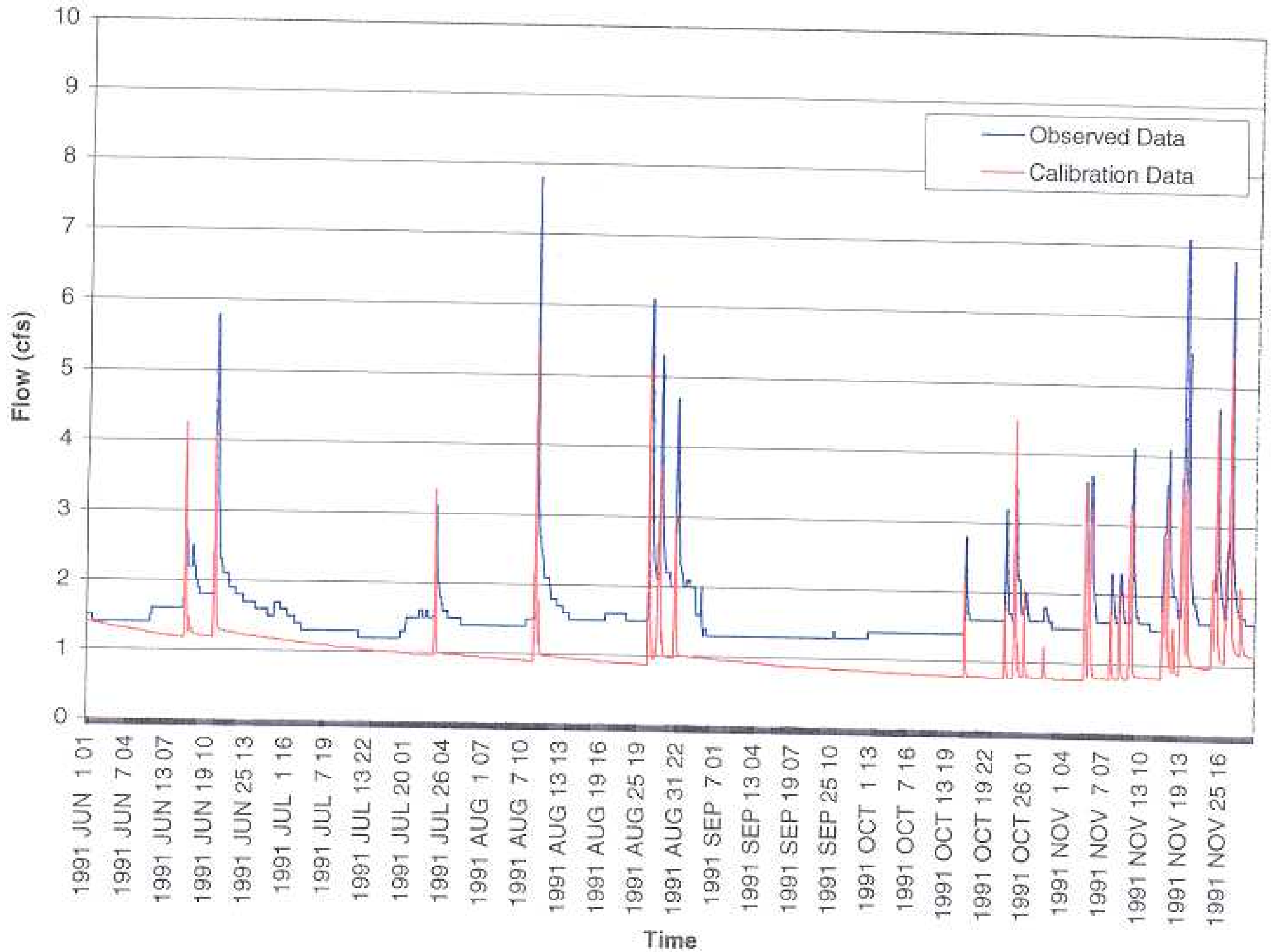
Water-Year	Observed Average Flow (cfs)	Calibrated Average Flow (cfs)	Difference (cfs)
1991	1.667	1.065	0.601
1992	1.458	0.956	0.502
1993	1.189	0.978	0.210
1994	1.203	0.898	0.306
1995	1.103	1.232	-0.129
1996	1.515	1.113	0.402
Average Difference	**1.252**	**1.055**	**0.197**

Table 3-4. Walker Creek near wetland, 7-day low flows for water-years 1991 through 1996.

Water-Year	Observed Average Flow (cfs)	Calibrated Average Flow (cfs)	Difference (cfs)
1991	1.208	0.786	0.422
1992	1.098	0.682	0.416
1993	0.800	0.666	0.134
1994	0.670	0.614	0.056
1995	0.256	0.750	-0.494
1996	0.896	0.870	0.026
Average Difference	**0.656**	**0.725**	**-0.069**

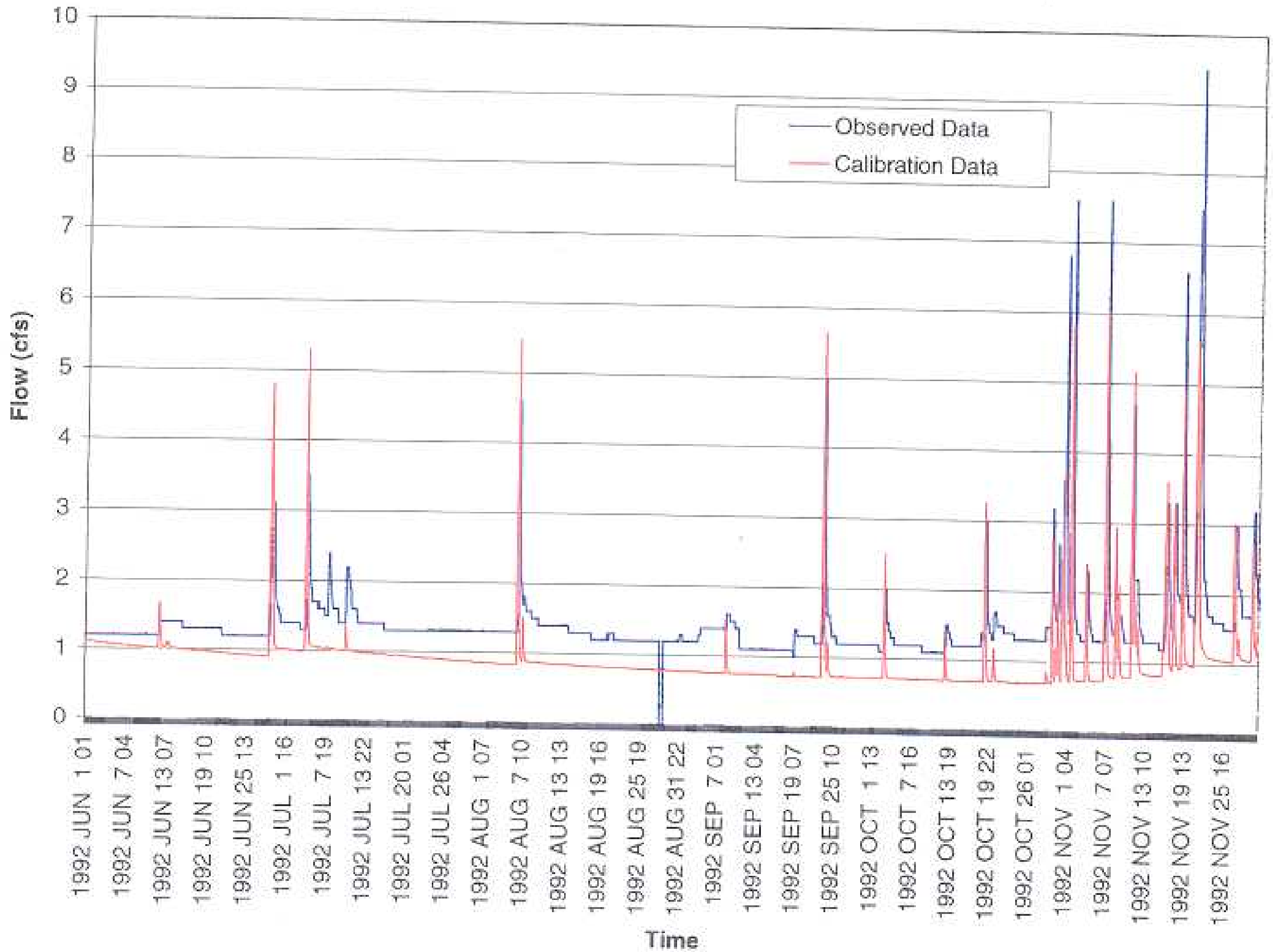
The 1995 low-flow period is not consistent with the other years. The 7-day observed low flow for this year was 0.25 cfs, compared to the simulated low flow of 0.75 cfs. The cause of this difference is unknown. However, this is the only year in which the simulated low flow was higher than the observed low flow. Furthermore, 7-day observed low flows at the mouth for years 1994 and 1995 were nearly identical (0.987 cfs and 0.915 cfs). The primary source of base flow for the Walker Creek watershed is the off-site groundwater area, which is routed into the wetland and is therefore upstream of both gage sites. Base flow at the wetland contributed on average 65 percent of all base flow at the mouth. A correlation between the gage near the wetland and the gage at the mouth helped determine the accuracy of this information. Average flows for both gage sites are listed in Tables 3-5 and 3-6. The year with the highest average annual flow at the mouth was 1995, and the year with the lowest average annual flow at the mouth was 1994. The year with the highest average

Figure 3-5. Walker Creek Near Wetland Observed vs. Calibrated Low Flow 1991



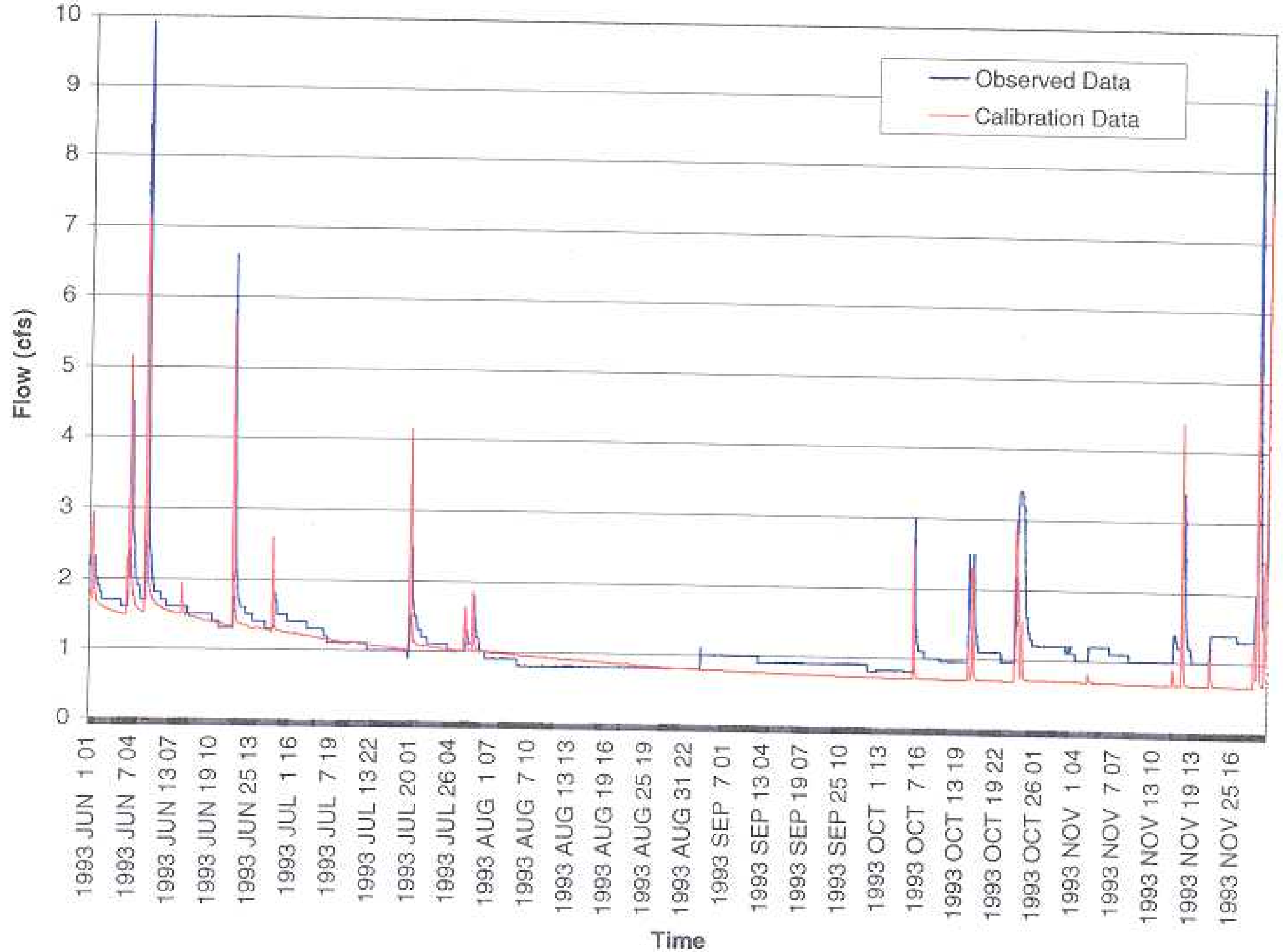
AR 052960

Figure 3-6. Walker Creek Near Wetland Observed vs. Calibrated Low Flow 1992



AR 052961

Figure 3-7. Walker Creek Near Wetland Observed vs. Calibrated Low Flow 1993



AR 052962

Figure 3-8. Walker Creek Near Wetland Observed vs. Calibrated Low Flow 1994

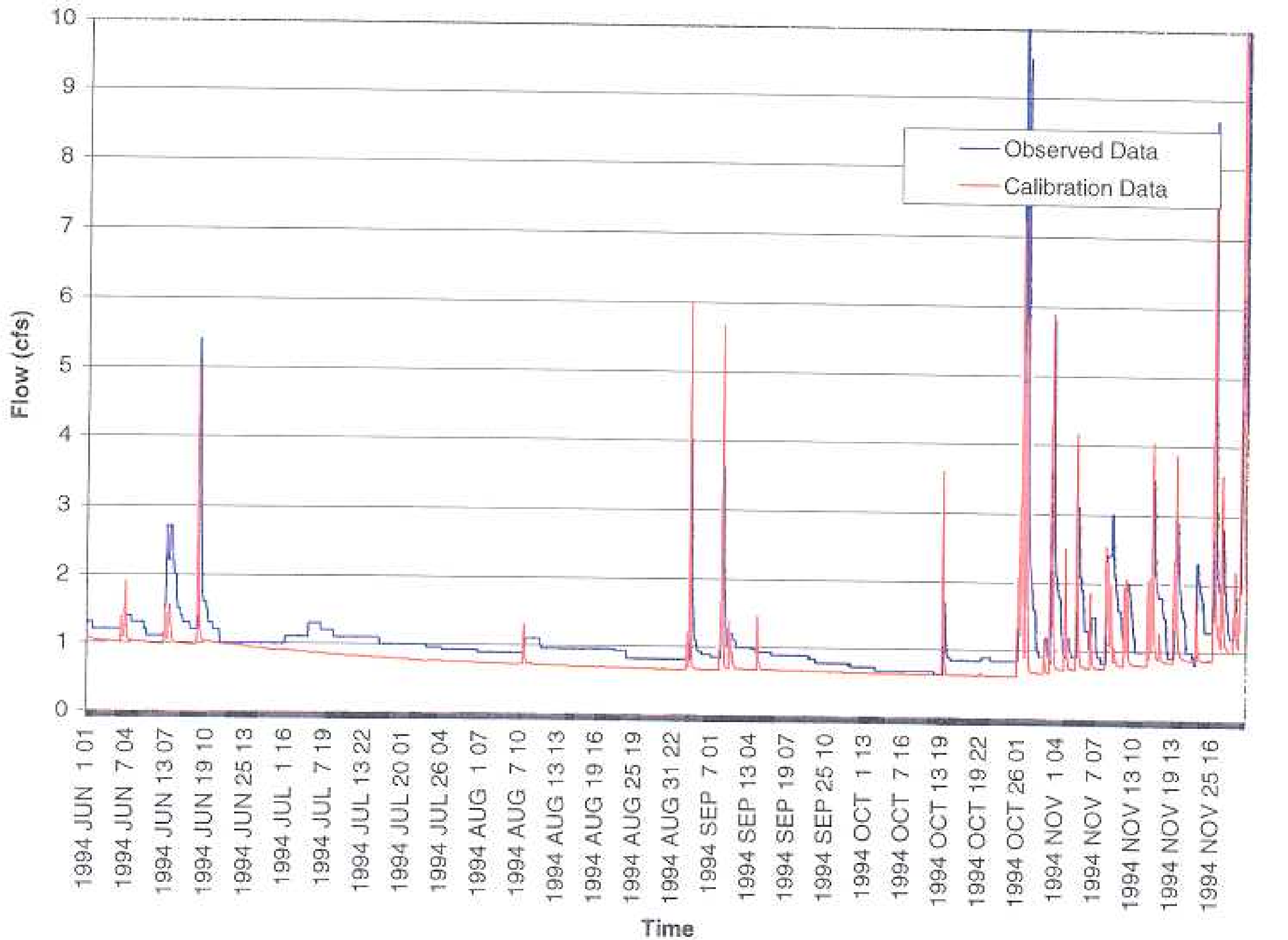
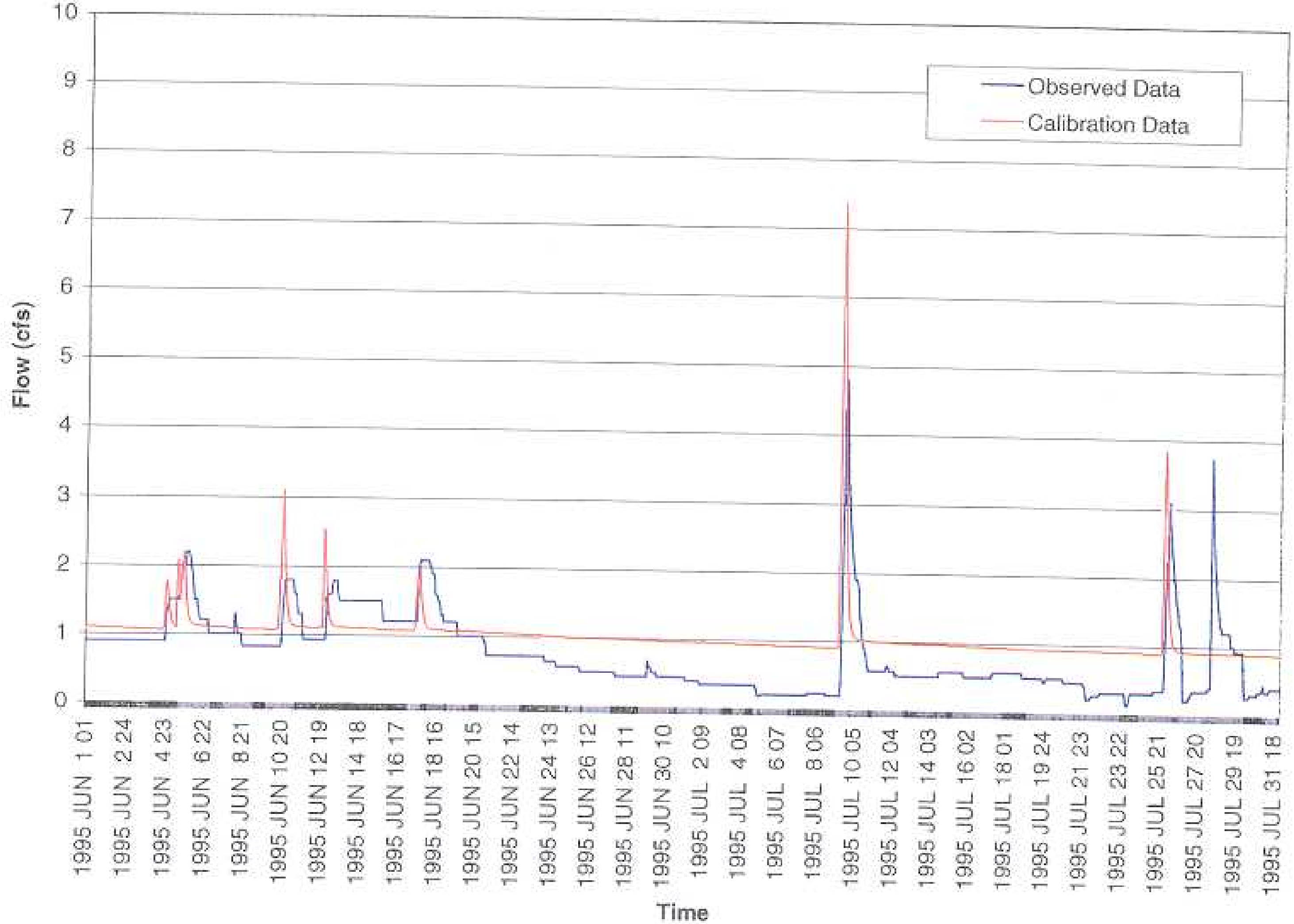
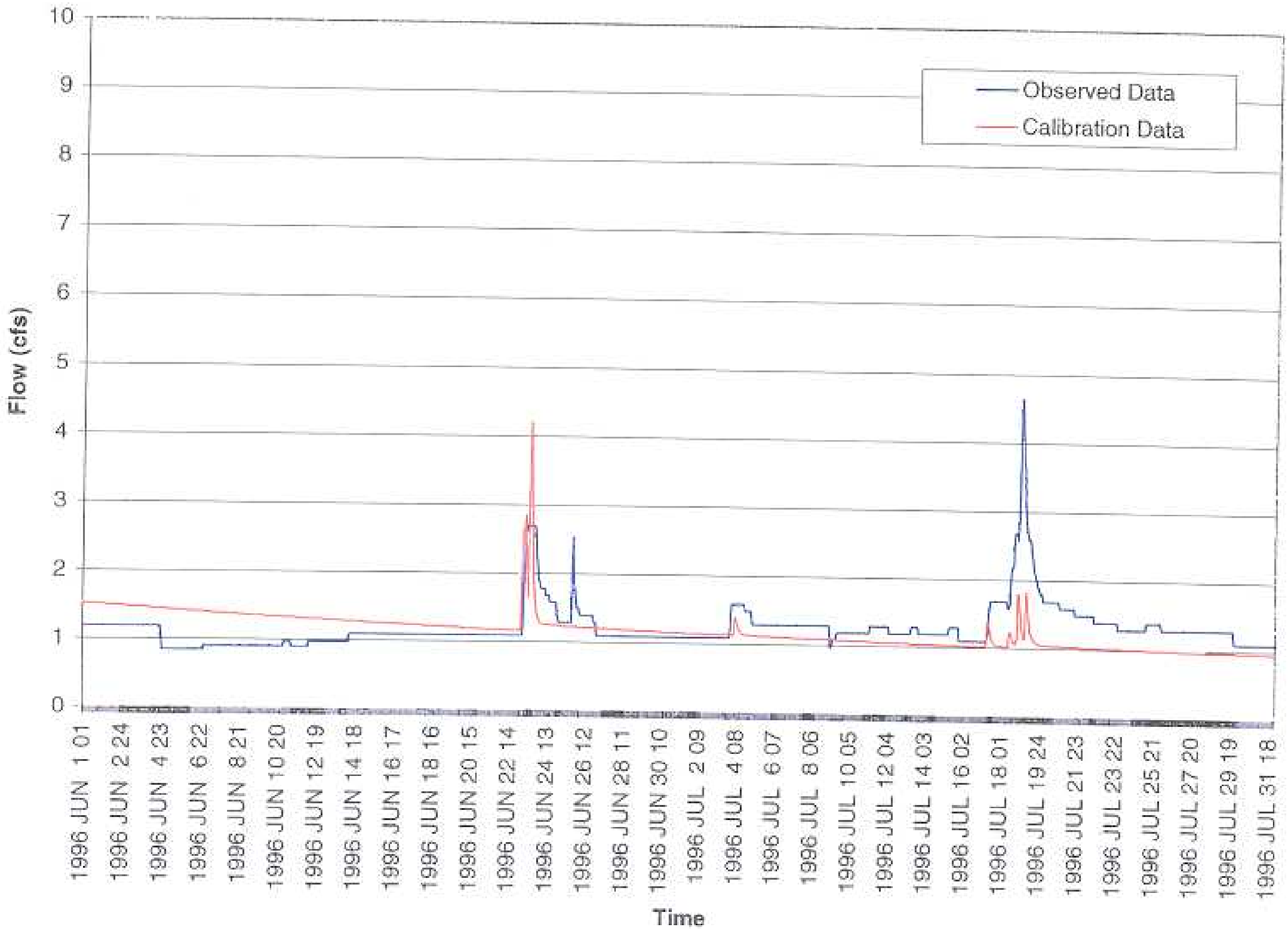


Figure 3-9. Walker Creek Near Wetland Observed vs. Calibrated Low Flow 1995



AR 052964

Figure 3-10. Walker Creek Near Wetland Observed vs. Calibrated Low Flow 1996



AR 052965

annual flow near the wetland was 1996, while the year with the lowest average annual flow was 1995. Given that 65 percent of the base flow for Walker Creek was recorded at the upstream gage near the wetland, it is difficult to understand why the year of maximum flow at the mouth was also the year of minimum flow at the upstream gage. Table 3-6 indicates that the 7-day low flow for 1995 at the downstream gage was not consistent with the other years.

Table 3-5. Walker Creek correlation of average annual gage flow at the mouth and near the wetland.

Water-Year	GAGE AT THE MOUTH Observed Average Flow (cfs)	Calibrated Average Flow (cfs)	Difference (cfs)
1993	1.879	1.442	0.437
1994	1.584	1.283	0.301
1995	2.318	1.937	0.380
1996	2.034	1.723	0.310
Average Difference	**1.953**	**1.596**	**0.357**

Water-Year	GAGE NEAR THE WETLAND Observed Average Flow (cfs)	Calibrated Average Flow (cfs)	Difference (cfs)
1993	1.189	0.978	0.210
1994	1.203	0.898	0.306
1995	1.103	1.232	-0.129
1996	1.515	1.113	0.402
Average Difference	**1.252**	**1.055**	**0.197**

Water-Year	DIFFERENCE BETWEEN GAGES Observed Average Flow (cfs)	Calibrated Average Flow (cfs)	Difference (cfs)
1993	0.690	0.464	0.226
1994	0.381	0.385	-0.005
1995	1.215	0.706	0.509
1996	0.519	0.610	-0.091
Average Difference	**0.701**	**0.541**	**0.160**

Table 3-6. Walker Creek correlation of 7-day low-flow gage flow at the mouth and near the wetland.

Water-Year	Observed Average Flow (cfs)	Calibrated Average Flow (cfs)	Difference (cfs)
	GAGE AT THE MOUTH		
1993	1.502	0.923	0.579
1994	0.987	0.833	0.154
1995	0.915	1.077	-0.163
1996	1.719	1.287	0.432
Average Difference	**1.281**	**1.030**	**0.250**
	GAGE NEAR THE WETLAND		
Water-Year	**Observed Average Flow (cfs)**	**Calibrated Average Flow (cfs)**	**Difference (cfs)**
1993	0.800	0.666	0.134
1994	0:670	0.614	0.056
1995	0.256	0.750	-0.494
1996	0.896	0.870	0.026
Average Difference	**0.656**	**0.725**	**-0.069**
	DIFFERENCE BETWEEN GAGES		
Water-Year	**Observed Average Flow (cfs)**	**Calibrated Average Flow (cfs)**	**Difference (cfs)**
1993	0.702	0.257	0.445
1994	0.316	0.219	0.097
1995	0.658	0.327	0.331
1996	0.823	0.417	0.406
Average Difference	**0.625**	**0.305**	**0.320**

4. DES MOINES CREEK LOW STREAMFLOW

Two streamflow gages located in the Des Moines Creek watershed were used in the low-streamflow calibration renew (see Figure 2-1 in the main text for gage locations). One of the streamflow gages was located near the mouth of Des Moines Creek, and the other gage (11c) was located further upstream. Data for the streamflow gages were collected by King County DNR. The analysis period covers water-years 1992 through 1996. The modeling team selected this period because it appeared to contain the most reliable data. However, the observed data from these water-years contain several gaps.

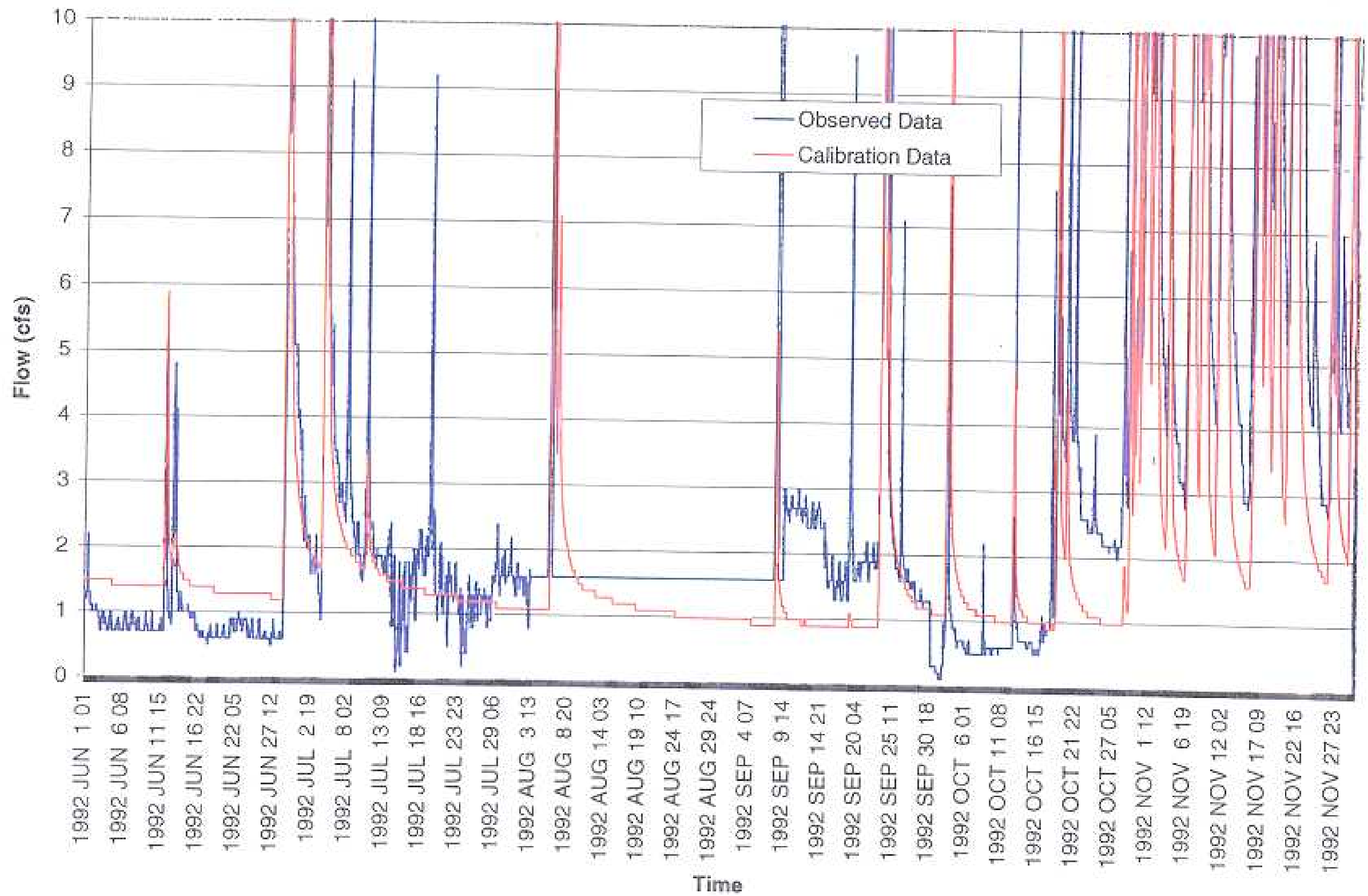
4.1 DES MOINES CREEK AT THE MOUTH

Observed and calibrated low flows for Des Moines Creek at the mouth are shown in Figures 4-1 through 4-5. Average simulated and observed streamflows for each low-flow period are listed in Table 4-1. Average simulated and observed streamflows for each 7-day low-flow period are listed in Table 4-2. The 7-day low-flow period for each observed water-year did not occur during the same 7-day period as the simulated low-flow period. Water-year 1992 exhibited some odd behavior in the month of July, as the observed base flow jumped up and down erratically. For example, on July 15th, the base flow ranged from 0.1 cfs to 1.8 cfs (Table 4-3). This type of flashiness is duplicated throughout the observed data and was not duplicated by the simulated data. In general, low flow at the mouth represents the general behavior of the observed flows. Average simulated flows for water-years 1994 through 1996 were within 0.26 cfs of observed flows, while average simulated flows for water-years 1992 and 1993 were within 0.5 cfs of observed flows. Calibrated 7-day low flows were within 0.32 cfs of observed low flows for all years.

Table 4-1. Des Moines Creek at the mouth, June through November low-flow average flows for water-years 1992 through 1996.

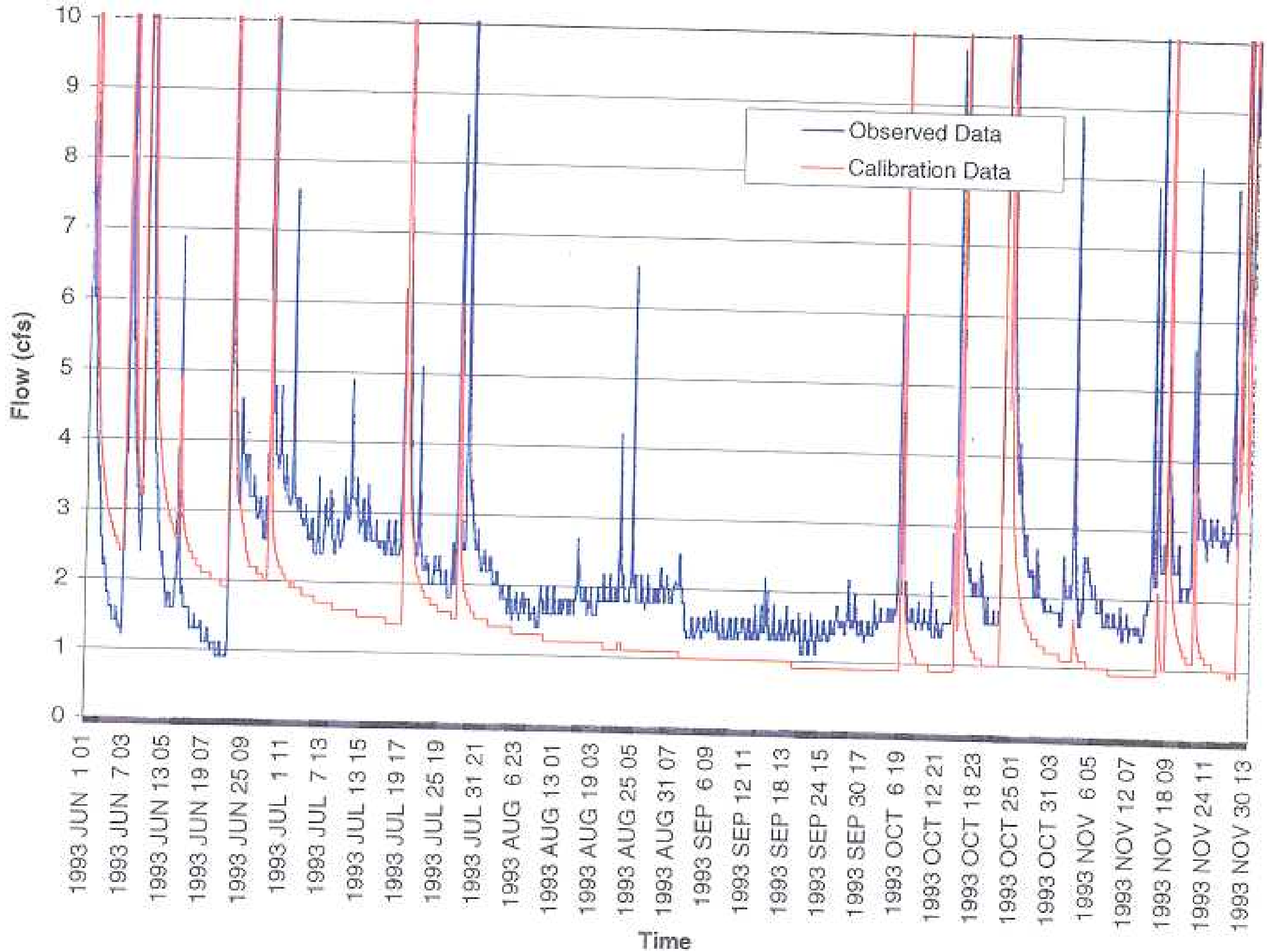
Water-Year	Observed Average Flow (cfs)	Calibrated Average Flow (cfs)	Difference (cfs)
1992	3.370	2.909	0.461
1993	2.726	2.198	0.528
1994	3.146	3.068	0.078
1995	5.754	5.623	0.131
1996	2.534	2.785	-0.251
Average Difference	**3.540**	**3.418**	**0.122**

Figure 4-1. Des Moines Creek at the Mouth Observed vs. Calibrated Low Flow 1992



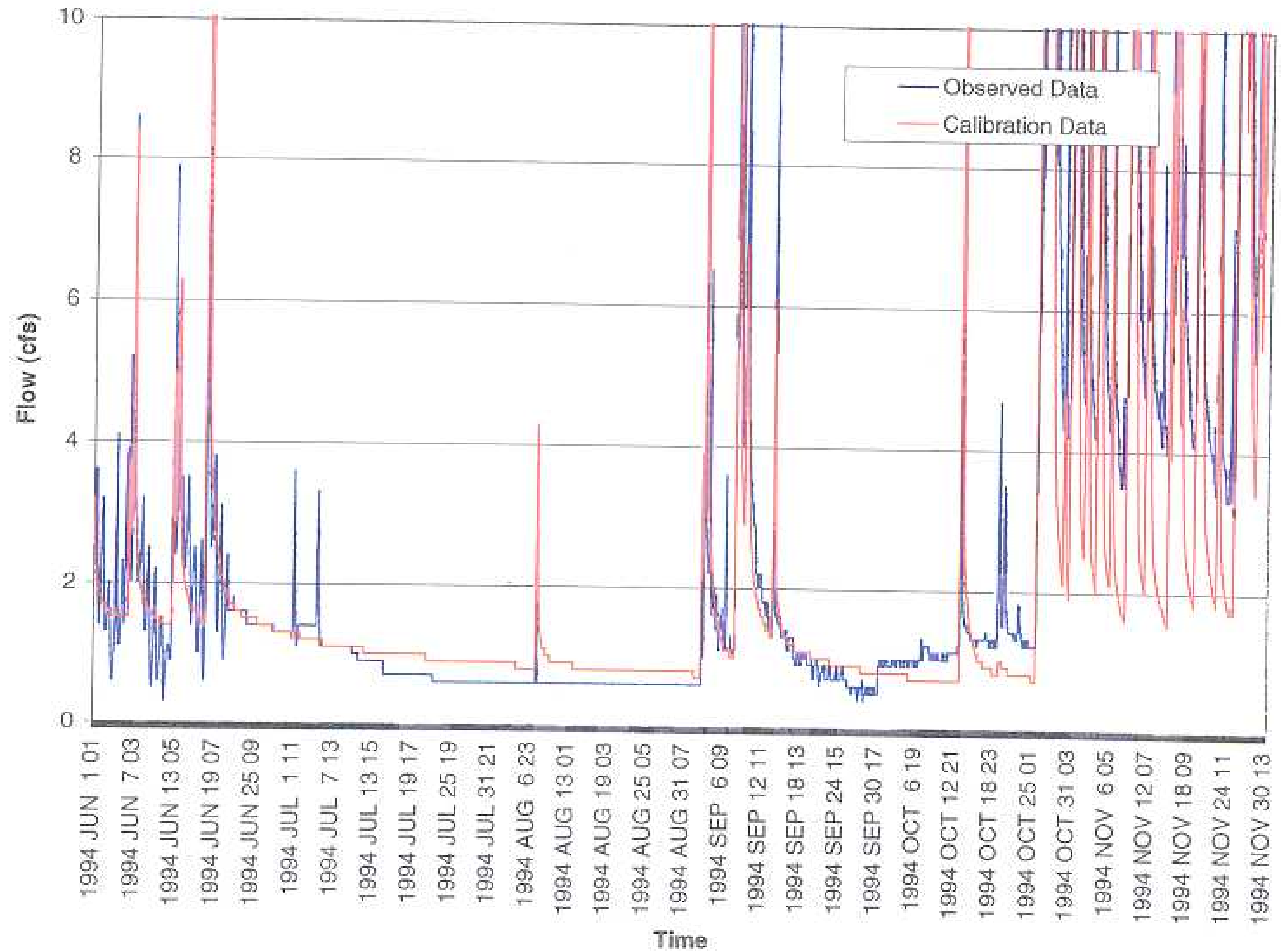
AR 052969

Figure 4-2. Des Moines Creek at the Mouth Observed vs. Calibrated Low Flow 1993



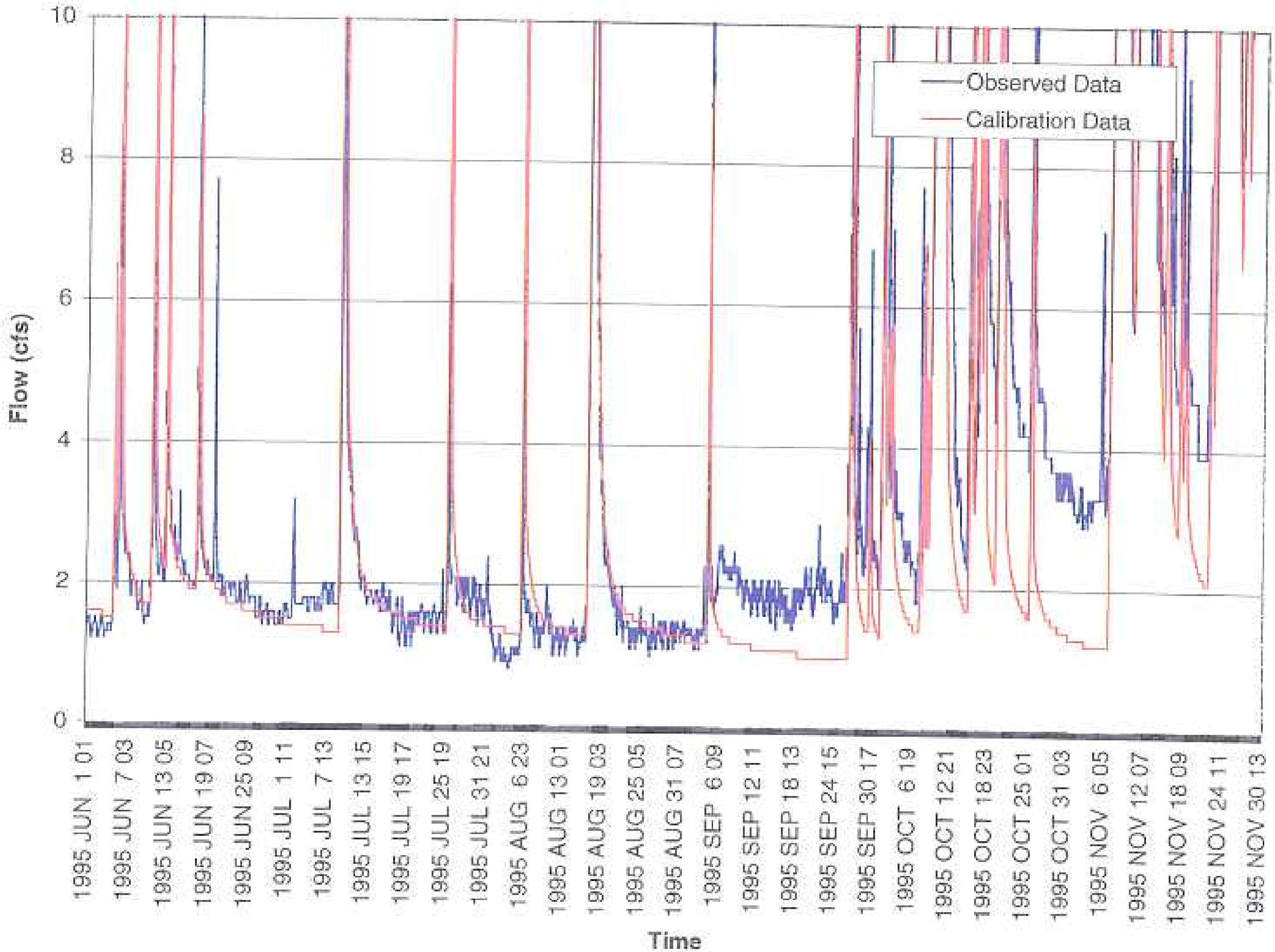
AR 052970

Figure 4-3. Des Moines Creek at the Mouth Observed vs. Calibrated Low Flow 1994



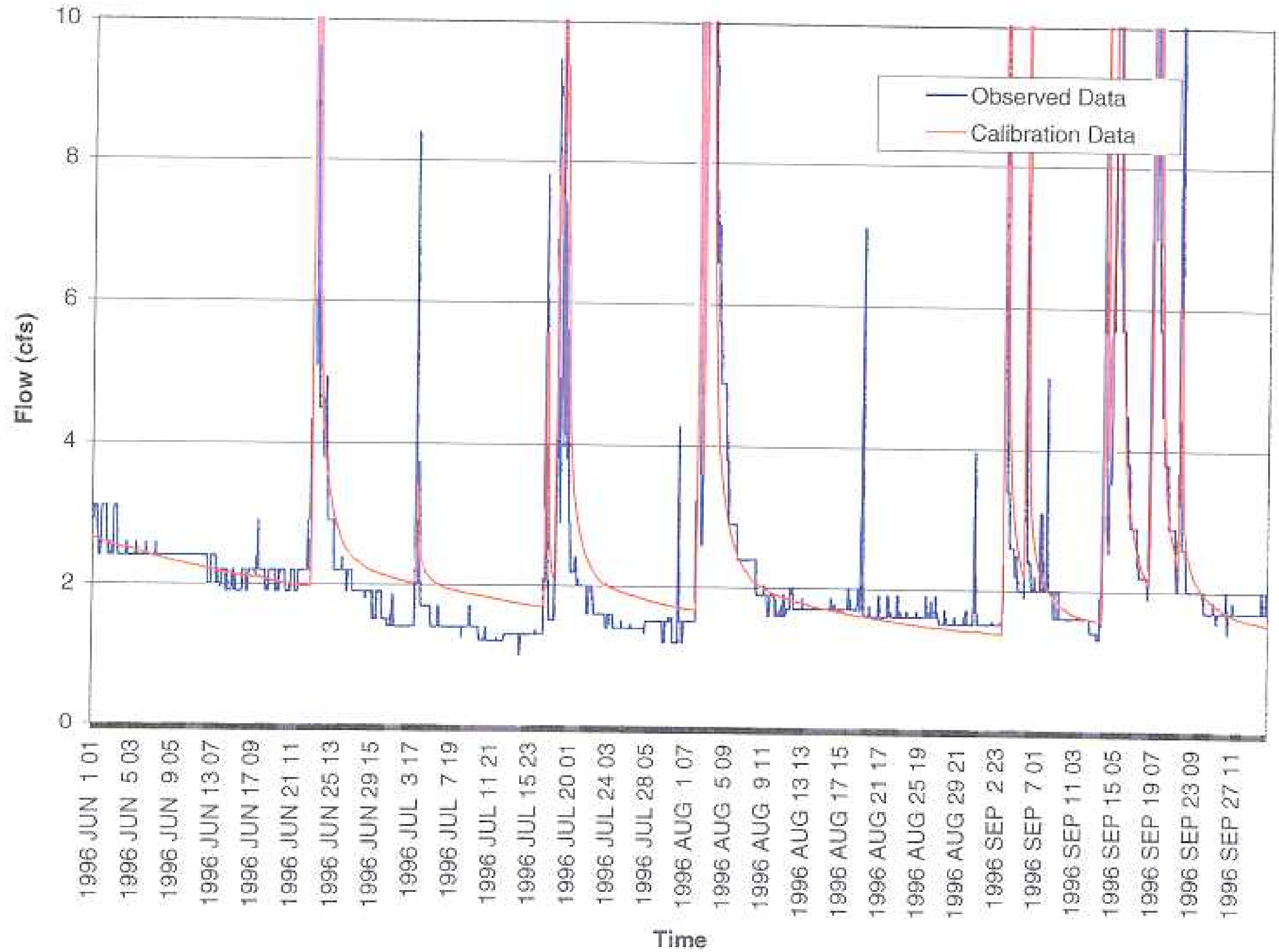
AR 052971

Figure 4-4. Des Moines Creek at the Mouth Observed vs. Calibrated Low Flow 1995



AR 052972

Figure 4-5. Des Moines Creek at the Mouth Observed vs. Calibrated Low Flow 1996



AR 052973

Table 4-2. Des Moines Creek at the mouth, June through November 7-day low flows for water-years 1992 through 1996.

Water-Year	Observed Average Flow (cfs)	Calibrated Average Flow (cfs)	Difference (cfs)
1992	0.585	0.904	-0.318
1993	1.205	0.900	0.305
1994	0.600	0.700	-0.100
1995	1.284	1.000	0.284
1996	1.268	1.411	-0.144
Average Difference	**1.089**	**1.003**	**0.086**

Table 4-3. Des Moines Creek low flow at the mouth, recorded July 15, 1992 base flow.

Date/Hour	Flow (cfs)
1992 JUL 15 01	0.6
1992 JUL 15 02	0.4
1992 JUL 15 03	0.4
1992 JUL 15 04	0.2
1992 JUL 15 05	0.1
1992 JUL 15 06	0.2
1992 JUL 15 07	0.2
1992 JUL 15 08	0.2
1992 JUL 15 09	0.4
1992 JUL 15 10	0.4
1992 JUL 15 11	0.7
1992 JUL 15 12	0.4
1992 JUL 15 13	0.9
1992 JUL 15 14	1.6
1992 JUL 15 15	1.3
1992 JUL 15 16	0.9
1992 JUL 15 17	1.8
1992 JUL 15 18	1.5
1992 JUL 15 19	0.6
1992 JUL 15 20	0.2
1992 JUL 15 21	0.2
1992 JUL 15 22	0.2
1992 JUL 15 23	0.2
1992 JUL 15 24	0.8

4.2 DES MOINES CREEK AT GAGE 11C

Observed and calibrated low flows for Des Moines Creek at gage 11c are shown in Figures 4-6 through 4-11. Average simulated and observed streamflows for each low-flow period are listed in Table 4-4. Average simulated and observed streamflows for each 7-day low-flow period are listed in Table 4-5. The 7-day low-flow period for each observed water-year did not occur during the same 7-day period as the simulated low-flow period. Water-year 1991 had a small gap missing from the observed data.

The simulated average 7-day low flow for all years was consistently lower than the observed low flow. The average difference was 0.61 cfs, with the maximum difference of 1.09 cfs occurring in

1995. Calibrated base flows were generally very flat and ranged between 0.1 and 0.2 cfs, while the observed base flow was more flashy and generally ranged between 0.3 and 1.0 cfs. The simulated 7-day low-flow values were within 0.21 cfs of the observed 7-day low-flow values. The observed maximum 7-day low flow for the period of study was 0.3 cfs, while the simulated maximum 7-day low flow for the period of study was 0.2 cfs.

Table 4-4. Des Moines Creek at gage 11c, June through November low-flow average flows for water-years 1991 through 1996.

Water-Year	Observed Average Flow (cfs)	Calibrated Average Flow (cfs)	Difference (cfs)
1991	1.549	0.954	0.596
1992	1.346	0.948	0.398
1993	1.009	0.581	0.428
1994	1.516	1.043	0.472
1995	3.008	1.923	1.085
1996	1.112	0.652	0.460
Average Difference	**1.661**	**1.050**	**0.611**

Table 4-5. Des Moines Creek at gage 11c, June through November 7-day low flows for water-years 1991 through 1996.

Water-Year	Observed Average Flow (cfs)	Calibrated Average Flow (cfs)	Difference (cfs)
1991	0.300	0.100	0.200
1992	0.172	0.090	0.082
1993	0.133	0.100	0.033
1994	0.046	0.100	-0.054
1995	0.300	0.100	0.200
1996	0.301	0.100	0.201
Average Difference	**0.195**	**0.100**	**0.095**

5. SUMMARY

Low-flow analysis was performed for two gage locations in Miller, Walker, and Des Moines Creeks. Results indicate that calibrated low flows at the mouth of each stream are good, while calibrated low flows at the upstream gages show lower flows than observed flows. Groundwater conditions in each of the watersheds are somewhat speculative and may account for these discrepancies at the upstream gage locations.

Description of Low Flow Landuse Summary Tables

A-1a Miller Creek Surface Water Subbasin Characteristics – 1994 (STIA basins)
A-1b Miller Creek Surface Water Subbasin Characteristics – 2006 (STIA basins)

A-2a Miller Creek Contiguous Groundwater Subbasin Characteristics – 1994 (STIA basins)
A-2b Miller Creek Contiguous Groundwater Subbasin Characteristics – 2006 (STIA basins)

A-3a Miller Creek Non-Contiguous Groundwater Subbasin Characteristics – 1994 (STIA basins)
A-3b Miller Creek Non-Contiguous Groundwater Subbasin Characteristics – 2006 (STIA basins)

A-4a Walker Creek Surface Water Subbasin Characteristics – 1994 (STIA basins)
A-4b Walker Creek Surface Water Subbasin Characteristics – 2006 (STIA basins)

A-5a Walker Creek Contiguous Groundwater Subbasin Characteristics – 1994 (STIA basins)
A-5b Walker Creek Contiguous Groundwater Subbasin Characteristics – 2006 (STIA basins)

A-6a Walker Creek Non-Contiguous Groundwater Subbasin Characteristics – 1994 (STIA basins)
A-6b Walker Creek Non-Contiguous Groundwater Subbasin Characteristics – 2006 (STIA basins)

A-7a Des Moines Creek Surface Water Subbasin Characteristics – 1994 (STIA basins)
A-7b Des Moines Creek Surface Water Subbasin Characteristics – 2006 (STIA basins)

A-8a Des Moines Creek Contiguous Groundwater Subbasin Characteristics – 1994 (STIA basins)
A-8b Des Moines Creek Contiguous Groundwater Subbasin Characteristics – 2006 (STIA basins)

A-9a Des Moines Non-Contiguous Groundwater Subbasin Characteristics – 1994 (STIA basins)
A-9b Des Moines Non-Contiguous Groundwater Subbasin Characteristics – 2006 (STIA basins)

Legend for Miller and Walker Surface Water Subbasin Tables

A-1a, A-1b, A-4a, and A-4b

Soil Types:

M	Till	Modified land (Holocene)
Qb	Outwash	Beach deposits (Holocene)
Qpf	Outwash	Sedimentary deposits of pre-Fraser glaciation age (Pleistocene)
Qu	Outwash	Surficial deposits, undivided (Holocene and Pleistocene)
Qvi	Outwash	Ice-contact deposits
Qvr	Outwash	Recessional outwash deposits
Qvrl	Till	Silt-dominated deposits
Qvt	Till	Till
Qvu	Outwash	Vashon drift, undivided
Qw	Outwash	Wetland deposits (Holocene)
Qyal	Outwash	Younger alluvium (Holocene)
SA	Wetland	
Fill	Airport fill	
TIA	Total impervious area	
EIA	Effective impervious area	

Land Use Types:

COMM	Commercial
F	Forest
HD	High density residential
LD	Low density residential
MF	Multi-family
OG	Grass or open
STIA	Commercial airport and measured EIA
TRANS	Transport

PERLND numbers refer to the unique soil pervious land segment in HSPF.
IMPLND numbers refer to the impervious land segment in HSPF.

Legend for Des Moines Surface Water Subbasin Tables
A-7a and A7b

Soil Types:

OFF	Outwash forest, flat
OFM	Outwash forest, moderate
OFS	Outwash forest, steep
OF	Outwash forest (all slopes)
OGF	Outwash grass, flat
OGM	Outwash grass, moderate
OGS	Outwash grass, steep
OG	Outwash grass (all slopes)
LAC	Lacustrine (till)
TFF	Till forest, flat
TFM	Till forest, moderate
TFS	Till forest, steep
TF	Till forest (all slopes)
TGF	Till grass, flat
TGM	Till grass, moderate
TGS	Till grass, steep
TG	Till grass (all slopes)
SA	Wetland
IMP	Impervious area
TIA	Total impervious area

Land Use Types:

AP	Commercial airport and measured EIA
C	Commercial
TR	Transport
MF	Multi-family
HD	High density residential
LD	Low density residential
G	Grass or open
F	Forest

PERLND numbers refer to the unique soil pervious land segment in HSPF.
IMPLND numbers refer to the impervious land segment in HSPF.

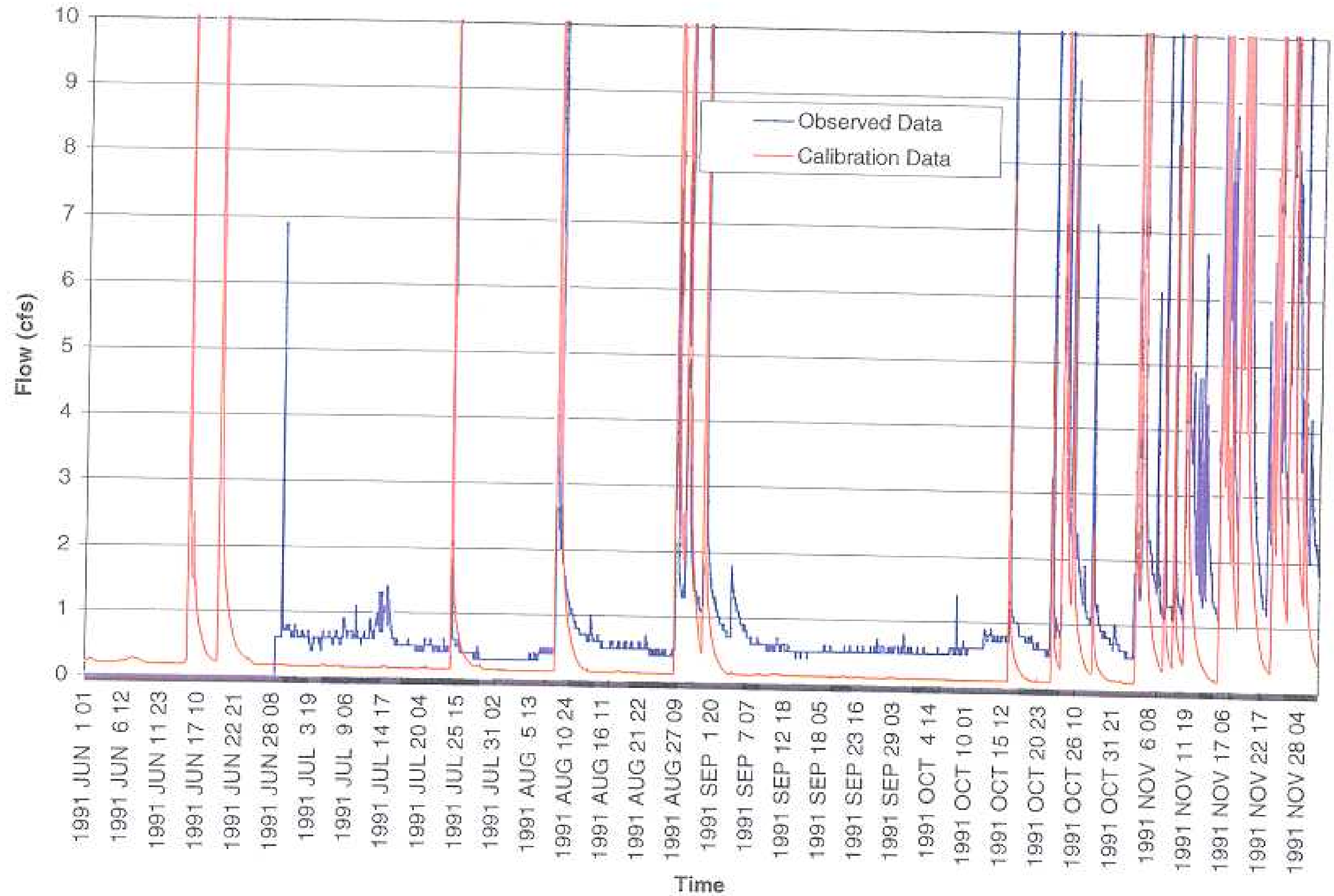
Legend for Groundwater Subbasin Tables

A-2a, A-2b, A-3a, A-3b, A-5a, A-5b, A-6a, A-6b, A-8a, A-8b, A-9a, and A-9b

PERLND Areas:
For each groundwater subbasin, land uses and soil types correspond to those listed for the respective surface water subbasin. PERLND subtotals are calculated separately based on the land use and soil types that apply to a given subbasin. Results of those calculations have been summarized on the groundwater subbasin tables contained in this appendix.

IMPLND Areas:
Impervious areas have been included on the groundwater subbasin tables for tracking purposes only. Impervious areas have not been included in groundwater models.

Figure 4-6. Des Moines Creek at Gage 11c Observed vs. Calibrated Low Flow 1991



AR 052981

Figure 4-7. Des Moines Creek at Gage 11c Observed vs. Calibrated Low Flow 1992

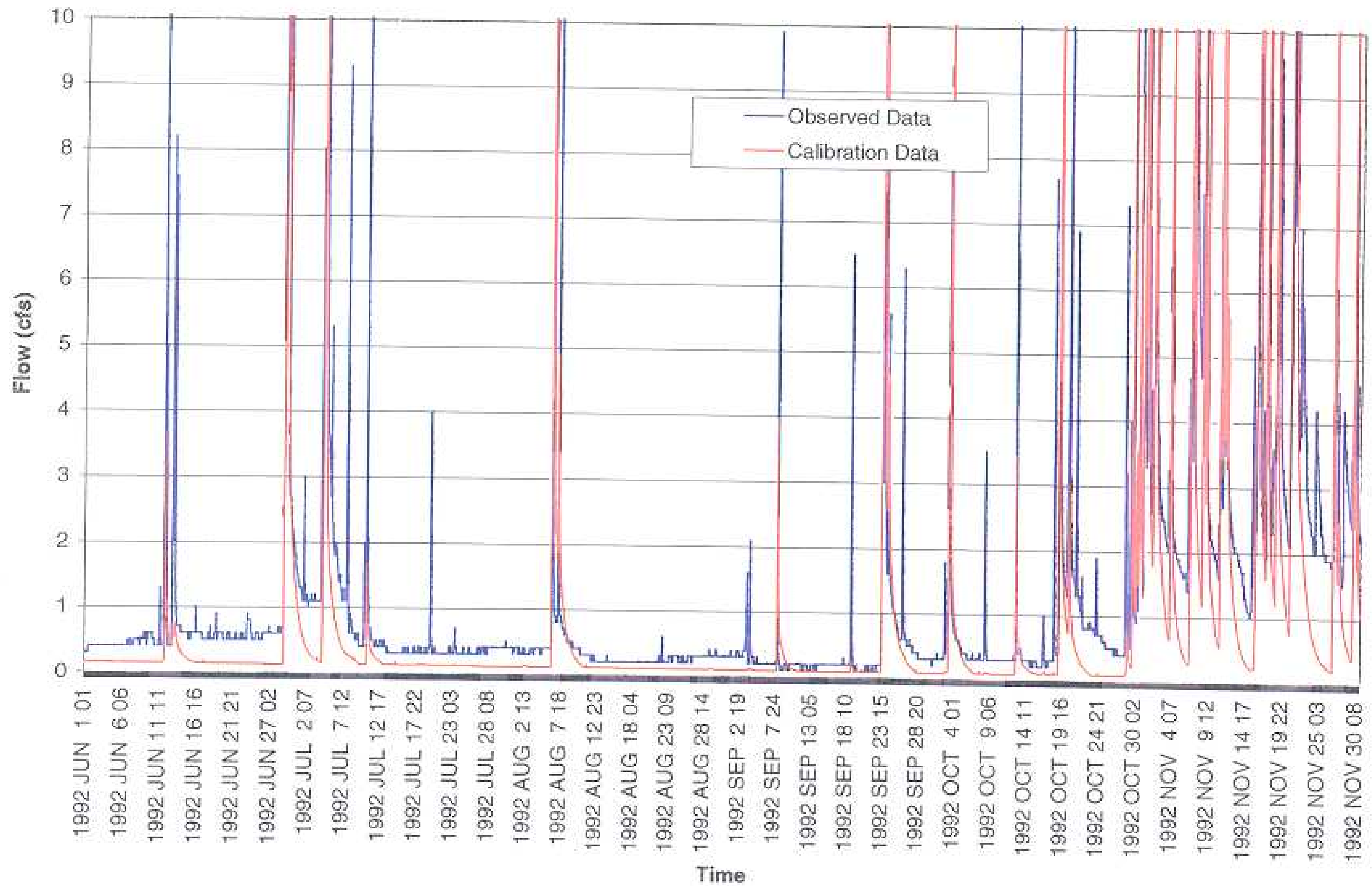
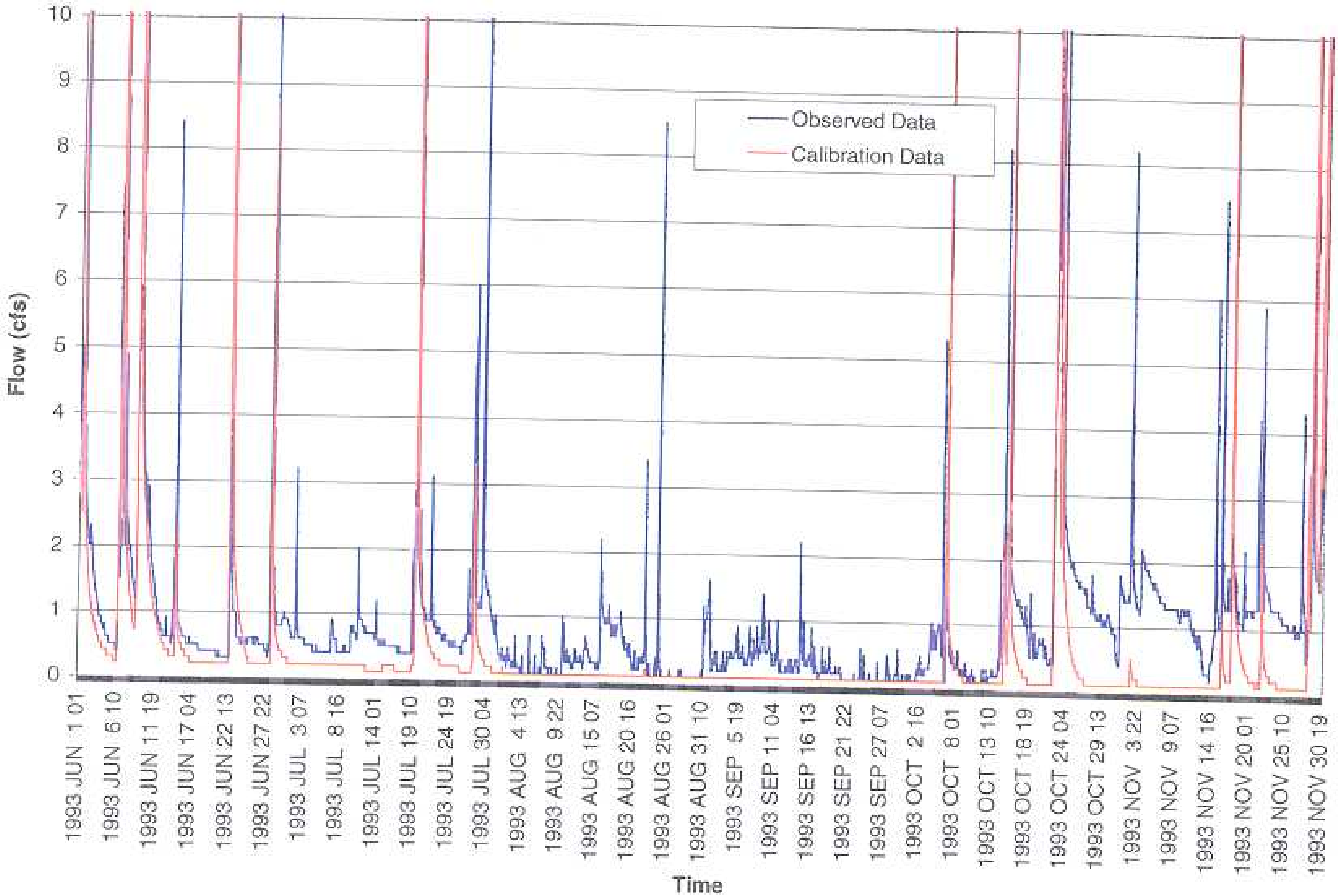
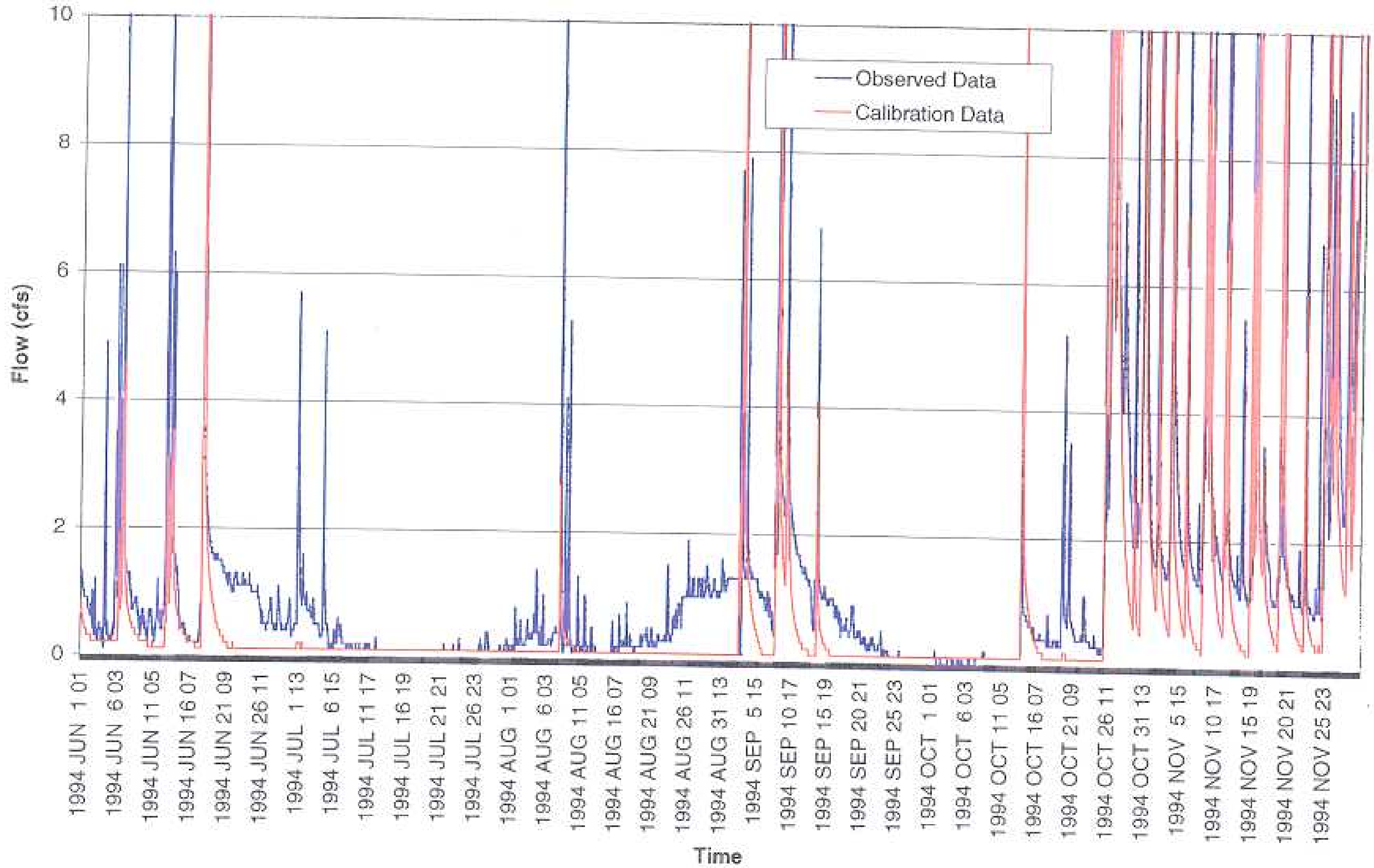


Figure 4-8. Des Moines Creek at Gage 11c Observed vs. Calibrated Low Flow 1993



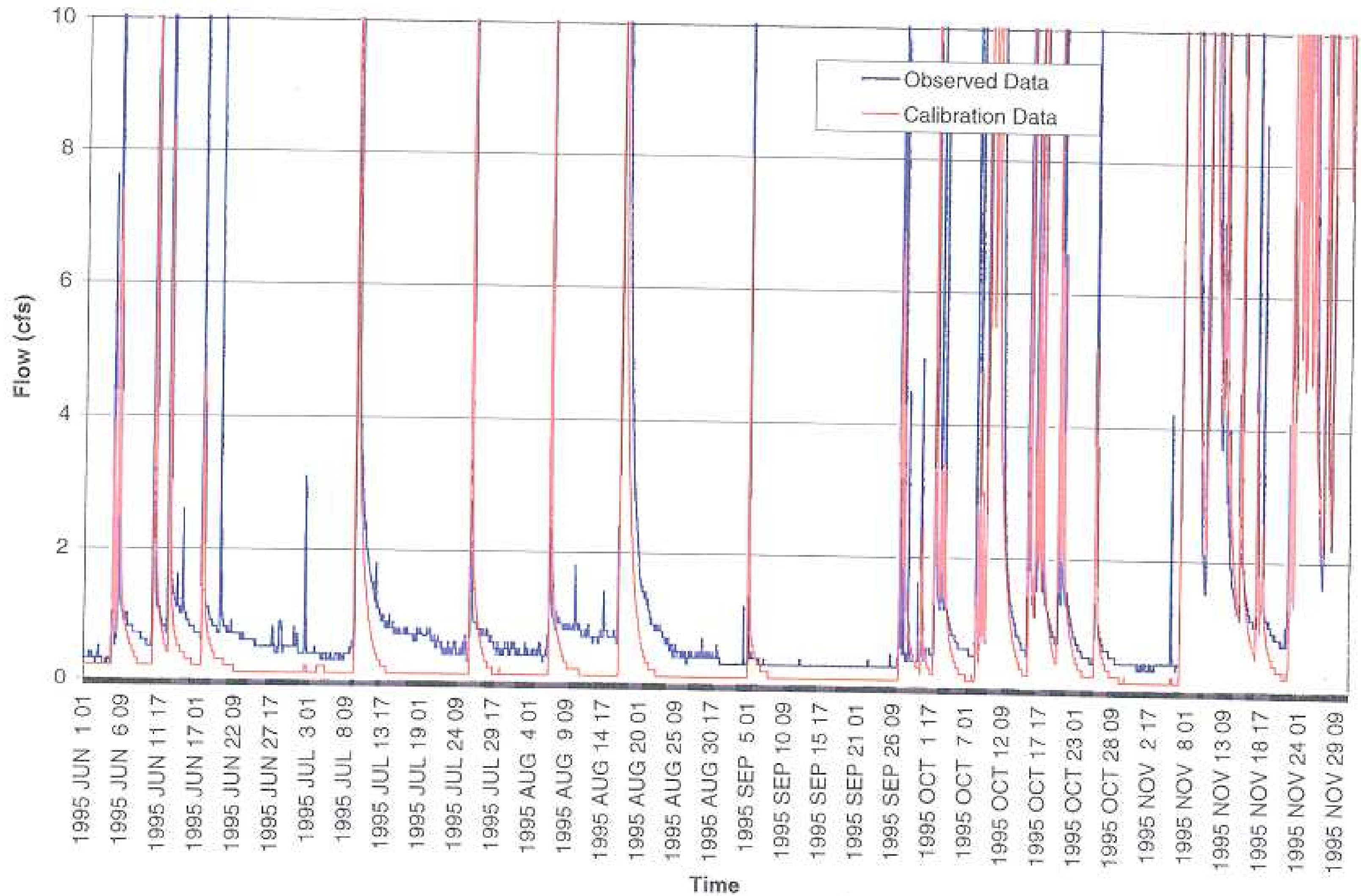
AR 052983

Figure 4-9. Des Moines Creek at Gage 11c Observed vs. Calibrated Low Flow 1994



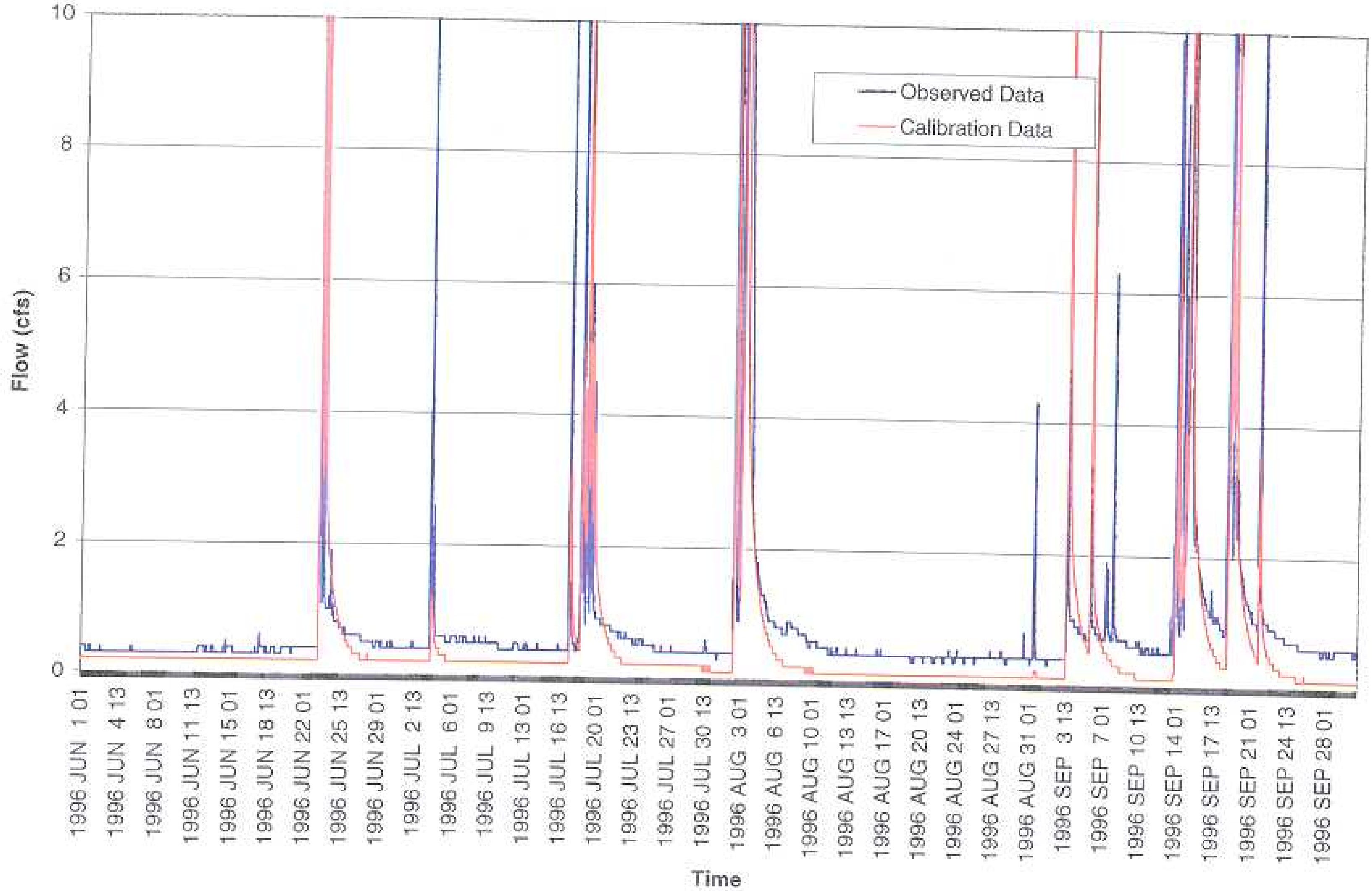
AR 052984

Figure 4-10. Des Moines Creek at Gage 11c Observed vs. Calibrated Low Flow 1995



AR 052985

Figure 4-11. Des Moines Creek at Gage 11c Observed vs. Calibrated Low Flow 1996



AR 052986

Explanation of Calculation of Effective Impervious Area

For all STIA basins:

Effective Impervious Area

- Land use AP/STIA and TR/TRANS: impervious acreage from GIS analysis
- All other land use categories: total acreage within the basin for a given land use and soil type multiplied by the EIA percentage

Pervious Area

- Land use AP/STIA and TR/TRANS: pervious acreage within the basin for a given land use and soil type from GIS analysis
- All other land use categories: total acreage within the basin for a given land use and soil type multiplied by the pervious percentage

Table ı. Miller Creek Surface Water Subbasin Characteristics - 1994 (S ɹasins)

Land Use	Soil Type	% of total basin equal to EIA	Surface Water Subbasin Areas (Acres)													
			M5		M6		M8		M9		M10		M16		MC1n	
			Pervious	Effective Impervious	Pervious	Effective Impervious	Pervious	Effective Impervious	Pervious	Effective Impervious	Pervious	Effective Impervious	Pervious	Effective Impervious	Pervious	Effective Impervious
COMM	Qvr	85%	0.53	3.01	-	-	-	-	-	-	5.35	30.34	0.02	0.12	-	-
	Qvrl	85%	-	-	-	-	-	-	-	-	-	-	0.46	2.60	-	-
	Qvt	85%	2.18	12.34	0.06	0.44	-	-	-	-	-	-	-	-	-	-
F	M	0%	-	-	0.07	-	-	-	-	-	-	-	1.17	-	-	-
	Qu	0%	-	-	-	-	-	-	-	-	-	-	0.77	-	-	-
	Qvr	0%	-	-	13.43	-	-	-	0.05	-	-	-	19.26	-	-	-
	Qvrl	0%	-	-	-	-	-	-	-	-	-	-	9.76	-	-	-
	Qvt	0%	-	-	1.37	-	-	-	4.98	-	4.15	-	-	-	-	-
	Qw	0%	-	-	-	-	-	-	-	-	-	-	-	-	-	-
HD	Qvr	15%	-	-	-	-	0.48	0.06	46.39	8.19	6.98	1.23	15.22	2.69	-	-
	Qvrl	15%	-	-	-	-	-	-	-	-	-	-	16.63	2.94	-	-
	Qvt	15%	-	-	5.70	1.01	-	-	14.03	2.48	19.60	3.46	-	-	-	-
	Qw	15%	-	-	-	-	-	-	-	-	-	-	-	-	-	-
LD	M	4%	-	-	-	-	-	-	-	-	-	-	0.16	0.01	-	-
	Qu	4%	-	-	-	-	-	-	-	-	-	-	0.01	0.00	-	-
	Qvr	4%	9.67	0.40	-	-	14.21	0.59	1.26	0.05	51.59	2.15	5.78	0.24	-	-
	Qvrl	4%	-	-	-	-	-	-	-	-	-	-	9.38	0.39	-	-
	Qvt	4%	-	-	-	-	-	-	-	-	8.02	0.33	-	-	-	-
	Qw	4%	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MF	Qvr	47%	0.62	0.55	-	-	6.68	5.92	5.13	4.55	19.97	17.71	1.19	1.06	-	-
	Qvrl	47%	-	-	-	-	-	-	-	-	-	-	0.20	0.17	-	-
OG	M	0%	-	-	0.21	-	-	-	-	-	-	-	-	-	0.07	-
	Qvr	0%	39.23	-	8.35	-	0.84	-	0.10	-	-	-	1.98	-	7.33	-
	Qvrl	0%	-	-	-	-	-	-	-	-	-	-	0.00	-	-	-
	Qvt	0%	8.11	-	14.35	-	-	-	-	-	-	-	-	-	-	-
	Qw	0%	0.47	-	-	-	-	-	-	-	-	-	-	-	-	-
STIA	M	0%	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Qvr	0%	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Qvt	0%	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Qw	0%	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	TIA	100%	-	-	-	-	-	-	-	-	-	-	-	-	-	-

AR 052988

Table ı. Miller Creek Surface Water Subbasin Characteristics - 1994 (S ȷasins)

Land Use	Soil Type	% of total basin equal to EIA	Surface Water Subbasin Areas (Acres) M5 Pervious	M5 Effective Impervious	M6 Pervious	M6 Effective Impervious	M8 Pervious	M8 Effective Impervious	M9 Pervious	M9 Effective Impervious	M10 Pervious	M10 Effective Impervious	M16 Pervious	M16 Effective Impervious	MC1n Pervious	MC1n Effective Impervious
TRANS	M	0%	-	-	0.03	-	-	-	-	-	-	-	-	-	0.10	-
	Qvr	0%	-	-	3.44	-	-	-	3.83	-	11.34	-	7.22	-	3.82	-
	Qvrl	0%	-	-	-	-	-	-	-	-	-	-	3.48	-	-	-
	Qvt	0%	-	-	-	-	-	-	0.36	-	4.32	-	-	-	-	-
	Qw	0%	-	-	0.01	-	-	-	0.01	-	-	-	-	-	-	-
	TIA	100%	-	-	-	4.79	-	-	-	7.21	-	16.75	-	5.40	-	0.37
	Wetland	0%	10.27	-	0.80	-	-	-	-	-	-	-	-	-	0.27	-
	Lake		0.44		-		-		-		-		-		-	
	Mcrk-df		-		0.07		-		-		-		-		-	
	Other		-		0.01		-		-		0.00		-		-	
Basin total:			71.08	16.31	47.84	6.23	22.21	6.60	76.14	22.47	131.32	71.98	92.70	15.62	11.60	0.37
PERLND areas:																
(16)	Till-Forest		-		1.43		-		4.98		4.15		10.93		-	
(26)	Till-Grass		10.29		20.37		-		14.38		31.94		30.30		0.17	
(34)	Outwash-Forest		-		13.43		-		0.05		-		20.03		-	
(44)	Outwash-Grass		50.05		11.79		22.21		56.71		95.23		31.43		11.15	
(54)	Wetland		10.74		0.82		-		0.01		-		-		0.27	
	subtotal:		71.08		47.84		22.21		76.14		131.32		92.70		11.60	
IMPLND areas:																
	EIA			16.31		6.23		6.60		22.47		71.98		15.62		0.37
Basin total:			87.39		54.07		28.80		98.61		203.30		108.32		11.97	
Percent impervious				18.7%		11.5%		22.9%		22.8%		35.4%		14.4%		3.1%
			M5		M6		M8		M9		M10		M16		MC1n	
NETWORK FACTORS																
PERLND 16	(TF)		-		1.435		-		4.981		4.155		10.932		-	
PERLND 26	(TG)		10.293		20.373		-		14.384		31.943		30.304		0.173	
PERLND 34	(OF)		-		13.426		-		0.048		-		20.035		-	
PERLND 44	(OG)		50.047		11.790		22.206		56.712		95.227		31.426		11.151	
PERLND 54	(SA)		10.742		0.816		-		0.011		-		-		0.272	
IMPLND 14	(EIA)		16.310		6.233		6.598		22.472		71.975		15.619		0.369	
SUM			87.392		54.073		28.804		98.608		203.300		108.315		11.966	

AR 052989

Table .. Miller Creek Surface Water Subbasin Characteristics - 1994 (S asins)

Land Use	Soil Type	% of total basin equal to EIA	Surface Water Subbasin Areas (Acres) MC2 Pervious	MC2 Effective Impervious	MC3 Pervious	MC3 Effective Impervious	MC4 Pervious	MC4 Effective Impervious	MC5 Pervious	MC5 Effective Impervious	MC6 Pervious	MC6 Effective Impervious	MC7 Pervious	MC7 Effective Impervious	CARGO Pervious	CARGO Effective Impervious
COMM	Qvr	85%	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Qvrl	85%	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Qvt	85%	-	-	-	-	-	-	-	-	-	-	-	-	-	-
F	M	0%	0.08	-	-	-	-	-	-	-	-	-	-	-	-	-
	Qu	0%	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Qvr	0%	6.66	-	5.53	-	0.05	-	-	-	-	-	-	-	-	-
	Qvrl	0%	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Qvt	0%	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Qw	0%	4.17	-	1.28	-	-	-	-	-	-	-	-	-	-	-
HD	Qvr	15%	-	-	-	-	9.41	1.66	0.30	0.05	1.74	0.31	2.77	0.49	-	-
	Qvrl	15%	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Qvt	15%	-	-	-	-	-	-	-	-	-	-	9.06	1.60	6.09	1.07
	Qw	15%	-	-	-	-	0.92	0.16	-	-	-	-	-	-	-	-
LD	M	4%	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Qu	4%	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Qvr	4%	-	-	2.55	0.11	3.43	0.14	30.11	1.25	11.62	0.49	23.01	0.96	-	-
	Qvrl	4%	-	-	-	-	-	-	-	-	-	-	0.08	0.00	-	-
	Qvt	4%	-	-	-	-	-	-	13.49	0.56	-	-	0.05	0.00	-	-
	Qw	4%	-	-	-	-	0.33	0.01	-	-	-	-	-	-	-	-
MF	Qvr	47%	-	-	-	-	0.07	0.06	0.71	0.63	-	-	-	-	-	-
	Qvrl	47%	-	-	-	-	-	-	-	-	-	-	-	-	-	-
OG	M	0%	0.62	-	-	-	-	-	-	-	-	-	-	-	-	-
	Qvr	0%	7.86	-	1.16	-	6.56	-	-	-	-	-	4.74	-	-	-
	Qvrl	0%	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Qvt	0%	-	-	-	-	-	-	-	-	-	-	0.04	-	0.96	-
	Qw	0%	0.55	-	0.05	-	7.51	-	-	-	-	-	-	-	-	-
STIA	M	0%	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Qvr	0%	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Qvt	0%	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Qw	0%	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	TIA	100%	-	-	-	-	-	-	-	-	-	-	-	-	-	-

AR 052990

Table . Miller Creek Surface Water Subbasin Characteristics - 1994 (S asins)

Land Use	Soil Type	% of total basin equal to EIA	Surface Water Subbasin Areas (Acres): MC2 Pervious	MC2 Effective Impervious	MC3 Pervious	MC3 Effective Impervious	MC4 Pervious	MC4 Effective Impervious	MC5 Pervious	MC5 Effective Impervious	MC6 Pervious	MC6 Effective Impervious	MC7 Pervious	MC7 Effective Impervious	CARGO Pervious	CARGO Effective Impervious
TRANS	M	0%	0.02	-	-	-	-	-	-	-	-	-	-	-	-	-
	Qvr	0%	2.55	-	1.32	-	-	-	-	-	-	-	0.02	-	-	-
	Qvrl	0%	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Qvt	0%	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Qw	0%	0.22	-	0.43	-	-	-	-	-	-	-	-	-	-	-
	TIA	100%	-	0.27	-	0.01	-	-	-	-	-	-	-	-	-	-
	Wetland	0%	10.30	-	0.52	-	5.94	-	7.60	-	0.99	-	3.47	-	-	-
	Lake		2.98		-		3.35		0.76		0.29		0.24		-	
	Mcrk-dl		7.00		13.17		-		-		-		-		-	
	Other		-		-		-		-		-		-		-	
Basin total:			33.04	0.27	12.83	0.11	34.22	2.04	52.21	2.50	14.55	0.80	43.24	3.05	7.04	1.07
PERLND areas:																
(16)	Till-Forest		0.08		-		-		-		-		-		-	
(26)	Till-Grass		0.64		-		-		13.49		-		9.23		7.04	
(34)	Outwash-Forest		6.66		5.53		0.05		-		-		-		-	
(44)	Outwash-Grass		10.41		5.03		19.47		31.13		13.56		30.54		-	
(54)	Wetland		15.25		2.27		14.70		7.60		0.99		3.47		-	
	subtotal:		33.04		12.83		34.22		52.21		14.55		43.24		7.04	
IMPLND areas:																
	EIA			0.27		0.11		2.04		2.50		0.80		3.05		1.07
Basin total:			33.31		12.94		36.26		54.71		15.35		46.29		8.12	
Percent Impervious				0.8%		0.9%		5.6%		4.6%		5.2%		6.6%		13.2%

		MC2	MC3	MC4	MC5	MC6	MC7	CARGO
NETWORK FACTORS								
PERLND 16	(TF)	0.078	-	-	-	-	-	-
PERLND 26	(TG)	0.635	-	-	13.487	-	9.227	7.043
PERLND 34	(OF)	6.663	5.525	0.049	-	-	-	-
PERLND 44	(OG)	10.414	5.033	19.470	31.127	13.561	30.540	-
PERLND 54	(SA)	15.250	2.273	14.700	7.596	0.987	3.469	-
IMPLND 14	(EIA)	0.270	0.112	2.043	2.503	0.799	3.052	1.074
SUM		33.311	12.943	36.263	54.714	15.347	46.288	8.117

AR 052991

Table [illegible]. Miller Creek Surface Water Subbasin Characteristics - 1994 (S[illegible]basins)

			Surface Water Subbasin Areas (Acres)													
		% of total basin equal to EIA	NEPL		SDN1		SDN1-LWR		SDN1-OFF		SDN2-Xn		SDN3		SDN-3A-I	
Land Use	Soil Type		Pervious	Effective Impervious	Pervious	Effective Impervious	Pervious	Effective Impervious	Pervious	Effective Impervious	Pervious	Effective Impervious	Pervious	Effective Impervious	Pervious	Effective Impervious
COMM	Qvr	85%	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Qvrl	85%	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Qvt	85%	0.15	0.87	-	-	-	-	-	-	-	-	-	-	-	-
F	M	0%	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Qu	0%	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Qvr	0%	8.78	-	-	-	-	-	-	-	-	-	-	-	1.03	-
	Qvrl	0%	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Qvt	0%	8.77	-	-	-	-	-	-	-	-	-	-	-	-	-
	Qw	0%	-	-	-	-	-	-	-	-	-	-	-	-	-	-
HD	Qvr	15%	-	-	-	-	-	-	-	-	-	-	-	-	2.12	0.37
	Qvrl	15%	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Qvt	15%	-	-	-	-	-	-	14.65	2.58	-	-	-	-	-	-
	Qw	15%	-	-	-	-	-	-	-	-	-	-	-	-	-	-
LD	M	4%	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Qu	4%	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Qvr	4%	-	-	-	-	-	-	-	-	-	-	-	-	0.62	0.03
	Qvrl	4%	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Qvt	4%	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Qw	4%	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MF	Qvr	47%	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Qvrl	47%	-	-	-	-	-	-	-	-	-	-	-	-	-	-
OG	M	0%	-	-	-	-	-	-	0.00	-	1.14	-	0.02	-	-	-
	Qvr	0%	2.40	-	1.05	-	4.87	-	0.37	-	3.12	-	-	-	1.09	-
	Qvrl	0%	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Qvt	0%	21.32	-	1.82	-	-	-	3.40	-	-	-	7.85	-	5.27	-
	Qw	0%	-	-	-	-	-	-	-	-	-	-	-	-	-	-
STIA	M	0%	-	-	-	-	-	-	-	-	-	-	6.62	-	-	-
	Qvr	0%	-	-	0.47	-	-	-	-	-	-	-	-	-	-	-
	Qvt	0%	-	-	1.93	-	-	-	-	-	-	-	18.87	-	-	-
	Qw	0%	-	-	0.17	-	-	-	-	-	-	-	-	-	-	-
	TIA	100%	-	-	-	8.69	-	-	-	-	-	-	-	14.50	-	-

AR 052992

Table 1. Miller Creek Surface Water Subbasin Characteristics - 1994 (S... basins)

Land Use	Soil Type	% of total basin equal to EIA	Surface Water Subbasin Areas (Acres) NEPL Pervious	NEPL Effective Impervious	SDN1 Pervious	SDN1 Effective Impervious	SDN1-LWR Pervious	SDN1-LWR Effective Impervious	SDN1-OFF Pervious	SDN1-OFF Effective Impervious	SDN2-Xn Pervious	SDN2-Xn Effective Impervious	SDN3 Pervious	SDN3 Effective Impervious	SDN-3A-I Pervious	SDN-3A-I Effective Impervious
TRANS	M	0%	-	-	-	-	-	-	0.68	-	-	-	-	-	-	-
	Qvr	0%	-	-	0.78	-	0.10	-	3.28	-	-	-	-	-	-	-
	Qvrl	0%	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Qvt	0%	-	-	-	-	-	-	1.76	-	-	-	-	-	-	-
	Qw	0%	-	-	0.03	-	-	-	1.63	-	-	-	-	-	-	-
	TIA	100%	-	-	-	1.22	-	0.38	-	7.88	-	-	-	-	-	-
	Wetland	0%	-	-	-	-	0.07	-	0.04	-	-	-	-	-	-	-
	Lake		-		-		-		-		-		-		-	
	Mcrk-df		-		-		-		-		-		-		-	
	Other		-		-		-		0.04		-		-		-	
Basin total:			41.42	0.87	6.24	9.90	5.04	0.38	25.81	10.46	4.26	-	33.36	14.50	10.13	0.40
PERLND areas:																
(16)	Till-Forest		8.77		-		-		-		-		-		-	
(26)	Till-Grass		21.47		3.74		-		20.48		1.14		33.36		5.27	
(34)	Outwash-Forest		8.78		-		-		-		-		-		1.03	
(44)	Outwash-Grass		2.40		2.29		4.97		3.65		3.12		-		3.82	
(54)	Wetland		-		0.20		0.07		1.67		-		-		-	
	subtotal:		41.42		6.24		5.04		25.81		4.26		33.36		10.13	
IMPLND areas:																
	EIA			0.87		9.90		0.38		10.46		-		14.50		0.40
Basin total:			42.29		16.14		5.42		36.27		4.26		47.86		10.52	
Percent Impervious				2.1%		61.4%		7.0%		28.8%		0.0%		30.3%		3.8%
			NEPL		SDN1		SDN1-LWR		SDN1-OFF		SDN2-Xn		SDN3		SDN-3A-I	
NETWORK FACTORS																
PERLND 16	(TF)		8.771		-		-		-		-		-		-	
PERLND 26	(TG)		21.470		3.743		-		20.485		1.138		33.359		5.272	
PERLND 34	(OF)		8.779		-		-		-		-		-		1.028	
PERLND 44	(OG)		2.398		2.292		4.974		3.651		3.122		-		3.825	
PERLND 54	(SA)		-		0.200		0.071		1.673		-		-		-	
IMPLND 14	(EIA)		0.873		9.904		0.378		10.461		-		14.497		0.399	
SUM			42.291		16.139		5.423		36.269		4.260		47.856		10.524	

AR 052993

Table ı. Miller Creek Surface Water Subbasin Characteristics - 1994 (S asins)

			Surface Water Subbasin Areas (Acres)													
		% of total basin	SDN-3A-O		SDN3-X		SDN4		SDN4-X		SDW-1A-I		SDW-1A-O		SDW-1B-I	
Land Use	Soil Type	equal to EIA	Pervious	Effective Impervious	Pervious	Effective Impervious	Pervious	Effective Impervious	Pervious	Effective Impervious	Pervious	Effective Impervious	Pervious	Effective Impervious	Pervious	Effective Impervious
COMM	Qvr	85%	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Qvrl	85%	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Qvt	85%	-	-	-	-	-	-	-	-	-	-	-	-	-	-
F	M	0%	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Qu	0%	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Qvr	0%	8.09	-	12.20	-	-	-	1.22	-	-	-	-	-	-	-
	Qvrl	0%	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Qvt	0%	-	-	0.65	-	-	-	-	-	-	-	-	-	-	-
	Qw	0%	-	-	-	-	-	-	-	-	-	-	-	-	-	-
HD	Qvr	15%	8.28	1.46	-	-	-	-	-	-	-	-	0.06	0.01	0.75	0.13
	Qvrl	15%	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Qvt	15%	-	-	-	-	-	-	-	-	-	-	-	-	4.63	0.82
	Qw	15%	-	-	-	-	-	-	-	-	-	-	-	-	-	-
LD	M	4%	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Qu	4%	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Qvr	4%	0.16	0.01	-	-	-	-	-	-	8.50	0.35	12.14	0.51	4.95	0.21
	Qvrl	4%	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Qvt	4%	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Qw	4%	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MF	Qvr	47%	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Qvrl	47%	-	-	-	-	-	-	-	-	-	-	-	-	-	-
OG	M	0%	-	-	-	-	4.70	-	0.22	-	-	-	-	-	2.49	-
	Qvr	0%	1.74	-	5.01	-	3.18	-	9.51	-	4.18	-	-	-	14.61	-
	Qvrl	0%	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Qvt	0%	-	-	6.94	-	-	-	0.71	-	24.10	-	-	-	31.33	-
	Qw	0%	-	-	-	-	-	-	-	-	-	-	-	-	-	-
STIA	M	0%	-	-	-	-	19.72	-	1.83	-	-	-	-	-	14.15	-
	Qvr	0%	-	-	-	-	0.02	-	0.66	-	-	-	-	-	-	-
	Qvt	0%	-	-	-	-	0.06	-	-	-	-	-	-	-	0.47	-
	Qw	0%	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	TIA	100%	-	-	-	-	-	2.63	-	1.05	-	-	-	-	-	2.02

AR 052994

Table .. Miller Creek Surface Water Subbasin Characteristics - 1994 (S ¡asins)

Land Use	Soil Type	% of total basin equal to EIA	SDN-3A-O Pervious	SDN-3A-O Effective Impervious	SDN3-X Pervious	SDN3-X Effective Impervious	SDN4 Pervious	SDN4 Effective Impervious	SDN4-X Pervious	SDN4-X Effective Impervious	SDW-1A-I Pervious	SDW-1A-I Effective Impervious	SDW-1A-O Pervious	SDW-1A-O Effective Impervious	SDW-1B-I Pervious	SDW-1B-I Effective Impervious
			Surface Water Subbasin Areas (Acres)													
TRANS	M	0%	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Qvr	0%	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Qvrl	0%	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Qvt	0%	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Qw	0%	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	TIA	100%	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Wetland	0%	0.19	-	0.57	-	-	-	-	-	0.33	-	2.63	-	3.31	-
	Lake		-		-		-		-		-		-		-	
	Mcrk-df		-		-		-		-		-		-		-	
	Other		-		-		-		-		-		-		-	
Basin total:			18.45	1.47	25.38	-	27.69	2.63	14.14	1.05	37.11	0.35	14.84	0.52	76.68	3.18
PERLND areas:																
(16)	Till-Forest		-		0.65		-		-		-		-		-	
(26)	Till-Grass		-		6.94		24.49		2.76		24.10		-		53.06	
(34)	Outwash-Forest		8.09		12.20		-		1.22		-		-		-	
(44)	Outwash-Grass		10.18		5.01		3.20		10.16		12.68		12.21		20.31	
(54)	Wetland		0.19		0.57		-		-		0.33		2.63		3.31	
	subtotal:		18.45		25.38		27.69		14.14		37.11		14.84		76.68	
IMPLND areas:																
	EIA			1.47		-		2.63		1.05		0.35		0.52		3.18
Basin total:			19.92		25.38		30.32		15.18		37.47		15.36		79.86	
Percent impervious				7.4%		0.0%		8.7%		6.9%		0.9%		3.4%		4.0%
			SDN-3A-O		SDN3-X		SDN4		SDN4-X		SDW-1A-I		SDW-1A-O		SDW-1B-I	
NETWORK FACTORS																
PERLND 16	(TF)		-		0.650		-		-		-		-		-	
PERLND 26	(TG)		-		6.944		24.488		2.757		24.102		-		53.059	
PERLND 34	(OF)		8.092		12.201		-		1.215		-		-		-	
PERLND 44	(OG)		10.176		5.010		3.204		10.163		12.681		12.207		20.312	
PERLND 54	(SA)		0.186		0.574		-		-		0.330		2.634		3.308	
IMPLND 14	(EIA)		1.467		-		2.627		1.049		0.354		0.517		3.176	
SUM			19.921		25.379		30.319		15.184		37.467		15.358		79.856	

AR 052995

Table . Miller Creek Surface Water Subbasin Characteristics - 1994 (S asins)

Land Use	Soil Type	% of total basin equal to EIA	SDW-1B-O Pervious	SDW-1B-O Effective Impervious	IWS-MILLER Pervious	IWS-MILLER Effective Impervious	IWS-NCPS Pervious	IWS-NCPS Effective Impervious	IWS-NSMPS Pervious	IWS-NSMPS Effective Impervious	Total Pervious	Total Effective Impervious	Percent of Total Pervious	Percent of Total Effective Impervious
COMM	Qvr	85%	-	-	-	-	-	-	-	-	5.91	33.48	0.47%	2.69%
	Qvrl	85%	-	-	-	-	-	-	-	-	0.46	2.60	0.04%	0.21%
	Qvt	85%	-	-	-	-	-	-	-	-	2.41	13.66	0.19%	1.10%
F	M	0%	-	-	-	-	-	-	-	-	1.32	-	0.11%	0.00%
	Qu	0%	-	-	-	-	-	-	-	-	0.77	-	0.06%	0.00%
	Qvr	0%	-	-	-	-	-	-	-	-	76.29	-	6.13%	0.00%
	Qvrl	0%	-	-	-	-	-	-	-	-	9.76	-	0.78%	0.00%
	Qvt	0%	-	-	-	-	-	-	-	-	19.92	-	1.60%	0.00%
	Qw	0%	-	-	-	-	-	-	-	-	5.44	-	0.44%	0.00%
HD	Qvr	15%	0.89	0.16	-	-	-	-	-	-	95.38	16.83	7.66%	1.35%
	Qvrl	15%	-	-	-	-	-	-	-	-	16.63	2.94	1.34%	0.24%
	Qvt	15%	4.21	0.74	-	-	-	-	-	-	77.96	13.76	6.26%	1.11%
	Qw	15%	-	-	-	-	-	-	-	-	0.92	0.16	0.07%	0.01%
LD	M	4%	-	-	-	-	-	-	-	-	0.16	0.01	0.01%	0.00%
	Qu	4%	-	-	-	-	-	-	-	-	0.01	0.00	0.00%	0.00%
	Qvr	4%	6.30	0.26	-	-	-	-	-	-	186.10	7.75	14.95%	0.62%
	Qvrl	4%	-	-	-	-	-	-	-	-	9.45	0.39	0.76%	0.03%
	Qvt	4%	-	-	-	-	-	-	-	-	21.56	0.90	1.73%	0.07%
	Qw	4%	-	-	-	-	-	-	-	-	0.33	0.01	0.03%	0.00%
MF	Qvr	47%	-	-	-	-	-	-	-	-	34.37	30.48	2.76%	2.45%
	Qvrl	47%	-	-	-	-	-	-	-	-	0.20	0.17	0.02%	0.01%
OG	M	0%	-	-	-	-	0.41	-	1.73	-	11.61	-	0.93%	0.00%
	Qvr	0%	-	-	8.54	-	-	-	1.86	-	131.15	-	10.53%	0.00%
	Qvrl	0%	-	-	-	-	-	-	-	-	0.00	-	0.00%	0.00%
	Qvt	0%	-	-	3.85	-	-	-	-	-	126.20	-	10.14%	0.00%
	Qw	0%	-	-	-	-	-	-	-	-	8.59	-	0.69%	0.00%
STIA	M	0%	-	-	0.06	-	6.52	-	1.97	-	50.81	-	4.08%	0.00%
	Qvr	0%	-	-	0.08	-	-	-	1.02	-	2.17	-	0.17%	0.00%
	Qvt	0%	-	-	0.33	-	-	-	-	-	21.32	-	1.71%	0.00%
	Qw	0%	-	-	0.00	-	-	-	-	-	0.17	-	0.01%	0.00%
	TIA	100%	-	-	-	30.41	-	28.79	-	0.04	-	57.71	0.00%	4.64%

AR 052996

Table ‹. Miller Creek Surface Water Subbasin Characteristics - 1994 (S ›asins)

Land Use	Soil Type	% of total basin equal to EIA	SDW-1B-O Pervious	SDW-1B-O Effective Impervious	IWS-MILLER Pervious	IWS-MILLER Effective Impervious	IWS-NCPS Pervious	IWS-NCPS Effective Impervious	IWS-NSMPS Pervious	IWS-NSMPS Effective Impervious	Total Pervious	Total Effective Impervious	Percent of Total Pervious	Percent of Total Effective Impervious
			Surface Water Subbasin Areas (Acres)											
TRANS	M	0%	-	-	-	-	-	-	-	-	0.83	-	0.07%	0.00%
	Qvr	0%	-	-	0.00	-	-	-	-	-	37.71	-	3.03%	0.00%
	Qvrl	0%	-	-	-	-	-	-	-	-	3.48	-	0.28%	0.00%
	Qvt	0%	-	-	-	-	-	-	-	-	6.43	-	0.52%	0.00%
	Qw	0%	-	-	-	-	-	-	-	-	2.33	-	0.19%	0.00%
	TIA	100%	-	-	-	0.50	-	-	-	-	-	44.27	0.00%	3.56%
	Wetland	0%	4.43	-	-	-	-	-	-	-	51.73		4.15%	
	Lake		-		-		-		-		8.06		0.65%	
	Mcrk-dl		-		-		-		-		20.24		1.63%	
	Other		-		-		-		-		0.04		0.00%	
Basin total:			15.84	1.16	12.86	30.92	6.93	28.79	6.58	0.04	1019.90	225.13	81.92%	18.08%
PERLND areas:														
(16)	Till-Forest		-		-		-		-		31.00		2.41%	
(26)	Till-Grass		4.21		4.23		6.93		3.71		353.76		27.45%	
(34)	Outwash-Forest		-		-		-		-		77.06		5.98%	
(44)	Outwash-Grass		7.20		8.62		-		2.88		501.42		38.91%	
(54)	Wetland		4.43		0.00		-		-		69.52		5.39%	
	subtotal:		15.84		12.86		6.93		6.58		1032.76		80.13%	
IMPLND areas:														
	EIA			1.16		30.92		28.79		0.04		256.05		19.87%
Basin total:			17.00		43.78		35.71		6.63		1288.81		100.00%	
Percent Impervious				6.8%		70.6%		80.6%		0.7%				

		SDW-1B-O	IWS-MILLER	IWS-NCPS	IWS-NSMPS	Total	Percent of Total
NETWORK FACTORS							
PERLND 16	(TF)	-	-	-	-	31.001	2.41%
PERLND 26	(TG)	4.214	4.230	6.928	3.705	353.755	27.45%
PERLND 34	(OF)	-	-	-	-	77.062	5.98%
PERLND 44	(OG)	7.198	8.625	-	2.877	501.422	38.91%
PERLND 54	(SA)	4.427	0.004	-	-	69.523	5.39%
IMPLND 14	(EIA)	1.164	30.917	28.787	0.044	256.046	19.87%
SUM		17.004	43.775	35.715	6.626	1288.809	100.00%

AR 052997

Table J. Miller Creek Surface Water Subbasin Characteristics - 2006 (S Jasins)

Land Use	Soil Type	% of total basin equal to EIA	Surface Water Subbasin Areas (Acres)													
			M5		M6		M8		M9		M10		M16		MC1n	
			Pervious	Effective Impervious	Pervious	Effective Impervious	Pervious	Effective Impervious	Pervious	Effective Impervious	Pervious	Effective Impervious	Pervious	Effective Impervious	Pervious	Effective Impervious
COMM	Qvr	85%	0.53	3.01	-	-	-	-	-	-	5.35	30.34	0.02	0.12	-	-
	Qvrl	85%	-	-	-	-	-	-	-	-	-	-	0.46	2.60	-	-
	Qvt	85%	2.18	12.34	0.08	0.44	-	-	-	-	-	-	-	-	-	-
F	Fill		-	-	-	-	-	-	-	-	-	-	-	-	-	-
	M	0%	-	-	0.07	-	-	-	-	-	-	-	1.17	-	-	-
	Qu	0%	-	-	-	-	-	-	-	-	-	-	0.77	-	-	-
	Qvr	0%	-	-	13.44	-	-	-	0.05	-	-	-	19.26	-	-	-
	Qvrl	0%	-	-	-	-	-	-	-	-	-	-	9.76	-	-	-
	Qvt	0%	-	-	1.35	-	-	-	4.98	-	4.15	-	-	-	-	-
	Qw	0%	-	-	-	-	-	-	-	-	-	-	-	-	-	-
HD	Qvr	15%	-	-	-	-	0.48	0.08	46.39	8.19	6.98	1.23	15.22	2.69	-	-
	Qvrl	15%	-	-	-	-	-	-	-	-	-	-	16.63	2.94	-	-
	Qvt	15%	-	-	5.70	1.01	-	-	14.03	2.48	19.60	3.46	-	-	-	-
LD	M	4%	-	-	-	-	-	-	-	-	-	-	0.15	0.01	-	-
	Qu	4%	-	-	-	-	-	-	-	-	-	-	0.01	0.00	-	-
	Qvr	4%	9.67	0.40	-	-	14.21	0.59	1.26	0.05	51.59	2.15	5.35	0.22	-	-
	Qvrl	4%	-	-	-	-	-	-	-	-	-	-	8.95	0.37	-	-
	Qvt	4%	-	-	-	-	-	-	-	-	8.02	0.33	-	-	-	-
MF	Qvr	47%	0.62	0.55	-	-	6.68	5.92	5.13	4.55	19.97	17.71	1.19	1.06	-	-
	Qvrl	47%	-	-	-	-	-	-	-	-	-	-	0.20	0.17	-	-
OG	M	0%	-	-	0.21	-	-	-	-	-	-	-	-	-	0.04	-
	Qvr	0%	39.23	-	8.34	-	0.84	-	0.10	-	-	-	2.82	-	2.41	-
	Qvrl	0%	-	-	-	-	-	-	-	-	-	-	0.06	-	-	-
	Qvt	0%	8.12	-	14.36	-	-	-	-	-	-	-	-	-	-	-
	Qw	0%	0.47	-	-	-	-	-	-	-	-	-	-	-	-	-
STIA	Fill	0%	-	-	-	-	-	-	-	-	-	-	-	-	0.14	-
	M	0%	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Qvr	0%	-	-	-	-	-	-	-	-	-	-	-	-	3.19	-
	Qvt	0%	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Qw	0%	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	TIA	100%	-	-	-	-	-	0.00	-	-	-	-	-	-	-	1.63

Table ɔ. Miller Creek Surface Water Subbasin Characteristics - 2006 (S ɔasins)

Land Use	Soil Type	% of total basin equal to EIA	M5 Pervious	M5 Effective Impervious	M6 Pervious	M6 Effective Impervious	M8 Pervious	M8 Effective Impervious	M9 Pervious	M9 Effective Impervious	M10 Pervious	M10 Effective Impervious	M16 Pervious	M16 Effective Impervious	MC1n Pervious	MC1n Effective Impervious
			Surface Water Subbasin Areas (Acres)													
TRANS	M	0%	-	-	0.03	-	-	-	-	-	-	-	-	-	0.10	-
	Qvr	0%	-	-	3.45	-	-	-	3.83	-	11.33	-	7.22	-	3.84	-
	Qvrl	0%	-	-	-	-	-	-	-	-	-	-	3.48	-	-	-
	Qvt	0%	-	-	-	-	-	-	0.36	-	4.32	-	-	-	-	-
	Qw	0%	-	-	0.01	-	-	-	0.01	-	-	-	-	-	-	-
	TIA	100%	-	-	-	4.78	-	-	-	7.21	-	16.76	-	5.40	-	0.35
	Wetland	0%	10.27	-	0.80	-	-	-	-	-	-	-	-	-	0.27	-
	Lake		0.44		-		-		-		-		-		-	
	Mcrk-df		-		0.07		-		-		-		-		-	
	Other		-		0.01		-		-		0.00		-		-	
Basin total:			71.08	16.31	47.84	6.23	22.21	6.60	76.14	22.47	131.32	71.98	92.73	15.58	9.99	1.98
PERLND areas:																
(16)	Till-Forest		-		1.42		-		4.98		4.15		10.93		-	
(26)	Till-Grass		10.29		20.38		-		14.38		31.94		29.93		0.14	
(34)	Outwash-Forest		-		13.44		-		0.05		-		20.03		-	
(44)	Outwash-Grass		50.05		11.79		22.21		56.71		95.22		31.83		9.44	
(45)	Fill		-		-		-		-		-		-		0.14	
(54)	Wetland		10.74		0.82		-		0.01		-		-		0.27	
	subtotal:		71.08		47.84		22.21		76.14		131.32		92.73		9.99	
IMPLND areas:																
	EIA			16.31		6.23		6.60		22.47		71.98		15.58		1.98
Basin total:			87.39		54.07		28.80		98.61		203.30		108.32		11.97	
Percent Impervious				18.7%		11.5%		22.9%		22.8%		35.4%		14.4%		16.5%
			M5		M6		M8		M9		M10		M16		MC1n	
NETWORK FACTORS																
PERLND 16	(TF)		-		1.417		-		4.981		4.155		10.932		-	
PERLND 26	(TG)		10.293		20.376		-		14.384		31.940		29.933		0.138	
PERLND 34	(OF)		-		13.444		-		0.048		-		20.035		-	
PERLND 44	(OG)		50.047		11.791		22.206		56.712		95.222		31.833		9.437	
PERLND 45	(FL)		-		-		-		-		-		-		0.140	
PERLND 54	(SA)		10.743		0.816		-		0.011		-		-		0.272	
IMPLND 14	(EIA)		16.309		6.229		6.599		22.472		71.984		15.582		1.979	
SUM			87.392		54.073		28.804		98.608		203.300		108.315		11.966	

AR 052999

Table ‚. Miller Creek Surface Water Subbasin Characteristics - 2006 (S ›asins)

Land Use	Soil Type	% of total basin equal to EIA	MC2 Pervious	MC2 Effective Impervious	MC3 Pervious	MC3 Effective Impervious	MC4 Pervious	MC4 Effective Impervious	MC5 Pervious	MC5 Effective Impervious	MC6 Pervious	MC6 Effective Impervious	MC7 Pervious	MC7 Effective Impervious	CARGO Pervious	CARGO Effective Impervious
			Surface Water Subbasin Areas (Acres)													
COMM	Qvr	85%	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Qvrl	85%	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Qvt	85%	-	-	-	-	-	-	-	-	-	-	-	-	-	-
F	Fill		0.00	-	-	-	-	-	-	-	-	-	-	-	-	-
	M	0%	0.08	-	-	-	-	-	-	-	-	-	-	-	-	-
	Qu	0%	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Qvr	0%	3.60	-	3.70	-	0.27	-	-	-	-	-	-	-	-	-
	Qvrl	0%	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Qvt	0%	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Qw	0%	4.23	-	1.20	-	0.35	-	-	-	-	-	-	-	-	-
HD	Qvr	15%	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Qvrl	15%	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Qvt	15%	-	-	-	-	-	-	-	-	-	-	-	-	-	-
LD	M	4%	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Qu	4%	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Qvr	4%	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Qvrl	4%	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Qvt	4%	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MF	Qvr	47%	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Qvrl	47%	-	-	-	-	-	-	-	-	-	-	-	-	-	-
OG	M	0%	0.46	-	-	-	-	-	-	-	-	-	-	-	-	-
	Qvr	0%	3.57	-	2.99	-	13.36	-	33.42	-	2.37	-	31.75	-	-	-
	Qvrl	0%	-	-	-	-	-	-	-	-	-	-	0.07	-	-	-
	Qvt	0%	-	-	-	-	-	-	13.43	-	-	-	8.03	-	-	-
	Qw	0%	0.49	-	-	-	6.36	-	-	-	-	-	-	-	-	-
STIA	Fill	0%	2.22	-	1.07	-	4.23	-	-	-	0.09	-	-	-	-	-
	M	0%	0.06	-	-	-	-	-	-	-	-	-	-	-	-	-
	Qvr	0%	3.08	-	0.59	-	3.16	-	0.42	-	11.72	-	0.02	-	-	-
	Qvt	0%	-	-	-	-	-	-	-	-	-	-	3.17	-	-	-
	Qw	0%	0.03	-	0.18	-	0.26	-	-	-	-	-	-	-	-	-
	TIA	100%	-	2.27	-	1.41	-	3.31	-	0.02	-	0.26	-	0.03	-	8.12

AR 053000

Table . Miller Creek Surface Water Subbasin Characteristics - 2006 (S ,asins)

			Surface Water Subbasin Areas (Acres)													
		% of total basin	MC2		MC3		MC4		MC5		MC6		MC7		CARGO	
Land Use	Soil Type	equal to EIA	Pervious	Effective Impervious	Pervious	Effective Impervious	Pervious	Effective Impervious	Pervious	Effective Impervious	Pervious	Effective Impervious	Pervious	Effective Impervious	Pervious	Effective Impervious
TRANS	M	0%	0.02	-	-	-	-	-	-	-	-	-	-	-	-	-
	Qvr	0%	2.55	-	1.32	-	-	-	-	-	-	-	0.02	-	-	-
	Qvrl	0%	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Qvt	0%	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Qw	0%	0.22	-	0.43	-	-	-	-	-	-	-	-	-	-	-
	TIA	100%	-	0.27	-	0.01	-	-	-	-	-	-	-	-	-	-
	Wetland	0%	10.16	-	0.04	-	5.02	-	7.44	-	0.90	-	3.20	-	-	-
	Lake		2.98		-		3.30		0.73		0.29		0.24		-	
	Mcrk-df		7.00		13.17		-		-		-		-		-	
	Other		-		-		-		-		-		-		-	
Basin total:			30.77	2.54	11.52	1.42	33.00	3.31	54.71	0.02	15.09	0.26	46.26	0.03	-	8.12
PERLND areas:																
(16)	Till-Forest		0.08		-		-		-		-		-		-	
(26)	Till-Grass		0.53		-		-		13.43		-		11.26		-	
(34)	Outwash-Forest		3.60		3.70		0.27		-		-		-		-	
(44)	Outwash-Grass		9.20		4.91		16.51		33.84		14.10		31.80		-	
(45)	Fill		2.22		1.07		4.23		-		0.09		-		-	
(54)	Wetland		15.14		1.84		11.98		7.44		0.90		3.20		-	
	subtotal:		30.77		11.52		33.00		54.71		15.09		46.26		-	
IMPLND areas:																
	EIA			2.54		1.42		3.31		0.02		0.26		0.03		8.12
Basin total:			33.31		12.94		36.31		54.74		15.35		46.29		8.12	
Percent Impervious				7.6%		11.0%		9.1%		0.0%		1.7%		0.1%		100.0%
			MC2		MC3		MC4		MC5		MC6		MC7		CARGO	
NETWORK FACTORS																
PERLND 16	(TF)		0.078		-		-		-		-		-		-	
PERLND 26	(TG)		0.531		-		-		13.432		-		11.260		-	
PERLND 34	(OF)		3.598		3.701		0.274		-		-		-		-	
PERLND 44	(OG)		9.205		4.910		16.514		33.842		14.098		31.795		-	
PERLND 45	(FL)		2.221		1.070		4.230		-		0.092		-		-	
PERLND 54	(SA)		15.139		1.843		11.979		7.438		0.899		3.202		-	
IMPLND 14	(EIA)		2.538		1.419		3.311		0.025		0.260		0.032		8.117	
SUM			33.311		12.943		36.309		54.738		15.350		46.288		8.117	

AR 053001

Table). Miller Creek Surface Water Subbasin Characteristics - 2006 (S)asins)

Land Use	Soil Type	% of total basin equal to EIA	Surface Water Subbasin Areas (Acres)													
			NEPL		SDN1		SDN1-LWR		SDN1-OFF		SDN2-Xn		SDN3		SDN-3A-I	
			Pervious	Effective Impervious	Pervious	Effective Impervious	Pervious	Effective Impervious	Pervious	Effective Impervious	Pervious	Effective Impervious	Pervious	Effective Impervious	Pervious	Effective Impervious
COMM	Qvr	85%	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Qvrl	85%	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Qvt	85%	-	-	-	-	-	-	-	-	-	-	-	-	-	-
F	Fill		-	-	-	-	-	-	-	-	-	-	-	-	-	-
	M	0%	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Qu	0%	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Qvr	0%	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Qvrl	0%	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Qvt	0%	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Qw	0%	-	-	-	-	-	-	-	-	-	-	-	-	-	-
HD	Qvr	15%	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Qvrl	15%	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Qvt	15%	-	-	-	-	-	-	0.70	0.12	-	-	-	-	-	-
LD	M	4%	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Qu	4%	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Qvr	4%	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Qvrl	4%	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Qvt	4%	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MF	Qvr	47%	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Qvrl	47%	-	-	-	-	-	-	-	-	-	-	-	-	-	-
OG	M	0%	-	-	-	-	-	-	0.00	-	-	-	-	-	-	-
	Qvr	0%	-	-	-	-	4.66	-	0.30	-	-	-	-	-	-	-
	Qvrl	0%	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Qvt	0%	-	-	-	-	-	-	19.87	-	-	-	-	-	-	-
	Qw	0%	-	-	-	-	-	-	-	-	-	-	-	-	-	-
STIA	Fill	0%	-	-	-	-	-	-	-	-	0.86	-	-	-	4.58	-
	M	0%	-	-	-	-	-	-	-	-	0.63	-	4.73	-	-	-
	Qvr	0%	-	-	0.51	-	0.03	-	-	-	2.40	-	-	-	-	-
	Qvt	0%	-	-	1.97	-	-	-	-	-	-	-	18.83	-	0.08	-
	Qw	0%	-	-	0.17	-	-	-	-	-	-	-	-	-	-	-
	TIA	100%	-	42.29	-	11.46	-	0.19	-	-	-	0.36	-	24.30	-	5.87

Table). Miller Creek Surface Water Subbasin Characteristics - 2006 (S)asins)

Land Use	Soil Type	% of total basin equal to EIA	NEPL Pervious	NEPL Effective Impervious	SDN1 Pervious	SDN1 Effective Impervious	SDN1-LWR Pervious	SDN1-LWR Effective Impervious	SDN1-OFF Pervious	SDN1-OFF Effective Impervious	SDN2-Xn Pervious	SDN2-Xn Effective Impervious	SDN3 Pervious	SDN3 Effective Impervious	SDN-3A-I Pervious	SDN-3A-I Effective Impervious
			Surface Water Subbasin Areas (Acres)													
TRANS	M	0%	-	-	-	-	-	-	0.68	-	-	-	-	-	-	-
	Qvr	0%	-	-	0.78	-	0.10	-	3.28	-	-	-	-	-	-	-
	Qvrl	0%	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Qvt	0%	-	-	-	-	-	-	1.76	-	-	-	-	-	-	-
	Qw	0%	-	-	0.03	-	-	-	1.63	-	-	-	-	-	-	-
	TIA	100%	-	-	-	1.22	-	0.38	-	7.88	-	-	-	-	-	-
	Wetland	0%	-	-	-	-	0.07	-	0.04	-	-	-	-	-	-	-
	Lake		-		-		-		-		-		-		-	
	Mcrk-df		-		-		-		-		-		-		-	
	Other		-		-		-		0.04		-		-		-	
Basin total:			-	42.29	3.46	12.68	4.86	0.56	28.27	8.00	3.90	0.36	23.56	24.30	4.66	5.87
PERLND areas:																
(16)	Till-Forest		-		-		-		-		-		-		-	
(26)	Till-Grass		10.00		1.97		-		23.01		0.63		23.56		0.08	
(34)	Outwash-Forest		-		-		-		-		-		-		-	
(44)	Outwash-Grass		-		1.29		4.79		3.58		2.40		-		-	
(45)	Fill		-		-		-		-		0.86		-		4.58	
(54)	Wetland		-		0.20		0.07		1.67		-		-		-	
	subtotal:		10.00		3.46		4.86		28.27		3.90		23.56		4.66	
IMPLND areas:																
	EIA			32.29		12.68		0.56		8.00		0.36		24.30		5.87
Basin total:			42.29		16.14		5.42		36.27		4.26		47.86		10.52	
Percent Impervious				76.4%		78.6%		10.4%		22.1%		8.5%		50.8%		55.7%
			NEPL		SDN1		SDN1-LWR		SDN1-OFF		SDN2-Xn		SDN3		SDN-3A-I	
NETWORK FACTORS																
PERLND 16	(TF)		-		-		-		-		-		-		-	
PERLND 26	(TG)		10.000		1.968		-		23.013		0.632		23.556		0.077	
PERLND 34	(OF)		-		-		-		-		-		-		-	
PERLND 44	(OG)		-		1.290		4.787		3.584		2.405		-		-	
PERLND 45	(FL)		-		-		-		-		0.860		-		4.581	
PERLND 54	(SA)		-		0.200		0.071		1.673		-		-		-	
IMPLND 14	(EIA)		32.291		12.682		0.565		8.000		0.363		24.300		5.866	
SUM			42.291		16.139		5.423		36.269		4.260		47.856		10.524	

AR 053003

Table). Miller Creek Surface Water Subbasin Characteristics - 2006 (S)asins)

			Surface Water Subbasin Areas (Acres)													
		% of total basin	SDN-3A-O		SDN3-X		SDN4		SDN4-X		SDW-1A-I		SDW-1A-O		SDW-1B-I	
Land Use	Soil Type	equal to EIA	Pervious	Effective Impervious	Pervious	Effective Impervious	Pervious	Effective Impervious	Pervious	Effective Impervious	Pervious	Effective Impervious	Pervious	Effective Impervious	Pervious	Effective Impervious
COMM	Qvr	85%	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Qvrl	85%	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Qvt	85%	-	-	-	-	-	-	-	-	-	-	-	-	-	-
F	Fill		-	-	-	-	-	-	-	-	-	-	-	-	-	-
	M	0%	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Qu	0%	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Qvr	0%	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Qvrl	0%	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Qvt	0%	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Qw	0%	-	-	-	-	-	-	-	-	-	-	-	-	-	-
HD	Qvr	15%	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Qvrl	15%	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Qvt	15%	-	-	-	-	-	-	-	-	-	-	-	-	-	-
LD	M	4%	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Qu	4%	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Qvr	4%	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Qvrl	4%	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Qvt	4%	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MF	Qvr	47%	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Qvrl	47%	-	-	-	-	-	-	-	-	-	-	-	-	-	-
OG	M	0%	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Qvr	0%	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Qvrl	0%	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Qvt	0%	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Qw	0%	-	-	-	-	-	-	-	-	-	-	-	-	-	-
STIA	Fill	0%	17.54	-	23.77	-	0.99	-	8.31	-	19.41	-	13.03	-	35.97	-
	M	0%	-	-	-	-	15.69	-	1.35	-	-	-	-	-	11.17	-
	Qvr	0%	0.03	-	-	-	1.31	-	0.75	-	-	-	0.69	-	-	-
	Qvt	0%	-	-	1.61	-	0.06	-	0.57	-	4.28	-	-	-	9.20	-
	Qw	0%	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	TIA	100%	-	2.35	-	0.00	-	12.26	-	4.21	-	13.78	-	1.64	-	23.52

Table . Miller Creek Surface Water Subbasin Characteristics - 2006 (S asins)

Land Use	Soil Type	% of total basin equal to EIA	Surface Water Subbasin Areas (Acres) SDN-3A-O Pervious	SDN-3A-O Effective Impervious	SDN3-X Pervious	SDN3-X Effective Impervious	SDN4 Pervious	SDN4 Effective Impervious	SDN4-X Pervious	SDN4-X Effective Impervious	SDW-1A-I Pervious	SDW-1A-I Effective Impervious	SDW-1A-O Pervious	SDW-1A-O Effective Impervious	SDW-1B-I Pervious	SDW-1B-I Effective Impervious
TRANS	M	0%	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Qvr	0%	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Qvrl	0%	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Qvt	0%	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Qw	0%	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	TIA	100%	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Wetland	0%	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Lake		-		-		-		-		-		-		-	
	Mcrk-df		-		-		-		-		-		-		-	
	Other		-		-		-		-		-		-		-	
Basin total:			17.57	2.35	25.38	0.00	18.06	12.26	10.97	4.21	23.69	13.78	13.72	1.64	56.33	23.52
PERLND areas:																
(16)	Till-Forest		-		-		-		-		-		-		-	
(26)	Till-Grass		-		1.61		15.75		1.92		4.28		-		20.37	
(34)	Outwash-Forest		-		-		-		-		-		-		-	
(44)	Outwash-Grass		0.03		-		1.31		0.75		-		0.69		-	
(45)	Fill		17.54		23.77		0.99		8.31		19.41		13.03		35.97	
(54)	Wetland		-		-		-		-		-		-		-	
	subtotal:		17.57		25.38		18.06		10.97		23.69		13.72		56.33	
IMPLND areas:																
	EIA			2.35		0.00		12.26		4.21		13.78		1.64		23.52
Basin total:			19.92		25.38		30.32		15.18		37.47		15.36		79.86	
Percent impervious				11.8%		0.0%		40.4%		27.7%		36.8%		10.7%		29.5%
			SDN-3A-O		SDN3-X		SDN4		SDN4-X		SDW-1A-I		SDW-1A-O		SDW-1B-I	
NETWORK FACTORS																
PERLND 16	(TF)		-		-		-		-		-		-		-	
PERLND 26	(TG)		-		1.613		15.755		1.916		4.278		-		20.365	
PERLND 34	(OF)		-		-		-		-		-		-		-	
PERLND 44	(OG)		0.032		-		1.309		0.750		-		0.688		-	
PERLND 45	(FL)		17.537		23.766		0.992		8.305		19.412		13.031		35.966	
PERLND 54	(SA)		-		-		-		-		-		-		-	
IMPLND 14	(EIA)		2.352		0.000		12.263		4.213		13.777		1.639		23.525	
SUM			19.921		25.379		30.319		15.184		37.467		15.358		79.856	

AR 053005

Table . Miller Creek Surface Water Subbasin Characteristics - 2006 (S asins)

Land Use	Soil Type	% of total basin equal to EIA	Surface Water Subbasin Areas (Acres): SDW-1B-O Pervious	SDW-1B-O Effective Impervious	IWS-NCPS Pervious	IWS-NCPS Effective Impervious	IWS-NSMPS Pervious	IWS-NSMPS Effective Impervious	Total Pervious	Total Effective Impervious	Percent of Total Pervious	Percent of Total Effective Impervious
COMM	Qvr	85%	-	-	-	-	-	-	5.91	33.48	0.47%	2.69%
	Qvrl	85%	-	-	-	-	-	-	0.46	2.60	0.04%	0.21%
	Qvt	85%	-	-	-	-	-	-	2.26	12.78	0.18%	1.03%
F	Fill		-	-	-	-	-	-	0.00	-	0.00%	0.00%
	M	0%	-	-	-	-	-	-	1.32	-	0.11%	0.00%
	Qu	0%	-	-	-	-	-	-	0.77	-	0.06%	0.00%
	Qvr	0%	-	-	-	-	-	-	40.33	-	3.24%	0.00%
	Qvrl	0%	-	-	-	-	-	-	9.76	-	0.78%	0.00%
	Qvt	0%	-	-	-	-	-	-	10.49	-	0.84%	0.00%
	Qw	0%	-	-	-	-	-	-	5.78	-	0.46%	0.00%
HD	Qvr	15%	-	-	-	-	-	-	69.07	12.19	5.55%	0.98%
	Qvrl	15%	-	-	-	-	-	-	16.63	2.94	1.34%	0.24%
	Qvt	15%	-	-	-	-	-	-	40.03	7.06	3.22%	0.57%
LD	M	4%	-	-	-	-	-	-	0.15	0.01	0.01%	0.00%
	Qu	4%	-	-	-	-	-	-	0.01	0.00	0.00%	0.00%
	Qvr	4%	-	-	-	-	-	-	82.07	3.42	6.59%	0.27%
	Qvrl	4%	-	-	-	-	-	-	8.95	0.37	0.72%	0.03%
	Qvt	4%	-	-	-	-	-	-	8.02	0.33	0.64%	0.03%
MF	Qvr	47%	-	-	-	-	-	-	33.59	29.78	2.70%	2.39%
	Qvrl	47%	-	-	-	-	-	-	0.20	0.17	0.02%	0.01%
OG	M	0%	-	-	-	-	-	-	0.70	-	0.06%	0.00%
	Qvr	0%	-	-	-	-	-	-	146.18	-	11.74%	0.00%
	Qvrl	0%	-	-	-	-	-	-	0.13	-	0.01%	0.00%
	Qvt	0%	-	-	-	-	-	-	63.80	-	5.12%	0.00%
	Qw	0%	-	-	-	-	-	-	7.32	-	0.59%	0.00%
STIA	Fill	0%	10.30	-	-	-	0.01	-	142.51	-	11.45%	0.00%
	M	0%	-	-	4.78	-	2.69	-	41.10	-	3.30%	0.00%
	Qvr	0%	2.39	-	-	-	1.97	-	32.28	-	2.59%	0.00%
	Qvt	0%	0.89	-	-	-	-	-	40.64	-	3.26%	0.00%
	Qw	0%	-	-	-	-	-	-	0.64	-	0.05%	0.00%
	TIA	100%	-	3.42	-	30.93	-	1.95	-	195.61	0.00%	15.71%

AR 053006

Table .. Miller Creek Surface Water Subbasin Characteristics - 2006 (S ,asins)

Land Use	Soil Type	% of total basin equal to EIA	Surface Water Subbasin Areas (Acres) SDW-1B-O Pervious	SDW-1B-O Effective Impervious	IWS-NCPS Pervious	IWS-NCPS Effective Impervious	IWS-NSMPS Pervious	IWS-NSMPS Effective Impervious	Total Pervious	Total Effective Impervious	Percent of Total Pervious	Percent of Total Effective Impervious
TRANS	M	0%	-	-	-	-	-	-	0.83	-	0.07%	0.00%
	Qvr	0%	-	-	-	-	-	-	37.72	-	3.03%	0.00%
	Qvrl	0%	-	-	-	-	-	-	3.48	-	0.28%	0.00%
	Qvt	0%	-	-	-	-	-	-	6.43	-	0.52%	0.00%
	Qw	0%	-	-	-	-	-	-	2.33	-	0.19%	0.00%
	TIA	100%	-	-	-	-	-	-	-	44.25	0.00%	3.55%
	Wetland	0%	0.00	-	-	-	-	-	38.22	-	3.07%	
	Lake		-		-		-		7.98		0.64%	
	Mcrk-dl		-		-		-		20.24		1.63%	
	Other		-		-		-		0.04		0.00%	
Basin total:			13.58	3.42	4.78	30.93	4.67	1.95	900.10	345.00	72.29%	27.71%
PERLND areas:												
(16)	Till-Forest		-		-		-		21.56		1.73%	
(26)	Till-Grass		0.89		4.78		2.69		243.82		19.58%	
(34)	Outwash-Forest		-		-		-		41.10		3.30%	
(44)	Outwash-Grass		2.39		-		1.97		406.82		32.67%	
(45)	Fill		10.30		-		0.01		142.51		11.45%	
(54)	Wetland		0.00		-		-		54.29		4.36%	
	subtotal:		13.58		4.78		4.67		910.10		73.09%	
IMPLND areas:												
	EIA			3.42		30.93		1.95		335.00		26.91%
Basin total:			17.00		35.71		6.63		1245.11		100.00%	
Percent Impervious				20.1%		86.6%		29.5%				
			SDW-1B-O		IWS-NCPS		IWS-NSMPS		Total		Percent of Total	
NETWORK FACTORS												
PERLND 16	(TF)		-		-		-		21.562		1.73%	
PERLND 26	(TG)		0.888		4.781		2.686		243.817		19.58%	
PERLND 34	(OF)		-		-		-		41.101		3.30%	
PERLND 44	(OG)		2.392		-		1.975		406.822		32.67%	
PERLND 45	(FL)		10.298		-		0.012		142.514		11.45%	
PERLND 54	(SA)		0.005		-		-		54.289		4.36%	
IMPLND 14	(EIA)		3.421		30.934		1.954		335.002		26.91%	
SUM			17.004		35.715		6.626		1245.106		100.00%	

AR 053007

Table ı. Miller Creek Contiguous Groundwater Subbasin Characteristi. ı994 (STIA basins)

Land Use	Soil Type	% of total basin equal to EIA	Groundwater Subbasin Areas (Acres)													
			SDS3A		IWS PRIMARY		CARGO		M10		M16		M5		M6	
			Pervious	Effective Impervious	Pervious	Effective Impervious	Pervious	Effective Impervious	Pervious	Effective Impervious	Pervious	Effective Impervious	Pervious	Effective Impervious	Pervious	Effective Impervious
PERLND areas:																
(16)	Till-Forest		-		-		-		4.15		10.93		-		1.43	
(26)	Till-Grass		2.15		0.06		7.04		31.94		30.30		10.29		20.37	
(34)	Outwash-Forest		-		-		-		-		20.03		-		13.43	
(44)	Outwash-Grass		-		-		-		95.23		31.43		50.05		11.79	
(54)	Wetland		-		-		-		-		-		10.74		0.82	
	subtotal:		2.15		0.06		7.04		131.32		92.69		71.08		47.84	
IMPLND areas:																
	EIA			0.28		6.30		1.07		71.98		15.62		16.31		6.23
Basin total:			2.43		6.36		8.12		203.30		108.31		87.39		54.07	
Percent Impervious				11.5%		99.1%		13.2%		35.4%		14.4%		18.7%		11.5%
			SDS3A		IWS PRIMARY		CARGO		M10		M16		M5		M6	
NETWORK FACTORS																
PERLND 16	(TF)		-		-		-		4.155		10.932		-		1.435	
PERLND 26	(TG)		2.148		0.056		7.043		31.943		30.302		10.293		20 373	
PERLND 34	(OF)		-		-		-		-		20.035		-		13.426	
PERLND 44	(OG)		-		-		-		95.227		31.426		50.047		11.790	
PERLND 54	(SA)		-		-		-		-		-		10.742		0.816	
IMPLND 14	(EIA)		0.279		6.300		1.074		71.975		15.619		16.310		6.233	
SUM			2.427		6.357		8.117		203.300		108.313		87.392		54.073	

Table .. Miller Creek Contiguous Groundwater Subbasin Characteristi .994 (STIA basins)

Land Use	Soil Type	% of total basin equal to EIA	Groundwater Subbasin Areas (Acres)													
			M8		M9		MC1n		MC2		MC3		MC4		MC5	
			Pervious	Effective Impervious	Pervious	Effective Impervious	Pervious	Effective Impervious	Pervious	Effective Impervious	Pervious	Effective Impervious	Pervious	Effective Impervious	Pervious	Effective Impervious
PERLND areas:																
(16)	Till-Forest		-		4.98		-		0.08		-		-		-	
(26)	Till-Grass		-		14.38		0.17		0.64		-		-		13.49	
(34)	Outwash-Forest		-		0.05		-		6.66		5.53		0.05		-	
(44)	Outwash-Grass		22.21		56.71		11.15		10.41		5.03		19.47		31.13	
(54)	Wetland		-		0.01		0.27		15.25		2.27		14.70		7.60	
	subtotal:		22.21		76.14		11.60		33.04		12.83		34.22		52.21	
IMPLND areas:																
	EIA			6.60		22.47		0.37		0.27		0.11		2.04		2.50
Basin total:			28.80		98.61		11.97		33.31		12.94		36.26		54.71	
Percent Impervious				22.9%		22.8%		3.1%		0.8%		0.9%		5.6%		4.6%
			M8		M9		MC1n		MC2		MC3		MC4		MC5	
NETWORK FACTORS																
PERLND 16	(TF)		-		4.981		-		0.078		-		-		-	
PERLND 26	(TG)		-		14.384		0.173		0.635		-		-		13.487	
PERLND 34	(OF)		-		0.048		-		6.663		5.525		0.049		-	
PERLND 44	(OG)		22.206		56.712		11.151		10.414		5.033		19.470		31.127	
PERLND 54	(SA)		-		0.011		0.272		15.250		2.273		14.700		7.596	
IMPLND 14	(EIA)		6.598		22.472		0.369		0.270		0.112		2.043		2.503	
SUM			28.804		98.608		11.966		33.311		12.943		36.263		54.714	

Table . Miller Creek Contiguous Groundwater Subbasin Characteristi 994 (STIA basins)

Land Use	Soil Type	% of total basin equal to EIA	Groundwater Subbasin Areas (Acres)													
			MC6		MC7		NEPL		SDN1		SDN1-LWR		SDN1-OFF		SDN2-Xn	
			Pervious	Effective Impervious	Pervious	Effective Impervious	Pervious	Effective Impervious	Pervious	Effective Impervious	Pervious	Effective Impervious	Pervious	Effective Impervious	Pervious	Effective Impervious
PERLND areas:																
(16)	Till-Forest		-		-		8.77		-		-		-		-	
(26)	Till-Grass		-		9.23		21.47		1.83		-		11.12		1.14	
(34)	Outwash-Forest		-		-		8.78		-		-		-		-	
(44)	Outwash-Grass		13.56		30.54		2.40		1.88		4.97		2.26		3.12	
(54)	Wetland		0.99		3.47		-		0.01		0 07		1.08		-	
	subtotal:		14 55		43.24		41.42		3.71		5.04		14.46		4.26	
IMPLND areas:																
	EIA			0.80		3.05		0.87		3.77		0.38		5.85		-
Basin total:			15.35		46.29		42.29		7.48		5.42		20.32		4.26	
Percent Impervious				5.2%		6.6%		2.1%		50.4%		7.0%		28.8%		0.0%
			MC6		MC7		NEPL		SDN1		SDN1-LWR		SDN1-OFF		SDN2-Xn	
NETWORK FACTORS																
PERLND 16	(TF)		-		-		8.771		-		-		-		-	
PERLND 26	(TG)		-		9.227		21.470		1.829		-		11.124		1.138	
PERLND 34	(OF)		-		-		8.779		-		-		-		-	
PERLND 44	(OG)		13.561		30.540		2.398		1.877		4.974		2.264		3 122	
PERLND 54	(SA)		0.987		3.469		-		0.006		0.071		1.078		-	
IMPLND 14	(EIA)		0.799		3.052		0.873		3.766		0.378		5.851		-	
SUM			15.347		46.288		42.291		7.478		5.423		20.316		4.260	

AR 053010

Table . Miller Creek Contiguous Groundwater Subbasin Characteristic 994 (STIA basins)

Land Use / Soil Type	% of total basin equal to EIA	Groundwater Subbasin Areas (Acres)													
		SDN3		SDN3-A-I		SDN3-A-O		SDN3-X		SDN4		SDN4-X		SDW1 A-I	
		Pervious	Effective Impervious	Pervious	Effective Impervious	Pervious	Effective Impervious	Pervious	Effective Impervious	Pervious	Effective Impervious	Pervious	Effective Impervious	Pervious	Effective Impervious
PERLND areas:															
(16) Till-Forest		-		-		-		0.65		-		-		-	
(26) Till-Grass		33.36		5.27		-		6.94		24.49		2.76		24.10	
(34) Outwash-Forest		-		1.03		8.09		12.20		-		1.22		-	
(44) Outwash-Grass		-		3.82		10.18		5.01		3.20		10.16		12.68	
(54) Wetland		-		-		0.19		0.57		-		-		0.33	
subtotal:		33.36		10.13		18.45		25.38		27.69		14.14		37.11	
IMPLND areas:															
EIA			14.50		0.40		1.47		-		2.63		1.05		0.35
Basin total:		47.86		10.52		19.92		25.38		30.32		15.18		37.47	
Percent Impervious			30.3%		3.8%		7.4%		0.0%		8.7%		6.9%		0.9%
		SDN3		SDN3-A-I		SDN3-A-O		SDN3-X		SDN4		SDN4-X		SDW1-A-I	
NETWORK FACTORS															
PERLND 16 (TF)		-		-		-		0.650		-		-		-	
PERLND 26 (TG)		33.359		5.272		-		6.944		24.488		2.757		24.102	
PERLND 34 (OF)		-		1.028		8.092		12.201		-		1.215		-	
PERLND 44 (OG)		-		3.825		10.176		5.010		3.204		10.163		12.681	
PERLND 54 (SA)		-		-		0.186		0.574		-		-		0.330	
IMPLND 14 (EIA)		14.497		0.399		1.467		-		2.627		1.049		0.354	
SUM		47.856		10.524		19.921		25.379		30.319		15.184		37.467	

Table .. Miller Creek Contiguous Groundwater Subbasin Characteristi ,994 (STIA basins)

Land Use	Soil Type	% of total basin equal to EIA	Groundwater Subbasin Areas (Acres)													
			SDW1-A-O		SDW1-B-I		SDW1-B-O		SDW2a		IWS MILLER		IWS-NCPS		IWS-NSMPS	
			Pervious	Effective Impervious	Pervious	Effective Impervious	Pervious	Effective Impervious	Pervious	Effective Impervious	Pervious	Effective Impervious	Pervious	Effective Impervious	Pervious	Effective Impervious
PERLND areas:																
(16)	Till-Forest		-		-		-		-		-		-		-	
(26)	Till-Grass		-		42.91		4.21		9.42		3.98		6.13		3 71	
(34)	Outwash-Forest		-		-		-		-		-		-		-	
(44)	Outwash-Grass		12.21		20.31		7.20		-		8.55		-		2.88	
(54)	Wetland		2.63		3.31		4.43		-		-		-		-	
	subtotal:		14.84		66.54		15.84		9 42		12 53		6.13		6.58	
IMPLND areas:																
	EIA			0.52		1.38		1.16		0.68		21.42		28.46		0.04
Basin total:			15.36		67.92		17.00		10.10		33.95		34.58		6.63	
Percent impervious				3.4%		2.0%		6.8%		6.7%		63.1%		82.3%		0.7%
			SDW1-A-O		SDW1-B-I		SDW1-B-O		SDW2a		IWS MILLER		IWS-NCPS		IWS-NSMPS	
NETWORK FACTORS																
PERLND 16	(TF)		-		-		-		-		-		-		-	
PERLND 26	(TG)		-		42.915		4.214		9.421		3.982		6.127		3.705	
PERLND 34	(OF)		-		-		-		-		-		-		-	
PERLND 44	(OG)		12.207		20.312		7.198		-		8.549		-		2.877	
PERLND 54	(SA)		2.634		3.308		4.427		-		-		-		-	
IMPLND 14	(EIA)		0.517		1.384		1.164		0.679		21.418		28.456		0 044	
SUM			15.358		67.919		17.004		10.101		33.948		34.583		6.626	

AR 053012

Table .. Miller Creek Contiguous Groundwater Subbasin Characteristi .994 (STIA basins)

Land Use	Soil Type	% of total basin equal to EIA	Areas (Acres) TOTAL Pervious	Areas (Acres) TOTAL Effective Impervious
PERLND areas:				
(16)	Till-Forest		31.00	
(26)	Till-Grass		342.91	
(34)	Outwash-Forest		77.06	
(44)	Outwash-Grass		499.54	
(54)	Wetland		68.73	
	subtotal:		1019.25	
IMPLND areas:			-	
	EIA			240.93
Basin total:			1260.18	
Percent Impervious				19.1%
			TOTAL	
NETWORK FACTORS				
PERLND 16		(TF)	31.001	
PERLND 26		(TG)	342.911	
PERLND 34		(OF)	77.062	
PERLND 44		(OG)	499.543	
PERLND 54		(SA)	68.731	
IMPLND 14		(EIA)	240.934	
SUM			1260.181	

AR 053013

Table ·. Miller Creek Contiguous Groundwater Subbasin Characteristi :006 (STIA basins)

Land Use	Soil Type	% of total basin equal to EIA	IWS PRIMARY Pervious	IWS PRIMARY Effective Impervious	CARGO Pervious	CARGO Effective Impervious	M10 Pervious	M10 Effective Impervious	M16 Pervious	M16 Effective Impervious	M5 Pervious	M5 Effective Impervious	M6 Pervious	M6 Effective Impervious	M8 Pervious	M8 Effective Impervious
			Groundwater Subbasin Areas (Acres)													
PERLND areas:																
(16)	Till-Forest		-		-		4.15		10.93		-		1.42		-	
(26)	Till-Grass		0.01		-		31.94		29.93		10.29		20.38		-	
(34)	Outwash-Forest		-		-		-		20.03		-		13.44		-	
(44)	Outwash-Grass		0.01		-		95.22		31.83		50.05		11.79		22.21	
(45)	Fill		-		-		-		-		-		-		-	
(54)	Wetland		-		-		-		-		10.74		0.82		-	
	subtotal:		0.02		-		131.32		92.73		71.08		47.84		22.21	
IMPLND areas:																
	EIA			40.29		8.12		71.98		15.58		16.31		6.23		6.60
Basin total:			40.30		8.12		203.30		108.31		87.39		54.07		28.80	
Percent impervious				100.0%		100.0%		35.4%		14.4%		18.7%		11.5%		22.9%

NETWORK FACTORS		IWS PRIMARY	CARGO	M10	M16	M5	M6	M8
PERLND 16	(TF)	-	-	4.155	10.932	-	1.416	-
PERLND 26	(TG)	0.008	-	31.940	29.931	10.293	20.376	-
PERLND 34	(OF)	-	-	-	20.035	-	13.444	-
PERLND 44	(OG)	0 009	-	95.222	31.833	50.047	11.791	22.206
PERLND 45	(FL)	-	-	-	-	-	-	-
PERLND 54	(SA)	-	-	-	-	10.743	0.816	-
IMPLND 14	(EIA)	40.288	8.117	71.984	15.582	16.310	6.229	6.599
SUM		40.305	8.117	203.300	108.313	87.392	54.073	28.804

AR 053014

Table . Miller Creek Contiguous Groundwater Subbasin Characteristi .006 (STIA basins)

Land Use	Soil Type	% of total basin equal to EIA	Groundwater Subbasin Areas (Acres)													
			M9		MC1n		MC2		MC3		MC4		MC5		MC6	
			Pervious	Effective Impervious	Pervious	Effective Impervious	Pervious	Effective Impervious	Pervious	Effective Impervious	Pervious	Effective Impervious	Pervious	Effective Impervious	Pervious	Effective Impervious
PERLND areas:																
(16)	Till-Forest		4.98		-		0.08		-		-		-		-	
(26)	Till-Grass		14.38		0.14		0.53		-		-		13.43		-	
(34)	Outwash-Forest		0.05		-		3.60		3.70		0.27		-		-	
(44)	Outwash-Grass		56.71		9.44		9.20		4.91		16.51		33.84		14.10	
(45)	Fill		-		0.14		2.22		1.07		4.23		-		0.09	
(54)	Wetland		0.01		0.27		15.14		1.84		11.98		7.44		0.90	
	subtotal:		76.14		9.99		30.77		11.52		33.00		54.71		15.09	
IMPLND areas:																
	EIA			22.47		1.98		2.54		1.42		3.31		0.02		0.26
Basin total:			98.61		11.97		33.31		12.94		36.31		54.74		15.35	
Percent Impervious				22.8%		16.5%		7.6%		11.0%		9.1%		0.0%		1.7%
			M9		MC1n		MC2		MC3		MC4		MC5		MC6	
NETWORK FACTORS																
PERLND 16	(TF)		4.981		-		0.078		-		-		-		-	
PERLND 26	(TG)		14.384		0.138		0.531		-		-		13.432		-	
PERLND 34	(OF)		0.048		-		3.598		3.701		0.274		-		-	
PERLND 44	(OG)		56.712		9.437		9.205		4.910		16.514		33.842		14.098	
PERLND 45	(FL)		-		0.140		2.221		1.070		4.230		-		0.092	
PERLND 54	(SA)		0.011		0.272		15.139		1.843		11.979		7.438		0.899	
IMPLND 14	(EIA)		22.472		1.979		2.538		1.419		3.311		0.025		0.260	
SUM			98.608		11.966		33.311		12.943		36.309		54.738		15.350	

Table . Miller Creek Contiguous Groundwater Subbasin Characteristi .006 (STIA basins)

Land Use	Soil Type	% of total basin equal to EIA	Groundwater Subbasin Areas (Acres) MC7 Pervious	MC7 Effective Impervious	NEPL Pervious	NEPL Effective Impervious	SDN1 Pervious	SDN1 Effective Impervious	SDN1-LWR Pervious	SDN1-LWR Effective Impervious	SDN1-OFF Pervious	SDN1-OFF Effective Impervious	SDN2-Xn Pervious	SDN2-Xn Effective Impervious	SDN3 Pervious	SDN3 Effective Impervious
PERLND areas:																
(16)	Till-Forest		-		-		-		-		-		-		-	
(26)	Till-Grass		11.26		10.00		0.09		-		12.27		0.63		23.56	
(34)	Outwash-Forest		-		-		-		-		-		-		-	
(44)	Outwash-Grass		31.80		-		0.87		4.79		2.22		2.40		-	
(45)	Fill		-		-		-		-		-		0.86		-	
(54)	Wetland		3.20		-		0.01		0.07		1.06		-		-	
	subtotal:		46.26		10.00		0.97		4.86		15.57		3.90		23.56	
IMPLND areas:																
	EIA			0.03		32.29		6.51		0.56		4.74		0.36		24.30
Basin total:			46.29		42.29		7.48		5.42		20.32		4.26		47.86	
Percent impervious				0.1%		76.4%		87.1%		10.4%		23.3%		8.5%		50.8%
			MC7		NEPL		SDN1		SDN1-LWR		SDN1-OFF		SDN2-Xn		SDN3	
NETWORK FACTORS																
PERLND 16	(TF)		-		-		-		-		-		-		-	
PERLND 26	(TG)		11.260		10.000		0.087		-		12.275		0.632		23.556	
PERLND 34	(OF)		-		-		-		-		-		-		-	
PERLND 44	(OG)		31.795		-		0.874		4.787		2.222		2.405		-	
PERLND 45	(FL)		-		-		-		-		-		0.860		-	
PERLND 54	(SA)		3.202		-		0.006		0.071		1.078		-		-	
IMPLND 14	(EIA)		0.032		32.291		6.511		0.565		4.742		0.363		24.300	
SUM			46.288		42.291		7.478		5.423		20.316		4.260		47.856	

AR 053016

Table ı. Miller Creek Contiguous Groundwater Subbasin Characteristi ²006 (STIA basins)

Land Use / Soil Type	% of total basin equal to EIA	Groundwater Subbasin Areas (Acres)													
		SDN3-A-I		SDN3-A-O		SDN3-X		SDN4		SDN4-X		SDW1-A-I		SDW1-A-O	
		Pervious	Effective Impervious	Pervious	Effective Impervious	Pervious	Effective Impervious	Pervious	Effective Impervious	Pervious	Effective Impervious	Pervious	Effective Impervious	Pervious	Effective Impervious
PERLND areas:															
(16) Till-Forest		-		-		-		-		-		-		-	
(26) Till-Grass		0.08		-		1.61		15.75		1.92		4.28		-	
(34) Outwash-Forest		-		-		-		-		-		-		-	
(44) Outwash-Grass		-		0.03		-		1.31		0.75		-		0.69	
(45) Fill		4.58		17.54		23.77		0.99		8.31		19.41		13.03	
(54) Wetland		-		-		-		-		-		-		-	
subtotal:		4.66		17.57		25.38		18.06		10.97		23.69		13.72	
IMPLND areas:															
EIA			5.87		2.35		0.00		12.26		4.21		13.78		1.64
Basin total:		10.52		19.92		25.38		30.32		15.18		37.47		15.36	
Percent Impervious			55.7%		11.8%		0.0%		40.4%		27.7%		36.8%		10.7%
		SDN3-A-I		SDN3-A-O		SDN3-X		SDN4		SDN4-X		SDW1-A-I		SDW1-A-O	
NETWORK FACTORS															
PERLND 16 (TF)		-		-		-		-		-		-		-	
PERLND 26 (TG)		0.077		-		1.613		15.755		1.916		4.278		-	
PERLND 34 (OF)		-		-		-		-		-		-		-	
PERLND 44 (OG)		-		0.032		-		1.309		0.750		-		0.688	
PERLND 45 (FL)		4.581		17.537		23.766		0.992		8.305		19.412		13.031	
PERLND 54 (SA)		-		-		-		-		-		-		-	
IMPLND 14 (EIA)		5.866		2.352		0.000		12.263		4.213		13.777		1.639	
SUM		10.524		19.921		25.379		30.319		15.184		37.467		15.358	

AR 053017

Table ı. Miller Creek Contiguous Groundwater Subbasin Characteristi ı006 (STIA basins)

Land Use	Soil Type	% of total basin equal to EIA	Groundwater Subbasin Areas (Acres) SDW1-B-I Pervious	SDW1-B-I Effective Impervious	SDW1-B-O Pervious	SDW1-B-O Effective Impervious	IWS-NCPS Pervious	IWS-NCPS Effective Impervious	IWS-NSMPS Pervious	IWS-NSMPS Effective Impervious	TOTAL Pervious	TOTAL Effective Impervious
PERLND areas:												
(16)	Till-Forest		-		-		-		-		21.56	
(26)	Till-Grass		20.37		0.89		4.78		2.69		231.20	
(34)	Outwash-Forest		-		-		-		-		41.10	
(44)	Outwash-Grass		-		2.39		-		1.97		405.05	
(45)	Fill		35.97		10.30		-		0.01			
(54)	Wetland		-		0.00		-		-		53.50	
	subtotal:		56.33		13.58		4.78		4.67		894.93	
IMPLND areas:											-	
	EIA			23.52		3.42		29.80		1.95		364.73
Basin total:			79.86		17.00		34.58		6.63		1259.66	
Percent Impervious				29.5%		20.1%		86.2%		29.5%		29.0%
			SDW1-B-I		SDW1-B-O		IWS-NCPS		IWS-NSMPS		TOTAL	
NETWORK FACTORS											-	
PERLND 16	(TF)		-		-		-		-		21.562	
PERLND 26	(TG)		20.365		0.888		4.781		2.686		231.204	
PERLND 34	(OF)		-		-		-		-		41.101	
PERLND 44	(OG)		-		2.392		-		1.975		405.053	
PERLND 45	(FL)		35.966		10.298		-		0.012			
PERLND 54	(SA)		-		0.005		-		-		53.500	
IMPLND 14	(EIA)		23.525		3.421		29.802		1.954		364.729	
SUM			79.856		17.004		34.583		6.626		1259.663	

AR 053018

Table . Miller Creek Non-Contiguous Groundwater Subbasin Characte cs - 1994 (STIA basins)

Land Use	Soil Type	% of total basin equal to EIA	Groundwater Subbasin Areas (Acres): SDE4 Pervious	SDE4 Effective Impervious	SDW-1B-I Pervious	SDW-1B-I Effective Impervious	SDW-2a Pervious	SDW-2a Effective Impervious	TOTAL Pervious	TOTAL Effective Impervious
PERLND areas:										
(16)	Till-Forest		-		-		-		-	
(26)	Till-Grass		0.04		10.14		4.06		14.24	
(34)	Outwash-Forest		-		-		-		-	
(44)	Outwash-Grass		-		-		-		-	
(54)	Wetland		-		-		-		-	
	subtotal:		0.04		10.14		4.06		14.24	
IMPLND areas:									-	
	EIA			6.52		1.79		0.61		8.92
Basin total:			6.56		11.94		4.67		23.16	
Percent Impervious				99.4%		15.0%		13.1%		38.5%
			SDE4		SDW-1B-I		SDW-2a		TOTAL	
NETWORK FACTORS										
PERLND 16	(TF)		-		-		-		-	
PERLND 26	(TG)		0.037		10.144		4.059		14.240	
PERLND 34	(OF)		-		-		-		-	
PERLND 44	(OG)		-		-		-		-	
PERLND 54	(SA)		-		-		-		-	
IMPLND 14	(EIA)		6.519		1.793		0.610		8.922	
SUM			6.556		11.936		4.669		23.162	

AR 053019

Table . Miller Creek Non-Contiguous Groundwater Subbasin Characti cs - 2006 (STIA basins)

			Groundwater Subbasin Areas (Acres)							
Land Use	Soil Type	% of total basin equal to EIA	SDE4 Pervious	SDE4 Effective Impervious	SDS3A Pervious	SDS3A Effective Impervious	SDW-2a Pervious	SDW-2a Effective Impervious	TOTAL Pervious	TOTAL Effective Impervious
PERLND areas:										
(16)	Till-Forest		-		-		-		-	
(26)	Till-Grass		0.04		1.72		11.06		12.82	
(34)	Outwash-Forest		-		-		-		-	
(44)	Outwash-Grass		-		-		-		-	
(45)	Fill		-		-		1.09			
(54)	Wetland		-		-		-		-	
	subtotal:		0.04		1.72		12.15		13.91	
IMPLND areas:										
	EIA			6.52		0.70		2.62	-	9.84
Basin total:			6.56		2.43		14.77		23.75	
Percent Impervious				99.4%		29.0%		17.8%		41.4%
			SDE4		SDS3A		SDW-2a		TOTAL	
NETWORK FACTORS										
PERLND 16	(TF)		-		-		-		-	
PERLND 26	(TG)		0.039		1.722		11.057		12.817	
PERLND 34	(OF)		-		-		-		-	
PERLND 44	(OG)		-		-		-		-	
PERLND 45	(FL)		-		-		1.091			
PERLND 54	(SA)		-		-		-		-	
IMPLND 14	(EIA)		6.518		0.705		2.622		9.844	
SUM			6.556		2.427		14.770		23.753	

AR 053020

Table . Walker Creek Surface Water Subbasin Characteristics - 1994 (: basins)

			Surface Water Subbasin Areas (Acres)											
		% of total basin equal to EIA	M20		MC8		MC9		SDW-2		Total		Percent of Total	
Land Use	Soil Type		Pervious	Effective Impervious	Pervious	Effective Impervious	Pervious	Effective Impervious	Pervious	Effective Impervious	Pervious	Effective Impervious	Pervious	Effective Impervious
COMM	Qvr	85%	7.04	39.91	-	-	-	-	-	-	7.04	39.91	3.01%	17.06%
	Qvrl	85%	-	-	-	-	-	-	-	-	-	-	0.00%	0.00%
	Qvt	85%	-	-	-	-	-	-	-	-	-	-	0.00%	0.00%
F	M	0%	-	-	-	-	-	-	-	-	-	-	0.00%	0.00%
	Qu	0%	-	-	-	-	-	-	-	-	-	-	0.00%	0.00%
	Qvr	0%	-	-	-	-	-	-	-	-	-	-	0.00%	0.00%
	Qvrl	0%	-	-	-	-	-	-	-	-	-	-	0.00%	0.00%
	Qvt	0%	-	-	-	-	-	-	-	-	-	-	0.00%	0.00%
	Qw	0%	-	-	-	-	-	-	-	-	-	-	0.00%	0.00%
HD	Qvr	15%	3.66	0.65	3.58	0.63	-	-	1.54	0.27	8.79	1.55	3.75%	0.66%
	Qvrl	15%	0.16	0.03	-	-	-	-	-	-	0.16	0.03	0.07%	0.01%
	Qvt	15%	-	-	3.99	0.70	-	-	6.26	1.11	10.25	1.81	4.38%	0.77%
	Qw	15%	-	-	-	-	-	-	-	-	-	-	0.00%	0.00%
LD	M	4%	-	-	-	-	-	-	-	-	-	-	0.00%	0.00%
	Qu	4%	-	-	-	-	-	-	-	-	-	-	0.00%	0.00%
	Qvr	4%	20.81	0.87	-	-	-	-	-	-	20.81	0.87	8.89%	0.37%
	Qvrl	4%	0.00	0.00	-	-	-	-	-	-	0.00	0.00	0.00%	0.00%
	Qvt	4%	-	-	-	-	-	-	-	-	-	-	0.00%	0.00%
	Qw	4%	-	-	-	-	-	-	-	-	-	-	0.00%	0.00%
MF	Qvr	47%	-	-	-	-	-	-	-	-	-	-	0.00%	0.00%
	Qvrl	47%	-	-	-	-	-	-	-	-	-	-	0.00%	0.00%
OG	M	0%	-	-	-	-	6.37	-	0.41	-	6.79	-	2.90%	0.00%
	Qvr	0%	11.16	-	13.79	-	0.41	-	0.78	-	26.14	-	11.17%	0.00%
	Qvrl	0%	9.37	-	-	-	-	-	-	-	9.37	-	4.00%	0.00%
	Qvt	0%	0.31	-	0.11	-	-	-	11.55	-	11.97	-	5.11%	0.00%
	Qw	0%	-	-	-	-	-	-	-	-	-	-	0.00%	0.00%
STIA	M	0%	-	-	-	-	1.31	-	19.07	-	20.38	-	8.71%	0.00%
	Qvr	0%	-	-	-	-	-	-	-	-	-	-	0.00%	0.00%
	Qvt	0%	-	-	-	-	-	-	0.54	-	0.54	-	0.23%	0.00%
	Qw	0%	-	-	-	-	-	-	-	-	-	-	0.00%	0.00%
	TIA	100%	-	-	-	-	-	0.23	-	1.94	-	2.17	0.00%	0.93%

Table . Walker Creek Surface Water Subbasin Characteristics - 1994 (. basins)

Land Use	Soil Type	% of total basin equal to EIA	Surface Water Subbasin Areas (Acres) M20 Pervious	M20 Effective Impervious	MC8 Pervious	MC8 Effective Impervious	MC9 Pervious	MC9 Effective Impervious	SDW-2 Pervious	SDW-2 Effective Impervious	Total Pervious	Total Effective Impervious	Percent of Total Pervious	Percent of Total Effective Impervious
TRANS	M	0%	1.74	-	-	-	1.76	-	-	-	3.50	-	1.50%	0.00%
	Qvr	0%	10.76	-	1.19	-	0.33	-	-	-	12.28	-	5.25%	0.00%
	Qvrl	0%	0.95	-	-	-	-	-	-	-	0.95	-	0.41%	0.00%
	Qvt	0%	-	-	-	-	-	-	-	-	-	-	0.00%	0.00%
	Qw	0%	-	-	-	-	-	-	-	-	-	-	0.00%	0.00%
	TIA	100%	-	11.38	-	0.01	-	0.01	-	-	-	11.39	0.00%	4.87%
	Wetland	0%	33.43	-	2.72	-	-	-	1.13	-	37.28		15.93%	
	Lake		-		-		-		-		-		0.00%	
	Mcrk-df		-		-		-		-		-		0.00%	
	Other		-		-		-		-		-		0.00%	
Basin total:			99.40	52.83	25.38	1.34	10.19	0.24	41.29	3.31	176.26	57.73	75.33%	24.67%
PERLND areas:														
(16)	Till-Forest		-		-		-		-		-		0.00%	
(26)	Till-Grass		12.53		4.10		9.44		37.84		63.92		27.32%	
(34)	Outwash-Forest		-		-		-		-		-		0.00%	
(44)	Outwash-Grass		53.43		18.57		0.74		2.32		75.06		32.08%	
(54)	Wetland		33.43		2.72		-		1.13		37.28		15.93%	
	subtotal:		99.40		25.38		10.19		41.29		176.26		75.33%	
IMPLND areas:														
	EIA			52.83		1.34		0.24		3.31		57.73		24.67%
Basin total:			152.23		26.73		10.43		44.60		233.99		100.00%	
Percent Impervious				34.7%		5.0%		2.3%		7.4%				
			M20		MC8		MC9		SDW-2		Total		Percent of Total	
NETWORK FACTORS														
PERLND 16	(TF)		-		-		-		-		-		0.00%	
PERLND 26	(TG)		12.534		4.098		9.445		37.840		63.917		27.32%	
PERLND 34	(OF)		-		-		-		-		-		0.00%	
PERLND 44	(OG)		53.431		18.568		0.743		2.321		75.063		32.08%	
PERLND 54	(SA)		33.431		2.717		-		1.129		37.277		15.93%	
IMPLND 14	(EIA)		52.833		1.343		0.239		3.313		57.729		24.67%	
SUM			152.229		26.727		10.427		41.603		233.986		100.00%	

AR 053022

Table .. Walker Creek Surface Water Subbasin Characteristics - 1994 (basins)

			Area (Acres) (Model SDW2) Special MC-8b	
Land Use	Soil Type	% of total basin equal to EIA	Pervious	Effective Impervious
COMM	Qvr	85%	-	-
	Qvrl	85%	-	-
	Qvt	85%	-	-
F	M	0%	-	-
	Qu	0%	-	-
	Qvr	0%	-	-
	Qvrl	0%	-	-
	Qvt	0%	-	-
	Qw	0%	-	-
HD	Qvr	15%	4.28	0.76
	Qvrl	15%	-	-
	Qvt	15%	6.59	1.16
	Qw	15%	-	-
LD	M	4%	-	-
	Qu	4%	-	-
	Qvr	4%	-	-
	Qvrl	4%	-	-
	Qvt	4%	-	-
	Qw	4%	-	-
MF	Qvr	47%	-	-
	Qvrl	47%	-	-
OG	M	0%	1.85	-
	Qvr	0%	16.42	-
	Qvrl	0%	-	-
	Qvt	0%	11.15	-
	Qw	0%	-	-
STIA	M	0%	0.69	-
	Qvr	0%	-	-
	Qvt	0%	0.63	-
	Qw	0%	-	-
	TIA	100%	-	0.28

AR 053023

Table . Walker Creek Surface Water Subbasin Characteristics - 1994 (. basins)

Land Use	Soil Type	% of total basin equal to EIA	Area (Acres) (Model SDW2) Special MC-8b Pervious	Effective Impervious
TRANS	M	0%	-	-
	Qvr	0%	-	-
	Qvrl	0%	-	-
	Qvt	0%	-	-
	Qw	0%	-	-
	TIA	100%	-	-
	Wetland	0%	1.05	-
	Lake		-	
	Mcrk-df		-	
	Other		-	
Basin total:			42.66	2.20
PERLND areas:				
(16)	Till-Forest		-	
(26)	Till-Grass		20.91	
(34)	Outwash-Forest		-	
(44)	Outwash-Grass		20.70	
(54)	Wetland		1.05	
	subtotal:		42.66	
IMPLND areas:				
	EIA			2.20
Basin total:			44.86	
Percent impervious				4.9%
			Special MC-8b	
NETWORK FACTORS				
PERLND 16	(TF)		-	
PERLND 26	(TG)		20.906	
PERLND 34	(OF)		-	
PERLND 44	(OG)		20.704	
PERLND 54	(SA)		1.050	
IMPLND 14	(EIA)		2.197	
SUM			44.857	

AR 053024

Table . Walker Creek Surface Water Subbasin Characteristics - 2006 (basins)

Land Use	Soil Type	% of total basin equal to EIA	M20 Pervious	M20 Effective Impervious	MC8 Pervious	MC8 Effective Impervious	MC9 Pervious	MC9 Effective Impervious	SDW-2 Pervious	SDW-2 Effective Impervious	Total Pervious	Total Effective Impervious	Percent of Total Pervious	Percent of Total Effective Impervious
			Surface Water Subbasin Areas (Acres)											
COMM	Qvr	85%	7.04	39.91	-	-	-	-	-	-	7.04	39.91	3.03%	17.16%
	Qvrl	85%	-	-	-	-	-	-	-	-	-	-	0.00%	0.00%
	Qvt	85%	-	-	-	-	-	-	-	-	-	-	0.00%	0.00%
F	Fill		-	-	-	-	-	-	-	-	-	-	0.00%	0.00%
	M	0%	-	-	-	-	-	-	-	-	-	-	0.00%	0.00%
	Qu	0%	-	-	-	-	-	-	-	-	-	-	0.00%	0.00%
	Qvr	0%	-	-	-	-	-	-	-	-	-	-	0.00%	0.00%
	Qvrl	0%	-	-	-	-	-	-	-	-	-	-	0.00%	0.00%
	Qvt	0%	-	-	-	-	-	-	-	-	-	-	0.00%	0.00%
	Qw	0%	-	-	-	-	-	-	-	-	-	-	0.00%	0.00%
HD	Qvr	15%	3.66	0.65	-	-	-	-	-	-	3.66	0.65	1.57%	0.28%
	Qvrl	15%	0.16	0.03	-	-	-	-	-	-	0.16	0.03	0.07%	0.01%
	Qvt	15%	-	-	-	-	-	-	-	-	-	-	0.00%	0.00%
LD	M	4%	-	-	-	-	-	-	-	-	-	-	0.00%	0.00%
	Qu	4%	-	-	-	-	-	-	-	-	-	-	0.00%	0.00%
	Qvr	4%	20.80	0.87	-	-	-	-	-	-	20.80	0.87	8.94%	0.37%
	Qvrl	4%	0.00	0.00	-	-	-	-	-	-	0.00	0.00	0.00%	0.00%
	Qvt	4%	-	-	-	-	-	-	-	-	-	-	0.00%	0.00%
MF	Qvr	47%	-	-	-	-	-	-	-	-	-	-	0.00%	0.00%
	Qvrl	47%	-	-	-	-	-	-	-	-	-	-	0.00%	0.00%
OG	M	0%	-	-	-	-	5.10	-	-	-	5.10	-	2.19%	0.00%
	Qvr	0%	11.05	-	16.42	-	0.30	-	-	-	27.78	-	11.94%	0.00%
	Qvrl	0%	9.33	-	-	-	-	-	-	-	9.33	-	4.01%	0.00%
	Qvt	0%	0.31	-	2.89	-	-	-	-	-	3.20	-	1.38%	0.00%
	Qw	0%	-	-	-	-	-	-	-	-	-	-	0.00%	0.00%
STIA	Fill	0%	-	-	-	-	-	-	6.70	-	6.70	-	2.88%	0.00%
	M	0%	-	-	-	-	2.42	-	20.39	-	22.81	-	9.81%	0.00%
	Qvr	0%	-	-	1.11	-	0.12	-	1.51	-	2.74	-	1.18%	0.00%
	Qvt	0%	-	-	1.04	-	-	-	6.49	-	7.53	-	3.24%	0.00%
	Qw	0%	-	-	-	-	-	-	-	-	-	-	0.00%	0.00%
	TIA	100%	-	-	-	-	-	0.39	-	9.51	-	9.90	0.00%	4.26%

AR 053025

Table .. Walker Creek Surface Water Subbasin Characteristics - 2006 (.basins)

Land Use	Soil Type	% of total basin equal to EIA	Surface Water Subbasin Areas (Acres) M20 Pervious	M20 Effective Impervious	MC8 Pervious	MC8 Effective Impervious	MC9 Pervious	MC9 Effective Impervious	SDW-2 Pervious	SDW-2 Effective Impervious	Total Pervious	Total Effective Impervious	Percent of Total Pervious	Percent of Total Effective Impervious
TRANS	M	0%	1.74	-	-	-	1.76	-	-	-	3.50	-	1.51%	0.00%
	Qvr	0%	10.87	-	1.19	-	0.33	-	-	-	12.39	-	5.33%	0.00%
	Qvrl	0%	1.00	-	-	-	-	-	-	-	1.00	-	0.43%	0.00%
	Qvt	0%	-	-	-	-	-	-	-	-	-	-	0.00%	0.00%
	Qw	0%	-	-	-	-	-	-	-	-	-	-	0.00%	0.00%
	TIA	100%	-	11.38	-	0.01	-	0.01	-	-	-	11.40	0.00%	4.90%
	Wetland	0%	33.43	-	2.70	-	-	-	.	-	36.13	-	15.53%	
	Lake		-		1.36		-		-		1.36		0.58%	
	Mcrk-df		-		-		-		-		-		0.00%	
	Other		0.00		-		-		-		0.00		0.00%	
Basin total:			99.39	52.83	25.36	0.01	10.03	0.40	35.09	9.51	169.88	62.75	73.02%	26.98%
PERLND areas:														
(16)	Till-Forest		-		-		-				-		0.00%	
(26)	Till-Grass		12.54		3.93		9.28		26.88		52.63		22.63%	
(34)	Outwash-Forest		-		-		-		-		-		0.00%	
(44)	Outwash-Grass		53.42		18.73		0.76		1.51		74.42		31.99%	
(45)	Fill		-		-		-		6.70		6.70		2.88%	
(54)	Wetland		33.43		2.70		-		-		36.13		15.53%	
	subtotal:		99.39		25.36		10.03		35.09		169.88		73.02%	
IMPLND areas:														
	EIA			52.83		0.01		0.40		9.51		62.75		26.98%
Basin total:			152.23		25.37		10.43		44.60		232.63		100.00%	
Percent impervious				34.7%		0.0%		3.8%		21.3%				
			M20		MC8		MC9		SDW-2		Total		Percent of Total	
NETWORK FACTORS														
PERLND 16	(TF)		-		-		-		-		-		0.00%	
PERLND 26	(TG)		12.540		3.934		9.275		26.884		52.633		22.63%	
PERLND 34	(OF)		-		-		-		-		-		0.00%	
PERLND 44	(OG)		53.424		18.729		0.756		1.508		74.417		31.99%	
PERLND 45	(FL)		-		-		-		6.697		6.697		2.88%	
PERLND 54	(SA)		33.431		2.699		-		-		36.130		15.53%	
IMPLND 14	(EIA)		52.835		0.008		0.395		9.514		62.752		26.98%	
SUM			152.229		25.370		10.427		44.603		232.629		100.00%	

AR 053026

Table ,. Walker Creek Contiguous Groundwater Subbasin Characteris · 1994 (STIA basins)

			Groundwater Subbasin Areas (Acres)													
		% of total basin equal to EIA	SDS7a		SDS7b		M16		M20		MC8		MC9		SDW-2a	
Land Use	Soil Type		Pervious	Effective Impervious	Pervious	Effective Impervious	Pervious	Effective Impervious	Pervious	Effective Impervious	Pervious	Effective Impervious	Pervious	Effective Impervious	Pervious	Effective Impervious
PERLND areas:																
(16)	Till-Forest		-		-		-		-		-		-		-	
(26)	Till-Grass		0.22		23.06		0.00		12.53		4.10		8.81		10.64	
(34)	Outwash-Forest		-		-		-		-		-		-		-	
(44)	Outwash-Grass		-		4.59		0.00		53.43		18.57		0.75		2.31	
(54)	Wetland		-		0.37		-		33.43		2.72		-		0.68	
	subtotal:		0.22		28.03		0.00		99.40		25.38		9.56		13.62	
IMPLND areas:																
	EIA			0.08		1.72		0.00		52.83		1.34		0.24		1.14
Basin total:			0.30		29.75		0.00		152.23		26.73		9.80		14.76	
Percent impervious				25.3%		5.8%		4.2%		34.7%		5.0%		2.4%		7.7%
			SDS7a		SDS7b		M16		M20		MC8		MC9		SDW-2a	
NETWORK FACTORS																
PERLND 16	(TF)		-		-		-		-		-		-		-	
PERLND 26	(TG)		0.223		23.060		0.002		12.534		4.098		8.813		10.640	
PERLND 34	(OF)		-		-		-		-		-		-		-	
PERLND 44	(OG)		-		4.593		0.000		53.431		18.568		0.746		2.305	
PERLND 54	(SA)		-		0.375		-		33.431		2.717		-		0.675	
IMPLND 14	(EIA)		0.076		1.721		0.000		52.833		1.343		0.239		1.140	
SUM			0.299		29.748		0.002		152.229		26.727		9.798		14.761	

AR 053027

Table . Walker Creek Contiguous Groundwater Subbasin Characteris · 1994 (STIA basins)

Land Use	Soil Type	% of total basin equal to EIA	Areas (Acres) TOTAL Pervious	Effective Impervious
PERLND areas:				
(16)	Till-Forest		-	
(26)	Till-Grass		59.37	
(34)	Outwash-Forest		-	
(44)	Outwash-Grass		79.64	
(54)	Wetland		37.20	
	subtotal:		176.21	
IMPLND areas:				
	EIA			57.35
Basin total:			233.56	
Percent Impervious				24.6%
			TOTAL	
NETWORK FACTORS				
PERLND 16	(TF)		-	
PERLND 26	(TG)		59.370	
PERLND 34	(OF)		-	
PERLND 44	(OG)		79.644	
PERLND 54	(SA)		37.198	
IMPLND 14	(EIA)		57.352	
SUM			233.564	

AR 053028

Table ,. Walker Creek Contiguous Groundwater Subbasin Characteris · 2006 (STIA basins)

Land Use	Soil Type	% of total basin equal to EIA	SDS7a Pervious	SDS7a Effective Impervious	M16 Pervious	M16 Effective Impervious	M20 Pervious	M20 Effective Impervious	MC8 Pervious	MC8 Effective Impervious	MC9 Pervious	MC9 Effective Impervious	SDW-2a Pervious	SDW-2a Effective Impervious	SDW-2b Pervious	SDW-2b Effective Impervious
			Groundwater Subbasin Areas (Acres)													
PERLND areas:																
(16)	Till-Forest		-		-		-		-		-		-		-	
(26)	Till-Grass		0.16		0.00		12.54		3.93		8.65		2.16		13.67	
(34)	Outwash-Forest		-		-		-		-		-		-		-	
(44)	Outwash-Grass		-		0.00		53.42		18.73		0.76		1.51		-	
(45)	Fill		-		-		-		-		-		5.61		-	
(54)	Wetland		-		-		33.43		2.70		-		-		-	
	subtotal:		0.16		0.00		99.39		25.36		9.40		9.27		13.67	
IMPLND areas:																
	EIA			0.13		0.00		52.83		0.01		0.40		5.49		1.41
Basin total:			0.30		0.00		152.23		25.37		9.80		14.76		15.07	
Percent Impervious				45.1%		4.2%		34.7%		0.0%		4.0%		37.2%		9.3%
			SDS7a		M16		M20		MC8		MC9		SDW-2a		SDW-2b	
NETWORK FACTORS																
PERLND 16	(TF)		-		-		-		-		-		-		-	
PERLND 26	(TG)		0.164		0.002		12.540		3.934		8.646		2.160		13.666	
PERLND 34	(OF)		-		-		-		-		-		-		-	
PERLND 44	(OG)		-		0.000		53.424		18.729		0.756		1.508		-	
PERLND 45	(FL)		-		-		-		-		-		5.606		-	
PERLND 54	(SA)		-		-		33.431		2.699		-		-		-	
IMPLND 14	(EIA)		0.135		0.000		52.835		0.008		0.395		5.486		1.406	
SUM			0.299		0.002		152.229		25.370		9.798		14.761		15.073	

AR 053029

Table .. Walker Creek Contiguous Groundwater Subbasin Characteris 2006 (STIA basins)

Land Use	Soil Type	% of total basin equal to EIA	Areas (Acres) TOTAL Pervious	Effective Impervious
PERLND areas:				
(16)	Till-Forest		-	
(26)	Till-Grass		41.11	
(34)	Outwash-Forest		-	
(44)	Outwash-Grass		74.42	
(45)	Fill		5.61	
(54)	Wetland		36.13	
	subtotal:		157.27	
IMPLND areas:				
	EIA			60.27
Basin total:			217.53	
Percent Impervious				27.7%
			TOTAL	
NETWORK FACTORS				
PERLND 16	(TF)		-	
PERLND 26	(TG)		41.112	
PERLND 34	(OF)		-	
PERLND 44	(OG)		74.417	
PERLND 45	(FL)		5.606	
PERLND 54	(SA)		36.130	
IMPLND 14	(EIA)		60.265	
SUM			217.531	

AR 053030

Table . Walker Creek Non-Contiguous Groundwater Subbasin Charac tics - 1994 (STIA basins)

Land Use	Soil Type	% of total basin equal to EIA	Groundwater Subbasin Areas (Acres)													
			D3		D8		SDE4		SDS1		SDS3		SDS3A		SDS5	
			Pervious	Effective Impervious	Pervious	Effective Impervious	Pervious	Effective Impervious	Pervious	Effective Impervious	Pervious	Effective Impervious	Pervious	Effective Impervious	Pervious	Effective Impervious
PERLND areas:																
(16)	Till-Forest		-		-		-		-		-		-		-	
(26)	Till-Grass		0.01		1.82		48.98		0.07		162.03		60.57		21.53	
(34)	Outwash-Forest		-		-		-		-		-		-		-	
(44)	Outwash-Grass		-		1.46		-		-		-		-		-	
(54)	Wetland		-		0.05		-		-		-		-		-	
	subtotal:		0.01		3.33		48.98		0.07		162.03		60.57		21.53	
IMPLND areas:																
	EIA			0.06		2.80		99.12		7.73		175.20		6.78		0.04
Basin total:			0.07		6.13		148.10		7.80		337.23		67.35		21.57	
Percent impervious				85.0%		45.7%		66.9%		99.1%		52.0%		10.1%		0.2%
			D3		D8		SDE4		SDS1		SDS3		SDS3A		SDS5	
NETWORK FACTORS																
PERLND 16	(TF)		-		-		-		-		-		-		-	
PERLND 26	(TG)		0.010		1.820		48.975		0.069		162.030		60.575		21.531	
PERLND 34	(OF)		-		-		-		-		-		-		-	
PERLND 44	(OG)		-		1.459		-		-		-		-		-	
PERLND 54	(SA)		-		0.050		-		-		-		-		-	
IMPLND 14	(EIA)		0.058		2.801		99.123		7.732		175.197		6.776		0.041	
SUM			0.068		6.130		148.098		7.801		337.227		67.350		21.572	

AR 053031

Table ı. Walker Creek Non-Contiguous Groundwater Subbasin Charac ·tics - 1994 (STIA basins)

Land Use	Soil Type	% of total basin equal to EIA	Groundwater Subbasin Areas (Acres)													
			SDS6		SDS7a		IWS NSPS		IWS PRIMARY		IWS WEST		MC9		SDW2b	
			Pervious	Effective Impervious	Pervious	Effective Impervious	Pervious	Effective Impervious	Pervious	Effective Impervious	Pervious	Effective Impervious	Pervious	Effective Impervious	Pervious	Effective Impervious
PERLND areas:																
(16)	Till-Forest		-		-		-		-		-		-		-	
(26)	Till-Grass		10.69		54.98		0.31		11.96		1.63		0.51		13.74	
(34)	Outwash-Forest		-		-		-		-		-		-		-	
(44)	Outwash-Grass		-		-		-		-		-		-		-	
(54)	Wetland		-		0.02		-		-		-		-		0.45	
	subtotal:		10.69		54.99		0.31		11.96		1.63		0.51		14.19	
IMPLND areas:																
	EIA			4.10		6.21		13.44		215.98		0.42		-		0.88
Basin total:			14.79		61.21		13.75		227.94		2.04		0.51		15.07	
Percent impervious				27.7%		10.2%		97.8%		94.8%		20.4%		0.0%		5.9%
			SDS6		SDS7a		IWS NSPS		IWS PRIMARY		IWS WEST		MC9		SDW2b	
NETWORK FACTORS																
PERLND 16	(TF)		-		-		-		-		-		-		-	
PERLND 26	(TG)		10.686		54.978		0.307		11 961		1.625		0.514		13.735	
PERLND 34	(OF)		-		-		-		-		-		-		-	
PERLND 44	(OG)		-		-		-		-		-		-		-	
PERLND 54	(SA)		-		0.016		-		-		-		-		0.454	
IMPLND 14	(EIA)		4.102		6.214		13.441		215 980		0.416		-		0.883	
SUM			14.788		61.207		13.747		227.941		2.041		0.514		15.073	

AR 053032

Table ı. Walker Creek Non-Contiguous Groundwater Subbasin Charac tics - 1994 (STIA basins)

Land Use	Soil Type	% of total basin equal to EIA	Groundwater Subbasin Areas (Acres): IWS-NCPS Pervious	IWS-NCPS Effective Impervious	TOTAL Pervious	TOTAL Effective Impervious
PERLND areas:						
(16)	Till-Forest		-		-	
(26)	Till-Grass		0.80		389.62	
(34)	Outwash-Forest		-		-	
(44)	Outwash-Grass		-		1.46	
(54)	Wetland		-		0.52	
	subtotal:		0.80		391.60	
IMPLND areas:						
	EIA			0.33		533.09
Basin total:			1.13		924.69	
Percent Impervious				29.2%		57.7%
			IWS-NCPS		TOTAL	
NETWORK FACTORS						
PERLND 16	(TF)		-		-	
PERLND 26	(TG)		0.801		389.618	
PERLND 34	(OF)		-		-	
PERLND 44	(OG)		-		1.459	
PERLND 54	(SA)		-		0.519	
IMPLND 14	(EIA)		0.331		533.093	
SUM			1.132		924.689	

AR 053033

Table ,. Walker Creek Non-Contiguous Groundwater Subbasin Charac tics - 2006 (STIA basins)

Land Use	Soil Type	% of total basin equal to EIA	D3 Pervious	D3 Effective Impervious	D8 Pervious	D8 Effective Impervious	SDE4 Pervious	SDE4 Effective Impervious	SDS1 Pervious	SDS1 Effective Impervious	SDS3 Pervious	SDS3 Effective Impervious	SDS3A Pervious	SDS3A Effective Impervious	SDS5 Pervious	SDS5 Effective Impervious
			Groundwater Subbasin Areas (Acres)													
PERLND areas:																
(16)	Till-Forest		-		-		-		-		-		-		-	
(26)	Till-Grass		0.01		1.82		38.41		-		141.36		32.92		18.72	
(34)	Outwash-Forest		-		-		-		-		-		-		-	
(44)	Outwash-Grass		-		1.47		-		-		-		-		-	
(45)	Fill		-		-		-		-		-		-		-	
(54)	Wetland		-		0.05		-		-		-		-		-	
	subtotal:		0.01		3.34		38.41		-		141.36		32.92		18.72	
IMPLND areas:																
	EIA			0.06		2.82		109.69		7.80		196.06		34.43		2.85
Basin total:			0.07		6.16		148.10		7.80		337.42		67.35		21.57	
Percent Impervious				85.0%		45.8%		74.1%		100.0%		58.1%		51.1%		13.2%
			D3		D8		SDE4		SDS1		SDS3		SDS3A		SDS5	
NETWORK FACTORS																
PERLND 16	(TF)		-		-		-		-		-		-		-	
PERLND 26	(TG)		0.010		1.820		38.405		-		141.363		32.916		18.719	
PERLND 34	(OF)		-		-		-		-		-		-		-	
PERLND 44	(OG)		-		1.468		-		-		-		-		-	
PERLND 45	(FL)		-		-		-		-		-		-		-	
PERLND 54	(SA)		-		0.050		-		-		-		-		-	
IMPLND 14	(EIA)		0.058		2.824		109.692		7.801		196.056		34.434		2.853	
SUM			0.069		6.162		148.097		7.801		337.419		67.350		21.572	

Table ·. Walker Creek Non-Contiguous Groundwater Subbasin Charac tics - 2006 (STIA basins)

			Groundwater Subbasin Areas (Acres)													
		% of total basin	SDS6		SDS7a		SDS7b		IWS NSPS		IWS PRIMARY		MC9		IWS-NCPS	
Land Use	Soil Type	equal to EIA	Pervious	Effective Impervious	Pervious	Effective Impervious	Pervious	Effective Impervious	Pervious	Effective Impervious	Pervious	Effective Impervious	Pervious	Effective Impervious	Pervious	Effective Impervious
PERLND areas:																
(16)	Till-Forest		-		-		-		-		-		-		-	
(26)	Till-Grass		11.92		41.21		4.32		0.31		2.51		0.51		-	
(34)	Outwash-Forest		-		-		-		-		-		-		-	
(44)	Outwash-Grass		-		-		3.93		-		-		-		-	
(45)	Fill		-		-		5.48		-		-		-		-	
(54)	Wetland		-		-		-		-		-		-		-	
	subtotal:		11.92		41.21		13.73		0.31		2.51		0.51		-	
IMPLND areas:																
	EIA			2.87		20.00		16.02		13.44		227.47		-		1.13
Basin total:			14.79		61.21		29.75		13.75		229.98		0.51		1.13	
Percent Impervious				19.4%		32.7%		53.8%		97.8%		98.9%		0.0%		100.0%
			SDS6		SDS7a		SDS7b		IWS NSPS		IWS PRIMARY		MC9		IWS-NCPS	
NETWORK FACTORS																
PERLND 16	(TF)		-		-		-		-		-		-		-	
PERLND 26	(TG)		11.922		41.207		4.320		0.307		2.508		0.514		-	
PERLND 34	(OF)		-		-		-		-		-		-		-	
PERLND 44	(OG)		-		-		3.929		-		-		-		-	
PERLND 45	(FL)		-		-		5.482		-		-		-		-	
PERLND 54	(SA)		-		-		-		-		-		-		-	
IMPLND 14	(EIA)		2.866		20.000		16.017		13.441		227.474		-		1.132	
SUM			14.788		61.207		29.748		13.747		229.982		0.514		1.132	

Table . Walker Creek Non-Contiguous Groundwater Subbasin Charac tics - 2006 (STIA basins)

Land Use	Soil Type	% of total basin equal to EIA	Areas (Acres) TOTAL Pervious	Effective Impervious
PERLND areas:				
(16)	Till-Forest		-	
(26)	Till-Grass		294.01	
(34)	Outwash-Forest		-	
(44)	Outwash-Grass		5.40	
(45)	Fill		5.48	
(54)	Wetland		0.05	
	subtotal:		304.94	
IMPLND areas:				
	EIA			634.65
Basin total:			939.59	
Percent impervious				56067.3%
			TOTAL	
NETWORK FACTORS				
PERLND 16	(TF)		-	
PERLND 26	(TG)		294.012	
PERLND 34	(OF)		-	
PERLND 44	(OG)		5.397	
PERLND 45	(FL)		5.482	
PERLND 54	(SA)		0.050	
IMPLND 14	(EIA)		634.648	
SUM			939.588	

AR 053036

Table . Des Moines Creek Surface Water Subbasin Characteristics -1t STIA basins)

Land Use			Surface Water Subbasin Areas (Acres)													
		% of total basin	DM-3		DM-4		DM-5		DM-6		DM-7		DM-8		DM-9	
Land Use	Soil Type	equal to EIA	Pervious	Effective Impervious	Pervious	Effective Impervious	Pervious	Effective Impervious	Pervious	Effective Impervious	Pervious	Effective Impervious	Pervious	Effective Impervious	Pervious	Effective Impervious
COMM	LAC	85%	3.09	17.51	-	-	-	-	-	-	2.15	12.16	-	-	-	-
	OGF	85%	-	-	-	-	-	-	0.01	0.06	0.65	3.68	2.27	12.87	-	-
	OGM	85%	-	-	-	-	0.27	1.53	0.00	0.02	0.07	0.39	-	-	-	-
	TGF	85%	2.80	15.85	3.69	20.92	0.00	0.00	0.00	0.01	-	-	1.86	10.54	-	-
	TGM	85%	3.29	18.63	3.38	19.15	1.44	8.13	-	-	-	-	-	-	-	-
	TGS	85%	-	-	-	-	-	-	-	-	-	-	-	-	-	-
F	LAC	0%	-	-	-	-	-	-	-	-	22.07	-	-	-	0.02	-
	OFF	0%	-	-	-	-	-	-	0.02	-	15.40	-	8.58	-	-	-
	OFM	0%	-	-	-	-	0.88	-	-	-	8.23	-	-	-	0.20	-
	TFF	0%	-	-	1.59	-	-	-	0.00	-	4.21	-	2.43	-	-	-
	TFM	0%	-	-	1.91	-	2.08	-	-	-	-	-	-	-	-	-
	TFS	0%	-	-	-	-	-	-	-	-	-	-	-	-	-	-
HD	LAC	30%	1.39	0.59	-	-	-	-	-	-	-	-	-	-	-	-
	TGF	30%	9.67	4.14	-	-	-	-	-	-	0.96	0.41	-	-	-	-
	TGM	30%	0.43	0.19	-	-	-	-	-	-	-	-	-	-	-	-
	TGS	30%	-	-	-	-	-	-	-	-	-	-	-	-	-	-
LD	LAC	13%	1.21	0.18	-	-	-	-	-	-	5.93	0.89	-	-	1.25	0.19
	OGF	13%	-	-	-	-	-	-	-	-	37.34	5.58	10.37	1.55	8.69	1.30
	OGM	13%	-	-	-	-	-	-	-	-	11.55	1.73	-	-	26.75	4.00
	OGS	13%	-	-	-	-	-	-	-	-	0.09	0.01	-	-	1.04	0.16
	TGF	13%	14.66	2.19	-	-	-	-	-	-	26.29	3.93	0.64	0.10	10.26	1.53
	TGM	13%	7.21	1.08	-	-	-	-	-	-	-	-	-	-	2.89	0.43
OG	LAC	0%	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	OGF	0%	-	-	-	-	0.18	-	8.49	-	-	-	-	-	-	-
	OGM	0%	-	-	-	-	0.51	-	-	-	-	-	-	-	-	-
	TGF	0%	-	-	-	-	1.96	-	4.83	-	-	-	-	-	-	-
	TGM	0%	-	-	-	-	0.79	-	1.57	-	-	-	-	-	-	-
	TGS	0%	-	-	-	-	-	-	-	-	-	-	-	-	-	-
STIA	LAC	0%	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	OGF	0%	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	OGM	0%	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	TGF	0%	-	-	-	-	0.16	0.01	-	-	-	-	-	-	-	-
	TGM	0%	-	-	-	-	1.57	0.07	-	-	-	-	-	-	-	-
	TGS	0%	-	-	-	-	-	-	-	-	-	-	-	-	-	-
TRANS	OGF	0%	-	-	-	-	-	-	-	-	-	-	0.94	0.03	-	-
	TGF	0%	-	-	-	-	-	-	-	-	-	-	4.81	3.95	-	-

AR 053037

Table J. Des Moines Creek Surface Water Subbasin Characteristics -1! STIA basins)

Land Use			Surface Water Subbasin Areas (Acres)													
Land Use	Soil Type	% of total basin equal to EIA	DM-3		DM-4		DM-5		DM-6		DM-7		DM-8		DM-9	
			Pervious	Effective Impervious	Pervious	Effective Impervious	Pervious	Effective Impervious	Pervious	Effective Impervious	Pervious	Effective Impervious	Pervious	Effective Impervious	Pervious	Effective Impervious
	Wetland	0%	0.16		0.06		1.35		3.74		6.62		1.93		0.12	
	Lake		-		-		-		[illegible]		-		-		-	
	Other		0.07		0.02		-		-		0.01		0.01		-	
Basin total:			43.91	60.36	10.62	40.08	11.18	9.74	[illegible]	0.09	141.55	28.79	33.83	29.04	51.22	7.60
PERLND areas:																
(16)	TF		-		3.49		2.08		0.00		26.28		2.43		0.02	
(26)	TG		43.74		7.07		5.91		6.41		35.33		7.31		14.40	
(34)	OF		-		-		0.88		0.02		23.63		8.58		0.20	
(44)	OG		-		-		0.96		8.50		49.70		13.58		36.48	
(54)	Wetland		0.16		0.06		1.35		3.74		6.62		1.93		0.12	
	subtotal:		43.91		10.62		11.18		18.68		141.55		33.83		51.22	
IMPLND areas:																
	EIA			60.36		40.08		9.74		0.09		28.79		29.04		7.60
Basin total:			104.27		50.70		20.92		18.77		170.34		62.87		58.82	
Percent impervious				57.9%		79.0%		46.6%		0.5%		16.9%		46.2%		12.9%
			DM-3		DM-4		DM-5		DM-6		DM-7		DM-8		DM-9	
NETWORK FACTORS																
PERLND 16	(TF)		-		0.291		0.173		0.000		2.190		0.203		0.002	
PERLND 26	(TG)		3.645		0.589		0.493		0.534		2.944		0.609		1.200	
PERLND 34	(OF)		-		-		0.074		0.002		1.969		0.715		0.016	
PERLND 44	(OG)		-		-		0.080		0.709		4.142		1.132		3.040	
PERLND 54	(SA)		0.013		0.005		0.112		0.312		0.551		0.161		0.010	
IMPLND 14	(EIA)		5.030		3.340		0.812		0.006		2.399		2.420		0.634	
SUM			8.689		4.225		1.743		1.564		14.195		5.239		4.902	

AR 053038

Table ı. Des Moines Creek Surface Water Subbasin Characteristics -1ŀ ƽTIA basins)

Land Use			Surface Water Subbasin Areas (Acres)													
		% of total basin	DM-10		DM-11		DM-12		DM-13		SDE-4		SDS-1		SDS 2	
Land Use	Soil Type	equal to EIA	Pervious	Effective Impervious	Pervious	Effective Impervious	Pervious	Effective Impervious	Pervious	Effective Impervious	Pervious	Effective Impervious	Pervious	Effective Impervious	Pervious	Effective Impervious
COMM	LAC	85%	-	-	1.12	6.35	-	-	-	-	1.28	7.25	-	-	-	-
	OGF	85%	-	-	2.89	16.37	-	-	-	-	-	-	-	-	0.15	0.83
	OGM	85%	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	TGF	85%	-	-	1.36	7.72	-	-	2.59	14.66	1.69	9.58	0.81	4.61	0.05	0.30
	TGM	85%	-	-	-	-	-	-	0.04	0.20	0.16	0.92	0.12	0.66	-	-
	TGS	85%	-	-	-	-	-	-	-	-	-	-	-	-	-	-
F	LAC	0%	11.16	-	0.73	-	6.13	-	0.00	-	-	-	-	-	-	-
	OFF	0%	8.80	-	12.28	-	0.02	-	0.02	-	-	-	-	-	4.06	-
	OFM	0%	14.42	-	-	-	4.48	-	14.42	-	-	-	-	-	-	-
	TFF	0%	0.18	-	3.12	-	-	-	4.94	-	-	-	-	-	2.76	-
	TFM	0%	-	-	-	-	-	-	6.34	-	-	-	-	-	-	-
	TFS	0%	-	-	-	-	-	-	0.24	-	-	-	-	-	-	-
HD	LAC	30%	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	TGF	30%	-	-	-	-	-	-	0.06	0.02	-	-	-	-	-	-
	TGM	30%	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	TGS	30%	-	-	-	-	-	-	-	-	-	-	-	-	-	-
LD	LAC	13%	2.50	0.37	-	-	-	-	-	-	-	-	-	-	-	-
	OGF	13%	0.67	0.10	-	-	-	-	1.47	0.22	-	-	-	-	-	-
	OGM	13%	5.39	0.81	-	-	-	-	0.04	0.01	-	-	-	-	-	-
	OGS	13%	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	TGF	13%	6.33	0.95	-	-	-	-	-	-	-	-	-	-	-	-
	TGM	13%	-	-	-	-	-	-	-	-	-	-	-	-	-	-
OG	LAC	0%	0.02	-	-	-	0.01	-	-	-	-	-	-	-	-	-
	OGF	0%	0.06	-	2.72	-	18.95	-	16.25	-	-	-	-	-	-	-
	OGM	0%	0.00	-	-	-	1.93	-	4.35	-	-	-	-	-	-	-
	TGF	0%	-	-	1.42	-	-	-	9.54	-	10.57	-	-	-	-	-
	TGM	0%	-	-	-	-	-	-	6.52	-	-	-	-	-	-	-
	TGS	0%	-	-	-	-	-	-	-	-	-	-	-	-	-	-
STIA	LAC	0%	-	-	-	-	-	-	-	-	0.78	0.11	-	-	-	-
	OGF	0%	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	OGM	0%	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	TGF	0%	-	-	-	-	-	-	-	-	34.50	96.73	-	11.54	-	-
	TGM	0%	-	-	-	-	-	-	-	-	1.77	0.89	-	0.01	-	-
	TGS	0%	-	-	-	-	-	-	-	-	-	-	-	-	-	-
TRANS	OGF	0%	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	TGF	0%	-	-	0.99	2.27	-	-	-	-	-	-	-	-	0.12	0.36

Table ‚. Des Moines Creek Surface Water Subbasin Characteristics -1ℓ ƷTIA basins)

Land Use			Surface Water Subbasin Areas (Acres)													
		% of total basin equal to EIA	DM-10		DM-11		DM-12		DM-13		SDE-4		SDS-1		SDS-2	
Land Use	Soil Type		Pervious	Effective Impervious	Pervious	Effective Impervious	Pervious	Effective Impervious	Pervious	Effective Impervious	Pervious	Effective Impervious	Pervious	Effective Impervious	Pervious	Effective Impervious
	Wetland	0%	8.55		12.43		6.51		0.30		-		-		0.52	
	Lake		0.97		5.33	.	0.63		0.85		-		-		-	
	Other		0.00		-		0.00		0.07		0.13		-		-	
Basin total:			58.08	2.22	39.06	32.71	38.02	-	67.10	15.11	50.75	115.49	0.93	16.81	7.66	1.49
PERLND areas:																
(16)	TF		11.34		3.85		6.13		11.53		-		-		2.76	
(26)	TG		8.85		4.89		0.01		18.74		50.75		0.93		0.17	
(34)	OF		23.22		12.28		4.50		14.44		-		-		4.06	
(44)	OG		6.12		5.61		20.88		22.10		-		-		0.15	
(54)	Wetland		8.55		12.43		6.51		0.30		-		-		0.52	
	subtotal:		58.08		39.06		38.02		67.10		50.75		0.93		7.66	
IMPLND areas:																
	EIA			2.22		32.71		-		15.11		115.49		16.81		1.49
Basin total:			60.30		71.77		38.02		82.22		166.24		17.74		9.15	
Percent impervious				3.7%		45.6%		0.0%		18.4%		69.5%		94.8%		16.3%
			DM-10		DM-11		DM-12		DM-13		SDE-4		SDS-1		SDS-2	
NETWORK FACTORS																
PERLND 16	(TF)		0.945		0.321		0.510		0.961		-		-		0.230	
PERLND 26	(TG)		0.738		0.408		0.001		1.562		4.229		0.077		0.014	
PERLND 34	(OF)		1.935		1.024		0.375		1.203		-		-		0.338	
PERLND 44	(OG)		0.510		0.467		1.740		1.842		-		-		0.012	
PERLND 54	(SA)		0.712		1.036		0.543		0.025		-		-		0.043	
IMPLND 14	(EIA)		0.185		2.726		-		1.259		9.624		1.401		0.124	
SUM			5.025		5.981		3.168		6.851		13.853		1.478		0.762	

AR 053040

Table .. Des Moines Creek Surface Water Subbasin Characteristics -1ٍ ƽTIA basins)

Land Use			Surface Water Subbasin Areas (Acres)													
		% of total basin equal to EIA	SDS-3		SDS-3A		SDS-4		SDS-5		SDS-6		SDS-7		SASA	
Land Use	Soil Type		Pervious	Effective Impervious	Pervious	Effective Impervious	Pervious	Effective Impervious	Pervious	Effective Impervious	Pervious	Effective Impervious	Pervious	Effective Impervious	Pervious	Effective Impervious
COMM	LAC	85%	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	OGF	85%	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	OGM	85%	-	-	-	-	0.02	0.10	-	-	-	-	-	-	0.01	0.08
	TGF	85%	-	-	-	-	-	-	-	-	-	-	-	-	1.37	7.76
	TGM	85%	0.00	0.00	-	-	0.00	0.00	-	-	-	-	-	-	0.19	1.10
	TGS	85%	-	-	-	-	-	-	-	-	-	-	-	-	-	-
F	LAC	0%	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	OFF	0%	-	-	-	-	0.14	-	-	-	-	-	-	-	-	-
	OFM	0%	-	-	-	-	-	-	-	-	-	-	-	-	0.23	-
	TFF	0%	-	-	-	-	-	-	-	-	-	-	-	-	12.32	-
	TFM	0%	-	-	-	-	0.00	-	-	-	-	-	-	-	9.89	-
	TFS	0%	-	-	-	-	-	-	-	-	-	-	-	-	0.58	-
HD	LAC	30%	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	TGF	30%	-	-	-	-	-	-	-	-	-	-	0.95	0.41	-	-
	TGM	30%	-	-	-	-	-	-	-	-	-	-	1.15	0.49	-	-
	TGS	30%	-	-	-	-	-	-	-	-	-	-	1.29	0.55	-	-
LD	LAC	13%	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	OGF	13%	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	OGM	13%	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	OGS	13%	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	TGF	13%	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	TGM	13%	-	-	-	-	-	-	-	-	-	-	-	-	-	-
OG	LAC	0%	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	OGF	0%	-	-	-	-	25.08	-	-	-	-	-	4.59	-	-	-
	OGM	0%	-	-	-	-	0.61	-	-	-	-	-	-	-	-	-
	TGF	0%	-	-	-	-	2.94	-	-	-	1.31	-	49.88	-	-	-
	TGM	0%	-	-	2.14	-	0.00	-	-	-	-	-	2.01	-	0.19	-
	TGS	0%	-	-	-	-	-	-	-	-	-	-	1.91	-	-	-
STIA	LAC	0%	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	OGF	0%	-	-	-	-	9.96	11.40	-	-	-	-	-	-	-	-
	OGM	0%	-	-	-	-	0.45	1.79	-	-	-	-	-	-	-	-
	TGF	0%	160.43	170.75	50.52	4.43	6.17	5.91	31.99	0.39	11.12	4.27	20.55	6.52	-	-
	TGM	0%	5.07	7.04	10.06	2.63	-	-	-	-	-	-	0.23	0.03	-	-
	TGS	0%	-	-	-	-	-	-	-	-	-	-	0.28	0.01	-	-
TRANS	OGF	0%	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	TGF	0%	-	-	-	-	0.01	-	0.08	-	0.03	0.00	-	-	-	-

AR 053041

Table 1. Des Moines Creek Surface Water Subbasin Characteristics -1(3TIA hasins)

Land Use			Surface Water Subbasin Areas (Acres)													
Land Use	Soil Type	% of total basin equal to EIA	SDS-3		SDS-3A		SDS-4		SDS-5		SDS-6		SDS-7		SASA	
			Pervious	Effective Impervious	Pervious	Effective Impervious	Pervious	Effective Impervious	Pervious	Effective Impervious	Pervious	Effective Impervious	Pervious	Effective Impervious	Pervious	Effective Impervious
	Wetland	0%	-		-		0.00		-		-		0.39		0.54	
	Lake		-		-		-		-		-		-		-	
	Other		-		-		-		-		-		-		-	
Basin total:			165.49	177.79	62.72	7.05	45.37	19.19	32.07	0.39	12.46	4.27	83.24	8.01	25.33	8.94
PERLND areas:																
(16)	TF		-		-		0.00		-		-		-		22.79	
(26)	TG		165.49		62.72		9.13		32.07		12.46		78.26		1.76	
(34)	OF		-		-		0.14		-		-		-		0.23	
(44)	OG		-		-		36.11		-		-		4.59		0.01	
(54)	Wetland		-		-		0.00		-		-		0.39		0.54	
	subtotal:		165.49		62.72		45.37		32.07		12.46		83.24		25.33	
IMPLND areas:																
	EIA			177.79		7.05		19.19		0.39		4.27		8.01		8.94
Basin total:			343.28		69.78		64.57		32.46		16.72		91.25		34.27	
Percent impervious				51.8%		10.1%		29.7%		1.2%		25.5%		8.8%		26.1%
			SDS-3		SDS-3A		SDS-4		SDS-5		SDS-6		SDS-7		SASA	
NETWORK FACTORS																
PERLND 16	(TF)		-		-		0.000		-		-		-		1.899	
PERLND 26	(TG)		13.791		5.227		0.761		2.672		1.038		6.522		0.146	
PERLND 34	(OF)		-		-		0.011		-		-		-		0.019	
PERLND 44	(OG)		-		-		3.009		-		-		0.383		0.001	
PERLND 54	(SA)		-		-		0.000		-		-		0.033		0.045	
IMPLND 14	(EIA)		14.816		0.588		1.599		0.032		0.356		0.668		0.745	
SUM			28.607		5.815		5.380		2.705		1.394		7.605		2.856	

AR 053042

Table ı. Des Moines Creek Surface Water Subbasin Characteristics -1ᒐ ƷTIA basins)

Land Use			Surface Water Subbasin Areas (Acres)											
		% of total basin equal to	IWS NSPS		IWS PRIMARY		IWS WEST		IWS SASA		Total		Percent of Total	
Land Use	Soil Type	EIA	Pervious	Effective Impervious	Pervious	Effective Impervious	Pervious	Effective Impervious	Pervious	Effective Impervious	Pervious	Effective Impervious	Pervious	Effective Impervious
COMM	LAC	85%	-	-	-	-	-	-	-	-	7.64	43.27	0.40%	2.26%
	OGF	85%	-	-	-	-	-	-	0.01	0.04	5.98	33.86	0.31%	1.77%
	OGM	85%	-	-	-	-	-	-	0.45	2.53	0.82	4.65	0.04%	0.24%
	TGF	85%	-	-	0.23	1.30	-	-	0.02	0.13	16.48	93.39	0.86%	4.88%
	TGM	85%	-	-	0.08	0.48	-	-	0.48	2.73	9.18	52.01	0.48%	2.72%
	TGS	85%	-	-	-	-	-	-	0.20	1.15	0.20	1.15	0.01%	0.06%
F	LAC	0%	-	-	-	-	-	-	-	-	40.10	-	2.09%	0.00%
	OFF	0%	-	-	-	-	6.14	-	0.04	-	55.49	-	2.90%	0.00%
	OFM	0%	-	-	-	-	-	-	0.20	-	43.06	-	2.25%	0.00%
	TFF	0%	-	-	-	-	2.67	-	1.08	-	35.31	-	1.84%	0.00%
	TFM	0%	-	-	-	-	-	-	28.69	-	48.90	-	2.55%	0.00%
	TFS	0%	-	-	-	-	-	-	6.80	-	7.61	-	0.40%	0.00%
HD	LAC	30%	-	-	-	-	-	-	-	-	1.39	0.59	0.07%	0.03%
	TGF	30%	-	-	-	-	-	-	-	-	11.64	4.99	0.61%	0.26%
	TGM	30%	-	-	-	-	-	-	-	-	1.58	0.68	0.08%	0.04%
	TGS	30%	-	-	-	-	-	-	-	-	1.29	0.55	0.07%	0.03%
LD	LAC	13%	-	-	-	-	-	-	-	-	10.90	1.63	0.57%	0.09%
	OGF	13%	-	-	-	-	-	-	-	-	58.54	8.75	3.06%	0.46%
	OGM	13%	-	-	-	-	-	-	-	-	43.72	6.53	2.28%	0.34%
	OGS	13%	-	-	-	-	-	-	-	-	1.13	0.17	0.06%	0.01%
	TGF	13%	-	-	-	-	-	-	-	-	58.18	8.69	3.04%	0.45%
	TGM	13%	-	-	-	-	-	-	-	-	10.10	1.51	0.53%	0.08%
OG	LAC	0%	-	-	-	-	-	-	-	-	0.03	-	0.00%	0.00%
	OGF	0%	-	-	-	-	-	-	0.09	-	76.41	-	3.99%	0.00%
	OGM	0%	-	-	-	-	-	-	2.71	-	10.10	-	0.53%	0.00%
	TGF	0%	-	-	0.05	-	-	-	0.32	-	82.82	-	4.32%	0.00%
	TGM	0%	-	-	0.12	-	-	-	9.01	-	22.36	-	1.17%	0.00%
	TGS	0%	-	-	-	-	-	-	-	-	1.91	-	0.10%	0.00%
STIA	LAC	0%	-	-	-	-	-	-	-	-	0.78	0.11	0.04%	0.01%
	OGF	0%	-	-	-	-	-	-	-	0.00	9.96	11.40	0.52%	0.60%
	OGM	0%	-	-	-	-	-	-	0.37	-	0.82	1.79	0.04%	0.09%
	TGF	0%	0.31	13.44	11.95	225.09	2.72	0.44	-	-	330.42	539.50	17.25%	28.17%
	TGM	0%	-	-	0.96	6.61	-	-	-	-	19.66	17.28	1.03%	0.90%
	TGS	0%	-	-	-	-	-	-	-	-	0.28	0.01	0.01%	0.00%
TRANS	OGF	0%	-	-	-	-	-	-	-	-	0.94	0.03	0.05%	0.00%
	TGF	0%	-	-	-	-	-	-	-	-	6.04	6.58	0.32%	0.34%

AR 053043

Table ,. Des Moines Creek Surface Water Subbasin Characteristics -1! 3TIA basins)

Land Use			Surface Water Subbasin Areas (Acres)											
		% of total basin	IWS NSPS		IWS PRIMARY		IWS WEST		IWS SASA		Total		Percent of Total	
Land Use	Soil Type	equal to EIA	Pervious	Effective Impervious	Pervious	Effective Impervious	Pervious	Effective Impervious	Pervious	Effective Impervious	Pervious	Effective Impervious	Pervious	Effective Impervious
	Wetland	0%	-		-		0.00		1.35		44.58		2.33%	
	Lake		-		-		6.65		-		14.45		0.75%	
	Other		-		-		-		-		0.31		0.02%	
Basin total:			0.31	13.44	13.40	233.48	11.53	0.44	51 82	6.57	1076.33	839.11	56.19%	43.81%
PERLND areas:														
(16)	TF		-		-		2.67		36 57		131.93		6.89%	
(26)	TG		0.31		13.40		2.72		10 04		592.87		30.95%	
(34)	OF		-		-		6.14		0 24		98.55		5.14%	
(44)	OG		-		-		-		3 63		208 41		10.88%	
(54)	Wetland		-		-		0.00		1 35		44 58		2.33%	
	subtotal:		0.31		13.40		11.53		51 82		1076.33		56.19%	
IMPLND areas:														
	EIA			13.44		233.48		0.44		6.57		839.11		43.81%
Basin total:			13 75		246.87		11.97		58.40		1915.44		100.00%	
Percent Impervious				97.8%		94.6%		3.7%		11.3%				
			IWS NSPS		IWS PRIMARY		IWS WEST		IWS SASA		Total		Percent of Total	
NETWORK FACTORS														
PERLND 16	(TF)		-		-		0.222		3 047		10.994		6.89%	
PERLND 26	(TG)		0.026		1.117		0.226		0.837		49.405		30.95%	
PERLND 34	(OF)		-		-		0.512		0.020		8.212		5.14%	
PERLND 44	(OG)		-		-		-		0.302		17.368		10.88%	
PERLND 54	(SA)		-		-		0.000		0 113		3.715		2.33%	
IMPLND 14	(EIA)		1.120		19.456		0.037		0 548		69.926		43.81%	
SUM			1.146		20.573		0.997		4.866		159.620		100.00%	

AR 053044

Table . Des Moines Creek Surface Water Subbasin Characteristics -2(5TIA basins)

Land Use			Surface Water Subbasin Areas (Acres)													
		% of total basin equal to EIA	DM-3		DM-4		DM-5		DM-6		DM-7		DM-8		DM-9	
Land Use	Soil Type		Pervious	Effective Impervious	Pervious	Effective Impervious	Pervious	Effective Impervious	Pervious	Effective Impervious	Pervious	Effective Impervious	Pervious	Effective Impervious	Pervious	Effective Impervious
COMM	LAC	85%	3.09	17.52	-	-	-	-	-	-	2.15	12.17	-	-	-	-
	OGF	85%	-	-	-	-	-	-	0.01	0.06	0.65	3.70	2.28	12.89	-	-
	OGM	85%	-	-	-	-	0.27	1.53	0.00	0.02	0.07	0.39	-	-	-	-
	TGF	85%	2.54	14.37	3.71	21.04	0.00	0.00	-	-	-	-	1.86	10.54	-	-
	TGM	85%	2.44	13.83	3.38	19.16	1.37	7.79	-	-	-	-	-	-	-	-
F	LAC	0%	-	-	-	-	-	-	-	-	22.07	-	-	-	0.02	-
	OFF	0%	-	-	-	-	-	-	0.02	-	15.40	-	8.58	-	-	-
	OFM	0%	-	-	-	-	0.88	-	-	-	8.23	-	-	-	0.20	-
	TFF	0%	-	-	1.52	-	-	-	-	-	4.21	-	2.43	-	-	-
	TFM	0%	-	-	1.91	-	2.07	-	-	-	-	-	-	-	-	-
	TFS	0%	-	-	-	-	-	-	-	-	-	-	-	-	-	-
HD	LAC	30%	1.39	0.59	-	-	-	-	-	-	-	-	-	-	-	-
	TGF	30%	9.67	4.15	-	-	-	-	-	-	0.96	0.41	-	-	-	-
	TGM	30%	0.43	0.19	-	-	-	-	-	-	-	-	-	-	-	-
LD	LAC	13%	1.21	0.18	-	-	-	-	-	-	5.93	0.89	-	-	1.25	0.19
	OGF	13%	-	-	-	-	-	-	-	-	37.35	5.58	10.37	1.55	8.69	1.30
	OGM	13%	-	-	-	-	-	-	-	-	11.55	1.73	-	-	26.75	4.00
	OGS	13%	-	-	-	-	-	-	-	-	0.09	0.01	-	-	1.04	0.16
	TGF	13%	14.66	2.19	-	-	-	-	-	-	26.29	3.93	0.64	0.10	10.27	1.53
	TGM	13%	7.21	1.08	-	-	-	-	-	-	-	-	-	-	2.89	0.43
OG	LAC	0%	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	OGF	0%	-	-	-	-	0.15	-	8.49	-	-	-	-	-	-	-
	OGM	0%	-	-	-	-	0.51	-	-	-	-	-	-	-	-	-
	TGF	0%	-	-	-	-	1.97	-	4.83	-	-	-	-	-	-	-
	TGM	0%	-	-	-	-	0.78	-	1.57	-	-	-	-	-	-	-
STIA	FLF	0%	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	LAC	0%	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	OGF	0%	-	-	-	-	-	0.03	-	-	-	-	-	-	-	-
	OGM	0%	-	-	-	-	0.00	0.00	-	-	-	-	-	-	-	-
	TGF	0%	-	-	-	0.08	0.16	0.00	-	-	-	-	-	-	-	-
	TGM	0%	-	-	-	0.01	1.53	0.24	-	-	-	-	-	-	-	-
	TGS	0%	-	-	-	-	-	-	-	-	-	-	-	-	-	-
TRANS	OGF	0%	-	-	-	-	-	-	-	-	-	-	0.95	0.03	-	-
	OGM	0%	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	TGF	0%	-	-	-	-	-	-	-	-	-	-	4.81	3.95	-	-

AR 053045

Table . Des Moines Creek Surface Water Subbasin Characteristics -2C ;TIA basins)

Land Use			Surface Water Subbasin Areas (Acres)													
Land Use	Soil Type	% of total basin equal to EIA	DM-3 Pervious	DM-3 Effective Impervious	DM-4 Pervious	DM-4 Effective Impervious	DM-5 Pervious	DM-5 Effective Impervious	DM-6 Pervious	DM-6 Effective Impervious	DM-7 Pervious	DM-7 Effective Impervious	DM-8 Pervious	DM-8 Effective Impervious	DM-9 Pervious	DM-9 Effective Impervious
	Wetland	0%	0.07		0.06		1.35		3.74		6.62		1.93		0.12	
	Lake		-		-		-		0.03		-		-		-	
	Sasa-dp		7.42		-		0.28		-		-		-		-	
	Other		0.00		0.06		-		-		0.01		0.01		-	
Basin total:			42.72	54.10	10.58	40.28	11.05	9.59	18.67	0.08	141.59	28.81	33.84	29.06	51.23	7.60
PERLND areas:																
(16)	TF		-		3.43		2.07		-		26.28		2.43		0.02	
(26)	TG		42.65		7.09		5.82		6.41		35.33		7.31		14.41	
(34)	OF		-		-		0.88		0.02		23.63		8.58		0.20	
(44)	OG		-		-		0.93		8.50		49.72		13.59		36.48	
(45)	FL		-		-		-		-		-		-		-	
(54)	Wetland		0.07		0.06		1.35		3.74		6.62		1.93		0.12	
	subtotal:		42.72		10.58		11.05		18.67		141.59		33.84		51.23	
IMPLND areas:																
	EIA			54.10		40.28		9.59		0.08		28.81		29.06		7.60
Basin total:			96.82		50.87		20.64		18.75		170.40		62.90		58.83	
Percent Impervious				55.9%		79.2%		46.5%		0.4%		16.9%		46.2%		12.9%
			DM-3		DM-4		DM-5		DM-6		DM-7		DM-8		DM-9	
NETWORK FACTORS																
PERLND 16	(TF)		-		0.286		0.173		-		2.190		0.203		0.002	
PERLND 26	(TG)		3.554		0.591		0.485		0.534		2.944		0.609		1.201	
PERLND 34	(OF)		-		-		0.074		0.002		1.970		0.715		0.017	
PERLND 44	(OG)		-		-		0.077		0.709		4.143		1.133		3.040	
PERLND 45	(FL)		-		-		-		-		-		-		-	
PERLND 54	(SA)		0.006		0.005		0.112		0.312		0.552		0.161		0.010	
IMPLND 14	(EIA)		4.508		3.357		0.799		0.007		2.401		2.422		0.634	
SUM			8.068		4.239		1.720		1.563		14.200		5.242		4.903	

AR 053046

Table ı. Des Moines Creek Surface Water Subbasin Characteristics -2ι 3TIA basins)

Land Use			Surface Water Subbasin Areas (Acres)													
		% of total basin	DM-10		DM-11		DM-12		DM-13		SDE-4		SDS-1		SDS-2	
Land Use	Soil Type	equal to EIA	Pervious	Effective Impervious	Pervious	Effective Impervious	Pervious	Effective Impervious	Pervious	Effective Impervious	Pervious	Effective Impervious	Pervious	Effective Impervious	Pervious	Effective Impervious
COMM	LAC	85%	-	-	1.12	6.35	-	-	-	-	-	-	-	-	-	-
	OGF	85%	-	-	2.89	16.37	-	-	-	-	-	-	-	-	-	-
	OGM	85%	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	TGF	85%	-	-	1.36	7.72	-	-	2.59	14.66	-	-	-	-	-	-
	TGM	85%	-	-	-	-	-	-	0.04	0.20	-	-	-	-	-	-
F	LAC	0%	11.16	-	0.73	-	6.13	-	0.00	-	-	-	-	-	-	-
	OFF	0%	8.80	-	12.28	-	0.02	-	0.02	-	-	-	-	-	-	-
	OFM	0%	14.42	-	-	-	4.48	-	14.42	-	-	-	-	-	-	-
	TFF	0%	0.18	-	3.12	-	-	-	4.94	-	-	-	-	-	-	-
	TFM	0%	-	-	-	-	-	-	6.35	-	-	-	-	-	-	-
	TFS	0%	-	-	-	-	-	-	0.24	-	-	-	-	-	-	-
HD	LAC	30%	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	TGF	30%	-	-	-	-	-	-	0.06	0.02	-	-	-	-	-	-
	TGM	30%	-	-	-	-	-	-	-	-	-	-	-	-	-	-
LD	LAC	13%	2.50	0.37	-	-	-	-	-	-	-	-	-	-	-	-
	OGF	13%	0.67	0.10	-	-	-	-	1.47	0.22	-	-	-	-	-	-
	OGM	13%	5.39	0.81	-	-	-	-	0.04	0.01	-	-	-	-	-	-
	OGS	13%	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	TGF	13%	6.33	0.95	-	-	-	-	-	-	-	-	-	-	-	-
	TGM	13%	-	-	-	-	-	-	-	-	-	-	-	-	-	-
OG	LAC	0%	0.02	-	-	-	0.01	-	-	-	-	-	-	-	-	-
	OGF	0%	0.06	-	2.72	-	18.81	-	15.48	-	-	-	-	-	-	-
	OGM	0%	0.00	-	-	-	1.93	-	4.35	-	-	-	-	-	-	-
	TGF	0%	-	-	1.42	-	-	-	9.55	-	-	-	-	-	-	-
	TGM	0%	-	-	-	-	-	-	6.52	-	-	-	-	-	-	-
STIA	FLF	0%	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	LAC	0%	-	-	-	-	-	-	-	-	1.60	7.82	-	-	-	-
	OGF	0%	-	-	0.00	-	-	-	-	-	-	-	-	-	4.61	0.42
	OGM	0%	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	TGF	0%	-	-	-	-	-	-	0.00	0.00	37.54	115.50	1.09	15.84	2.87	0.24
	TGM	0%	-	-	-	-	-	-	-	-	0.98	2.76	0.30	0.49	-	-
	TGS	0%	-	-	-	-	-	-	-	-	-	-	-	-	-	-
TRANS	OGF	0%	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	OGM	0%	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	TGF	0%	-	-	0.99	2.27	-	-	-	-	-	-	-	-	0.12	0.36

AR 053047

Table). Des Moines Creek Surface Water Subbasin Characteristics -2\ STIA basins)

Land Use			Surface Water Subbasin Areas (Acres)													
		% of total basin	DM-10		DM-11		DM-12		DM-13		SDE-4		SDS-1		SDS-2	
Land Use	Soil Type	equal to EIA	Pervious	Effective Impervious	Pervious	Effective Impervious	Pervious	Effective Impervious	Pervious	Effective Impervious	Pervious	Effective Impervious	Pervious	Effective Impervious	Pervious	Effective Impervious
	Wetland	0%	8.55		12.43		6.65		1.07		-		-		0.52	
	Lake		0.97		5.33		0.63		0.85		-		-		-	
	Sasa-dp		-		-		-		-		0.03		0.04		-	
	Other		0.00		-		0.00		0.07		0.13		-		-	
Basin total:			58.08	2.22	39.06	32.71	38.02	-	67.13	15.11	40.12	126.09	1.39	16.32	8.12	1.03
PERLND areas:																
(16)	TF		11.34		3.85		6.13		11.53		-		-		-	
(26)	TG		8.85		4.89		0.01		18.75		40.12		1.39		2.99	
(34)	OF		23.22		12.28		4.50		14.44		-		-		-	
(44)	OG		6.12		5.61		20.73		21.33		-		-		4.61	
(45)	FL		-		-		-		-		-		-		-	
(54)	Wetland		8.55		12.43		6.65		1.07		-		-		0.52	
	subtotal:		58.08		39.06		38.02		67.13		40.12		1.39		8.12	
IMPLND areas:																
	EIA			2.22		32.71		-		15.11		126.09		16.32		1.03
Basin total:			60.30		71.77		38.02		82.24		166.21		17.71		9.15	
Percent Impervious				3.7%		45.6%		0.0%		18.4%		75.9%		92.2%		11.3%
			DM-10		DM-11		DM-12		DM-13		SDE-4		SDS-1		SDS-2	
NETWORK FACTORS																
PERLND 16	(TF)		0.945		0.321		0.510		0.961		-		-		-	
PERLND 26	(TG)		0.738		0.408		0.001		1.562		3.344		0.115		0.249	
PERLND 34	(OF)		1.935		1.024		0.375		1.203		-		-		-	
PERLND 44	(OG)		0.510		0.467		1.728		1.778		-		-		0.384	
PERLND 45	(FL)		-		-		-		-		-		-		-	
PERLND 54	(SA)		0.712		1.036		0.554		0.089		-		-		0.043	
IMPLND 14	(EIA)		0.185		2.726		-		1.259		10.507		1.360		0.086	
SUM			5.025		5.981		3.168		6.853		13.851		1.476		0.762	

AR 053048

Table). Des Moines Creek Surface Water Subbasin Characteristics -2(STIA basins)

Land Use			Surface Water Subbasin Areas (Acres)													
		% of total basin	SDS-3		SDS-3A		SDS-4		SDS-5		SDS-6		SDS-7		SASA	
Land Use	Soil Type	equal to EIA	Pervious	Effective Impervious	Pervious	Effective Impervious	Pervious	Effective Impervious	Pervious	Effective Impervious	Pervious	Effective Impervious	Pervious	Effective Impervious	Pervious	Effective Impervious
COMM	LAC	85%	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	OGF	85%	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	OGM	85%	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	TGF	85%	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	TGM	85%	-	-	-	-	-	-	-	-	-	-	-	-	-	-
F	LAC	0%	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	OFF	0%	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	OFM	0%	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	TFF	0%	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	TFM	0%	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	TFS	0%	-	-	-	-	-	-	-	-	-	-	-	-	-	-
HD	LAC	30%	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	TGF	30%	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	TGM	30%	-	-	-	-	-	-	-	-	-	-	-	-	-	-
LD	LAC	13%	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	OGF	13%	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	OGM	13%	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	OGS	13%	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	TGF	13%	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	TGM	13%	-	-	-	-	-	-	-	-	-	-	-	-	-	-
OG	LAC	0%	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	OGF	0%	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	OGM	0%	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	TGF	0%	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	TGM	0%	-	-	-	-	-	-	-	-	-	-	-	-	-	-
STIA	FLF	0%	-	-	-	-	-	-	-	-	-	-	5.48	7.47	-	-
	LAC	0%	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	OGF	0%	-	-	-	-	24.91	21.67	-	-	-	-	3.93	0.69	-	-
	OGM	0%	-	-	-	-	0.40	2.53	-	-	-	-	-	-	-	0.33
	TGF	0%	144.03	198.63	34.64	35.14	6.76	8.28	28.20	4.18	13.51	3.18	45.69	27.99	0.01	21.44
	TGM	0%	0.28	0.54	-	-	-	-	-	-	-	-	-	-	0.00	11.92
	TGS	0%	-	-	-	-	-	-	-	-	-	-	-	-	-	0.58
TRANS	OGF	0%	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	OGM	0%	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	TGF	0%	-	-	-	-	0.01	0.00	0.08	-	0.03	0.00	-	-	-	-

Table [illegible]. Des Moines Creek Surface Water Subbasin Characteristics -2[illegible] 3TIA basins)

Land Use			Surface Water Subbasin Areas (Acres)													
Land Use	Soil Type	% of total basin equal to EIA	SDS-3		SDS-3A		SDS-4		SDS-5		SDS-6		SDS-7		SASA	
			Pervious	Effective Impervious	Pervious	Effective Impervious	Pervious	Effective Impervious	Pervious	Effective Impervious	Pervious	Effective Impervious	Pervious	Effective Impervious	Pervious	Effective Impervious
	Wetland	0%	-		-		-		-		-		-		-	
	Lake		-		-		-		-		-		-		-	
	Sasa-dp		-		-		-		-		-		-		-	
	Other		-		-		-		-		-		-		-	
Basin total:			144.31	199.17	34.64	35.14	32.08	32.48	28.28	4.18	13.54	3.18	55.10	36.15	0.01	34.26
PERLND areas:																
(16)	TF		-		-		-		-		-		-		-	
(26)	TG		144.31		34.64		6.77		28.28		13.54		-		-	
(34)	OF		-		-		-		-		-		45.69		0.01	
(44)	OG		-		-		25.31		-		-		-		-	
(45)	FL		-		-		-		-		-		3.93		-	
(54)	Wetland		-		-		-		-		-		5.48		-	
	subtotal:		144.31		34.64		32.08		28.28		13.54		55.10		0.01	
IMPLND areas:																
	EIA			199.17		35.14		32.48		4.18		3.18		36.15		34.26
Basin total:			343.49		69.78		64.56		32.46		16.72		91.25		34.27	
Percent Impervious				58.0%		50.4%		50.3%		12.9%		19.0%		39.6%		100.0%
			SDS-3		SDS-3A		SDS-4		SDS-5		SDS-6		SDS-7		SASA	
NETWORK FACTORS																
PERLND 16	(TF)		-		-		-		-		-		-		-	
PERLND 26	(TG)		12.026		2.886		0.564		2.356		1.128		-		-	
PERLND 34	(OF)		-		-		-		-		-		3.808		0.001	
PERLND 44	(OG)		-		-		2.109		-		-		-		-	
PERLND 45	(FL)		-		-		-		-		-		0.327		-	
PERLND 54	(SA)		-		-		-		-		-		0.457		-	
IMPLND 14	(EIA)		16.598		2.928		2.707		0.348		0.265		3.013		2.855	
SUM			28.624		5.815		5.380		2.705		1.394		7.605		2.856	

AR 053050

Table . Des Moines Creek Surface Water Subbasin Characteristics -2(;TIA basins)

Land Use			Surface Water Subbasin Areas (Acres)									
		% of total basin	IWS NSPS		IWS PRIMARY		IWS SASA		Total		Percent of Total	
Land Use	Soil Type	equal to EIA	Pervious	Effective Impervious	Pervious	Effective Impervious	Pervious	Effective Impervious	Pervious	Effective Impervious	Pervious	Effective Impervious
COMM	LAC	85%	-	-	-	-	-	-	6.36	39.12	0.32%	1.97%
	OGF	85%	-	-	-	-	-	-	5.83	33.03	0.29%	1.66%
	OGM	85%	-	-	-	-	-	-	0.34	1.94	0.02%	0.10%
	TGF	85%	-	-	-	-	-	-	12.06	70.87	0.61%	3.57%
	TGM	85%	-	-	-	-	-	-	7.23	43.43	0.36%	2.19%
F	LAC	0%	-	-	-	-	-	-	40.10	-	2.02%	0.00%
	OFF	0%	-	-	-	-	-	-	45.13	-	2.27%	0.00%
	OFM	0%	-	-	-	-	-	-	42.63	-	2.15%	0.00%
	TFF	0%	-	-	-	-	-	-	16.41	-	0.83%	0.00%
	TFM	0%	-	-	-	-	-	-	10.32	-	0.52%	0.00%
	TFS	0%	-	-	-	-	-	-	0.24	-	0.01%	0.00%
HD	LAC	30%	-	-	-	-	-	-	1.39	1.98	0.07%	0.10%
	TGF	30%	-	-	-	-	-	-	10.69	14.26	0.54%	0.72%
	TGM	30%	-	-	-	-	-	-	0.43	0.62	0.02%	0.03%
LD	LAC	13%	-	-	-	-	-	-	10.90	2.84	0.55%	0.14%
	OGF	13%	-	-	-	-	-	-	58.56	8.75	2.95%	0.44%
	OGM	13%	-	-	-	-	-	-	43.72	6.53	2.20%	0.33%
	OGS	13%	-	-	-	-	-	-	1.13	0.17	0.06%	0.01%
	TGF	13%	-	-	-	-	-	-	58.18	23.35	2.93%	1.18%
	TGM	13%	-	-	-	-	-	-	10.10	8.72	0.51%	0.44%
OG	LAC	0%	-	-	-	-	-	-	0.03	-	0.00%	0.00%
	OGF	0%	-	-	-	-	-	-	45.70	-	2.30%	0.00%
	OGM	0%	-	-	-	-	-	-	6.79	-	0.34%	0.00%
	TGF	0%	-	-	-	-	-	-	17.77	-	0.89%	0.00%
	TGM	0%	-	-	-	-	-	-	8.88	-	0.45%	0.00%
STIA	FLF	0%	-	-	-	-	-	-	5.48	7.47	0.28%	0.38%
	LAC	0%	-	-	-	1.73	-	-	1.60	9.55	0.08%	0.48%
	OGF	0%	-	-	6.15	6.42	-	0.18	39.59	34.02	1.99%	1.71%
	OGM	0%	-	-	0.00	5.45	0.04	6.23	0.45	14.54	0.02%	0.73%
	TGF	0%	0.31	13.44	6.52	259.31	-	1.75	321.33	692.03	16.18%	34.84%
	TGM	0%	-	-	0.86	15.67	0.05	42.01	4.00	73.15	0.20%	3.68%
	TGS	0%	-	-	-	-	-	8.15	-	8.72	0.00%	0.44%
TRANS	OGF	0%	-	-	-	0.20	-	-	0.95	0.23	0.05%	0.01%
	OGM	0%	-	-	0.00	0.29	-	-	0.00	0.29	0.00%	0.01%
	TGF	0%	-	-	0.00	0.01	-	-	6.03	6.71	0.30%	0.34%

AR 053051

Table ,. Des Moines Creek Surface Water Subbasin Characteristics -2\ 3TIA basins)

Land Use			Surface Water Subbasin Areas (Acres)									
Land Use	Soil Type	% of total basin equal to EIA	IWS NSPS		IWS PRIMARY		IWS SASA		Total		Percent of Total	
			Pervious	Effective Impervious	Pervious	Effective Impervious	Pervious	Effective Impervious	Pervious	Effective Impervious	Pervious	Effective Impervious
	Wetland	0%	-		0.00		0.01		43.14		2.17%	
	Lake		-		6.65		-		14.45		0.73%	
	Sasa-dp		-		-		-		7.76		0.39%	
	Other		-		-		-		0.29		0.01%	
Basin total:			0.31	13.44	13.53	289.08	0.11	58.32	883.50	1102.93	44.48%	55.52%
PERLND areas:												
(16)	TF		-		-		-		67.08		3.44%	
(26)	TG		0.31		7.38		0.05		476.99		24.44%	
(34)	OF		-		-		-		87.76		4.50%	
(44)	OG		-		6.15		0.04		203.05		10.40%	
(45)	FL		-		-		-		5.48		0.28%	
(54)	Wetland		-		0.00		0.01		43.14		2.21%	
	subtotal:		0.31		13.53		0.11		883.50		45.26%	
IMPLND areas:												
	EIA			13.44		289.08		58.32		1068.42		54.74%
Basin total:			13.75		302.62		58.42		1951.92	.	100.00%	
Percent impervious				97.8%		95.5%		99.8%				
			IWS NSPS		IWS PRIMARY		IWS SASA		Total		Percent of Total	
NETWORK FACTORS												
PERLND 16	(TF)		-		-		-		5.590		3.44%	
PERLND 26	(TG)		0.026		0.615		0.004		39.749		24.44%	
PERLND 34	(OF)		-		-		-		7.313		4.50%	
PERLND 44	(OG)		-		0.512		0.004		16.921		10.40%	
PERLND 45	(FL)		-		-		-		0.457		0.28%	
PERLND 54	(SA)		-		0.000		0.001		3.595		2.21%	
IMPLND 14	(EIA)		1.120		24.090		4.860		89.035		54.74%	
SUM			1.146		25.218		4.869		162.660		100.00%	

AR 053052

Table ı. Des Moines Creek Contiguous Groundwater Subbasin Charac tics - 1994 (STIA basins)

Land Use	Soil Type	% of total basin equal to EIA	DM-10 Pervious	DM-10 Effective Impervious	DM-11 Pervious	DM-11 Effective Impervious	DM-12 Pervious	DM-12 Effective Impervious	DM-13 Pervious	DM-13 Effective Impervious	DM-3 Pervious	DM-3 Effective Impervious	DM-4 Pervious	DM-4 Effective Impervious	DM-5 Pervious	DM-5 Effective Impervious
			Groundwater Subbasin Areas (Acres)													
PERLND areas:																
(16)	Till-Forest		11.34		3.85		6.13		11.53		-		3.49		2.08	
(26)	Till-Grass		8.85		4.89		0.01		18.74		43.54		7.06		5.91	
(34)	Outwash-Forest		23.22		12.28		4.50		14.44		-		-		0.88	
(44)	Outwash-Grass		6.12		5.61		20.88		22.10		-		-		0.96	
(54)	Wetland		8.55		12.43		6.51		0.30		0.16		0.06		1.35	
	subtotal:		58.08		39.06		38.02		67.10		43.70		10.62		11.18	
IMPLND areas:																
	EIA			2.22		32.71		-		15.10		60.25		40.02		9.74
Basin total:			60.30		71.77		38.02		82.20		103.95		50.64		20.92	
Percent Impervious				3.7%		45.6%		0.0%		18.4%		58.0%		79.0%		46.6%

NETWORK FACTORS		DM-10	DM-11	DM-12	DM-13	DM-3	DM-4	DM-5
PERLND 16	(TF)	0.945	0.321	0.510	0.961	-	0.291	0.173
PERLND 26	(TG)	0.738	0.408	0.001	1.561	3.628	0.589	0.493
PERLND 34	(OF)	1.935	1.024	0.375	1.203	-	-	0.074
PERLND 44	(OG)	0.510	0.467	1.740	1.842	-	-	0.080
PERLND 54	(SA)	0.712	1.036	0.543	0.025	0.013	0.005	0.112
IMPLND 14	(EIA)	0.185	2.726	-	1.259	5.021	3.335	0.812
SUM		5.025	5.981	3.168	6.850	8.662	4.220	1.743

AR 053053

Table ı. Des Moines Creek Contiguous Groundwater Subbasin Charac tics - 1994 (STIA basins)

Land Use	Soil Type	% of total basin equal to EIA	Groundwater Subbasin Areas (Acres)													
			DM-6		DM-7		DM-8		DM-9		SASA		SDE-4		SDS-1	
			Pervious	Effective Impervious	Pervious	Effective Impervious	Pervious	Effective Impervious	Pervious	Effective Impervious	Pervious	Effective Impervious	Pervious	Effective Impervious	Pervious	Effective Impervious
PERLND areas:																
(16)	Till-Forest		0.00		20.41		-		0.02		22.79		-		-	
(26)	Till-Grass		6.41		9.11		1.18		5.22		1.76		1.71		0.86	
(34)	Outwash-Forest		0.02		8.18		2.71		0.20		0.23		-		-	
(44)	Outwash-Grass		8.50		3.75		1.85		18.14		0.01		-		-	
(54)	Wetland		3.74		4.44		1.39		0.12		0.54		-		-	
	subtotal:		18.68		45.89		7.13		23.70		25.33		1.71		0.86	
IMPLND areas:																
	EIA			0.09		17.73		17.04		3.49		8.94		9.71		9.08
Basin total:			18.77		63.62		24.17		27.19		34.27		11.41		9.94	
Percent Impervious				0.5%		27.9%		70.5%		12.8%		26.1%		85.0%		91.3%
			DM-6		DM-7		DM-8		DM-9		SASA		SDE-4		SDS-1	
NETWORK FACTORS																
PERLND 16	(TF)		0.000		1.701		-		0.002		1.899		-		-	
PERLND 26	(TG)		0.534		0.759		0.098		0.435		0.146		0.142		0.072	
PERLND 34	(OF)		0.002		0.681		0.226		0.016		0.019		-		-	
PERLND 44	(OG)		0.709		0.313		0.154		1.512		0.001		-		-	
PERLND 54	(SA)		0.312		0.370		0.116		0.010		0.045		-		-	
IMPLND 14	(EIA)		0.008		1.478		1.420		0.291		0.745		0.809		0.757	
SUM			1.564		5.302		2.014		2.266		2.856		0.951		0.828	

Table .. Des Moines Creek Contiguous Groundwater Subbasin Charac ... tics - 1994 (STIA basins)

Land Use	Soil Type	% of total basin equal to EIA	Groundwater Subbasin Areas (Acres) SDS-2 Pervious	SDS-2 Effective Impervious	SDS-3 Pervious	SDS-3 Effective Impervious	SDS-4 Pervious	SDS-4 Effective Impervious	SDS-5 Pervious	SDS-5 Effective Impervious	SDS-6 Pervious	SDS-6 Effective Impervious	IWS-PRIMARY Pervious	IWS-PRIMARY Effective Impervious	IWS-WEST Pervious	IWS-WEST Effective Impervious
PERLND areas:																
(16)	Till-Forest		2.76		-		0.00		-		-		-		2.67	
(26)	Till-Grass		0.17		3.46		9.13		10.54		1.77		1.38		1.09	
(34)	Outwash-Forest		4.06		-		0.14		-		-		-		6.14	
(44)	Outwash-Grass		0.15		-		36.11		-		-		-		-	
(54)	Wetland		0.52		-		0.00		-		-		-		0.00	
	subtotal:		7.66		3.46		45.37		10.54		1.77		1.38		9.90	
IMPLND areas:																
	EIA			1.49		2.60		19.19		0.35		0.17		11.18		0.02
Basin total:			9.15		6.06		64.57		10.89		1.94		12.56		9.93	
Percent Impervious				16.3%		42.9%		29.7%		3.2%		8.5%		89.0%		0.2%
			SDS-2		SDS-3		SDS-4		SDS-5		SDS-6		IWS-PRIMARY		IWS-WEST	
NETWORK FACTORS																
PERLND 16	(TF)		0.230		-		0.000		-		-		-		0.222	
PERLND 26	(TG)		0.014		0.288		0.761		0.878		0.148		0.115		0.091	
PERLND 34	(OF)		0.338		-		0.011		-		-		-		0.512	
PERLND 44	(OG)		0.012		-		3.009		-		-		-		-	
PERLND 54	(SA)		0.043		-		0.000		-		-		-		0.000	
IMPLND 14	(EIA)		0.124		0.216		1.599		0.029		0.014		0.931		0.002	
SUM			0.762		0.505		5.380		0.907		0.161		1.046		0.827	

AR 053055

Table . Des Moines Creek Contiguous Groundwater Subbasin Charac ıics - 1994 (STIA basins)

			Groundwater Subbasin Areas (Acres)					
			IWS-SASA		MC9		TOTAL	
Land Use	Soil Type	% of total basin equal to EIA	Pervious	Effective Impervious	Pervious	Effective Impervious	Pervious	Effective Impervious
PERLND areas:						-		
(16)	Till-Forest		36.57		-		123.63	
(26)	Till-Grass		10.04		0.07		152.90	
(34)	Outwash-Forest		0.24		-		77.23	
(44)	Outwash-Grass		3.63		-		127.80	
(54)	Wetland		1.35		-		41.47	
	subtotal:		51.82		0.07		523.02	
IMPLND areas:								
	EIA			6.57		-		267.69
Basin total:			58.40		0.07		790.71	
Percent Impervious				11.3%		0.0%		33.9%
			IWS-SASA		MC9		TOTAL	
NETWORK FACTORS								
PERLND 16	(TF)		3.047		-		10.302	
PERLND 26	(TG)		0.837		0.005		12.741	
PERLND 34	(OF)		0.020		-		6.436	
PERLND 44	(OG)		0.302		-		10.650	
PERLND 54	(SA)		0.113		-		3.455	
IMPLND 14	(EIA)		0.548		-		22.308	
SUM			4.866		0.005		65.893	

Table ,. Des Moines Creek Contiguous Groundwater Subbasin Charac .tics - 2006 (STIA basins)

Land Use	Soil Type	% of total basin equal to EIA	Groundwater Subbasin Areas (Acres) DM-10 Pervious	DM-10 Effective Impervious	DM-11 Pervious	DM-11 Effective Impervious	DM-12 Pervious	DM-12 Effective Impervious	DM-13 Pervious	DM-13 Effective Impervious	DM-3 Pervious	DM-3 Effective Impervious	DM-4 Pervious	DM-4 Effective Impervious	DM-5 Pervious	DM-5 Effective Impervious
PERLND areas:																
(16)	Till-Forest		11.34		3.85		6.13		11.53		-		3.43		2.07	
(26)	Till-Grass		8.85		4.89		0.01		18.75		42.44		7.08		5.82	
(34)	Outwash-Forest		23.22		12.28		4.50		14.44		-		-		0.88	
(44)	Outwash-Grass		6.12		5.61		20.73		21.33		-		-		0.93	
(45)	Fill		-		-		-		-		-		-		-	
(54)	Wetland		8.55		12.43		6.65		1.07		0.07		0.06		1.35	
	subtotal:		58.08		39.06		38.02		67.12		42.51		10.57		11.05	
IMPLND areas:																
	EIA			2.22		32.71		-		15.10		53.99		40.20		9.59
Basin total:			60.30		71.77		38.02		82.23		96.50		50.77		20.64	
Percent Impervious				3.7%		45.6%		0.0%		18.4%		55.9%		79.2%		46.5%
			DM-10		DM-11		DM-12		DM-13		DM-3		DM-4		DM-5	
NETWORK FACTORS																
PERLND 16	(TF)		0.945		0.321		0.510		0.961		-		0.286		0.173	
PERLND 26	(TG)		0.738		0.408		0.001		1.562		3.537		0.590		0.485	
PERLND 34	(OF)		1.935		1.024		0.375		1.203		-		-		0.074	
PERLND 44	(OG)		0.510		0.467		1.728		1.778		-		-		0.077	
PERLND 45	(FL)		-		-		-		-		-		-		-	
PERLND 54	(SA)		0.712		1.036		0.554		0.089		0.006		0.005		0.112	
IMPLND 14	(EIA)		0.185		2.726		-		1.258		4.499		3.350		0.799	
SUM			5.025		5.981		3.168		6.852		8.042		4.230		1.720	

AR 053057

Table). Des Moines Creek Contiguous Groundwater Subbasin Charac .tics - 2006 (STIA basins)

Land Use	Soil Type	% of total basin equal to EIA	Groundwater Subbasin Areas (Acres)													
			DM-6		DM-7		DM-8		DM-9		SASA		SDE-4		SDS-1	
			Pervious	Effective Impervious	Pervious	Effective Impervious	Pervious	Effective Impervious	Pervious	Effective Impervious	Pervious	Effective Impervious	Pervious	Effective Impervious	Pervious	Effective Impervious
PERLND areas:																
(16)	Till-Forest		-		20.41		-		0.02		-		-		-	
(26)	Till-Grass		6.41		9.11		1.18		5.22		0.01		1.65		1.39	
(34)	Outwash-Forest		0.02		8.18		2.71		0.20		-		-		-	
(44)	Outwash-Grass		8.50		3.76		1.85		18.14		-		-		-	
(45)	Fill		-		-		-		-		-		-		-	
(54)	Wetland		3.74		4.44		1.39		0.12		-		-		-	
	subtotal:		18.67		45.90		7.13		23.71		0.01		1.65		1.39	
IMPLND areas:																
	EIA			0.08		17.76		17.04		3.49		34.26		9.74		8.52
Basin total:			18.75		63.66	-	24.17		27.20		34.27		11.39		9.91	
Percent Impervious				0.4%		27.9%		70.5%		12.8%		100.0%		85.5%		86.0%
			DM-6		DM-7		DM-8		DM-9		SASA		SDE-4		SDS-1	
NETWORK FACTORS																
PERLND 16	(TF)		-		1.701		-		0.002		-		-		-	
PERLND 26	(TG)		0.534		0.759		0.098		0.435		0.001		0.137		0.115	
PERLND 34	(OF)		0.002		0.681		0.226		0.017		-		-		-	
PERLND 44	(OG)		0.709		0.313		0.154		1.512		-		-		-	
PERLND 45	(FL)		-		-		-		-		-		-		-	
PERLND 54	(SA)		0.312		0.370		0.116		0.010		-		-		-	
IMPLND 14	(EIA)		0.007		1.480		1.420		0.291		2.855		0.811		0.710	
SUM			1.563		5.305		2.014		2.267		2.856		0.949		0.825	

Table . Des Moines Creek Contiguous Groundwater Subbasin Charac tics - 2006 (STIA basins)

Land Use	Soil Type	% of total basin equal to EIA	Groundwater Subbasin Areas (Acres)													
			SDS-2		SDS-3		SDS-4		SDS-5		SDS-6		PRIMARY		SASA	
			Pervious	Effective Impervious	Pervious	Effective Impervious	Pervious	Effective Impervious	Pervious	Effective Impervious	Pervious	Effective Impervious	Pervious	Effective Impervious	Pervious	Effective Impervious
PERLND areas:																
(16)	Till-Forest		-		-		-		-		-		-		-	
(26)	Till-Grass		2.99		2.95		6.77		9.56		1.62		4.71		0.05	
(34)	Outwash-Forest		-		-		-		-		-		-		-	
(44)	Outwash-Grass		4.61		-		25.31		-		-		6.14		0.04	
(45)	Fill		-		-		-		-		-		-		-	
(54)	Wetland		0.52		-		-		-		-		0.00		0.01	
	subtotal:		8.12		2.95		32.08		9.56		1.62		10.86		0.11	
IMPLND areas:																
	EIA			1.03		3.12		32.48		1.33		0.32		11.63		58.32
Basin total:			9.15		6.07		64.56		10.89		1.94		22.48		58.42	
Percent impervious				11.3%		51.4%		50.3%		12.2%		16.4%		51.7%		99.8%
			SDS-2		SDS-3		SDS-4		SDS-5		SDS-6		PRIMARY		SASA	
NETWORK FACTORS																
PERLND 16	(TF)		-		-		-		-		-		-		-	
PERLND 26	(TG)		0.249		0.246		0.564		0.796		0.135		0.393		0.004	
PERLND 34	(OF)		-		-		-		-		-		-		-	
PERLND 44	(OG)		0.384		-		2.109		-		-		0.512		0.004	
PERLND 45	(FL)		-		-		-		-		-		-		-	
PERLND 54	(SA)		0.043		-		-		-		-		0.000		0.001	
IMPLND 14	(EIA)		0.086		0.260		2.707		0.111		0.026		0.969		4.860	
SUM			0.762		0.506		5.380		0.907		0.161		1.874		4.869	

AR 053059

Table . Des Moines Creek Contiguous Groundwater Subbasin Charac tics - 2006 (STIA basins)

Land Use	Soil Type	% of total basin equal to EIA	Groundwater Subbasin Areas (Acres) MC9 Pervious	MC9 Effective Impervious	TOTAL Pervious	TOTAL Effective Impervious
PERLND areas:						
(16)	Till-Forest		-		58.77	
(26)	Till-Grass		0.07		141.53	
(34)	Outwash-Forest		-		66.44	
(44)	Outwash-Grass		-		123.07	
(45)	Fill		-			
(54)	Wetland		-		40.41	
	subtotal:		0.07		430.22	
IMPLND areas:						
	EIA			-		352.91
Basin total:			0.07		783.13	
Percent Impervious				0.0%		45.1%
			MC9		TOTAL	
NETWORK FACTORS						
PERLND 16	(TF)		-		4.898	
PERLND 26	(TG)		0.005		11.794	
PERLND 34	(OF)		-		5.537	
PERLND 44	(OG)		-		10.256	
PERLND 45	(FL)		-			
PERLND 54	(SA)		-		3.368	
IMPLND 14	(EIA)		-		29.409	-
SUM			0.005		65.260	

Table . Des Moines Non-Contiguous Groundwater Subbasin Characte :s - 1994 (STIA basins)

Land Use	Soil Type	% of total basin equal to EIA	Groundwater Subbasin Areas (Acres) D13 Pervious	D13 Effective Impervious	D3 Pervious	D3 Effective Impervious	D4 Pervious	D4 Effective Impervious	TOTAL Pervious	TOTAL Effective Impervious
PERLND areas:										
(16)	Till-Forest		-		-		-		-	
(26)	Till-Grass		0.00		0.20		0.01		0.21	
(34)	Outwash-Forest		-		-		-		-	
(44)	Outwash-Grass		-		-		-		-	
(54)	Wetland		-		-		-		-	
	subtotal:		0.00		0.20		0.01		0.21	
IMPLND areas:										
	EIA			0.01		0.06		0.05		0.12
Basin total:			0.01		0.26		0.06		0.33	
Percent impervious				85.0%		23.2%		85.0%		36.9%
			D13		D3		D4		TOTAL	
NETWORK FACTORS										
PERLND 16	(TF)		-		-		-		-	
PERLND 26	(TG)		0.000		0.016		0.001		0.017	
PERLND 34	(OF)		-		-		-		-	
PERLND 44	(OG)		-		-		-		-	
PERLND 54	(SA)		-		-		-		-	
IMPLND 14	(EIA)		0.001		0.005		0.004		0.010	
SUM			0.001		0.021		0.005		0.027	

AR 053061

Table . Des Moines Non-Contiguous Groundwater Subbasin Charact ...s - 2006 (STIA basins)

			Groundwater Subbasin Areas (Acres)							
		% of total basin	D13		D3		D4		TOTAL	
Land Use	Soil Type	equal to EIA	Pervious	Effective Impervious	Pervious	Effective Impervious	Pervious	Effective Impervious	Pervious	Effective Impervious
PERLND areas:										
(16)	Till-Forest		-		-		-		-	
(26)	Till-Grass		0.00		0.20		0.02		0.21	
(34)	Outwash-Forest		-		-		-		-	
(44)	Outwash-Grass		-		-		-		-	
(45)	Fill		-		-		-			
(54)	Wetland		-		-		-		-	
	subtotal:		0.00		0.20		0.02		0.21	
IMPLND areas:										
	EIA			0.01		0.05		0.09		0.15
Basin total:			0.01		0.25		0.10		0.36	
Percent Impervious				85.0%		20.9%		85.0%		40.9%
			D13		D3		D4		TOTAL	
NETWORK FACTORS										
PERLND 16	(TF)		-		-		-		-	
PERLND 26	(TG)		0.000		0.016		0.001		0.018	
PERLND 34	(OF)		-		-		-		-	
PERLND 44	(OG)		-		-		-		-	
PERLND 45	(FL)		-		-		-			
PERLND 54	(SA)		-		-		-		-	
IMPLND 14	(EIA)		0.001		0.004		0.007		0.012	
SUM			0.001		0.021		0.008		0.030	

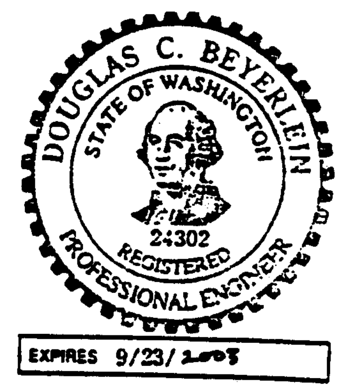
AR 053062

MILLER CREEK WATERSHED
HSPF INPUT FILES

- **1994 CONDITIONS**
- **2006 CONDITIONS**

CERTIFICATE OF ENGINEER

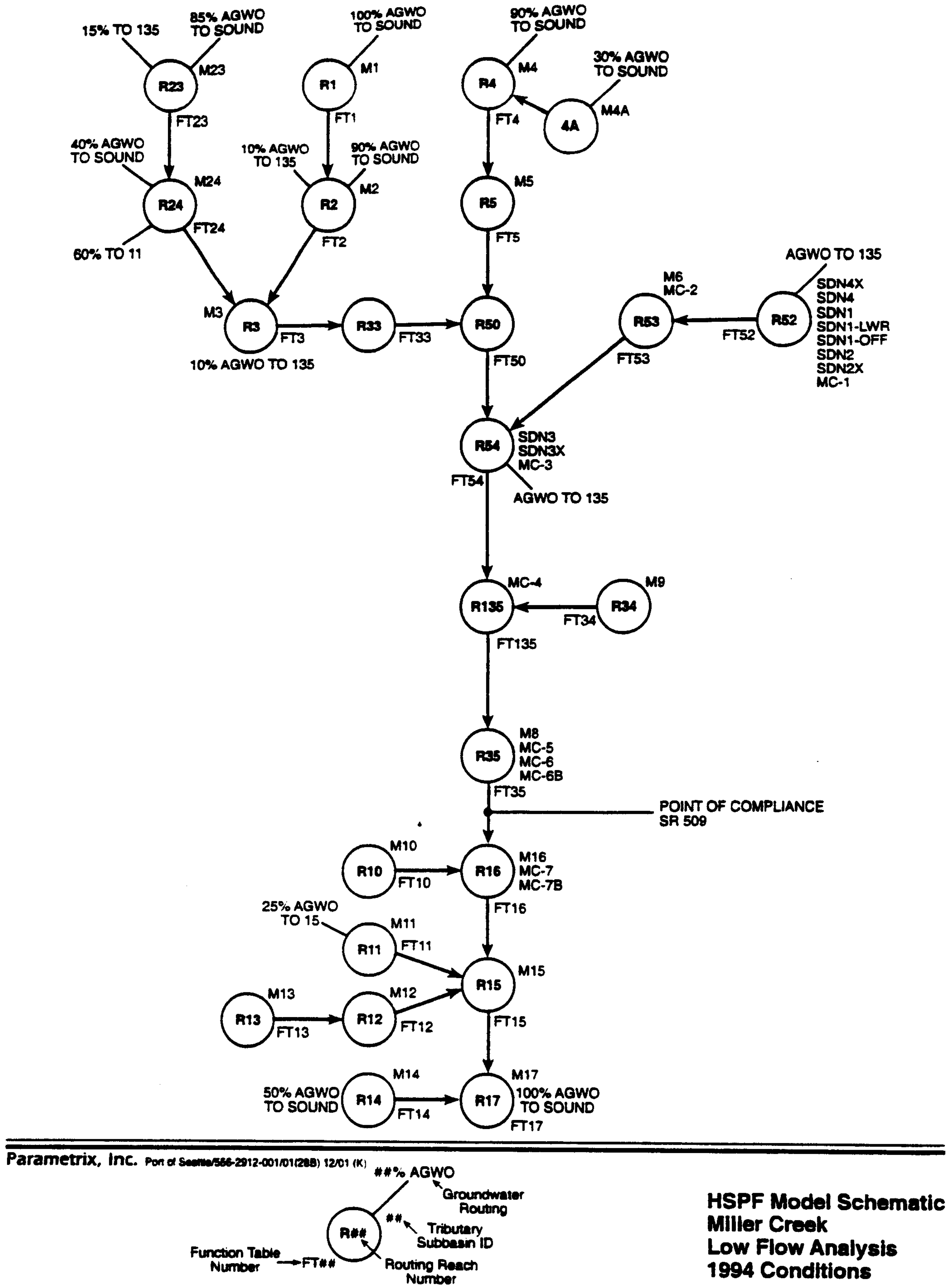
The technical material and data for the Miller Creek watershed and Walker Creek watershed low flow-specific HSPF modeling were prepared under the supervision and direction of the undersigned, whose seal, as a professional engineer licensed to practice as such, is affixed below.



(affix seal here)

Douglas Beyerlein, P.E., Senior Engineer

1994 CONDITIONS



HSPF Model Schematic
Miller Creek
Low Flow Analysis
1994 Conditions

```
RUN
GLOBAL
  ***  FILE: mill65.inp REVISED Aug 2000  Joe Brascher(atc)
  *** for parameterix
  ***  SEATAC AIRPORT HSPF BASIN MODEL OF MILLER CREEK
  ***  - POST-MILLER CK DETENTION FACITY 10/92-6/93
  *** m23 AND M24 new area west of m2.  Flows to rdf
  *** Calibration file run for FOUR YEARS using full length calibration run 1990
  *** data for initial conditions
  MILLER CREEK BASIN HSPF MODEL
  START       1990 10  1  0  0  END    1994  9 30 24  0
  RUN INTERP OUTPUT LEVEL    3
  RESUME     0 RUN     1
END GLOBAL

FILES
<type>  <fun>***<------------fname------------------------------------------->
MESSU     24    D:\PARA\SEATAC\MILLER\lowflow\MILL.MES
WDM       25    D:\PARA\SEATAC\MILLER\lowflow\Mlowflow.wdm
          61    D:\PARA\SEATAC\MILLER\lowflow\PER.L61
          62    D:\PARA\SEATAC\MILLER\lowflow\RCH.L62
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      23
      RCHRES      24
      RCHRES       2
      RCHRES       3
      RCHRES      33
      RCHRES       4
      RCHRES       5
      RCHRES      50
      RCHRES      52
      RCHRES      53
      RCHRES      54
      RCHRES      34
      RCHRES     135
      RCHRES      35
      RCHRES      10
      RCHRES      16
      RCHRES      11
      RCHRES      13
      RCHRES      12
      RCHRES      15
      RCHRES      14
      RCHRES      17
    END INGRP
END OPN SEQUENCE

COPY                                                                    ***
  TIMESERIES
```

```
  Copy-opn                                                                ***
   # -  #  NPT  NMN                                                       ***
   1    5        1
  END TIMESERIES
END COPY

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   61    0
   16     TFM- TILL FOR MOD          1     1     1    1   61    0
   18     TFS- TILL FOR STP          1     1     1    1   61    0
   24     TGF- TILL GR FLT           1     1     1    1   61    0
   26     TGM- TILL GR MOD           1     1     1    1   61    0
   28     TGS- TILL GR STP           1     1     1    1   61    0
   34     OF - OUTWASH FOR           1     1     1    1   61    0
   44     OG - OUTWASH GR            1     1     1    1   61    0
 ***PERLND FOR NEW AIRPORT FILL; NONE IN CALIBRATION
   45     AIRPORT FILL               1     1     1    1   61    0
   54     SA - WETLANDS              1     1     1    1   61    0
   64     RES- GROUNDWATER           1     1     1    1   61    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    5    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         0    0    0    0    0    0    0    0    0
   16         0    0    0    0    0    0    0    0    0
   18         0    0    0    0    0    0    0    0    0
   24         0    0    0    0    0    0    0    0    0
   26         0    0    0    0    0    0    0    0    0
   28         0    0    0    0    0    0    0    0    0
   34         0    0    0    0    0    0    0    0    0
   44         0    0    0    0    0    0    0    0    0
   45         0    0    0    0    0    0    0    0    0
   54         0    0    0    0    0    0    0    0    0
   64         0    0    0    0    0    0    0    0    0
  END PWAT-PARM1
  PWAT-PARM2
    <PLS > ***
    # -  # ***FOREST       LZSN    INFILT      LSUR     SLSUR     KVARY     AGWRC
   14                    9.0000    0.3200    400.00    0.0500    0.5000    0.9960
   16                    9.0000    0.3200    400.00    0.1000    0.5000    0.9960
   18                    9.0000    0.3200    200.00    0.2000    0.5000    0.9960
   24                    9.0000    0.1200    400.00    0.0500    0.5000    0.9960
   26                    9.0000    0.1200    400.00    0.1000    0.5000    0.9960
   28                    9.0000    0.1200    200.00    0.2000    0.5000    0.9960
   34                   10.0000    2.0000    400.00    0.0500    0.3000    0.9960
   44                   10.0000    0.8000    400.00    0.0500    0.3000    0.9960
   45                    7.5000    0.0200    300.00    0.0700    0.0000    0.9000
   54                    8.0000    2.0000    100.00    0.0010    0.5000    0.9960
  END PWAT-PARM2
```

```
  PWAT-PARM3
    <PLS >***
    # -  #*** PETMAX    PETMIN    INFEXP    INFILD    DEEPFR    BASETP    AGWETP
   14                           2.0000    2.0000      0.33      0.00       0.0
   16                           2.0000    2.0000      0.33      0.00       0.0
   18                           2.0000    2.0000      0.33      0.00       0.0
   24                           2.0000    2.0000      0.33      0.00        0.
   26                           2.0000    2.0000      0.33        0.        0.
   28                           2.0000    2.0000      0.33        0.        0.
   34                           2.0000    2.0000      0.33      0.00       0.0
   44                           2.0000    2.0000      0.33        0.        0.
   54                           10.000    2.0000      0.33        0.       0.7
  END PWAT-PARM3
  PWAT-PARM4
    <PLS >                                                         ***
    # -  #     CEPSC      UZSN      NSUR     INTFW       IRC     LZETP***
   14         0.2000    1.5000    0.3500     9.000    0.7000    0.7000
   16         0.2000    0.7500    0.3500     9.000    0.7000    0.7000
   18         0.2000    0.4500    0.3500     9.000    0.3000    0.7000
   24         0.1000    0.7500    0.2500     9.000    0.7000    0.2500
   26         0.1000    0.3750    0.2500     9.000    0.7000    0.2500
   28         0.1000    0.2250    0.2500     9.000    0.3000    0.2500
   34         0.2000    0.7500    0.3500     0.000    0.7000    0.7000
   44         0.1000    0.7500    0.2500     0.000    0.7000    0.2500
   54         0.1000    2.2500    0.5000     1.000    0.7000    0.8000
  END PWAT-PARM4
  PWAT-STATE1
    <PLS >  PWATER state variables***
    # -  #***   CEPS      SURS       UZS      IFWS       LZS      AGWS      GWVS
   16          0.000        0.    0.0010      0.00     0.941     3.108     0.048
   26          0.000        0.    0.0010      0.00     7.672     3.341     0.071
   34          0.000        0.    0.0010      0.00     1.187     3.776     0.052
   44          0.000        0.    0.0040      0.00     9.402     4.905     0.104
   45          0.000        0.    0.0000      0.00     2.000     2.000     0.000
   54          0.000        0.    0.0960      0.00     3.211     0.000     0.000
   14          0.078        0.    0.2500      0.10     2.000     2.000     0.000
   18          0.078        0.    0.2500      0.10     2.000     2.000     0.000
   24          0.051        0.    0.2500      0.10     2.000     2.000     0.000
   28          0.051        0.    0.2500      0.10     2.000     2.000     0.000
   64          0.051        0.    0.2500      0.10     2.000     2.000     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        100.00     0.0100    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> # #  ***
*** PRECIP/EVAP TO PERVIOUS/IMPERV SURFACES
WDM    1002 PREC      ENGLZERO  1.00        PERLND  14 200 EXTNL   PREC
WDM    1002 PREC      ENGLZERO  1.00        IMPLND  14     EXTNL   PREC
WDM       1 EVAP      ENGLZERO  0.8         PERLND  14  18 EXTNL   PETINP
WDM       1 EVAP      ENGLZERO  0.8         PERLND  24  28 EXTNL   PETINP
WDM       1 EVAP      ENGLZERO  0.8         PERLND  34  54 EXTNL   PETINP
WDM       1 EVAP      ENGLZERO  0.8         PERLND  64     EXTNL   PETINP
WDM       1 EVAP      ENGLZERO  0.8         IMPLND  14     EXTNL   PETINP
*** PRECIP/EVAP TO LAKES
WDM    1002 PREC      ENGLZERO              RCHRES   1     EXTNL   PREC
WDM       1 EVAP      ENGLZERO    0.8       RCHRES   1     EXTNL   POTEV
WDM    1002 PREC      ENGLZERO              RCHRES   4     EXTNL   PREC
WDM       1 EVAP      ENGLZERO    0.8       RCHRES   4     EXTNL   POTEV
WDM       1 EVAP      ENGLZERO    0.8       RCHRES   1     EXTNL   POTEV
WDM    1002 PREC      ENGLZERO              RCHRES   1     EXTNL   PREC
WDM       1 EVAP      ENGLZERO    0.8       RCHRES   4     EXTNL   POTEV
WDM    1002 PREC      ENGLZERO              RCHRES   4     EXTNL   PREC
WDM    1002 PREC      ENGLZERO              RCHRES  11     EXTNL   PREC
WDM       1 EVAP      ENGLZERO    0.8       RCHRES  11     EXTNL   POTEV
WDM    1002 PREC      ENGLZERO              RCHRES  13     EXTNL   PREC
WDM       1 EVAP      ENGLZERO    0.8       RCHRES  13     EXTNL   POTEV
WDM    1002 PREC      ENGLZERO              RCHRES  23     EXTNL   PREC
WDM       1 EVAP      ENGLZERO    0.8       RCHRES  23     EXTNL   POTEV
WDM    1002 PREC      ENGLZERO              RCHRES  34     EXTNL   PREC
WDM       1 EVAP      ENGLZERO    0.8       RCHRES  34     EXTNL   POTEV
WDM    1002 PREC      ENGLZERO              RCHRES  53     EXTNL   PREC
WDM       1 EVAP      ENGLZERO    0.8       RCHRES  53     EXTNL   POTEV
WDM    1002 PREC      ENGLZERO              RCHRES  54     EXTNL   PREC
WDM       1 EVAP      ENGLZERO    0.8       RCHRES  54     EXTNL   POTEV

END EXT SOURCES

EXT TARGETS
<-Volume-> <-Grp> <-Member-><--Mult-->Tran <-Volume-> <Member> Tsys Tgap Amd ***
<Name>   #        <Name> # #<-factor->strg <Name>   # <Name>    tem strg strg***
*** UPPER MILLER CREEK GROUNDWATER PUMPING
COPY *** 1 OUTPUT MEAN   1     12.1        WDM     18 FLOW      ENGL      REPL
*** GAUGE POINTS (17=MOUTH, 54=MILLER RDF, 50=SR 518, 18=WALKER CK)
RCHRES  35 HYDR    RO                      WDM   8035 FLOW      ENGL      REPL
```

```
RCHRES  17 HYDR    RO                            WDM     33 FLOW     ENGL       REPL
RCHRES  54 HYDR    RO                            WDM     34 FLOW     ENGL       REPL
RCHRES  50 HYDR    RO           ***              WDM     35 FLOW     ENGL       REPL
RCHRES  18 HYDR    RO           ***              WDM     36 FLOW     ENGL       REPL
*** MISC (20=WALKER WETLAND, 55=SR509, 56=1ST AVE, 1=ARBOR LAKE)
RCHRES  23 HYDR    STAGE   ***                   WDM     91 STAG     ENGL       REPL
RCHRES  20 HYDR    RO      ***                   WDM     37 FLOW     ENGL       REPL
RCHRES  55 HYDR    RO      ***                   WDM     38 FLOW     ENGL       REPL
RCHRES  62 HYDR    RO      ***                   WDM     39 FLOW     ENGL       REPL
RCHRES   1 HYDR    RO      ***                   WDM     80 FLOW     ENGL       REPL
<-Volume-> <-Grp> <-Member-><--Mult-->Tran <-Volume-> <Member> Tsys Tgap Amd ***
<Name>   #        <Name> # #<-factor->strg <Name>   # <Name>    tem strg strg***
 ***MOUTH
RCHRES  54 HYDR    RO      1 1 0.000419    *** WDM     60 SIMQ     ENGL       REPL
RCHRES  17 HYDR    RO      1 1 0.000213    *** WDM     70 SIMQ     ENGL       REPL
END EXT TARGETS
                                                                                ***
SCHEMATIC
<-Source->                   <--Area-->      <-Target->   MBLK    ***
<Name>   #                   <-factor->      <Name>   #   Tbl#    ***
  *** SUB-CATCHMENT 1 all agwo goes to sound
PERLND  16                        3.41      RCHRES   1      6
PERLND  26                      232.36      RCHRES   1      6
PERLND  34                        3.07      RCHRES   1      6
PERLND  44                       38.03      RCHRES   1      6
PERLND  54                        3.87      RCHRES   1      6
IMPLND  14                       56.14      RCHRES   1      2
 *** SUB-CATCHMENT 2 10% of area GW goes to vaca 90% goes to sound
PERLND  16                        5.56      RCHRES   2      6
PERLND  26                      200.05      RCHRES   2      6
PERLND  34                        0.46      RCHRES   2      6
PERLND  44                       38.71      RCHRES   2      6
PERLND  16                        0.56      RCHRES 135      7
PERLND  26                       20.01      RCHRES 135      7
PERLND  34                        0.05      RCHRES 135      7
PERLND  44                        3.87      RCHRES 135      7
IMPLND  14                       42.22      RCHRES   2      2
 *** SUB-CATCHMENT 23 New subbasin 15 % OF GW GOES TO VACCA 85% TO SOUND
PERLND  16                        3.09      RCHRES  23      6
PERLND  26                      156.15      RCHRES  23      6
PERLND  34                        2.25      RCHRES  23      6
PERLND  44                       45.84      RCHRES  23      6
PERLND  16                        0.46      RCHRES 135      7
PERLND  26                       23.42      RCHRES 135      7
PERLND  34                        0.34      RCHRES 135      7
PERLND  44                        6.88      RCHRES 135      7
IMPLND  14                       58.44      RCHRES  23      2
 *** SUB-CATCHMENT 24 New subbasin 60 % OF GW GOES TO 11 40% TO SOUND
PERLND  26                      135.43      RCHRES  24      6
PERLND  34                        2.02      RCHRES  24      6
PERLND  44                       69.29      RCHRES  24      6
PERLND  26                       81.26      RCHRES  11      7
PERLND  34                        1.21      RCHRES  11      7
PERLND  44                       41.57      RCHRES  11      7
IMPLND  14                       79.98      RCHRES  24      2
  *** SUB-CATCHMENT 3 agwo goes to vaca(135)
PERLND  16                        8.26      RCHRES   3      6
PERLND  26                      108.38      RCHRES   3      6
PERLND  34                       16.02      RCHRES   3      6
PERLND  44                      102.89      RCHRES   3      6
PERLND  54                        0.04      RCHRES   3      6
PERLND  16                        8.26      RCHRES 135      7
PERLND  26                      108.38      RCHRES 135      7
```

```
PERLND  34                  16.02      RCHRES 135      7
PERLND  44                 102.89      RCHRES 135      7
PERLND  54                   0.04      RCHRES 135      7
IMPLND  14                  27.30      RCHRES   3      2
  *** SUB-CATCHMENT 4 10% of agwo goes to rchres 90% goes to sound
PERLND  16                   2.95      RCHRES   4      6
PERLND  26                  85.95      RCHRES   4      6
PERLND  34                   3.75      RCHRES   4      6
PERLND  44                  92.06      RCHRES   4      6
PERLND  16                   0.30      RCHRES   4      7
PERLND  26                   8.60      RCHRES   4      7
PERLND  34                   0.38      RCHRES   4      7
PERLND  44                   9.21      RCHRES   4      7
IMPLND  14                  18.43      RCHRES   4      2
  *** SUB-CATCHMENT 4a 70% of agwo goes to rchres 30% goes to sound
PERLND  16                   8.66      RCHRES   4      6
PERLND  26                  61.64      RCHRES   4      6
PERLND  34                  22.06      RCHRES   4      6
PERLND  44                  78.09      RCHRES   4      6
PERLND  54                  12.50      RCHRES   4      6
PERLND  16                   6.06      RCHRES   4      7
PERLND  26                  43.15      RCHRES   4      7
PERLND  34                  15.44      RCHRES   4      7
PERLND  44                  54.66      RCHRES   4      7
PERLND  54                   8.75      RCHRES   4      7
IMPLND  14                  29.14      RCHRES   4      2
  *** SUB-CATCHMENT 5
PERLND  26                  10.29      RCHRES   5      1
PERLND  44                  50.04      RCHRES   5      1
PERLND  54                  10.74      RCHRES   5      1
IMPLND  14                  16.31      RCHRES   5      2
  *** SUB-CATCHMENT 6
PERLND  16                  10.66      RCHRES  53      1
PERLND  26                  41.08      RCHRES  53      1
PERLND  34                  21.75      RCHRES  53      1
PERLND  44                  13.39      RCHRES  53      1
PERLND  54                   0.82      RCHRES  53      1
IMPLND  14                   7.14      RCHRES  53      2
  *** SUB-CATCHMENT 8
PERLND  44                  22.21      RCHRES  35      1
IMPLND  14                   6.60      RCHRES  35      2
  *** SUB-CATCHMENT 9
PERLND  16                   4.94      RCHRES  34      1
PERLND  26                  14.32      RCHRES  34      1
PERLND  34                   0.05      RCHRES  34      1
PERLND  44                  56.70      RCHRES  34      1
PERLND  54                   0.01      RCHRES  34      1
IMPLND  14                  22.46      RCHRES  34      2
  *** SUB-CATCHMENT 10
PERLND  16                   4.15      RCHRES  10      1
PERLND  26                  31.94      RCHRES  10      1
PERLND  44                  95.23      RCHRES  10      1
IMPLND  14                  71.97      RCHRES  10      2
  *** SUB-CATCHMENT 11 25% OF AGWO GOES TO 15
PERLND  16                   0.89      RCHRES  11      6
PERLND  26                 217.92      RCHRES  11      6
PERLND  34                   1.32      RCHRES  11      6
PERLND  44                  65.65      RCHRES  11      6
PERLND  16                   0.67      RCHRES  11      7
PERLND  26                 163.44      RCHRES  11      7
PERLND  34                   0.99      RCHRES  11      7
PERLND  44                  49.24      RCHRES  11      7
PERLND  16                   0.22      RCHRES  15      7
```

PERLND	26	54.48	RCHRES	15	7
PERLND	34	0.33	RCHRES	15	7
PERLND	44	16.41	RCHRES	15	7
IMPLND	14	230.80	RCHRES	11	2
*** SUB-CATCHMENT 12					
PERLND	16	0.39	RCHRES	12	1
PERLND	26	101.18	RCHRES	12	1
PERLND	34	5.64	RCHRES	12	1
PERLND	44	54.98	RCHRES	12	1
PERLND	54	0.64	RCHRES	12	1
IMPLND	14	79.83	RCHRES	12	2
*** SUB-CATCHMENT 13					
PERLND	16	0.79	RCHRES	13	1
PERLND	26	197.68	RCHRES	13	1
IMPLND	14	27.66	RCHRES	13	2
*** SUB-CATCHMENT 14 50% OF AGWO GOES TO SOUND					
PERLND	16	0.24	RCHRES	14	6
PERLND	26	118.67	RCHRES	14	6
PERLND	34	13.46	RCHRES	14	6
PERLND	44	41.91	RCHRES	14	6
PERLND	16	0.12	RCHRES	14	7
PERLND	26	59.34	RCHRES	14	7
PERLND	34	6.73	RCHRES	14	7
PERLND	44	20.95	RCHRES	14	7
IMPLND	14	20.66	RCHRES	14	2
*** SUB-CATCHMENT 15					
PERLND	16	6.59	RCHRES	15	1
PERLND	26	49.55	RCHRES	15	1
PERLND	34	50.09	RCHRES	15	1
PERLND	44	86.52	RCHRES	15	1
IMPLND	14	19.47	RCHRES	15	2
*** SUB-CATCHMENT 16					
PERLND	16	10.93	RCHRES	16	1
PERLND	26	30.30	RCHRES	16	1
PERLND	34	20.03	RCHRES	16	1
PERLND	44	31.42	RCHRES	16	1
IMPLND	14	15.54	RCHRES	16	2
*** SUB-CATCHMENT 17 AGWO GOES TO SOUND					
PERLND	16	0.90	RCHRES	17	6
PERLND	26	16.31	RCHRES	17	6
PERLND	34	34.82	RCHRES	17	6
PERLND	44	82.11	RCHRES	17	6
PERLND	54	2.19	RCHRES	17	6
IMPLND	14	10.49	RCHRES	17	2
*** SUB-CATCHMENT MC-1					
PERLND	26	0.17	RCHRES	52	1
PERLND	44	8.21	RCHRES	52	1
PERLND	54	0.27	RCHRES	52	1
IMPLND	14	0.09	RCHRES	52	2
*** SUB-CATCHMENT MC-2					
PERLND	16	0.08	RCHRES	53	1
PERLND	26	0.64	RCHRES	53	1
PERLND	34	6.72	RCHRES	53	1
PERLND	44	10.43	RCHRES	53	1
PERLND	54	15.25	RCHRES	53	1
IMPLND	14	0.27	RCHRES	53	2
*** SUB-CATCHMENT MC-3					
PERLND	34	5.44	RCHRES	54	1
PERLND	44	5.03	RCHRES	54	1
PERLND	54	2.28	RCHRES	54	1
IMPLND	14	0.11	RCHRES	54	2
*** SUB-CATCHMENT MC-4					
PERLND	44	17.32	RCHRES	135	1

```
PERLND  54                          14.41      RCHRES 135       1
IMPLND  14                           1.77      RCHRES 135       2
  *** SUB-CATCHMENT MC-5
PERLND  26                          13.49      RCHRES  35       1
PERLND  44                          31.06      RCHRES  35       1
PERLND  54                           5.95      RCHRES  35       1
IMPLND  14                           2.50      RCHRES  35       2
  *** SUB-CATCHMENT MC-6
PERLND  44                          17.75      RCHRES  35       1
PERLND  54                           6.54      RCHRES  35       1
IMPLND  14                           0.95      RCHRES  35       2
  *** SUB-CATCHMENT MC-6B
PERLND  26                          34.94      RCHRES  35       1
PERLND  34                           7.81      RCHRES  35       1
PERLND  44                          52.91      RCHRES  35       1
PERLND  54                           4.61      RCHRES  35       1
IMPLND  14                           3.14      RCHRES  35       2
  *** SUB-CATCHMENT MC-7
PERLND  26                          12.66      RCHRES  16       1
PERLND  44                          33.53      RCHRES  16       1
PERLND  54                           4.16      RCHRES  16       1
IMPLND  14                           3.88      RCHRES  16       2
  *** SUB-CATCHMENT MC-7B
PERLND  26                          36.16      RCHRES  16       1
PERLND  44                           8.46      RCHRES  16       1
PERLND  54                           1.92      RCHRES  16       1
IMPLND  14                           2.12      RCHRES  16       2
***all sdn basin agwo goes to 35
  *** SUB-CATCHMENT SDN-1
PERLND  26                           3.23      RCHRES  52       6
PERLND  44                           2.11      RCHRES  52       6
PERLND  54                           0.20      RCHRES  52       6
PERLND  26                           3.23      RCHRES 135       7
PERLND  44                           2.11      RCHRES 135       7
PERLND  54                           0.20      RCHRES 135       7
IMPLND  14                           8.29      RCHRES  52       2

  *** SUB-CATCHMENT SDN-1-LWR
PERLND  44                           4.97      RCHRES  52       6
PERLND  54                           0.07      RCHRES  52       6
PERLND  44                           4.97      RCHRES 135       7
PERLND  54                           0.07      RCHRES 135       7
IMPLND  14                           0.38      RCHRES  52       2

  *** SUB-CATCHMENT SDN-1-OFF
PERLND  26                          29.12      RCHRES  52       6
PERLND  44                           3.62      RCHRES  52       6
PERLND  54                           1.67      RCHRES  52       6
PERLND  26                          29.12      RCHRES 135       7
PERLND  44                           3.62      RCHRES 135       7
PERLND  54                           1.67      RCHRES 135       7
IMPLND  14                          11.50      RCHRES  52       2

  *** SUB-CATCHMENT SDN-2
PERLND  26                          10.41      RCHRES  52       6
PERLND  44                           3.04      RCHRES  52       6
PERLND  26                          10.41      RCHRES 135       7
PERLND  44                           3.04      RCHRES 135       7
IMPLND  14                          33.22      RCHRES  52       2

  *** SUB-CATCHMENT SDN-2X
PERLND  26                           1.37      RCHRES  52       6
PERLND  44                           5.84      RCHRES  52       6
```

```
PERLND  26                    1.37     RCHRES 135       7
PERLND  44                    5.84     RCHRES 135       7
IMPLND  14                    0.28     RCHRES  52       2

  *** SUB-CATCHMENT SDN-3
PERLND  26                   49.79     RCHRES  54       6
PERLND  26                   49.79     RCHRES 135       7
IMPLND  14                   15.82     RCHRES  54       2

  *** SUB-CATCHMENT SDN-3X
PERLND  16                    0.65     RCHRES  54       6
PERLND  26                    5.17     RCHRES  54       6
PERLND  34                   13.64     RCHRES  54       6
PERLND  44                    5.34     RCHRES  54       6
PERLND  54                    0.57     RCHRES  54       6
PERLND  16                    0.65     RCHRES 135       7
PERLND  26                    5.17     RCHRES 135       7
PERLND  34                   13.64     RCHRES 135       7
PERLND  44                    5.34     RCHRES 135       7
PERLND  54                    0.57     RCHRES 135       7

  *** SUB-CATCHMENT SDN-4
PERLND  26                   24.43     RCHRES  52       6
PERLND  44                    3.19     RCHRES  52       6
PERLND  26                   24.43     RCHRES 135       7
PERLND  44                    3.19     RCHRES 135       7
IMPLND  14                    2.61     RCHRES  52       2

  *** SUB-CATCHMENT SDN-4X
PERLND  26                    1.57     RCHRES  52       6
PERLND  34                    1.16     RCHRES  52       6
PERLND  44                   10.01     RCHRES  52       6
PERLND  26                    1.57     RCHRES 135       7
PERLND  34                    1.16     RCHRES 135       7
PERLND  44                   10.01     RCHRES 135       7

***new areas added 11/19/01
***SDE4
PERLND  26                    0.04     RCHRES  35       7
***sdw1b1
PERLND  26                   10.14     RCHRES  35       7
***sdw2
PERLND  26                    4.06     RCHRES  35       7

***ROUTING FOR MILLER CREEK
*** M1 TO M2 TO M3 TO STORAGE 50.  M4 TO M5 TO STORAGE 50
RCHRES   1                             RCHRES   2       4
RCHRES  23                             RCHRES  24       4
RCHRES  24                             RCHRES   3       3
RCHRES   2                             RCHRES   3       3
RCHRES   3                             RCHRES  33       3
RCHRES  33                             RCHRES  50       3
RCHRES   4                             RCHRES   5       4
RCHRES   5                             RCHRES  50       3
*** NEW STREAM REACH 52 TO LAKE REBA 53 TO RDF 54
RCHRES  52                             RCHRES  53       3
RCHRES  53                             RCHRES  54       3
RCHRES  50                             RCHRES  54       3
*** RDF 54 TO 35
RCHRES  54                             RCHRES 135       3
RCHRES  34                             RCHRES 135       4
RCHRES  34                             RCHRES 135       5
RCHRES 135                             RCHRES  35       3
```

```
RCHRES  10                                     RCHRES  16      3
RCHRES  35                                     RCHRES  16      3
RCHRES  11                                     RCHRES  15      3
RCHRES  13                                     RCHRES  12      4
RCHRES  13                                     RCHRES  12      5
RCHRES  12                                     RCHRES  15      3
RCHRES  16                                     RCHRES  15      3
RCHRES  14                                     RCHRES  17      3
RCHRES  15                                     RCHRES  17      3
END SCHEMATIC

NETWORK
                                                                              ***
***        <MEMBER> SSYSSGAP<--MULT-->TRAN <-TARGET VOLS>        <-MEMBER->
<NAME>   # <NAME>    TEM STRG<-FACTOR->STRG <NAME>    #    # <-GRP> <NAME> # #  ***
                                                                              ***
END NETWORK
                                                                              ***
RCHRES
  GEN-INFO
    RCHRES        Name          Nexits   Unit Systems   Printer               ***
    # -  #<------------------><---> User T-series  Engl Metr LKFG             ***
                                          in  out                             ***
    1      Arbor Lake  M 1         2     1    1    1    62    0    0
    2      Arbor Ck -03710 M 2     1     1    1    1    62    0    0
    3      Arbor Ck    M 3         1     1    1    1    62    0    0
    4      Tub Lake    M 4         2     1    1    1    62    0    0
    5      Miller Ck SR518 M5      1     1    1    1    62    0    0
   10      Trib (0371G)   M 10     1     1    1    1    62    0    0
   11      M11 Ambaum Detention    1     1    1    1    62    0    0
   12      Trib(0354)  M 12        1     1    1    1    62    0    0
   13      Burien Lake M 13        2     1    1    1    62    0    0
   14      Trib (0353) M 14        1     1    1    1    62    0    0
   15      M/S U/S OF 17           1     1    1    1    62    0    0
   16      U/S OF 15 M/S           1     1    1    1    62    0    0
   17      GAGE                    1     1    1    1    62    0    0
   23      BASIN M23               2     1    1    1    62    0    0
   24      BASIN M24               1     1    1    1    62    0    0
   33      detention m3            1     1    1    1    62    0    0
   34      LORA LAKE               2     1    1    1    62    0    0
   35      D/S OF VACA FARM        1     1    1    1    62    0    0
   38      MC basins               1     1    1    1    62    0    0
   50      sr 518                  1     1    1    1    62    0    0
   52      U/S OF LAKE REBA        1     1    1    1    62    0    0
   53      Reba outflow            1     1    1    1    62    0    0
   54      Miller RDF outflow      1     1    1    1    62    0    0
  135      VACA FARMS              1     1    1    1    62    0    0
  END GEN-INFO
  ACTIVITY
    RCHRES *************** Active Sections *****************
    # -  # HYFG ADFG CNFG HTFG SDFG GQFG OXFG NUFG PKFG PHFG                 ***
    1  999    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  999    5    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         0  1  0  0    4  5  0  0  0      0  0  0  0  0      2  2  2  2  2
    2         0  0  0  0    4  0  0  0  0      0  0  0  0  0      2  2  2  2  2
    3         0  0  0  0    4  0  0  0  0      0  0  0  0  0      2  2  2  2  2
    4         0  1  0  0    4  5  0  0  0      0  0  0  0  0      2  2  2  2  2
    5    12   0  0  0  0    4  0  0  0  0      0  0  0  0  0      2  2  2  2  2
   13         0  1  0  0    4  5  0  0  0      0  0  0  0  0      2  2  2  2  2
   14    22   0  0  0  0    4  0  0  0  0      0  0  0  0  0      2  2  2  2  2
   23         0  1  0  0    4  5  0  0  0      0  0  0  0  0      2  2  2  2  2
   24    33   0  0  0  0    4  0  0  0  0      0  0  0  0  0      2  2  2  2  2
   34         0  1  0  0    4  5  0  0  0      0  0  0  0  0      2  2  2  2  2
   35   999   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     0.776                                0.3
    3              3     0.980                                0.3
    4              4     0.010                                0.3
    5              5     0.380                                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     0.587                                0.3
   17             17     0.379                                0.3
   23             23     0.379                 300.0          0.3
   24             24     0.379                                0.3
   33             33     0.200                                0.3
   34             34     0.852                                0.3
   35             35     0.663                                0.3
   38             38     0.010                                0.3
   50             50     0.010                                0.3
   52             52     0.010                                0.3
   53             53     0.010                                0.3
   54             54     0.010                                0.3
  135            135     0.350                                0.3
  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  5.0
    2       0.0            4.0
    3       0.0            4.0  5.0
    4       2.0            4.0
    5       0.0            4.0
   10       0.0            4.0
   11       0.0            4.0
   12       0.0            4.0
   13      10.0            4.0  5.0
   14       0.0            4.0
   15       0.0            4.0
   16       0.0            4.0
   17       0.0            4.0
   23       6.0            4.0  5.0
   24       0.0            4.0
   33       0.0            4.0
   34       9.0            4.0  5.0
```

```
   35      0.1               4.0
   38      0.1               4.0
   50      0.0               4.0
   52      0.0               4.0
   53      0.1               4.0
   54      2.25              4.0
  135      0.00              4.0
  END HYDR-INIT
END RCHRES

FTABLES
***UPPER BASIN
***===========

  FTABLE       1
 ROWS COLS ***
  11    5
     DEPTH       AREA     VOLUME    OUTFLOW OUTFLOW2***
     0.00        3.00     0.00       0.00    0.00
     2.50        3.00     7.50       0.00    0.11
     3.00        3.00     9.00       1.80    0.11
     3.50        3.30    10.58       5.00    0.11
     4.00        3.60    12.30      10.90    0.11
     4.50        3.90    14.18      17.50    0.11
     5.00        4.10    16.18      26.20    0.11
     5.50        4.30    18.28      32.50    0.11
     6.00        4.50    20.48      35.90    0.11
     7.00        5.00    25.23      38.10    0.11
     8.00        5.50    30.48      46.40    0.11
  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 ***
  7    5
    DEPTH      AREA     VOLUME    OUTFLOW OUTFLOW2***
     0.00     3.00     0.00       0.00      0.00
     2.50     4.50     9.38       0.00      0.11
     3.00     6.00     12.00      6.00      0.11
     4.00     10.00    20.00      13.00     0.11
     5.00     15.00    32.50      20.00     0.11
     6.00     20.00    50.00      26.00     0.11
     7.00     25.00    72.50      168.00    0.11
 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     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

 POST AMBAUM DETENTION ***
 FTABLE     11
ROWS COLS ***
 11    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     12
ROWS COLS ***
  6    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     13
ROWS COLS ***
  7    5
   DEPTH      AREA     VOLUME    OUTFLOW OUTFLOW2***
   0.000    40.000     0.0000       0.00     0.00
   1.000    41.400     40.000       0.00     0.11
   1.500    42.000     60.000      10.00     0.11
   2.000    42.700     80.000      16.00     0.11
   2.500    43.300     100.00      20.00     0.11
   3.000    44.000     120.00      28.00     0.11
   5.000    45.000     210.00      45.00     0.11
 END FTABLE 13

 FTABLE     14
ROWS COLS ***
  6    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     15
ROWS COLS ***
  4    4
   DEPTH      AREA     VOLUME    OUTFLOW    ***
    0.00      0.10      0.00       0.00
    1.00      1.00      0.55      91.00
    2.00      1.10      1.60     268.00
    3.00      1.20      2.75     493.00
 END FTABLE 15

 FTABLE     16
ROWS COLS ***
  4    4
   DEPTH      AREA     VOLUME    OUTFLOW    ***
    0.00      0.10      0.00       0.00
    1.00      1.00      0.55      74.00
    2.00      1.10      1.60     219.00
    3.00      1.20      2.75     403.00
```

```
 END FTABLE 16

 FTABLE      17
ROWS COLS ***
  5   4
    DEPTH       AREA     VOLUME    OUTFLOW    ***
     0.00       0.10      0.00      0.00
     1.00       1.00      0.55     59.00
     2.00       1.10      1.60    173.00
     3.00       1.20      2.75    318.00
     4.00       1.30      4.00    484.00
 END FTABLE 17

 FTABLE      23
ROWS COLS ***   HERMES
  9   5
    DEPTH       AREA     VOLUME    OUTFLOW  OUTFLOW    ***
     0.00       0.00      0.00      0.00      0.00              0.00
     5.00       0.50      1.91      0.00      0.00            305.00
    11.00       0.79      5.79      0.00      0.00            311.00
    15.00       1.13      9.64      0.50      0.01            315.00
    19.00       1.72     15.34      0.50      0.05            319.00
    29.00       2.86     38.25      0.50      0.10            329.00
    39.00       4.40     74.55      0.50      0.20            339.00
    50.00       6.22    132.98      0.50      0.30            350.00
    60.00      10.00   1212.98      0.50      0.40            360.00
 END FTABLE 23

 FTABLE      24
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 24

 FTABLE      33
ROWS COLS ***
 11   4
    DEPTH       AREA     VOLUME    OUTFLOW    ***
     0.00       1.00      0.00      0.00
     0.50       1.20      0.55      2.00
     1.00       1.40      1.20      6.00
     1.50       1.60      1.95      9.00
     2.00       1.80      2.80     13.00
     2.50       2.00      3.75     16.50
     3.00       2.20      4.80     20.00
     3.50       2.40      5.95     23.00
     4.00       2.60      7.20     26.00
     5.00       2.80      9.90    104.00
     6.00       3.00     12.80    246.00
 END FTABLE 33

 FTABLE      34
ROWS COLS *** REVISED 11/19/97 BASED ON HEC-RAS MODEL
  6   5
```

DEPTH	AREA	VOLUME	OUTFLOW	OUTFLOW2***
0.00	3.00	0.00	0.00	0.00
3.00	3.05	9.08	0.00	0.11
4.00	3.10	12.15	0.00	0.11
5.00	3.15	15.28	0.00	0.11
6.00	3.20	18.45	72.0	0.11
7.00	3.25	21.68	225.0	0.11

END FTABLE 34

FTABLE 35
ROWS COLS *** REVISED 11/19/97 BASED ON HECRAS MODEL
5 4

DEPTH	AREA	VOLUME	OUTFLOW ***
0.00	0.10	0.00	0.00
1.00	1.10	0.60	38.00
2.00	1.20	1.75	108.00
3.00	1.30	3.00	194.00
4.00	1.40	4.35	290.00

END FTABLE 35

FTABLE 38
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 38

FTABLE 45
ROWS COLS ***
NORTH EMPLOYEE PARKING LOT VAULT (AS-BUILT)***
12 4

DEPTH	AREA	VOLUME	OUTFLOW ***
0.000	0.2200	0.0000	0.00
2.000	0.2200	0.4500	1.20
4.000	0.2200	0.9000	1.70
6.000	0.2200	1.3400	2.10
8.000	0.2200	1.7900	2.40
10.000	0.2200	2.2400	2.70
12.240	0.2200	2.7400	3.00
14.000	0.2200	3.1400	6.90
15.440	0.2200	3.4600	8.30
16.000	0.2200	3.5800	10.30
18.000	0.2200	4.0300	13.60
20.000	0.2200	4.4800	30.79

END FTABLE 45

FTABLE 50
ROWS COLS ***
10 4

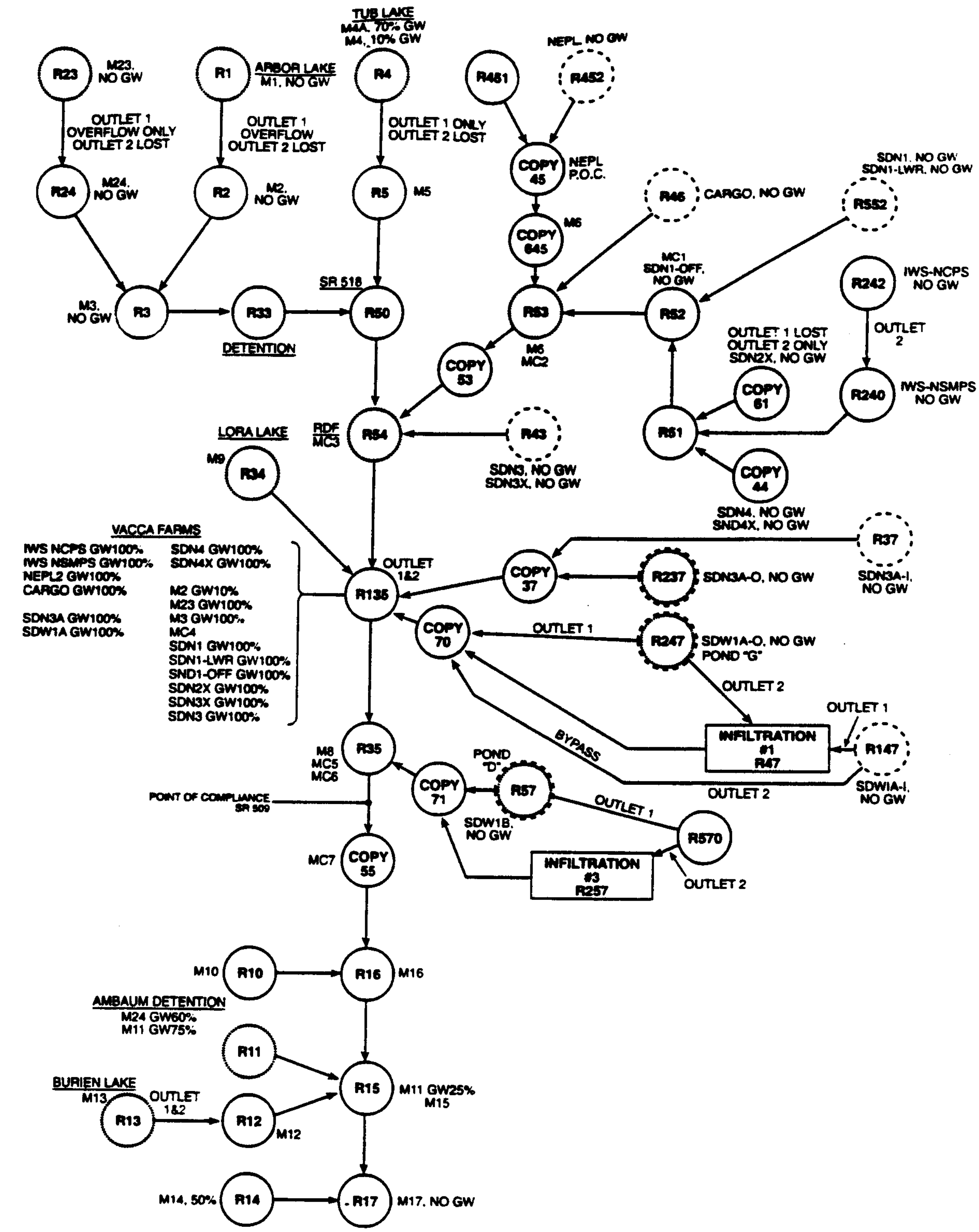
DEPTH	AREA	VOLUME	OUTFLOW ***
0.00	1.00	0.00	0.00
0.50	1.10	0.53	5.00
1.00	1.20	1.10	15.00
1.50	1.30	1.73	25.00
2.00	1.40	2.40	35.00
2.50	1.50	3.13	52.00
3.00	1.60	3.90	70.00

```
    3.50     1.70      4.73     87.00
    4.00     1.80      5.60    105.00
    6.00     1.90      9.30    165.00
  END FTABLE 50

  FTABLE     52
 ROWS COLS ***
   6    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
  END FTABLE 52

  FTABLE     53
 OLD LAKE REBA                                        ***
 MAX DEPTH = 4.9 FEET                                 ***
 30" CMP, 40 CFS DISCHARGE AT MAX DEPTH               ***
 ROWS COLS ***
   7    4
     DEPTH      AREA     VOLUME    OUTFLOW    ***
     0.000    2.4000    0.0000       0.00
     1.000    2.5800    2.5000      18.00
     2.000    2.9400    5.3000      26.00
     3.000    3.4100    8.4000      31.00
     4.000    3.8800    12.100      36.00
     4.900    4.3000    15.800      40.00
     6.000    4.3000    15.810     500.00
  END FTABLE 53

  FTABLE     54
 EXISTING MILLER CREEK DETENTION FACILITY*** REVISED STORAGE/Q DATA
 GATE SETTING: 2.0 FEET***
 ROWS COLS ***
  12    4
     DEPTH      AREA     VOLUME    OUTFLOW    ***
     0.000      0.00      0.00       0.00
     1.300      0.01      0.01      10.00
     2.000      0.01      0.02      20.00
     2.900      0.70      0.40      30.00
     4.000      1.50      1.50      40.00
     5.400      3.50      4.90      50.00
     7.000      8.60     13.30      60.00
     8.800     15.60     34.80      70.00
    10.000     19.90     57.30      76.00
    10.500     21.50     68.00      92.00
    11.000     23.10     78.80     179.00
    11.500     24.70     88.60     303.00
  END FTABLE 54

  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

  FTABLE    135
 ROWS COLS *** VACA FARM
    6    4
     DEPTH      AREA     VOLUME    OUTFLOW    ***
      0.00      0.10      0.00       0.00
      1.00      0.10      0.10       4.00
      2.00      0.11      0.21       8.00
      2.50      1.00      0.48      13.00
      3.50      6.50      4.23      86.00
      4.50     13.00     13.98     235.00
  END FTABLE135
                                                                                ***
END FTABLES


MASS-LINK
<Volume>   <-Grp> <-Member-><--Mult-->     <Target>        <-Grp> <-Member->***
<Name>            <Name> # #<-factor->     <Name>                 <Name> # #***
  MASS-LINK       1
  conversion from acre-inches to acre-ft (1/12)              ***
PERLND     PWATER PERO       0.0833333     RCHRES          INFLOW IVOL
  END MASS-LINK   1

  MASS-LINK       2
IMPLND     IWATER SURO       0.0833333     RCHRES          INFLOW IVOL
  END MASS-LINK   2

  MASS-LINK       3
RCHRES     ROFLOW                          RCHRES          INFLOW
  END MASS-LINK   3

  MASS-LINK       4
RCHRES     OFLOW  OVOL   1                 RCHRES          INFLOW IVOL
  END MASS-LINK   4

  MASS-LINK       5
RCHRES     OFLOW  OVOL   2                 RCHRES          INFLOW IVOL
  END MASS-LINK   5

  MASS-LINK       6
PERLND     PWATER SURO       0.0833333     RCHRES          INFLOW IVOL
PERLND     PWATER IFWO       0.0833333     RCHRES          INFLOW IVOL
  END MASS-LINK   6

  MASS-LINK       7
PERLND     PWATER AGWO       0.0833333     RCHRES          INFLOW IVOL
  END MASS-LINK   7

  MASS-LINK       8
PERLND     PWATER PERO       0.0833333     COPY            INPUT  MEAN
  END MASS-LINK   8
```

```
  MASS-LINK        12
PERLND      PWATER AGWO         0.0833333      COPY             INPUT   MEAN
  END MASS-LINK    12

  MASS-LINK         9
IMPLND      IWATER SURO         0.0833333      COPY             INPUT   MEAN
  END MASS-LINK     9

  MASS-LINK        10
COPY        OUTPUT MEAN                        RCHRES           INFLOW IVOL
  END MASS-LINK    10

END MASS-LINK
END RUN
```

2006 CONDITIONS



Notes: GW routed to reach unless otherwise noted.
Reaches have one outlet unless otherwise noted.
Reach table # is the same as reach # unless otherwise noted.

Parametrix, Inc. [illegible]

GW Ground Water Routing

Precipitation and Evaporation

Future Pond/ Vault Site

R5 — M5 ← Tributary Subbasin ID; R5 ← Routing Reach Number

COPY 52 — Summation of Upstream Flow

HSPF Model Schematic
Miller Creek
Low Flow Analysis
2006 Conditions

```
RUN
GLOBAL
  ***  SEATAC AIRPORT HSPF BASIN MODEL OF MILLER CREEK
  ***  FILE: MC23inif.INP - 2006 future condition
  ***  USED FOR LOW FLOW.  12/06/01 BY ATC JTB
  ***  MADE The following Changes to input file to deal with fill inflow: ***
  ***  Combined infiltration from sdw1a and sdw1b ponds into one file
  ***  BASED ON MILL65.INP FILE FROM AQUA TERRA
  ***  Mlowflow.WDM:
  ***  REMOVED FILL AREAS FOR PGG CUT OUT AREA
  ***  USING FULL LENGTH OF RECORD TO SET STATE VARIBLES
  ***  END CHANGES ***
  ***  ADDED PERLND 47,57,
  ***  ADDED GROUND WATER INFILTRATION TO WDM FOR USE WITH MCAGWO.INP
  ***  FK revised SDW1A and SDW1B with flow splitters, storages at SDN3/3X,
SDN2X/4X;
  ***  FK revised MC-1 and SDN-2X land uses, added POC at Lake Reba, removed
run-of-river tables
  ***  FK added POC downstream of facilities SDW1A and SDW1B
  MILLER CREEK BASIN HSPF MODEL
***  START       1994  1  1  0  0  END     1996  8 30 24  0
  START       1990 10  1  0  0  END     1994  9 30 24  0
  RUN INTERP OUTPUT LEVEL    3
  RESUME     0 RUN     1
END GLOBAL

FILES
<type>  <fun>***<------------fname------------------------------------------>
MESSU      24    d:\PARA\SEATAC\MILLER\LOWFLOW\MLOWFLO4.MES
WDM        25    d:\PARA\SEATAC\MILLER\LOWFLOW\MLOWFLOW.WDM
           61    d:\PARA\SEATAC\MILLER\LOWFLOW\PER.L61
           62    d:\PARA\SEATAC\MILLER\LOWFLOW\RCH.L62
END FILES

OPN SEQUENCE
    INGRP              INDELT 01:00
      PERLND      16
      PERLND      26
      PERLND      34
      PERLND      44
      PERLND      45
      PERLND      54
***SPECIAL PERLND FOR INFLOW OF GROUNDWATER FROM PGG
      PERLND      80
      IMPLND      14
      RCHRES       1
      RCHRES      23
      RCHRES      24
      RCHRES       2
      RCHRES       3
      RCHRES      33
      RCHRES       4
      RCHRES       5
      RCHRES      50
      RCHRES     242
      RCHRES     240
      COPY        61
      COPY        44
      RCHRES      51
      RCHRES      43
      RCHRES     451
      RCHRES     452
      COPY        45
```


AR 053088

```
      COPY        645
      RCHRES       46
      RCHRES      552
      RCHRES       52
      RCHRES       53
      COPY         53
      RCHRES       54
      RCHRES       37
      RCHRES      237
      COPY         37
      RCHRES      147
      RCHRES      247
      COPY         66
      COPY         69
      RCHRES       47
***PERLND FOR INFILTRATION POND 47 OUTLET
      PERLND       47
      COPY         62
      COPY         63
      COPY         67
      COPY         68
  ***   --> output SDW1A infiltration discharge to WDM dataset 5 in in/ac <--
      COPY         47
      COPY         70
      RCHRES       34
      RCHRES      135
      RCHRES      570
      RCHRES       57
      RCHRES      257
*** PERLND FOR INFILTRATION POND 57 OUTLET
      PERLND       57
      COPY         64
      COPY         65
      COPY        357
      COPY         56
      COPY         57
      COPY         71
      RCHRES       35
      COPY         55
      RCHRES       10
      RCHRES       16
      RCHRES       11
      RCHRES       13
      RCHRES       12
      RCHRES       15
      RCHRES       14
      RCHRES       17
    END INGRP
END OPN SEQUENCE
                                                                               ***
PERLND
  GEN-INFO
    <PLS >       Name            NBLKS   Unit-systems   Printer                ***
    # -  #                               User  t-series Engl Metr              ***
                                               in  out                         ***
   16     TFM- TILL FOR MOD         1     1    1    1    61    0
   26     TGM- TILL GR MOD          1     1    1    1    61    0
   34     OF - OUTWASH FOR          1     1    1    1    61    0
   44     OG - OUTWASH GR           1     1    1    1    61    0
***PERLND FOR NEW AIRPORT FILL; NONE IN CALIBRATION
   45     AIRPORT FILL              1     1    1    1    61    0
   47     OG - INFILTRATION 1       1     1    1    1    61    0
   54     SA - WETLANDS             1     1    1    1    61    0
```

```
 57       OG - INFILTRATION 3     1    1    1    1   61    0
 80       LOW FLOW                1    1    1    1   61    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    5    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
 16                    9.0000    0.3200    400.00    0.1000    0.5000    0.9960
 26                    9.0000    0.1200    400.00    0.1000    0.5000    0.9960
 34                   10.0000    2.0000    400.00    0.0500    0.3000    0.9960
 44                   10.0000    0.8000    400.00    0.0500    0.3000    0.9960
 45                    7.5000    0.0200    300.00    0.0700    0.0000    0.9960
 47                   10.0000    0.8000    400.00    0.0500    0.3000    0.9960
 54                    8.0000    2.0000    100.00    0.0010    0.5000    0.9960
 57                   10.0000    0.8000    400.00    0.0500    0.3000    0.9960
 80                    9.0000    0.1200    400.00    0.1000    0.5000    0.9960
END PWAT-PARM2
PWAT-PARM3
   <PLS >***
   #  -  #*** PETMAX    PETMIN    INFEXP    INFILD    DEEPFR    BASETP    AGWETP
 16                              2.0000    2.0000      0.33      0.00       0.0
 26                              2.0000    2.0000      0.33        0.        0.
 34                              2.0000    2.0000      0.33      0.00       0.0
 44                              2.0000    2.0000      0.33        0.        0.
 47                              2.0000    2.0000      0.33        0.        0.
 45                              2.0000    2.0000      0.33        0.        0.
 54                              10.000    2.0000      0.33        0.       0.7
 57                              2.0000    2.0000      0.33        0.        0.
 80                              2.0000    2.0000      0.33        0.        0.
END PWAT-PARM3
PWAT-PARM4
   <PLS >                                                            ***
   #  -  #     CEPSC      UZSN      NSUR     INTFW       IRC    LZETP***
 16           0.2000    0.7500    0.3500     9.000    0.7000    0.7000
 26           0.1000    0.3750    0.2500     9.000    0.7000    0.2500
 34           0.2000    0.7500    0.3500     0.000    0.7000    0.7000
 44           0.1000    0.7500    0.2500     0.000    0.7000    0.2500
 47           0.1000    0.7500    0.2500     0.000    0.7000    0.2500
 45           0.1000    0.2800    0.2500     6.000    0.1500    0.6000
 54           0.1000    2.2500    0.5000     1.000    0.7000    0.8000
 57           0.1000    0.7500    0.2500     0.000    0.7000    0.2500
 80           0.1000    0.3750    0.2500     9.000    0.7000    0.2500
END PWAT-PARM4
PWAT-STATE1
   <PLS >  PWATER state variables***
   #  -  #***   CEPS      SURS       UZS      IFWS       LZS      AGWS      GWVS
 16            0.000        0.    0.0010      0.00     0.941     3.108     0.048
 26            0.000        0.    0.0010      0.00     7.672     3.341     0.071
 34            0.000        0.    0.0010      0.00     1.187     3.776     0.052
```

```
    44          0.000        0.    0.0040      0.00      9.402     4.905      0.104
    45          0.000        0.    0.0000      0.00      2.000     2.000      0.000
    54          0.000        0.    0.0960      0.00      3.211     0.000      0.000
    47          0.000        0.    0.0000      0.00      2.000     2.000      0.000
    57          0.000        0.    0.0000      0.00      2.000     2.000      0.000
    80          0.000        0.    0.0000      0.00      7.672     3.341      0.071
  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          100.00     0.0100     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 and ponds ***
*** FOLLOWING RCHRES ARE PONDS: 57, 247, 237

<-Volume-> <Member> SsysSgap<--Mult-->Tran <-Target vols> <-Grp> <-Member->  ***
<Name>   # <Name> # tem strg<-factor->strg <Name>   #   #        <Name> # #  ***
*** PRECIP/EVAP TO PERVIOUS/IMPERV SURFACES                                   ***
WDM     1002 PREC      ENGLZERO  1.00        PERLND  14  46 EXTNL  PREC
WDM     1002 PREC      ENGLZERO  0.00        PERLND  47     EXTNL  PREC
WDM     1002 PREC      ENGLZERO  0.00        PERLND  57     EXTNL  PREC
WDM     1002 PREC      ENGLZERO  1.00        PERLND  48  56 EXTNL  PREC
WDM     1002 PREC      ENGLZERO  1.00        PERLND  58  79 EXTNL  PREC
WDM     1002 PREC      ENGLZERO  1.00        PERLND  80     EXTNL  PREC
WDM     1002 PREC      ENGLZERO  1.00        IMPLND  14     EXTNL  PREC
```

```
WDM       1 EVAP     ENGLZERO  0.8          PERLND  14  46 EXTNL   PETINP
WDM       1 EVAP     ENGLZERO  0.0          PERLND  47     EXTNL   PETINP
WDM       1 EVAP     ENGLZERO  0.0          PERLND  57     EXTNL   PETINP
WDM       1 EVAP     ENGLZERO  0.8          PERLND  48  56 EXTNL   PETINP
WDM       1 EVAP     ENGLZERO  0.8          PERLND  58  79 EXTNL   PETINP
WDM       1 EVAP     ENGLZERO  0.8          PERLND  80     EXTNL   PETINP
WDM       1 EVAP     ENGLZERO  0.8          IMPLND  14     EXTNL   PETINP
*** PRECIP/EVAP TO LAKES
WDM    1002 PREC     ENGLZERO               RCHRES   1     EXTNL   PREC
WDM       1 EVAP     ENGLZERO    0.8        RCHRES   1     EXTNL   POTEV
WDM    1002 PREC     ENGLZERO               RCHRES   4     EXTNL   PREC
WDM       1 EVAP     ENGLZERO    0.8        RCHRES   4     EXTNL   POTEV
WDM    1002 PREC     ENGLZERO               RCHRES  11     EXTNL   PREC
WDM       1 EVAP     ENGLZERO    0.8        RCHRES  11     EXTNL   POTEV
WDM    1002 PREC     ENGLZERO               RCHRES  13     EXTNL   PREC
WDM       1 EVAP     ENGLZERO    0.8        RCHRES  13     EXTNL   POTEV
WDM    1002 PREC     ENGLZERO               RCHRES  23     EXTNL   PREC
WDM       1 EVAP     ENGLZERO    0.8        RCHRES  23     EXTNL   POTEV
WDM    1002 PREC     ENGLZERO               RCHRES  34     EXTNL   PREC
WDM       1 EVAP     ENGLZERO    0.8        RCHRES  34     EXTNL   POTEV
WDM    1002 PREC     ENGLZERO               RCHRES  53     EXTNL   PREC
WDM       1 EVAP     ENGLZERO    0.8        RCHRES  53     EXTNL   POTEV
WDM    1002 PREC     ENGLZERO               RCHRES  54     EXTNL   PREC
WDM       1 EVAP     ENGLZERO    0.8        RCHRES  54     EXTNL   POTEV
WDM    1002 PREC     ENGLZERO               RCHRES 237     EXTNL   PREC
WDM       1 EVAP     ENGLZERO    0.8        RCHRES 237     EXTNL   POTEV
WDM    1002 PREC     ENGLZERO               RCHRES 247     EXTNL   PREC
WDM       1 EVAP     ENGLZERO    0.8        RCHRES 247     EXTNL   POTEV
WDM    1002 PREC     ENGLZERO               RCHRES  57     EXTNL   PREC
WDM       1 EVAP     ENGLZERO    0.8        RCHRES  57     EXTNL   POTEV
*** Fill flow directly to stream:
*** Conversion factor from cu. ft./day to acre-ft/interval
*** divide by 43560*24
WDM    7000 FLOW     ENGL     .000000957SAME RCHRES  35     INFLOW IVOL
*** till seapage groundwater flow from Fill area.  PGG time series
*** Conversion factor from cu. ft./day to inches
*** (1/(43560*24) * 12)/area    (114.81ac)
*** finally convert for deepfr of .33 by multiplying by .67
WDM    7001 FLOW     ENGLZERO.000000067SAME PERLND  80     EXTNL   AGWLI
*** surface runoff to infiltration facilities
*** Conversion factor from cu. ft./hr to acre-ft/interval
*** divide by 43560*24
*** converted for contributing area ratios.
*** 22.35 ac
WDM    7002 FLOW     ENGL     .000004561SAME RCHRES 237     INFLOW IVOL
*** 31.22 ac
WDM    7002 FLOW     ENGL     .000006371SAME RCHRES  47     INFLOW IVOL
*** 58.93 ac
WDM    7002 FLOW     ENGL     .000012025SAME RCHRES 257     INFLOW IVOL

END EXT SOURCES

EXT TARGETS
<-Volume-> <-Grp> <-Member-><--Mult-->Tran <-Volume-> <Member> Tsys Tgap Amd ***
<Name>   #        <Name> # #<-factor->strg <Name>   # <Name>    tem strg strg***
***PROJECT CONDITION FLOWS
*** RCHRES=LOCATION:
*** 54=MCDF       47=SDW1A INFILTRATION TANK      43=SDN3X       247=SDW1A POND G
*** 17=MOUTH      49=SDW2          44=SDN4X         52=SDN1        451= EXISTING NEPL
*** 61=SDN2X      57=SDW1B         51=SDN2X+SDN4X   53=Lake Reba 452=NEW NEPL
*** 45=NEPL POC   55=SR509         39=SDN3A/SDW1A POC
*** 46=CARGO      37=SDN3AI VAULT 237=SDN3AO POND
*** GAUGE POINTS (17=MOUTH, 54=MILLER RDF, 55=SR509)
```

```
RCHRES  35 HYDR    RO       1 1                   WDM   7036 FLOW     ENGL      REPL
***RCHRES  17 HYDR    RO       1 1                WDM    113 FLOW     ENGL      REPL
***COPY    55 OUTPUT MEAN      1 1 12.1           WDM    118 FLOW     ENGL      REPL
***RCHRES  54 HYDR    RO       1 1                WDM    114 FLOW     ENGL      REPL
*** DETENTION POND FLOWS
***COPY    61 OUTPUT MEAN      1 1 12.1           WDM    101 FLOW     ENGL      REPL
***RCHRES 552 HYDR    RO       1 1                WDM    102 FLOW     ENGL      REPL
***RCHRES 451 HYDR    RO       1 1                WDM    105 FLOW     ENGL      REPL
***RCHRES 452 HYDR    RO       1 1                WDM    119 FLOW     ENGL      REPL
***RCHRES  46 HYDR    RO       1 1                WDM    106 FLOW     ENGL      REPL
****** write SDW1A Inf.Tank # 1 outlets to WDM 107 and 108 like so:
***COPY    62 OUTPUT MEAN      1 1 12.1           WDM    107 FLOW     ENGL      REPL
***COPY    63 OUTPUT MEAN      1 1 12.1           WDM    108 FLOW     ENGL      REPL
****** write SDW1A det. pond G outlets to WDM files:
***COPY    66 OUTPUT MEAN      1 1 12.1           WDM    112 FLOW     ENGL      REPL
***COPY    69 OUTPUT MEAN      1 1 12.1           WDM   1120 FLOW     ENGL      REPL
****** write SDW1A det. vault G1 to WDM files:
***COPY    67 OUTPUT MEAN      1 1 12.1           WDM    109 FLOW     ENGL      REPL
***COPY    68 OUTPUT MEAN      1 1 12.1           WDM   1090 FLOW     ENGL      REPL
****** write flow splitter outlets to WDM files:
***RCHRES 570 HYDR    RO       1 1                WDM    210 FLOW     ENGL      REPL
***COPY    64 OUTPUT MEAN      1 1 12.1           WDM    110 FLOW     ENGL      REPL
***COPY    65 OUTPUT MEAN      1 1 12.1           WDM    115 FLOW     ENGL      REPL
****** write SDW1B inf. tank outlets to WDM files:
***COPY    56 OUTPUT MEAN      1 1 12.1           WDM    121 FLOW     ENGL      REPL
***COPY    57 OUTPUT MEAN      1 1 12.1           WDM    120 FLOW     ENGL      REPL
****** write SDW1B pond D outlet to WDM file:
***COPY   357 OUTPUT MEAN      1 1 12.1           WDM    211 FLOW     ENGL      REPL
****** write SDN3A vaults to WDM files:
***RCHRES  37 HYDR    RO       1 1                WDM    111 FLOW     ENGL      REPL
***RCHRES 237 HYDR    RO       1 1                WDM    122 FLOW     ENGL      REPL
****** write SDN3/3x, SDN4/4X, and SDN4X/2X vaults to WDM files:
***RCHRES  43 HYDR    RO       1 1                WDM    103 FLOW     ENGL      REPL
***COPY    44 OUTPUT MEAN      1 1 12.1           WDM    104 FLOW     ENGL      REPL
***RCHRES  51 HYDR    RO       1 1                WDM    139 FLOW     ENGL      REPL
****** DETENTION STAGES
***RCHRES  47 HYDR    STAGE                       WDM    652 STAG     ENGL      REPL
***RCHRES 147 HYDR    STAGE                       WDM    657 STAG     ENGL      REPL
***RCHRES 247 HYDR    STAGE                       WDM    654 STAG     ENGL      REPL
***RCHRES 552 HYDR    STAGE                       WDM    601 STAG     ENGL      REPL
***RCHRES  57 HYDR    STAGE                       WDM    651 STAG     ENGL      REPL
***RCHRES 257 HYDR    STAGE                       WDM    655 STAG     ENGL      REPL
***RCHRES 237 HYDR    STAGE                       WDM    656 STAG     ENGL      REPL
***RCHRES  37 HYDR    STAGE                       WDM    650 STAG     ENGL      REPL
***RCHRES  54 HYDR    STAGE                       WDM     61 STAG     ENGL      REPL
***RCHRES 451 HYDR    STAGE                       WDM    662 STAG     ENGL      REPL
***RCHRES 452 HYDR    STAGE                       WDM    667 STAG     ENGL      REPL
***RCHRES  46 HYDR    STAGE                       WDM    663 STAG     ENGL      REPL
***RCHRES  43 HYDR    STAGE                       WDM    664 STAG     ENGL      REPL
***RCHRES  44 HYDR    STAGE                       WDM    665 STAG     ENGL      REPL
***RCHRES  51 HYDR    STAGE                       WDM    666 STAG     ENGL      REPL
*** DETENTION VOLUMES
***RCHRES  47 HYDR    VOL                         WDM    752 VOL      ENGL      REPL
***RCHRES 147 HYDR    VOL                         WDM    757 VOL      ENGL      REPL
***RCHRES 247 HYDR    VOL                         WDM    754 VOL      ENGL      REPL
***RCHRES 552 HYDR    VOL                         WDM    602 VOL      ENGL      REPL
***RCHRES  57 HYDR    VOL                         WDM    751 VOL      ENGL      REPL
***RCHRES 257 HYDR    VOL                         WDM    755 VOL      ENGL      REPL
***RCHRES 237 HYDR    VOL                         WDM    756 VOL      ENGL      REPL
***RCHRES  37 HYDR    VOL                         WDM    750 VOL      ENGL      REPL
***RCHRES  54 HYDR    VOL                         WDM     62 VOL      ENGL      REPL
***RCHRES 451 HYDR    VOL                         WDM    762 VOL      ENGL      REPL
***RCHRES 452 HYDR    VOL                         WDM    767 VOL      ENGL      REPL
```

```
***RCHRES  46 HYDR   VOL                              WDM     763 VOL        ENGL        REPL
***RCHRES  43 HYDR   VOL                              WDM     764 VOL        ENGL        REPL
******RCHRES  44 HYDR   VOL                              WDM     765 VOL        ENGL        REPL

***RCHRES  51 HYDR   VOL                              WDM     766 VOL        ENGL        REPL
****** POINT OF COMPLIANCE (POC)FLOWS
***COPY    37 OUTPUT MEAN   1 1 12.1                  WDM     125 FLOW       ENGL        REPL
***COPY    45 OUTPUT MEAN   1 1 12.1                  WDM     199 FLOW       ENGL        REPL
***COPY    53 OUTPUT MEAN   1 1 12.1                  WDM     399 FLOW       ENGL        REPL
***COPY    70 OUTPUT MEAN   1 1 12.1                  WDM    7000 FLOW       ENGL        REPL
***COPY    71 OUTPUT MEAN   1 1 12.1                  WDM    7001 FLOW       ENGL        REPL
END EXT TARGETS

SCHEMATIC
<-Source->                  <--Area-->    <-Target->   MBLK    ***
<Name>   #                  <-factor->    <Name>   #   Tbl#    ***
  *** SUB-CATCHMENT 1 all agwo goes to sound
PERLND  16                        3.41    RCHRES   1      6
PERLND  26                      232.36    RCHRES   1      6
PERLND  34                        3.07    RCHRES   1      6
PERLND  44                       38.03    RCHRES   1      6
PERLND  54                        3.87    RCHRES   1      6
IMPLND  14                       56.14    RCHRES   1      2
 *** SUB-CATCHMENT 2 10% of area GW goes to vaca 90% goes to sound
PERLND  16                        5.56    RCHRES   2      6
PERLND  26                      200.05    RCHRES   2      6
PERLND  34                        0.46    RCHRES   2      6
PERLND  44                       38.71    RCHRES   2      6
PERLND  16                        0.56    RCHRES 135      7
PERLND  26                       20.00    RCHRES 135      7
PERLND  34                        0.05    RCHRES 135      7
PERLND  44                        3.87    RCHRES 135      7
IMPLND  14                       42.22    RCHRES   2      2
 *** SUB-CATCHMENT 23 New subbasin 15 % OF GW GOES TO VACCA 85% TO SOUND
PERLND  16                        3.09    RCHRES  23      6
PERLND  26                      156.15    RCHRES  23      6
PERLND  34                        2.25    RCHRES  23      6
PERLND  44                       45.84    RCHRES  23      6
PERLND  16                        0.46    RCHRES 135      7
PERLND  26                       23.42    RCHRES 135      7
PERLND  34                        0.34    RCHRES 135      7
PERLND  44                        6.88    RCHRES 135      7
IMPLND  14                       58.44    RCHRES  23      2
 *** SUB-CATCHMENT 24 New subbasin 60 % OF GW GOES TO 11 40% TO SOUND
PERLND  26                      135.43    RCHRES  24      6
PERLND  34                        2.02    RCHRES  24      6
PERLND  44                       69.29    RCHRES  24      6
PERLND  26                       81.26    RCHRES  11      7
PERLND  34                        1.21    RCHRES  11      7
PERLND  44                       41.57    RCHRES  11      7
IMPLND  14                       79.98    RCHRES  24      2
  *** SUB-CATCHMENT 3 agwo goes to vaca(135)
PERLND  16                        8.26    RCHRES   3      6
PERLND  26                      108.38    RCHRES   3      6
PERLND  34                       16.02    RCHRES   3      6
PERLND  44                      102.89    RCHRES   3      6
PERLND  54                        0.04    RCHRES   3      6
PERLND  16                        8.26    RCHRES 135      7
PERLND  26                      108.38    RCHRES 135      7
PERLND  34                       16.02    RCHRES 135      7
PERLND  44                      102.89    RCHRES 135      7
PERLND  54                        0.04    RCHRES 135      7
IMPLND  14                       27.30    RCHRES   3      2
```

```
  *** SUB-CATCHMENT 4 10% of agwo goes to rchres 90% goes to sound
PERLND  16                    2.95     RCHRES   4      6
PERLND  26                   85.95     RCHRES   4      6
PERLND  34                    3.75     RCHRES   4      6
PERLND  44                   92.06     RCHRES   4      6
PERLND  16                    0.30     RCHRES   4      7
PERLND  26                    8.59     RCHRES   4      7
PERLND  34                    0.38     RCHRES   4      7
PERLND  44                    9.21     RCHRES   4      7
IMPLND  14                   18.43     RCHRES   4      2
  *** SUB-CATCHMENT 4a 70% of agwo goes to rchres 30% goes to sound
PERLND  16                    8.66     RCHRES   4      6
PERLND  26                   61.64     RCHRES   4      6
PERLND  34                   22.06     RCHRES   4      6
PERLND  44                   78.09     RCHRES   4      6
PERLND  54                   12.50     RCHRES   4      6
PERLND  16                    6.06     RCHRES   4      7
PERLND  26                   43.15     RCHRES   4      7
PERLND  34                   15.44     RCHRES   4      7
PERLND  44                   54.66     RCHRES   4      7
PERLND  54                    8.75     RCHRES   4      7
IMPLND  14                   29.14     RCHRES   4      2
  *** SUB-CATCHMENT 5
PERLND  26                   10.29     RCHRES   5      1
PERLND  44                   50.05     RCHRES   5      1
PERLND  54                   10.74     RCHRES   5      1
IMPLND  14                   16.31     RCHRES   5      2
  *** SUB-CATCHMENT 6
PERLND  16                    1.42     COPY   645     26
PERLND  26                   20.38     COPY   645     26
PERLND  34                   13.44     COPY   645     26
PERLND  44                   11.79     COPY   645     26
PERLND  54                    0.82     COPY   645     26
PERLND  16                    1.42     RCHRES  53      7
PERLND  26                   20.38     RCHRES  53      7
PERLND  34                   13.44     RCHRES  53      7
PERLND  44                   11.79     RCHRES  53      7
PERLND  54                    0.82     RCHRES  53      7
IMPLND  14                    6.23     COPY   645     22
  *** SUB-CATCHMENT 8
PERLND  44                   22.21     RCHRES  35      1
IMPLND  14                    6.60     RCHRES  35      2
  *** SUB-CATCHMENT 9
PERLND  16                    4.98     RCHRES  34      1
PERLND  26                   14.38     RCHRES  34      1
PERLND  34                    0.05     RCHRES  34      1
PERLND  44                   56.71     RCHRES  34      1
PERLND  54                    0.01     RCHRES  34      1
IMPLND  14                   22.47     RCHRES  34      2
  *** SUB-CATCHMENT 10
PERLND  16                    4.15     RCHRES  10      1
PERLND  26                   31.94     RCHRES  10      1
PERLND  44                   95.22     RCHRES  10      1
IMPLND  14                   71.98     RCHRES  10      2
  *** SUB-CATCHMENT 11 25% OF AGWO GOES TO 15
PERLND  16                    0.89     RCHRES  11      6
PERLND  26                  217.92     RCHRES  11      6
PERLND  34                    1.32     RCHRES  11      6
PERLND  44                   65.65     RCHRES  11      6
PERLND  16                    0.67     RCHRES  11      7
PERLND  26                  163.44     RCHRES  11      7
PERLND  34                    0.99     RCHRES  11      7
PERLND  44                   49.24     RCHRES  11      7
```

```
PERLND  16        0.22    RCHRES  15    7
PERLND  26       54.48    RCHRES  15    7
PERLND  34        0.33    RCHRES  15    7
PERLND  44       16.41    RCHRES  15    7
IMPLND  14      230.80    RCHRES  11    2
  *** SUB-CATCHMENT 12
PERLND  16        0.39    RCHRES  12    1
PERLND  26      101.18    RCHRES  12    1
PERLND  34        5.64    RCHRES  12    1
PERLND  44       54.98    RCHRES  12    1
PERLND  54        0.64    RCHRES  12    1
IMPLND  14       79.83    RCHRES  12    2
  *** SUB-CATCHMENT 13
PERLND  16        0.79    RCHRES  13    1
PERLND  26      197.68    RCHRES  13    1
IMPLND  14       27.66    RCHRES  13    2
  *** SUB-CATCHMENT 14 50% OF AGWO GOES TO SOUND
PERLND  16        0.24    RCHRES  14    6
PERLND  26      118.67    RCHRES  14    6
PERLND  34       13.46    RCHRES  14    6
PERLND  44       41.91    RCHRES  14    6
PERLND  16        0.12    RCHRES  14    7
PERLND  26       59.34    RCHRES  14    7
PERLND  34        6.73    RCHRES  14    7
PERLND  44       20.95    RCHRES  14    7
IMPLND  14       20.66    RCHRES  14    2
  *** SUB-CATCHMENT 15
PERLND  16        6.59    RCHRES  15    1
PERLND  26       49.55    RCHRES  15    1
PERLND  34       50.09    RCHRES  15    1
PERLND  44       86.52    RCHRES  15    1
IMPLND  14       19.47    RCHRES  15    2
  *** SUB-CATCHMENT 16
PERLND  16       10.93    RCHRES  16    1
PERLND  26       29.93    RCHRES  16    1
PERLND  34       20.03    RCHRES  16    1
PERLND  44       31.83    RCHRES  16    1
IMPLND  14       15.58    RCHRES  16    2
  *** SUB-CATCHMENT 17 AGWO GOES TO SOUND
PERLND  16        0.90    RCHRES  17    6
PERLND  26       16.31    RCHRES  17    6
PERLND  34       34.82    RCHRES  17    6
PERLND  44       82.11    RCHRES  17    6
PERLND  54        2.19    RCHRES  17    6
IMPLND  14       10.49    RCHRES  17    2
  *** SUB-CATCHMENT MC-1
PERLND  26        0.14    RCHRES  52    1
PERLND  44        9.44    RCHRES  52    1
PERLND  45        0.14    RCHRES  52    1
PERLND  54        0.27    RCHRES  52    1
IMPLND  14        1.98    RCHRES  52    2
  *** SUB-CATCHMENT MC-2
PERLND  16        0.08    RCHRES  53    1
PERLND  26        0.53    RCHRES  53    1
PERLND  34        3.60    RCHRES  53    1
PERLND  44        9.20    RCHRES  53    1
PERLND  45        2.22    RCHRES  53    1
PERLND  54       15.14    RCHRES  53    1
IMPLND  14        2.54    RCHRES  53    2
  *** SUB-CATCHMENT MC-3
PERLND  34        3.70    RCHRES  54    1
PERLND  44        4.91    RCHRES  54    1
PERLND  45        1.07    RCHRES  54    1
```

```
 PERLND  54                              1.84      RCHRES  54       1
 IMPLND  14                              1.42      RCHRES  54       2
   *** SUB-CATCHMENT MC-4
 PERLND  34                              0.27      RCHRES 135       1
 PERLND  44                             16.51      RCHRES 135       1
 PERLND  45                              4.23      RCHRES 135       1
 PERLND  54                             11.98      RCHRES 135       1
 IMPLND  14                              3.31      RCHRES 135       2
   *** SUB-CATCHMENT MC-5
 PERLND  26                             13.43      RCHRES  35       1
 PERLND  44                             33.84      RCHRES  35       1
 PERLND  54                              7.44      RCHRES  35       1
 IMPLND  14                              0.02      RCHRES  35       2
   *** SUB-CATCHMENT MC-6
 PERLND  44                             14.10      RCHRES  35       1
 PERLND  45                              0.09      RCHRES  35       1
 PERLND  54                              0.90      RCHRES  35       1
 IMPLND  14                              0.26      RCHRES  35       2
   *** SUB-CATCHMENT MC-7
 PERLND  26                             11.26      COPY    55      21
 PERLND  44                             31.80      COPY    55      21
 PERLND  54                              3.20      COPY    55      21
 IMPLND  14                              0.03      COPY    55      22

***note: SDN AGWO TO VACCA FARMS (135)NOT TO PONDS

   *** SUB-CATCHMENT SDN-1
 PERLND  26                              1.97      RCHRES 552       6
 PERLND  44                              1.29      RCHRES 552       6
 PERLND  54                              0.20      RCHRES 552       6
 PERLND  26                              1.97      RCHRES 135       7
 PERLND  44                              1.29      RCHRES 135       7
 PERLND  54                              0.20      RCHRES 135       7
 IMPLND  14                             12.68      RCHRES 552       2

   *** SUB-CATCHMENT SDN-1-LWR
 PERLND  44                              4.79      RCHRES 552       6
 PERLND  54                              0.07      RCHRES 552       6
 PERLND  44                              4.79      RCHRES 135       7
 PERLND  54                              0.07      RCHRES 135       7
 IMPLND  14                              0.56      RCHRES 552       2

   *** SUB-CATCHMENT SDN-1-OFF
 PERLND  26                             23.01      RCHRES  52       6
 PERLND  44                              3.58      RCHRES  52       6
 PERLND  54                              1.67      RCHRES  52       6
 PERLND  26                             23.01      RCHRES 135       7
 PERLND  44                              3.58      RCHRES 135       7
 PERLND  54                              1.67      RCHRES 135       7
 IMPLND  14                              8.00      RCHRES  52       2

   *** SUB-CATCHMENT SDN-2X (TO POND)
 PERLND  26                              0.63      COPY    61      26
 PERLND  44                              2.40      COPY    61      26
 PERLND  45                              0.86      COPY    61      26
 PERLND  26                              0.63      RCHRES 135       7
 PERLND  44                              2.40      RCHRES 135       7
 PERLND  45                              0.86      RCHRES 135       7
 IMPLND  14                              0.36      COPY    61      22

   *** SUB-CATCHMENT SDN-3 (TO POND)
 PERLND  26                             23.56      RCHRES  43       6
 PERLND  26                             23.56      RCHRES 135       7
```

```
IMPLND  14                          24.30     RCHRES  43       2

  *** SUB-CATCHMENT SDN-3X (TO POND)
PERLND  26                           1.61     RCHRES  43       6
***original PERLND area
***PERLND  45                          23.77     RCHRES  43       6
***PERLND AREA TO BE REMOVED = 0.45 AC
PERLND  80                          00.45     RCHRES  43       7
PERLND  45                          23.32     RCHRES  43       6
PERLND  26                           1.61     RCHRES 135       7
PERLND  45                          23.77     RCHRES 135       7

  *** SUB-CATCHMENT SDN-4 (TO POND)
PERLND  26                          15.75     COPY    44      26
PERLND  44                           1.31     COPY    44      26
PERLND  45                           0.99     COPY    44      26
PERLND  26                          15.75     RCHRES 135       7
PERLND  44                           1.31     RCHRES 135       7
PERLND  45                           0.99     RCHRES 135       7
IMPLND  14                          12.26     COPY    44      22

  *** SUB-CATCHMENT SDN-4X (TO POND)
PERLND  26                           1.92     COPY    44      26
PERLND  44                           0.75     COPY    44      26
PERLND  45                           8.31     COPY    44      26
PERLND  26                           1.92     RCHRES 135       7
PERLND  44                           0.75     RCHRES 135       7
PERLND  45                           8.31     RCHRES 135       7
IMPLND  14                           4.21     COPY    44      22

  *** SUB-CATCHMENT IWS-NCPS (TO POND)
PERLND  26                           4.78     RCHRES 242       6
PERLND  26                           4.78     RCHRES 135       7
IMPLND  14                          30.93     RCHRES 242       2

  *** SUB-CATCHMENT IWS-NSMPS (TO POND)
PERLND  26                           2.69     RCHRES 240       6
PERLND  44                           1.97     RCHRES 240       6
PERLND  45                           0.01     RCHRES 240       6
PERLND  26                           2.69     RCHRES 135       7
PERLND  44                           1.97     RCHRES 135       7
PERLND  45                           0.01     RCHRES 135       7
IMPLND  14                           1.95     RCHRES 240       2

  *** SUB-CATCHMENT NEPL (TO POND)
PERLND  26                          10.00     RCHRES 452       6
PERLND  26                          10.00     RCHRES 135       7
IMPLND  14                           6.00     RCHRES 451       2
IMPLND  14                          26.29     RCHRES 452       2

  *** SUB-CATCHMENT CARGO (TO POND)
IMPLND  14                           8.12     RCHRES  46       2

  *** SUB-CATCHMENT SDN3AI (TO VAULT)
***original IMPLND area
***IMPLND  14                           5.87     RCHRES  37       2
***IMPLND AREA TO BE REMOVED = 5.62 AC
IMPLND  14                           0.25     RCHRES  37       2
PERLND  80                           5.62     RCHRES  37       7

  *** SUB-CATCHMENT SDN3AO (TO POND)
PERLND  26                           0.08     RCHRES 237       6
PERLND  44                           0.03     RCHRES 237       6
```

```
***PERLND AREA TO BE REMOVED = 10.63 AC
***PERLND AREA TO BE REMOVED = 4.55 AC
***original PERLND area
***PERLND  45                         22.12     RCHRES 237        6
PERLND  80                          10.63     RCHRES 237      7
PERLND  80                           4.55     RCHRES 237      7
PERLND  45                           6.94     RCHRES 237      6
PERLND  25                           0.08     RCHRES 135      7
PERLND  44                           0.03     RCHRES 135      7
PERLND  45                          22.12     RCHRES 135      7
***original IMPLND area
***IMPLND  14                          2.35     RCHRES 237        2
***IMPLND AREA TO BE REMOVED = 1.66 AC
IMPLND  14                           0.69     RCHRES 237      2
PERLND  80                           1.66     RCHRES 237      7

  *** SUB-CATCHMENT SDW1O (TO POND)SDW1A0.  +PERLND FOR SDW1AI
  *** SUB-CATCHMENT SDW1O (TO POND)MIS NAMED
PERLND  26                           4.28     RCHRES 247      6
PERLND  44                           0.69     RCHRES 247      6
***PERLND AREA TO BE REMOVED = 17.08 AC
***PERLND AREA TO BE REMOVED = 1.53 AC
***original PERLND area
***PERLND  45                         32.44     RCHRES 247        6
PERLND  80                          17.08     RCHRES 247      7
PERLND  80                           1.53     RCHRES 247      7
PERLND  45                          13.83     RCHRES 247      6
PERLND  26                           4.28     RCHRES 135      7
PERLND  44                           0.69     RCHRES 135      7
PERLND  45                          32.44     RCHRES 135      7
IMPLND  14                           1.64     RCHRES 247      2

  *** SUB-CATCHMENT SDW1AI (TO VAULT)CORRECT NAME
  *** SUB-CATCHMENT SDN1AI (TO VAULT)*** MIS NAMES
***original IMPLND area
***IMPLND  14                         13.78     RCHRES 147        2
***IMPLND AREA TO BE REMOVED = 12.6 AC
IMPLND  14                           1.18     RCHRES 147      2
PERLND  80                          12.6      RCHRES 147      7

  *** SUB-CATCHMENT SDW1B (TO POND)
  *** AGWO TO 35, AS 57 IS D/S OF VACCA FARMS (135)
PERLND  26                          21.25     RCHRES 570      6
PERLND  44                           2.39     RCHRES 570      6
***PERLND AREA TO BE REMOVED = 35.32 AC
***PERLND AREA TO BE REMOVED = 2.92 AC
***original PERLND area
***PERLND  45                         46.26     RCHRES 570        6
PERLND  80                          35.32     RCHRES 570      7
PERLND  80                           2.92     RCHRES 570      7
PERLND  45                           8.02     RCHRES 570      6
PERLND  26                          21.25     RCHRES  35      7
PERLND  44                           2.39     RCHRES  35      7
PERLND  45                          46.26     RCHRES  35      7
***original IMPLND area
***IMPLND  14                         26.95     RCHRES 570        2
***IMPLND AREA TO BE REMOVED = 20.69 AC
IMPLND  14                           6.26     RCHRES 570      2
PERLND  80                          20.69     RCHRES 570      7
***ADD SDW2 FROM WALKER CREEK
PERLND  80                           1.06     RCHRES 570      7
*** this impervious does not go to miller but walker
IMPLND  14                ***        0.70     RCHRES 570      2
```

```
PERLND  80                         0.70      RCHRES 570        7
*** FIND OUT WHERE THIS GOES?????
***NEW AREAS ADDED 11/19/01
***SDS3A
PERLND  26                         1.72      RCHRES  37        7
IMPLND  14                         0.70      RCHRES  37        2
***SDW-2
PERLND  26                        11.06      RCHRES  35        7
PERLND  45                         1.09      RCHRES  35        7

*** SPECIAL INFILTRATION PERLNDS
PERLND  47                         2.0       RCHRES  35        7
PERLND  57                         2.0       RCHRES  16        7
***SDE4 0.04 ACRES OF PERLND 26
PERLND  26                         0.04      RCHRES  35        7

  *** ADD SUB-CATCHMENT IWS-PRIMARY TO PREDEVELOPEMENT ONLY

***ROUTING FOR MILLER CREEK
 *** M1 TO M2 TO M3 TO STORAGE 50.  M4 TO M5 TO STORAGE 50
RCHRES   1                                   RCHRES   2        4
RCHRES  23                                   RCHRES  24        4
RCHRES  24                                   RCHRES   3        3
RCHRES   2                                   RCHRES   3        3
RCHRES   3                                   RCHRES  33        3
RCHRES  33                                   RCHRES  50        3
RCHRES   4                                   RCHRES   5        4
RCHRES   5                                   RCHRES  50        3
 *** PONDS TO 52, 53 & 54
RCHRES 242                                   RCHRES 240        5
 *** OVERFLOW ONLY TO 61
RCHRES 240                                   RCHRES  51        5
COPY    61                                   RCHRES  51       12
COPY    44                                   RCHRES  51       12
RCHRES  51                                   RCHRES  52        3
RCHRES  43                                   RCHRES  54        3
 *** 2 NEPL VAULTS* (FK-Changed to eliminate run-of-river tables)
RCHRES 451                                   COPY    45       11
RCHRES 452                                   COPY    45       11
COPY    45                                   COPY   645       10
COPY   645                                   RCHRES  53       12
RCHRES  46                                   RCHRES  53        3
 *** NEW STREAM REACH 52 TO LAKE REBA 53 TO RDF 54 (FK-changed to insert new POC at
Lake Reba)
RCHRES 552                                   RCHRES  52        3
RCHRES  52                                   RCHRES  53        3
RCHRES  53                                   COPY    53       11
COPY    53                                   RCHRES  54       12
RCHRES  50                                   RCHRES  54        3
 *** RDF 54 TO 35
RCHRES  54                                   RCHRES 135        3
<-Source->                 <--Area-->        <-Target->     MBLK     ***
<Name>   #                 <-factor->        <Name>   #     Tbl#     ***
 *** PONDS TO 34
RCHRES  37                                   COPY    37       11
RCHRES 237                                   COPY    37       11
COPY    37                                   RCHRES 135       12
 *** SDW1A flow to bypass added (FK, June 2001)
SDW1AI VAULT FLOW TO INFILTRATION 1                                      ***
RCHRES 147                                   RCHRES  47        4
SDW1AI VAULT FLOW TO BYPASS                                              ***
RCHRES 147                                   COPY    70       15
STORMWATER Q 1ST EXIT AT POND G (Bypass)                                 ***
```

```
RCHRES 247                                        COPY     70     14
RCHRES 247                                        COPY     66     14
2ND EXIT TO INFILTRATION TANK-MILLER CREEK                               ***
RCHRES 247                                        RCHRES   47      5
RCHRES 247                                        COPY     69     15
STORMWATER Q 1ST EXIT TO BYPASS                                          ***
RCHRES  47                                        COPY     70     14
2ND EXIT TO SOIL AND MILLER CREEK                                        ***
***REMOVE CONNECTION FOR INFILTRATION OUTLET.  THIS FLOW IS NOW GOING TO AGWLI FOR
INFILTRATION PERLND
RCHRES  47                                        COPY     70     15     ***
COPY BLOCK FOR OUTPUT PURPOSES                                           ***
RCHRES  47                                        COPY     62     14
RCHRES  47                                        COPY     63     15
RCHRES 147                                        COPY     67     14
RCHRES 147                                        COPY     68     15
  ***   --> output SDW1A infiltration discharge to WDM dataset 5 <--
*** SEND FLOW TO PERLND 47 FOR INFILTRATION OF SECOND OUTLET
*** 2 acre area for infiltration before stream reach
***REDUCED FOR DEEP FRAC FROM 0.5 TO 0.335
RCHRES  47                        0.335           PERLND   47     28
COPY    70                                        RCHRES  135     12
RCHRES  34                                        RCHRES  135      4
RCHRES  34                                        RCHRES  135      5
RCHRES 135                                        RCHRES   35      3
RCHRES  10                                        RCHRES   16      3
 *** PONDS TO 35
 *** Configuration changed to flow splitter to Pond D and Infiltration Basin 3 (FK,
June 2001)
STORM Q - 1ST EXIT OF FLOW SPLITTER TO POND D                            ***
RCHRES 570                                        RCHRES   57      4
INFILTRATION Q - 2ND EXIT OF FLOW SPLITTER TO SOIL                       ***
RCHRES 570                                        RCHRES  257      5
STORM Q EXIT OF POND D TO MILLER CREEK                               ***
RCHRES  57                                        COPY     71     11
COPY BLOCK FOR OUTPUT PURPOSES                                           ***
RCHRES  57                                        COPY    357     11
RCHRES 570                                        COPY     64     14
RCHRES 570                                        COPY     65     15
  ***   --> output SDW1B infiltration discharge to WDM dataset 6 <--
RCHRES 257                                        COPY     56     14
***ROUTE WATER TO AGWLI FOR PERLND 57 INFILTRATION PERLND
***2 ACRE AREA for infiltration before stream reach
***REDUCED FOR DEEP FRAC FROM 0.5 TO 0.335
RCHRES 257                        .335            PERLND   57     28
RCHRES 257                                        COPY     71     14
***REMOVE INFILTRATION FOR  SECOND OUTLET ROUTE WATER TO AGWLI
RCHRES 257                                        COPY     71     15***
COPY    71                                        RCHRES   35     12
RCHRES  35                                        COPY     55     11
COPY    55                                        RCHRES   16     12
RCHRES  11                                        RCHRES   15      3
RCHRES  13                                        RCHRES   12      4
RCHRES  13                                        RCHRES   12      5
RCHRES  12                                        RCHRES   15      3
RCHRES  16                                        RCHRES   15      3
RCHRES  14                                        RCHRES   17      3
RCHRES  15                                        RCHRES   17      3
END SCHEMATIC

NETWORK
***       <MEMBER> SSYSSGAP<--MULT-->TRAN <-TARGET VOLS>           <-MEMBER->
<NAME>   # <NAME>    TEM STRG<-FACTOR->STRG <NAME>    #    # <-GRP> <NAME> # # ***
```

```
END NETWORK                                                                     ***

RCHRES
  GEN-INFO                                                                      ***
    RCHRES       Name        Nexits   Unit Systems   Printer                    ***
    # -  #<------------------><---> User T-series  Engl Metr LKFG               ***
                                           in  out
     1     Arbor Lake  M 1        2    1    1    1    62    0    0
     2     Arbor Ck -03710 M 2    1    1    1    1    62    0    0
     3     Arbor Ck    M 3        1    1    1    1    62    0    0
     4     Tub Lake    M 4        2    1    1    1    62    0    0
     5     Miller Ck SR518 M5     1    1    1    1    62    0    0
    10     Trib (0371G)    M 10   1    1    1    1    62    0    0
    11     M11 Ambaum Detention   1    1    1    1    62    0    0
    12     Trib(0354)  M 12       1    1    1    1    62    0    0
    13     Burien Lake M 13       2    1    1    1    62    0    0
    14     Trib (0353) M 14       1    1    1    1    62    0    0
    15     M/S U/S OF 17          1    1    1    1    62    0    0
    16     U/S OF 15 M/S          1    1    1    1    62    0    0
    17     GAGE                   1    1    1    1    62    0    0
    23     BASIN M23              2    1    1    1    62    0    0
    24     BASIN M24              1    1    1    1    62    0    0
    33     detention m3           1    1    1    1    62    0    0
    34     LORA LAKE              2    1    1    1    62    0    0
    35     D/S OF VACA FARM       1    1    1    1    62    0    0
    37     sdn3ai vault           1    1    1    1    62    0    0
    38     MC basins              1    1    1    1    62    0    0
***   39      SDN3A/SDW1A POC        1    1    1    1    62    0    0
    43     sdn3 pond              1    1    1    1    62    0    0
***   44      sdn4 pond              1    1    1    1    62    0    0
***   45      nepl poc               1    1    1    1    62    0    0
    46     cargo pond             1    1    1    1    62    0    0
    47     sdw1a infiltration     2    1    1    1    62    0    0
    50     sr 518                 1    1    1    1    62    0    0
    51     SDN2X+SDN4X            1    1    1    1    62    0    0
    52     U/S OF LAKE REBA       1    1    1    1    62    0    0
    53     Reba outflow           1    1    1    1    62    0    0
    54     Miller RDF outflow     1    1    1    1    62    0    0
    57     sdw1b pond             1    1    1    1    62    0    0
   135     VACA FARMS             1    1    1    1    62    0    0
   147     sdw1a vault            2    1    1    1    62    0    0
   237     sdn3ao-pond c          1    1    1    1    62    0    0
   240     iws-ncps               2    1    1    1    62    0    0
   242     iws-nsmps              2    1    1    1    62    0    0
   247     sdw1a pond g           2    1    1    1    62    0    0
   257     sdw1b infiltration     2    1    1    1    62    0    0
   451     nepl VAULT             1    1    1    1    62    0    0
   452     nepl VAULT             1    1    1    1    62    0    0
   552     SDN1 POC               1    1    1    1    62    0    0
   570     SDW1B flow splitter    2    1    1    1    62    0    0
***  645      nepl POC               1    1    1    1    62    0    0
  END GEN-INFO

  ACTIVITY
    RCHRES *************** Active Sections *****************
    # -  # HYFG ADFG CNFG HTFG SDFG GQFG OXFG NUFG PKFG PHFG                     ***
    1  999    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  999    5    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        0  1  0  0   4  5  0  0  0       0  0  0  0  0       2  2  2  2  2
  2        0  0  0  0   4  0  0  0  0       0  0  0  0  0       2  2  2  2  2
  3        0  0  0  0   4  0  0  0  0       0  0  0  0  0       2  2  2  2  2
  4        0  1  0  0   4  5  0  0  0       0  0  0  0  0       2  2  2  2  2
  5    12  0  0  0  0   4  0  0  0  0       0  0  0  0  0       2  2  2  2  2
 13        0  1  0  0   4  5  0  0  0       0  0  0  0  0       2  2  2  2  2
 14    22  0  0  0  0   4  0  0  0  0       0  0  0  0  0       2  2  2  2  2
 23        0  1  0  0   4  5  0  0  0       0  0  0  0  0       2  2  2  2  2
 24    33  0  0  0  0   4  0  0  0  0       0  0  0  0  0       2  2  2  2  2
 34        0  1  0  0   4  5  0  0  0       0  0  0  0  0       2  2  2  2  2
 35    46  0  1  0  0   4  0  0  0  0       0  0  0  0  0       2  2  2  2  2
 47        0  1  0  0   4  5  0  0  0       0  0  0  0  0       2  2  2  2  2
 50    54  0  1  0  0   4  0  0  0  0       0  0  0  0  0       2  2  2  2  2
 57        0  1  0  0   4  0  0  0  0       0  0  0  0  0       2  2  2  2  2
100   135  0  1  1  0   4  0  0  0  0       0  0  0  0  0       2  2  2  2  2
147        0  1  1  0   4  0  0  0  0       0  0  0  0  0       2  2  2  2  2
237        0  1  1  0   4  0  0  0  0       0  0  0  0  0       2  2  2  2  2
240   300  0  1  1  0   4  5  0  0  0       0  0  0  0  0       2  2  2  2  2
301   552  0  1  0  0   4  0  0  0  0       0  0  0  0  0       2  2  2  2  2
570        0  1  1  0   4  5  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     0.776                              0.3
  3              3     0.980                              0.3
  4              4     0.010                              0.3
  5              5     0.380                              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     0.587                              0.3
 17             17     0.379                              0.3
 23             23     0.379                    0.0       0.3
 24             24     0.379                              0.3
 33             33     0.200                              0.3
 34             34     0.852                              0.3
 35             35     0.663                              0.3
 37             37     0.010                    0.0       0.3
 38             38     0.010                              0.3
 43             43     0.010                              0.3
 46             46     0.010                              0.3
 47             47     0.010                    0.0       0.3
 50             50     0.010                              0.3
 51             51     0.010                              0.3
 52             52     0.010                              0.3
 53             53     0.010                              0.3
 54             54     0.010                    0.0       0.3
 57             57     0.010                    0.0       0.3
135            135     0.350                              0.3
```

```
147               147  0.010                      0.0         0.3
237               237  0.010                      0.0         0.3
240               240  0.010                                  0.3
242               242  0.010                                  0.3
247               247  0.010                      0.0         0.3
257               257  0.010                      0.0         0.3
451               451  0.010                      0.0         0.3
452               452  0.010                      0.0         0.3
552               552  0.010                      0.0         0.3
570               570  0.010                      0.0         0.3
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  5.0
   2    0.0               4.0
   3    0.0               4.0
   4    2.0               4.0  5.0
   5    0.0               4.0
  10    0.0               4.0
  11    0.0               4.0
  12    0.0               4.0
  13    10.0              4.0  5.0
  14    0.0               4.0
  15    0.0               4.0
  16    0.0               4.0
  17    0.0               4.0
  23    6.0               4.0  5.0
  24    0.0               4.0
  33    0.0               4.0
  34    9.0               4.0  5.0
  35    0.1               4.0
  37    0.0               4.0
  38    0.1               4.0
  43    0.0               4.0
  46    0.0               4.0
  47    0.0               4.0  5.0
  50    0.0               4.0
  51    0.0               4.0
  52    0.0               4.0
  53    0.1               4.0
  54    2.25              4.0
  57    0.0               4.0
 237    0.00              4.0
 147    1.00              4.0  5.0
 135    0.00              4.0
 240    0.0               4.0  5.0
 242    0.0               4.0  5.0
 247    0.0               4.0  5.0
 257    0.0               4.0  5.0
 451    0.0               4.0
 452    0.0               4.0
 552    0.0               4.0
 570    0.0               4.0  5.0
  END HYDR-INIT
END RCHRES

FTABLES
***UPPER BASIN
```

```
***==========

  FTABLE       1
           *** REVISED 8/16/00 ADDED 2ND OUTFLOW
 ROWS COLS ***
   11    5
     DEPTH        AREA      VOLUME     OUTFLOW  OUTFLOW2***
     0.00         3.00      0.00        0.00     0.00
     2.50         3.00      7.50        0.00     0.11
     3.00         3.00      9.00        1.80     0.11
     3.50         3.30      10.58       5.00     0.11
     4.00         3.60      12.30      10.90     0.11
     4.50         3.90      14.18      17.50     0.11
     5.00         4.10      16.18      26.20     0.11
     5.50         4.30      18.28      32.50     0.11
     6.00         4.50      20.48      35.90     0.11
     7.00         5.00      25.23      38.10     0.11
     8.00         5.50      30.48      46.40     0.11
  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
           *** REVISED 8/16/00 ADDED 2ND OUTFLOW
 ROWS COLS ***
    7    5
     DEPTH      AREA      VOLUME     OUTFLOW  OUTFLOW2***
     0.00      3.00       0.00       0.00        0.00
     2.50      4.50       9.38       0.00        0.11
     3.00      6.00       12.00      6.00        0.11
     4.00      10.00      20.00      13.00       0.11
     5.00      15.00      32.50      20.00       0.11
```

```
     6.00     20.00     50.00      26.00      0.11
     7.00     25.00     72.50     168.00      0.11
  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     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

  POST AMBAUM DETENTION ***
  FTABLE     11
 ROWS COLS ***
   12    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    6.0000     500.00
    11.500    1.3000    11.000    1300.00
  END FTABLE 11

  FTABLE     12
 ROWS COLS ***
    6    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     13
           *** REVISED 8/16/00 ADDED 2ND OUTFLOW
 ROWS COLS ***
    7    5
     DEPTH       AREA     VOLUME    OUTFLOW OUTFLOW2***
     0.000     40.000     0.0000      0.00      0.00
     1.000     41.400     40.000      0.00      0.11
     1.500     42.000     60.000     10.00      0.11
     2.000     42.700     80.000     16.00      0.11
     2.500     43.300     100.00     20.00      0.11
     3.000     44.000     120.00     28.00      0.11
     5.000     45.000     210.00     45.00      0.11
  END FTABLE 13

  FTABLE     14
 ROWS COLS ***
    6    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     15
 ROWS COLS ***
    4    4
     DEPTH       AREA     VOLUME    OUTFLOW    ***
      0.00       0.10       0.00      0.00
      1.00       1.00       0.55     91.00
      2.00       1.10       1.60    268.00
      3.00       1.20       2.75    493.00
  END FTABLE 15

  FTABLE     16
 ROWS COLS ***
    4    4
     DEPTH       AREA     VOLUME    OUTFLOW    ***
      0.00       0.10       0.00      0.00
      1.00       1.00       0.55     74.00
      2.00       1.10       1.60    219.00
      3.00       1.20       2.75    403.00
  END FTABLE 16

  FTABLE     17
 ROWS COLS ***
    5    4
     DEPTH       AREA     VOLUME    OUTFLOW    ***
      0.00       0.10       0.00      0.00
      1.00       1.00       0.55     59.00
```

```
     2.00      1.10       1.60     173.00
     3.00      1.20       2.75     318.00
     4.00      1.30       4.00     484.00
 END FTABLE 17

 FTABLE      23
ROWS COLS ***   HERMES
  9    5
   DEPTH       AREA     VOLUME     OUTFLOW  OUTFLOW    ***
    0.00       0.00       0.00       0.00     0.00           0.00
    5.00       0.50       1.91       0.00     0.00         305.00
   11.00       0.79       5.79       0.00     0.00         311.00
   15.00       1.13       9.64       0.50     0.01         315.00
   19.00       1.72      15.34       0.50     0.05         319.00
   29.00       2.86      38.25       0.50     0.10         329.00
   39.00       4.40      74.55       0.50     0.20         339.00
   50.00       6.22     132.98       0.50     0.30         350.00
   60.00      10.00    1212.98       0.50     0.40         360.00
 END FTABLE 23

 FTABLE      24
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 24

 FTABLE      33
ROWS COLS ***
 11    4
   DEPTH       AREA     VOLUME     OUTFLOW    ***
    0.00       1.00      0.00        0.00
    0.50       1.20      0.55        2.00
    1.00       1.40      1.20        6.00
    1.50       1.60      1.95        9.00
    2.00       1.80      2.80       13.00
    2.50       2.00      3.75       16.50
    3.00       2.20      4.80       20.00
    3.50       2.40      5.95       23.00
    4.00       2.60      7.20       26.00
    5.00       2.80      9.90      104.00
    6.00       3.00     12.80      246.00
 END FTABLE 33

 FTABLE      34
ROWS COLS *** REVISED 11/19/97 BASED ON HEC-RAS MODEL
          *** REVISED 8/16/00 ADDED 2ND OUTFLOW
  6    5
   DEPTH       AREA     VOLUME     OUTFLOW  OUTFLOW2***
    0.00       3.00      0.00       0.00     0.00
    3.00       3.05      9.08       0.00     0.11
    4.00       3.10     12.15       0.00     0.11
    5.00       3.15     15.28       0.00     0.11
    6.00       3.20     18.45       72.0     0.11
    7.00       3.25     21.68      225.0     0.11
```

```
 END FTABLE 34

 FTABLE     35
ROWS COLS *** REVISED 11/19/97 BASED ON HECRAS MODEL
  5    4
     DEPTH       AREA      VOLUME    OUTFLOW    ***
      0.00       0.10       0.00       0.00
      1.00       1.10       0.60      38.00
      2.00       1.20       1.75     108.00
      3.00       1.30       3.00     194.00
      4.00       1.40       4.35     290.00
 END FTABLE 35


 FTAB_E     38
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 38

 FTABLE     45
ROWS COLS ***
  4    4
     DEPTH       AREA      VOLUME    OUTFLOW    ***
     0.000     0.0010     0.0000       0.00
     0.000     0.0100     0.0100      10.00
     0.100     0.1000     0.1000     100.00
     1.000     1.0000     1.0000    1000.00
    10.000    10.0000    10.0000   10000.00
 END FTABLE 45

 FTABLE    645
ROWS COLS ***
  4    4
     DEPTH       AREA      VOLUME    OUTFLOW    ***
     0.000     0.0010     0.0000       0.00
     0.000     0.0100     0.0100      10.00
     0.100     0.1000     0.1000     100.00
     1.000     1.0000     1.0000    1000.00
    10.000    10.0000    10.0000   10000.00
 END FTABLE645

 FTABLE     50
ROWS COLS ***
 10    4
     DEPTH       AREA      VOLUME    OUTFLOW    ***
      0.00       1.00       0.00       0.00
      0.50       1.10       0.53       5.00
      1.00       1.20       1.10      15.00
      1.50       1.30       1.73      25.00
      2.00       1.40       2.40      35.00
      2.50       1.50       3.13      52.00
      3.00       1.60       3.90      70.00
      3.50       1.70       4.73      87.00
      4.00       1.80       5.60     105.00
      6.00       1.90       9.30     165.00
```

```
 END FTABLE 50

 FTABLE      52
ROWS COLS ***
  6    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
 END FTABLE 52

 FTABLE     552
ROWS COLS ***   SDN1 VAULT EFFECTIVE DEPTH=12 FT  RISER=24 INCHES
 15    4
    DEPTH      AREA     VOLUME    OUTFLOW  ***
    0.000     0.4308    0.0000      0.00
    1.290     0.4308    0.6520     0.111
    2.130     0.4308    1.0760     0.143
    3.530     0.4308    1.7830     0.184
    4.640     0.4308    2.3430     0.211
    5.200     0.4308    2.6260     0.223
    6.320     0.4308    3.1920     0.246
    7.430     0.4308    3.7530     0.267
    8.200     0.4308    4.1410     0.280
    9.220     0.4308    4.6570     0.407
   10.190     0.4308    5.1460     0.567
   11.250     0.4308    5.6820     0.954
   12.100     0.4308    6.1110     2.130
   12.300     0.4308    6.2120     4.730
   13.700     0.4308    6.9190    21.360
 END FTABLE552

 FTABLE      53
OLD LAKE REBA                                  ***
MAX DEPTH = 4.9 FEET                           ***
30" CMP, 40 CFS DISCHARGE AT MAX DEPTH         ***
ROWS COLS ***
  7    4
    DEPTH      AREA     VOLUME    OUTFLOW  ***
    0.000     2.4000    0.0000      0.00
    1.000     2.5800    2.5000     18.00
    2.000     2.9400    5.3000     26.00
    3.000     3.4100    8.4000     31.00
    4.000     3.8800    12.100     36.00
    4.900     4.3000    15.800     40.00
    6.000     4.3000    15.810    500.00
 END FTABLE 53

 FTABLE      54
EXISTING MILLER CREEK DETENTION FACILITY*** REVISED STORAGE/Q DATA
GATE SETTING: 2.0 FEET***  BASED ON CALIBRATION FILE
ROWS COLS ***
 12    4
    DEPTH      AREA     VOLUME    OUTFLOW  ***
    0.000      0.00       0.00      0.00
    1.300      0.01       0.01     10.00
    2.000      0.01       0.02     20.00
    2.900      0.70       0.40     30.00
    4.000      1.50       1.50     40.00
    5.400      3.50       4.90     50.00
```

```
    7.000      8.60      13.30      60.00
    8.800     15.60      34.80      70.00
   10.000     19.90      57.30      76.00
   10.500     21.50      68.00      92.00
   11.000     23.10      78.80     179.00
   11.500     24.70      88.60     303.00
  END FTABLE 54

  FTABLE    104
 MILLER CREEK DETENTION FACILITY*** WITH ADD'L AREA 1+AREA 2 55.5 ACFT @ 10FT
 GATE SETTING: 2.0 FEET*** EXISTING OUTLET NO LOW FLOW CONTROL
 ROWS COLS ***
   17    4
    DEPTH      AREA     VOLUME    OUTFLOW    ***
    0.000     0.0000    0.0000      0.00
    0.500     0.0100    0.0100      2.50
    1.500     0.0300    0.2800     14.29
    2.500     1.1100    1.3900     24.88
    3.500     2.6100    4.0000     34.51
    4.500     4.6100    9.1400     43.20
    5.500     7.1200    19.600     50.98
    6.000     8.3600    21.180     54.53
    6.500     11.870    30.060     57.87
    7.000     15.370    38.930     61.00
    7.500     18.870    47.800     63.91
    8.000     21.860    59.160     66.62
    8.500     24.850    70.510     69.12
    9.000     27.340    84.160     71.42
    9.500     29.820    97.820     73.53
   10.000     32.050    112.83     75.44
   10.500     34.275    127.84     90.74
   11.500     38.220    161.54    320.00
  END FTABLE104

  FTABLE     69
 PRE-MILLER CREEK DETENTION FACILITY***
 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 69

*** PROJECT CONDITION PONDS/VAULTS
  FTABLE    452
 ROWS COLS ***
 *** NEW NORTH EMPLOYEE PARKING LOT VAULT (NEPL)
 *** PARALLEL VAULT BASED ON KCRTS EFFECTIVE DEPTH=20 FT

   20    4
    DEPTH      AREA     VOLUME    OUTFLOW ***
    0.00      3.214     0.000      0.000
    1.11      3.214     0.826      0.129
```

1.57	3.214	1.168	0.154
3.43	3.214	2.551	0.227
4.83	3.214	3.593	0.269
8.08	3.214	6.010	0.348
10.41	3.214	7.743	0.395
12.74	3.214	9.476	0.437
14.00	3.214	10.413	0.458
14.65	3.214	10.897	0.557
16.09	3.214	11.968	0.665
16.23	3.214	12.072	0.754
17.92	3.214	13.329	1.140
18.22	3.214	13.552	1.310
18.81	3.214	13.991	1.860
19.11	3.214	14.214	2.190
20.00	3.214	14.876	3.350
20.20	3.214	15.025	5.110
20.70	32.14	15.397	14.820
21.00	32.14	15.620	18.560

END FTABLE452

FTABLE 451
ROWS COLS ***
*** NORTH EMPLOYEE PARKING LOT VAULT (NEPL)
*** EXISTING VAULT W/MODIFIED OUTLET EFFECTIVE DEPTH= 18.0 FT

14 4

DEPTH	AREA	VOLUME	OUTFLOW ***
0.000	0.2240	0.0000	0.00
2.170	0.2240	0.4860	0.031
4.260	0.2240	0.9550	0.043
5.930	0.2240	1.3290	0.051
8.030	0.2240	1.8000	0.059
10.120	0.2240	2.2680	0.066
12.210	0.2240	2.7360	0.073
14.040	0.2240	3.1460	0.109
15.510	0.2240	3.4760	0.166
16.220	0.2240	3.6350	0.295
18.000	0.2240	4.0340	1.080
18.400	0.2240	4.1240	5.400
19.000	0.2240	4.2580	12.680
19.900	0.2240	4.4600	17.080

END FTABLE451

FTABLE 46
ROWS COLS ***
SDN-6: 24TH STREET CARGO VAULT *** EFFECTIVE DEPTH=14 FT RISER DIA=12 IN
20 4

DEPTH	AREA	VOLUME	OUTFLOW ***
0.00	0.35	0.000	0.000
0.37	0.35	0.131	0.021
1.19	0.35	0.421	0.037
3.39	0.35	1.198	0.063
5.03	0.35	1.778	0.077
7.23	0.35	2.556	0.092
9.15	0.35	3.235	0.104
10.25	0.35	3.624	0.110
10.53	0.35	3.723	0.111
10.92	0.35	3.861	0.128
12.00	0.35	4.242	0.165
12.13	0.35	4.288	0.190
12.95	0.35	4.578	0.245
13.77	0.35	4.868	0.282

```
     14.00        0.35       4.949      0.291
     14.10        0.35       4.985      0.910
     14.20        0.35       5.020      2.040
     14.30        0.35       5.056      3.500
     14.50        0.35       5.126      7.200
     14.70        0.35       5.197     11.720
  END FTABLE 46

*** SDW-1A: 3RD RUNWAY POND G TO MILLER CREEK (LEVEL 2): ***
  FTABLE     47
  *** PROJECT  SDW1A    EFFECTIVE DIAMETER=3.0 FT
 ROWS COLS ***          INFILTRATION TANK TO OBTAIN 0.3 CFS
   14    5
    DEPTH       AREA      VOLUME      STORMQ   INFILTRQ ***
    0.000      0.000      0.000       0.000     0.000
    0.250      0.002      0.002       0.000     0.027
    0.500      0.004      0.004       0.000     0.054
    1.000      0.012      0.012       0.000     0.109
    1.500      0.020      0.020       0.000     0.164
    2.000      0.029      0.029       0.000     0.218
    2.500      0.036      0.036       0.000     0.272
    3.000      0.041     0.0406       0.000     0.327
    3.100      0.041     0.0419       0.596     0.338
    3.200      0.041     0.0420       1.685     0.349
    3.300      0.041     0.0421       3.096     0.360
    3.400      0.041     0.0422       4.766     0.371
    3.500      0.041     0.0423       6.661     0.382
    3.750      0.041     0.0424      12.237     0.409
  END FTABLE 47

*** SDW-1A: 3RD RUNWAY NORTH POND G TO MILLER CREEK (LEVEL 2): ***
  FTABLE     147
  *** PROJECT  SDW1A    EFFECTIVE DEPTH=14.0 FT RISER DIA 24 INCHES
 ROWS COLS ***          VAULT BASED ON INFILTRATION=0.15CFS
   17    5
    DEPTH       AREA      VOLUME    INFILTRQ    BYPASS Q***
    0.000      0.689      0.000      0.0000     0.0000
    0.010      0.689      0.007      0.1400     0.0000
    1.000      0.689      0.689      0.1408     0.0000
    2.000      0.689      1.377      0.1417     0.0000
    4.000      0.689      2.755      0.1432     0.0000
    6.000      0.689      4.132      0.1446     0.0000
    8.000      0.689      5.510      0.1461     0.0000
   10.000      0.689      6.887      0.1475     0.0000
   12.000      0.689      8.264      0.1489     0.0000
   14.000      0.689      9.642      0.1503     0.0000
   16.000      0.689     11.019      0.1517     0.0000
   16.750      0.689     11.536      0.1517    10.7600
   16.900      0.689     11.639      0.1517    13.9600
   17.000      0.689     11.708      0.1517    16.1000
   17.100      0.689     11.777      0.1517    18.5700
   17.300      0.689     11.915      0.1517    23.8600
   18.000      0.689     12.397      0.1517    45.5400
  END FTABLE147

*** SDW-1A: 3RD RUNWAY NORTH POND G TO MILLER CREEK (LEVEL 2): ***
  FTABLE     247
  *** PROJECT  SDW1A    EFFECTIVE DEPTH=12.0 FT RISER DIA 12 INCHES
 ROWS COLS ***          POND BASED ON INFILTRATION=0.15CFS
   17    5
    DEPTH       AREA      VOLUME      STORMQ   INFILTRQ ***
    0.000      1.300      0.000       0.00      0.00
```

0.010	1.310	0.010	0.001	0.15
1.000	1.320	1.320	0.007	0.15
2.000	1.342	2.650	0.010	0.15
3.000	1.363	4.000	0.012	0.15
4.000	1.385	5.370	0.013	0.15
5.000	2.672	8.000	0.015	0.15
6.000	2.739	10.700	0.017	0.15
7.000	2.807	13.470	0.018	0.15
8.000	2.876	16.300	0.019	0.15
8.300	2.896	17.176	0.031	0.15
9.000	2.945	19.210	0.041	0.15
10.000	3.014	22.180	0.051	0.15
11.000	3.084	25.228	0.058	0.15
11.100	3.092	25.540	0.675	0.15
11.300	3.106	26.162	3.260	0.15
12.000	3.155	28.340	15.190	0.15

END FTABLE247

*** SDN3A: 3RD RUNWAY VAULT TO MILLER CREEK (LEVEL 2): ***
FTABLE 37
*** PROJECT C SDN3A EFFECTIVE DEPTH=11.0FT RISER DIA=24 INCHES
ROWS COLS *** VAULT BASED ON IMPERVIOUS TOP SURO
14 4

DEPTH	AREA	VOLUME	OUTFLOW	***
0.000	0.644	0.000	0.000	
0.010	0.644	0.006	0.001	
1.000	0.644	0.643	0.016	
3.980	0.644	2.558	0.033	
6.030	0.644	3.876	0.041	
9.010	0.644	5.792	0.050	
10.00	0.644	6.428	0.052	
10.46	0.644	6.724	0.072	
11.00	0.644	7.071	0.082	
11.10	0.644	7.135	0.699	
11.20	0.644	7.199	1.830	
11.30	0.644	7.264	3.290	
11.40	0.644	7.328	5.020	
11.60	0.644	7.456	9.140	

END FTABLE 37

*** SDN3A: 3RD RUNWAY POND C TO MILLER CREEK (LEVEL 2): ***
FTABLE 237
*** PROJECT C SDN3A EFFECTIVE DEPTH= 9.0FT RISER DIA=24 INCHES
ROWS COLS *** POND BASED ON INTERFLOW AND PERVIOUS TOP SURO
19 4

DEPTH	AREA	VOLUME	OUTFLOW	***
0.000	1.3090	0.000	0.00	
0.020	1.3120	0.026	0.009	
1.020	1.3550	1.358	0.070	
2.070	1.4030	2.806	0.100	
3.130	1.4530	4.320	0.123	
4.020	1.4980	5.632	0.139	
5.070	1.5460	7.229	0.156	
7.750	1.6720	11.549	0.193	
7.800	1.6800	11.633	0.199	
7.850	1.6840	11.718	0.213	
8.250	1.7050	12.395	0.249	
8.340	1.7090	12.549	0.270	
8.570	1.7210	12.944	0.313	
8.950	1.7410	13.601	0.354	
9.500	1.7690	14.567	0.399	
9.600	1.7740	14.744	0.714	
9.800	1.7850	15.100	2.020	

```
   10.300     1.8110     15.999      3.840
   10.900     1.8430     17.095      4.960
  END FTABLE237

*** SDN-3X: 3RD RUNWAY NORTH VAULT (LEVEL 2): ***
  FTABLE     43
 ROWS COLS ***        EFFECTIVE DEPTH=20 FT RISER DIA=24 INCHES
   21    4                                                              ***
     DEPTH       AREA     VOLUME      FLOW                              ***
      (FT)    (ACRES)  (ACRE-FT)    (FT3/S)
      0.00      1.288       0.00       0.00
      0.14      1.288      0.180      0.067
      1.39      1.288      1.790      0.216
      3.35      1.288      4.314      0.336
      5.31      1.288      6.839      0.423
      8.06      1.288     10.380      0.521
      8.84      1.288     11.385      0.545
     10.02      1.288     12.905      0.580
     11.98      1.288     15.429      0.635
     12.37      1.288     15.931      0.645
     14.00      1.288     18.030      0.686
     14.10      1.288     18.159      0.705
     14.91      1.288     19.202      0.757
     16.09      1.288     20.722      0.810
     18.00      1.288     23.182      0.881
     18.32      1.288     23.594      1.150
     18.76      1.288     24.161      1.360
     20.00      1.288     25.758      1.680
     20.10      1.288     25.886      2.320
     20.50      1.288     26.402      8.620
     20.80      1.288     26.788     15.370
  END FTABLE 43

 *** SDN-4X/2X: 3RD RUNWAY NORTH VAULT      (COMBINED FACILITY)
  FTABLE     51
 ROWS COLS ***        EFFECTIVE DEPTH=19FT RISER DIA=24 INCHES
   20    4                                                              ***
     DEPTH       AREA     VOLUME    OUTFLOW                             ***
      (FT)    (ACRES)  (ACRE-FT)    (FT3/S)
      0.00      0.789      0.000      0.000
      0.16      0.789      0.126      0.056
      1.51      0.789      1.192      0.169
      3.28      0.789      2.588      0.249
      5.49      0.789      4.332      0.322
      7.26      0.789      5.729      0.370
     10.35      0.789      8.168      0.442
     12.12      0.789      9.564      0.478
     13.44      0.789     10.606      0.503
     14.33      0.789     11.308      0.520
     15.57      0.789     12.287      0.654
     16.72      0.789     13.194      0.828
     17.19      0.789     13.565      0.950
     17.63      0.789     13.913      1.030
     18.00      0.789     14.205      1.080
     19.00      0.789     14.994      1.960
     19.10      0.789     15.073      2.580
     19.40      0.789     15.309      6.930
     19.60      0.789     15.467     11.080
     20.00      0.789     15.783     17.190
  END FTABLE 51

*** SDW-1B:3RD RUNWAY CENTRAL SOUTH POND D TO MILLER CREEK (LEVEL 2): ***
  FTABLE     57
```

ROWS COLS *** EFFECTIVE DEPTH = 14.0 FT
17 4

DEPTH (FT)	AREA (ACRES)	VOLUME (ACRE-FT)	STORMQ (FT3/S) ***
0.00	2.430	0.000	0.000
0.01	2.430	0.041	0.010
1.00	2.680	2.411	0.183
2.00	2.760	4.860	0.257
3.00	2.818	7.370	0.319
4.00	3.079	9.945	0.366
5.00	5.832	15.320	0.411
6.00	5.927	20.742	0.450
7.00	6.022	26.264	0.481
8.00	6.118	31.888	0.518
9.00	6.210	37.613	0.550
10.00	6.311	43.441	0.583
11.00	6.408	49.372	0.609
12.00	6.607	55.406	0.634
13.00	6.405	61.543	0.764
14.00	6.504	67.786	1.320
15.00	7.000	70.000	16.600

END FTABLE 57

*** SDW-1B:3RD RUNWAY CENTRAL SOUTH POND D TO MILLER CREEK (LEVEL 2): ***
FTABLE 257
*** PROJECT SDW1B EFFECTIVE DIAMETER=3.0 FT
ROWS COLS *** INFILTRATION TANK TO OBTAIN 0.2 CFS
15 5

DEPTH	AREA	VOLUME	STORMQ	INFILTRQ ***
0.000	0.001	0.000	0.000	0.000
0.010	0.001	0.001	0.000	0.002
0.250	0.002	0.002	0.000	0.017
0.500	0.004	0.004	0.000	0.035
1.000	0.012	0.012	0.000	0.071
1.500	0.020	0.020	0.000	0.106
2.000	0.029	0.029	0.000	0.142
2.500	0.036	0.036	0.000	0.178
3.000	0.041	0.0406	0.000	0.213
3.100	0.041	0.0420	0.596	0.220
3.200	0.041	0.0421	1.685	0.227
3.300	0.041	0.0422	3.096	0.233
3.400	0.041	0.0423	4.766	0.241
3.500	0.041	0.0424	6.661	0.248
3.750	0.041	0.0425	12.237	0.266

END FTABLE257

FTABLE 570
*** PROJECT SDW1B FLOW SPLITTER (to 257 and 57)
ROWS COLS ***
15 5

DEPTH	AREA	VOLUME	STORMQ	INFILTRQ ***
0.000	0.00	0.000	0.000	0.000
0.100	0.01	0.0002	0.000	0.050
0.400	0.01	0.0009	0.000	0.110
0.600	0.01	0.0014	0.000	0.130
0.750	0.01	0.0017	0.000	0.150
0.800	0.01	0.0018	0.720	0.150
1.000	0.01	0.0023	8.050	0.170
1.100	0.01	0.0025	13.330	0.180
1.200	0.01	0.0027	19.440	0.190
1.300	0.01	0.0030	26.270	0.190
1.400	0.01	0.0032	33.750	0.200
1.420	0.01	0.0033	35.320	0.200

```
     1.440      0.01     0.0033      36.910      0.200
     1.450      0.01     0.0034      37.920      0.200
     1.460      0.01     0.0035      38.530      0.200
  END FTABLE570

  FTABLE     61
 ROWS COLS ***
*** SDN-2X: DETAIN OVERFLOW FROM NCPS AND NSMPS-
   17    4
     DEPTH       AREA     VOLUME    OUTFLOW    ***
     0.000     0.5740     0.0000       0.00
     1.200     0.5740     0.7710      0.151
     2.220     0.5740     1.4270      0.205
     3.240     0.5740     2.0830      0.247
     3.650     0.5740     2.3460      0.262
     4.260     0.5740     2.7380      0.283
     4.660     0.5740     2.9950      0.296
     5.680     0.5740     3.6510      0.327
     6.640     0.5740     4.2680      0.517
     7.650     0.5740     4.9170      0.644
     8.670     0.5740     5.9710      0.739
     9.810     0.5740     6.3570      0.836
    10.700     0.5740     6.8780      0.894
    12.000     0.5740     7.7130      0.978
    12.100     0.5740     7.7780      1.600
    12.300     0.5740     7.9060      4.200
    12.800     0.5740     8.2280     14.560
  END FTABLE 61

  PRE AMBAUM DETENTION ***
  FTABLE    111
 ROWS COLS ***
   15    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
     6.000     0.3800     5.0530     166.48
     6.500     0.3980     5.9430     225.31
     7.000     0.4150     6.9040     320.10
  END FTABLE111

  FTABLE    135
 ROWS COLS *** VACA FARM
    6    4
     DEPTH       AREA     VOLUME    OUTFLOW    ***
      0.00       0.10       0.00       0.00
      1.00       0.10       0.10       4.00
      2.00       0.11       0.21       8.00
      2.50       1.00       0.48      13.00
      3.50       6.50       4.23      86.00
      4.50      13.00      13.98     235.00
  END FTABLE135
```

```
  FTABLE     240
*** NORTH SNOWMELT PUMP STATION (SDN-2) (INSTALLED IN LATE 1997/1998)   ***
 ROWS COLS
   14    5
    DEPTH      AREA    VOLUME       (IWS)      (SDS)                     ***
     (FT)   (ACRES) (ACRE-FT)       (CFS)      (CFS)                     ***
      0.0     0.002      0.00        0.00       0.00
     1.00     0.002    0.0023        0.00       0.00
     2.00     0.002    0.0046        1.67       0.00
     3.00     0.002    0.0069        1.67       0.00
     4.00     0.002    0.0092        1.67       0.00
     5.00     0.002    0.0115        1.67       0.00
     5.25     0.002    0.0121        1.67       1.53
     5.50     0.002    0.0126        1.67       6.06
     5.75     0.002    0.0132        1.67      12.65
     6.00     0.002    0.0138        1.67      19.83
     6.25     0.002    0.0144        1.67      25.66
     6.50     0.002    0.0149        1.67      25.70
     6.75     0.002    0.0155        1.67      26.70
     7.00     0.002    0.0161        1.67      50.00
  END FTABLE240

  FTABLE     242
*** NORTH CARGO PUMP STATION (SDN-2) (INSTALLED IN OCTOBER 1997)
 ROWS COLS                                                               ***
   14    5
    DEPTH      AREA    VOLUME       (IWS)      (SDS)                     ***
     (FT)   (ACRES) (ACRE-FT)       (CFS)      (CFS)                     ***
      0.0     0.002      0.00        0.00       0.00
     1.00     0.002    0.0023        0.00       0.00
     2.00     0.002    0.0046        6.13       0.00
     3.00     0.002    0.0069        6.13       0.00
     4.00     0.002    0.0092        6.13       0.00
     5.00     0.002    0.0115        6.13       0.00
     5.25     0.002    0.0121        6.13       0.28
     5.50     0.002    0.0126        6.13       1.16
     5.75     0.002    0.0132        6.13       2.53
     6.00     0.002    0.0138        6.13       4.23
     6.25     0.002    0.0144        6.13       6.05
     6.50     0.002    0.0149        6.13       7.72
     6.75     0.002    0.0155        6.13       8.50
     7.00     0.002    0.0161        6.13       20.0
  END FTABLE242

END FTABLES

MASS-LINK
<Volume>   <-Grp> <-Member-><--Mult-->     <Target>       <-Grp> <-Member->***
<Name>            <Name> # #<-factor->     <Name>                <Name> # #***
  MASS-LINK        1
  conversion from acre-inches to acre-ft (1/12)               ***
PERLND     PWATER PERO        0.0833333    RCHRES         INFLOW IVOL
  END MASS-LINK    1

  MASS-LINK        2
IMPLND     IWATER SURO        0.0833333    RCHRES         INFLOW IVOL
  END MASS-LINK    2

  MASS-LINK        3
RCHRES     ROFLOW                          RCHRES         INFLOW
  END MASS-LINK    3

  MASS-LINK        4
```

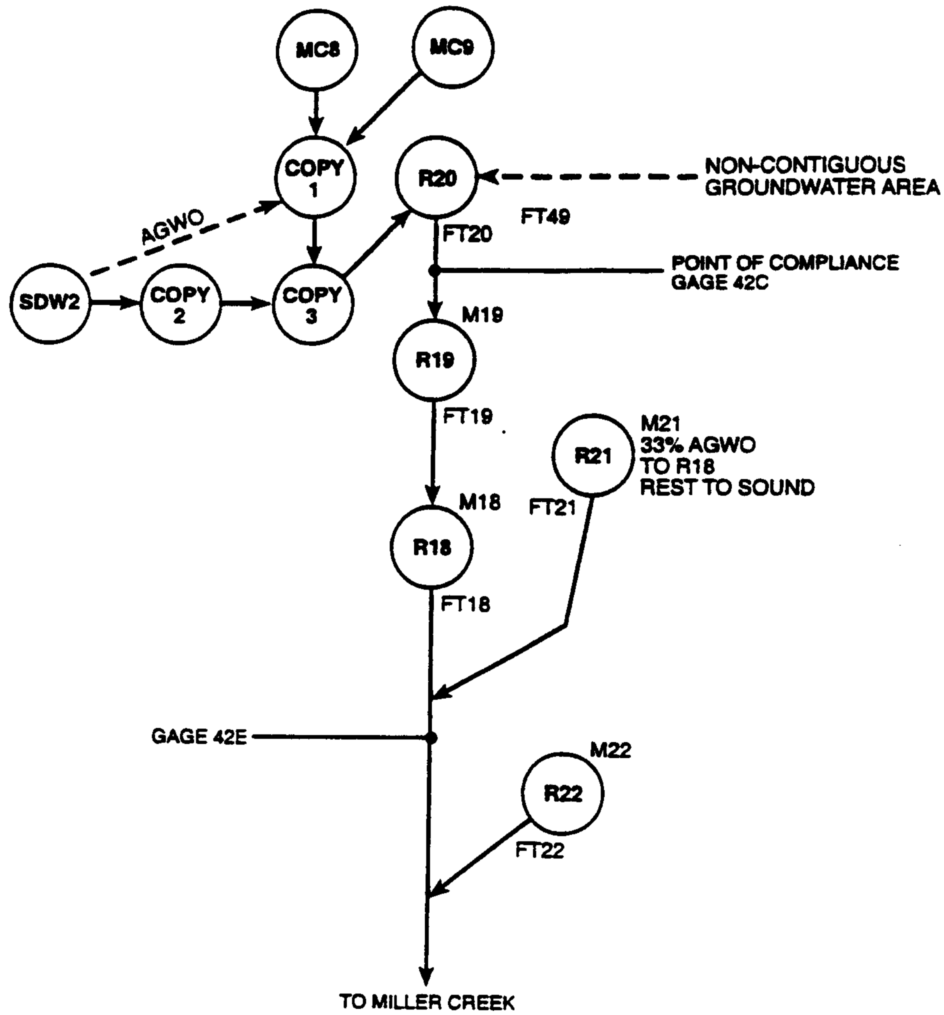
```
RCHRES      OFLOW  OVOL    1                       RCHRES          INFLOW IVOL
  END MASS-LINK    4

  MASS-LINK        5
RCHRES      OFLOW  OVOL    2                       RCHRES          INFLOW IVOL
  END MASS-LINK    5

  MASS-LINK        6
PERLND      PWATER SURO        0.0833333           RCHRES          INFLOW IVOL
PERLND      PWATER IFWO        0.0833333           RCHRES          INFLOW IVOL
  END MASS-LINK    6

  MASS-LINK        7
PERLND      PWATER AGWO        0.0833333           RCHRES          INFLOW IVOL
  END MASS-LINK    7

  MASS-LINK        10
COPY        OUTPUT MEAN                            COPY            INPUT  MEAN
  END MASS-LINK    10

  MASS-LINK        11
RCHRES      ROFLOW                                 COPY            INPUT  MEAN
  END MASS-LINK    11

  MASS-LINK        12
COPY        OUTPUT MEAN                            RCHRES          INFLOW IVOL
  END MASS-LINK    12

  MASS-LINK        14
RCHRES      OFLOW  OVOL    1                       COPY            INPUT  MEAN
  END MASS-LINK    14

  MASS-LINK        15
RCHRES      OFLOW  OVOL    2                       COPY            INPUT  MEAN
  END MASS-LINK    15

  MASS-LINK        21
PERLND      PWATER PERO        0.0833333           COPY            INPUT  MEAN
  END MASS-LINK    21

  MASS-LINK        22
IMPLND      IWATER SURO        0.0833333           COPY            INPUT  MEAN
  END MASS-LINK    22

  MASS-LINK        26
PERLND      PWATER SURO        0.0833333           COPY            INPUT  MEAN
PERLND      PWATER IFWO        0.0833333           COPY            INPUT  MEAN
  END MASS-LINK    26

  MASS-LINK        27
PERLND      PWATER AGWO        0.0833333           COPY            INPUT  MEAN
  END MASS-LINK    27

  MASS-LINK        28
RCHRES      OFLOW  OVOL    2       12              PERLND          EXTNL  AGWLI
  END MASS-LINK    28

END MASS-LINK

COPY
  TIMESERIES
  Copy-opn                                                                     ***
```

```
  # -  #  NPT  NMN                                   ***
  37   71         1
 240  242         1
 357  357         1
 645  645         1
  END TIMESERIES
END COPY

END RUN
```

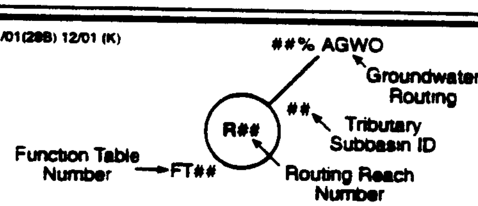
WALKER CREEK WATERSHED
HSPF INPUT FILES

- **1994 CONDITIONS**
- **2006 CONDITIONS**

1994 CONDITIONS



Parametrix, Inc. Port of Seattle/556-2912-001/01(28B) 12/01 (K)



HSPF Model Schematic
Walker Creek
Low Flow Analysis
1994 Conditions

```
RUN
GLOBAL
  ***  COPY COMMAND ADDED
  ***  FILE: WCPREDT.inp REVISED OCTOBER 2000
  ***  SEATAC AIRPORT HSPF BASIN MODEL OF WALKER CREEK
  ***  CALIBRATION FILE USING FULL LENGTH RUN 1990 DATA FOR INTITIAL CONDITIONS
  WALKER CREEK BASIN HSPF MODEL
  START       1990 10  1  0  0  END    1994  9 30 24  0
  RUN INTERP OUTPUT LEVEL    3
  RESUME     0 RUN     1
END GLOBAL

FILES
<type>  <fun>***<------------fname------------------------------------------->
MESSU      24    D:\PARA\SEATAC\MILLER\LOWFLOW\wpredt.MES
WDM        25    D:\PARA\SEATAC\MILLER\LOWFLOW\mlowflow.WDM
           61    D:\PARA\SEATAC\MILLER\LOWFLOW\wPER.L61
           62    D:\PARA\SEATAC\MILLER\LOWFLOW\wRCH.L62
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      45
      PERLND      54
      PERLND      64
      PERLND      65
      IMPLND      14
      COPY         2
      COPY         1
      COPY         3
      RCHRES      20
      RCHRES      19
      RCHRES      18
    END INGRP
END OPN SEQUENCE
                                                                      ***
COPY
  TIMESERIES
  Copy-opn                                                            ***
    # -   #  NPT  NMN                                                 ***
    1    5          1
  END TIMESERIES
END COPY

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   61    0
   16      TFM- TILL FOR MOD       1     1     1    1   61    0
   18      TFS- TILL FOR STP       1     1     1    1   61    0
   24      TGF- TILL GR FLT        1     1     1    1   61    0
   26      TGM- TILL GR MOD        1     1     1    1   61    0
   28      TGS- TILL GR STP        1     1     1    1   61    0
```

```
  34        OF - OUTWASH FOR          1    1    1    1   61     0
  44        OG - OUTWASH GR           1    1    1    1   61     0
***PERLND FOR NEW AIRPORT FILL; NONE IN CALIBRATION
  45        AIRPORT FILL              1    1    1    1   61     0
  54        SA - WETLANDS             1    1    1    1   61     0
  64        TGM DES MOINES            1    1    1    1   61     0
  65        OG  DES MOINES            1    1    1    1   61     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    5    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         0    0    0    0    0    0    0    0    0
 16         0    0    0    0    0    0    0    0    0
 18         0    0    0    0    0    0    0    0    0
 24         0    0    0    0    0    0    0    0    0
 26         0    0    0    0    0    0    0    0    0
 28         0    0    0    0    0    0    0    0    0
 34         0    0    0    0    0    0    0    0    0
 44         0    0    0    0    0    0    0    0    0
 45         0    0    0    0    0    0    0    0    0
 54         0    0    0    0    0    0    0    0    0
 64         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    0.0800    400.00    0.0500    0.5000    0.9960
 16                    4.5000    0.0800    400.00    0.1000    0.5000    0.9960
 18                    4.5000    0.0800    200.00    0.2000    0.5000    0.9960
 24                    4.5000    0.0300    400.00    0.0500    0.5000    0.9960
 26                    4.5000    0.0300    400.00    0.1000    0.5000    0.9960
 28                    4.5000    0.0300    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
 45                    7.5000    0.0200    300.00    0.0700    0.0000    0.9960
 54                    4.0000    2.0000    100.00    0.0010    0.5000    0.9960
 64                    4.5000    0.1200    400.00    0.1000    0.5000    0.9990
 65                    5.0000    0.8000    400.00    0.0500    0.5000    0.9960
END PWAT-PARM2
PWAT-PARM3
  <PLS >***
  # -  #*** PETMAX    PETMIN    INFEXP    INFILD    DEEPFR    BASETP    AGWETP
 14                              2.0000    2.0000      0.00      0.00       0.0
 16                              2.0000    2.0000      0.00      0.00       0.0
 18                              2.0000    2.0000      0.00      0.00       0.0
 24                              2.0000    2.0000      0.00      0.00        0.
 26                              2.0000    2.0000      0.00        0.        0.
 28                              2.0000    2.0000      0.00        0.        0.
 34                              2.0000    2.0000      0.00      0.00       0.0
 44                              2.0000    2.0000      0.00        0.        0.
 45                              2.0000    2.0000      0.00        0.        0.
 54                              10.000    2.0000      0.00        0.       0.7
 64                              2.0000    2.0000      0.00        0.       0.0
```

```
  END PWAT-PARM3
  PWAT-PARM4
                                                                         ***
    <PLS >
    # -  #     CEPSC       UZSN       NSUR      INTFW       IRC      LZETP***
   14         0.2000     1.0000     0.3500      2.000    0.1500     0.7000
   16         0.2000     0.5000     0.3500      2.000    0.1500     0.7000
   18         0.2000     0.3000     0.3500      2.000    0.1500     0.7000
   24         0.1000     0.5000     0.2500      2.000    0.1500     0.2500
   26         0.1000     0.2500     0.2500      2.000    0.1500     0.2500
   28         0.1000     0.1500     0.2500      2.000    0.1500     0.2500
   34         0.2000     0.5000     0.3500      0.000    0.5000     0.7000
   44         0.1000     0.5000     0.2500      0.000    0.5000     0.2500
   45         0.1000     0.2800     0.2500      6.000    0.1500     0.6000
   54         0.1000     3.0000     0.5000      1.000    0.7000     0.8000
   64         0.1000     0.2500     0.2500      3.000    0.5000     0.2500
   65         0.1000     0.5000     0.2500      0.000    0.5000     0.2500
  END PWAT-PARM4
  PWAT-STATE1
    <PLS >  PWATER state variables***
    # -  #***   CEPS      SURS       UZS      IFWS       LZS      AGWS      GWVS
   14          0.000        0.    0.0200      0.00     0.020      3.50     0.045
   16          0.000        0.    0.0010      0.00     0.020      3.51     0.047
   18          0.000        0.    0.0000      0.00     0.020      3.49     0.047
   26          0.000        0.    0.0000      0.00     1.758      2.90     0.043
   28          0.000        0.    0.0000      0.00     1.598      2.81     0.041
   34          0.000        0.    0.0000      0.00     1.516      2.74     0.039
   44          0.000        0.    0.0000      0.00     2.756      6.25     0.134
   45          0.000        0.    0.0000      0.00     0.373      3.01     0.000
   54          0.000        0.    0.3650      0.00     0.561      0.00     0.000
   64          0.000        0.    0.0000      0.00     1.978     22.28     0.000
   65          0.000        0.    0.0000      0.00     0.000     20.00     0.000
   80          0.000        0.    0.0000      0.00     1.758      2.90     0.043
  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         100.00    0.0100    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> # #  ***
*** PRECIP/EVAP TO PERVIOUS/IMPERV SURFACES
WDM   1002 PREC     ENGLZERO  1.00         PERLND  14 200 EXTNL  PREC
WDM   1002 PREC     ENGLZERO  1.00         IMPLND  14     EXTNL  PREC
WDM      1 EVAP     ENGLZERO  0.8          PERLND  14  65 EXTNL  PETINP
WDM      1 EVAP     ENGLZERO  0.8          IMPLND  14     EXTNL  PETINP
*** PRECIP/EVAP TO LAKES
WDM   1002 PREC     ENGLZERO               RCHRES  20     EXTNL  PREC
WDM      1 EVAP     ENGLZERO    0.8        RCHRES  20     EXTNL  POTEV

END EXT SOURCES
                                                                           ***
EXT TARGETS
<-Volume-> <-Grp> <-Member-><--Mult-->Tran <-Volume-> <Member> Tsys Tgap Amd ***
<Name>   #        <Name> # #<-factor->strg <Name>   # <Name>    tem strg strg***
***WALKER NR MTH
RCHRES  18 HYDR   RO          ***          WDM     96 FLOW      ENGL      REPL
*** MISC (20=WALKER WETLAND, 55=SR509, 56=1ST AVE)
RCHRES  20 HYDR   RO                       WDM   8097 FLOW      ENGL      REPL
COPY *** 2 OUTPUT MEAN   1 1     12.1      WDM     89 FLOW      ENGL      REPL
END EXT TARGETS
                                                                           ***
SCHEMATIC
<-Source->                  <--Area-->     <-Target->   MBLK    ***
<Name>   #                  <-factor->     <Name>   #   Tbl#    ***

***WALKER CREEK
  *** SUB-CATCHMENT  MC 8
PERLND  26                        4.10     COPY     1      8
PERLND  44                       18.57     COPY     1      8
PERLND  54                        2.72     COPY     1      8
IMPLND  14                        1.34     COPY     1      9
***  *** SUB-CATCHMENT   SDW2  10-75-15 PREDEVELOPMENT W/1994 IMP
***PERLND  16                      30.91     COPY     2      10
***PERLND  26                       7.16     COPY     2      10
***PERLND  34                       1.69     COPY     2      10
***PERLND  44                       0.39     COPY     2      10
***PERLND  54                       1.13     COPY     2      10
***PERLND  16                      30.91     COPY     1      11
***PERLND  26                       7.16     COPY     1      11
***PERLND  34                       1.69     COPY     1      11
***PERLND  44                       0.39     COPY     1      11
***PERLND  54                       1.13     COPY     1      11
***IMPLND  14                       3.31     COPY     2       9
  *** SUB-CATCHMENT  SDW2  10-75-15 PREDEVELOPMENT W/1994 IMP
***PERLND  26                       4.37     COPY     2      10
***PERLND  34                      16.47     COPY     2      10
***PERLND  44                       4.39     COPY     2      10
```

```
***PERLND  54                          1.05     COPY     2     10
***PERLND  16                         16.38     COPY     1     11
***PERLND  26                          4.37     COPY     1     11
***PERLND  34                         16.47     COPY     1     11
***PERLND  44                          4.39     COPY     1     11
***PERLND  54                          1.05     COPY     1     11
***IMPLND  14                          2.20     COPY     2      9
  *** SUB-CATCHMENT  SDW2  10-75-15 PREDEVELOPMENT W/1994 IMP
PERLND  26                         37.84     COPY     2     10
PERLND  44                          2.32     COPY     2     10
PERLND  54                          1.13     COPY     2     10
IMPLND  14                          3.31     COPY     2      9
***add sdw2-b area from contig and non-contig
***subtract from noncontig area just pervious
***sdw2-a
PERLND  26                         10.64     COPY     2     11
PERLND  44                          2.31     COPY     2     11
PERLND  54                          0.68     COPY     2     11
IMPLND  14          ***             1.14     COPY     2      9
***non-contig sdw2-b
PERLND  26                         13.74     COPY     2     11
PERLND  54                          0.45     COPY     2     11
IMPLND  14           ***            0.88     COPY     2      9


  *** SUB-CATCHMENT  MC 9
PERLND  26                          9.44     COPY     1      8
PERLND  44                          0.74     COPY     1      8
PERLND  54          ***             0.00     COPY     1      8
IMPLND  14                          0.24     COPY     1      9
  *** SUB-CATCHMENT 18
PERLND  16                          0.76     RCHRES  18      1
PERLND  26                         16.08     RCHRES  18      1
PERLND  34                         20.95     RCHRES  18      1
PERLND  44                         49.22     RCHRES  18      1
IMPLND  14                          3.30     RCHRES  18      2
  *** SUB-CATCHMENT 19
PERLND  16                         12.72     RCHRES  19      1
PERLND  26                         92.07     RCHRES  19      1
PERLND  34                          8.39     RCHRES  19      1
PERLND  44                         95.55     RCHRES  19      1
IMPLND  14                         30.53     RCHRES  19      2
  *** SUB-CATCHMENT 20
PERLND  26                         12.53     RCHRES  20      1
PERLND  44                         53.43     RCHRES  20      1
PERLND  54                         33.43     RCHRES  20      1
IMPLND  14                         52.83     RCHRES  20      2
*** DOWN STREAM OF WALKER CREEK GAGE
  *** SUB-CATCHMENT 21 33% OF GW GOES TO GAGE REST GOES TO SOUND
PERLND  16                          2.54     RCHRES  18      7
PERLND  26                         44.30     RCHRES  18      7
PERLND  34                          2.03     RCHRES  18      7
PERLND  44                         41.13     RCHRES  18      7
PERLND  16                          2.54     RCHRES  21      6
PERLND  26                         44.30     RCHRES  21      6
PERLND  34                          2.03     RCHRES  21      6
PERLND  44                         41.13     RCHRES  21      6
PERLND  16                          5.07     RCHRES  21      1
PERLND  26                         88.61     RCHRES  21      1
PERLND  34                          4.06     RCHRES  21      1
PERLND  44                         82.26     RCHRES  21      1
IMPLND  14                         33.09     RCHRES  21      2
IMPLND  14                         16.54     RCHRES  21      2
```

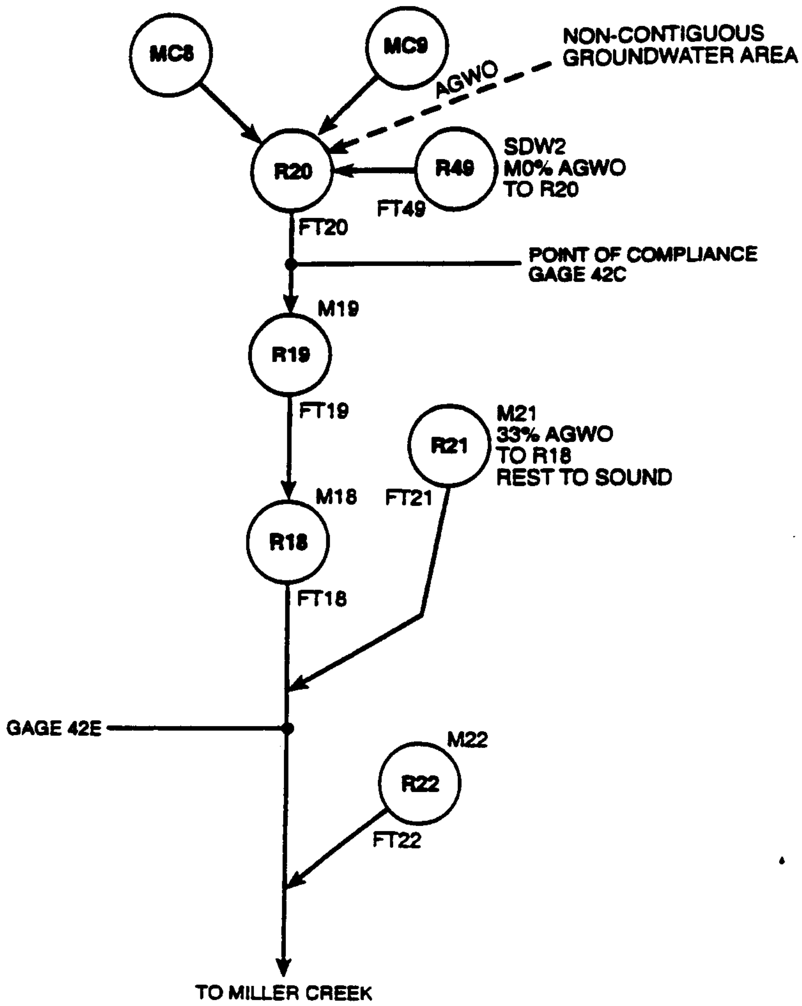
```
  *** SUB-CATCHMENT 22
PERLND  34                             4.30    RCHRES  22      1
PERLND  44                            19.49    RCHRES  22      1
PERLND  54                             3.21    RCHRES  22      1
IMPLND  14                             3.95    RCHRES  22      2

***sds7a - contig
PERLND  26                             0.22    RCHRES  20      1
IMPLND  14                             0.08    RCHRES  20      2
***sds7b - non-contig *** test change to surface also from gw
PERLND  26                            23.06    RCHRES  20      1
PERLND  44                             4.59    RCHRES  20      1
PERLND  54                             0.37    RCHRES  20      1

***GROUNDWATER FROM OUTSIDE OF WALKER CREEK
*** subtract sdw2 non-contig area from the 630
PERLND  64                           615.81    RCHRES  20      7
PERLND  65                    ***    130.00    RCHRES  20      7
*** changes to contig and non-contig groundwater based on 11/19/01 analysis
***see walker creek 2006 model for changes to future conditions
***STREAM ROUTING
COPY     2                                     COPY     3     14
COPY     1                                     COPY     3     14
COPY     3                                     RCHRES  20     13
RCHRES  20                                     RCHRES  19      3
RCHRES  19                                     RCHRES  18      3

END SCHEMATIC


NETWORK
                                                                                ***
***        <MEMBER> SSYSSGAP<--MULT-->TRAN <-TARGET VOLS>        <-MEMBER->
<NAME>   # <NAME>   TEM STRG<-FACTOR->STRG <NAME>    #    # <-GRP> <NAME> # # ***
                                                                                ***
END NETWORK
                                                                                ***
RCHRES
  GEN-INFO
    RCHRES       Name          Nexits   Unit Systems   Printer                  ***
    # -  #<------------------><---> User T-series  Engl Metr LKFG              ***
                                              in   out                          ***
   18     Trib (0371A) M 18        1     1     1    1    62    0    0
   19     Trib (0371A) M 19        1     1     1    1    62    0    0
   20     Trib   M 20              1     1     1    1    62    0    1
   21     Trib (0371H) M 21        1     1     1    1    62    0    0
   22     Trib (0371A) M 22        1     1     1    1    62    0    0

  END GEN-INFO
  ACTIVITY
    RCHRES *************** Active Sections *****************
    # -  # HYFG ADFG CNFG HTFG SDFG GQFG OXFG NUFG PKFG PHFG                    ***
    1   63    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   63    5    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
```

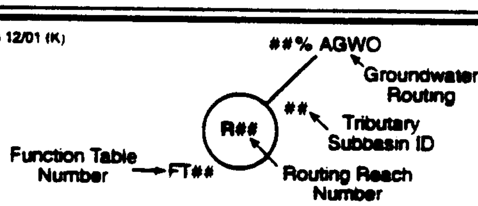
```
                                *  *  *  *    *  *  *  *  *    *  *  *  *  *    ***
  1   99    0  1  0  0     4  0  0  0  0     0  0  0  0  0     2  2  2  2  2
  END HYDR-PARM1
  HYDR-PARM2                                                                  ***
    RCHRES                                                                    ***
    # -  #      FTABNO        LEN      DELTH     STCOR        KS      DB50    ***
  <------><--------><--------><--------><--------><--------><-------->
   18            18   0.800                                0.3
   19            19   0.568                                0.3
   20            20   0.379                                0.3
   21            21   0.450                                0.3
   22            22   0.300                                0.3
  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
  <------><-------->      <---><---><---><---><---> *** <---><---><---><---><--->
   18      0.1             4.0
   19      0.1             4.0
   20      10.0            4.0
   21      0.1             4.0
   22      0.1             4.0
  END HYDR-INIT
END RCHRES

FTABLES

  FTABLE     18
 ROWS COLS ***
   3    4
     DEPTH       AREA     VOLUME    OUTFLOW   ***
      0.00       1.30       0.00       0.00
      1.00       1.30       1.30     166.00
      2.00       1.40       2.65     490.00
  END FTABLE 18

  FTABLE     19
 ROWS COLS ***
   3    4
     DEPTH       AREA     VOLUME    OUTFLOW   ***
      0.00       1.10       0.00       0.00
      1.00       1.10       1.10      65.00
      2.00       1.20       2.25     223.00
  END FTABLE 19

  FTABLE     20
*** WALKER CREEK WETLAND
 ROWS COLS ***
  10    4
     DEPTH       AREA     VOLUME    OUTFLOW   OUTFLOW ***
      0.00       0.00       0.00       0.00
      1.00       2.50       1.25       7.04
      2.00       5.00       5.00      17.84
      3.00      12.00      13.50      32.17
      4.00      19.00      29.00      45.13
      5.00      22.00      49.50      54.95
      6.00      23.00      72.00      61.62
      6.10      23.00      74.30      62.15
      7.00      23.50      95.25      67.00
      7.24      24.10     101.10     100.00
  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
END FTABLES
MASS-LINK
<Volume>   <-Grp> <-Member-><--Mult-->     <Target>        <-Grp> <-Member->***
<Name>            <Name> # #<-factor->     <Name>                 <Name> # #***
  MASS-LINK        1
  conversion from acre-inches to acre-ft (1/12)            ***
PERLND     PWATER PERO        0.0833333    RCHRES          INFLOW IVOL
  END MASS-LINK    1

  MASS-LINK        2
IMPLND     IWATER SURO        0.0833333    RCHRES          INFLOW IVOL
  END MASS-LINK    2

  MASS-LINK        3
RCHRES     ROFLOW                          RCHRES          INFLOW
  END MASS-LINK    3

  MASS-LINK        4
RCHRES     OFLOW  OVOL   1                 RCHRES          INFLOW IVOL
  END MASS-LINK    4

  MASS-LINK        5
RCHRES     OFLOW  OVOL   2                 RCHRES          INFLOW IVOL
  END MASS-LINK    5

  MASS-LINK        6
PERLND     PWATER SURO        0.0833333    RCHRES          INFLOW IVOL
PERLND     PWATER IFWO        0.0833333    RCHRES          INFLOW IVOL
  END MASS-LINK    6

  MASS-LINK        7
PERLND     PWATER AGWO        0.0833333    RCHRES          INFLOW IVOL
  END MASS-LINK    7

  MASS-LINK        8
```

```
PERLND      PWATER PERO        0.0833333      COPY          INPUT   MEAN
  END MASS-LINK     8

  MASS-LINK         9
IMPLND      IWATER SURO        0.0833333      COPY          INPUT   MEAN
  END MASS-LINK     9

  MASS-LINK         10
PERLND      PWATER SURO        0.0833333      COPY          INPUT   MEAN
PERLND      PWATER IFWO        0.0833333      COPY          INPUT   MEAN
  END MASS-LINK     10

  MASS-LINK         11
PERLND      PWATER AGWO        0.0833333      COPY          INPUT   MEAN
  END MASS-LINK     11

  MASS-LINK         12
PERLND      PWATER AGWO        0.0833333      COPY          INPUT   MEAN
  END MASS-LINK     12

  MASS-LINK         13
COPY        OUTPUT MEAN                       RCHRES        INFLOW IVOL
  END MASS-LINK     13

  MASS-LINK         14
COPY        OUTPUT MEAN                       COPY          INPUT   MEAN
  END MASS-LINK     14

END MASS-LINK
END RUN
```

2006 CONDITIONS





HSPF Model Schematic
Walker Creek
Low Flow Analysis
2006 Conditions

```
RUN
GLOBAL
  ***  FILE: WClowflo.inp REVISED July 2001. ATC
  ***  SEATAC AIRPORT HSPF BASIN MODEL OF WALKER CREEK
  ***  2006 FUTURE PROJECT CONDITION SIZING BASED
  ***  CHANGED PREC DSN 2 TO NEW PREC DSN 1002
  ***  WALKER CREEK FOUR YEAR RUN USING CALIBRATION INITIAL CONDITIONS
  WALKER CREEK BASIN HSPF MODEL
  START       1990 10  1  0  0  END    1994  9 30 24  0

  RUN INTERP OUTPUT LEVEL    3
  RESUME     0 RUN     1
END GLOBAL

FILES
<type>  <fun>***<------------fname------------------------------------------>
MESSU      24   D:\PARA\SEATAC\MILLER\LOWFLOW\WALKER.MES
WDM        25   D:\PARA\SEATAC\MILLER\LOWFLOW\mlowflow.WDM
           61   D:\PARA\SEATAC\MILLER\LOWFLOW\wPER.L61
           62   D:\PARA\SEATAC\MILLER\LOWFLOW\wRCH.L62
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      45
      PERLND      54
      PERLND      64
      PERLND      65
      PERLND      80
      IMPLND      14
      RCHRES      49
      RCHRES      20
      RCHRES      19
      RCHRES      18
    END INGRP
END OPN SEQUENCE
                                                                        ***
COPY
  TIMESERIES
  Copy-opn                                                              ***
    # -  #  NPT  NMN                                                    ***
    1   5         1
  END TIMESERIES
END COPY

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   61    0
   16       TFM- TILL FOR MOD      1     1    1    1   61    0
   18       TFS- TILL FOR STP      1     1    1    1   61    0
   24       TGF- TILL GR FLT       1     1    1    1   61    0
   26       TGM- TILL GR MOD       1     1    1    1   61    0
```

```
  28      TGS- TILL GR STP        1    1    1    1   61    0
  34      OF - OUTWASH FOR        1    1    1    1   61    0
  44      OG - OUTWASH GR         1    1    1    1   61    0
***PERLND FOR NEW AIRPORT FILL; NONE IN CALIBRATION
  45      AIRPORT FILL            1    1    1    1   61    0
  54      SA - WETLANDS           1    1    1    1   61    0
  64      TGM DES MOINES          1    1    1    1   61    0
  65      OG  DES MOINES          1    1    1    1   61    0
  80      Fill AGWO               1    1    1    1   61    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    5    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         0    0    0    0    0    0    0    0    0
  16         0    0    0    0    0    0    0    0    0
  18         0    0    0    0    0    0    0    0    0
  24         0    0    0    0    0    0    0    0    0
  26         0    0    0    0    0    0    0    0    0
  28         0    0    0    0    0    0    0    0    0
  34         0    0    0    0    0    0    0    0    0
  44         0    0    0    0    0    0    0    0    0
  45         0    0    0    0    0    0    0    0    0
  54         0    0    0    0    0    0    0    0    0
  64         0    0    0    0    0    0    0    0    0
  80         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    0.0800    400.00    0.0500    0.5000    0.9960
  16                    4.5000    0.0800    400.00    0.1000    0.5000    0.9960
  18                    4.5000    0.0800    200.00    0.2000    0.5000    0.9960
  24                    4.5000    0.0300    400.00    0.0500    0.5000    0.9960
  26                    4.5000    0.0300    400.00    0.1000    0.5000    0.9960
  28                    4.5000    0.0300    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
  45                    7.5000    0.0200    300.00    0.0700    0.0000    0.9960
  54                    4.0000    2.0000    100.00    0.0010    0.5000    0.9960
  64                    4.5000    0.1200    400.00    0.1000    0.5000    0.9990
  65                    5.0000    0.8000    400.00    0.0500    0.5000    0.9960
  80                    4.5000    0.0300    400.00    0.1000    0.5000    0.9960
 END PWAT-PARM2
 PWAT-PARM3
   <PLS >***
   # -  #*** PETMAX    PETMIN    INFEXP    INFILD    DEEPFR    BASETP    AGWETP
  14                            2.0000    2.0000      0.00      0.00       0.0
  16                            2.0000    2.0000      0.00      0.00       0.0
  18                            2.0000    2.0000      0.00      0.00       0.0
  24                            2.0000    2.0000      0.00      0.00        0.
  26                            2.0000    2.0000      0.00        0.        0.
  28                            2.0000    2.0000      0.00        0.        0.
  34                            2.0000    2.0000      0.00      0.00       0.0
```

```
    44                               2.0000    2.0000      0.00        0.        0.
    45                               2.0000    2.0000      0.00        0.        0.
    54                               10.000    2.0000      0.00        0.        0.7
    64                               2.0000    2.0000      0.00        0.        0.0
    80                               2.0000    2.0000      0.00        0.        0.
  END PWAT-PARM3
  PWAT-PARM4
    <PLS >                                                                ***
    # -  #     CEPSC      UZSN      NSUR     INTFW       IRC     LZETP***
   14         0.2000    1.0000    0.3500     2.000    0.1500    0.7000
   16         0.2000    0.5000    0.3500     2.000    0.1500    0.7000
   18         0.2000    0.3000    0.3500     2.000    0.1500    0.7000
   24         0.1000    0.5000    0.2500     2.000    0.1500    0.2500
   26         0.1000    0.2500    0.2500     2.000    0.1500    0.2500
   28         0.1000    0.1500    0.2500     2.000    0.1500    0.2500
   34         0.2000    0.5000    0.3500     0.000    0.5000    0.7000
   44         0.1000    0.5000    0.2500     0.000    0.5000    0.2500
   45         0.1000    0.2800    0.2500     6.000    0.1500    0.6000
   54         0.1000    3.0000    0.5000     1.000    0.7000    0.8000
   64         0.1000    0.2500    0.2500     3.000    0.5000    0.2500
   65         0.1000    0.5000    0.2500     0.000    0.5000    0.2500
   80         0.1000    0.2500    0.2500     2.000    0.1500    0.2500
  END PWAT-PARM4
  PWAT-STATE1
    <PLS >  PWATER state variables***
    # -  #***   CEPS      SURS       UZS      IFWS       LZS      AGWS      GWVS
   14          0.000        0.    0.0200      0.00     0.020      3.50     0.045
   16          0.000        0.    0.0010      0.00     0.020      3.51     0.047
   18          0.000        0.    0.0000      0.00     0.020      3.49     0.047
   26          0.000        0.    0.0000      0.00     1.758      2.90     0.043
   28          0.000        0.    0.0000      0.00     1.598      2.81     0.041
   34          0.000        0.    0.0000      0.00     1.516      2.74     0.039
   44          0.000        0.    0.0000      0.00     2.756      6.25     0.134
   45          0.000        0.    0.0000      0.00     0.373      3.01     0.000
   54          0.000        0.    0.3650      0.00     0.561      0.00     0.000
   64          0.000        0.    0.0000      0.00     1.978     22.28     0.000
   65          0.000        0.    0.0000      0.00     0.000     20.00     0.000
   80          0.000        0.    0.0000      0.00     1.758      2.90     0.043
  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
```


AR 053137

```
                                                                         ***
    <ILS >                                                               ***
    # -  #      LSUR     SLSUR      NSUR     RETSC
   14         100.00    0.0100    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> # #  ***
*** PRECIP/EVAP TO PERVIOUS/IMPERV SURFACES
WDM    1002 PREC     ENGLZERO  1.00        PERLND  14  65 EXTNL  PREC
WDM    1002 PREC     ENGLZERO  0.00        PERLND  80     EXTNL  PREC
WDM    1002 PREC     ENGLZERO  1.00        IMPLND  14     EXTNL  PREC
WDM       1 EVAP     ENGLZERO  0.8         PERLND  14  65 EXTNL  PETINP
WDM       1 EVAP     ENGLZERO  0.0         PERLND  80     EXTNL  PETINP
WDM       1 EVAP     ENGLZERO  0.8         IMPLND  14     EXTNL  PETINP
*** PRECIP/EVAP TO LAKES
WDM    1002 PREC     ENGLZERO              RCHRES  20     EXTNL  PREC
WDM       1 EVAP     ENGLZERO    0.8       RCHRES  20     EXTNL  POTEV
WDM    1002 PREC     ENGLZERO              RCHRES  49     EXTNL  PREC
WDM       1 EVAP     ENGLZERO    0.8       RCHRES  49     EXTNL  POTEV

*** Fill flow directly to stream
*** Conversion factor from cu. ft./day to acre-ft/interval
*** divide by 43560*24
WDM    7100 FLOW     ENGL     .000000957   RCHRES  20     INFLOW IVOL
*** till seapage groundwater flow from Fill area.  PGG time series
*** Conversion factor from cu. ft./day to inches
*** (1/(43560*24) * 12)/area     (16.74Ac)
WDM    7101 FLOW     ENGLZERO.000000686    PERLND  80     EXTNL  AGWLI
*** Fill surface flow to sdw2 pond
WDM    7102 FLOW     ENGL     .000022957   RCHRES  49     INFLOW IVOL
END EXT SOURCES
                                                                         ***
EXT TARGETS
<-Volume-> <-Grp> <-Member-><--Mult-->Tran <-Volume-> <Member> Tsys Tgap Amd ***
<Name>   #        <Name> # #<-factor->strg <Name>   # <Name>    tem strg strg***
RCHRES  18 HYDR   RO          ***          WDM   7196 FLOW     ENGL      REPL
RCHRES  20 HYDR   RO                       WDM   7197 FLOW     ENGL      REPL
 ***PROJECT CONDITION FLOWS
RCHRES  49 HYDR   RO     1 1      ***      WDM    109 FLOW     ENGL      REPL
*** DETENTION STAGES
RCHRES  49 HYDR   STAGE           ***      WDM    649 STAG     ENGL      REPL
*** DETENTION VOLUME
RCHRES  49 HYDR   VOL             ***      WDM    749 VOL      ENGL      REPL
*** 39=SR509     37=SDW2
END EXT TARGETS
                                                                         ***
SCHEMATIC
<-Source->                <--Area-->     <-Target->   MBLK    ***
```

```
<Name>   #                      <-factor->      <Name>   #    Tbl#    ***

***WALKER CREEK
*** SUB-CATCHMENT  MC 8
PERLND  26                          3.93        RCHRES  20        1
PERLND  44                         18.73        RCHRES  20        1
PERLND  54                          2.70        RCHRES  20        1
IMPLND  14                          0.01        RCHRES  20        2
***  *** SUB-CATCHMENT  SDW-2
***PERLND  26                         26.82        RCHRES  49        6
***PERLND  44                          1.42        RCHRES  49        6
***PERLND  45                          6.70        RCHRES  49        6
***PERLND  26                         26.82        RCHRES  20        7
***PERLND  44                          1.42        RCHRES  20        7
***PERLND  45                          6.70        RCHRES  20        7
***IMPLND  14                          9.51        RCHRES  49        2
***REPLACE SUBCATCHMENT SDW-2    WITH NEW SDW-2 SUBBASIN
***SUBBASIN SDW-2 ROUTING AS OF 4/19/01
PERLND  26                         26.88        RCHRES  49        6
PERLND  44                          1.51        RCHRES  49        6
*** old fill area
***PERLND  45                          6.700        RCHRES  49        6
*** area removed = 4.09 ac
PERLND  45                          2.610       RCHRES  49        6
*** old fill area
***IMPLND  14                          9.51        RCHRES  49        2
*** area removed = 2.00 ac
IMPLND  14                          7.51        RCHRES  49        2
*** FILL AGWO PERLND 80 ALL TO GROUNDWATER RCHRES 20
PERLND  80                         16.74        RCHRES  20        7
*** 10.66 ACRES OF SDS7 NOT CONTRIBUTION AND NOT INCLUDED
*** From Miller surface flow for walker.used to be mc7b
*** sdw1b basins
*** cut out groundwater flow from sdw2 from fill and imp
***ADD SDW2A AND SDW2B GROUNDWATER
***sdw2-a
PERLND  26                          2.16        RCHRES  20        7
PERLND  44                          1.51        RCHRES  20        7
PERLND  45                          1.52        RCHRES  20        7
IMPLND  14            ***           5.49        RCHRES  20        2
***sdw2-b
PERLND  26                         13.67        RCHRES  20        7
IMPLND  14            ***           1.14        RCHRES  20        2


*** SUB-CATCHMENT  MC 9
PERLND  26                          9.28        RCHRES  20        1
PERLND  44                          0.76        RCHRES  20        1
IMPLND  14                          0.40        RCHRES  20        2
  *** SUB-CATCHMENT 18
PERLND  16                          0.76        RCHRES  18        1
PERLND  26                         16.08        RCHRES  18        1
PERLND  34                         20.95        RCHRES  18        1
PERLND  44                         49.22        RCHRES  18        1
IMPLND  14                          3.30        RCHRES  18        2
  *** SUB-CATCHMENT 19
PERLND  16                         12.72        RCHRES  19        1
PERLND  26                         92.07        RCHRES  19        1
PERLND  34                          8.39        RCHRES  19        1
PERLND  44                         95.55        RCHRES  19        1
IMPLND  14                         30.53        RCHRES  19        2
  *** SUB-CATCHMENT 20
PERLND  26                         12.54        RCHRES  20        1
```

```
PERLND  44                         53.42     RCHRES  20      1
PERLND  54                         33.43     RCHRES  20      1
IMPLND  14                         52.83     RCHRES  20      2
*** DOWN STREAM OF WALKER CREEK GAGE
  *** SUB-CATCHMENT 21 33% OF GW GOES TO GAGE REST GOES TO SOUND
PERLND  16                          2.54     RCHRES  18      7
PERLND  26                         44.30     RCHRES  18      7
PERLND  34                          2.03     RCHRES  18      7
PERLND  44                         41.13     RCHRES  18      7
PERLND  16                          2.54     RCHRES  21      6
PERLND  26                         44.30     RCHRES  21      6
PERLND  34                          2.03     RCHRES  21      6
PERLNC  44                         41.13     RCHRES  21      6
IMPLND  14                         16.54     RCHRES  21      2
PERLND  16                          5.07     RCHRES  21      1
PERLND  26                         88.61     RCHRES  21      1
PERLND  34                          4.06     RCHRES  21      1
PERLND  44                         82.26     RCHRES  21      1
IMPLND  14                         33.09     RCHRES  21      2
  *** SUB-CATCHMENT 22
PERLND  34                          4.30     RCHRES  22      1
PERLND  44                         19.49     RCHRES  22      1
PERLND  54                          3.21     RCHRES  22      1
IMPLND  14                          3.95     RCHRES  22      2

***GROUNDWATER FROM OUTSIDE OF WALKER CREEK

PERLND  64          ***           615.81     RCHRES  20      7
*** reduce non-contig pervious area based on non-contig that becomes contig below
PERLND  64                        529.39     RCHRES  20      7
*** changes to contig and non-contig groundwater based on 11/19/01 analysis
***sds7 area lost from pre to post
*** SUBtract 0.82 acres from perlnd 26
PERLND  26  ***                     4.32     RCHRES  20      7
PERLND  26                          3.5      RCHRES  20      7
PERLND  44                          3.93     RCHRES  20      7
PERLND  45          ***             5.48     RCHRES  20      7
IMPLND  14          ***            36.02     RCHRES  20      2
***CONTIG SDS7A
PERLND  26                          0.17     RCHRES  20      1
IMPLND  14                          0.13     RCHRES  20      2


***STREAM ROUTING
RCHRES  49                                   RCHRES  20      3
RCHRES  20                                   RCHRES  19      3
RCHRES  19                                   RCHRES  18      3

END SCHEMATIC


NETWORK
                                                                             ***
***       <MEMBER> SSYSSGAP<--MULT-->TRAN <-TARGET VOLS>        <-MEMBER->
<NAME>    # <NAME>    TEM STRG<-FACTOR->STRG <NAME>    #    # <-GRP> <NAME> # # ***
                                                                             ***
END NETWORK
                                                                             ***
RCHRES
  GEN-INFO
    RCHRES       Name        Nexits   Unit Systems   Printer                 ***
    # -  #<------------------><---> User T-series  Engl Metr LKFG            ***
                                         in  out                             ***
```

```
  18      Trib (0371A) M 18        1     1     1     1    62     0     0
  19      Trib (0371A) M 19        1     1     1     1    62     0     0
  20      Trib   M 20              1     1     1     1    62     0     1
  21      Trib (0371H) M 21        1     1     1     1    62     0     0
  22      Trib (0371A) M 22        1     1     1     1    62     0     0
  39      SR509                    1     1     1     1    62     0     0
  49      SDW2 POND                1     1     1     1    62     0     0

  END GEN-INFO
  ACTIVITY
    RCHRES *************** Active Sections *****************
    # -  # HYFG ADFG CNFG HTFG SDFG GQFG OXFG NUFG PKFG PHFG                  ***
    1   63    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   63    5    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   99   0  1  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        ***
  <------><--------><--------><--------><--------><--------><-------->         ***
   18             18   0.800                                 0.3
   19             19   0.568                                 0.3
   20             20   0.379                                 0.3
   21             21   0.450                                 0.3
   22             22   0.300                                 0.3
   49             49   0.010                     0.0         0.3

  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
  <------><-------->     <---><---><---><---><---> *** <---><---><---><---><--->
   18      0.1            4.0
   19      0.1            4.0
   20      10.0           4.0
   21      0.1            4.0
   22      0.1            4.0
   49      0.0            4.0

  END HYDR-INIT
END RCHRES

FTABLES

  FTABLE     18
 ROWS COLS ***
    3    4
     DEPTH      AREA     VOLUME    OUTFLOW    ***
      0.00      1.30      0.00       0.00
      1.00      1.30      1.30     166.00
      2.00      1.40      2.65     490.00
  END FTABLE 18
```

```
 FTABLE     19
ROWS COLS ***
  3    4
    DEPTH       AREA     VOLUME    OUTFLOW    ***
     0.00       1.10       0.00       0.00
     1.00       1.10       1.10      65.00
     2.00       1.20       2.25     223.00
 END FTABLE 19

 FTABLE     49
 *** PROJECT POND F SDW2
ROWS COLS ***
 12    4
    DEPTH       AREA     VOLUME    OUTFLOW    ***
    0.000     0.8880     0.0000    0.00
    1.000     0.9270     1.0823    0.25
    2.000     0.9690     2.2096    0.35
    3.000     1.0450     3.3828    0.42
    4.000     1.0450     4.6027    0.49
    5.000     1.0860     5.8726    0.55
    6.000     1.1260     7.1935    0.60
    7.000     1.1670     8.5645    1.20
    8.000     1.2130     9.9861    2.69
    8.300     1.2560     10.454    3.09
    9.000     1.2560     11.459    7.57
   10.000     1.3000     12.987    16.88
 END FTABLE 49

 FTABLE     20
*** WALKER CREEK WETLAND
 ROWS COLS ***
  10   4
    DEPTH       AREA     VOLUME    OUTFLOW   OUTFLOW ***
     0.00       0.00       0.00       0.00
     1.00       2.50       1.25       7.04
     2.00       5.00       5.00      17.84
     3.00      12.00      13.50      32.17
     4.00      19.00      29.00      45.13
     5.00      22.00      49.50      54.95
     6.00      23.00      72.00      61.62
     6.10      23.00      74.30      62.15
     7.00      23.50      95.25      67.00
     7.24      24.10     101.10     100.00
 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
END FTABLES
MASS-LINK
<Volume>    <-Grp> <-Member-><--Mult-->       <Target>       <-Grp> <-Member->***
<Name>             <Name> # #<-factor->       <Name>                <Name> # #***
  MASS-LINK         1
  conversion from acre-inches to acre-ft (1/12)               ***
PERLND      PWATER PERO         0.0833333     RCHRES         INFLOW IVOL
  END MASS-LINK     1

  MASS-LINK         2
IMPLND      IWATER SURO         0.0833333     RCHRES         INFLOW IVOL
  END MASS-LINK     2

  MASS-LINK         3
RCHRES      ROFLOW                            RCHRES         INFLOW
  END MASS-LINK     3

  MASS-LINK         4
RCHRES      OFLOW  OVOL   1                   RCHRES         INFLOW IVOL
  END MASS-LINK     4

  MASS-LINK         5
RCHRES      OFLOW  OVOL   2                   RCHRES         INFLOW IVOL
  END MASS-LINK     5

  MASS-LINK         6
PERLND      PWATER SURO         0.0833333     RCHRES         INFLOW IVOL
PERLND      PWATER IFWO         0.0833333     RCHRES         INFLOW IVOL
  END MASS-LINK     6

  MASS-LINK         7
PERLND      PWATER AGWO         0.0833333     RCHRES         INFLOW IVOL
  END MASS-LINK     7

  MASS-LINK         8
PERLND      PWATER PERO         0.0833333     COPY           INPUT  MEAN
  END MASS-LINK     8
  MASS-LINK        12
PERLND      PWATER AGWO         0.0833333     COPY           INPUT  MEAN
  END MASS-LINK    12

  MASS-LINK         9
IMPLND      IWATER SURO         0.0833333     COPY           INPUT  MEAN
  END MASS-LINK     9

  MASS-LINK        10
COPY        OUTPUT MEAN                       RCHRES         INFLOW IVOL
  END MASS-LINK    10

END MASS-LINK
END RUN
```

HSPF INPUT FILE

(USED FOR INPUT TO THE HYDRUS/SLICE EMBANKMENT MODELING)

```
RUN
GLOBAL
  ***  FILE: OutwasH.inp Joe Brascher ATC
  ***  MILLER and Walker CREEK Outwash runoff generation.
  WALKER CREEK BASIN HSPF MODEL
  START       1983 10  1        END    1994  9 30
  RUN INTERP OUTPUT LEVEL    3
  RESUME     0 RUN     1
END GLOBAL

FILES
<type>  <fun>***<------------fname------------------------------------------------>
MESSU      24    D:\PARA\SEATAC\MILLER\RELOW\MILLOUT.mes
WDM        25    D:\PARA\SEATAC\MILLER\RELOW\MLOWFLOW.WDM
           61    D:\PARA\SEATAC\MILLER\RELOW\MILLOUT.L61
END FILES

OPN SEQUENCE
    INGRP              INDELT 00:60
      IMPLND      14
      PERLND      44
      COPY     ***  1
    END INGRP
END OPN SEQUENCE
                                                                             ***
COPY
  TIMESERIES
  Copy-opn                                                                   ***
    # -  #  NPT  NMN                                                          ***
    1    5        1
  END TIMESERIES
END COPY

PERLND
  GEN-INFO
    <PLS >       Name          NBLKS   Unit-systems   Printer                ***
    # -  #                          User  t-series Engl Metr                 ***
                                          in  out                            ***
   44     OF - OUTWASH GRA        1    1    1    1   61    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    5    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                      ***
   44         0    0    0    0    0    0    0    0    0
  END PWAT-PARM1
  PWAT-PARM2
    <PLS > ***
    # -  # ***FOREST      LZSN    INFILT      LSUR     SLSUR     KVARY     AGWRC
   44                   5.0000    0.8000    400.00    0.0500    0.3000    0.9960
  END PWAT-PARM2
  PWAT-PARM3
    <PLS >***
    # -  #*** PETMAX    PETMIN    INFEXP    INFILD    DEEPFR    BASETP    AGWETP
```

```
                                             OUTWASH
   44                                   2.0000    2.0000      0.00      0.00      0.0
  END PWAT-PARM3
  PWAT-PARM4
                                                                                ***
    <PLS >
    # -  #     CEPSC      UZSN      NSUR     INTFW       IRC    LZETP***
   44        0.1000    0.5000    0.2500     0.000    0.5000    0.2500
  END PWAT-PARM4
  PWAT-STATE1
    <PLS >  PWATER state variables***
    # -  #***   CEPS      SURS       UZS      IFWS       LZS      AGWS      GWVS
   44          0.000        0.    0.0000      0.00     2.756      6.25     0.134
  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         100.00    0.0100    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
<-Volume-> <Member> SsysSgap<--Mult-->Tran <-Target vols> <-Grp> <-Member->  ***
<Name>   # <Name> # tem strg<-factor->strg <Name>   #   #        <Name> # #  ***
*** PRECIP/EVAP TO PERVIOUS/IMPERV SURFACES
WDM   1002 PREC     ENGL      1.00         PERLND  44      EXTNL  PREC
WDM   1002 PREC     ENGL      1.00         IMPLND  14      EXTNL  PREC
WDM      1 EVAP     ENGL      0.8          PERLND  44      EXTNL  PETINP
WDM      1 EVAP     ENGLZERO  0.8          IMPLND  14      EXTNL  PETINP
END EXT SOURCES
                                                                                 ***
```

OUTWASH

```
EXT TARGETS
<-Volume-> <-Grp> <-Member-><--Mult-->Tran <-Volume-> <Member> Tsys Tgap Amd ***
<Name>   #        <Name> # #<-factor->strg <Name>   # <Name>    tem strg strg***
COPY     1 OUTPUT MEAN   1 1        ***    WDM   6104 FLOW     ENGL      REPL
***converts inches of runoff to cubic inches of runoff.
PERLND  44 PWATER AGWI        6272640      WDM   6102 FLOW     ENGL      REPL
IMPLND  14 IWATER SURO        6272640      WDM   6103 FLOW     ENGL      REPL
END EXT TARGETS                                                              ***

SCHEMATIC
<-Source->                  <--Area-->     <-Target->   MBLK     ***
<Name>   #                  <-factor->     <Name>   #   Tbl#     ***

IMPLND  14         ***            1.00     PERLND  44     23
PERLND  44         ***        0.714248     COPY     1     17
END SCHEMATIC


NETWORK                                                                      ***

***         <MEMBER> SSYSSGAP<--MULT-->TRAN <-TARGET VOLS>         <-MEMBER->
<NAME>    # <NAME>    TEM STRG<-FACTOR->STRG <NAME>   #    # <-GRP> <NAME> # # ***
                                                                             ***
END NETWORK                                                                  ***

MASS-LINK
<Volume>     <-Grp> <-Member-><--Mult-->     <Target>         <-Grp> <-Member->***
<Name>              <Name> # #<-factor->     <Name>                  <Name> # #***
  MASS-LINK         17
PERLND       PWATER AGWI       0.0833333     COPY             INPUT  MEAN
  END MASS-LINK     17

  MASS-LINK         23
IMPLND       IWATER SURO                     PERLND           EXTNL  SURLI
  END MASS-LINK     23
  MASS-LINK         24
IMPLND       IWATER SURO                     PERLND           EXTNL  AGWLI
  END MASS-LINK     24
END MASS-LINK
END RUN
```

DES MOINES CREEK WATERSHED
HSPF INPUT FILES

- **1994 CONDITIONS**
- **2006 CONDITIONS**

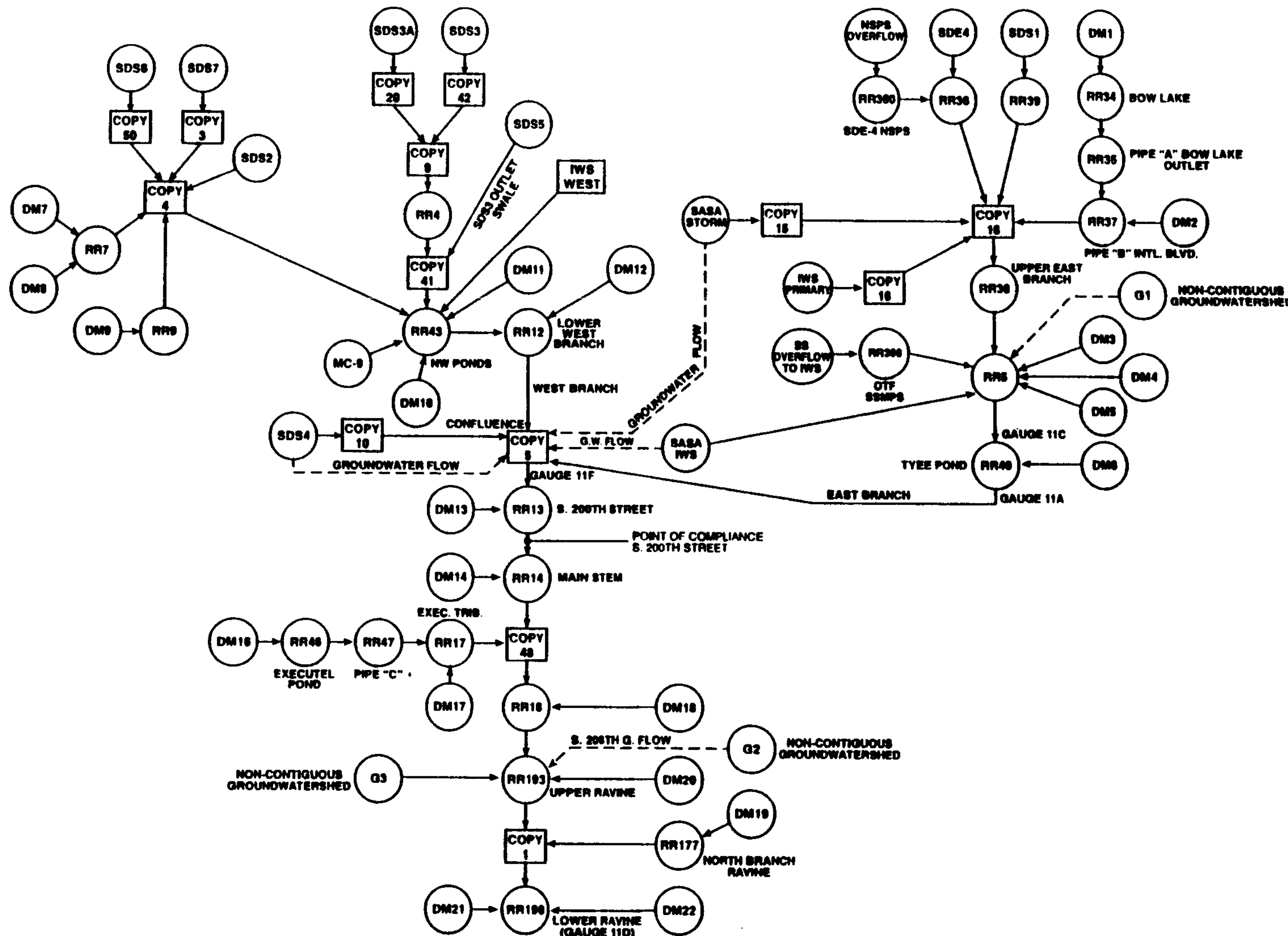
CERTIFICATE OF ENGINEER

The technical material and data for the Des Moines Creek watershed low flow-specific HSPF modeling were prepared under the supervision and direction of the undersigned, whose seal, as a professional engineer licensed to practice as such, is affixed below.

Felix C. Kristanovich, Ph.D., P.E.

(affix seal here)

1994 CONDITIONS



Parametrix, Inc.

Stormwater
IWS
Groundwater

DM# = Des Moines Creek Subbasin Number
SDS# = Storm Drainage South Number
SDE# = Storm Drainage East Number
R# = Routing Reach Number (Channel or Storage Pond)

DM1 —Subbasin ID
RR12 —Routing Reach Number

COPY 8 Summation of upstream flow

HSPF Model Schematic
Des Moines Creek
Low Flow Analysis
1994 Conditions

```
RUN
GLOBAL
  ***  FILE: DM94LOW.INP (MODIFY DMPRER5M.INP)
  ***  1994 conditions low flow analysis file
  ***  HSPF MODEL OF DES MOINES CREEK
  ***  UPDATE MODEL TO CREATE DOWNSTREAM EVALUATION POINT FOR SDS TO WEST BRANCH
  ***  Land uses based on 1994 conditions future basins
  ***  Land uses adjusted as per Parametrix correspondence on 11/09/01, all other land uses adjusted to
match 1994 calibration model.
  ***  Groundwater routing for IWS Primary and IWS West were excluded from the model.
  ***  Routing schematic and all other elememts are same as in the Des Moines Creek predevelopment
condition model (some WDM files are adjusted
  ***  to match 1994 designations)
  DES MOINES CREEK BASIN HSPF MODEL
  START       1948/10/01 00:00  END    1996/09/30 24:00
  START       1992/01/01 00:00  END    1996/09/30 24:00***
  RUN INTERP OUTPUT LEVEL    4
  RESUME     0 RUN     1
END GLOBAL

FILES
MESSU      24   DM94R.MES
WDM        25   DM94RL.WDM
END FILES

OPN SEQUENCE
    INGRP              INDELT 01:00
      PERLND      16
      PERLND      26
      PERLND      34
      PERLND      44
      PERLND      54
      IMPLND      14
      RCHRES     360
      RCHRES      36
      RCHRES      39
      COPY        20
      COPY        42
      COPY         9
      RCHRES       4
      COPY        41
      COPY        10
      RCHRES     366
      COPY        50
      COPY         3
      RCHRES       7
      RCHRES       9
      COPY         4
      RCHRES      43
      COPY        15
      RCHRES      34
      RCHRES      35
      RCHRES      37
      COPY        14
      COPY        16
      RCHRES      38
      RCHRES       5
      RCHRES      40
      RCHRES      12
      COPY         5
      RCHRES      13
      RCHRES      14
      RCHRES     177
      RCHRES      46
      RCHRES      47
      RCHRES      17
      COPY        48
      RCHRES      18
      RCHRES     193
      COPY         1
      RCHRES     198
    END INGRP
END OPN SEQUENCE

PERLND
  GEN-INFO
```

```
  <PLS >       Name                NBLKS   Unit-systems   Printer                    ***
  # -  #                                 User  t-series Engl Metr                    ***
                                                in  out                              ***
 16      TFM- TILL FOR MOD         1     1     1    1    60    0
 26      TGM- TILL GR MOD          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   54    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   54    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   54    0    0    0    0    0    0    0    0    0
END PWAT-PARM1

PWAT-PARM2
  <PLS > ***
  # -  # ***FOREST         LZSN    INFILT      LSUR     SLSUR     KVARY     AGWRC
 16                      4.5000    0.2000    200.00    0.1000    0.5000    0.9960
 26                      4.5000    0.0750    400.00    0.1000    0.5000    0.9960
 34                      5.0000    2.0000    200.00    0.0500    0.3000    0.9960
 44                      5.0000    0.8000    200.00    0.0500    0.3000    0.9960
 54                      4.0000    2.0000    200.00    0.0010    0.5000    0.9960
END PWAT-PARM2
PWAT-PARM3
  <PLS >***
  # -  #*** PETMAX    PETMIN    INFEXP    INFILD    DEEPFR    BASETP    AGWETP
 16                            2.0000    2.0000      0.55      0.00       0.0
 26                            2.0000    2.0000      0.55      0.00       0.0
 34                            2.0000    2.0000      0.55      0.00       0.0
 44                            2.0000    2.0000      0.55      0.00       0.0
 54                            10.000    2.0000      0.55      0.00       0.7
END PWAT-PARM3
PWAT-PARM4
  <PLS >                                                             ***
  # -  #     CEPSC      UZSN      NSUR     INTFW       IRC    LZETP***
 16         0.2000    0.5000    0.3500     3.000    0.5000    0.7000
 26         0.1000    0.2500    0.2500     3.000    0.5000    0.2500
 34         0.2000    0.5000    0.3500     0.000    0.7000    0.7000
 44         0.1000    0.5000    0.2500     0.000    0.7000    0.2500
 54         0.2000    3.0000    0.5000     1.000    0.7000    0.8000
END PWAT-PARM4

PWAT-STATE1
  <PLS >  PWATER state variables***
  # -  #***   CEPS      SURS       UZS      IFWS       LZS      AGWS      GWVS
 16          0.078        0.    0.0010        0.     0.075     0.267     0.026
 26          0.051        0.    0.0350        0.     1.928     0.680     0.049
 34          0.078        0.    0.0010        0.     0.090     0.676     0.038
 44          0.051        0.    0.0040        0.     1.127     0.614     0.152
 54          0.051        0.    0.3330        0.     0.622     0.000     0.000
END PWAT-STATE1
END PERLND

IMPLND
GEN-INFO
  <ILS >       Name             Unit-systems   Printer                           ***
  # -  #                      User  t-series Engl Metr                           ***
                                     in  out                                     ***
 13  140 IMPERVIOUS            1     1    1    60    0
END GEN-INFO
ACTIVITY
  <ILS > ************* Active Sections ****
  # -  # ATMP SNOW IWAT  SLD  IWG IQAL  ***
 13  140    0    0    1    0    0    0
END ACTIVITY
```

AR 053153

```
  PRINT-INFO
    <ILS > ******** Print-flags ******** PIVL  PYR
    # -  # ATMP SNOW IWAT  SLD  IWG IQAL *********
   13  140    0    0    6    0    0    0    1    9
  END PRINT-INFO
  IWAT-PARM1
    <ILS >           Flags              ***                                         ***
    # -  # CSNO RTOP  VRS  VNN RTLI     ***                                         ***
   13  140    0    0    0    0    0
  END IWAT-PARM1
  IWAT-PARM2
    <ILS >                                                                          ***
    # -  #       LSUR     SLSUR      NSUR     RETSC ***
   14           500.0    0.0100    0.1000    0.100
  140          100.00    0.0500    0.1000    0.0500
  END IWAT-PARM2
  IWAT-PARM3
    <ILS >                                                                          ***
    # -  #     PETMAX    PETMIN                                                     ***
   13  140
  END IWAT-PARM3
  IWAT-STATE1
    <ILS >  IWATER state variables                                                  ***
    # -  #        RETS      SURS                                                    ***
   13  140 1.0000E-3 1.0000E-3
  END IWAT-STATE1
END IMPLND

RCHRES
  GEN-INFO
    RCHRES       Name        Nexits   Unit Systems   Printer                        ***
    # -  #<------------------><---> User T-series  Engl Metr LKFG                   ***
                                             in  out                                ***
    4     SDS-3 Outlet Swale       1    1    1    1    0    0    0
    5     E.Branch above TyeeP     1    1    1    1    0    0    0
    7     DM7 & DM8 Conveyance     1    1    1    1    0    0    0
    9     DM9 Conveyance           1    1    1    1    0    0    0
   12     Lower W. Branch          1    1    1    1    0    0    0
   13     Confl. to 200th St.      1    1    1    1    0    0    0
   14     200th to Exec. Trib.     1    1    1    1    0    0    0
   17     Executel Tributary       1    1    1    1    0    0    0
   18     Exec.Confl. to 208th     1    1    1    1    0    0    0
   34     Bow Lake                 1    1    1    1    0    0    1
   35     Pipe A Bow LK Outlet     1    1    1    1    0    0    0
   36     SDE-4 Combined Disch     1    1    1    1    0    0    0
   37     Pipe B 60" Intl Blvd     1    1    1    1    0    0    0
   38     Upper E. Branch          1    1    1    1    0    0    0
   39     SDS-1 Storm Only         1    1    1    1    0    0    0
   40     Tyee Pond Reach          1    1    1    1    0    0    0
   43     Northwest Ponds Rch      1    1    1    1    0    0    1
   46     Executel Pond Reach      1    1    1    1    0    0    0
   47     Pipe C Exec.Pond Dis     1    1    1    1    0    0    0
  177     North Branch Ravine      1    1    1    1    0    0    0
  193     Upper Ravine             1    1    1    1    0    0    0
  198     Lower Ravine             1    1    1    1    0    0    0
  360     SDE-4 NSPS               1    1    1    1    0    0    0
  366     OTF   SSMPS              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  366    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  366    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
             *  *  *  *    *  *  *  *  *      *  *  *  *  *          ***
    4   17   0  1  1  0    4  0  0  0  0      0  0  0  0  0       2  2  2  2  2
   18   34   0  1  1  0    4  0  0  0  0      0  0  0  0  0       2  2  2  2  2
```

```
  35   42   0  1  1  0    4  0  0  0  0      0  0  0  0  0     2  2  2  2  2
  43        0  1  1  0    4  5  0  0  0      0  0  0  0  0     2  2  2  2  2
  46  198   0  1  1  0    4  0  0  0  0      0  0  0  0  0     2  2  2  2  2
 360  366   0  1  1  0    4  0  0  0  0      0  0  0  0  0     2  2  2  2  2
 END HYDR-PARM1

 HYDR-PARM2
***Modified by FK to include 40 and 46 in the model
   RCHRES                                                                    ***
   # -  #     FTABNO        LEN      DELTH      STCOR        KS      DB50    ***
 <------><--------><--------><--------><--------><--------><-------->        ***
   4              4  0.530                                  0.3
   5              5  0.380                                  0.3
   7              7  0.341                                  0.3
   9              9  0.189                                  0.3
  12             12  0.273                                  0.3
  13             13  0.218                                  0.3
  14             14  0.218                                  0.3
  17             17  0.246                                  0.3
  18             18  0.303                                  0.3
  34             34  0.208                                  0.3
  35             35  0.123                                  0.3
  36              1  0.100                                  0.3
  37             37  0.381                                  0.3
  38             38  0.142                                  0.3
  39              1  0.100                                  0.3
  40             40  0.189                                  0.3
  43             43  0.189                                  0.3
  46             46  0.047                                  0.3
  47             47  0.417                                  0.3
 177            177  0.407                                  0.3
 193            193  0.795                                  0.3
 198            198  0.631                                  0.3
 360              1  0.100                                  0.3
 366              1  0.100                                  0.3
 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
 <------><-------->     <---><---><---><---><---> *** <---><---><---><---><--->
   3    0.1              4.0
   4    0.1              4.0
   5    0.1              4.0
   7    0.1              4.0
   9    0.1              4.0
  12    0.1              4.0
  13    0.1              4.0
  14    0.1              4.0
  17    0.1              4.0
  18    0.1              4.0
  34    35.              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
  43    0.1              4.0  5.0
  46    0.0              4.0
  47    0.0              4.0
 177    0.0              4.0
 193    0.0              4.0
 198    0.0              4.0
 360    0.0              4.0
 366    0.0              4.0
 END HYDR-INIT
END RCHRES

FTABLES

 FTABLE      1
ROWS COLS ***
   8    4
    DEPTH      AREA     VOLUME      DISCH  OUTFLOW2 ***
```

AR 053155

```
       (FT)    (ACRES)    (AC-FT)       (CFS)        (CFS) ***
       0.00      0.000      0.000         0.0
       0.50      0.016      0.006           1
       1.00      0.016      0.011           4
       1.50      0.024      0.025          12
       2.00      0.032      0.045          30
       2.50      0.040      0.070          50
       3.00      0.048      0.101          80
       5.00      0.064      0.225         250
  END FTABLE  1

  FTABLE       4
*** SDS-3 OUTLET SWALE
 ROWS COLS ***
    7    4
***  DEPTH      AREA    VOLUME   OUTFLOW  OUTFLOW2                                  ***
      (FT)   (ACRES) (ACRE-FT)     (CFS)     (CFS)
      .000      .000       0.0       0.0
      .500      .198       0.1       9.0
     1.000      .236       0.5      30.9
     2.000      .306       1.0     115.8
     3.000      .376       1.5     265.5
     4.000      .446       5.0     491.8
     5.000      .517      20.0     806.3
  END FTABLE  4

  FTABLE       5
*** EAST BRANCH ABOVE TYEE POND
 ROWS COLS ***
   13    4
***  DEPTH      AREA    VOLUME   OUTFLOW  OUTFLOW2                                  ***
      (FT)   (ACRES) (ACRE-FT)     (CFS)     (CFS)
      .000      .000      .000      .000
      .550      .290      .100     4.900
     1.100      .543      .200    20.800
     1.650      .609      .300    46.500
     2.200      .671      .400    80.000
     2.750      .732     0.500   118.700
     3.300      .776     0.600   159.500
     3.850      .819     0.700   198.400
     4.400      .849     0.801   231.900
     4.950      .866     1.000   252.900
     5.500      .865     1.200   253.000
     8.200      .973     1.500   400.000
    10.200     1.043     2.000   520.000
  END FTABLE  5

  FTABLE       7
*** DM7 & DM8 CONVEYANCE
 ROWS COLS ***
    8    4
***  DEPTH      AREA    VOLUME   OUTFLOW  OUTFLOW2                                  ***
      (FT)   (ACRES) (ACRE-FT)     (CFS)     (CFS)
      .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   166.700
     4.000      .732     1.950   306.900
     5.000      .836     2.790   496.100
     6.000      .942     3.768   742.300
  END FTABLE  7

  FTABLE       9
*** DM9 CONVEYANCE
 ROWS COLS ***
    8    4
***  DEPTH      AREA    VOLUME   OUTFLOW  OUTFLOW2                                  ***
      (FT)   (ACRES) (ACRE-FT)     (CFS)     (CFS)
      .000       .00       0.0        .0
      .500       .20       0.7       9.7
     1.000       .23       3.1      32.6
     2.000       .29      14.9       118
     3.000       .35      38.4       265
     4.000       .41        77       482
     5.000       .47       135       778
```

```
    6.000        .52        214       1165
  END FTABLE  9

  FTABLE      12
*** LOWER WEST BRANCH
*** REVISED BASED ON HEC-RAS MODEL
 ROWS COLS ***
   13    4
***  DEPTH       AREA    VOLUME    OUTFLOW  OUTFLOW2                        ***
      (FT)    (ACRES)  (ACRE-FT)    (CFS)     (CFS)
      .000      .000     0.000      .000
      .500      .291     0.030     0.150
     1.000      .346     0.260     6.600
     2.000      .450     0.430    14.100
     3.000      .554     0.650    25.000
     4.000      .656     1.180    50.000
     5.000      .753     2.170    75.000
     6.000      .796     3.820   100.000
     7.000      .837     8.820   150.000
     8.000      .837    16.200   200.000
     9.000      .837    27.920   250.000
    10.000      .837    33.530   350.000
    11.000      .837    35.380   450.000
 END FTABLE 12

  FTABLE      13
*** CONFLUENCE TO 200TH STREET
 ROWS COLS ***
    9    4
***  DEPTH       AREA    VOLUME    OUTFLOW  OUTFLOW2                        ***
      (FT)    (ACRES)  (ACRE-FT)    (CFS)     (CFS)
      .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 FTABLE 13

  FTABLE      14
*** 200TH STREET TO EXECUTEL TRIBUTARY
*** REACH 190 FROM TR-20/KING COUNTY BASIN PLAN MODEL:
 ROWS COLS ***
    5    4
***  DEPTH       AREA    VOLUME    OUTFLOW  OUTFLOW2                        ***
      (FT)    (ACRES)  (ACRE-FT)    (CFS)     (CFS)
     0.000     0.000    0.000      0.000
     0.900     0.70     0.4000     30.00
     1.800     0.80     1.1000    115.60
     2.700     1.10     2.1000    269.80
     4.200     1.30     4.3000    707.10
 END FTABLE 14

  FTABLE      17
*** EXECUTEL TRIBUTARY
 ROWS COLS ***
   10    4
***  DEPTH       AREA    VOLUME    OUTFLOW  OUTFLOW2                        ***
      (FT)    (ACRES)  (ACRE-FT)    (CFS)     (CFS)
      .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 FTABLE 17

  FTABLE      18
*** CONFLUENCE WITH EXECUTEL TRIBUTARY TO 208TH STREET
```

```
*** REPRESENTS GW LOSS IN WETLAND BELOW 200TH
 ROWS COLS ***
  14    5
 **  DEPTH       AREA    VOLUME   OUTFLOW  OUTFLOW2                          ***
     (FT)     (ACRES)  (ACRE-FT)    (CFS)     (CFS)
     .000        .000       .000      .000      0.00
     .500        .572       .191     7.300      0.00
    1.000        .799       .438    10.000      0.00
    2.000        .968      1.001    20.700      0.00
    3.000       1.155      1.727   100.000      0.00
    4.000       1.317      2.542   2[illegible].700      0.00
    5.000       1.478      3.475   400.300      0.00
    6.000       1.643      4.545   570.200      0.00
    7.000       1.791      5.688   774.400      0.00
    8.000       1.932      6.822  1015.100      0.00
    9.000       1.945      7.025  1294.500      0.00
   10.000       1.958      7.244  1614.500      0.00
   11.000       1.970      7.481  1977.000      0.00
   12.000       1.983      7.734  2384.700      0.00
  END FTABLE 18

  FTABLE      34
*** BOW LAKE
*** BASED ON ENTRANCE CONTROL FOR 36 INCH OUTLET PIPE
 ROWS COLS ***
   8    5
***  DEPTH       AREA    VOLUME   OUTFLOW  OUTFLOW2                          ***
     (FT)     (ACRES)  (ACRE-FT)    (CFS)     (CFS)
    0.000      14.000      0.000     0.000      0.00
    1.000      14.000     14.000     7.000      0.00
    1.500      14.000     21.000    13.000      0.00
    2.000      14.000     28.000    17.000      0.00
    3.000      14.000     42.000    35.000      0.00
    4.000      14.000     56.000    49.000      0.00
    5.000      14.000     70.000    60.000      0.00
    6.000      14.000     84.000    70.000      0.00
  END FTABLE 34

  FTABLE      35
*** 36" BOW LAKE DISCHARGE PIPELINE (A)
 ROWS COLS ***
  16    4
***  DEPTH       AREA    VOLUME   OUTFLOW  OUTFLOW2                          ***
     (FT)     (ACRES)  (ACRE-FT)    (CFS)     (CFS)
     .000        .000       .000      .000
     .300        .020      .0006     1.000
     .600        .026      .0026     4.200
     .900        .032      .0068     9.400
    1.200        .034      .0134    16.200
    1.500        .037      .0226    24.000
    1.800        .039      .0346    32.300
    2.100        .040      .0492    40.100
    2.400        .040      .0667    46.900
    2.700        .039      .0857    51.200
    3.000        .037      .1000    55.300
*** SURCHARGING-
    3.300        .038      .2500    60.300
    4.000        .038      .4000    80.000
    5.000        .038      .6000   100.000
    6.000        .038     1.0000   150.000
   10.000        .038    10.0000   300.000
  END FTABLE 35

  FTABLE      37
*** 60" INTERNATIONAL BLVD PIPELINE (B)
 ROWS COLS ***
  13    4
***  DEPTH       AREA    VOLUME   OUTFLOW  OUTFLOW2                          ***
     (FT)     (ACRES)  (ACRE-FT)    (CFS)     (CFS)
     .000        .000       .000      .000
     .450        .134       .045     4.800
     .900        .190       .100    20.300
    1.350        .225       .150    45.400
    1.800        .249       .200    78.000
    2.250        .266       .250   115.900
    2.700        .271       .300   155.800
```

```
      3.150       .264       .350    193.800
      3.600       .251       .400    226.500
      4.050       .238       .450    247.000
      4.500       .234       .500    247.100
      6.500       .185       .600    340.000
      8.500       .166       .700    415.000
  END FTABLE 37

  FTABLE      38
*** UPPER EAST BRANCH
 ROWS COLS ***
    9    4
***  DEPTH       AREA     VOLUME    OUTFLOW   OUTFLOW2                        ***
      (FT)    (ACRES)  (ACRE-FT)      (CFS)      (CFS)
       .000       .000       .000       .000
       .500       .176       .100      9.200
      1.000       .194      0.150     30.400
      2.000       .232      0.200    105.800
      3.000       .271      0.250    228.900
      4.000       .310      0.350    405.800
      5.000       .349      0.450    642.700
      6.000       .387      0.600    945.700
      7.000       .426      0.800   1320.700
  END FTABLE 38

  FTABLE      40
*** TYEE POND
*** BASED ON TYEE POND AS-BUILTS AND AUTOMATED GATE OPERATION MANUAL
*** K RITLAND 2/4/98
*** Inserted by FK to reflect KC comments (03/22/2001)
 ROWS COLS ***
   20    4
***  DEPTH       AREA     VOLUME    OUTFLOW   OUTFLOW2                        ***
      (FT)    (ACRES)  (ACRE-FT)      (CFS)      (CFS)
       0.00       0.00       0.00       0.00
       0.90       0.01       0.01      10.00
       1.65       0.02       0.02      20.00
       3.11       0.07       0.07      30.00
       4.56       0.22       0.29      40.00
       6.02       0.63       0.89      50.00
       7.48       0.86       2.02      60.00
       8.62       1.06       3.18      70.00
       9.79       1.18       4.29      80.00
      10.88       1.34       5.83      90.00
      11.99       1.48       7.20     100.00
      13.12       1.69       9.17     110.00
      15.13       2.04      12.90     120.00
      16.10       2.20      14.92     124.10
      16.30       2.24      15.40     129.65
      16.57       2.28      15.88     150.36
      16.64       2.32      16.36     155.00
      16.80       2.36      16.84     208.74
      17.03       2.40      17.32     293.59
      17.26       2.43      17.79     428.11
  END FTABLE 40

  FTABLE      43
*** NORTHWEST PONDS
*** BASED ON KING COUNTY BASIN PLANNING MODEL
 ROWS COLS ***
   17    5
***  DEPTH       AREA     VOLUME    OUTFLOW   OUTFLOW2                        ***
      (FT)    (ACRES)  (ACRE-FT)      (CFS)      (CFS)
      0.000     12.000      0.000      0.000       0.00
      0.100     12.000     18.800      0.000       0.00
      1.000     12.000     24.000      0.200       0.00
      2.000     12.000     30.000      0.500       0.00
      3.000     12.000     37.000      1.000       0.00
      3.500     13.000     41.000      5.000       0.00
      4.000     13.000     45.700     15.000       0.00
      4.500     13.000     51.000     35.000       0.00
      5.000     14.000     56.500    150.000       0.00
      5.500     14.000     62.800    200.000       0.00
      6.000     14.000     69.000    300.000       0.00
      6.500     14.000     83.500    350.000       0.00
      7.000     15.000     99.900    400.000       0.00
```

```
      8.000     17.000     119.00    500.000         0.00
      9.000     20.000     141.50    550.000         0.00
     10.000     23.000     180.00    600.000         0.00
     11.000     27.000     200.00    650.000         0.00
  END FTABLE 43

  FTABLE     46
*** EXECUTEL POND
***Inserted by FK to reflect KC comments (03/22/2001)
 ROWS COLS ***
   20    4
***  DEPTH       AREA    VOLUME    OUTFLOW  OUTFLOW2                         ***
      (FT)    (ACRES) (ACRE-FT)      (CFS)     (CFS)
      .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
    13.000      1.000     7.320    500.900
  END FTABLE 46

  FTABLE     47
*** EXECUTEL POND DISCHARGE PIPELINE (C)
 ROWS COLS ***
   11    4
***  DEPTH       AREA    VOLUME    OUTFLOW  OUTFLOW2                         ***
      (FT)    (ACRES) (ACRE-FT)      (CFS)     (CFS)
      .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 FTABLE 47

  FTABLE    177
*** NORTH BRANCH RAVINE
 ROWS COLS ***
   14    4
***  DEPTH       AREA    VOLUME    OUTFLOW  OUTFLOW2                         ***
      (FT)    (ACRES) (ACRE-FT)      (CFS)     (CFS)
      .000       .000      .000         .0
      .500       .572      .191        7.3
     1.000       .799      .438       23.2
     2.000       .968     1.001       75.7
     3.000      1.155     1.727      155.1
     4.000      1.317     2.542      262.7
     5.000      1.478     3.475      400.3
     6.000      1.643     4.545      570.2
     7.000      1.791     5.688      774.4
     8.000      1.932     6.822     1015.1
     9.000      1.945     7.025     1294.5
    10.000      1.958     7.244     1614.5
    11.000      1.970     7.481     1977.0
    12.000      1.983     7.734     2384.7
  END FTABLE177
```

```
  FTABLE    193
*** UPPER RAVINE
 ROWS COLS ***
   14    4
***  DEPTH       AREA    VOLUME    OUTFLOW  OUTFLOW2                        ***
      (FT)     (ACRES) (ACRE-FT)    (CFS)     (CFS)
      0.00       0.00      0.00       0.0
      0.35       0.72      0.75       7.8
      0.70       0.72      1.51      23.5
      1.05       0.72      2.28      44.3
      1.40       0.72      3.03      68.2
      1.75       0.72      3.81      95.8
      2.10       0.72      4.56     125.2
      2.45       0.75      5.36     169.0
      2.80       0.89      6.30     171.5
      3.15       1.00      7.35     247.6
      3.50       1.08      8.49     332.7
      3.85       1.21      9.75     396.5
      4.20       1.32     11.13     521.2
      4.55       1.41     12.60     655.5
  END FTABLE193

  FTABLE    198
 ROWS COLS ***
*** LOWER RAVINE
*** ROUGH ESTIMATE BASED ON FIELD VISIT OF 12/20/95
*** FLOW WAS 6 TO 7 CFS WITH DEPTH OF 8"
*** NEAR OUTLET.
*** DRIVE WHICH REPRESENTS A RESTRICTION ACCORDING TO OBSERVATION
    8    4
***  DEPTH       AREA    VOLUME    OUTFLOW  OUTFLOW2                        ***
      (FT)     (ACRES) (ACRE-FT)    (CFS)     (CFS)
      0.00       0.00      0.00       0.0
      1.00       0.50      0.80      10.0
      2.00       0.55      1.30      25.0
      3.00       0.60      1.80      50.0
      5.00       0.70      2.50     100.0
 ** SUBMERGENCE OF CULVERT
     10.00       2.50     12.00     245.0
*** OVERBANK STORAGE
*** FLOWS BASED ON 243', .03 D-W FACTOR, PLUS LOSS OF 1. VELOCITY HEAD
     15.00      10.00     40.00     325.0
     20.00      11.00     90.00     390.0
  END FTABLE198

END FTABLES

COPY
  TIMESERIES
  Copy-opn                                                                  ***
    # -  #  NPT   NMN                                                       ***
    1   59          1
  END TIMESERIES
END COPY

EXT SOURCES
<-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      2 PREC     ENGLZERO               RCHRES  34     EXTNL  PREC
WDM      2 PREC     ENGLZERO               RCHRES  40     EXTNL  PREC
WDM      2 PREC     ENGLZERO               RCHRES  43     EXTNL  PREC
WDM      1 EVAP     ENGLZERO    0.8        PERLND  14 440 EXTNL  PETINP
WDM      1 EVAP     ENGLZERO    0.8        IMPLND  14 140 EXTNL  PETINP
WDM      1 EVAP     ENGLZERO    0.8        RCHRES  34     EXTNL  POTEV
WDM      1 EVAP     ENGLZERO    0.8        RCHRES  43     EXTNL  POTEV
WDM      1 EVAP     ENGLZERO    0.8        RCHRES  40     EXTNL  POTEV
END EXT SOURCES

EXT TARGETS
<-Volume-> <-Grp> <-Member-><--Mult-->Tran <-Volume-> <Member> Tsys Tgap Amd ***
<Name>   #        <Name> # #<-factor->strg <Name>   # <Name>    tem strg strg***
********************************************************************************
*** SDS
********************************************************************************
```

```
*** SDE-4 (TOTAL)
RCHRES  36 HYDR   RO                                WDM      21 FLOW      ENGL        REPL
*****************************************************************************************
** SDS-1 (TOTAL)
RCHRES  39 HYDR   RO                                WDM      22 FLOW      ENGL        REPL
*****************************************************************************************
*** SDS-3
COPY    42 OUTPUT MEAN   1     12.1                 WDM      23 FLOW      ENGL        REPL
*****************************************************************************************
*** SDS-4
COPY    10 OUTPUT MEAN   1     12.1                 WDM      28 FLOW      ENGL        REPL
*****************************************************************************************
*** SDS-3A TAXIWAY VAULT
COPY    20 OUTPUT MEAN   1     12.1                 WDM      24 FLOW      ENGL        REPL
*****************************************************************************************
*** SDS-7 3RD RUNWAY VAULT
COPY     3 OUTPUT MEAN   1     12.1                 WDM      26 FLOW      ENGL        REPL
*****************************************************************************************

*** WEST BRANCH
*****************************************************************************************
*** NORTHWEST PONDS REACH
RCHRES  43 HYDR   RO                                WDM      31 FLOW      ENGL        REPL
*****************************************************************************************
*** LOWER WEST BRANCH
RCHRES  12 HYDR   RO                                WDM      35 FLOW      ENGL        REPL
*****************************************************************************************
*** EVALUATION POINT FOR SDS DISCHARGE TO WEST BRANCH - POC-1
COPY    41 OUTPUT MEAN   1     12.1                 WDM     160 FLOW      ENGL        REPL
*****************************************************************************************
*** EVALUATION POINT FOR SDS DISCHARGE TO WEST BRANCH - POC-2
COPY     4 OUTPUT MEAN   1     12.1                 WDM     161 FLOW      ENGL        REPL
*****************************************************************************************

*** EAST BRANCH
*****************************************************************************************
*** BOW LAKE OUTFLOW
 **RCHRES  35 HYDR   RO                                WDM     136 FLOW      ENGL        REPL
 **RCHRES  37 HYDR   RO                                WDM      47 FLOW      ENGL        REPL
*** SASA POC
***COPY    16 OUTPUT MEAN   1     12.1                 WDM     438 FLOW      ENGL        REPL

*****************************************************************************************
*** EXISTING UPPER EAST BRANCH (FUTURE SASA DETENTION SITE)
RCHRES  38 HYDR   RO                                WDM      37 FLOW      ENGL        REPL
*****************************************************************************************
*** TYEE INFLOW (GAUGE 11C)
RCHRES   5 HYDR   RO                                WDM      38 FLOW      ENGL        REPL
*****************************************************************************************

*** MAIN STEM
*****************************************************************************************
*** BELOW CONFLUENCE AT TYEE GOLF COURSE WEIR (GAUGE 11F)
COPY     5 OUTPUT MEAN   1     12.1                 WDM      40 FLOW      ENGL        REPL
*****************************************************************************************
*** BELOW CONFLUENCE AT SOUTH 200TH STREET
RCHRES  13 HYDR   RO                                WDM      41 FLOW      ENGL        REPL
*****************************************************************************************
*** LOWER DES MOINES CREEK NEAR MOUTH (GAUGE 11D)
RCHRES 198 HYDR   RO                                WDM      42 FLOW      ENGL        REPL
*****************************************************************************************

END EXT TARGETS
                                                                                      ***
NETWORK
***             <MEMBER> SSYSSGAP<--MULT-->TRAN <-TARGET VOLS>        <-MEMBER->
<NAME>    # <NAME>    TEM STRG<-FACTOR->STRG <NAME>    #     # <-GRP> <NAME> # # ***
*****************************************************************************************
*** AIRPORT SUBBASINS
*****************************************************************************************
*** (DM23) SDE-4
PERLND  26 PWATER SURO           4.229       RCHRES  36        EXTNL  IVOL
PERLND  26 PWATER IFWO           4.229       RCHRES  36        EXTNL  IVOL
PERLND  26 PWATER AGWO           0.142       RCHRES  36        EXTNL  IVOL
IMPLND  14 IWATER SURO           9.624       RCHRES  36        EXTNL  IVOL
*****************************************************************************************
```

```
*** (DM24) SDS-1
PERLND  26 PWATER SURO          0.077      RCHRES  39      EXTNL  IVOL
PERLND  26 PWATER IFWO          0.077      RCHRES  39      EXTNL  IVOL
PERLND  26 PWATER AGWO          0.072      RCHRES  39      EXTNL  IVOL
IMPLND  14 IWATER SURO          1.401      RCHRES  39      EXTNL  IVOL
*******************************************************************************
*** (DM25) SDS-3A
PERLND  26 PWATER SURO          5.227      COPY    20      INPUT  MEAN   1
PERLND  26 PWATER IFWO          5.227      COPY    20      INPUT  MEAN   1
IMPLND  14 IWATER SURO          0.588      COPY    20      INPUT  MEAN   1
*******************************************************************************
*** (DM25) SDS-7
PERLND  26 PWATER SURO          6.522      COPY     3      INPUT  MEAN   1
PERLND  26 PWATER IFWO          6.522      COPY     3      INPUT  MEAN   1
PERLND  44 PWATER SURO          0.383      COPY     3      INPUT  MEAN   1
PERLND  44 PWATER IFWO          0.383      COPY     3      INPUT  MEAN   1
PERLND  54 PWATER SURO          0.033      COPY     3      INPUT  MEAN   1
PERLND  54 PWATER IFWO          0.033      COPY     3      INPUT  MEAN   1
IMPLND  14 IWATER SURO          0.668      COPY     3      INPUT  MEAN   1
*******************************************************************************
*** (DM25) SDS-3
PERLND  26 PWATER SURO         13.791      COPY    42      INPUT  MEAN   1
PERLND  26 PWATER IFWO         13.791      COPY    42      INPUT  MEAN   1
PERLND  26 PWATER AGWO          0.288      COPY    42      INPUT  MEAN   1
IMPLND  14 IWATER SURO         14.816      COPY    42      INPUT  MEAN   1
*******************************************************************************
*** (New watershed SDS-6)
PERLND  26 PWATER SURO          1.038      COPY    50      INPUT  MEAN   1
PERLND  26 PWATER IFWO          1.038      COPY    50      INPUT  MEAN   1
PERLND  26 PWATER AGWO          0.148      COPY    50      INPUT  MEAN   1
IMPLND  14 IWATER SURO          0.356      COPY    50      INPUT  MEAN   1
*******************************************************************************
*** (New watershed SDS-5)
PERLND  26 PWATER SURO          2.672      COPY    41      INPUT  MEAN   1
PERLND  26 PWATER IFWO          2.672      COPY    41      INPUT  MEAN   1
PERLND  26 PWATER AGWO          0.878      COPY    41      INPUT  MEAN   1
IMPLND  14 IWATER SURO          0.032      COPY    41      INPUT  MEAN   1
*******************************************************************************
*** (New watershed SDS-2)
PERLND  16 PWATER SURO          0.230      COPY     4      INPUT  MEAN   1
PERLND  16 PWATER IFWO          0.230      COPY     4      INPUT  MEAN   1
PERLND  16 PWATER AGWO          0.230      COPY     4      INPUT  MEAN   1
PERLND  26 PWATER SURO          0.014      COPY     4      INPUT  MEAN   1
PERLND  26 PWATER IFWO          0.014      COPY     4      INPUT  MEAN   1
PERLND  26 PWATER AGWO          0.014      COPY     4      INPUT  MEAN   1
PERLND  34 PWATER SURO          0.338      COPY     4      INPUT  MEAN   1
PERLND  34 PWATER IFWO          0.338      COPY     4      INPUT  MEAN   1
PERLND  34 PWATER AGWO          0.338      COPY     4      INPUT  MEAN   1
PERLND  44 PWATER SURO          0.012      COPY     4      INPUT  MEAN   1
PERLND  44 PWATER IFWO          0.012      COPY     4      INPUT  MEAN   1
PERLND  44 PWATER AGWO          0.012      COPY     4      INPUT  MEAN   1
PERLND  54 PWATER SURO          0.043      COPY     4      INPUT  MEAN   1
PERLND  54 PWATER IFWO          0.043      COPY     4      INPUT  MEAN   1
PERLND  54 PWATER AGWO          0.043      COPY     4      INPUT  MEAN   1
IMPLND  14 IWATER SURO          0.124      COPY     4      INPUT  MEAN   1
*******************************************************************************

*** (DM27) SDS-4
PERLND  16 PWATER SURO          *****      COPY    10      INPUT  MEAN   1
PERLND  16 PWATER IFWO          *****      COPY    10      INPUT  MEAN   1
PERLND  16 PWATER AGWO          *****      COPY     5      INPUT  MEAN   1
PERLND  26 PWATER SURO          0.761      COPY    10      INPUT  MEAN   1
PERLND  26 PWATER IFWO          0.761      COPY    10      INPUT  MEAN   1
PERLND  26 PWATER AGWO          0.761      COPY     5      INPUT  MEAN   1
PERLND  34 PWATER SURO          0.011      COPY    10      INPUT  MEAN   1
PERLND  34 PWATER IFWO          0.011      COPY    10      INPUT  MEAN   1
PERLND  34 PWATER AGWO          0.011      COPY     5      INPUT  MEAN   1
PERLND  44 PWATER SURO          3.009      COPY    10      INPUT  MEAN   1
PERLND  44 PWATER IFWO          3.009      COPY    10      INPUT  MEAN   1
PERLND  44 PWATER AGWO          3.009      COPY     5      INPUT  MEAN   1
IMPLND  14 IWATER SURO          1.599      COPY    10      INPUT  MEAN   1
*******************************************************************************
*** SASA STORM
PERLND  16 PWATER SURO          1.899      COPY    15      INPUT  MEAN   1
PERLND  16 PWATER IFWO          1.899      COPY    15      INPUT  MEAN   1
PERLND  16 PWATER AGWO          1.899      COPY     5      INPUT  MEAN   1
```

```
PERLND  26 PWATER SURO          0.146       COPY     15      INPUT  MEAN    1
PERLND  26 PWATER IFWO          0.146       COPY     15      INPUT  MEAN    1
PERLND  26 PWATER AGWO          0.146       COPY      5      INPUT  MEAN    1
PERLND  34 PWATER SURO          0.019       COPY     15      INPUT  MEAN    1
PERLND  34 PWATER IFWO          0.019       COPY     15      INPUT  MEAN    1
PERLND  34 PWATER AGWO          0.019       COPY      5      INPUT  MEAN    1
PERLND  44 PWATER SURO          0.001       COPY     15      INPUT  MEAN    1
PERLND  44 PWATER IFWO          0.001       COPY     15      INPUT  MEAN    1
PERLND  44 PWATER AGWO          0.001       COPY      5      INPUT  MEAN    1
PERLND  54 PWATER SURO          0.045       COPY     15      INPUT  MEAN    1
PERLND  54 PWATER IFWO          0.045       COPY     15      INPUT  MEAN    1
PERLND  54 PWATER AGWO          0.045       COPY      5      INPUT  MEAN    1
IMPLND  14 IWATER SURO          0.745       COPY     15      INPUT  MEAN    1
********************************************************************************

*** IWS SYSTEM PRIMARY SYSTEM AND PUMP STATIONS
********************************************************************************
*** I-3: NORTH SATELLITE PUMP STATION (NSPS) TO IWS
*** OVERFLOW TO SDE-4
*** INSTALLED IN 1995
PERLND  16 PWATER SURO          *****       RCHRES 360       EXTNL  IVOL
PERLND  16 PWATER IFWO          *****       RCHRES 360       EXTNL  IVOL
PERLND  26 PWATER SURO          0.026       RCHRES 360       EXTNL  IVOL
PERLND  26 PWATER IFWO          0.026       RCHRES 360       EXTNL  IVOL
IMPLND  14 IWATER SURO          1.120       RCHRES 360       EXTNL  IVOL
********************************************************************************
********************************************************************************
*** I-5: SOUTH SNOWMELT (OLYMPIC TANK FARM) PUMP STATION TO IWS
*** OVERFLOW TO DES MOINES EAST BRANCH
*** INSTALLED IN LATE 1997/1998***areas not changed
IMPLND  14 IWATER SURO          0.001       RCHRES 366       EXTNL  IVOL
********************************************************************************
********************************************************************************
*** I-7: IWS - PRIMARY
***
PERLND  16 PWATER SURO          *****       COPY     14      INPUT  MEAN    1
PERLND  16 PWATER IFWO          *****       COPY     14      INPUT  MEAN    1
PERLND  26 PWATER SURO          1.117       COPY     14      INPUT  MEAN    1
PERLND  26 PWATER IFWO          1.117       COPY     14      INPUT  MEAN    1
***PERLND  26 PWATER AGWO          0.115       COPY     14      INPUT  MEAN    1
IMPLND  14 IWATER SURO         19.456       COPY     14      INPUT  MEAN    1
********************************************************************************
*** SASA IWS
PERLND  16 PWATER SURO          3.047       RCHRES    5      EXTNL  IVOL
PERLND  16 PWATER IFWO          3.047       RCHRES    5      EXTNL  IVOL
PERLND  16 PWATER AGWO          3.047       COPY      5      INPUT  MEAN    1
PERLND  26 PWATER SURO          0.837       RCHRES    5      EXTNL  IVOL
PERLND  26 PWATER IFWO          0.837       RCHRES    5      EXTNL  IVOL
PERLND  26 PWATER AGWO          0.837       COPY      5      INPUT  MEAN    1
PERLND  34 PWATER SURO          0.020       RCHRES    5      EXTNL  IVOL
PERLND  34 PWATER IFWO          0.020       RCHRES    5      EXTNL  IVOL
PERLND  34 PWATER AGWO          0.020       COPY      5      INPUT  MEAN    1
PERLND  44 PWATER SURO          0.302       RCHRES    5      EXTNL  IVOL
PERLND  44 PWATER IFWO          0.302       RCHRES    5      EXTNL  IVOL
PERLND  44 PWATER AGWO          0.302       COPY      5      INPUT  MEAN    1
PERLND  54 PWATER SURO          0.113       RCHRES    5      EXTNL  IVOL
PERLND  54 PWATER IFWO          0.113       RCHRES    5      EXTNL  IVOL
PERLND  54 PWATER AGWO          0.113       COPY      5      INPUT  MEAN    1
IMPLND  14 IWATER SURO          0.548       RCHRES    5      EXTNL  IVOL
********************************************************************************
*** IWS WEST
PERLND  16 PWATER SURO          0.222       RCHRES   43      EXTNL  IVOL
PERLND  16 PWATER IFWO          0.222       RCHRES   43      EXTNL  IVOL
***PERLND  16 PWATER AGWO          0.222       RCHRES   43      EXTNL  IVOL
PERLND  26 PWATER SURO          0.226       RCHRES   43      EXTNL  IVOL
PERLND  26 PWATER IFWO          0.226       RCHRES   43      EXTNL  IVOL
***PERLND  26 PWATER AGWO          0.091       RCHRES   43      EXTNL  IVOL
PERLND  34 PWATER SURO          0.512       RCHRES   43      EXTNL  IVOL
PERLND  34 PWATER IFWO          0.512       RCHRES   43      EXTNL  IVOL
***PERLND  34 PWATER AGWO          0.512       RCHRES   43      EXTNL  IVOL
IMPLND  14 IWATER SURO          0.037       RCHRES   43      EXTNL  IVOL
********************************************************************************
*** MC-9 GW added (from Miller Creek)
ERLND   26 PWATER AGWO          0.005       RCHRES   43      EXTNL  IVOL
*** EAST BRANCH OF CREEK
********************************************************************************
```

```
*** DM1
PERLND  16 PWATER SURO          0.860        RCHRES  34       EXTNL  IVOL
PERLND  16 PWATER IFWO          0.860        RCHRES  34       EXTNL  IVOL
PERLND  16 PWATER AGWO          0.238        RCHRES  34       EXTNL  IVOL
PERLND  26 PWATER SURO         11.078        RCHRES  34       EXTNL  IVOL
PERLND  26 PWATER IFWO         11.078        RCHRES  34       EXTNL  IVOL
PERLND  26 PWATER AGWO          3.069        RCHRES  34       EXTNL  IVOL
PERLND  34 PWATER SURO          0.599        RCHRES  34       EXTNL  IVOL
PERLND  34 PWATER IFWO          0.599        RCHRES  34       EXTNL  IVOL
PERLND  34 PWATER AGWO          0.166        RCHRES  34       EXTNL  IVOL
PERLND  44 PWATER SURO          7.697        RCHRES  34       EXTNL  IVOL
PERLND  44 PWATER IFWO          7.697        RCHRES  34       EXTNL  IVOL
PERLND  44 PWATER AGWO          2.132        RCHRES  34       EXTNL  IVOL
PERLND  54 PWATER SURO          1.176        RCHRES  34       EXTNL  IVOL
PERLND  54 PWATER IFWO          1.176        RCHRES  34       EXTNL  IVOL
PERLND  54 PWATER AGWO          0.326        RCHRES  34       EXTNL  IVOL
IMPLND  14 IWATER SURO         14.274        RCHRES  34       EXTNL  IVOL
******************************************************************************
*** DM2
PERLND  16 PWATER SURO          *****        RCHRES  37       EXTNL  IVOL
PERLND  16 PWATER IFWO          *****        RCHRES  37       EXTNL  IVOL
PERLND  26 PWATER SURO          1.232        RCHRES  37       EXTNL  IVOL
PERLND  26 PWATER IFWO          1.232        RCHRES  37       EXTNL  IVOL
IMPLND  14 IWATER SURO          0.821        RCHRES  37       EXTNL  IVOL
******************************************************************************
*** DM3
PERLND  26 PWATER SURO          3.645        RCHRES   5       EXTNL  IVOL
PERLND  26 PWATER IFWO          3.645        RCHRES   5       EXTNL  IVOL
PERLND  26 PWATER AGWO          3.628        RCHRES   5       EXTNL  IVOL
PERLND  54 PWATER SURO          0.013        RCHRES   5       EXTNL  IVOL
PERLND  54 PWATER IFWO          0.013        RCHRES   5       EXTNL  IVOL
PERLND  54 PWATER AGWO          0.013        RCHRES   5       EXTNL  IVOL
IMPLND  14 IWATER SURO          5.030        RCHRES   5       EXTNL  IVOL
******************************************************************************
***Add non-contiguous GW basin***
PERLND  26 PWATER AGWO          0.016        RCHRES   5       EXTNL  IVOL
*** DM4
 RLND   16 PWATER PERO          0.291        RCHRES   5       EXTNL  IVOL
 RLND   26 PWATER PERO          0.589        RCHRES   5       EXTNL  IVOL
PERLND  54 PWATER PERO          0.005        RCHRES   5       EXTNL  IVOL
IMPLND  14 IWATER SURO          3.340        RCHRES   5       EXTNL  IVOL
******************************************************************************
***Add non-contiguous GW basin***
PERLND  26 PWATER AGWO          0.001        RCHRES   5       EXTNL  IVOL
*** DM5
PERLND  16 PWATER PERO          0.173        RCHRES   5       EXTNL  IVOL
PERLND  26 PWATER PERO          0.493        RCHRES   5       EXTNL  IVOL
PERLND  34 PWATER PERO          0.074        RCHRES   5       EXTNL  IVOL
PERLND  44 PWATER PERO          0.080        RCHRES   5       EXTNL  IVOL
PERLND  54 PWATER PERO          0.112        RCHRES   5       EXTNL  IVOL
IMPLND  14 IWATER SURO          0.812        RCHRES   5       EXTNL  IVOL
******************************************************************************
*** DM6
PERLND  16 PWATER PERO          0.000        RCHRES  40       EXTNL  IVOL
PERLND  26 PWATER PERO          0.534        RCHRES  40       EXTNL  IVOL
PERLND  34 PWATER PERO          0.002        RCHRES  40       EXTNL  IVOL
PERLND  44 PWATER PERO          0.709        RCHRES  40       EXTNL  IVOL
PERLND  54 PWATER PERO          0.312        RCHRES  40       EXTNL  IVOL
IMPLND  14 IWATER SURO          0.008        RCHRES  40       EXTNL  IVOL
******************************************************************************

*** WEST BRANCH OF CREEK
******************************************************************************
*** DM7
PERLND  16 PWATER SURO          2.190        RCHRES   7       EXTNL  IVOL
PERLND  16 PWATER IFWO          2.190        RCHRES   7       EXTNL  IVOL
PERLND  16 PWATER AGWO          1.701        RCHRES   7       EXTNL  IVOL
PERLND  26 PWATER SURO          2.944        RCHRES   7       EXTNL  IVOL
PERLND  26 PWATER IFWO          2.944        RCHRES   7       EXTNL  IVOL
PERLND  26 PWATER AGWO          0.759        RCHRES   7       EXTNL  IVOL
PERLND  34 PWATER SURO          1.969        RCHRES   7       EXTNL  IVOL
PERLND  34 PWATER IFWO          1.969        RCHRES   7       EXTNL  IVOL
PERLND  34 PWATER AGWO          0.681        RCHRES   7       EXTNL  IVOL
 RLND   44 PWATER SURO          4.142        RCHRES   7       EXTNL  IVOL
.ERLND  44 PWATER IFWO          4.142        RCHRES   7       EXTNL  IVOL
PERLND  44 PWATER AGWO          0.313        RCHRES   7       EXTNL  IVOL
```

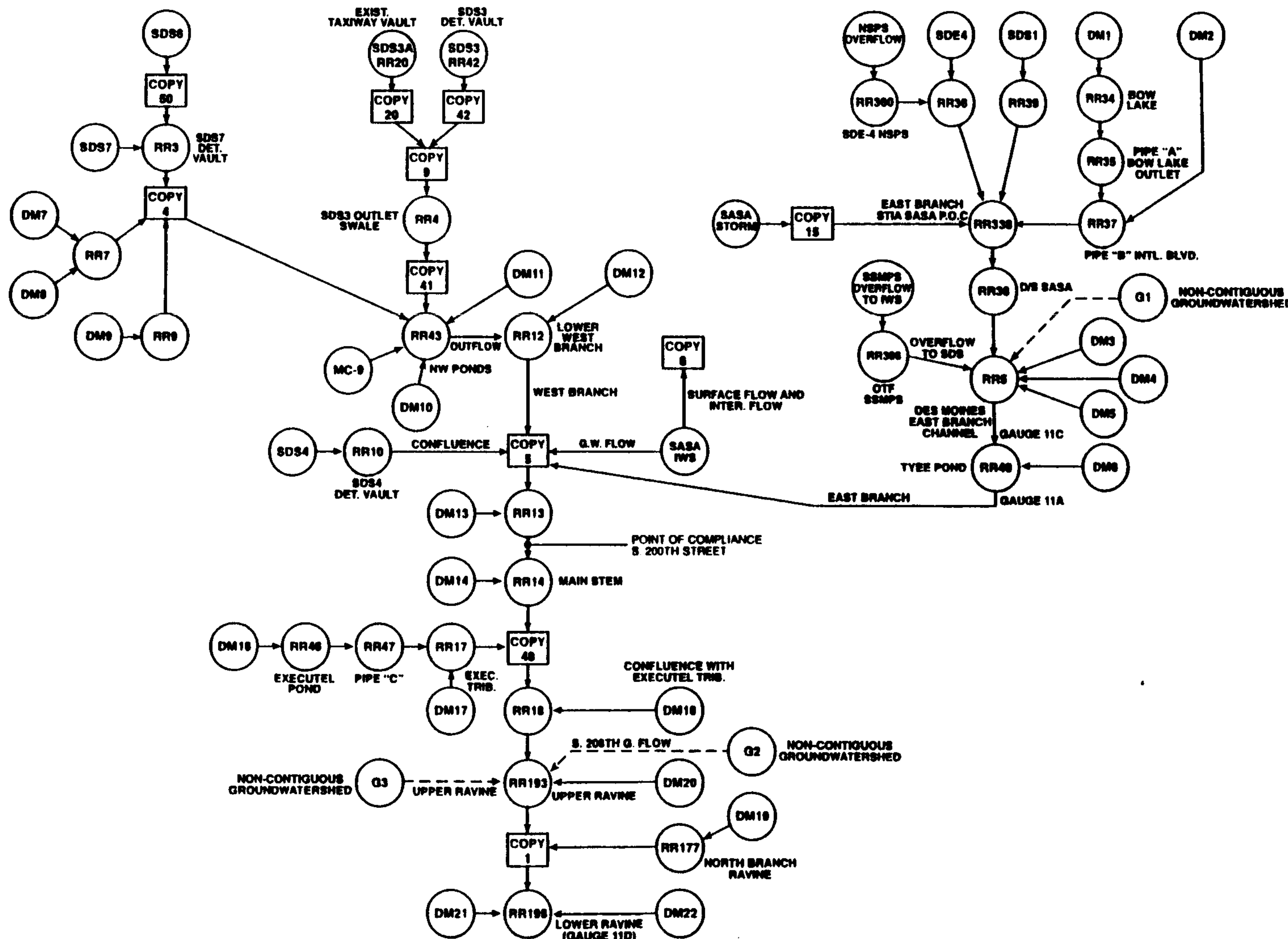
```
PERLND  54 PWATER SURO           0.551      RCHRES   7      EXTNL  IVOL
PERLND  54 PWATER IFWO           0.551      RCHRES   7      EXTNL  IVOL
PERLND  54 PWATER AGWO           0.370      RCHRES   7      EXTNL  IVOL
IMPLND  14 IWATER SURO           2.399      RCHRES   7      EXTNL  IVOL
******************************************************************************
*** DM8
PERLND  16 PWATER SURO           0.203      RCHRES   7      EXTNL  IVOL
PERLND  16 PWATER IFWO           0.203      RCHRES   7      EXTNL  IVOL
PERLND  16 PWATER AGWO           *****      RCHRES   7      EXTNL  IVOL
PERLND  26 PWATER SURO           0.609      RCHRES   7      EXTNL  IVOL
PERLND  26 PWATER IFWO           0.609      RCHRES   7      EXTNL  IVOL
PERLND  26 PWATER AGWO           0.098      RCHRES   7      EXTNL  IVOL
PERLND  34 PWATER SURO           0.715      RCHRES   7      EXTNL  IVOL
PERLND  34 PWATER IFWO           0.715      RCHRES   7      EXTNL  IVOL
PERLND  34 PWATER AGWO           0.226      RCHRES   7      EXTNL  IVOL
PERLND  44 PWATER SURO           1.132      RCHRES   7      EXTNL  IVOL
PERLND  44 PWATER IFWO           1.132      RCHRES   7      EXTNL  IVOL
PERLND  44 PWATER AGWO           0.154      RCHRES   7      EXTNL  IVOL
PERLND  54 PWATER SURO           0.161      RCHRES   7      EXTNL  IVOL
PERLND  54 PWATER IFWO           0.161      RCHRES   7      EXTNL  IVOL
PERLND  54 PWATER AGWO           0.116      RCHRES   7      EXTNL  IVOL
IMPLND  14 IWATER SURO           2.420      RCHRES   7      EXTNL  IVOL
******************************************************************************

*** DM9
PERLND  16 PWATER SURO           0.002      RCHRES   9      EXTNL  IVOL
PERLND  16 PWATER IFWO           0.002      RCHRES   9      EXTNL  IVOL
PERLND  16 PWATER AGWO           0.002      RCHRES   9      EXTNL  IVOL
PERLND  26 PWATER SURO           1.200      RCHRES   9      EXTNL  IVOL
PERLND  26 PWATER IFWO           1.200      RCHRES   9      EXTNL  IVOL
PERLND  26 PWATER AGWO           0.435      RCHRES   9      EXTNL  IVOL
PERLND  34 PWATER SURO           0.016      RCHRES   9      EXTNL  IVOL
PERLND  34 PWATER IFWO           0.016      RCHRES   9      EXTNL  IVOL
PERLND  34 PWATER AGWO           0.016      RCHRES   9      EXTNL  IVOL
PERLND  44 PWATER SURO           3.040      RCHRES   9      EXTNL  IVOL
PERLND  44 PWATER IFWO           3.040      RCHRES   9      EXTNL  IVOL
PERLND  44 PWATER AGWO           1.512      RCHRES   9      EXTNL  IVOL
PERLND  54 PWATER SURO           0.010      RCHRES   9      EXTNL  IVOL
PERLND  54 PWATER IFWO           0.010      RCHRES   9      EXTNL  IVOL
PERLND  54 PWATER AGWO           0.010      RCHRES   9      EXTNL  IVOL
IMPLND  14 IWATER SURO           0.634      RCHRES   9      EXTNL  IVOL
******************************************************************************
*** DM10
PERLND  16 PWATER PERO           0.945      RCHRES  43      EXTNL  IVOL
PERLND  26 PWATER PERO           0.738      RCHRES  43      EXTNL  IVOL
PERLND  34 PWATER PERO           1.935      RCHRES  43      EXTNL  IVOL
PERLND  44 PWATER PERO           0.510      RCHRES  43      EXTNL  IVOL
PERLND  54 PWATER PERO           0.712      RCHRES  43      EXTNL  IVOL
IMPLND  14 IWATER SURO           0.185      RCHRES  43      EXTNL  IVOL
******************************************************************************
*** DM11
PERLND  16 PWATER PERO           0.321      RCHRES  43      EXTNL  IVOL
PERLND  26 PWATER PERO           0.408      RCHRES  43      EXTNL  IVOL
PERLND  34 PWATER PERO           1.024      RCHRES  43      EXTNL  IVOL
PERLND  44 PWATER PERO           0.467      RCHRES  43      EXTNL  IVOL
PERLND  54 PWATER PERO           1.036      RCHRES  43      EXTNL  IVOL
IMPLND  14 IWATER SURO           2.726      RCHRES  43      EXTNL  IVOL
******************************************************************************
*** DM12
PERLND  16 PWATER PERO           0.510      RCHRES  12      EXTNL  IVOL
PERLND  26 PWATER PERO           0.001      RCHRES  12      EXTNL  IVOL
PERLND  34 PWATER PERO           0.375      RCHRES  12      EXTNL  IVOL
PERLND  44 PWATER PERO           1.740      RCHRES  12      EXTNL  IVOL
PERLND  54 PWATER PERO           0.543      RCHRES  12      EXTNL  IVOL
******************************************************************************
*** DM13
PERLND  16 PWATER PERO           0.961      RCHRES  13      EXTNL  IVOL
PERLND  26 PWATER PERO           1.562      RCHRES  13      EXTNL  IVOL
PERLND  34 PWATER PERO           1.203      RCHRES  13      EXTNL  IVOL
PERLND  44 PWATER PERO           1.842      RCHRES  13      EXTNL  IVOL
PERLND  54 PWATER PERO           0.025      RCHRES  13      EXTNL  IVOL
IMPLND  14 IWATER SURO           1.259      RCHRES  13      EXTNL  IVOL
******************************************************************************

*** LOWER BASIN
******************************************************************************
```

```
*** DM14
PERLND  16 PWATER PERO           0.481      RCHRES  14      EXTNL  IVOL
PERLND  26 PWATER PERO           0.295      RCHRES  14      EXTNL  IVOL
PERLND  34 PWATER PERO           1.940      RCHRES  14      EXTNL  IVOL
PERLND  44 PWATER PERO           1.195      RCHRES  14      EXTNL  IVOL
IMPLND  14 IWATER SURO           0.340      RCHRES  14      EXTNL  IVOL
*******************************************************************************

*** EXECUTEL TRIBUTARY
*******************************************************************************
*** DM16 INFLOW TO EXECUTEL POND REACH
PERLND  16 PWATER SURO           0.647      RCHRES  46      EXTNL  IVOL
PERLND  16 PWATER IFWO           0.647      RCHRES  46      EXTNL  IVOL
PERLND  16 PWATER AGWO           0.446      RCHRES  46      EXTNL  IVOL
PERLND  26 PWATER SURO           5.573      RCHRES  46      EXTNL  IVOL
PERLND  26 PWATER IFWO           5.573      RCHRES  46      EXTNL  IVOL
PERLND  26 PWATER AGWO           3.845      RCHRES  46      EXTNL  IVOL
PERLND  34 PWATER SURO           0.639      RCHRES  46      EXTNL  IVOL
PERLND  34 PWATER IFWO           0.639      RCHRES  46      EXTNL  IVOL
PERLND  34 PWATER AGWO           0.441      RCHRES  46      EXTNL  IVOL
PERLND  44 PWATER SURO           8.023      RCHRES  46      EXTNL  IVOL
PERLND  44 PWATER IFWO           8.023      RCHRES  46      EXTNL  IVOL
PERLND  44 PWATER AGWO           5.536      RCHRES  46      EXTNL  IVOL
PERLND  54 PWATER SURO           0.183      RCHRES  46      EXTNL  IVOL
PERLND  54 PWATER IFWO           0.183      RCHRES  46      EXTNL  IVOL
PERLND  54 PWATER AGWO           0.126      RCHRES  46      EXTNL  IVOL
IMPLND  14 IWATER SURO           4.249      RCHRES  46      EXTNL  IVOL
*******************************************************************************
*** DM17
PERLND  16 PWATER PERO           2.078      RCHRES  17      EXTNL  IVOL
PERLND  26 PWATER PERO           2.261      RCHRES  17      EXTNL  IVOL
PERLND  34 PWATER PERO           3.003      RCHRES  17      EXTNL  IVOL
PERLND  44 PWATER PERO           3.280      RCHRES  17      EXTNL  IVOL
IMPLND  14 IWATER SURO           2.655      RCHRES  17      EXTNL  IVOL
*******************************************************************************

*** MAINSTEM RAVINE
*******************************************************************************
*** DM18
PERLND  16 PWATER PERO           0.789      RCHRES  18      EXTNL  IVOL
PERLND  26 PWATER PERO           0.277      RCHRES  18      EXTNL  IVOL
PERLND  34 PWATER PERO           3.151      RCHRES  18      EXTNL  IVOL
PERLND  44 PWATER PERO           1.106      RCHRES  18      EXTNL  IVOL
PERLND  54 PWATER PERO           0.300      RCHRES  18      EXTNL  IVOL
IMPLND  14 IWATER SURO           0.296      RCHRES  18      EXTNL  IVOL
*******************************************************************************

*** NORTH BRANCH RAVINE
*******************************************************************************
*** DM19
PERLND  16 PWATER PERO           0.182      RCHRES 177      EXTNL  IVOL
PERLND  26 PWATER PERO           6.019      RCHRES 177      EXTNL  IVOL
PERLND  34 PWATER PERO           0.167      RCHRES 177      EXTNL  IVOL
PERLND  44 PWATER PERO           5.552      RCHRES 177      EXTNL  IVOL
IMPLND  14 IWATER SURO           2.617      RCHRES 177      EXTNL  IVOL
*******************************************************************************
*** DM20
PERLND  16 PWATER PERO           4.007      RCHRES 193      EXTNL  IVOL
PERLND  26 PWATER PERO           6.624      RCHRES 193      EXTNL  IVOL
PERLND  34 PWATER PERO           2.784      RCHRES 193      EXTNL  IVOL
PERLND  44 PWATER PERO           4.602      RCHRES 193      EXTNL  IVOL
PERLND  54 PWATER PERO           0.116      RCHRES 193      EXTNL  IVOL
IMPLND  14 IWATER SURO           3.714      RCHRES 193      EXTNL  IVOL
*******************************************************************************

*** LOWER MAINSTEM
*******************************************************************************
*** DM21
PERLND  16 PWATER PERO           2.143      RCHRES 198      EXTNL  IVOL
PERLND  26 PWATER PERO           6.306      RCHRES 198      EXTNL  IVOL
PERLND  34 PWATER PERO           1.429      RCHRES 198      EXTNL  IVOL
PERLND  44 PWATER PERO           4.205      RCHRES 198      EXTNL  IVOL
IMPLND  14 IWATER SURO           3.091      RCHRES 198      EXTNL  IVOL
*******************************************************************************
*** DM22
PERLND  16 PWATER PERO           0.381      RCHRES 198      EXTNL  IVOL
```

```
PERLND  26 PWATER PERO            4.654        RCHRES 198        EXTNL  IVOL
PERLND  34 PWATER PERO            0.218        RCHRES 198        EXTNL  IVOL
PERLND  44 PWATER PERO            2.620        RCHRES 198        EXTNL  IVOL
PERLND  54 PWATER PERO            0.016        RCHRES 198        EXTNL  IVOL
IMPLND  14 IWATER SURO            1.972        RCHRES 198        EXTNL  IVOL
*******************************************************************************

*** NONCONTIGUOUS GROUNDWATER BASINS
*******************************************************************************
*** G1
PERLND  16 PWATER AGWO            2.833        RCHRES   5        EXTNL  IVOL
PERLND  26 PWATER AGWO            9.917        RCHRES   5        EXTNL  IVOL
*******************************************************************************
*** G2
PERLND  16 PWATER AGWO            0.417        RCHRES 193        EXTNL  IVOL
PERLND  26 PWATER AGWO            1.333        RCHRES 193        EXTNL  IVOL
*******************************************************************************
*** G3
PERLND  16 PWATER AGWO            5.083        RCHRES 193        EXTNL  IVOL
PERLND  26 PWATER AGWO           17.667        RCHRES 193        EXTNL  IVOL
PERLND  34 PWATER AGWO            1.167        RCHRES 193        EXTNL  IVOL
PERLND  44 PWATER AGWO            4.250        RCHRES 193        EXTNL  IVOL
*******************************************************************************
*******************************************************************************

*** CHANNEL NETWORK LINKAGES ***
*******************************************************************************

*** DISCHARGE FROM IWS SUBBASINS
*******************************************************************************
RCHRES 360 HYDR    ROVOL  1                    RCHRES  36        EXTNL  IVOL
RCHRES 366 HYDR    ROVOL  1                    RCHRES   5        EXTNL  IVOL
*******************************************************************************

*** EAST BRANCH OF CREEK
*******************************************************************************
RCHRES  34 HYDR    ROVOL  1                    RCHRES  35        EXTNL  IVOL
RCHRES  35 HYDR    ROVOL  1                    RCHRES  37        EXTNL  IVOL
RCHRES  36 HYDR    ROVOL  1                    COPY    16        INPUT  MEAN   1
COPY    14 OUTPUT MEAN    1                    COPY    16        INPUT  MEAN   1
COPY    15 OUTPUT MEAN    1                    COPY    16        INPUT  MEAN   1
RCHRES  39 HYDR    ROVOL  1                    COPY    16        INPUT  MEAN   1
RCHRES  37 HYDR    ROVOL  1                    COPY    16        INPUT  MEAN   1
COPY    16 OUTPUT MEAN    1                    RCHRES  38        EXTNL  IVOL
RCHRES  38 HYDR    ROVOL  1                    RCHRES   5        EXTNL  IVOL
RCHRES   5 HYDR    ROVOL  1                    RCHRES  40        EXTNL  IVOL
RCHRES  40 HYDR    ROVOL  1                    COPY     5        INPUT  MEAN   1
*******************************************************************************


*** WEST BRANCH OF CREEK
*******************************************************************************
COPY    20 OUTPUT MEAN    1                    COPY     9        INPUT  MEAN   1
COPY    42 OUTPUT MEAN    1                    COPY     9        INPUT  MEAN   1
COPY     9 OUTPUT MEAN    1                    RCHRES   4        EXTNL  IVOL
RCHRES   4 HYDR    ROVOL  1                    COPY    41        INPUT  MEAN   1
COPY    50 OUTPUT MEAN    1                    COPY     4        INPUT  MEAN   1
COPY     3 OUTPUT MEAN    1                    COPY     4        INPUT  MEAN   1
RCHRES   7 HYDR    ROVOL  1                    COPY     4        INPUT  MEAN   1
RCHRES   9 HYDR    ROVOL  1                    COPY     4        INPUT  MEAN   1
COPY     4 OUTPUT MEAN    1                    RCHRES  43        EXTNL  IVOL
COPY    41 OUTPUT MEAN    1                    RCHRES  43        EXTNL  IVOL
RCHRES  43 HYDR    ROVOL  1                    RCHRES  12        EXTNL  IVOL
COPY    10 OUTPUT MEAN    1                    COPY     5        INPUT  MEAN   1
RCHRES  12 HYDR    ROVOL  1                    COPY     5        INPUT  MEAN   1
*******************************************************************************

*** MAINSTEM BELOW CONFLUENCE OF E. AND W. BRANCH
*******************************************************************************
*** MAINSTEM ABOVE EXECUTEL TRIBUTARY
COPY     5 OUTPUT MEAN    1                    RCHRES  13        EXTNL  IVOL
RCHRES  13 HYDR    ROVOL  1                    RCHRES  14        EXTNL  IVOL
RCHRES  14 HYDR    ROVOL  1                    COPY    48        INPUT  MEAN   1
*******************************************************************************
*** EXECUTEL TRIBUTARY
RCHRES  46 HYDR    ROVOL  1                    RCHRES  47        EXTNL  IVOL
```

```
RCHRES  47 HYDR    ROVOL  1                   RCHRES  17      EXTNL  IVOL
RCHRES  17 HYDR    ROVOL  1                   COPY    48      INPUT  MEAN   1
**********************************************************************************
*** MAINSTEM FROM HEAD OF RAVINE TO NORTH BRANCH CONFLUENCE
COPY    48 OUTPUT MEAN   1                    RCHRES  18      EXTNL  IVOL
RCHRES  18 HYDR    ROVOL  1                   RCHRES 193      EXTNL  IVOL
RCHRES 193 HYDR    ROVOL  1                   COPY     1      INPUT  MEAN   1
**********************************************************************************
*** NORTH BRANCH RAVINE TO MAINSTEM
RCHRES 177 HYDR    ROVOL  1                   COPY     1      INPUT  MEAN   1
**********************************************************************************
*** MAINSTEM FROM NORTH BRANCH CONFLUENCE TO PARK BELOW MVD CULVERT
COPY     1 OUTPUT MEAN   1                    RCHRES 198      EXTNL  IVOL
**********************************************************************************

END NETWORK

END RUN
```

2006 CONDITIONS



Parametrix, Inc.

———→ Stormwater	DM# = Des Moines Creek Subbasin Number
—·—·—→ IWS	SDS# = Storm Drainage South Number
– – – → Groundwater	SDE# = Storm Drainage East Number
	R# = Routing Reach Number (Channel or Storage Pond)

DM1 —Subbasin ID
RR12 —Routing Reach Number

COPY 6 — Summation of upstream flow

HSPF Model Schematic
Des Moines Creek
Low Flow Analysis
2006 Conditions

AR 053171

```
RUN
GLOBAL
  ***  FILE: DM06RLF4.INP (MODIFY DM06R6M.INP)
  ***  HSPF MODEL OF DES MOINES CREEK, Low Flow Analysis,2006 conditions
  ***  This is the low flow frequency analysis file only
  ***  GW contributions are based on the 2006 basins and 2006 conditions.
  ***  GW contributions were added/revised in most basins by revising AGWO
  ***  GW contributions were also added for SASA-SDS and MC-9(These basins were added to the model)
  ***  Surface water contributions were revised based on the 2006 basins land use.
  ***  PERO of basins DM-3, Dm-4, Dm-5, Dm-10, Dm-11, Dm-12, DM-13 were replaced.
  ***  with SURO, IFWO and AGWO flows.
  ***  GW contributions from non-contiguous D3 and D4 were added to the model.
  DES MOINES CREEK BASIN HSPF MODEL
  START       1948/10/01 00:00  END    1996/09/30 24:00
  START       1992/01/01 00:00  END    1996/09/30 24:00***
  RUN INTERP OUTPUT LEVEL    10
  RESUME     0 RUN     1
END GLOBAL

FILES
MESSU      24   DM06.MES
WDM        25   DM06RLF1.WDM
END FILES

OPN SEQUENCE
    INGRP              INDELT 01:00
      PERLND      16
      PERLND      26
      PERLND      34
      PERLND      44
      PERLND      45
      PERLND      54
      IMPLND      14
      RCHRES     360
      RCHRES      36
      RCHRES      39
      RCHRES      20
      RCHRES      42
      COPY         9
      RCHRES       4
      COPY        41
      RCHRES      10
      RCHRES     366
      COPY         8
      COPY        50
      RCHRES       3
      RCHRES       7
      RCHRES       9
      COPY         4
      RCHRES      43
      COPY        15
      RCHRES      34
      RCHRES      35
      RCHRES      37
      RCHRES     338
      RCHRES      38
      RCHRES       5
      RCHRES      40
      RCHRES      12
      COPY         5
      RCHRES      13
      RCHRES      14
      RCHRES     177
      RCHRES      46
      RCHRES      47
      RCHRES      17
      COPY        48
      RCHRES      18
      RCHRES     193
      COPY         1
      RCHRES     198
    END INGRP
END OPN SEQUENCE

PERLND
  GEN-INFO
```

AR 053172

```
    <PLS >       Name             NBLKS   Unit-systems   Printer                    ***
    # -  #                               User  t-series Engl Metr                   ***
                                               in   out                             ***
   16      TFM- TILL FOR MOD       1      1     1    1    60    0
   26      TGM- TILL GR MOD        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
   45      AF - AIRPORT FILL       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   54    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   54    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   54    0    0    0    0    0    0    0    0    0
  END PWAT-PARM1

  PWAT-PARM2
    <PLS > ***
    # -  # ***FOREST       LZSN     INFILT       LSUR      SLSUR      KVARY      AGWRC
   16                    4.5000     0.2000     200.00     0.1000     0.5000     0.9960
   26                    4.5000     0.0750     400.00     0.1000     0.5000     0.9960
   34                    5.0000     2.0000     200.00     0.0500     0.3000     0.9960
   44                    5.0000     0.8000     200.00     0.0500     0.3000     0.9960
   45                    7.5000     0.0200     300.00     0.0700     0.0000     0.9960
   54                    4.0000     2.0000     200.00     0.0010     0.5000     0.9960
  END PWAT-PARM2
  PWAT-PARM3
    <PLS >***
    # -  #***  PETMAX    PETMIN     INFEXP     INFILD     DEEPFR     BASETP     AGWETP
   16                               2.0000     2.0000       0.55       0.00        0.0
   26                               2.0000     2.0000       0.55       0.00        0.0
   34                               2.0000     2.0000       0.55       0.00        0.0
   44                               2.0000     2.0000       0.55       0.00        0.0
   45                               2.0000     2.0000       0.55       0.00        0.0
   54                               10.000     2.0000       0.55       0.00        0.7
  END PWAT-PARM3
  PWAT-PARM4
    <PLS >                                                               ***
    # -  #     CEPSC      UZSN       NSUR      INTFW        IRC      LZETP***
   16         0.2000    0.5000     0.3500      3.000     0.5000     0.7000
   26         0.1000    0.2500     0.2500      3.000     0.5000     0.2500
   34         0.2000    0.5000     0.3500      0.000     0.7000     0.7000
   44         0.1000    0.5000     0.2500      0.000     0.7000     0.2500
   45         0.1000    0.2800     0.2500      6.000     0.1500     0.6000
   54         0.2000    3.0000     0.5000      1.000     0.7000     0.8000
  END PWAT-PARM4
  PWAT-STATE1
    <PLS >  PWATER state variables***
    # -  #***     CEPS      SURS        UZS       IFWS        LZS       AGWS       GWVS
   16            0.078        0.     0.0010         0.      0.075      0.267      0.026
   26            0.051        0.     0.0350         0.      1.928      0.680      0.049
   34            0.078        0.     0.0010         0.      0.090      0.676      0.038
   44            0.051        0.     0.0040         0.      1.127      0.614      0.152
   45            0.051        0.     0.0200         0.      1.528      0.647      0.101
   54            0.051        0.     0.3330         0.      0.622      0.000      0.000
  END PWAT-STATE1
END PERLND

IMPLND
  GEN-INFO
    <ILS >       Name                Unit-systems   Printer                       ***
    # -  #                          User  t-series Engl Metr                      ***
                                           in   out                               ***
   13  140 IMPERVIOUS                1     1    1    60    0
  END GEN-INFO
  ACTIVITY
```

```
    <ILS > ************* Active Sections ****
    # -  # ATMP SNOW IWAT  SLD  IWG IQAL  ***
  13  140    0    0    1    0    0    0
  END ACTIVITY
  PRINT-INFO
    <ILS > ******** Print-flags ******** PIVL  PYR
    # -  # ATMP SNOW IWAT  SLD  IWG IQAL *********
  13  140    0    0    6    0    0    0    1    9
  END PRINT-INFO
  IWAT-PARM1
    <ILS >           Flags              ***                                        ***
    # -  # CSNO RTOP  VRS  VNN RTLI     ***                                        ***
  13  140    0    0    0    0    0
  END IWAT-PARM1
  IWAT-PARM2
    <ILS >                                                                         ***
    # -  #       LSUR     SLSUR      NSUR     RETSC ***
  14          500.0    0.0100    0.1000    0.100
  140        100.00    0.0500    0.1000    0.0500
  END IWAT-PARM2
  IWAT-PARM3
    <ILS >                                                                         ***
    # -  #     PETMAX    PETMIN                                                    ***
  13  140
  END IWAT-PARM3
  IWAT-STATE1
    <ILS >  IWATER state variables                                                 ***
    # -  #      RETS      SURS                                                     ***
  13  140 1.0000E-3 1.0000E-3
  END IWAT-STATE1
END IMPLND

RCHRES
  GEN-INFO
    RCHRES       Name        Nexits   Unit Systems   Printer                       ***
    # -  #<------------------><---> User T-series  Engl Metr LKFG                  ***
                                             in  out                               ***
    3     SDS-7 Det. Vault       1    1    1    1    0    0    0
    4     SDS-3 Outlet Swale     1    1    1    1    0    0    0
    5     E.Branch above TyeeP   1    1    1    1    0    0    0
    7     DM7 & DM8 Conveyance   1    1    1    1    0    0    0
    9     DM9 Conveyance         1    1    1    1    0    0    0
   10     SDS-4 Det. Vault       1    1    1    1    0    0    0
   12     Lower W. Branch        1    1    1    1    0    0    0
   13     Confl. to 200th St.    1    1    1    1    0    0    0
   14     200th to Exec. Trib.   1    1    1    1    0    0    0
   17     Executel Tributary     1    1    1    1    0    0    0
   18     Exec.Confl. to 208th   2    1    1    1    0    0    0
   20     SDS-3A Det. Vault      1    1    1    1    0    0    0
   34     Bow Lake               2    1    1    1    0    0    1
   35     Pipe A Bow LK Outlet   1    1    1    1    0    0    0
   36     SDE-4 Combined Disch   1    1    1    1    0    0    0
   37     Pipe B 60" Intl Blvd   1    1    1    1    0    0    0
   38     D/S SASA               1    1    1    1    0    0    0
   39     SDS-1 Storm Only       1    1    1    1    0    0    0
   40     Tyee Pond              1    1    1    1    0    0    0
   42     SDS-3 Det. Vault       1    1    1    1    0    0    0
   43     NW Ponds               2    1    1    1    0    0    1
   46     Executel Pond          1    1    1    1    0    0    0
   47     Pipe C Exec.Pond Dis   1    1    1    1    0    0    0
  177     North Branch Ravine    1    1    1    1    0    0    0
  193     Upper Ravine           1    1    1    1    0    0    0
  198     Lower Ravine           1    1    1    1    0    0    0
  338     E.BR. STIA SASA POC    1    1    1    1    0    0    0
  360     SDE-4 NSPS             2    1    1    1    0    0    0
  366     OTF   SSMPS            2    1    1    1    0    0    0
  END GEN-INFO

  ACTIVITY
    RCHRES *************** Active Sections *****************
    # -  # HYFG ADFG CNFG HTFG SDFG GQFG OXFG NUFG PKFG PHFG                       ***
    1  366    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 *********
```

AR 053174

```
  1  366     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
           *  *  *  *   *  *  *  *  *       *  *  *  *  *           ***
  3   17   0  1  1  0   4  0  0  0  0       0  0  0  0  0        2  2  2  2  2
 18        0  1  1  0   4  5  0  0  0       0  0  0  0  0        2  2  2  2  2
 20        0  1  1  0   4  0  0  0  0       0  0  0  0  0        2  2  2  2  2
 34        0  1  1  0   4  5  0  0  0       0  0  0  0  0        2  2  2  2  2
 35   40   0  1  1  0   4  0  0  0  0       0  0  0  0  0        2  2  2  2  2
 42        0  1  1  0   4  0  0  0  0       0  0  0  0  0        2  2  2  2  2
 43        0  1  1  0   4  5  0  0  0       0  0  0  0  0        2  2  2  2  2
 46  338   0  1  1  0   4  0  0  0  0       0  0  0  0  0        2  2  2  2  2
360  366   0  1  1  0   4  5  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          ***
<------><--------><--------><--------><--------><--------><-------->                ***
  3              3   0.071                                  0.3
  4              4   0.530                                  0.3
  5              5   0.380                                  0.3
  7              7   0.341                                  0.3
  9              9   0.189                                  0.3
 10             10   0.071                                  0.3
 12             12   0.273                                  0.3
 13             13   0.218                                  0.3
 14             14   0.218                                  0.3
 17             17   0.246                                  0.3
 18             18   0.303                                  0.3
 20             20   0.071                                  0.3
 34             34   0.208                                  0.3
 35             35   0.123                                  0.3
 36             36   0.100                                  0.3
 37             37   0.381                                  0.3
 38             38   0.142                                  0.3
 39             39   0.100                                  0.3
 40             40   0.189                                  0.3
 42             42   0.071                                  0.3
 43             43   0.189                                  0.3
 46             46   0.047                                  0.3
 47             47   0.417                                  0.3
177            177   0.407                                  0.3
193            193   0.795                                  0.3
198            198   0.631                                  0.3
338            338   0.010                                  0.3
360            360   0.010                                  0.0
366            366   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
<------><-------->    <---><---><---><---><---> *** <---><---><---><---><--->
  3      0.1            4.0
  4      0.1            4.0
  5      0.1            4.0
  7      0.1            4.0
  9      0.1            4.0
 10      0.1            4.0
 12      0.1            4.0
 13      0.1            4.0
 14      0.1            4.0
 17      0.1            4.0
 18      0.1            4.0  5.0
 20      0.1            4.0
 34      35.            4.0  5.0
 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
     42      0.1               4.0
     43      0.7               4.0  5.0
     46      0.0               4.0
     47      0.0               4.0
    177      0.0               4.0
    193      0.0               4.0
    198      0.0               4.0
    338      0.0               4.0
    360      0.0               4.0  5.0
    366      0.0               4.0  5.0
  END HYDR-INIT
END RCHRES

FTABLES
  FTABLE        3

*** SDS-7 DETENTION VAULT   20 FT DEPTH 36-in riser diam.+3 orifices
***SDS-7 DEt. VAULT accepts runoff from SDS-6 and SDS-7
 ROWS COLS ***
   23    4
     DEPTH        AREA    VOLUME    OUTFLOW                                        ***
      (FT)     (ACRES)  (ACRE-FT)     (CFS)                                        ***
      0.00      1.079       0.00      0.00
      1.72      1.079       1.86      0.53
      7.30      1.079       7.87      1.10
     14.28      1.079      15.40      1.54
     14.50      1.079      15.64      1.55
     14.59      1.079      15.74      1.58
     15.34      1.079      16.55      2.10
     17.20      1.079      18.55      2.59
     17.50      1.079      18.88      2.66
     17.55      1.079      18.93      2.67
     17.69      1.079      19.08      2.79
     17.83      1.079      19.23      2.99
     18.25      1.079      19.69      3.28
     18.69      1.079      20.16      3.94
     19.13      1.079      20.64      4.73
     19.56      1.079      21.10      5.53
     20.00      1.079      21.57      6.61
     20.10      1.079      21.68      7.57
     20.20      1.079      21.79      9.29
     20.30      1.079      21.90     11.51
     21.00      1.079      22.65     36.14
     21.30      1.079      22.98     45.82
     21.90      1.079      23.62     54.10
  END FTABLE  3


  FTABLE        4
*** SDS-3 OUTLET SWALE
 ROWS COLS ***
    7    4
***  DEPTH       AREA    VOLUME    OUTFLOW   OUTFLOW2
      (FT)    (ACRES)  (ACRE-FT)     (CFS)      (CFS)                             ***
      .000       .000       0.0       0.0
      .500       .198       0.1       9.0
     1.000       .236       0.5      30.9
     2.000       .306       1.0     115.8
     3.000       .376       1.5     265.5
     4.000       .446       5.0     491.8
     5.000       .517      20.0     806.3
  END FTABLE  4

  FTABLE        5
*** EAST BRANCH ABOVE TYEE POND
 ROWS COLS ***
   13    4
***  DEPTH       AREA    VOLUME    OUTFLOW   OUTFLOW2
      (FT)    (ACRES)  (ACRE-FT)     (CFS)      (CFS)                             ***
     0.000       .000      .000      .000
     0.550       .290      .100     4.900
     1.100       .543      .200    20.800
     1.650       .609      .300    46.500
     2.200       .671      .400    80.000
     2.750       .732     0.500   118.700
```

AR 053176

```
    3.300       .778      0.600    159.500
    3.850       .819      0.700    198.400
    4.400       .849      0.801    231.900
    4.950       .866      1.000    252.900
    5.500       .865      1.200    253.000
    8.200       .973      1.500    400.000
   10.200      1.043      2.000    520.000
  END FTABLE  5

  FTABLE       7
*** DM7 & DM8 CONVEYANCE
 ROWS COLS ***
    8    4
***  DEPTH      AREA    VOLUME    OUTFLOW  OUTFLOW2                        ***
      (FT)    (ACRES) (ACRE-FT)     (CFS)     (CFS)
      .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 FTABLE  7

  FTABLE       9
*** DM9 CONVEYANCE
 ROWS COLS ***
    8    4
***  DEPTH      AREA    VOLUME    OUTFLOW  OUTFLOW2                        ***
      (FT)    (ACRES) (ACRE-FT)     (CFS)     (CFS)
      .000       .00       0.0        .0
      .500       .20       0.7       9.7
     1.000       .23       3.1      32.6
     2.000       .29      14.9       118
     3.000       .35      38.4       265
     4.000       .41        77       482
     5.000       .47       135       778
     6.000       .52       214      1165
  END FTABLE  9

  FTABLE      10
*** SDS-4 DETENTION VAULT  15 FT DEPTH 10-IN RISER DIA
 ROWS COLS ***
   18    4
     DEPTH      AREA    VOLUME    OUTFLOW  ***
      0.00      0.87      0.00      0.00
      0.54      0.87     0.471     0.180
      1.72      0.87     1.501     0.320
      2.60      0.87     2.270     0.394
      3.49      0.87     3.047     0.456
      5.25      0.87     4.583     0.559
      7.60      0.87     6.634     0.673
      8.19      0.87     7.149     0.699
      8.78      0.87     7.664     0.723
      9.37      0.87     8.179     0.747
      9.96      0.87     8.694     0.770
     10.54      0.87     9.201     0.793
     12.21      0.87    10.659     1.220
     14.55      0.87    12.701     2.240
     15.00      0.87    13.094     2.390
     15.10      0.87    13.181     2.670
     15.50      0.87    13.530     4.390
     16.80      0.80    14.665     6.400
  END FTABLE 10

  FTABLE      12
*** LOWER WEST BRANCH
*** REVISED BASED ON HEC-RAS MODEL
 ROWS COLS ***
   13    4
***  DEPTH      AREA    VOLUME    OUTFLOW  OUTFLOW2                        ***
      (FT)    (ACRES) (ACRE-FT)     (CFS)     (CFS)
      .000      .000     0.000      .000
      .500      .291     0.030     0.150
     1.000      .346     0.260     6.600
```

```
      2.000       .450      0.430     14.100
      3.000       .554      0.650     25.000
      4.000       .656      1.180     50.000
      5.000       .753      2.170     75.000
      6.000       .796      3.820    100.000
      7.000       .837      8.820    150.000
      8.000       .837     16.200    200.000
      9.000       .837     27.920    250.000
     10.000       .837     33.530    350.000
     11.000       .837     35.380    450.000
  END FTABLE 12

  FTABLE     13
*** CONFLUENCE TO 200TH STREET
 ROWS COLS ***
    9    4
***  DEPTH       AREA     VOLUME    OUTFLOW   OUTFLOW2
      (FT)    (ACRES) (ACRE-FT)     (CFS)     (CFS)                      ***
      .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 FTABLE 13

  FTABLE     14
*** 200TH STREET TO EXECUTEL TRIBUTARY
*** REACH 190 FROM TR-20/KING COUNTY BASIN PLAN MODEL:
 ROWS COLS ***
    5    4
***  DEPTH       AREA     VOLUME    OUTFLOW   OUTFLOW2
      (FT)    (ACRES) (ACRE-FT)     (CFS)     (CFS)                      ***
     0.000      0.000     0.000      0.000
     0.900      0.70      0.4000     30.00
     1.800      0.80      1.1000    115.60
     2.700      1.10      2.1000    269.80
     4.200      1.30      4.3000    707.10
  END FTABLE 14

  FTABLE     17
*** EXECUTEL TRIBUTARY
 ROWS COLS ***
   10    4
***  DEPTH       AREA     VOLUME    OUTFLOW   OUTFLOW2
      (FT)    (ACRES) (ACRE-FT)     (CFS)     (CFS)                      ***
      .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 FTABLE 17

  FTABLE     18
*** CONFLUENCE WITH EXECUTEL TRIBUTARY TO 208TH STREET
*** REPRESENTS GW LOSS IN WETLAND BELOW 200TH
 ROWS COLS ***
   14    5
***  DEPTH       AREA     VOLUME    OUTFLOW   OUTFLOW2
      (FT)    (ACRES) (ACRE-FT)     (CFS)     (CFS)                      ***
      .000       .000       .000       .000      0.00
      .500       .572       .191      7.300      0.00
     1.000       .799       .438     10.000      0.00
     2.000       .968      1.001     20.700      0.00
     3.000      1.155      1.727    100.000      0.00
     4.000      1.317      2.542    262.700      0.00
     5.000      1.478      3.475    400.300      0.00
     6.000      1.643      4.545    570.200      0.00
```

AR 053178

```
     7.000      1.791     5.688   774.400        0.00
     8.000      1.932     6.822  1015.100        0.00
     9.000      1.945     7.025  1294.500        0.00
    10.000      1.958     7.244  1614.500        0.00
    11.000      1.970     7.481  1977.000        0.00
    12.000      1.983     7.734  2384.700        0.00
  END FTABLE 18

  FTABLE      20
*** SDS-3A EXISTING TAXIWAY DETENTION VAULT  EFFECTIVE DEPTH=7.94 FT 36-IN RISER
 ROWS COLS ***
   14    4
     DEPTH      AREA    VOLUME   OUTFLOW                                     ***
      (FT)   (ACRES) (ACRE-FT)     (CFS)                                     ***
      0.00      0.69      0.00      0.00
      1.06      0.69      0.73      1.09
      2.00      0.69      1.38      1.50
      3.08      0.69      2.12      1.86
      4.00      0.69      2.77      2.12
      5.10      0.69      3.51      2.39
      5.70      0.69      3.93      2.53
      6.24      0.69      4.30      4.47
      7.05      0.69      4.86      9.28
      7.58      0.69      5.22     12.80
      7.94      0.69      5.47     15.07
      8.54      0.69      5.88     28.76
      9.04      0.69      6.23     48.98
      9.54      0.69      6.57     58.41
  END FTABLE 20

  FTABLE      34
*** BOW LAKE
*** BASED ON ENTRANCE CONTROL FOR 36 INCH OUTLET PIPE
 ROWS COLS ***
    8    5
***  DEPTH      AREA    VOLUME   OUTFLOW  OUTFLOW2
      (FT)   (ACRES) (ACRE-FT)     (CFS)     (CFS)                           ***
     0.000    14.000     0.000     0.000      0.00
     1.000    14.000    14.000     7.000      0.00
     1.500    14.000    21.000    13.000      0.00
     2.000    14.000    28.000    17.000      0.00
     3.000    14.000    42.000    35.000      0.00
     4.000    14.000    56.000    49.000      0.00
     5.000    14.000    70.000    60.000      0.00
     6.000    14.000    84.000    70.000      0.00
  END FTABLE 34

  FTABLE      35
*** 36" BOW LAKE DISCHARGE PIPELINE (A)
 ROWS COLS ***
   13    4
***  DEPTH      AREA    VOLUME   OUTFLOW  OUTFLOW2
      (FT)   (ACRES) (ACRE-FT)     (CFS)     (CFS)                           ***
      .000      .000      .000      .000
      .300      .020     .0006     1.000
      .600      .026     .0026     4.200
      .900      .032     .0068     9.400
     1.200      .034     .0134    16.200
     1.500      .037     .0226    24.000
     1.800      .039     .0346    32.300
     2.100      .040     .0492    40.100
     2.400      .040     .0667    46.900
     2.700      .039     .0857    51.200
     3.000      .037     .1000    55.300
*** SURCHARGING-
     3.300      .038     .2500    60.300
     4.000      .038     .4000    80.000
  END FTABLE 35

  FTABLE      36
*** SDE-4 COMBINED DISCHARGE
 ROWS COLS ***
   11    4
**   DEPTH      AREA    VOLUME   OUTFLOW  OUTFLOW2
      (FT)   (ACRES) (ACRE-FT)     (CFS)     (CFS)                           ***
      .000      .000      .000      .000
```

```
        .400        .343      0.090      2.200
        .800        .442      0.150      9.500
       1.200        .523      0.200     21.100
       1.600        .577      0.250     36.300
       2.000        .618      0.300     54.000
       2.400        .646      0.350     72.500
       2.800        .659      0.400     90.200
       3.200        .662      0.450    105.500
       3.600        .649      0.550    115.000
       4.000        .618      0.650    115.100
  END FTABLE 36

  FTABLE      37
*** 60" INTERNATIONAL BLVD PIPELINE (B)
 ROWS COLS ***
   13    4
***  DEPTH      AREA    VOLUME   OUTFLOW  OUTFLOW2                          ***
      (FT)   (ACRES) (ACRE-FT)     (CFS)     (CFS)
      .000      .000      .000      .000
      .450      .134      .045     4.800
      .900      .190      .100    20.300
     1.350      .225      .150    45.400
     1.800      .249      .200    78.000
     2.250      .266      .250   115.900
     2.700      .271      .300   155.800
     3.150      .264      .350   193.800
     3.600      .251      .400   226.500
     4.050      .238      .450   247.000
     4.500      .234      .500   247.100
     6.500      .185      .600   340.000
     8.500      .166      .700   415.000
  END FTABLE 37

  FTABLE     238
  *** STIA FLOW COMBINED (NOT USED)
 ROWS COLS ***
    5    4
     DEPTH      AREA    VOLUME   OUTFLOW   ***
     0.000    0.0010    0.0000      0.00
     0.000    0.0100    0.0100     10.00
     0.100    0.1000    0.1000    100.00
     1.000    1.0000    1.0000   1000.00
    10.000   10.0000   10.0000  10000.00
  END FTABLE238

  FTABLE     338
*** SASA DETENTION FACILITY RETROFIT SIZE ***
 ROWS COLS ***                                EFFECTIVE DEPTH=14 FT
   14    4
     DEPTH      AREA    VOLUME      DISCH              ***
      (FT)   (ACRES)   (AC-FT)      (CFS)              ***
      0.00     0.000      0.00       0.00
      1.31     2.802     3.620      13.70
      2.30     2.881     6.472      18.14
      3.40     2.983     9.761      22.05
      4.22     3.043    12.296      24.57
      5.32     3.151    15.809      27.59
      6.14     3.233    18.514      29.65
      7.13     3.326    21.878      33.26
      8.05     3.426    25.103      38.80
     10.10     3.608    32.636      56.04
     11.20     3.699    36.860      76.55
     12.29     4.053    41.227      99.16
     13.12     4.154    44.633     116.70
     14.40     4.311    50.050     144.31
  END FTABLE338

  FTABLE      39
*** SDS-1 DISCHARGE
 ROWS COLS ***
   11    4
***  DEPTH      AREA    VOLUME   OUTFLOW  OUTFLOW2                          ***
      (FT)   (ACRES) (ACRE-FT)     (CFS)     (CFS)
      .000      .000      .000      .000
      .250      .020      .030     2.200
      .500      .027      .035     9.400
```

```
      .750       .031       .042     21.000
     1.000       .035       .049     36.000
     1.250       .039      0.056     53.600
     1.500       .039      0.064     72.000
     1.750       .041      0.074     89.500
     2.000       .041      0.084    104.700
     2.250       .041      0.094    114.200
     2.500       .038      0.100    114.300
  END FTABLE 39

  FTABLE     40
*** TYEE POND
*** BASED ON TYEE POND AS-BUILTS AND AUTOMATED GATE OPERATION MANUAL
*** K RITLAND 2/4/98
 ROWS COLS ***
   20    4
***  DEPTH      AREA    VOLUME   OUTFLOW  OUTFLOW2                              ***
      (FT)   (ACRES) (ACRE-FT)     (CFS)     (CFS)
      0.00      0.00      0.00      0.00
      0.90      0.01      0.01     10.00
      1.65      0.02      0.02     20.00
      3.11      0.07      0.07     30.00
      4.56      0.22      0.29     40.00
      6.02      0.63      0.89     50.00
      7.48      0.88      2.02     60.00
      8.62      1.06      3.18     70.00
      9.79      1.18      4.29     80.00
     10.88      1.34      5.83     90.00
     11.99      1.48      7.20    100.00
     13.12      1.69      9.17    110.00
     15.13      2.04     12.90    120.00
     16.10      2.20     14.92    124.10
     16.30      2.24     15.40    129.65
     16.57      2.28     15.88    150.36
     16.64      2.32     16.36    155.00
     16.80      2.36     16.84    208.74
     17.03      2.40     17.32    293.59
     17.26      2.43     17.79    428.11
  END FTABLE 40

  FTABLE     42
*** SDS-3 DETENTION VAULT EFFECTIVE DEPTH = 20.0 FT
 ROWS COLS ***
   17    4
     DEPTH      AREA    VOLUME   OUTFLOW                ***
      (FT)   (ACRES) (ACRE-FT)     (CFS)                ***
      0.00      4.19       .00      0.00
      0.51      4.19     2.254      0.95
      1.37      4.19     6.054      1.55
      3.33      4.19    14.716      2.42
      6.07      4.19    26.824      3.28
      8.43      4.19    37.254      3.86
     10.00      4.19    44.192      4.20
     12.74      4.19    56.301      4.74
     14.50      4.19    64.078      5.06
     15.46      4.19    68.321      8.74
     16.63      4.19    73.491     10.66
     18.39      4.19    81.269     16.63
     20.00      4.19    88.384     20.79
     20.20      4.19    89.268     23.84
     20.70      4.19    91.477     39.37
     21.00      4.19    92.803     52.07
     21.90      4.19    96.780     71.43
  END FTABLE 42

  FTABLE     43
*** NORTHWEST PONDS
*** BASED ON KING COUNTY BASIN PLANNING MODEL
 ROWS COLS ***
   17    5
***  DEPTH      AREA    VOLUME   OUTFLOW  OUTFLOW2                              ***
      (FT)   (ACRES) (ACRE-FT)     (CFS)     (CFS)
     0.000    12.000     0.000     0.000      0.00
     0.100    12.000    18.800     0.000      0.00
     1.000    12.000    24.000     0.200      0.00
     2.000    12.000    30.000     0.500      0.00
```

```
      3.000     12.000     37.000      1.000         0.00
      3.500     13.000     41.000      5.000         0.00
      4.000     13.000     45.700     15.000         0.00
      4.500     13.000     51.000     35.000         0.00
      5.000     14.000     56.500    150.000         0.00
      5.500     14.000     62.800    200.000         0.00
      6.000     14.000     69.000    300.000         0.00
      6.500     14.000     83.500    350.000         0.00
      7.000     15.000     99.900    400.000         0.00
      8.000     17.000     119.00    500.000         0.00
      9.000     20.000     141.50    550.000         0.00
     10.000     23.000     180.00    600.000         0.00
     11.000     27.000     200.00    650.000         0.00
  END FTABLE 43

  FTABLE      46
*** EXECUTEL POND
 ROWS COLS ***
   20    4
***   DEPTH       AREA    VOLUME    OUTFLOW  OUTFLOW2                          ***
       (FT)    (ACRES) (ACRE-FT)      (CFS)     (CFS)
       .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
     13.000      1.000     7.320    500.900
  END FTABLE 46

  FTABLE      47
*** EXECUTEL POND DISCHARGE PIPELINE (C)
 ROWS COLS ***
   11    4
***   DEPTH       AREA    VOLUME    OUTFLOW  OUTFLOW2                          ***
       (FT)    (ACRES) (ACRE-FT)      (CFS)     (CFS)
       .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 FTABLE 47

  FTABLE     177
*** NORTH BRANCH RAVINE
 ROWS COLS ***
   14    4
***   DEPTH       AREA    VOLUME    OUTFLOW  OUTFLOW2                          ***
       (FT)    (ACRES) (ACRE-FT)      (CFS)     (CFS)
       .000       .000      .000         .0
       .500       .572      .191        7.3
      1.000       .799      .438       23.2
      2.000       .968     1.001       75.7
      3.000      1.155     1.727      155.1
      4.000      1.317     2.542      262.7
      5.000      1.478     3.475      400.3
      6.000      1.643     4.545      570.2
```

AR 053182

```
     7.000      1.791      5.688      774.4
     8.000      1.932      6.822     1015.1
     9.000      1.945      7.025     1294.5
    10.000      1.958      7.244     1614.5
    11.000      1.970      7.481     1977.0
    12.000      1.983      7.734     2384.7
  END FTABLE177

  FTABLE    193
*** UPPER RAVINE
 ROWS COLS ***
   14    4
***  DEPTH       AREA     VOLUME    OUTFLOW  OUTFLOW2                          ***
      (FT)    (ACRES)  (ACRE-FT)     (CFS)     (CFS)
      0.00      0.00      0.00        0.0
      0.35      0.72      0.75        7.8
      0.70      0.72      1.51       23.5
      1.05      0.72      2.28       44.3
      1.40      0.72      3.03       68.2
      1.75      0.72      3.81       95.8
      2.10      0.72      4.56      125.2
      2.45      0.75      5.36      169.0
      2.80      0.89      6.30      171.5
      3.15      1.00      7.35      247.6
      3.50      1.08      8.49      332.7
      3.85      1.21      9.75      396.5
      4.20      1.32     11.13      521.2
      4.55      1.41     12.60      655.5
  END FTABLE193

  FTABLE    198
 ROWS COLS ***
*** LOWER RAVINE
*** ROUGH ESTIMATE BASED ON FIELD VISIT OF 12/20/95
*** FLOW WAS 6 TO 7 CFS WITH DEPTH OF 8"
*** NEAR OUTLET.
*** DRIVE WHICH REPRESENTS A RESTRICTION ACCORDING TO OBSERVATION
    8    4
  *  DEPTH       AREA     VOLUME    OUTFLOW  OUTFLOW2
      (FT)    (ACRES)  (ACRE-FT)     (CFS)     (CFS)                          ***
      0.00      0.00      0.00        0.0
      1.00      0.50      0.80       10.0
      2.00      0.55      1.30       25.0
      3.00      0.60      1.80       50.0
      5.00      0.70      2.50      100.0
*** SUBMERGENCE OF CULVERT
     10.00      2.50     12.00      245.0
*** OVERBANK STORAGE
*** FLOWS BASED ON 243', .03 D-W FACTOR, PLUS LOSS OF 1. VELOCITY HEAD
     15.00     10.00     40.00      325.0
     20.00     11.00     90.00      390.0
  END FTABLE198

  FTABLE    38
*** UPPER EAST BRANCH
 ROWS COLS ***
    9    4
***  DEPTH       AREA     VOLUME    OUTFLOW
      (FT)    (ACRES)  (ACRE-FT)     (CFS)         ***
      .000       .000      .000       .000
      .500       .176      .100      9.200
     1.000       .194     0.150     30.400
     2.000       .232     0.200    105.800
     3.000       .271     0.250    228.900
     4.000       .310     0.350    405.800
     5.000       .349     0.450    642.700
     6.000       .387     0.600    945.700
     7.000       .426     0.800   1320.700
  END FTABLE 38

  FTABLE    360
*** NORTH SATELLITE PUMP STATION (SDE-4) (INSTALLED IN 1995)
 ROWS COLS                                                                     ***
    5    5
     DEPTH       AREA     VOLUME      (IWS)     (SDS)                          ***
      (FT)    (ACRES)  (ACRE-FT)      (CFS)     (CFS)                          ***
```

```
      .0        1.0       .00       0.00      0.00
    1.00        1.0       .01       4.79      0.00
    2.00        1.0       .02       4.79      0.00
    3.00        1.0       .03       4.79     25.00
    4.00        1.0       .04       4.79     50.00
  END FTABLE360


  FTABLE    366
*** SOUTH SNOWMELT (OLYMPIC TANK FARM) PUMP STATION (INSTALLED IN LATE 1997/1998)
 ROWS COLS                                                                ***
   5    5
    DEPTH      AREA    VOLUME       (IWS)       (SDS)                     ***
     (FT)   (ACRES) (ACRE-FT)       (CFS)       (CFS)                     ***
      .0      1.00       .00        0.00        0.00
    1.00      1.00       .01        1.67        0.00
    2.00      1.00       .02        1.67        0.00
    3.00      1.00       .03        1.67       25.00
    4.00      1.00       .04        1.67       50.00
  END FTABLE366


END FTABLES

COPY
  TIMESERIES
  Copy-opn                                                                      ***
    # -  #  NPT  NMN                                                            ***
    1   54         1
  END TIMESERIES
END COPY

EXT SOURCES
<-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      2 PREC     ENGLZERO               RCHRES  34     EXTNL  PREC
WDM      2 PREC     ENGLZERO               RCHRES  40     EXTNL  PREC
WDM      2 PREC     ENGLZERO               RCHRES  43     EXTNL  PREC
WDM      1 EVAP     ENGLZERO    0.8        PERLND  14 440 EXTNL  PETINP
WDM      1 EVAP     ENGLZERO    0.8        IMPLND  14 140 EXTNL  PETINP
WDM      1 EVAP     ENGLZERO    0.8        RCHRES  34     EXTNL  POTEV
WDM      1 EVAP     ENGLZERO    0.8        RCHRES  43     EXTNL  POTEV
WDM      1 EVAP     ENGLZERO    0.8        RCHRES  40     EXTNL  POTEV
END EXT SOURCES

EXT TARGETS
<-Volume-> <-Grp> <-Member-><--Mult-->Tran <-Volume-> <Member> Tsys Tgap Amd ***
<Name>   #        <Name> # #<-factor->strg <Name>   # <Name>    tem strg strg***
*******************************************************************************
*** SDS
*******************************************************************************
*** SDE-4 (TOTAL)
RCHRES  36 HYDR   RO                       WDM    221 FLOW     ENGL      REPL
*******************************************************************************
*** SDS-1 (TOTAL)
RCHRES  39 HYDR   RO                       WDM    222 FLOW     ENGL      REPL
*******************************************************************************
*** SDS-3
RCHRES  42 HYDR   RO                       WDM    257 FLOW     ENGL      REPL
RCHRES  42 HYDR   STAGE                    WDM    757 STAG     ENGL      REPL
RCHRES  42 HYDR   VOL                      WDM    857 VOL      ENGL      REPL

*******************************************************************************
*** SDS-4
RCHRES  10 HYDR   RO                       WDM    258 FLOW     ENGL      REPL
RCHRES  10 HYDR   STAGE                    WDM    758 STAG     ENGL      REPL
RCHRES  10 HYDR   VOL                      WDM    858 VOL      ENGL      REPL

*******************************************************************************
*** SDS-3A TAXIWAY VAULT
RCHRES  20 HYDR   RO                       WDM    224 FLOW     ENGL      REPL
RCHRES  20 HYDR   STAGE                    WDM    724 STAG     ENGL      REPL
RCHRES  20 HYDR   VOL                      WDM    824 VOL      ENGL      REPL
```

```
*****************************************************************************
 * SDS-7 3RD RUNWAY VAULT
..CHRES   3 HYDR   RO                            WDM     226 FLOW      ENGL       REPL
RCHRES   3 HYDR   STAGE                          WDM     726 STAG      ENGL       REPL
RCHRES   3 HYDR   VOL                            WDM     826 VOL       ENGL       REPL

*****************************************************************************
*** SASA DETENTION FACILITY
RCHRES 338 HYDR   RO                             WDM     338 FLOW      ENGL       REPL
RCHRES 338 HYDR   STAGE                          WDM     745 STAG      ENGL       REPL
RCHRES 338 HYDR   VOL                            WDM     845 VOL       ENGL       REPL

*****************************************************************************
*** EVALUATION POINT 1 FOR SDS DISCHARGE TO WEST BRANCH
COPY    41 OUTPUT MEAN   1     12.1              WDM     260 FLOW      ENGL       REPL
*****************************************************************************
*** EVALUATION POINT 2 FOR SDS DISCHARGE TO WEST BRANCH
COPY     4  OUTPUT MEAN   1     12.1             WDM     261 FLOW      ENGL       REPL

*** WEST BRANCH
*****************************************************************************
*** NORTHWEST PONDS
RCHRES  43 HYDR   RO                             WDM     231 FLOW      ENGL       REPL
*****************************************************************************
*** LOWER WEST BRANCH
RCHRES  12 HYDR   RO                             WDM     235 FLOW      ENGL       REPL
*****************************************************************************

*** EAST BRANCH
*****************************************************************************
*** BOW LAKE OUTFLOW
RCHRES  35 HYDR   RO                             WDM     236 FLOW      ENGL       REPL
RCHRES  37 HYDR   RO                             WDM      37 FLOW      ENGL       REPL
*** D/S SASA
RCHRES  38 HYDR   RO                             WDM     245 FLOW      ENGL       REPL

 ****************************************************************************
*** TYEE INFLOW (GAUGE 11C)
RCHRES   5 HYDR   RO                             WDM     238 FLOW      ENGL       REPL
*****************************************************************************
*** TYEE OUTFLOW
RCHRES  40 HYDR   RO                             WDM     239 FLOW      ENGL       REPL
*****************************************************************************

*** MAIN STEM
*****************************************************************************
*** BELOW CONFLUENCE AT TYEE GOLF COURSE WEIR (GAUGE 11F)
COPY     5 OUTPUT MEAN   1     12.1              WDM     240 FLOW      ENGL       REPL
*****************************************************************************
*** BELOW CONFLUENCE AT SOUTH 200TH STREET
RCHRES  13 HYDR   RO                             WDM     241 FLOW      ENGL       REPL
*****************************************************************************
*** LOWER DES MOINES CREEK NEAR MOUTH (GAUGE 11D)
RCHRES 198 HYDR   RO                             WDM     242 FLOW      ENGL       REPL
*****************************************************************************

END EXT TARGETS
                                                                                      ***
NETWORK
***          <MEMBER> SSYSSGAP<--MULT-->TRAN <-TARGET VOLS>        <-MEMBER->
<NAME>    # <NAME>    TEM STRG<-FACTOR->STRG <NAME>    #    # <-GRP> <NAME> # # ***
*****************************************************************************
*** AIRPORT SUBBASINS
*****************************************************************************
*** (DM23) SDE-4
***  GW contributions added
PERLND  26 PWATER SURO          3.344       RCHRES  36        EXTNL  IVOL
PERLND  26 PWATER IFWO          3.344       RCHRES  36        EXTNL  IVOL
PERLND  26 PWATER AGWO          0.137       RCHRES  36        EXTNL  IVOL
IMPLND  14 IWATER SURO         10.507       RCHRES  36        EXTNL  IVOL
*****************************************************************************
 * (DM24) SDS-1
-*** GW contributions added
PERLND  26 PWATER SURO          0.115       RCHRES  39        EXTNL  IVOL
PERLND  26 PWATER IFWO          0.115       RCHRES  39        EXTNL  IVOL
```

```
PERLND  26 PWATER AGWO           0.115      RCHRES  39      EXTNL  IVOL
IMPLND  14 IWATER SURO           1.360      RCHRES  39      EXTNL  IVOL
*************************************************************************
*** (DM25) SDS-3A  TAXIWAY VAULT
PERLND  26 PWATER SURO           2.886      RCHRES  20      EXTNL  IVOL
PERLND  26 PWATER IFWO           2.886      RCHRES  20      EXTNL  IVOL
IMPLND  14 IWATER SURO           2.928      RCHRES  20      EXTNL  IVOL
*************************************************************************
*** (DM25) SDS-7   3RD RUNWAY VAULT
PERLND  26 PWATER SURO           3.808      RCHRES   3      EXTNL  IVOL
PERLND  26 PWATER IFWO           3.808      RCHRES   3      EXTNL  IVOL
PERLND  44 PWATER SURO           0.327      RCHRES   3      EXTNL  IVOL
PERLND  44 PWATER IFWO           0.327      RCHRES   3      EXTNL  IVOL
PERLND  45 PWATER SURO           0.457      RCHRES   3      EXTNL  IVOL
PERLND  45 PWATER IFWO           0.457      RCHRES   3      EXTNL  IVOL
IMPLND  14 IWATER SURO           3.013      RCHRES   3      EXTNL  IVOL
*************************************************************************
*** (DM25) SDS-3
**** GW contributions added
PERLND  26 PWATER SURO          12.026      RCHRES  42      EXTNL  IVOL
PERLND  26 PWATER IFWO          12.026      RCHRES  42      EXTNL  IVOL
PERLND  26 PWATER AGWO           0.246      RCHRES  42      EXTNL  IVOL
IMPLND  14 IWATER SURO          16.598      RCHRES  42      EXTNL  IVOL
*************************************************************************
****SDS-6*NEW WATERSHED
*** GW contributions added
PERLND  26 PWATER SURO           1.128      COPY    50      INPUT  MEAN   1
PERLND  26 PWATER IFWO           1.128      COPY    50      INPUT  MEAN   1
PERLND  26 PWATER AGWO           0.135      COPY    50      INPUT  MEAN   1
PERLND  44 PWATER SURO           *****      COPY    50      INPUT  MEAN   1
PERLND  44 PWATER IFWO           *****      COPY    50      INPUT  MEAN   1
PERLND  54 PWATER SURO           *****      COPY    50      INPUT  MEAN   1
PERLND  54 PWATER IFWO           *****      COPY    50      INPUT  MEAN   1
IMPLND  14 IWATER SURO           0.265      COPY    50      INPUT  MEAN   1
*************************************************************************
****SDS-5*NEW WATERSHED
****GW contributions added
PERLND  26 PWATER SURO           2.356      COPY    41      INPUT  MEAN   1
PERLND  26 PWATER IFWO           2.356      COPY    41      INPUT  MEAN   1
PERLND  26 PWATER AGWO           0.796      COPY    41      INPUT  MEAN   1
PERLND  44 PWATER SURO           *****      COPY    41      INPUT  MEAN   1
PERLND  44 PWATER IFWO           *****      COPY    41      INPUT  MEAN   1
PERLND  54 PWATER SURO           *****      COPY    41      INPUT  MEAN   1
PERLND  54 PWATER IFWO           *****      COPY    41      INPUT  MEAN   1
IMPLND  14 IWATER SURO           0.348      COPY    41      INPUT  MEAN   1
*************************************************************************
****SDS-2*NEW WATERSHED
**** GW contributions added
PERLND  26 PWATER SURO           0.249      COPY     4      INPUT  MEAN   1
PERLND  26 PWATER IFWO           0.249      COPY     4      INPUT  MEAN   1
PERLND  26 PWATER AGWO           0.249      COPY     4      INPUT  MEAN   1
PERLND  44 PWATER SURO           0.384      COPY     4      INPUT  MEAN   1
PERLND  44 PWATER IFWO           0.384      COPY     4      INPUT  MEAN   1
PERLND  44 PWATER AGWO           0.384      COPY     4      INPUT  MEAN   1
PERLND  54 PWATER SURO           0.043      COPY     4      INPUT  MEAN   1
PERLND  54 PWATER IFWO           0.043      COPY     4      INPUT  MEAN   1
PERLND  54 PWATER AGWO           0.043      COPY     4      INPUT  MEAN   1
IMPLND  14 IWATER SURO           0.086      COPY     4      INPUT  MEAN   1
*************************************************************************

*** (DM27) SDS-4
PERLND  26 PWATER SURO           0.564      RCHRES  10      EXTNL  IVOL
PERLND  26 PWATER IFWO           0.564      RCHRES  10      EXTNL  IVOL
PERLND  26 PWATER AGWO           0.564      COPY     5      INPUT  MEAN   1
PERLND  44 PWATER SURO           2.109      RCHRES  10      EXTNL  IVOL
PERLND  44 PWATER IFWO           2.109      RCHRES  10      EXTNL  IVOL
PERLND  44 PWATER AGWO           2.109      COPY     5      INPUT  MEAN   1
IMPLND  14 IWATER SURO           2.707      RCHRES  10      EXTNL  IVOL
*************************************************************************
*** SASA STORM
*** PERLND 26 added for surface water and GW
PERLND  26 PWATER SURO           0.001      COPY    15      INPUT  MEAN   1
PERLND  26 PWATER IFWO           0.001      COPY    15      INPUT  MEAN   1
PERLND  26 PWATER AGWO           0.001      COPY    15      INPUT  MEAN   1
IMPLND  14 IWATER SURO           2.855      COPY    15      INPUT  MEAN   1
*************************************************************************
```

```
*** MC-9 GW added (from Miller Creek)
PERLND  26 PWATER AGWO          0.005       RCHRES  43      EXTNL  IVOL
********************************************************************************
 ** IWS SYSTEM PUMP STATION OVERFLOWS
********************************************************************************
********************************************************************************
*** I-3: NORTH SATELLITE PUMP STATION (NSPS) TO IWS
*** OVERFLOW TO SDE-4
*** INSTALLED IN 1995
PERLND  26 PWATER SURO          0.026       RCHRES 360      EXTNL  IVOL
PERLND  26 PWATER IFWO          0.026       RCHRES 360      EXTNL  IVOL
IMPLND  14 IWATER SURO          1.120       RCHRES 360      EXTNL  IVOL
********************************************************************************
********************************************************************************
*** I-5: SOUTH SNOWMELT (OLYMPIC TANK FARM) PUMP STATION (SSMPS) TO IWS
*** OVERFLOW TO DES MOINES EAST BRANCH
*** INSTALLED IN LATE 1997/1998
IMPLND  14 IWATER SURO          0.001       RCHRES 366      EXTNL  IVOL
********************************************************************************
*** SASA IWS
*** AGWO revised
PERLND  26 PWATER SURO          0.004       COPY     8      INPUT  MEAN    1
PERLND  26 PWATER IFWO          0.004       COPY     8      INPUT  MEAN    1
PERLND  26 PWATER AGWO          0.004       COPY     5      INPUT  MEAN    1
PERLND  44 PWATER SURO          0.004       COPY     8      INPUT  MEAN    1
PERLND  44 PWATER IFWO          0.004       COPY     8      INPUT  MEAN    1
PERLND  44 PWATER AGWO          0.004       COPY     5      INPUT  MEAN    1
PERLND  54 PWATER SURO          0.001       COPY     8      INPUT  MEAN    1
PERLND  54 PWATER IFWO          0.001       COPY     8      INPUT  MEAN    1
PERLND  54 PWATER AGWO          0.001       COPY     5      INPUT  MEAN    1
IMPLND  14 IWATER SURO          4.860       COPY     8      INPUT  MEAN    1
********************************************************************************
*** Add IWS groundwater
***PERLND  26 PWATER AGWO          0.393       COPY     5      INPUT  MEAN    1
***PERLND  44 PWATER AGWO          0.512       COPY     5      INPUT  MEAN    1
*** EAST BRANCH OF CREEK
********************************************************************************
*** DM1
PERLND  16 PWATER SURO          0.860       RCHRES  34      EXTNL  IVOL
PERLND  16 PWATER IFWO          0.860       RCHRES  34      EXTNL  IVOL
PERLND  16 PWATER AGWO          0.241       RCHRES  34      EXTNL  IVOL
PERLND  26 PWATER SURO         11.078       RCHRES  34      EXTNL  IVOL
PERLND  26 PWATER IFWO         11.078       RCHRES  34      EXTNL  IVOL
PERLND  26 PWATER AGWO          3.102       RCHRES  34      EXTNL  IVOL
PERLND  34 PWATER SURO          0.599       RCHRES  34      EXTNL  IVOL
PERLND  34 PWATER IFWO          0.599       RCHRES  34      EXTNL  IVOL
PERLND  34 PWATER AGWO          0.168       RCHRES  34      EXTNL  IVOL
PERLND  44 PWATER SURO          7.697       RCHRES  34      EXTNL  IVOL
PERLND  44 PWATER IFWO          7.697       RCHRES  34      EXTNL  IVOL
PERLND  44 PWATER AGWO          2.155       RCHRES  34      EXTNL  IVOL
PERLND  54 PWATER SURO          1.176       RCHRES  34      EXTNL  IVOL
PERLND  54 PWATER IFWO          1.176       RCHRES  34      EXTNL  IVOL
PERLND  54 PWATER AGWO          0.329       RCHRES  34      EXTNL  IVOL
IMPLND  14 IWATER SURO         14.274       RCHRES  34      EXTNL  IVOL
********************************************************************************
*** DM2
PERLND  26 PWATER SURO          1.232       RCHRES  37      EXTNL  IVOL
PERLND  26 PWATER IFWO          1.232       RCHRES  37      EXTNL  IVOL
IMPLND  14 IWATER SURO          0.821       RCHRES  37      EXTNL  IVOL
********************************************************************************
*** DM3
*** PERO replaced with SURO, IFWO and AGWO.
PERLND  26 PWATER SURO          3.554       RCHRES   5      EXTNL  IVOL
PERLND  26 PWATER IFWO          3.554       RCHRES   5      EXTNL  IVOL
PERLND  26 PWATER AGWO          3.537       RCHRES   5      EXTNL  IVOL
PERLND  54 PWATER SURO          0.006       RCHRES   5      EXTNL  IVOL
PERLND  54 PWATER IFWO          0.006       RCHRES   5      EXTNL  IVOL
PERLND  54 PWATER AGWO          0.006       RCHRES   5      EXTNL  IVOL
IMPLND  14 IWATER SURO          4.508       RCHRES   5      EXTNL  IVOL
********************************************************************************
*** contribution from non-contiguous basin
PERLND  26 PWATER AGWO          0.016       RCHRES   5      EXTNL  IVOL
*** DM4
 ** PERO replaced with SURO, IFWO and AGWO.
PERLND  16 PWATER SURO          0.286       RCHRES   5      EXTNL  IVOL
PERLND  16 PWATER IFWO          0.286       RCHRES   5      EXTNL  IVOL
```

```
PERLND  16 PWATER AGWO            0.286       RCHRES    5      EXTNL  IVOL
PERLND  26 PWATER SURO            0.591       RCHRES    5      EXTNL  IVOL
PERLND  26 PWATER IFWO            0.591       RCHRES    5      EXTNL  IVOL
PERLND  26 PWATER AGWO            0.590       RCHRES    5      EXTNL  IVOL
PERLND  54 PWATER SURO            0.005       RCHRES    5      EXTNL  IVOL
PERLND  54 PWATER IFWO            0.005       RCHRES    5      EXTNL  IVOL
PERLND  54 PWATER AGWO            0.005       RCHRES    5      EXTNL  IVOL
IMPLND  14 IWATER SURO            3.357       RCHRES    5      EXTNL  IVOL
******************************************************************************
*** contribution from non-contiguous basin
PERLND  [illegible]6 PWATER AGWO            0.0[illegible]       RCHRES    5      EXTNL  IVOL
*** DM5
*** PERO replaced with SURO, IFWO and AGWO.
PERLND  16 PWATER SURO            0.173       RCHRES    5      EXTNL  IVOL
PERLND  16 PWATER IFWO            0.173       RCHRES    5      EXTNL  IVOL
PERLND  16 PWATER AGWO            0.173       RCHRES    5      EXTNL  IVOL
PERLND  26 PWATER SURO            0.485       RCHRES    5      EXTNL  IVOL
PERLND  26 PWATER IFWO            0.485       RCHRES    5      EXTNL  IVOL
PERLND  26 PWATER AGWO            0.485       RCHRES    5      EXTNL  IVOL
PERLND  34 PWATER SURO            0.074       RCHRES    5      EXTNL  IVOL
PERLND  34 PWATER IFWO            0.074       RCHRES    5      EXTNL  IVOL
PERLND  34 PWATER AGWO            0.074       RCHRES    5      EXTNL  IVOL
PERLND  44 PWATER SURO            0.077       RCHRES    5      EXTNL  IVOL
PERLND  44 PWATER IFWO            0.077       RCHRES    5      EXTNL  IVOL
PERLND  44 PWATER AGWO            0.077       RCHRES    5      EXTNL  IVOL
PERLND  54 PWATER SURO            0.112       RCHRES    5      EXTNL  IVOL
PERLND  54 PWATER IFWO            0.112       RCHRES    5      EXTNL  IVOL
PERLND  54 PWATER AGWO            0.112       RCHRES    5      EXTNL  IVOL
IMPLND  14 IWATER SURO            0.799       RCHRES    5      EXTNL  IVOL
******************************************************************************
*** DM6
*** PERO replaced with SURO, IFWO and AGWO.
PERLND  16 PWATER PERO            *****       RCHRES   40      EXTNL  IVOL
PERLND  26 PWATER SURO            0.534       RCHRES   40      EXTNL  IVOL
PERLND  26 PWATER IFWO            0.534       RCHRES   40      EXTNL  IVOL
PERLND  26 PWATER AGWO            0.534       RCHRES   40      EXTNL  IVOL
PERLND  34 PWATER SURO            0.002       RCHRES   40      EXTNL  IVOL
PERLND  34 PWATER IFWO            0.002       RCHRES   40      EXTNL  IVOL
PERLND  34 PWATER AGWO            0.002       RCHRES   40      EXTNL  IVOL
PERLND  44 PWATER SURO            0.709       RCHRES   40      EXTNL  IVOL
PERLND  44 PWATER IFWO            0.709       RCHRES   40      EXTNL  IVOL
PERLND  44 PWATER AGWO            0.709       RCHRES   40      EXTNL  IVOL
PERLND  54 PWATER SURO            0.312       RCHRES   40      EXTNL  IVOL
PERLND  54 PWATER IFWO            0.312       RCHRES   40      EXTNL  IVOL
PERLND  54 PWATER AGWO            0.312       RCHRES   40      EXTNL  IVOL
IMPLND  14 IWATER SURO            0.007       RCHRES   40      EXTNL  IVOL
******************************************************************************

*** WEST BRANCH OF CREEK
******************************************************************************
*** DM7
*** AGWO revised
PERLND  16 PWATER SURO            2.190       RCHRES    7      EXTNL  IVOL
PERLND  16 PWATER IFWO            2.190       RCHRES    7      EXTNL  IVOL
PERLND  16 PWATER AGWO            1.701       RCHRES    7      EXTNL  IVOL
PERLND  26 PWATER SURO            2.944       RCHRES    7      EXTNL  IVOL
PERLND  26 PWATER IFWO            2.944       RCHRES    7      EXTNL  IVOL
PERLND  26 PWATER AGWO            0.759       RCHRES    7      EXTNL  IVOL
PERLND  34 PWATER SURO            1.970       RCHRES    7      EXTNL  IVOL
PERLND  34 PWATER IFWO            1.970       RCHRES    7      EXTNL  IVOL
PERLND  34 PWATER AGWO            0.681       RCHRES    7      EXTNL  IVOL
PERLND  44 PWATER SURO            4.143       RCHRES    7      EXTNL  IVOL
PERLND  44 PWATER IFWO            4.143       RCHRES    7      EXTNL  IVOL
PERLND  44 PWATER AGWO            0.313       RCHRES    7      EXTNL  IVOL
PERLND  54 PWATER SURO            0.552       RCHRES    7      EXTNL  IVOL
PERLND  54 PWATER IFWO            0.552       RCHRES    7      EXTNL  IVOL
PERLND  54 PWATER AGWO            0.370       RCHRES    7      EXTNL  IVOL
IMPLND  14 IWATER SURO            2.401       RCHRES    7      EXTNL  IVOL
******************************************************************************
*** DM8
*** AGWO revised
PERLND  16 PWATER SURO            0.203       RCHRES    7      EXTNL  IVOL
PERLND  16 PWATER IFWO            0.203       RCHRES    7      EXTNL  IVOL
PERLND  16 PWATER AGWO            0.000       RCHRES    7      EXTNL  IVOL
PERLND  26 PWATER SURO            0.609       RCHRES    7      EXTNL  IVOL
PERLND  26 PWATER IFWO            0.609       RCHRES    7      EXTNL  IVOL
```

```
PERLND  26 PWATER AGWO          0.098        RCHRES   7       EXTNL  IVOL
PERLND  34 PWATER SURO          0.715        RCHRES   7       EXTNL  IVOL
PERLND  34 PWATER IFWO          0.715        RCHRES   7       EXTNL  IVOL
PERLND  34 PWATER AGWO          0.226        RCHRES   7       EXTNL  IVOL
PERLND  44 PWATER SURO          1.133        RCHRES   7       EXTNL  IVOL
PERLND  44 PWATER IFWO          1.133        RCHRES   7       EXTNL  IVOL
PERLND  44 PWATER AGWO          0.154        RCHRES   7       EXTNL  IVOL
PERLND  54 PWATER SURO          0.161        RCHRES   7       EXTNL  IVOL
PERLND  54 PWATER IFWO          0.161        RCHRES   7       EXTNL  IVOL
PERLND  54 PWATER AGWO          0.116        RCHRES   7       EXTNL  IVOL
IMPLND  14 IWATER SURO          2.422        RCHRES   7       EXTNL  IVOL
*******************************************************************************
*** DM9
*** AGWO revised
PERLND  16 PWATER SURO          0.002        RCHRES   9       EXTNL  IVOL
PERLND  16 PWATER IFWO          0.002        RCHRES   9       EXTNL  IVOL
PERLND  16 PWATER AGWO          0.002        RCHRES   9       EXTNL  IVOL
PERLND  26 PWATER SURO          1.201        RCHRES   9       EXTNL  IVOL
PERLND  26 PWATER IFWO          1.201        RCHRES   9       EXTNL  IVOL
PERLND  26 PWATER AGWO          0.435        RCHRES   9       EXTNL  IVOL
PERLND  34 PWATER SURO          0.017        RCHRES   9       EXTNL  IVOL
PERLND  34 PWATER IFWO          0.017        RCHRES   9       EXTNL  IVOL
PERLND  34 PWATER AGWO          0.017        RCHRES   9       EXTNL  IVOL
PERLND  44 PWATER SURO          3.040        RCHRES   9       EXTNL  IVOL
PERLND  44 PWATER IFWO          3.040        RCHRES   9       EXTNL  IVOL
PERLND  44 PWATER AGWO          1.512        RCHRES   9       EXTNL  IVOL
PERLND  54 PWATER SURO          0.010        RCHRES   9       EXTNL  IVOL
PERLND  54 PWATER IFWO          0.010        RCHRES   9       EXTNL  IVOL
PERLND  54 PWATER AGWO          0.010        RCHRES   9       EXTNL  IVOL
IMPLND  14 IWATER SURO          0.634        RCHRES   9       EXTNL  IVOL
*******************************************************************************
*** DM10
*** PERO replaced with SURO, IFWO, and AGWO
PERLND  16 PWATER SURO          0.945        RCHRES  43       EXTNL  IVOL
PERLND  16 PWATER IFWO          0.945        RCHRES  43       EXTNL  IVOL
PERLND  16 PWATER AGWO          0.945        RCHRES  43       EXTNL  IVOL
PERLND  26 PWATER SURO          0.738        RCHRES  43       EXTNL  IVOL
PERLND  26 PWATER IFWO          0.738        RCHRES  43       EXTNL  IVOL
PERLND  26 PWATER AGWO          0.738        RCHRES  43       EXTNL  IVOL
PERLND  34 PWATER SURO          1.935        RCHRES  43       EXTNL  IVOL
PERLND  34 PWATER IFWO          1.935        RCHRES  43       EXTNL  IVOL
PERLND  34 PWATER AGWO          1.935        RCHRES  43       EXTNL  IVOL
PERLND  44 PWATER SURO          0.510        RCHRES  43       EXTNL  IVOL
PERLND  44 PWATER IFWO          0.510        RCHRES  43       EXTNL  IVOL
PERLND  44 PWATER AGWO          0.510        RCHRES  43       EXTNL  IVOL
PERLND  54 PWATER SURO          0.712        RCHRES  43       EXTNL  IVOL
PERLND  54 PWATER IFWO          0.712        RCHRES  43       EXTNL  IVOL
PERLND  54 PWATER AGWO          0.712        RCHRES  43       EXTNL  IVOL
IMPLND  14 IWATER SURO          0.185        RCHRES  43       EXTNL  IVOL
*******************************************************************************
*** DM11
*** PERO replaced with SURO, IFWO, and AGWO
PERLND  16 PWATER SURO          0.321        RCHRES  43       EXTNL  IVOL
PERLND  16 PWATER IFWO          0.321        RCHRES  43       EXTNL  IVOL
PERLND  16 PWATER AGWO          0.321        RCHRES  43       EXTNL  IVOL
PERLND  26 PWATER SURO          0.408        RCHRES  43       EXTNL  IVOL
PERLND  26 PWATER IFWO          0.408        RCHRES  43       EXTNL  IVOL
PERLND  16 PWATER AGWO          0.408        RCHRES  43       EXTNL  IVOL
PERLND  34 PWATER SURO          1.024        RCHRES  43       EXTNL  IVOL
PERLND  34 PWATER IFWO          1.024        RCHRES  43       EXTNL  IVOL
PERLND  34 PWATER AGWO          1.024        RCHRES  43       EXTNL  IVOL
PERLND  44 PWATER SURO          0.467        RCHRES  43       EXTNL  IVOL
PERLND  44 PWATER IFWO          0.467        RCHRES  43       EXTNL  IVOL
PERLND  44 PWATER AGWO          0.467        RCHRES  43       EXTNL  IVOL
PERLND  54 PWATER SURO          1.036        RCHRES  43       EXTNL  IVOL
PERLND  54 PWATER IFWO          1.036        RCHRES  43       EXTNL  IVOL
PERLND  54 PWATER AGWO          1.036        RCHRES  43       EXTNL  IVOL
IMPLND  14 IWATER SURO          2.726        RCHRES  43       EXTNL  IVOL
*******************************************************************************
*** DM12
*** PERO replaced with SURO, IFWO, and AGWO
PERLND  16 PWATER SURO          0.510        RCHRES  12       EXTNL  IVOL
PERLND  16 PWATER IFWO          0.510        RCHRES  12       EXTNL  IVOL
PERLND  16 PWATER AGWO          0.510        RCHRES  12       EXTNL  IVOL
PERLND  26 PWATER SURO          0.001        RCHRES  12       EXTNL  IVOL
PERLND  26 PWATER IFWO          0.001        RCHRES  12       EXTNL  IVOL
```

```
PERLND  26 PWATER AGWO            0.001        RCHRES  12        EXTNL  IVOL
PERLND  34 PWATER SURO            0.375        RCHRES  12        EXTNL  IVOL
 RLND   34 PWATER IFWO            0.375        RCHRES  12        EXTNL  IVOL
 RLND   34 PWATER AGWO            0.375        RCHRES  12        EXTNL  IVOL
PERLND  44 PWATER SURO            1.728        RCHRES  12        EXTNL  IVOL
PERLND  44 PWATER IFWO            1.728        RCHRES  12        EXTNL  IVOL
PERLND  44 PWATER AGWO            1.728        RCHRES  12        EXTNL  IVOL
PERLND  54 PWATER SURO            0.554        RCHRES  12        EXTNL  IVOL
PERLND  54 PWATER IFWO            0.554        RCHRES  12        EXTNL  IVOL
PERLND  54 PWATER AGWO            0.554        RCHRES  12        EXTNL  IVOL
*******************************************************************************
*** DM13
*** PERO replaced with SURO, IFWO, and AGWO
PERLND  16 PWATER SURO            0.961        RCHRES  13        EXTNL  IVOL
PERLND  16 PWATER IFWO            0.961        RCHRES  13        EXTNL  IVOL
PERLND  16 PWATER AGWO            0.961        RCHRES  13        EXTNL  IVOL
PERLND  26 PWATER SURO            1.562        RCHRES  13        EXTNL  IVOL
PERLND  26 PWATER IFWO            1.562        RCHRES  13        EXTNL  IVOL
PERLND  26 PWATER AGWO            1.562        RCHRES  13        EXTNL  IVOL
PERLND  34 PWATER SURO            1.203        RCHRES  13        EXTNL  IVOL
PERLND  34 PWATER IFWO            1.203        RCHRES  13        EXTNL  IVOL
PERLND  34 PWATER AGWO            1.203        RCHRES  13        EXTNL  IVOL
PERLND  44 PWATER SURO            1.778        RCHRES  13        EXTNL  IVOL
PERLND  44 PWATER IFWO            1.778        RCHRES  13        EXTNL  IVOL
PERLND  44 PWATER AGWO            1.778        RCHRES  13        EXTNL  IVOL
PERLND  54 PWATER SURO            0.089        RCHRES  13        EXTNL  IVOL
PERLND  54 PWATER IFWO            0.089        RCHRES  13        EXTNL  IVOL
PERLND  54 PWATER AGWO            0.089        RCHRES  13        EXTNL  IVOL
IMPLND  14 IWATER SURO            1.259        RCHRES  13        EXTNL  IVOL
*******************************************************************************

*** LOWER BASIN
*******************************************************************************
*** DM14
PERLND  16 PWATER PERO            0.481        RCHRES  14        EXTNL  IVOL
PERLND  26 PWATER PERO            0.295        RCHRES  14        EXTNL  IVOL
PERLND  34 PWATER PERO            1.940        RCHRES  14        EXTNL  IVOL
 RLND   44 PWATER PERO            1.195        RCHRES  14        EXTNL  IVOL
 PLND   14 IWATER SURO            0.340        RCHRES  14        EXTNL  IVOL
*******************************************************************************

*** EXECUTEL TRIBUTARY
*******************************************************************************
*** DM16 INFLOW TO EXECUTEL POND
PERLND  16 PWATER SURO            0.647        RCHRES  46        EXTNL  IVOL
PERLND  16 PWATER IFWO            0.647        RCHRES  46        EXTNL  IVOL
PERLND  16 PWATER AGWO            0.446        RCHRES  46        EXTNL  IVOL
PERLND  26 PWATER SURO            5.573        RCHRES  46        EXTNL  IVOL
PERLND  26 PWATER IFWO            5.573        RCHRES  46        EXTNL  IVOL
PERLND  26 PWATER AGWO            3.845        RCHRES  46        EXTNL  IVOL
PERLND  34 PWATER SURO            0.639        RCHRES  46        EXTNL  IVOL
PERLND  34 PWATER IFWO            0.639        RCHRES  46        EXTNL  IVOL
PERLND  34 PWATER AGWO            0.441        RCHRES  46        EXTNL  IVOL
PERLND  44 PWATER SURO            8.023        RCHRES  46        EXTNL  IVOL
PERLND  44 PWATER IFWO            8.023        RCHRES  46        EXTNL  IVOL
PERLND  44 PWATER AGWO            5.536        RCHRES  46        EXTNL  IVOL
PERLND  54 PWATER SURO            0.183        RCHRES  46        EXTNL  IVOL
PERLND  54 PWATER IFWO            0.183        RCHRES  46        EXTNL  IVOL
PERLND  54 PWATER AGWO            0.126        RCHRES  46        EXTNL  IVOL
IMPLND  14 IWATER SURO            4.249        RCHRES  46        EXTNL  IVOL
*******************************************************************************
*** DM17
PERLND  16 PWATER PERO            2.078        RCHRES  17        EXTNL  IVOL
PERLND  26 PWATER PERO            2.261        RCHRES  17        EXTNL  IVOL
PERLND  34 PWATER PERO            3.003        RCHRES  17        EXTNL  IVOL
PERLND  44 PWATER PERO            3.280        RCHRES  17        EXTNL  IVOL
IMPLND  14 IWATER SURO            2.655        RCHRES  17        EXTNL  IVOL
*******************************************************************************

*** MAINSTEM RAVINE
*******************************************************************************
*** DM18
 ERLND  16 PWATER PERO            0.789        RCHRES  18        EXTNL  IVOL
 RLND   26 PWATER PERO            0.277        RCHRES  18        EXTNL  IVOL
 ERLND  34 PWATER PERO            3.151        RCHRES  18        EXTNL  IVOL
PERLND  44 PWATER PERO            1.106        RCHRES  18        EXTNL  IVOL
```

AR 053190

```
PERLND  54 PWATER PERO            0.300      RCHRES  18      EXTNL  IVOL
IMPLND  14 IWATER SURO            0.296      RCHRES  18      EXTNL  IVOL
*****************************************************************************

*** NORTH BRANCH RAVINE
*****************************************************************************
*** DM19
PERLND  16 PWATER PERO            0.182      RCHRES 177      EXTNL  IVOL
PERLND  26 PWATER PERO            6.019      RCHRES 177      EXTNL  IVOL
PERLND  34 PWATER PERO            0.167      RCHRES 177      EXTNL  IVOL
PERLND  44 PWATER PERO            5.552      RCHRES 177      EXTNL  IVOL
IMPLND  14 IWATER SURO            2.617      RCHRES 177      EXTNL  IVOL
*****************************************************************************
*** DM20
PERLND  16 PWATER PERO            4.007      RCHRES 193      EXTNL  IVOL
PERLND  26 PWATER PERO            6.624      RCHRES 193      EXTNL  IVOL
PERLND  34 PWATER PERO            2.784      RCHRES 193      EXTNL  IVOL
PERLND  44 PWATER PERO            4.602      RCHRES 193      EXTNL  IVOL
PERLND  54 PWATER PERO            0.116      RCHRES 193      EXTNL  IVOL
IMPLND  14 IWATER SURO            3.714      RCHRES 193      EXTNL  IVOL
*****************************************************************************

*** LOWER MAINSTEM
*****************************************************************************
*** DM21
PERLND  16 PWATER PERO            2.143      RCHRES 198      EXTNL  IVOL
PERLND  26 PWATER PERO            6.306      RCHRES 198      EXTNL  IVOL
PERLND  34 PWATER PERO            1.429      RCHRES 198      EXTNL  IVOL
PERLND  44 PWATER PERO            4.205      RCHRES 198      EXTNL  IVOL
IMPLND  14 IWATER SURO            3.091      RCHRES 198      EXTNL  IVOL
*****************************************************************************
*** DM22
PERLND  16 PWATER PERO            0.381      RCHRES 198      EXTNL  IVOL
PERLND  26 PWATER PERO            4.654      RCHRES 198      EXTNL  IVOL
PERLND  34 PWATER PERO            0.218      RCHRES 198      EXTNL  IVOL
PERLND  44 PWATER PERO            2.620      RCHRES 198      EXTNL  IVOL
PERLND  54 PWATER PERO            0.016      RCHRES 198      EXTNL  IVOL
IMPLND  14 IWATER SURO            1.972      RCHRES 198      EXTNL  IVOL
*****************************************************************************

*** NONCONTIGUOUS GROUNDWATER BASINS
*****************************************************************************
*** G1
PERLND  16 PWATER AGWO            2.833      RCHRES   5      EXTNL  IVOL
PERLND  26 PWATER AGWO            9.917      RCHRES   5      EXTNL  IVOL
*****************************************************************************
*** G2
PERLND  16 PWATER AGWO            0.417      RCHRES 193      EXTNL  IVOL
PERLND  26 PWATER AGWO            1.333      RCHRES 193      EXTNL  IVOL
*****************************************************************************
*** G3
PERLND  16 PWATER AGWO            5.083      RCHRES 193      EXTNL  IVOL
PERLND  26 PWATER AGWO           17.667      RCHRES 193      EXTNL  IVOL
PERLND  34 PWATER AGWO            1.167      RCHRES 193      EXTNL  IVOL
PERLND  44 PWATER AGWO            4.250      RCHRES 193      EXTNL  IVOL
*****************************************************************************
*****************************************************************************

*** CHANNEL NETWORK LINKAGES ***
*****************************************************************************


*****************************************************************************

*** PUMP STATION OVERFLOW TO SDS
*****************************************************************************
RCHRES 360 HYDR   OVOL   2                   RCHRES  36      EXTNL  IVOL
RCHRES 366 HYDR   OVOL   2                   RCHRES   5      EXTNL  IVOL
*****************************************************************************

*** EAST BRANCH OF CREEK
*****************************************************************************
RCHRES  34 HYDR   OVOL   1                   RCHRES  35      EXTNL  IVOL
RCHRES  35 HYDR   ROVOL  1                   RCHRES  37      EXTNL  IVOL
RCHRES  36 HYDR   ROVOL  1                   RCHRES 338      EXTNL  IVOL
COPY    15 OUTPUT MEAN   1                   RCHRES 338      EXTNL  IVOL
RCHRES  39 HYDR   ROVOL  1                   RCHRES 338      EXTNL  IVOL
```

```
RCHRES  37 HYDR    ROVOL  1                     RCHRES 338     EXTNL  IVOL
RCHRES 338 HYDR    ROVOL  1                     RCHRES  38     EXTNL  IVOL
RCHRES  38 HYDR    ROVOL  1                     RCHRES   5     EXTNL  IVOL
RCHRES   5 HYDR    ROVOL  1                     RCHRES  40     EXTNL  IVOL
RCHRES  40 HYDR    ROVOL  1                     COPY     5     INPUT  MEAN   1
*******************************************************************************

*** WEST BRANCH OF CREEK
*******************************************************************************
RCHRES  20 HYDR    ROVOL  1                     COPY     9     INPUT  MEAN   1
RCHRES  42 HYDR    ROVOL  1                     COPY     9     INPUT  MEAN   1
COPY     9 OUTPUT  MEAN   1                     RCHRES   4     EXTNL  IVOL
RCHRES   4 HYDR    ROVOL  1                     COPY    41     INPUT  MEAN   1
COPY    50 OUTPUT  MEAN   1                     RCHRES   3     EXTNL  IVOL
RCHRES   3 HYDR    ROVOL  1                     COPY     4     INPUT  MEAN   1
RCHRES   7 HYDR    ROVOL  1                     COPY     4     INPUT  MEAN   1
RCHRES   9 HYDR    ROVOL  1                     COPY     4     INPUT  MEAN   1
COPY    41 OUTPUT  MEAN   1                     RCHRES  43     EXTNL  IVOL
COPY     4 OUTPUT  MEAN   1                     RCHRES  43     EXTNL  IVOL
RCHRES  43 HYDR    OVOL   1                     RCHRES  12     EXTNL  IVOL
RCHRES  10 HYDR    ROVOL  1                     COPY     5     INPUT  MEAN   1
RCHRES  12 HYDR    ROVOL  1                     COPY     5     INPUT  MEAN   1
*******************************************************************************

*** MAINSTEM BELOW CONFLUENCE OF E. AND W. BRANCH
*******************************************************************************
*** MAINSTEM ABOVE EXECUTEL TRIBUTARY
COPY     5 OUTPUT  MEAN   1                     RCHRES  13     EXTNL  IVOL
RCHRES  13 HYDR    ROVOL  1                     RCHRES  14     EXTNL  IVOL
RCHRES  14 HYDR    ROVOL  1                     COPY    48     INPUT  MEAN   1
*******************************************************************************
*** EXECUTEL TRIBUTARY
RCHRES  46 HYDR    ROVOL  1                     RCHRES  47     EXTNL  IVOL
RCHRES  47 HYDR    ROVOL  1                     RCHRES  17     EXTNL  IVOL
RCHRES  17 HYDR    ROVOL  1                     COPY    48     INPUT  MEAN   1
*******************************************************************************
*** MAINSTEM FROM HEAD OF RAVINE TO NORTH BRANCH CONFLUENCE
COPY    48 OUTPUT  MEAN   1                     RCHRES  18     EXTNL  IVOL
RCHRES  18 HYDR    OVOL   1                     RCHRES 193     EXTNL  IVOL
RCHRES 193 HYDR    ROVOL  1                     COPY     1     INPUT  MEAN   1
*******************************************************************************
*** NORTH BRANCH RAVINE TO MAINSTEM
RCHRES 177 HYDR    ROVOL  1                     COPY     1     INPUT  MEAN   1
*******************************************************************************
*** MAINSTEM FROM NORTH BRANCH CONFLUENCE TO PARK BELOW MVD CULVERT
COPY     1 OUTPUT  MEAN   1                     RCHRES 198     EXTNL  IVOL
*******************************************************************************

END NETWORK

END RUN
```

AR 053192

HSPF Non-Contiguous Groundwater Areas

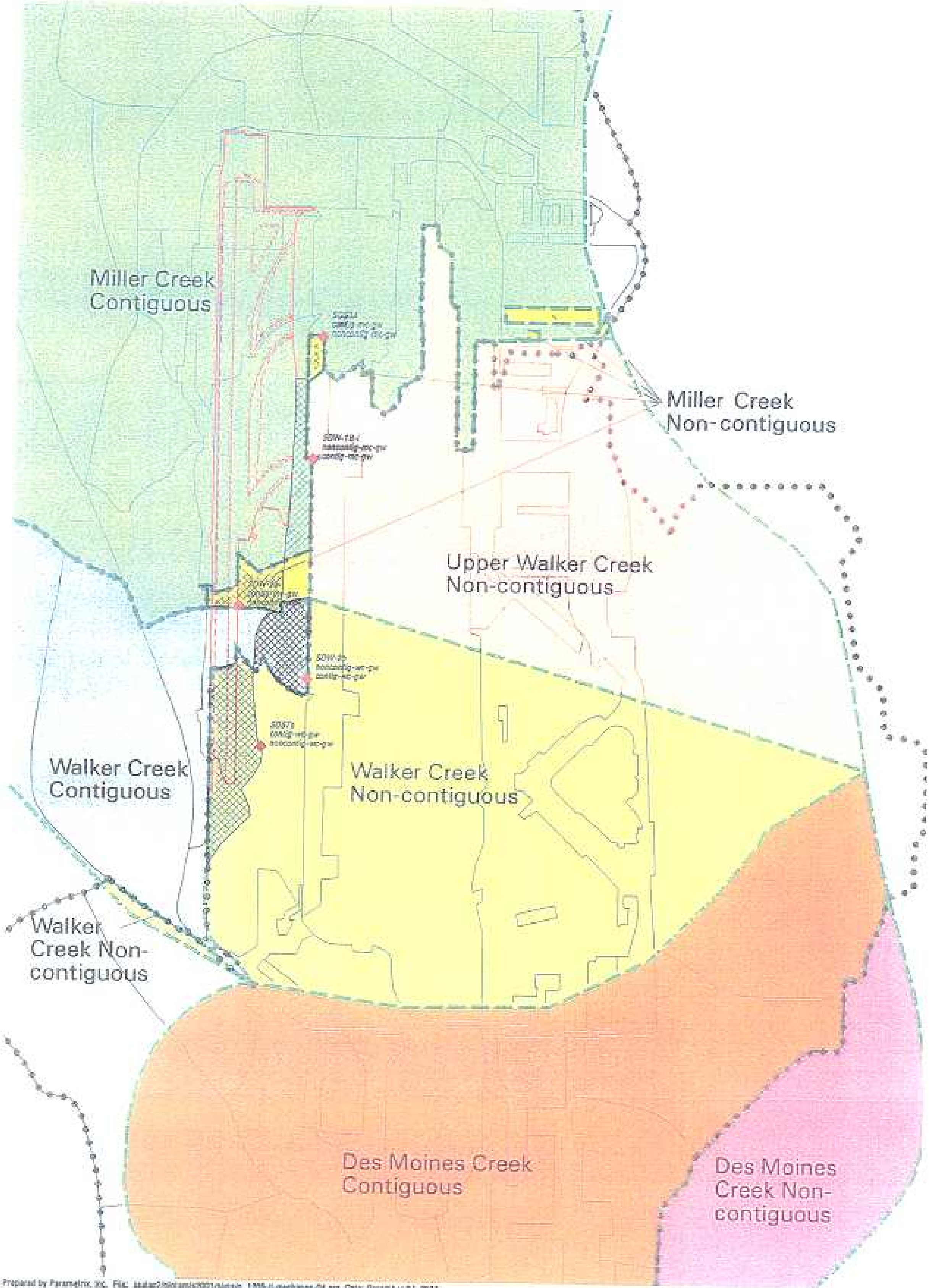
For the purposes of the low flow HSPF models, the project condition 2006 surface water basins were divided into contiguous and non-contiguous groundwater basins based on the future groundwater divide. A non-contiguous groundwater area occurs where the groundwater flows to a different stream or water body than the surface runoff from that same area. The attached figure shows the contiguous and non-contiguous groundwater areas for Des Moines, Walker, and Miller Creeks.

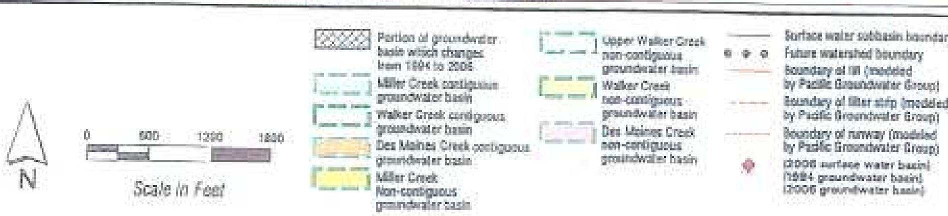
For Des Moines Creek, the groundwater routing of contiguous and non-contiguous areas for each subbasin was unchanged in the 1994 and 2006 conditions. Pervious land segments are per the land use tables contained in Appendix A.

For Walker Creek, during the calibration of the Walker Creek model, it was determined that 630 acres of non-contiguous groundwater area drain to the creek. The low flow models use 2006 surface water subbasin boundaries, which aren't necessarily coincident with the 1994 surface water subbasins used in the calibration model. Therefore, it was necessary to independently track those areas which transition from contiguous to non-contiguous, and vice versa, from the 1994 subbasin boundaries to the 2006 subbasin boundaries. These transitional areas are hatched and labeled on the attached figure.

The groundwater routing from the transitional areas was tracked separately from the 630 acres of non-contiguous groundwater area. The pervious area of Walker Creek that transitions from non-contiguous to contiguous from the 1994 to the 2006 subbasin boundaries (groundwater basin SDW2B) was subtracted from the 630 acres to prevent double counting. These steps were taken so that the added impervious area from 1994 to 2006 conditions for each of the groundwater areas could be calculated.

For Miller Creek, there are three subbasins (SDW2, SDS3A, and SDE4) with non-contiguous groundwater areas that are routed to Miller Creek in the 1994 and 2006 conditions. SDS3A and SDE4 are located in the Des Moines Creek surface basin and SDW2 is located in the Walker Creek basin.





Change between Existing (1994) and Future (2006) Groundwater Basins

AR 053194