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Wetland and Stream Delineation Technical Report

Seattle-Tacoma International Airport Sustainable Airport Master Plan (SAMP) Near Term Projects Wetlands and Streams Report

Prepared for
Port of Seattle

February 2024

Parametrix

Seattle-Tacoma International Airport Sustainable Airport Master Plan (SAMP) Near Term Projects Wetlands and Streams Report

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Acronyms and Abbreviations

AAA	Airport Activity Area
AOA	Airport Operations Area
BMPs	best management practices
Corps	U.S. Army Corps of Engineers
CWA	Clean Water Act
Ecology	Washington State Department of Ecology
EPA	U.S. Environmental Protection Agency
FAA	Federal Aviation Administration
GIS	geographic information system
HGM	hydrogeomorphic (classification)
HPA	Hydraulic Project Approval
NOAA	National Oceanic and Atmospheric Administration
NRCS	Natural Resources Conservation Service
NWI	National Wetlands Inventory
OHWL	ordinary high water line
PHS	Priority Habitats and Species
RSA	Runway Safety Area
SASA	South Airport Support Area
SMC	SeaTac Municipal Code
SP	Soil Plot
SR	State Route
USDA	U.S. Department of Agriculture
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
WAC	Washington Administrative Code
WDFW	Washington State Department of Fish and Wildlife
WDNR	Washington State Department of Natural Resources
WRIA	Water Resource Inventory Area
WSDOT	Washington State Department of Transportation

1. Introduction

Parametrix prepared this report on behalf of the Port of Seattle to determine the presence and location of wetlands, streams, and other waters within the SAMP Near Term Project (NTP) study area. Methods and results of the wetland and stream investigation in accordance with federal, state, and City of SeaTac regulations are detailed below. Included in this report is information from wetlands and other waters delineation conducted in 2019 and 2020, with updates based on the wetland and waters verification conducted in 2024.

1.1 General Study Area

The General Study Area (GSA) represents the area where it is anticipated that direct or indirect impacts may occur as a result of constructing the Proposed Action or its alternatives. The GSA includes an area encompassing 3,692 acres (5.8 square miles) that is bounded by S. 140th Street to the north, 33rd Avenue S. to the east, S. 20th Street to the South, and Des Moines Way to the west. Within the GSA, Parametrix conducted field delineations in 2019 and 2020 and verifications in 2024 in areas that would be directly impacted by a proposed project. All of the areas of direct impact are located entirely within the City of SeaTac in King County, Washington, within Sections 16, 20, 21, 29, and 31 of Township 23 North, Range 4 East of the Willamette Meridian and Section 4 of Township 22 North, Range 4 East of the Willamette Meridian. For the purposes of this report, the GSA was divided into six study area zones where the direct impacts would be located: the North Study Area Zone, the North Runway Safety Area (RSA) Study Area Zone, the West Study Area Zone, the South RSA Study Area Zone, the East Study Area Zone, and the Runway Study Area Zone. See Figure 1-1 for the GSA and study area zone locations. The North Study Area extends beyond the GSA to include the full boundary of wetland systems that may be potentially impacted.

The North Study Area Zone is 127 acres and extends north from State Route (SR) 518. This area is currently used as vegetated open land and park space. During the 1980s and 1990s, the Port of Seattle acquired these parcels to address noise-related issues. At that time these parcels were used for residential housing. The Port of Seattle cleared most structures off the parcels. Some old roadways and foundations persist, as well as horticultural species from the landscaping. A portion of this land is part of a lease agreement with the City of SeaTac for use as park space.

The North RSA Study Area Zone comprises the Miller Creek Regional Detention Facility and extends north from the airport runways to SR 518. The Miller Creek Regional Detention Facility receives a high volume of stormwater runoff from the airport. The main features are the mainstem Miller Creek and a large wetland complex partitioned by roads maintained for lighting tower access, of which Lake Reba is a part. Lake Reba is a stormwater feature constructed by King County in 1973 (Port of Seattle 2019b). There is also stormwater infrastructure in the upland between the runways and the stream/wetland complex.

The West Study Area Zone extends from the southern boundary of the Miller Creek Buffer Mitigation area to the corner parcel between SR 509 and the airport. This area was previously residential housing and is currently forested open land, wetland, stormwater facilities, and maintenance facilities.

The South RSA Study Area Zone contains the fuel farm area, the former Tyee Valley Golf Course, wetlands, stormwater facilities, and mitigation areas. The former Tyee Valley Golf Course was operational until 2014. The Port has since removed all golf course-related structures and routinely mows and maintains this area.

The Runway Study Area Zone is within the Airport Operations Area (AOA) and is maintained to abide by Federal Aviation Administration (FAA) standards.

The East Study Area Zone is between the northeast corner of the Seattle-Tacoma International Airport and SR 99. This area comprises commercial/industrial uses and the Bonney-Watson Cemetery.

1.2 Landscape Setting

The study area is located within the nearshore subwatershed of Water Resource Inventory Area (WRIA) 9 and contains portions of the Miller/Walker Creek, Gilliam Creek/Lower Green River, and Des Moines Creek drainage basins (See Figure 1-1). The Miller Creek/Walker Creek drainage basin is primarily residential but also includes significant areas of commercial/industrial and parkland uses, as well as large, forested wetlands. The north and western portions of the study area drain into the Miller Creek/Walker Creek drainage basin. The East Fork of Miller Creek originates from a series of wetlands and flows into the Miller Creek Regional Detention Facility within the North RSA Study Area Zone. The West Fork Miller Creek occurs outside of the study area and also flows into the Regional Detention Facility. Miller Creek continues outside the overall study area and through a series of Port mitigation sites, off Port property, before eventually reaching the Puget Sound. The Walker Creek headwaters originate within the study area directly west of the airport and flow west outside of the study area into a large, forested wetland west of SR 509. Walker Creek flows into Miller Creek before reaching the Puget Sound. Lower Walker Creek and lower Mill Creek are listed on Ecology's 303d list as Category 5 for bacteria, dissolved oxygen, and temperature standards (2024a). The proposed *Miller and Walker Creek Basin Plan* was completed in 2006 (King County). The basin plan is in draft form and has not yet been adopted by the local governments; however, portions of the plan have been implemented.

The Gilliam Creek/Lower Green River drainage basin is located east of the airport near SR 518 and I-5 interchange. Gilliam Creek flows east and drains into the Lower Green River. The drainage basin consists of residential, commercial/industrial (including the airport), and open land/parkland uses. A small portion of Gilliam Creek is listed in the Washington State Department of Ecology (Ecology) 303d-list for bioassessment standards (Ecology 2024a).

The southern portion of the study area drains into the Des Moines Creek drainage basin. This drainage basin consists of aviation, residential, commercial/industrial, and open land/parkland uses. Several large wetland and stream mitigation areas maintained by the Port of Seattle and basin committee are present within this basin. The East Branch of Des Moines Creek originates from Bow Lake and flows south through the former Tyee Valley Golf Course. The west branch of Des Moines Creek joins the East Branch of Des Moines Creek within the Des Moines Creek Regional Detention Facility mitigation area. The entire stream from origin to its terminus in the Puget Sound is listed on Ecology's 303d-list for bacteria, copper, dissolved oxygen, and temperature standards (Ecology 2024a).

1.3 Regulatory Framework

Wetlands and other waters including streams in the project area are subject to federal, state, and local regulations. Before construction of NTPs that would impact wetlands or other waters, the Port would need to meet the requirements of these regulations. At the federal level, wetlands and other waters are regulated by Section 404 of the Clean Water Act (CWA), which regulates placement of fill in waters of the United States. The U.S. Army Corps of Engineers (Corps) is responsible for issuing permits under Section 404 of the CWA. Other federal agencies with regulatory responsibility over wetlands and waters include the U.S. Environmental Protection Agency (EPA), which reviews applications for Water Quality Certifications under Section 401 of the Clean Water Act, and the National Oceanic and Atmospheric Administration (NOAA), which oversees Endangered Species Act consultation for anadromous fish species. At the state level, Ecology implements the Section 401 Water Quality Certification program by reviewing projects for compliance with state water quality standards and makes permitting and mitigation decisions based on the nature and extent of impacts, as well as the type and quality of wetlands or streams being affected. Additionally, Ecology issues administrative orders under the state Water Pollution Control Act (Chapter 90.48 Revised Code of Washington (RCW)) to regulate impacts to wetlands considered non-federally jurisdictional. Activities that use, divert, obstruct, or change the flow of a water of the state, including streams and some wetlands, typically require a Hydraulic Project Approval (HPA) issued by the Washington State Department of Fish and Wildlife (WDFW). In addition, Native American Tribes participate in the regulatory process to ensure protection of their treaty fishing rights and through consultation under Section 106 of the National Historic Preservation Act.

To comply with these regulations, the Port will document proposed project impacts and mitigation through the completion of a Joint Aquatic Resource Permit Application (JARPA). The agencies with jurisdiction will review the JARPA and determine whether the projects comply with the regulations and whether the proposed mitigation is sufficient to address the identified impacts. Permit approvals typically include a set of conditions with which the applicant must comply during project construction and operation, such as best management practices (BMPs) to minimize impacts and monitoring of construction activities and mitigation sites. In addition, the construction contractor will be required to develop a stormwater management plan to ensure compliance with the Construction Stormwater General Permit.

The Port and City of SeaTac signed an ILA (ILA) in 2018 which addresses the Port’s compliance with the City’s critical areas ordinances on Port-owned property within City boundaries. The Port complies with City of SeaTac critical areas codes (SMC Chapter 15.700) to the extent practicable. The 2018 Port-SeaTac Interlocal Agreement (ILA) states that the Port administers permitting within an area identified as the Airport Activities Area (AAA) while the City of SeaTac administers permitting outside the AAA.

The only portion of the study area that is not within the AAA is the North Study Area Zone, which is subject to City of SeaTac permitting. Pertinent to this wetland and streams report, SMC 15.700.275 outlines the requirements for the identification and rating of wetlands. SMC 15.700.285 outlines the wetland buffers and possible minimization measures. SMC 15.700.330 outlines the classification and buffers for streams.

2. Research Methods

This wetland and streams report reviewed conditions within the study area, as defined in Section 1.1. The wetland and stream analyses are based on data obtained through a review of existing information and field investigations. The goal of these efforts was to document existing information that reflects current site conditions, collect new information necessary to assess streams and wetland boundaries and identify any other waters of the United States and/or the State. This information was used to inform the wetland and stream delineation in 2019 and 2020 and verification in 2024.

2.1 Existing Information Review

Before conducting fieldwork, project biologists reviewed maps and materials including, but not limited to:

- Sea-Tac Airport Natural Resource Geodatabase (Port of Seattle 2019a)
- National Wetlands Inventory (NWI) online interactive mapper (USFWS 2024)
- Natural Resources Conservation Service (NRCS) Web Soil Survey (NRCS 2024)
- Forest Practices Application Mapping Tool (WDNR 2024)
- Northwest Indian Fisheries Commission Statewide Washington Integrated Fish Distribution database and mapping application (NWIFC 2024)
- Priority Habitats and Species (PHS) data (WDFW 2024a)
- WDFW Washington State Fish Passage Mapper (WDFW 2024bc)
- Washington State Water Quality Atlas for water quality standards (Ecology 2024a)
- Aerial photography of the project corridor (Google Earth database)
- Climate data for King County as measured at the Seattle-Tacoma International Airport Weather Station (ACIS 2019; 2020; 2024)
- Critical Areas code for the City of SeaTac (SeaTac 2023)
- Port-SeaTac ILA (2018a)
- Low Impact Development Guideline Seattle-Tacoma International Airport (Port of Seattle 2018b)
- Seattle-Tacoma International Airport Stormwater Management Manual (Port of Seattle 2017)
- Infiltration Infeasibility Assessment Seattle-Tacoma International Airport (Aspect 2018)
- Seattle-Tacoma International Airport Stormwater Pollution Prevention Plan (Port of Seattle 2019b)
- Seattle-Tacoma International Airport Final Environmental Impact Statement for the Proposed Master Plan Update Development Actions (Port of Seattle 1996)
- Third Runway Redelineation Assessment [Seattle-Tacoma International Airport 1997 Master Plan Update 2017 Wetland Redelineation Assessment (ESA 2017)]
- South Airport Support Area (SASA) Wetland and Stream Report (ESA 2015)

- Critical Areas Special Study Seattle-Tacoma International Airport Flight Corridor Safety Program (Anchor QEA 2016)

2.2 Wetland Identification and Delineation

Wetland assessments were based on a review of existing information on previously mapped wetlands, soil mapping, and other geographic and weather data, followed by field investigations, during which wetland boundaries were mapped on site. The methods for these assessment steps are described in the sections below.

A formal delineation of wetlands and waters was completed in 2019 and 2020. Project biologists used the methods specified in the *Corps of Engineers Wetlands Delineation Manual* (Environmental Laboratory 1987) and the indicators described in the *Regional Supplement to the Corps of Engineers Wetland Delineation Manual: Western Mountains, Valleys, and Coast Region* (Corps 2010) to delineate on-site wetlands. The delineated wetland boundaries and sample plot locations were instrument surveyed by professional land surveyors.

Wetlands were defined as those areas that are inundated or saturated by surface water or groundwater at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions. An area must have met these three criteria or exhibit at least one positive field indicator of wetland vegetation, soils, and hydrology to be considered a wetland. Wetland determination data forms from the *Regional Supplement to the Corps of Engineers Wetland Delineation Manual: Western Mountains, Valleys, and Coast Region* (Corps 2010) were recorded for each wetland. The wetland field assessment evaluated vegetation, soils, and hydrologic conditions. Each of these parameters is described in the following subsections.

Formal delineation of wetland boundaries and determination of agency jurisdiction are required only in areas where impacts will occur. To provide context, estimated boundaries were identified for certain stream and wetland features outside the study area that are not anticipated to be impacted or subject to regulatory compliance. Within the study areas, some boundaries (e.g., portions of the South RSA Study Area Zone) were estimated based on information from the Port regarding the locations of the NTPs. These include boundaries for wetlands and streams that are more than 225 feet (the maximum critical areas buffer width) from planned developments or are separated from planned developments by another wetland or stream.

In January 2024 biologists conducted a wetland and waters verification in to assess the quality and function of wetlands within the GSA. Wetland, streams, and jurisdictional tributary linework from the 2019/2020 delineations were loaded into ArcGIS Field Maps with connection to a DA2 Trimble device with sub-meter accuracy. This tool allowed biologists to review previous boundaries in the field and capture georeferenced photographs to document current conditions. Additionally, previous wetland rating forms were annotated in the field to document any changes (such as increases in invasive species, changes in vegetation classes, etc.), which may change the wetland rating.

2.2.1 Vegetation

During the field investigations by project biologists, dominant plant species were observed and recorded on data forms for each sample plot. The dominant plants and their wetland indicator status were evaluated to determine whether the vegetation was hydrophytic. Hydrophytic vegetation is generally defined as vegetation adapted to prolonged saturated soil conditions. To meet the hydrophytic vegetation criterion, typically more than 50 percent of the dominant plants must be

Facultative, Facultative Wetland, or Obligate, based on the plant indicator status category assigned to each plant species by the U.S. Fish and Wildlife Service (USFWS) (Lichvar et al. 2016).

Scientific and common plant names follow currently accepted nomenclature. Plant names are consistent with *Flora of the Pacific Northwest* (Hitchcock and Cronquist 2018), *Plants of the Pacific Northwest Coast* (Pojar and MacKinnon 2004), and the U.S. Department of Agriculture (USDA) PLANTS Database (USDA, NRCS 2019).

2.2.2 Soils

Generally, an area must have hydric soils to be regulated as a wetland. Hydric soil forms when soils are saturated, flooded, or ponded long enough during the growing season to develop anaerobic conditions in the upper layer. Biological activities in saturated soil result in reduced oxygen concentrations that cause a preponderance of organisms using anaerobic processes for metabolism. Over time, anaerobic biological processes result in accumulation of organic soil (e.g., peat) and/or certain mineral soil color patterns, which are used as field indicators of hydric soils. Soils were examined by excavating sample plots to a depth of at least 16 inches, where feasible, to observe soil profiles, colors, and textures. Munsell color charts (Munsell Color 2017) were used to describe soil colors.

2.2.3 Hydrology

The study area was examined for evidence of hydrology. An area is considered to have wetland hydrology when soils are ponded or saturated consecutively for 12.5 percent of the growing season. In the study area, the growing season (as determined using the Seattle-Tacoma International Airport weather station) is generally 306 days long and lasts from February 10 to December 13 (ACIS 2024). Therefore, ponding or saturation must be present for approximately 38 consecutive days at 28 degrees Fahrenheit or warmer. Primary indicators of hydrology include, but are not limited to, surface inundation, sediment deposits, high water table, and saturated soils. Secondary indicators of hydrology include drainage patterns, watermarks on vegetation, and water-stained leaves. A soil plot must meet two secondary indicators to have wetland hydrology.

Hydrology was investigated in the early growing season of 2020 to verify wetland hydrology conditions from fall 2019. Sample plots that did not meet primary indicators of hydrology during the fall field investigation were revisited in the spring when groundwater tables were recharged. Biologists sampled these flagged plots in March 2020. They excavated to depths of at least 20 inches and left these pits open for at least one hour to investigate for the presence of a groundwater table or saturation. The results of this hydrologic investigation are detailed throughout Section 3.3. Additionally, biologists noted hydrologic conditions during the January 2024 wetland and waters verification.

2.3 Wetland Classification, Rating, and Buffers

Delineated wetlands were classified according to the USFWS *Classification of Wetlands and Deepwater Habitats of the United States* (FGDC 2013; Cowardin et al. 1979). Hydrogeomorphic (HGM) classifications were assigned to wetlands using methods established by Brinson (1993). Wetlands were rated according to the *Washington State Wetland Rating System for Western Washington, 2014 Update Version 2* (Hruby & Yahnke 2023), as specified in SMC 15.700.275.B. City of SeaTac buffer widths are assigned based on the wetland rating score, with higher habitat values increasing buffer width (SMC 15.700.285.B). New wetland ratings were prepared for all wetlands within the GSA using the Washington Tool for Online Rating (WATOR) tool (Ecology 2024b).

See Table 2-1 below for the City of SeaTac Municipal Code standard buffer widths.

Table 2-1. Standard Buffer Widths from the City of SeaTac

Wetland Category	Habitat Score			
	3-4	5	6-7	8-9
	Buffer Width in Feet			
Category I	75	105	165	225
Category II	75	105	165	225
Category III	60	105	165	225
Category IV	40			

2.4 Stream Identification and Delineation

The Ordinary High Water Line (OHWL) was determined and delineated for all streams in the investigation areas using methods developed by Ecology (Stockdale et al. 2016) and the definition of "ordinary high water" in Washington Administrative Code (WAC) Section 220-660-030. The OHWL flags were instrument-surveyed by professional land surveyors.

According to SMC 15.700.330, streams within SeaTac are classified as Class 1, Class 2, or Class 3. Buffer widths assigned to streams in the study area reflect requirements of the City code (SMC 15.700.330.A).

- Class 1 Streams include only streams inventoried as "Shoreline of the State" under the adopted Shore Master Program and require a 100-foot buffer.
- Class 2 Streams include only streams smaller than Class 1 streams which flow year-round during years of normal rainfall or those which are used by salmonids and require a 100-foot buffer.
- Class 2 streams include only streams smaller than Class 1 streams which flow year-round during years of normal rainfall or those which are not used by salmonids and require a 50-foot buffer.
- Class 3 Streams include only streams which are intermittent or ephemeral during years of normal rainfall and which are not used by salmonids and require a 25-foot buffer.

Fish presence or absence was investigated using the review of existing information described in Section 2.1 above, or visual observation of fish.

2.5 Jurisdictional Tributaries

Some ditches in the GSA meet criteria to be considered under federal jurisdiction as "Tributaries" to Waters of the U.S. They also do not meet criteria to be considered wetlands or streams (which may also be tributaries to waters of the U.S. and are discussed in the sections above). Tributaries as defined here were identified following the Final Revised Definition of "Waters of the United States"

(EPA and USACE 2023). "Tributaries" in this context are ditches that ultimately flow into traditional navigable waters, the territorial seas, interstate waters, or impoundments of jurisdictional waters. These tributaries are documented and described in Section 3.3.3.

2.6 Additional Drainage Features

The Port of Seattle maintains various stormwater facilities including non-jurisdictional ditches, detention ponds, bioswales, and vaults. Parametrix reviewed the documented stormwater best management practices (BMPs) within the study area as described in the Seattle-Tacoma International Airport Stormwater Pollution Prevention Plan (Port of Seattle 2019b). Key stormwater features within the study area were identified in the field to distinguish these documented and maintained stormwater features from the jurisdictional wetlands and other waters in the study area.

2.7 Incorporating Previous Studies

Parametrix reviewed relevant and recent previous studies to provide a comprehensive review of wetlands and streams in the study area. The Port has been monitoring and assessing these wetlands repeatedly for over 20 years and has very good documentation of their extents (Port of Seattle 1996; ESA 2015, 2017; Anchor QEA 2016). The Port and its consultants had formally delineated wetlands as part of Clean Water Act permitting for the Third Runway project approved in 2004. Most of the permitted wetlands are also within the SAMP study area. Only the North Zone of the SAMP study area was excluded from the Third Runway permitting. The Third Runway permits required the Port to delineate wetlands in 2013 and 2017. The 2017 effort included confirming the presence of streams and wetlands in the North Zone and prepared functional ratings for the wetlands.

Parametrix used the information in the 2017 Redelineation Assessment and the natural resource geodatabase provided by the Port of Seattle to inform the 2019/2020 wetland and stream assessment within the SAMP Near Term Projects study area.

3. Results

The results of the background information review and field investigations for the wetland and stream are presented below. Wetland and stream delineations were conducted by project biologists from September to December 2019 with supplemental hydrologic studies conducted in March 2020. A wetland and waters verification to assess boundaries, wetland quality, and function was conducted in January 2024. Wetlands, streams, and other jurisdictional waters were identified and mapped within the study area and are described in detail in the sections below.

3.1 Review of Existing Information

The natural resources geodatabase provided by the Port (Port of Seattle 2019a) was reviewed prior to the field investigation. Figures from that geodatabase are presented in Figure A-1 in Appendix A of this report. The North Study Area Zone contains multiple wetland features, including Tub Lake, which outlets into the East Fork of Miller Creek within the study area. The West Fork of Miller Creek, originating outside of the study area, confluences with the East Fork of Miller Creek before flowing under SR 518. South of SR 518, Miller Creek flows south into the North RSA Study Area Zone and into the Miller Creek Buffer Mitigation Area.

Data from the NWI (USFWS 2024), PHS (WDFW 2024a), and WDNR (2024) also show multiple streams, wetlands, ponds, and lakes mapped throughout the study area (Figures A-4, A-5, and A-6 in Appendix A of this report). Within the North and North RSA Study Area Zones, USFWS (2024) maps wetlands associated with Tub Lake (PFOC/PSSC/PEM1F/PUBH), Lake Reba (PSSC, PUBHx) and other small emergent (PEM) wetlands. Miller Creek and drainage from Tub Lake are mapped flowing south through the North RSA and North Study Area Zones. Miller Creek is mapped as continuing south into the Miller Creek Buffer Mitigation Area just north of the West Study Area Zone. Within the West Study Area Zone, USFWS maps only one small emergent wetland (PEM1Ch). West of this Study Area Zone is a large, forested wetland (PFOC) complex called Airport Park, which drains into Walker Creek (R4SBC). Within the South RSA Study Area Zone, USFWS maps the east branch of Des Moines Creek with riverine wetland features (R4SBC). The east and west branches of Des Moines Creek converge south of the study area. East of the study area within the Gilliam Creek/Lower Green River drainage basin, USFWS maps a small section of Gilliam Creek (R5UBH) flowing north along SR 518 and paralleling I-5 for a short distance. (Figure A-3 in Appendix A of this report).

SWIFD (NWIFC 2024) maps the potential presence of coho salmon (*Oncorhynchus kisutch*) in Miller Creek within the study area. PHS maps resident coastal cutthroat trout (*Oncorhynchus clarkii*) occurrence within Miller Creek and Des Moines Creek within the study area. PHS also maps northwestern pond turtle (*Actinemys marmorata*) in township (T23R04E) in the North wetland zone of the study area (WDFW 2024a).

Three soil types were identified and mapped in the study area by NRCS (2024):

- Urban land (Hydric Rating: 0)
- Urban land-Alderwood complex (Hydric Rating: 10)
- Alderwood-Everett-Urban Land complex (Hydric Rating: 5)

Most soils mapped within the study area have been extensively disturbed and have a low hydric rating. Urban soils are incorporated with the Alderwood and Everett soils series throughout the study area. The Alderwood soil series consists of moderately well-drained soils formed in glacial drift and outwash. The A horizon of these soils (0-7 inches) is typically a very dark grayish brown (10YR 3/2) gravelly sandy loam. The Bw1 horizon (7-20 inches) is typically a dark yellowish brown (10YR 4/4) very gravelly loam. The Everett soil series consists of somewhat excessively drained soils formed of historic glacial features. The A horizon (0-2 inches) is typically a very dark brown (7.5YR 2.5/2) very gravelly sandy loam. The Bw horizon (2-24 inches) is a dark brown (7.5YR 3/4) very gravelly sandy loam (NRCS 2024). See Figure A- 7 in Appendix A of this report for the mapped locations of these soils within the study area.

3.1.1 Existing Information Review for the Runway Study Area Zone

Several small portions of the runway of the Seattle-Tacoma International Airport are within the study area and collectively make up the Runway Study Area Zone (see Figure 1-1). The Seattle-Tacoma International Airport Infiltration Infeasibility Assessment and Low Impact Development Guideline were reviewed to gain background information on modifications to the runway (Aspect 2018; Port of Seattle 2018b).

All of the soils within the Runway Study Area Zone of the Airport Operations Area (AOA) have been heavily manipulated. All of this area is covered with fill material or pavement. According to Table 3-1 in the Infiltration Infeasibility Assessment, soils within the AOA are compacted per FAA requirements. The majority of soils within the AOA area are also covered with filtration strips, which include compost amendments 4 inches deep (see Figure A-14 in Appendix A of this report, extracted from the Low Impact Development Guideline) (Port of Seattle 2018b).

Because of the documented fill material and compost amendments, the Runway Study Area Zone within the AOA does not contain regulated wetlands, streams, or other waters.

3.2 Climate Data

According to the NRCS climate analysis for wetlands tables (WETS tables) recorded at the Seattle-Tacoma International Airport weather station (ACIS 2019), the period (June, July, August) prior to the September 2019 field investigation had normal hydrologic conditions. The 3-month period prior to October had hydrologic conditions wetter than normal. The 3-month period prior to November and December had normal hydrologic conditions. September received 3.32 inches of rainfall and was much wetter than the high end of the recorded average range (2.01 inches). October received 3.67 inches of rainfall and is within the recorded average range but within the very low end. November received 1.71 inches of rainfall, far below the lower end of the recorded average range (4.27 inches). While overall WETS tables compute to either normal or wetter than normal conditions for these months, there were several stretches of very dry conditions during October, November, and December with several weeks of 0 inches of rainfall.

The WETS tables recorded at the Seattle-Tacoma International Airport weather station (ACIS 2020) were analyzed for the 3-month period prior to the hydrology investigation on March 13 and 25, 2020. The 3-month period prior to March had hydrologic conditions wetter than normal conditions for this time frame.

The WETS table recorded at the Seattle-Tacoma International Airport weather station (ACIS 2024) were analyzed for the 3-month period prior to the wetland verification in January 2024. The 3-month period prior to January had hydrologic conditions wetter than normal conditions for this time frame. The WETS tables are provided in Figures A-8 through A-13 in Appendix A of this report.

This climatic information summarizes recent precipitation compared to normal monthly averages and provides a basis of what groundwater table and saturation levels may look like compared to the normal average. This assists biologists in determining adequate wetland hydrology and to investigate further if recent hydrology has not been normal.

3.3 Field Investigation Results

3.3.1 Wetlands

Wetland delineations in the study area occurred between September 25, 2019, and December 6, 2019. Biologists again visited the study area in March 13 and 25, 2020, to investigate wetland hydrology. Parametrix biologists identified and delineated 31 wetlands in the study area. A wetland and waters verification to assess boundaries, wetland quality, and function occurred in January 2024.

These wetlands are categorized by study area zones (North, North RSA, West, and South RSA). There were no wetlands documented within the Runway or East Study Area Zones. Wetlands within the North Study Area Zone are within City of SeaTac jurisdiction. The North RSA, West, and South RSA Study Area Zones are within the Port of Seattle jurisdiction. The wetland boundaries will be verified by the Corps during the permitting phase, and the Corps may also conduct a jurisdictional determination at its discretion. The permittee can also request a jurisdictional determination; however, the Port does not anticipate requesting a jurisdictional determination prior to permitting because the determination may expire or become invalid if Clean Water Act Rules change in the interim. Delineations are valid for 5 years.

Summaries of the wetlands in the study area are provided in Table 3-1. General background information is provided in Appendix A of this report, representative photographs are provided in Appendix B, wetland determination forms are provided in Appendix C, and wetland rating forms are provided in Appendix D. General characteristics of wetlands are discussed in the sections below. See Figures 3-1a to 3-1g for wetland locations mapped within the study area.

Wetlands were initially investigated in the late growing season, a time when groundwater tables may not be fully recharged. During this time direct observation of hydrology within some of the wetlands was limited and biologists had to rely on secondary indicators of hydrology in some areas. These areas were revisited in March 2020 when early season hydrology provided a clearer indication of wetland hydrology. Based on the WETS tables for the 3-month period prior to the hydrology investigation, hydrologic conditions were wetter than normal. Using this information, biologists were confident that sample plots, which were found to be dry during the March visit, did not meet wetland hydrology indicators. Early season hydrology and wetter than normal hydrologic conditions would present adequate wetland hydrology at this time. The results of this hydrology investigation are integrated within this report. Table A-2 within Appendix A of this report provides an overview table of groundwater monitoring efforts.

Table 3-1. Summary of Wetlands within the Study Area

Study Area Zone	Wetland	Area (square feet/acres)[a]	USFWS Classification[b]	HGM Classification[c]	Ecology/Local Rating (2014)[d]	Habitat Rating Score[e]	Buffer Width (feet)[f]
North	N3	826,374/18.9	PFO/PSS/PEM	Depressional	I	7	165
	N4	50,935/1.22	PFO/PSS	Slope	IV	4	40
	1	3,623/0.11	PSS	Slope	IV	3	40
	2	36,699/0.8	PFO/PSS/PEM	Slope	III	5	105
	A	3,954/0.11	PSS/PEM	Slope	III	4	60
North RSA	4	205,019/4.7	PFO	Depressional	II	6	165
	5	229,364/5.3	PFO	Depressional	II	6	165
	6	37,761/0.91	PFO	Depressional	II	6	165
	7	294,115/6.8	PFO/PSS/PEM	Depressional	II	6	165
	8	199,266/4.6	PFO/PSS/PEM	Depressional	I	7	165
	9	135,130/3.1	PFO/PSS/PEM	Depressional	II	6	165
	10	15,723/0.41	PFO/PSS	Depressional	III	6	165
	11	558/0.0	PFO	Depressional	III	4	60
West	39	113,256/2.6	PFO/PSS	Slope	III	6	165
	R15	97,629/2.21	PFO	Depressional/Riverine	II	7	165
	A20	23,889/0.55	PFO/PSS/PEM	Depressional	III	5	105
	A14a	8,974/0.21	PFO/PSS/PEM	Slope	III	6	165
	44	133,548/3.12	PFO	Riverine/Slope	II	6	165
	A14b	3,694/0.12	PFO/PEM	Slope	III	6	165
	R13	48,780/1.12	PFO	Riverine/Slope	II	6	165
	R14a	2,610/0.06	PFO	Riverine	II	6	165
	R15b	26,135/0.61	PFO	Riverine/Slope	II	6	165
	R9/37a/18	246,580/5.66	PFO	Depressional/Riverine	II	6	165
	R3	901/0.02	PEM	Riverine	II	6	165
	R2	3,485/0.08	PFO	Riverine	II	6	165
South RSA	E1	9,102/0.21	PFO	Slope	III	4	60
	DC	23,522/0.54	PFO/PSS/PEM	Riverine	II	6	165
	52A/DC	72,119/1.72	PFO	Slope	II	6	165
	DMC1	5/0.0	PSS/PEM	Slope	III	5	105
	DMC2	2,052/0.05	PSS/PEM	Slope	III	5	105
	52B	43,830/1.01	PFO/PSS	Slope	III	6	165
	52C	33,329/0.82	PFO/PEM	Riverine	II	6	165
	G12	105,560/2.41	PFO/PSS/PEM	Depressional/Slope	II	6	165
	G1	150/0.00	PFO/PSS	Slope	III	5	105
	G4	406/0.00	PSS	Slope	III	5	105
	G5	39796/0.93	PSS/PEM	Slope	III	5	105
	H	2962/0.07	PSS/PEM	Slope	III	5	105
	D	164,962/3.81	PFO/PSS	Riverine	II	6	165

a Total wetland area
b FGDC 2013; Cowardin et al. 1979. PFO = palustrine forested; PSS = palustrine scrub-shrub; PEM = palustrine emergent
c Brinson 1993
d Hruby & Yahnke 2023, SMC 15.700.275.B
e Habitat score based on Hruby & Yahnke 2023
f SMC 15.700.285.B

3.3.1.1 North Wetlands

Wetland N3

Wetland N3, otherwise known as Tub Lake, is a large depressional wetland located directly south of Sunset Park (see Figure 3-1g). Wetland N3 consists of a bog surrounded by forested and scrub-shrub wetland. Wetland hydrology is supported by both precipitation and locally high groundwater tables. There is small surface water inflow on the north end along the eastern boundary of Wetland N3 and an outflow stream (East Fork of Miller Creek) on the south end. Parametrix biologists delineated a small depressional lobe feature along the eastern boundary of Wetland N3 in 2019.

Soils sampled along the eastern boundary of Wetland N3 met the hydric soil criterion for Depleted Matrix (F3), Depleted Below Dark Surface (A11), and Black Histic (A3). Soil Plot WL N3-7 is representative of hydric soils present within Wetland N3. The top 2-inch layer is a very dark brown (10YR 2/2) loam. The bottom layer extending down to 13 inches is a dark grayish brown (10YR 4/2) loam with strong brown (7.5YR 5/6) redoximorphic features, therefore meeting the indicator for Depleted Matrix (F3).

Vegetation within the central bog portion of the wetland consists of Labrador tea (*Ledum groenlandicum*), stunted Western hemlock (*Tsuga heterophylla*) trees, and bog cranberry (*Vaccinium oxycoccos*). The bog portion of the wetland is outside of the study area and not assessed by Parametrix biologists. The scrub-shrub stratum surrounding the bog portion of Wetland N3 comprises hardhack (*Spiraea douglasii*), salmonberry (*Rubus spectabilis*), and redtwig dogwood (*Cornus sericea* [= *C. alba* in Lichvar, et al 2016]). The forested stratum surrounding the inner scrub-shrub stratum is primarily red alder (*Alnus rubra*), black cottonwood (*Populus balsamifera*), Western redcedar (*Thuja plicata*) and willow species (*Salix* spp.).

Wetland N3 is classified as palustrine forested, scrub-shrub, and emergent under the USFWS system and depressional under the HGM system.

Using the 2014 Ecology rating system, Wetland N3 scored as a Category II wetland with a habitat score of 7 points. However, Wetland N3 meets the Ecology's 2014 rating system definition of a bog and is considered a Category I wetland due to special characteristics. Therefore, Wetland N3 requires a regulated buffer of 165 feet (see table 2-1).

Wetland N4

Wetland N4 is located south of S 136th Street (see Figure 3-1g). This area was previously residential development until the 1980s and 1990s when the Port of Seattle acquired the properties and removed most of the structures. Parametrix entirely delineated this wetland. In some areas the boundaries vary from previous delineations. Hydrology for Wetland N4 is supported primarily by surface water runoff and groundwater expression off the hillslope. Wetland N4 is classified as palustrine forested/scrub-shrub/emergent under the USFWS system and slope under the HGM system.

Soils sampled within this wetland met the hydric soil criterion for Depleted Matrix (F3) and Redox Dark Surface (F6).

The forested stratum of Wetland N4 consists primarily of red alder, black cottonwood, Oregon Ash (*Fraxinus latifolia*), and weeping willow (*Salix babylonica*). The sapling and shrub stratum is dominated by invasive Himalayan blackberry (*Rubus armeniacus*). The herbaceous understory includes giant horsetail (*Equisetum telmateia*), lady fern (*Athyrium cyclosorum*), creeping buttercup (*Ranunculus repens*), and reed canarygrass (*Phalaris arundinacea*). The vegetated buffer surrounding the wetland is used as a park and contains walking and bike trails with high use. The vegetated buffer is primarily red alder, bigleaf maple (*Acer macrophyllum*), various remnant landscaping trees, Himalayan blackberry, and sword fern (*Polystichum munitum*).

Using the 2014 Ecology rating system, Wetland N4 scored as a Category III wetland with a habitat score of 4 points, thus requiring a regulated buffer of 40 feet (See Table 2-1).

Wetland 1

Wetland 1, approximately 0.1 acre, is located directly north of SR 518 in a previous residential area (see Figure 3-1f). Wetland 1 is classified as palustrine scrub-shrub under the USFWS system and depressional/slope under the HGM system. The primary sources of hydrology for Wetland 1 include surface water runoff and groundwater expression off the hillslope. Surface water leaves the wetland via a swale feature paralleling the road. Soils sampled within Wetland 1 met the hydric soil criterion for Depleted Below Dark Surface (A11). Soils sampled at SP WL 1-1 had a very dark gray brown (10YR 3/2) loam top layer 7 inches deep. The middle 2-inch layer was a grayish brown (2.5Y 5/2) loamy sand with dark yellowish brown (10YR 4/6) redoximorphic features. The bottom layer extending to 16 inches was a dark grayish brown (2.5Y 4/2) sand with dark yellowish brown (10YR 4/4) redoximorphic features.

The sapling and shrub stratum is dominated by Himalayan blackberry, salmonberry, and willow saplings. The herbaceous understory includes reed canarygrass, giant horsetail, lady fern, and creeping buttercup. The buffer surrounding Wetland 1 extends into Wetland 2 and into the remainder of the locally forested area and is then limited by roads and parking lots.

Using the 2014 Ecology rating system, Wetland 1 scored as a Category IV wetland with a habitat score of 3 points, thus requiring a regulated buffer of 40 feet (See Table 2-1).

Wetland 2

Wetland 2, approximately 0.8 acres, is located directly north of SR 518 in a previous residential area (see Figure 3-1f). Wetland 2 is classified as palustrine forest/scrub-shrub/emergent under the USFWS system and slope under the HGM system. A gravel road separates Wetland 2 and Wetland 1. The primary sources of hydrology for Wetland 2 include surface water runoff and groundwater expression off the hillslope.

Soils sampled within Wetland 2 met the hydric soil criterion for Redox Dark Surface (F6) and Depleted Matrix (F3). Soil Plot WL 2-5 is representative of hydric soils present within Wetland 2. This plot extends to a depth of 18 inches and consists of very dark grayish brown (10YR 3/2) gravelly loam soil with strong brown (7.5YR 4/6) redoximorphic features, thus meeting the indicator for Redox Dark Surface (F6).

The forested stratum of Wetland 2 consists primarily of red alder, black cottonwood, and willow species. The sapling and shrub stratum is dominated by Himalayan blackberry and willow saplings. The herbaceous understory is primarily reed canarygrass and creeping buttercup. The buffer surrounding Wetland 2 extends into Wetland 1 and into the remainder of the forested parcel and is then limited by roads and parking lots.

Using the 2014 Ecology rating system, Wetland 2 scored as a Category III wetland with a habitat score of 5 points, thus requiring a regulated buffer of 105 feet (See Table 2-1).

Wetland A

Wetland A is a small, previously unmapped wetland within the same forested area as Wetlands 1 and 2. Wetland A is classified as palustrine scrub-shrub/emergent under the USFWS system and slope under the HGM system. Wetland A extends along a hillslope and into a swale feature before draining into Ditch 7. Ditch 7 flows downslope into a catch basin and the NEPL bioswale stormwater feature. The primary sources of hydrology for Wetland A include stormwater runoff from the parking facility upslope and groundwater expression off the hillslope.

Soils sampled within Wetland A met the hydric soil criterion for Redox Dark Surface (F6). Soils sampled at SP WL A-1 had a very dark gray brown (10YR 3/2) gravelly sandy loam top layer 4 inches deep. The bottom layer extending to 13 inches was very dark gray brown (10YR 3/2) sandy loam with strong brown (7.5YR 4/6) and dark brown (7.5YR 3/4) redoximorphic features.

The sapling and shrub stratum of Wetland A is dominated by Himalayan blackberry. The herbaceous stratum is primarily reed canarygrass, velvetgrass *(Holcus lanatus*), and soft rush (*Juncus effusus*). The buffer surrounding Wetland A extends into forested parcel and is then limited by roads and parking facility upslope.

Using the 2014 Ecology rating system, Wetland A scored as a Category III wetland with a habitat score of 4 points, thus requiring a regulated buffer of 60 feet (See Table 2-1).

3.3.1.2 North RSA Wetlands

Wetland 5

Wetland 5 is located within the Miller Creek Regional Detention Facility. Wetland 5 is classified as palustrine forested under the USFWS system and depressional under the HGM system. Wetland hydrology is primarily supported by a high groundwater table and stormwater inputs. A perennial stream labeled as Stream A flows into the southwest corner of Wetland 5, with flows partially contributed from adjacent stormwater discharges (see Figure 3-1f).

Soils sampled within Wetland 5 met the hydric soil criterion for Depleted Matrix (F3) and Redox Dark Surface (F6). Soil Plot WL 5-1 is representative of hydric soils present within Wetland 5. The soil plot extends to a depth of 14 inches and consists of a dark gray (10YR 4/1) gravelly sandy loam with dark yellowish brown (10YR 3/4) redoximorphic features. Therefore, the soil plot meets indicators for Depleted Matrix (F3).

The forest stratum of Wetland 5 consists primarily of red alder, black cottonwood, and willow species. The sapling and shrub stratum is dominated by Himalayan blackberry, red-osier dogwood, and willow saplings. The herbaceous understory includes reed canarygrass, giant horsetail, lady fern, and small-fruited bulrush. The buffer surrounding Wetland 5 is limited by roads and the airport to the south. To the north and west the buffer abuts the Miller Creek riparian corridor and Lake Reba.

Using the 2014 Ecology rating system, Wetland 5 scored as a Category II wetland with a habitat score of 6 points, thus requiring a regulated buffer of 165 feet (See Table 2-1).

Wetland 6

Wetland 6 is located within the Miller Creek Regional Detention Facility. Wetland 6 is classified as palustrine forested under the USFWS system and depressional under the HGM system. Wetland hydrology is primarily supported by a high groundwater table and stormwater inputs. A seasonal stream labeled as Stream A flows into the northwest corner of Wetland 6. The stream openly flows for 40 feet within Wetland 6 before it flows into a culvert and is piped to Lake Reba (see Figure 3-1f).

Soils sampled within Wetland 6 met the hydric soil criterion for Depleted Matrix (F3) and Histosol (A1). Soil Plot WL 6-3 is representative of hydric soils present within Wetland 6. The top 2-inch layer was a very dark grayish brown (10YR 3/2) loam. The middle layer from 2 to 10 inches was a dark grayish brown (10YR 4/2) sandy loam. The bottom layer extending to a depth of 19 inches was a dark grayish brown (10YR 4/2) gravelly sandy loam with strong brown (7.5YR 4/6) redoximorphic features. Therefore, this soil plot met for Depleted Matrix (F3).

The forest stratum of Wetland 6 consists primarily of red alder, black cottonwood, and willow species. The sapling and shrub stratum is dominated by Himalayan blackberry, red-osier dogwood, and willow saplings. The herbaceous understory includes reed canarygrass, giant horsetail, soft rush, lady fern, and sword fern on hummocks. The buffer surrounding Wetland 6 is limited by roads and the stormwater pond to the south. To the north and west the buffer abuts the Miller Creek riparian corridor and Lake Reba.

Using the 2014 Ecology rating system, Wetland 6 scored as a Category II wetland with a habitat score of 6 points, thus requiring a regulated buffer of 165 feet (See Table 2-1).

Wetlands 4/7/8/9

Wetlands 4, 7, 8, and 9 are located within the Miller Creek Regional Detention Facility area (see Figure 3-1f). Reba Lake, Miller Creek, stormwater inputs, and a high groundwater table provide hydrology to these wetlands. These wetlands have the potential to store a high volume of incoming stormwater. Wetland 4 is classified as palustrine forested under the USFWS system and depressional under the HGM system. Wetlands 7, 8, and 9 are classified as palustrine forested/scrub-shrub/emergent under the USFWS system and depressional under the HGM system.

Soils sampled within Wetland 7 met the hydric soil criterion for Sandy Redox (S5) and Depleted Below Dark Surface (A11). Soils sampled at SP WL 7-2 had a very dark grayish brown (10YR 3/2) loam top layer 6 inches deep. The middle layer from 6 to 12 inches was grayish brown (2.5Y 5/1) sand with dark yellowish brown (10YR 4/6) redoximorphic features. The bottom layer extending to 22 inches was a dark gray (2.5Y 4/1) sand. Therefore, SP WL 7-2 meets the Sandy Redox (S5) and Depleted Below Dark Surface (A11) indicators.

The forest stratum for Wetlands 4, 7, 8, and 9 is primarily red alder, black cottonwood, and willow species. The sapling and shrub stratum is dominated by Himalayan blackberry, salmonberry, red-osier dogwood, and willow saplings. The herbaceous understory includes reed canarygrass, giant horsetail, soft rush, stinging nettle (*Urtica dioica*), lady fern, and sword fern on hummocks. The upland buffer for these wetlands is very limited by roads. Near the western edge of Wetland 9 there is a narrow road bisecting the Miller Creek riparian corridor. Wildlife connectivity may be possible in this area.

Under the 2014 Ecology rating system, Wetlands 4,7, and 9 scored as Category II with a habitat score of 6 points, thus requiring a standard buffer of 165 feet. Wetland 8 scored as a Category I with a habitat score of 7 points, thus requiring a standard buffer of 165 feet (see Table 2-1).

Wetland 10

Wetland 10 is located within the Miller Creek Regional Detention Facility. Wetland 10 is classified as palustrine forested/scrub-shrub under the USFWS system and depressional under the HGM system. Wetland 10 has no surface water outlet and with seasonal and occasional ponding.

Soils sampled within Wetland 10 met the hydric soil criterion for Loamy Mucky Mineral (F1). Soils sampled at SP WL 10-1 were a black (7.5YR 2.5/1) mucky loam to a depth of 22 inches.

The forested stratum of Wetland 10 consists primarily of red alder, black cottonwood, and Sitka willow. The sapling and shrub stratum is dominated by Himalayan blackberry, red-osier dogwood, and willow saplings. The herbaceous understory includes reed canarygrass, giant horsetail, lady fern, and small-fruited bulrush (*Scirpus microcarpus*). The buffer surrounding Wetland 10 is limited by roads and the airport to the south. To the north and west the buffer abuts the Miller Creek riparian corridor and Lake Reba.

Using the 2014 Ecology rating system, Wetland 10 scored as a Category III wetland with a habitat score of 6 points, thus requiring a regulated buffer of 165 feet (See Table 2-1).

Wetland 11

Wetland 11 is a small depressional wetland located directly south of Wetland 10. The majority of Wetland 11 was directly permanently impacted by the Third Runway Project, and the remaining wetland was impacted indirectly. Wetland 11 is classified as palustrine forested under the USFWS system and slope under the HGM system. The remaining portion of the wetland is 0.01-acre in size and is separated from Wetland 10 by an upland berm (see Figure 3-1f). The wetland receives stormwater inputs and has no outlet. Seasonal ponding occurs in over half of the wetland.

Soils sampled within Wetland 11 met the hydric soil criterion for Depleted Matrix (F3) and Depleted Below Dark Surface (A11). Soils sampled within Wetland 11 had a black (10YR 2/1) loam top layer 3 inches deep. The bottom layer extending to 15 inches was a dark gray (10YR 4/1) gravelly loam with dark yellowish brown (10YR 4/6) redoximorphic features.

The forest stratum of Wetland 11 is dominated by black cottonwood. The sapling and shrub stratum consists of Himalayan blackberry and willow saplings. No herbaceous understory vegetation was observed within the wetland during the field visit.

Using the 2014 Ecology rating system, Wetland 11 scored as a Category III wetland with a habitat score of 4 points, thus requiring a regulated buffer of 60 feet (See Table 2-1).

3.3.1.3 West Wetlands

Wetland 39

Wetland 39 is located near South 168 Street and is south of the Miller Creek Buffer Mitigation Area (see Figure 3-1e). The wetland is also directly northwest of the Port's Engineering and Survey field office. Wetland 39 is classified as palustrine forested/scrub-shrub under the USFWS system and slope under the HGM system. The primary source of hydrology to Wetland 39 is a shallow ground water table along the hillslope. During the field visit, most of the soil plots did not have a water table or saturation present within the top 12 inches of the soil plot but had the presence of oxidized rhizospheres as a primary wetland hydrology indicator. Only two plots, soil plot WL 39-7 and soil plot 12, had water table and/or saturation present within the top 12 inches.

Soils sampled within Wetland 39 met the hydric soil criterion for Depleted Matrix (F3), Redox Dark Surface (F6), and Depleted Below Dark Surface (A11). Soil Plot WL 39-2 is representative of hydric soils present within Wetland 39. The top 2-inch layer is a very dark gray (10YR 3/1) loam. The middle layer from 2 to 7 inches is a very dark gray (10YR 3/1) gravelly loam. The bottom layer extending down to 18 inches is a very dark gray (10YR 3/1) loam with dark yellowish brown (10YR 4/4) redoximorphic features, therefore meeting the indicator for redox dark surface (F6).

The forest stratum of Wetland 39 consists primarily of red alder, Oregon Ash, and weeping willow. Numerous trees present within the wetland appear to be remnant landscaping trees, such as pin oak (*Quercus palustris*). The scrub-shrub stratum is dominated by invasive Himalayan blackberry. The herbaceous understory includes giant horsetail, lady fern, and creeping buttercup. The buffer surrounding Wetland 39 is limited by roads and field office to the south. To the north the buffer habitat is contiguous with the Miller Creek Buffer mitigation area. The vegetated buffer is primarily red alder, bigleaf maple, various remnant landscaping trees, and Himalayan blackberry.

Using the 2014 Ecology rating system, Wetland 39 scored as a Category III wetland with a habitat score of 6 points, thus requiring a regulated buffer of 165 feet (See Table 2-1).

Wetland R15

Wetland R15 is located on the west side of the Seattle-Tacoma International Airport between Des Moines Drive South and FAA Seattle Terminal Radar Approach Control Facilities (TRACON) service road (see Figure 3-1e). Wetland R15 is classified as palustrine forested under the USFWS system and depressional under the HGM system. Within the southern portion of R15 there is a small culvert providing stormwater discharge into the wetland This area also sits within a topographic depression and collects surface water runoff from nearby impervious road surfaces. The northern portion of Wetland R15 has additional hydrology inputs provided by Miller Creek overbank flooding.

Soils sampled within Wetland R15 met the hydric soil indicator for Depleted Below Dark Surface (A11). Soils sampled at SP WL R15-1 had a very dark grayish brown (2.5Y 3/2) loam top layer 8 inches deep overlaying fragmented depleted layers with distinct redoximorphic concentrations.

The forest stratum of Wetland R15 consists primarily of red alder, Western redcedar, and black cottonwood. Numerous trees present within the wetland appear to be remnant landscaping trees, such as Japanese maple (*Acer palmatum*). The sapling and shrub stratum is dominated by invasive Himalayan blackberry and salmonberry. The herbaceous understory includes giant horsetail (*Equisetum telmateia*), lady fern, and creeping buttercup (*Ranunculus repens*). The buffer surrounding Wetland R15 is limited by roads and facilities in the WSDOT right-of-way to the south and west. To the north, the buffer habitat is contiguous with the riparian corridor of Miller Creek, all of which are within the Miller Creek Buffer mitigation area.

Using the 2014 Ecology rating system, Wetland R15 scored as a Category II wetland with a habitat score of 6 points, thus requiring a regulated buffer of 165 feet (See Table 2-1).

Wetland A20

Wetland A20 is located on a corner parcel west of the maintenance facility and is bound by SR 509, South 168th Street, and access roads. The portion of wetland on WSDOT right-of-way was estimated based on field observations and contour maps. Wetland A20 is located within a depression and extends up the gradual hillslope leading to the west airport tower. Wetland A20 is classified as palustrine forested/ scrub-shrub/ emergent under the USFWS system and depressional/slope under the HGM system. The northern boundary of the wetland along South 168th Street has water ponded within a swale feature. The primary sources of hydrology to Wetland A20 are stormwater inputs and groundwater expression along the hillslope.

Soils sampled within Wetland A20 met the hydric soil criterion for Depleted Matrix (F3). Soils sampled at SP WL A19b-2 had a top layer 7 inches deep consisting of dark gray (10YR 4/1) sandy loam soils with dark yellowish brown (10YR 4/4) redoximorphic features. The bottom layer extending to 16 inches was a dark gray (10YR 4/1) gravelly loamy sand with dark yellowish brown (10YR 4/4) redoximorphic features.

The forested stratum of Wetland A20 is dominated by red alder, black cottonwood, western redcedar, and willow species. The sapling and shrub stratum is dominated by Himalayan blackberry and willow saplings. Emergent vegetation within Wetland A20 consists primarily of reed canarygrass, creeping buttercup, and bentgrass (*Agrostis* sp.). The upland buffer surrounding the wetland is limited by roads on all sides. Vegetation within the upland buffer consists primarily of Himalayan blackberry, grasses, and remnant landscaping trees such as Japanese maple.

Using the 2014 Ecology rating system, Wetland A20 scored as a Category III wetland with a habitat score of 5 points, thus requiring a regulated buffer of 105 feet (See Table 2-1).

Wetland 44

Wetland 44 is located in a corner parcel between the third runway and SR 509 (see Figure 3-1d). Wetland 44 is classified as palustrine forested under the USFWS system and riverine/slope under the HGM system. The primary sources of hydrology to Wetland 44 are groundwater expression from a series of seeps along the hillslope and discharge from a low-flow mitigation well in the southeastern lobe of the wetland. These seeps and flow from the mitigation well drain directly into the headwaters of Walker Creek. During the field visit, there was channelized water flowing downslope into Walker Creek.

Soils sampled within Wetland 44 met the hydric soil criterion for Depleted Matrix (F3), Redox Dark Surface (F6), Depleted Below Dark Surface (A11), and Thick Dark Surface (A12). Soil Plot WL 44-7 is representative of hydric soils present within Wetland 44. The top 8-inch layer is a very dark gray (10YR 3/1) loam. The middle layer from 8 to 10 inches is a very dark grayish brown (10YR 3/2) loam with dark yellowish brown (10YR 4/6) redoximorphic features. The bottom layer extending down to 18 inches is a dark gray (2.5Y 4/1) loam with reddish yellow (7.5YR 6/8) redoximorphic features, therefore meeting the indicators for depleted matrix (F3) and depleted below dark surface (A11).

The forested stratum of Wetland 44 is dominated by red alder, black cottonwood, and Pacific willow. The sapling and shrub stratum is dominated by salmonberry and invasive Himalayan blackberry. The herbaceous understory includes giant horsetail, lady fern, and sword fern on hummocks. The upland buffer surrounding the wetland is limited by the airport to the east, SR 509 to the west, and the Engineering and Field Survey office to the north. Vegetation within the upland buffer consists primarily of red alder, black cottonwood, bigleaf maple, Himalayan blackberry, and common pasture grasses.

Using the 2014 Ecology rating system, Wetland 44 scored as a Category II wetland with a habitat score of 6 points, thus requiring a regulated buffer of 165 feet (See Table 2-1).

Wetland A14a/A14b

Wetlands A14a and A14b are small slope wetlands bisected by an old residential road and are located northeast of the Engineering and Survey Field office (see Figure 3-1e). These wetlands are directly south of the Miller Creek Buffer Mitigation area. Wetland A14a is classified as palustrine forest/scrub shrub/emergent under the USFWS system and slope under the HGM system. A14b is classified as palustrine forest/emergent under the USFWS system and slope under the HGM system. The primary sources of hydrology to these wetlands are stormwater inputs from South 168 Street and groundwater expression along the hillslope.

Soils sampled within Wetland A14b met the hydric soil indicator for Depleted Below Dark Surface (A11). Soils sampled at SP WL A14b-2 were black (2.5Y 2.5/1) and very dark gray (2.5Y 2.5Y/1) to a depth of 11 inches. Underneath these dark top layers were depleted very dark grayish brown (10YR 4/1) loam and sandy loam layers with distinct redoximorphic features extending to a depth of 16 inches.

The forested stratum of Wetlands A14a/A14b consists primarily of red alder and black cottonwood. The sapling and shrub stratum is dominated by invasive Himalayan blackberry, salmonberry, and oso berry (*Oemleria cerasiformis*). The herbaceous understory includes giant horsetail, lady fern, skunk cabbage (*Lysichiton americanus*), and small fruited bulrush (*Scirpus microcarpus*). The buffer surrounding these wetlands is limited by South 168th Street and 8th Avenue South to the south and west, respectively. To the north, the buffer habitat is contiguous with the riparian corridor of Miller Creek and additional wetlands, all of which are within the Miller Creek Buffer mitigation area.

Using the 2014 Ecology rating system, Wetlands A14a and A14b scored as Category III wetlands with a habitat score of 6 points, thus requiring a regulated buffer of 165 feet (See Table 2-1).

Wetlands R15b/14a/13

Wetlands R15b/14a/13 are riverine wetlands which receive overbank flooding from Miller Creek. These wetlands are classified as palustrine forested under the USFWS system and riverine under the HGM system. The wetlands are located within the Miller Creek Buffer mitigation area, and the site receives routine maintenance such as invasive species control.

The forest stratum of Wetlands R15b/14a/13 consists primarily of red alder, Western redcedar, and black cottonwood. The shrub stratum is dominated by salmonberry. The herbaceous understory includes giant horsetail, lady fern, and creeping buttercup.

Using the 2014 Ecology rating system, Wetlands R15b/14a/13 scored as a Category II wetland with a habitat score of 6 points, thus requiring a regulated buffer of 165 feet (See Table 2-1).

Wetlands R9/37a/18

Wetlands R9/37a/18 are located along Miller Creek east and southeast of the FAA Seattle TRACON building. These wetlands are classified as palustrine forested under the USFWS system and depressional/riverine under the HGM system. The wetlands are within a topographic depression and collect surface water runoff from nearby impervious road surfaces and receive overbank flooding from Miller Creek.

Using the 2014 Ecology rating system, Wetlands R9/37a/18 scored as a Category II wetland with a habitat score of 6 points, thus requiring a regulated buffer of 165 feet (See Table 2-1).

Wetland R3

Wetland R3 is a small riverine wetland which receives hydrologic input from Miller Creek. The wetland is located south of the S 157th Place crossing over Miller Creek. Wetland R3 is classified as palustrine emergent under the USFWS system and riverine under the HGM system.

Using the 2014 Ecology rating system, Wetland R3 scored as a Category II wetland with a habitat score of 6 points, thus requiring a regulated buffer of 165 feet (See Table 2-1).

Wetland R2

Wetland R3 is a small riverine wetland which receives hydrologic input from Miller Creek. The wetland is located north of the S 157th Place crossing over Miller Creek. Wetland R3 is classified as palustrine forested under the USFWS system and riverine under the HGM system.

Using the 2014 Ecology rating system, Wetland R3 scored as a Category II wetland with a habitat score of 6 points, thus requiring a regulated buffer of 165 feet (See Table 2-1).

3.3.1.4 South RSA Wetlands

Wetland E1

Wetland E1 is located southeast of the airport runways near the fuel tank farm and South 188 Street. Wetland E1 is classified as palustrine forested under the USFWS system and slope under the HGM system. The primary sources of hydrology include groundwater expression off the hillslope and stormwater inputs. Directly northeast of Wetland E1, there is a culvert with a small gravel fill pad below it.

Soils sampled within Wetland E1 met the hydric soil criterion for Depleted Matrix (F3) and Redox Dark Surface (F6). Soil Plot WL E1-1 is representative of hydric soils present within Wetland E1. The top 6-inch layer is a very dark brown (10YR 2/2) sandy loam. The bottom layer extending down to 17 inches is a very dark brown (10YR 2/2) sandy loam with distinct redoximorphic features, therefore meeting the indicators for Redox Dark Surface (F6).

The forested stratum of Wetland E1 is dominated by red alder, black cottonwood, western redcedar, and willow species. The sapling and shrub stratum is primarily Himalayan blackberry, hardhack, red-osier dogwood, and willow saplings. The herbaceous understory includes soft rush, lady fern, and sword fern on hummocks. The upland buffer surrounding the wetland is very limited by airport facilities.

Using the 2014 Ecology rating system, Wetland E1 scored as a Category III wetland with a habitat score of 4 points, thus requiring a regulated buffer of 60 feet (See Table 2-1).

Wetland 52A/Wetland DC

Wetland 52A is located along the East Fork Des Moines Creek directly southeast of the airport runways and extends into the former Tyee Valley Golf Course (see Figure 3-1b/c). Wetland 52A is classified as palustrine forest under the USFWS system and slope under the HGM system. The primary source of hydrology to Wetland 52A is groundwater expression from a series of seeps along the steep hillslope east of the creek. Stormwater sheet flow also enters the wetland from the Port of Seattle parking area and South 192nd Street upslope of the wetland. Des Moines Creek flows adjacent to Wetland 52A but is fairly incised and subsequently does not provide substantial overbank flooding to the wetland. The wetland is on a fairly steep slope and the majority of the wetland lies above the level of the creek.

Within the Des Moines Creek riparian corridor there is also wetland present below OHWL ((Wetland DC). The presence of wetland below the OHWL extends into the three smaller segments of Des Moines Creek near the fuel farm area (see Figure 3-1c).

Soils sampled within Wetland 52A met the hydric soil criterion for Depleted Matrix (F3), Depleted below dark surface (A11), and Loamy Gleyed Matrix (F2). Soil Plot WL 52A-3 is representative of hydric soils present within Wetland 52A. The top 5-inch layer is a black (10YR 2/1) loam. The middle layer from 5 to 10 inches is a very dark grayish brown (10YR 3/2) loam. The bottom layer extending down to 16 inches is a gray (10YR 6/1) sandy loam with dark yellowish brown (10YR 4/6) and light olive brown (2.5Y 5/3) redoximorphic features, therefore meeting the indicators for Depleted Matrix (F3) and Depleted Below Dark Surface (A11).

The forested stratum of Wetland 52A is dominated by red alder and Pacific willow. The sapling and shrub stratum is primarily dense invasive Himalayan blackberry, salmonberry, and Pacific willow saplings. The herbaceous understory includes giant horsetail, soft rush, lady fern, and sword fern on hummocks. The vegetated buffer surrounding the wetland is limited by parking lots and roads. The vegetated buffer extending into the former golf course offers connection to other habitat that is routinely maintained and disturbed. Vegetation within the upland buffer consists primarily of Lombardi poplar (*Populus nigra*), Himalayan blackberry, and grasses.

Using the 2014 Ecology rating system, Wetland 52A scored as a Category II wetland with a habitat score of 6 points, thus requiring a regulated buffer of 165 feet. Wetland DC also scored as a Category II wetland with a habitat score of 6 points, thus requiring a regulated buffer of 165 feet (See Table 2-1).

Wetlands 52B/52C/DMC1/DMC2/G1

Wetlands 52B, 52C, DMC1, DMC2, and G1 are located within the Des Moines Creek riparian corridor in the former Tyee Valley Golf Course (see Figure 3-1b). The Tyee Detention Pond has a downstream outlet control structure that backs up water from the East Fork of Des Moines Creek in the bowl-shaped local topography. Parametrix biologists found Wetland 52C to be entirely below the OHWL for the East Fork of Des Moines Creek. Wetlands 52B, DMC1, DMC2, and G1 are located along a hillslope and have hydrology supported by groundwater seeps. Wetland 52B is classified as palustrine forest/ scrub-shrub under the USFWS system and slope under the HGM system. Wetland 52C is classified as palustrine forest/emergent under the USFWS system and riverine under the HGM system. Wetland G1 is classified as palustrine forested and scrub-shrub under the USFWS system and slope under the HGM system. Wetlands DMC1 and DMC2 are palustrine scrub-shrub and emergent wetlands under the USFWS system and slope under the HGM system.

Soils sampled within Wetland 52B met the hydric soil criterion for Loamy Gleyed Matrix (F2). Soils at SP WL 52B-1 had a top 5-inch layer consisting of very dark grayish brown (10YR 3/2) silty clay loam. The bottom layer extending down to 14 inches was a dark greenish gray (10Y 4/1) gley soil.

Wetlands 52B, 52C, and G1 are primarily vegetated by red alder, black cottonwood, Himalayan blackberry, creeping buttercup, and pasture grasses. Wetlands DMC1 and DMC2 are dominated by reed canarygrass.

Under the 2014 Ecology rating system, Wetland 52C scored as a Category II with a habitat score of 6 points, thus requiring a standard buffer of 165 feet. Wetland 52B scored as a Category III with a habitat score of 6 points, thus requiring a standard buffer of 165 feet. Wetlands DMC1, DMC2, and G1 are Category III wetlands with a habitat score of 5 points, thus requiring a regulated buffer of 105 feet (See Table 2.1).

Wetland G12

Wetland G12 is located in the former Tyee Valley Golf Course (see Figure 3-1b). Wetland G12 is classified as palustrine forested/scrub-shrub/emergent under the USFWS system and depressional/slope under the HGM system. The primary source of hydrology to Wetland G12 appears to be a seasonally high groundwater table and seepage from the runway embankment. The wetland is ditched at the toe of the embankment slope and drains into a manhole.

Soils sampled within Wetland G12 met the hydric soil criterion for Depleted Matrix (F3) and Depleted Below Dark Surface (A11). Soil Plot WL G12-7 is representative of hydric soils present within Wetland G12. The top 7-inch layer is a very dark grayish brown (10YR 3/2) loam. The bottom layer extending down to 19 inches is a grayish brown (10YR 5/2) loam with dark yellowish brown (10YR 5/6) redoximorphic features, therefore meeting the indicators for depleted matrix (F3) and depleted below dark surface (A11).

The forested stratum of Wetland G12 is dominated by Lombardi poplar and willow species. Trees in the former golf course area are routinely trimmed to maintain line of sight. The sapling and shrub stratum is primarily dense invasive Himalayan blackberry, salmonberry, and willow saplings. Herbaceous vegetation is present in the maintained field area. This area consists primarily of bentgrasses *(Agrostis sp.*), bluegrasses (*Poa sp*.), and velvetgrass (*Holcus lanatus*). The upland buffer surrounding the wetland is limited by the airport to the west. The vegetated buffer extending into the former golf course offers additional habitat connectivity; however, this area is routinely maintained and disturbed.

Using the 2014 Ecology rating system, Wetland G12 scored as a Category II wetland with a habitat score of 6 points, thus requiring a regulated buffer of 165 feet (See Table 2-1).

Wetlands G4/G5

Wetlands G4 and G5 are located in the central portion of the former Tyee Valley Golf Course (see Figure 3-1b). Wetland G4 is classified as palustrine scrub-shrub under the USFWS system and slope under the HGM system. Wetland G5 is classified as palustrine scrub-shrub and emergent under the USFWS system and slope under the HGM system. These slope wetlands appear to have hydrology primarily supported by a seasonally high groundwater table. At a soil test pit within Wetland G5, Parametrix biologists found a high water table and saturation 8 inches below the surface. Soils at this pit were a black (10YR 2/1) mucky loam to a depth of 16 inches and met for the hydric soil criterion for Loamy Mucky Mineral (F1).

Wetland G4 is dominated Himalayan blackberry. Wetland G5 is primarily Himalayan blackberry, creeping buttercup, and typical pasture grasses including red fescue (*Festuca rubra*).

Under the 2014 Ecology rating system, Wetlands G4 and G5 scored as a Category III with a habitat score of 5 points, thus requiring a standard buffer of 105 feet (See Table 2-1).

Wetland H

Wetland H is located within former Tyee Valley Golf Course and is directly east of the gravel access road and Wetland G12 (See Figure 3-1b). The wetland lies in a small depression that drains along a gradual slope into a swale feature with no outlet. The primary source of hydrology is a seasonally high groundwater table. Wetland H is classified as palustrine scrub-shrub and emergent under the USFWS system and depressional/slope under the HGM system.

Soils sampled within Wetland H met the hydric soil criterion for Depleted Matrix (F3) and Depleted Below Dark Surface (A11). Soil Plot WLH-2 is representative of hydric soils present within Wetland H. The top 4-inch layer is a very dark brown (10YR 2/2) loam. The middle layer from 4 to 17 inches is a very dark grayish brown (10YR 3/2) loam with distinct redoximorphic features. The bottom layer extending down to 22 inches is a dark gray (2.5Y 4/1) loamy sand with distinct redoximorphic features.

Wetland H is dominated by typical pasture grasses including bluegrass and velvetgrass species and contains willow saplings.

Under the 2014 Ecology rating system, Wetland H scored as a Category III with a habitat score of 5 points, thus requiring a standard buffer of 105 feet (See Table 2-1).

Wetland D (Des Moines Creek Regional Detention Facility mitigation area)

Wetland D is located in the Des Moines Creek Regional Detention Facility mitigation area (under a restrictive covenant) (see Figure 3-1b). Wetland D is classified as palustrine forested/scrub-shrub under the USFWS system and riverine under the HGM system. This wetland holds the confluence of the east and west forks of Des Moines Creek and associated riparian habitat and extends into depressions within the maintained field to the north.

The vegetation within Wetland D consists of shrubs and younger saplings, such as willow species and redtwig dogwood along the northern boundary of the wetland. Further interior in the wetland there are red alder and conifer trees.

Under the 2014 Ecology rating system, Wetland D scored as a Category II with a habitat score of 6 points, thus requiring a standard buffer of 165 feet (See Table 2-1).

3.3.2 Streams

Parametrix biologists identified and delineated four streams in the study area. Summaries of the streams in the study area are provided in Table 3-2. All streams are governed by the City of SeaTac critical areas code (Chapter 15.30) as indicated by the 2018 Port-SeaTac ILA (Port of Seattle 2018a). General background information is provided in Appendix A, and representative photographs are provided in Appendix B of this report. General characteristics of the streams are discussed in the sections below.

Table 3-2. Summary of Streams within the Study Area

Stream	Stream Width (feet)[a]	Flow Duration	WDNR Classification[b]	USFWS Classification[c]	SeaTac Stream Class[d]	Standard Buffer (feet)[e]
Miller Creek	20	Perennial	F	R3UBH	2	50
Stream A	8	Perennial	F	None	2	50
Walker Creek	6	Perennial	F	None	2	50
East Fork of Des Moines Creek	30	Perennial	F	R4SBC	2	50

Stream	Stream Width (feet)[a]	Flow Duration	WDNR Classification[b]	USFWS Classification[c]	SeaTac Stream Class[d]	Standard Buffer (feet)[e]
Des Moines Creek	20	Perennial	F	PEM1Cx	2	100

[a] As measured within the study area
[b] WDNR FPARS mapping (2024), as mapped within the study area
[c] USFWS NWI mapping (2024), as mapped within the study area
[d] SMC 15.700.330: The Port of Seattle has adopted SMC 15.700.330 with respect to classification of streams and application of appropriate buffer widths.
[e] SMC 15.700.330.A: : The Port of Seattle has adopted SMC 15.700.330 with respect to classification of streams and application of appropriate buffer widths.

3.3.2.1 Miller Creek

Miller Creek flows south through the Miller Creek Regional Detention Facility and the Miller Creek Buffer Mitigation area within the study area. There is a full fish barrier on Miller Creek downstream of the study area (Site ID: 930591) (WDFW 2024b). Because the stream meets the physical characteristics for a fish-bearing stream as outlined in the WAC (222-16-031), the East Fork of Miller Creek is classified as fish-bearing. Therefore, according to SMC 15.700.330 (See Table 3-2 above), Miller Creek is classified as a Class 2 stream without salmonid use and would require a standard buffer of 50 feet (SMC 15.700.330.A).

3.3.2.2 Stream A

Stream A is a perennial stream that flows into the southwest corner of Wetland 5 through two culverts. Flows are partially contributed from stormwater discharge. The stream flows north through Wetland 5, through a culvert under the road, and into Wetland 6 where it daylights for 40 feet before flowing into a culvert. The downstream end of this culvert could not be located but likely flows into Lake Reba. WDFW maps the east end of the culvert as a partial fish barrier (Site ID: 938411) and the west end of the culvert as a full fish barrier (Site ID: 938410). There are also several other fish barriers between the surveyed portion of Stream A and Miller Creek, and a full fish barrier on Miller Creek (2019c). Because the stream meets the physical characteristics for a fish-bearing stream as outlined in the WAC (222-16-031), Stream A is classified as fish-bearing. Therefore, according to SMC 15.700.330 (See Table 3-2 above), Stream A is classified as a Class 2 stream without salmonid use and would require a standard buffer of 50 feet (SMC 15.700.330.A).

3.3.2.3 Walker Creek

The portion of Walker Creek within the Project study area consists of the headwater flows originating within Wetland 44 (see Figure 3-1c). These headwater flows are supported by groundwater seeps off the hillslope and drainage from a low-flow mitigation discharge well. These flows concentrate at the base of the hillslope and flow west through a culvert under SR-509 and into the Airport Park wetlands. The stream at the base of the hillslope within Wetland 44 is perennial. The headwaters of Walker Creek within the study area are unmapped by WDNR (2019a) and WDFW (2019a). Because the stream is perennial but does not support salmonids, it is classified as a Class 2 stream and requires a standard buffer of 50 feet (SMC 15.700.330.A).

3.3.2.4 East Fork of Des Moines Creek

The East Fork of Des Moines Creek originates from Bow Lake and flows through a series of subsurface pipes before daylighting southeast of the airport runways. From here the East Fork of Des Moines Creek flows through a narrow riparian corridor and into the former Tyee Valley Golf Course (see Figure 3-1b). The stream flows through the Tyee Detention Pond within the former golf course and then flows via a culvert into Des Moines Creek within the Des Moines Regional Detention Facility Mitigation Area (Wetland D). At the downstream end of the Tyee Detention Pond is an outlet control structure that blocks anadromous fish use. Because the stream meets the physical characteristics for a fish-bearing stream as outlined in the WAC (222-16-031), the East Fork of Des Moines Creek is classified as fish-bearing. Therefore, according to SMC 15.700.330 (see Table 3-2 above), the East Fork of Des Moines Creek is classified as a Class 2 stream without salmonid use and would require a standard buffer of 50 feet (SMC 15.700.330.A).

3.3.2.5 Des Moines Creek

The West Fork and East Fork of Des Moines Creek converge within the Des Moines Regional Detention Facility Mitigation Area south of the airport runways. According to the WDFW Washington State Fish Passage mapper, there is a potential barrier with an unknown status (Site ID: 09.0377 2.12) for the culvert conveying Des Moines Creek under South 200 Street (2024b). Because of the unknown status, it is assumed that the stream section north of the culvert does have anadromous fish use. Therefore, according to SMC 15.700.330 (See Table 3-2 above), Des Moines Creek is classified as a Class 2 stream with salmonid use and would require a standard buffer of 100 feet (SMC 15.700.330.A).

3.3.3 Jurisdictional Tributaries

Seven tributaries were identified in the study area. For the purposes of this review, the tributaries were considered to be under the jurisdiction of the Corps. The Corps will make a jurisdictional determination to confirm the status of the tributaries during the formal permitting process. Tributaries 1 through 7 are described below.

3.3.3.1 Tributary 1

Tributary 1 is 350 feet in length and conveys surface water runoff downslope along 8th Place North (see Figure 3-1e). Tributary 1 flows into a small culvert and likely discharges into Wetland A14b. Tributary 1 is 1 foot in width and is assumed to be intermittently flowing.

3.3.3.2 Tributary 2

Tributary 2 is 500 feet in length and conveys surface water runoff downslope along the gravel access road to the TRACON building (see Figure 3-1e). The Tributary flows into a stormwater treatment wetland and then outflows into Wetland A14b. Tributary 2 is 2 feet in width and is assumed to be intermittently flowing.

3.3.3.3 Tributary 3

Tributaries 3a and 3b are located within the WSDOT right-of-way along SR-509 and span 1,000 feet in length (see Figure 3-1e). Tributary 3a is 3 feet in width and flows downslope into a culvert and into Tributary 3b. Tributary 3b is approximately 5 feet in width, likely perennially flowing, and flows into the headwater streams of Walker Creek within Wetland 44.

3.3.3.4 Tributary 4

Tributary 4 is 100 feet in length and conveys surface water runoff downslope and into the headwaters of Walker Creek (see Figure 3-1d). Tributary 4 is 3 feet in width and is assumed to be intermittently flowing.

3.3.3.5 Tributary 5

Tributary 5 is 60 feet in length and flows downslope into Wetland 5 within the Miller Creek Regional Detention Facility (see Figure 3-1f). Tributary 5 is 1 foot in width and is assumed to be intermittently flowing.

3.3.3.6 Tributary 6

Tributary 6 is 90 feet in length and is located in the forested parcel north of SR 518. Wetland A is directly upslope and discharges surface water flows in Tributary 6 (see Figure 3-1f). Tributary 6 flows downslope and drains into a catch basin and into a stormwater treatment wetland. The tributary then flows along SR 518 and then conveyed under the road and into the Miller Creek Regional Detention Facility. Tributary 6 is 2 feet in width and is assumed to be intermittently flowing.

3.3.3.7 Tributary 7

Tributary 7 comprises three segments separated by small culverts under pavement. Tributary 7a, 7b, and 7c span 450 feet and flow south along the east side of 16th Avenue, directly across from the PacWest baseball fields (see Figure 3-1f). Tributary 7 is approximately 4 feet in width, is assumed to be intermittently flowing, and ultimately drains into the Miller Creek Regional Detention Facility. SP-4(UPL) was excavated within the Tributary 7a segment and confirmed non-wetland conditions.

3.3.4 Stormwater Features

Four key stormwater facilities were identified within the SAMP Near Term Project study area and are documented stormwater best management practices (BMPs) in the Seattle-Tacoma International Airport Stormwater Pollution Prevention Plan (Port of Seattle 2019b). These particular stormwater features are identified to distinguish them from jurisdictional wetland features within the study area. These key stormwater features are mapped on Figures 3-1a to 3-1g.

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5. List of Preparers

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Figures

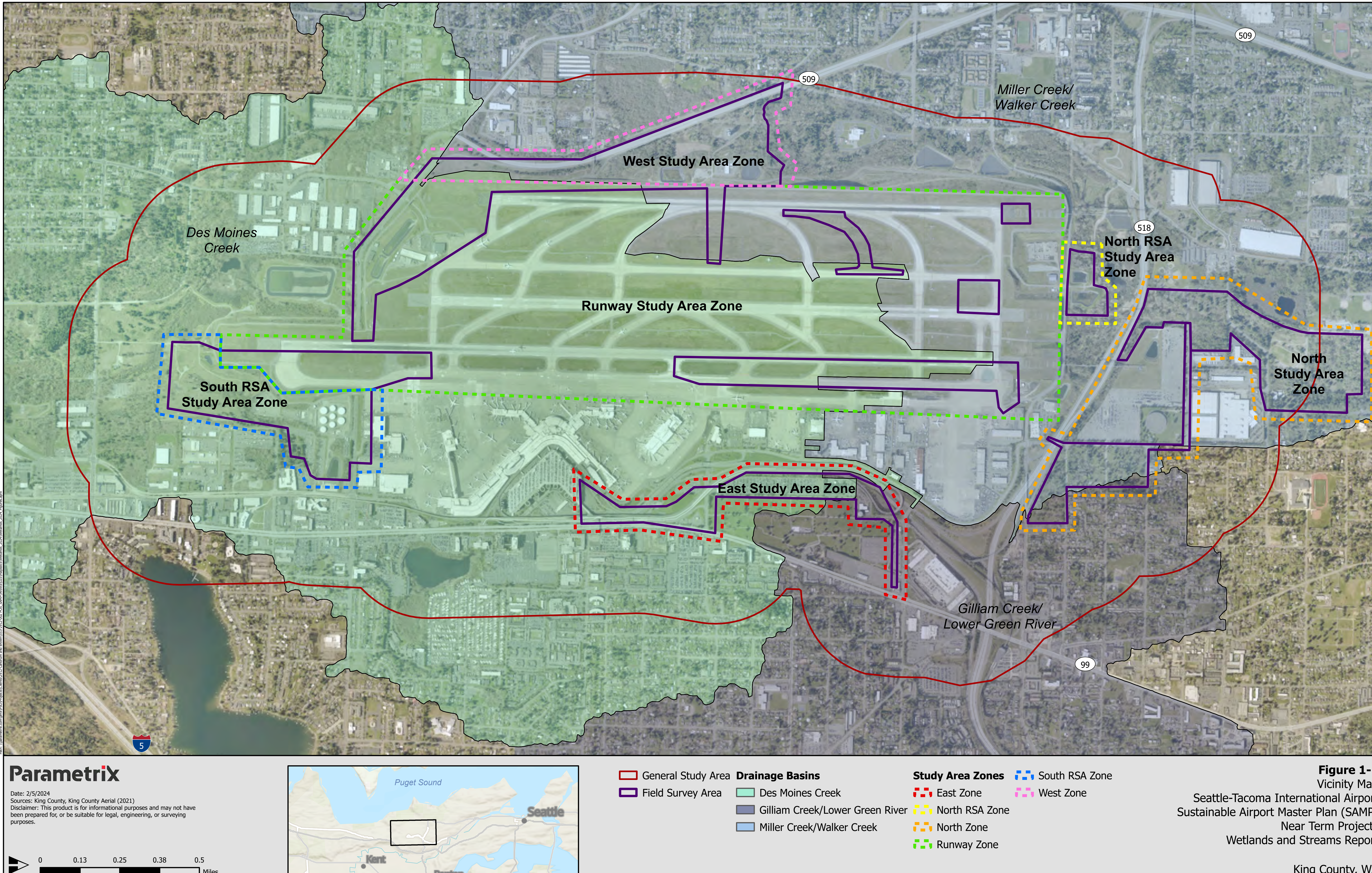
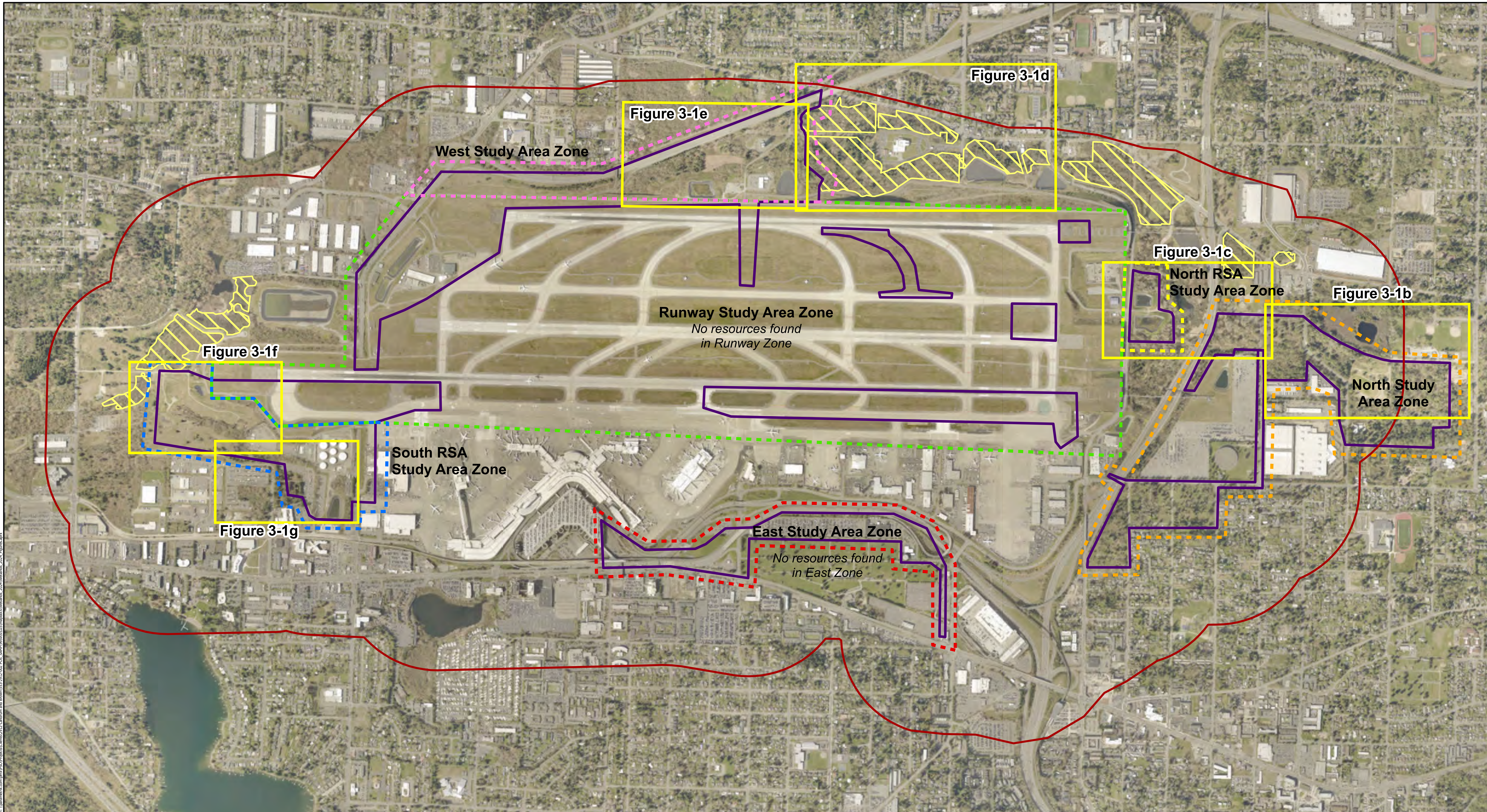


Figure 1-1
Vicinity Map
Seattle-Tacoma International Airport
Sustainable Airport Master Plan (SAMP)
Near Term Projects
Wetlands and Streams Report

King County, WA



Parametrix

Date: 5/21/2024
Sources: King County, King County Aerial (2021)
Disclaimer: This product is for informational purposes and may not have been prepared for, or be suitable for legal, engineering, or surveying purposes.

0 0.13 0.25 0.38 0.5 Miles

Figures 3-1b to 3-1g Page Extents
General Study Area
Field Survey Area
Restrictive Covenant Wetland Area

Study Area Zones
East Zone
North RSA Zone
North Zone
Runway Zone
South RSA Zone
West Zone

Figure 3-1a
Seattle-Tacoma International Airport
Sustainable Airport Master Plan (SAMP)
Near Term Projects
Wetlands and Streams Report

King County, WA

Parametrix

Date: 5/21/2024
Sources: King County, King County Aerial (2021)
Disclaimer: This product is for informational purposes and may not have been prepared for, or be suitable for legal, engineering, or surveying purposes.

0 100 200 300 400 Feet

- Sample Plot
- Wetland Boundary
- General Study Area
- Miller Creek
- Wetland Area
- King County Parcel
- Field Survey Area
- Restrictive Covenant
- Lake/Pond

Figure 3-1b
Seattle-Tacoma International Airport
Sustainable Airport Master Plan (SAMP)
Near Term Projects
Wetlands and Streams Report
Page 1 of 6

King County, WA

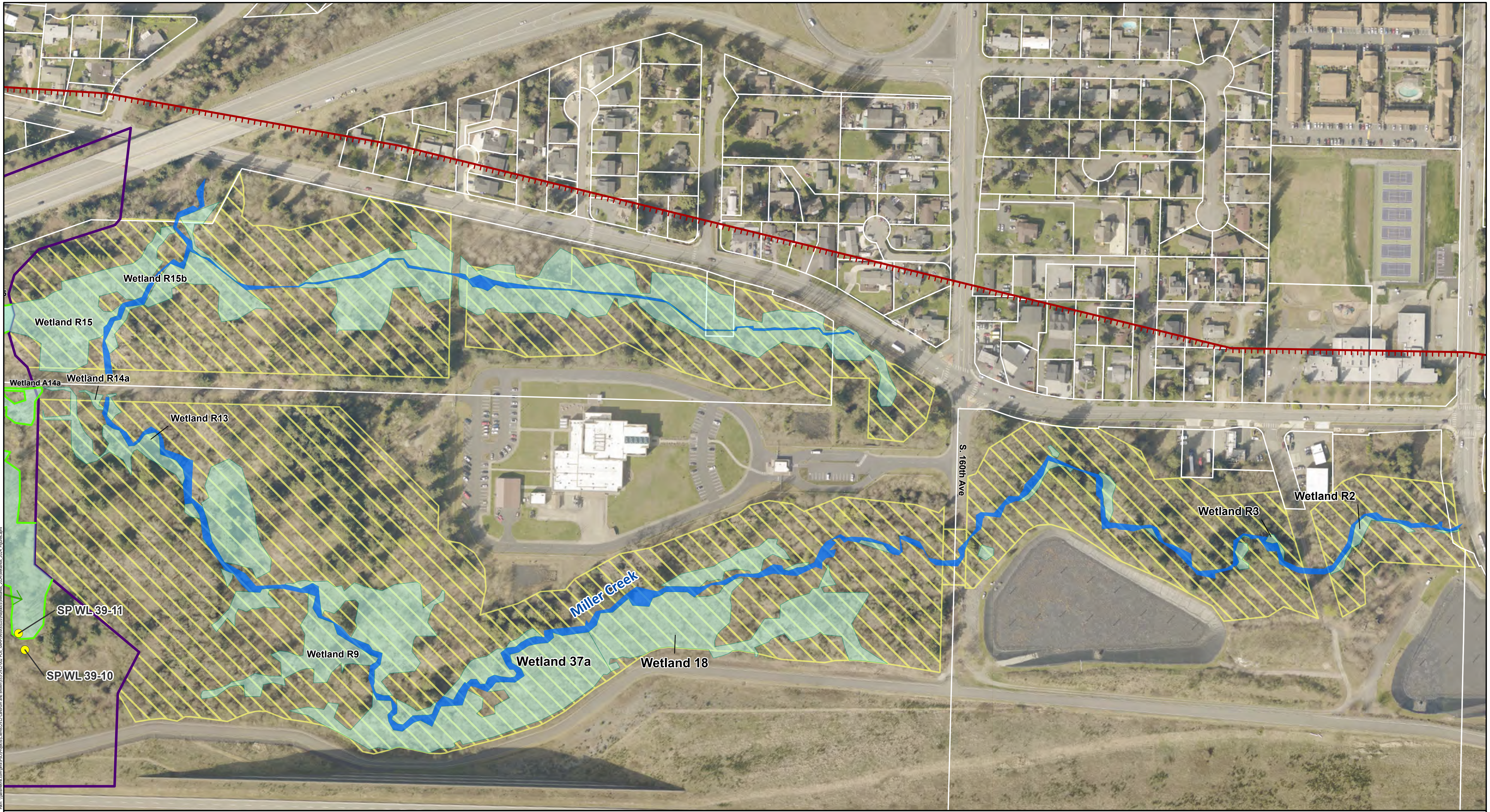
Parametrix

Date: 5/21/2024
Sources: King County, King County Aerial (2021)
Disclaimer: This product is for informational purposes and may not have been prepared for, or be suitable for legal, engineering, or surveying purposes.

Sample Plot
Culvert
Stormwater Feature
Tributaries
Wetland Boundary
OHWL
General Study Area
Miller Creek
Wetland Area
King County Parcel
Field Survey Area
Restrictive Covenant
Lake/Pond

Figure 3-1c
Seattle-Tacoma International Airport
Sustainable Airport Master Plan (SAMP)
Near Term Projects
Wetlands and Streams Report
Page 2 of 6

King County, WA



Parametrix

Date: 5/21/2024
Sources: King County, King County Aerial (2021)
Disclaimer: This product is for informational purposes and may not have been prepared for, or be suitable for legal, engineering, or surveying purposes.

Sample Plot
Wetland Boundary
General Study Area
Miller Creek
Wetland Area
King County Parcel
Field Survey Area
Restrictive Covenant

0 100 200 300 400 Feet

Figure 3-1d
Seattle-Tacoma International Airport
Sustainable Airport Master Plan (SAMP)
Near Term Projects
Wetlands and Streams Report
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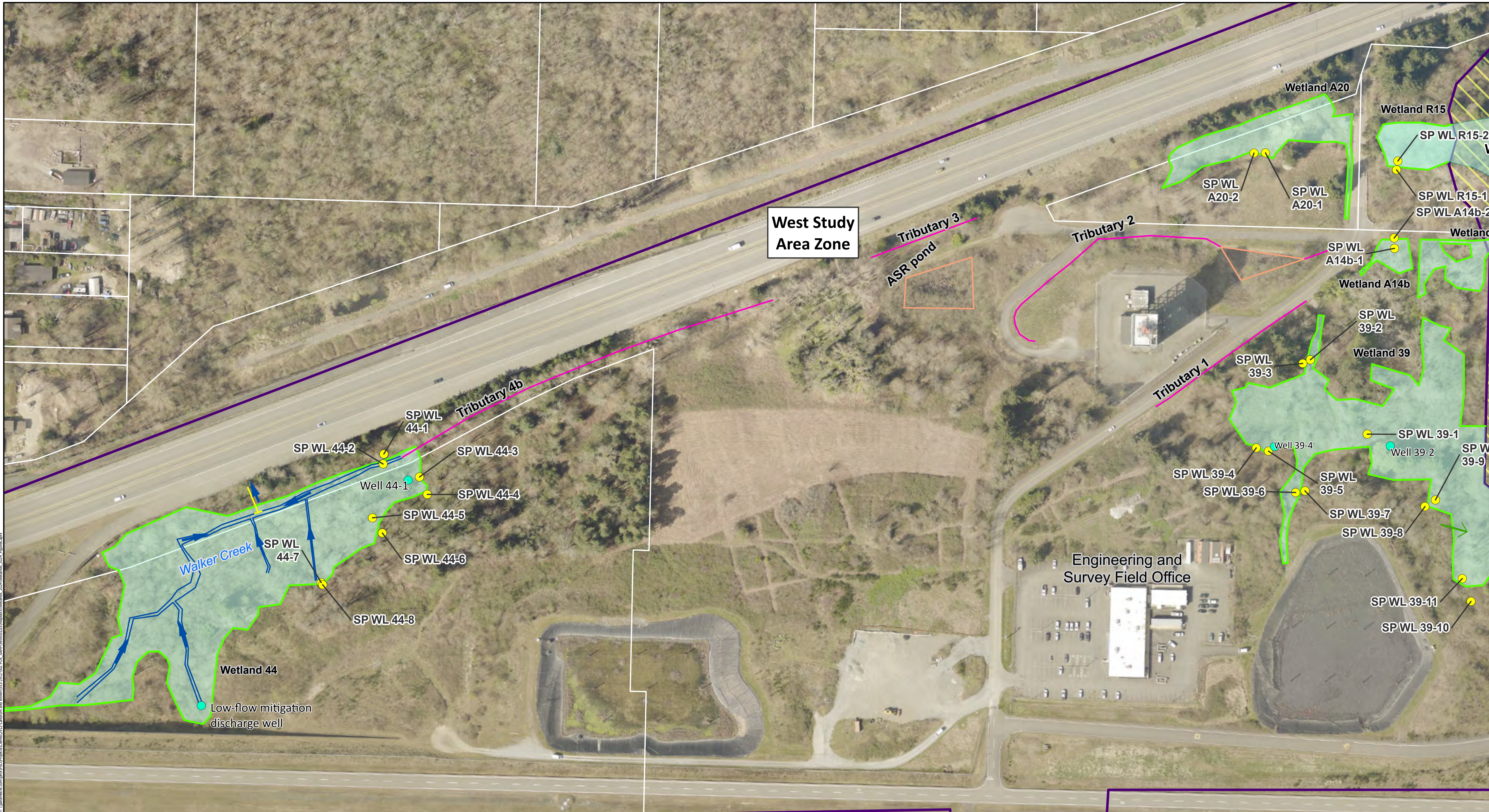
King County, WA



Parametrix

Date: 5/21/2024
Sources: King County, King County Aerial (2021)
Disclaimer: This product is for informational purposes and may not have been prepared for, or be suitable for legal, engineering, or surveying purposes.

0 100 200 300 400 Feet

Wells
Sample Plot
Culvert
Stormwater Feature
Tributaries
Wetland Boundary
OHWL
General Study Area
Miller Creek
Wetland Area
King County Parcel
Field Survey Area
Restrictive Covenant

Figure 3-1e
Seattle-Tacoma International Airport
Sustainable Airport Master Plan (SAMP)
Near Term Projects
Wetlands and Streams Report
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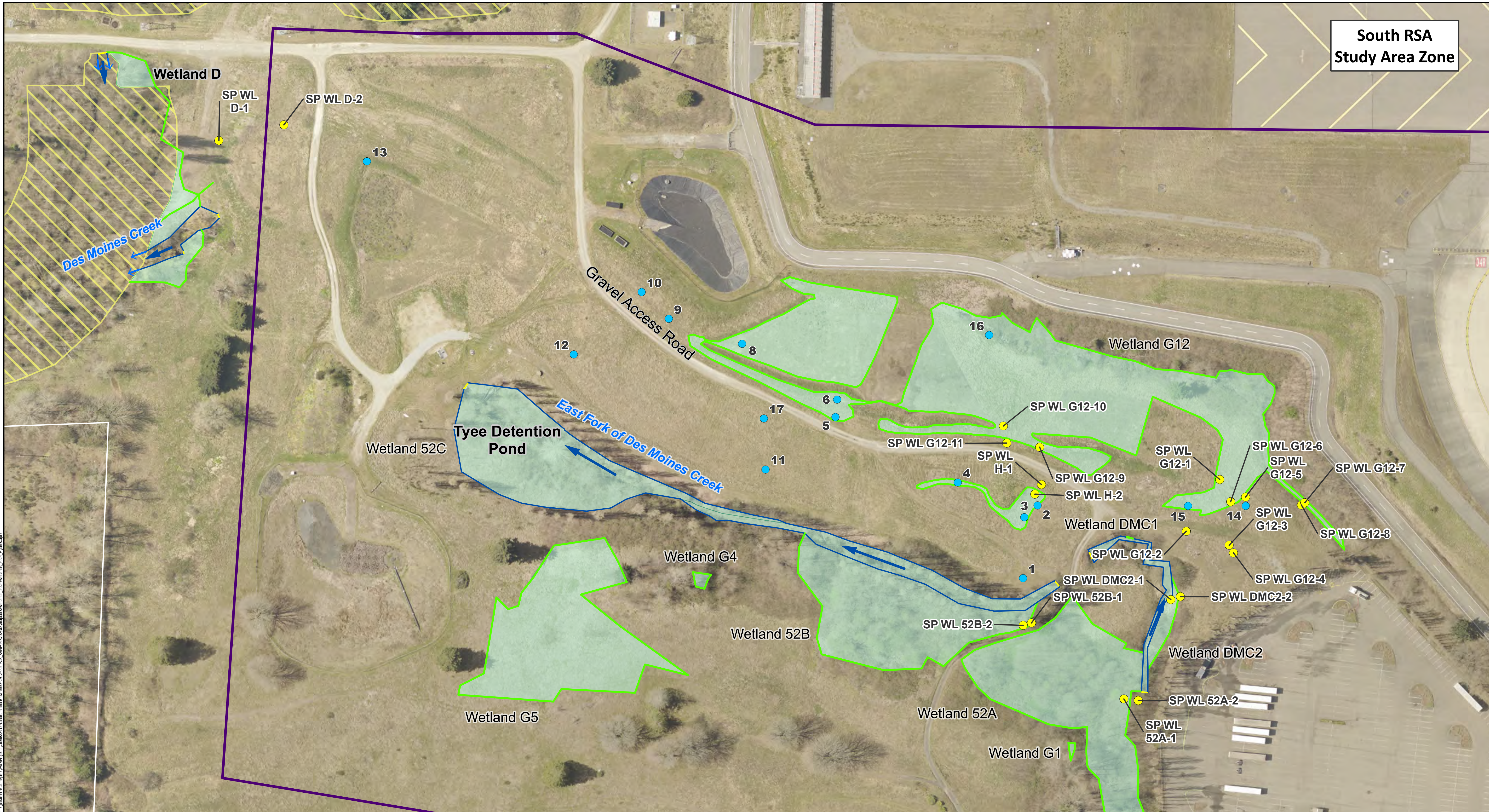
King County, WA



Parametrix

Date: 5/21/2024
Sources: King County, King County Aerial (2021)
Disclaimer: This product is for informational purposes and may not have been prepared for, or be suitable for legal, engineering, or surveying purposes.

0 100 200 300 400 Feet

- Sample Plot
- Hydrology Test Plot
- Culvert
- Wetland Boundary
- OHWL
- General Study Area
- Miller Creek
- Wetland Area
- King County Parcel
- Field Survey Area
- Restrictive Covenant

Figure 3-1f
Seattle-Tacoma International Airport
Sustainable Airport Master Plan (SAMP)
Near Term Projects
Wetlands and Streams Report
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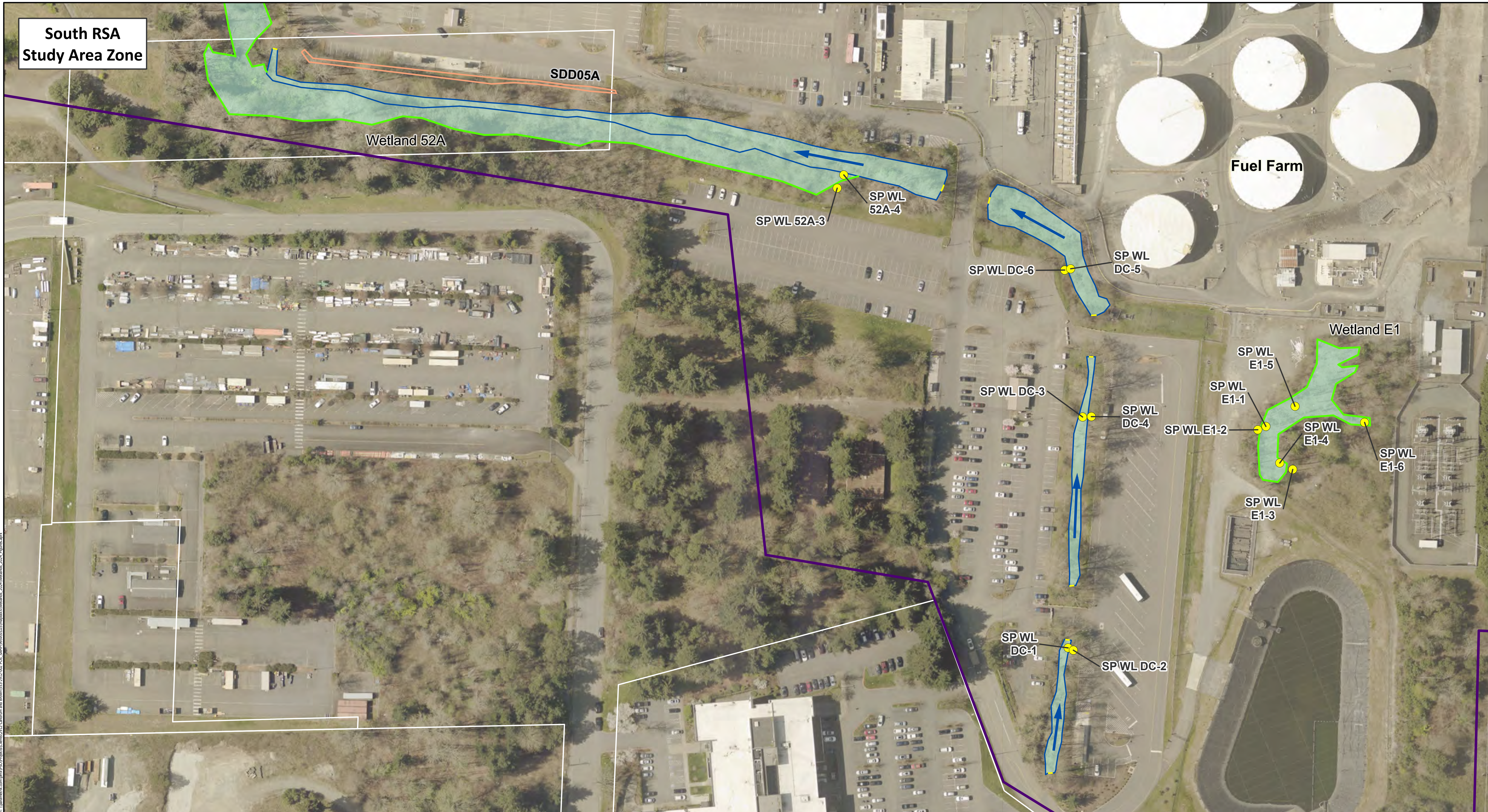
King County, WA



Parametrix

Date: 5/21/2024
Sources: King County, King County Aerial (2021)
Disclaimer: This product is for informational purposes and may not have been prepared for, or be suitable for legal, engineering, or surveying purposes.

0 100 200 300 400 Feet

- Sample Plot
- Culvert
- Stormwater Feature
- Wetland Boundary
- OHWL
- General Study Area
- Miller Creek
- Wetland Area
- King County Parcel
- Field Survey Area
- Restrictive Covenant

Figure 3-1g
Seattle-Tacoma International Airport
Sustainable Airport Master Plan (SAMP)
Near Term Projects
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King County, WA

Appendix A

Background Information
(Available by Request)

Appendix B

Site Photographs
(Available by Request)

Appendix C

Data Forms
(Available by Request)

Appendix D

Ecology Rating Forms (Available by Request)

APPENDIX M

Water Resources

Impacts Assessment for Aquatic Critical Areas

Technical Memorandum

DATE:	May 22, 2024
TO:	Adele Pozzuto and Steve Rybolt, Port of Seattle
FROM:	Kaylee Moser, PWS and Josh Wozniak, PWS
SUBJECT:	Sustainable Airport Master Plan (SAMP) Impacts Assessment for Aquatic Critical Areas
CC:	Sarah Potter and Erik Schwenke, Landrum & Brown
PROJECT NUMBER:	553-2912-002
PROJECT NAME:	Sustainable Airport Master Plan (SAMP)

This memo describes estimated project impacts to aquatic critical areas based on the current designs for the Near-Term Projects (NTP). Impacts were calculated by overlaying the footprint of these NTPs and associated utility features provided by Landrum & Brown with mapped aquatic critical areas. Sources of mapped aquatic critical areas used in this analysis include:

- Wetland and streams delineated within the study areas (Parametrix 2024).
- Wetland and stream mapping provided by the Port for areas outside of the delineation study areas.
- Wetland and stream buffers created in compliance with SeaTac Municipal Code
- Wellhead protection areas and floodplains sourced from King County, City of SeaTac (SeaTac) and the Federal Emergency Management Agency (FEMA).

Impact assessments are based on the overlap between these GIS datasets and the NTP footprints. This memo provides only the spatial overlay of the projects with these features, pending further design refinement or technical studies. This memo and impact assessment provides information to the planning and design team, alerting them to potential aquatic critical area issues within certain portions of the NTP footprints.

Critical Areas Jurisdiction

The Port and City of SeaTac signed an ILA (ILA) in 2018 which addresses the Port's compliance with the City's critical areas ordinances on Port-owned property within City boundaries. The ILA provides that the Port complies with local critical area codes (SMC 15.700) to the extent practicable. The Port administers permitting for projects on Port property within the Airport Activity Area (AAA), while the City administers permitting outside the AAA. The major exception is that, if 401/404 or Hydraulic Project Act permitting is required for a project, the City's critical area regulations shall not apply. The Port will administer permitting for all of the critical areas permits except for projects in the North Study Area Zone, which is within City of SeaTac jurisdiction. This portion of the study area is directly north of State Route (SR) 518 (See Figure 1-1 Vicinity Map in Attachment A).

The City of SeaTac regulates the following aquatic critical areas under Chapter 15.700:

- Flood hazard areas
- Wetlands
- Stream
- Wellhead protection areas (WHPAs)
- Fish and wildlife habitat conservation areas

Overview of Project Impacts to Aquatic Critical Areas

The mapped aquatic critical areas within the study area include wetland, stream, floodways, WHPAs, and fish and wildlife habitat conservation areas. These layers were mapped by Parametrix or downloaded from the GIS data sites of government agencies, including the City of SeaTac, King County, and FEMA. The NTP footprints do not have any impacts on the mapped floodway or 100-year floodplain, nor are impacts to fish and wildlife habitat conservation areas anticipated to occur. The NTP footprints, utility lines, and stormwater ponds do have impacts to WHPAs, jurisdictional tributaries, wetlands, streams, and their associated buffers. Three WHPAs are mapped within the study area. The impacts to WHPAs were calculated based on a 10- year contaminant travel time. Wetlands and streams mapped within the study area were delineated between September and December 2019 and in March 2020, with a wetland and waters verification in January 2024. The mapped wetlands and streams within the study area drain into the Miller/Walker Creek, Gilliam Creek/Lower Green River, and Des Moines Creek drainage basins.

The NTPs are divided into five project groups: Airfield Operational Efficiency Projects, Airfield Safety/Standards Projects, Cargo Expansion Projects, North Terminal Projects, and Sustainable Aviation Fuel Projects. There is also associated utility infrastructure, including new stormwater ponds and 10 types of utility lines to be installed for the projects. Only the project elements that have impacts to aquatic critical areas are discussed in this memorandum. Permanent impacts to aquatic critical areas from utility line installation were calculated based on a 20- foot-wide buffer polygon applied to individual utility lines. Access roads are assumed to be 30 feet wide, with 5 feet of temporary disturbance on each side during construction, except in the vicinity of the Miller Creek crossing, where temporary disturbance extends to the limits of a covenant boundary that restricts impacts (20-50 feet). Temporary construction impact areas to critical areas were calculated based on a 50-foot buffer polygon applied to NTP footprints and stormwater ponds.

Impacts were specifically calculated so that there was no double counting for project elements that overlap spatially. In particular, for areas where permanent impacts from NTPs and utility lines overlapped, permanent “impact values” (acreages of impact) were assigned to the NTPs. As an example, consider a theoretical NTP served by an upgraded water line. The NTP would impact 0.5 acres of wetland. The new theoretical water line would impact 0.1 acre of the wetland inside the NTP footprint. Therefore, the water line impact would not be counted because it has already been included as an NTP impact. For areas where permanent impacts from new stormwater ponds and utility lines overlapped, permanent impact values were assigned to stormwater ponds. Where permanent and temporary buffer impacts overlapped, impact values were assigned to the project element that was permanent.

Table 1 summarizes the total permanent and temporary construction impacts for the NTP footprints, utility lines, and stormwater ponds within critical areas and associated buffers. Tables 2, 3, and 4 provide further details on permanent and temporary impacts for NTP footprints, utility lines, and stormwater ponds. In Tables 1 and 4 stream buffer impacts overlap wetland buffer impacts in some areas but are accounted for separately. Also, all buffers have existing development such as buildings and impervious surfaces clipped out for the impact analysis.

See Attachment A for Figures 1-1 through 1-6d, displaying a vicinity map and the location of NTP footprints, utilities, stormwater ponds, and impacts to aquatic critical areas.

Table 1. Overview of Impacts to Aquatic Critical Areas and Buffers (acres)

Aquatic Critical Areas and Buffers	Permanent Impacts	Temporary Impacts
Stream/Jurisdictional Tributaries	0.02	0.08
Stream Buffer	0.12	0.20
Wetland	0.79	0.21
Wetland Buffer	2.66	3.43
Wetland, Stream and Buffer Total	**3.59**	**3.92**
Wellhead Protection Area	52.10	7.55

The current project design results in a total of 0.79 acres of permanent wetland impacts for all NTP footprints, utility lines, and stormwater ponds. Permanent stream/ jurisdictional tributary impacts—associated with the West Maintenance Campus access road—total 0.02 acre. Permanent wetland and stream buffer impacts total 2.66 acres and 0.12 acre, respectively. Temporary construction impacts, which would be restored after construction is complete, total 3.92 acres for wetland, stream, and buffer. Projects would protect WHPAs from groundwater contamination, as required by the State of Washington Department of Health. Based on the current spatial analysis, permanent WHPA impacts are estimated at 52.10 acres, with temporary construction impacts totaling 7.56 acres. Additional analysis of WHPA impacts will be conducted during design development for individual projects, and specific measures to protect WHPAs will be integrated into project designs as appropriate.

Permanent Impacts

Permanent project impacts are a result of excavation and fill to construct the NTPs, associated utility lines, and stormwater ponds. Permanent impacts for utility lines were calculated based on an assumption of a 20-foot-wide buffer polygon, as discussed with Landrum & Brown. Project impacts are a combination of impacts from the NTPs, as well as associated infrastructure. Impacts for NTP projects and associated infrastructure are broken down and described below.

The NTP footprints permanently impact a total of 0.23 acre of wetland and 2.31 acres of wetland buffer. Additionally, the NTP footprints permanently impact 0.01 acre of stream and impact 0.07 acre of stream buffer.

Associated infrastructure improvements (utility lines and stormwater ponds) permanently impact 0.56 acres of wetlands and 0.35 acres of wetland buffer. The infrastructure projects permanently impact 0.05 acre of stream buffer and 0.01 acre of streams/ jurisdictional tributaries. See Figure 1-4 for locations of permanent NTP impacts and Figure 1-5 for permanent utility/stormwater impacts.

Table 2 details the impacts to critical areas and buffers for individual project elements and sums up permanent impacts. Only the individual projects that have impacts to aquatic critical areas are listed.

Table 2. Permanent Impacts to Aquatic Critical Areas and Buffers (acres)

Project Element	Streams/ Jurisdictional Tributaries	Stream Buffer	Wetland	Wetland Buffer	WHPAs
Employee Parking Structure	--	--	0.02	0.60	--
Fuel Farm Expansion	--	--	0.21	0.01	--
North GT Holding Lot	--	--	--	--	5.02
Off-site Cargo PH 1 (L-Shape)	--	--	--	--	34.08
Off-site Cargo PH 2 (L-Shape)	--	--	--	--	3.17
Taxiway A/B Extension	--	--	--	--	6.12
Westside Maintenance Campus	0.01	0.07	<0.01	1.70	--
NTP Projects Subtotal	*0.01*	*0.07*	*0.23*	*2.31*	*48.39*
Stormwater Pond (Miller Creek detention pond)	--	--	0.55**	--	--
Stormwater Pond (Pond M)	--	--	--	0.11	--
Stormwater Pond (Pond F detention pond)	--	--	--	<0.01	--
Stormwater Pond (SDS4 pond)	--	--	--	<0.01	0.13
Sanitary Sewer Lines	--	--	--	0.01	2.24
Storm Lines	0.01	0.05	0.01	0.23	1.33
Water Lines	--	--	--	--	--
Infrastructure Improvements Subtotal	*0.01*	*0.05*	*0.56*	*0.35*	*3.71*
Grand Total*	*0.02*	*0.12*	*0.79*	*2.66*	*52.10*

Impacts values in the table are rounded from more detailed calculations. The grand total is rounded from the calculated grand total, not the sum of the individualrounded values presented in the table.
** Future design may include a vault, reducing or eliminating this impact.

Table 3 below summarizes all permanent wetland impacts by project element and Wetland ID (as identified in the Port wetland GIS layers and the 2024 Parametrix report).

Table 3. Permanently Impacted Wetlands

Project Element	Wetland Impact (acre)	Wetland ID	2014 Ecology Rating [a]
Employee Parking Structure	0.02	Wetland A	III
Westside Maintenance Campus	<0.01	Wetland 39	III
Stormwater Pond (Miller Creek detention pond)	0.55**	Wetland A20	III
Fuel Farm Expansion	0.21	Wetland E1	III
Storm (UMP Line)	<0.01	Wetland A14	III
	0.01	Wetland 44	II
	<0.01	Wetland A20	III
	<0.01	Wetland R13	II
	<0.01	Wetland R14a	II
Grand Total*	*0.79*		

[a] Hruby and Yahnke 2023
* Impacts values in the table are rounded from more detailed calculations. The grand total is rounded from the calculated grand total, not the sum of theindividual rounded values presented in the table.** Future design may include a vault, reducing or eliminating this impact.

Wetlands having the greatest permanent impact include Wetland E1, Wetland A20, and Wetland A. Wetland E1 is a Category III wetland permanently impacted by the Fuel Farm Expansion project within the Sustainable Aviation Fuel Project group (See Figure 1-6c in Attachment A). This wetland would be entirely impacted. Wetland A20 is a Category III wetland located near the WMC project and is fully permanently impacted by UMP projects including a stormwater pond (See Figure 1-6d in

Attachment A). Wetland A is a Category III wetland also located at the north end of the study area and is permanently impacted by the Employee Parking Structure (See Figure 1-6a in Attachment A).

More detailed information on these wetlands can be found within the Seattle-Tacoma International Airport Sustainable Airport Master Plan (SAMP) Near Term Projects Wetlands and Streams Report (Parametrix 2024).

Temporary Construction Impacts

Temporary construction impacts would occur where aquatic critical areas or buffers are affected by clearing and ground-disturbing work but are revegetated following construction. Temporary construction impacts were calculated based on the assumption of a 50-foot buffer polygon applied to NTP footprints and stormwater ponds, as discussed with Landrum & Brown. The temporary construction impacts for the WMC access road were calculated based on a 5- foot buffer from the edge of the road. At the Miller Creek stream crossing, the temporary construction impacts were extended to meet the boundaries of the restrictive covenant on either side of the road. The duration of temporary construction impacts is unknown at this time, and, therefore, temporary construction impacts are not further divided into short-term versus long-term.

The temporary construction impacts for wetlands are 0.21 acre for NTP footprints. The utility infrastructure projects would have 0.70 acre of temporary wetland buffer impacts. Additionally, 130 linear feet of jurisdictional tributaries would be permanently impacted for the WMC, Miller Creek detention pond, and some proposed utility lines.

Table 4 details the impacts to critical areas and buffers for individual project elements and sums up the temporary construction impacts. Only the individual projects that have temporary impacts to critical areas and/or associated buffers are listed in this table.

Table 4. Temporary NTP Construction Impacts to Aquatic Critical Areas and Buffers (acres)

Project Element	Stream	Stream Buffer	Wetland	Wetland Buffer	WHPAs
Employee Parking Structure	--	--	0.04	0.55	0.31
Fuel Farm Expansion	0.07	--	0.07	0.35	--
North GT Holding Lot	--	--	--	--	0.24
Off-site Cargo PH 1 (L-Shape)	--	--	--	--	1.79
Taxiway A/B Extension	--	--	--	0.42	4.58
Westside Maintenance Campus	0.01	0.20	0.10	1.41	--
NTP Projects Subtotal	*0.08*	*0.20*	*0.21*	*2.73*	*6.92*
Stormwater Pond (Miller Creek detention pond)	--	--		--	--
Stormwater Pond (Pond F detentionpond)	--	--	--	0.11	--
Stormwater Pond (SDS4 Pond)	--	--	--	0.06	0.63
Stormwater Pond buffer (Pond M)	--	--	--	0.53	--
Infrastructure Improvements Subtotal	*--*	*--*		*0.70*	*0.63*
Grand Total*	*0.08*	*0.20*	*0.21*	*3.43*	*7.55*

* Impact values in the table are rounded from more detailed calculations. The grand total is rounded from the calculated grand total, not the sum of the individual rounded values presented in the table.

Discussion of Impacts by Project Element

The following sections describe impacts for each NTP group and detail individual projects within each group that impact aquatic critical areas and/or buffers. Details on the use and purpose of these individual projects were extracted from the SAMP Facilities Implementation and Financial Feasibility

Technical Memorandum No. 7 and Environmental Overview Technical Memorandum No. 8 (Leigh-Fisher 2018a, 2018b). Utility line and stormwater pond project impacts are also discussed in this section.

Cargo Expansion Projects

The Cargo Expansion Projects group contains three individual projects with impacts to aquatic critical areas and/or associated buffers. Construction of these projects could permanently and temporarily impact WHPAs, wetlands, and wetland/stream buffers.

Land use conversion within a WHPA presents the potential for impact if construction or operation of new projects could result in a release of contaminants to groundwater. However, these impacts can be avoided by project design and operational measures that minimize the risk of contamination. During the project design and permitting phase, detailed geotechnical and hydrogeological assessments will be developed to characterize the potential for groundwater contamination from the proposed projects. The potential of the proposed uses to release contaminants will then be assessed, and appropriate measures applied to minimize any risk of contaminant release. The City of SeaTac requires non-residential developments within WHPAs to submit hazardous material inventory sheets to the respective water district at a minimum of once every two years. In addition, a critical area report may be required with details regarding geologic and hydrogeologic characteristics of the site, groundwater depth, and available historic water quality data. The Port will work with the relevant authorities to comply with all applicable requirements to avoid and/or minimize the potential for contamination.

- Off-site Cargo Phase 1 (L-Shape) – The building would provide warehouse and office space, truck terminals, and parking for visitors and employees. This NTP is located within the WHPA in the northern portion of the Port property. The project results in 34.08 acres of permanent land use conversion in the WHPA and 1.79 acres of temporary construction impacts to the WHPA.
- Off-site Cargo Phase 2 (L-Shape) – The building would provide warehouse and office space, truck terminals, and parking for visitors and employees. This NTP is located within the WHPA in the northern portion of the Airport. The project would result in 3.17 acres of permanent land use conversion in the WHPA.
- Westside Maintenance Campus – This project would relocate the Aviation Maintenance Facility from its current location in the North Cargo area to allow for construction of the Hardstand (north) project. This project would result in 0.01 acre of permanent wetland impact to Wetland 39 and 1.70 acre of permanent wetland buffer impact. The access road into the WMC crosses over Miller Creek and would result in 0.01 acre of permanent stream impact and 0.07 acre of permanent stream buffer impact. Temporary wetland impacts would be 0.1 acre, and temporary wetland buffer impacts would be 1.41 acre (See Figure 1-6d in Attachment A). Temporary stream impact would be 0.01 acre, and temporary stream buffer impact would be 0.20 acre.

North Terminal Projects

The North Terminal Projects group contains two individual projects with impacts to critical areas and/or associated buffers. Construction of these projects could permanently and temporarily impact WHPAs, wetland, and wetland/stream buffer.

- Employee Parking Structure – A large new parking structure would be constructed on Port property adjacent to and west of the North Employee Parking Lot, directly north of SR 518. Construction of this project would result in impacts to Wetland A. Permanent wetland impacts are 0.02 acre and permanent wetland buffer impacts are 0.60 acre. Temporary construction impacts to the wetland are 0.04 acre and temporary wetland buffer impacts are 0.55 acre. This project is directly adjacent to the WHPA in the northern portion of the Port property and would result in 0.31 acre of temporary construction impacts to the WHPA.

- North Ground Holding (GT) Lot – A new GT lot is needed replace the current lot displaced by the Elevated Busway. This project is located within the WHPA in the northern portion of the Airport. The project results in 5.02 acres of permanent impacts and 0.24 acre of temporary construction impacts to the WHPA.

Fuel Farm Expansion Projects

The Fuel Farm Expansion Projects group includes the Fuel Farm Expansion project, which would have impacts to critical areas and/or associated buffers. Construction of this project would permanently and temporarily impact wetland, stream, and wetland/stream buffer.

Fuel Expansion of the fuel farm would include four new settling tanks, 10 million additional gallons of storage capacity, an approximately 500,000 gallon blending tank, an approximately 100,000-gallon Sustainable Aviation Fuel receipt tank, and infrastructure to support these improvements. The project is located in the southeast portion of the Airport, near the East Fork of Des Moines Creek. Construction would permanently impact the entirety of Wetland E1. Permanent impacts would include 0.21 acre of wetland and 0.01 acre of wetland buffer (See Figure 1-6c in Attachment A).

Taxiway A/B Projects

The Taxiway A/B Projects group contains the Taxiway A/B Extension project, which would have impacts to critical areas and/or associated buffers. Construction of this project would temporarily impact wetland buffers and would require protecting wellhead areas from impacts of contaminant discharge.

The extension of Taxiways A and B to provide access to the south end of Runway 16L/34R includes construction of parallel taxiway connectors from Taxiway B to Runway 16L/34R and the relocation of Taxiway S by 310 feet southward. The project would also include glideslope modifications the construction of a new vehicle service road bridge over S 188th St. Construction would result in 6.12 acres of permanent land use conversion within WHPAs. Temporary impacts would include 0.42 acre of wetland buffer associated with Wetland G12 and 4.58 acres of WHPA.

Utility Lines

As currently designed, the project would result in 0.01 acre of permanent wetland impacts and 0.01 acre of permanent stream impacts associated with stormwater utility lines. Wetlands impacted would include Wetland 44, Wetland A14a, and Wetland A20, all located on the west side of the airport. Additionally, utility lines would result in 0.24 acre of permanent wetland buffer impact for storm and water lines, and 3.57 acres of permanent land use conversion within WHPAs for sanitary sewer and storm lines (See Figure 1-6d in Attachment A).

Stormwater Ponds

The current design for stormwater ponds would result in 0.55 acre of permanent wetland impact. Wetland A20 near the WMC footprint would be entirely impacted by the Miller Creek detention pond (See Figure 1-6d in Attachment A). As the design evolves, it is possible that a vault rather than a stormwater pond will be proposed, reducing or eliminating this impact. New stormwater ponds would result in 0.70 acre of temporary wetland buffer impacts. Stormwater ponds would result in 0.13 acre of permanent land use conversion within WHPAs and would temporarily impact 0.63 acres.

Indirect Impacts

Indirect impacts from construction of the NTPs listed previously may result in long-term wetland degradation from stormwater discharges and alteration in wetland hydrology; however, stormwater detention and treatment activities would minimize long-term indirect water quality impacts on wetlands. Indirect impacts from stormwater ponds may also result in minimal wetland hydrology alteration. For aquatic habitat, indirect impacts would be minimal given the surrounding areas near project impacts are heavily developed.

Mitigation, Avoidance, And Minimization Measures

The avoidance and minimization of impacts to wetlands, streams and buffers was a guiding principle for the preliminary project design. Additional avoidance and minimization measures would be implemented, as practical, as the project design continues to develop. The Port is exploring options to reduce permanent wetland and stream impacts associated with utility lines and to minimize buffer impacts. Additional strategies include minimizing vegetation clearing and restoring temporarily affected areas as soon after the initial impact as possible.

The Port would comply with standard specifications, best management practices (BMPs),[1] and applicable federal and state mitigation requirements during design, construction, and post-construction activities. The Port would meet all regulatory requirements and continue to meet or exceed avoidance and minimization measures related to these BMPs in adherence with federal and state regulations.

[1] BMPs include various methods and devices to control, remove, or reduce pollution, and are listed in the Airport's Stormwater Pollution Prevention Plan (https://www.portseattle.org/file-documents/sea-tac-stormwater-pollution-prevention-plan). BMPs include operational practices (e.g. training and spill prevention), structural controls (e.g. stormwater ponds and oil/water separators), and erosion and sediment controls (e.g. silt fence and filter strips).

For unavoidable permanent impacts to wetlands, streams, temporary impacts to wetlands lasting more than one year, and permanent impacts to associated buffers, the Port would develop a compensatory mitigation plan during the permitting phase in accordance with applicable federal and state requirements and guidelines. These guidelines are listed in the U.S. Army Corps of Engineers and EPA's Compensatory Mitigation for Losses of Aquatic Resources,[2] and Ecology's interagency guidance contained in Wetland Mitigation in Washington State: Parts 1 and 2.[3] The Port anticipates that it has capacity on its current property to construct all or most of the mitigation, while acknowledging that other mechanisms, such as purchasing mitigation credits from banks or in-lieu fee programs, ensure capacity is available to provide the required quantity of mitigation.

The mitigation plan would be developed following a mitigation sequencing approach based on a hierarchy of avoiding and minimizing adverse impacts through careful design, rectifying temporary impacts, and compensating for unavoidable adverse impacts. The specific portfolio of mitigation, including location, design, and timing of permitting and construction, would be developed concurrent with the progression of NTP construction designs, which would be required to adhere to mitigation sequencing guidelines.

In cooperation with resource agencies and tribes, the Port would develop plans to mitigate unavoidable effects of the project on wetlands, streams, and regulatory buffers on a watershed basis. To the extent possible, compensatory mitigation sites would be identified and compensated for lost values in kind. It may be necessary to use several sites and mitigation approaches, given the project size, complexity of identifying mitigation opportunities, and mitigation requirements. The project would adhere to the mitigation requirements, including replacement ratios, specified by federal regulators, state resource agencies, and local critical area codes. Stream impacts are included in the wetland mitigation calculations below.

The Port has seven sites within its ownership identified as being suitable for compensatory mitigation. Proposed mitigation approaches have been evaluated and described based on each sites' opportunities and potential (Anchor 2019). Six sites are within the airport and one site is located along the Green River in Auburn. They encompass over 150 acres and include potential for greater than 40 acres of wetland re-establishment, 11 acres of wetland enhancement, almost 8 acres of preservation, and 80 acres of buffer enhancement (Anchor QEA 2019).

The area needed for compensatory mitigation is dictated by federal and state guidance, with a minimum 1:1 compensation ratio required by the Corps. Some agencies use the credit/debit system (Hruby 2012) to evaluate mitigation is some situations. Table 5 provides a summary of the compensatory mitigation ratios recommended by an interagency review committee composed of the Corps, EPA, and Ecology (Ecology, et al 2021).

Table 5. Interagency Recommended Compensatory Mitigation Ratios for Wetland Impacts

Category and Type of Wetland	Creation or Reestablishment	Rehabilitation	Enhancement
Category I: Mature Forested	6:1	12:1	24:1
Category I: Based on Functions	4:1	8:1	16:1
Category II	3:1	6:1	12:1
Category III	2:1	4:1	8:1
Category IV	1.5:1	3:1	6:1

[2] 33 CFR Parts 325 and 332/ 40 CFR Part 230

[3] *Wetland Mitigation in Washington State Part 1: Agency Policies and Guidance (2021)*, and *Part 2: Developing Mitigation Plans* (2006)

Table 6 provides a summary of the compensatory wetland mitigation area calculation anticipated to be requiredby the current preliminary design, based on the unavoidable, permanent impacts to wetlands and the required mitigation ratios. Buffer impacts are mitigated at a 1:1 ratio and would require 2.66 acres.

Table 6. Compensatory Wetland Mitigation Area Calculations

Project Element	Wetland Impact (acre/Rating)	Re-establishment Area Needed (acres)	Rehabilitation Area Needed (acres)	Enhancement Area Needed (acres)
Facilities	0.23/III	0.46	0.92	1.84
UMP Line	0.01/III	0.02	0.04	0.08
Utility Lines	0.01/II	0.03	0.06	0.12
StormwaterPonds	0.55/III	1.10	2.75	4.40
	Total Areas	**1.61**	**3.77**	**6.44**

Based on these calculations, the mitigation areas identified by the Port have sufficient capacity to provide theneeded compensatory mitigation for the anticipated impacts of the proposed action.

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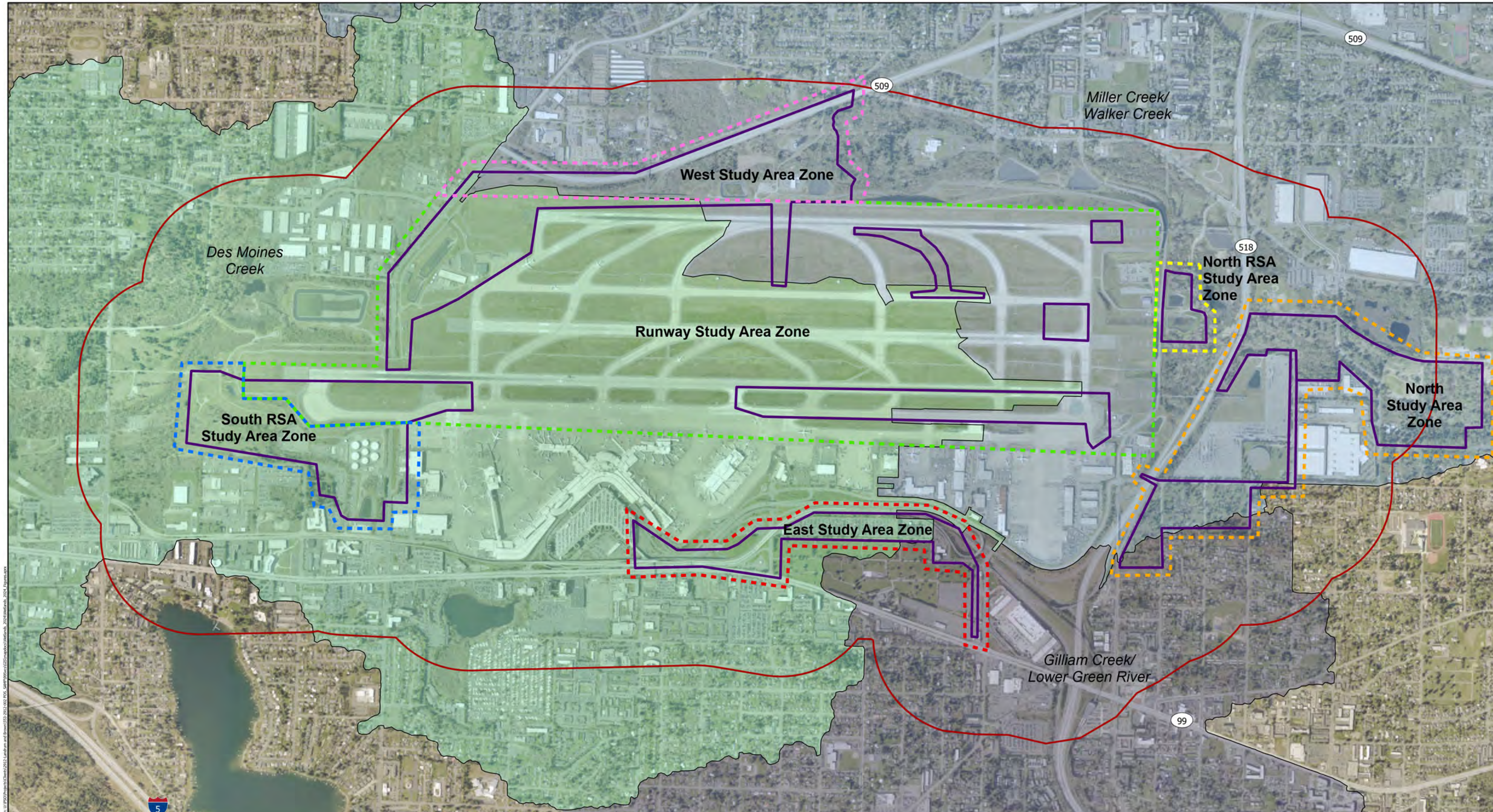
Attachment A

Figures



Parametrix

Date: 2/12/2024
Sources: King County, King County Aerial (2021)
Disclaimer: This product is for informational purposes and may not have been prepared for, or be suitable for legal, engineering, or surveying purposes.

0 0.13 0.25 0.38 0.5 Miles

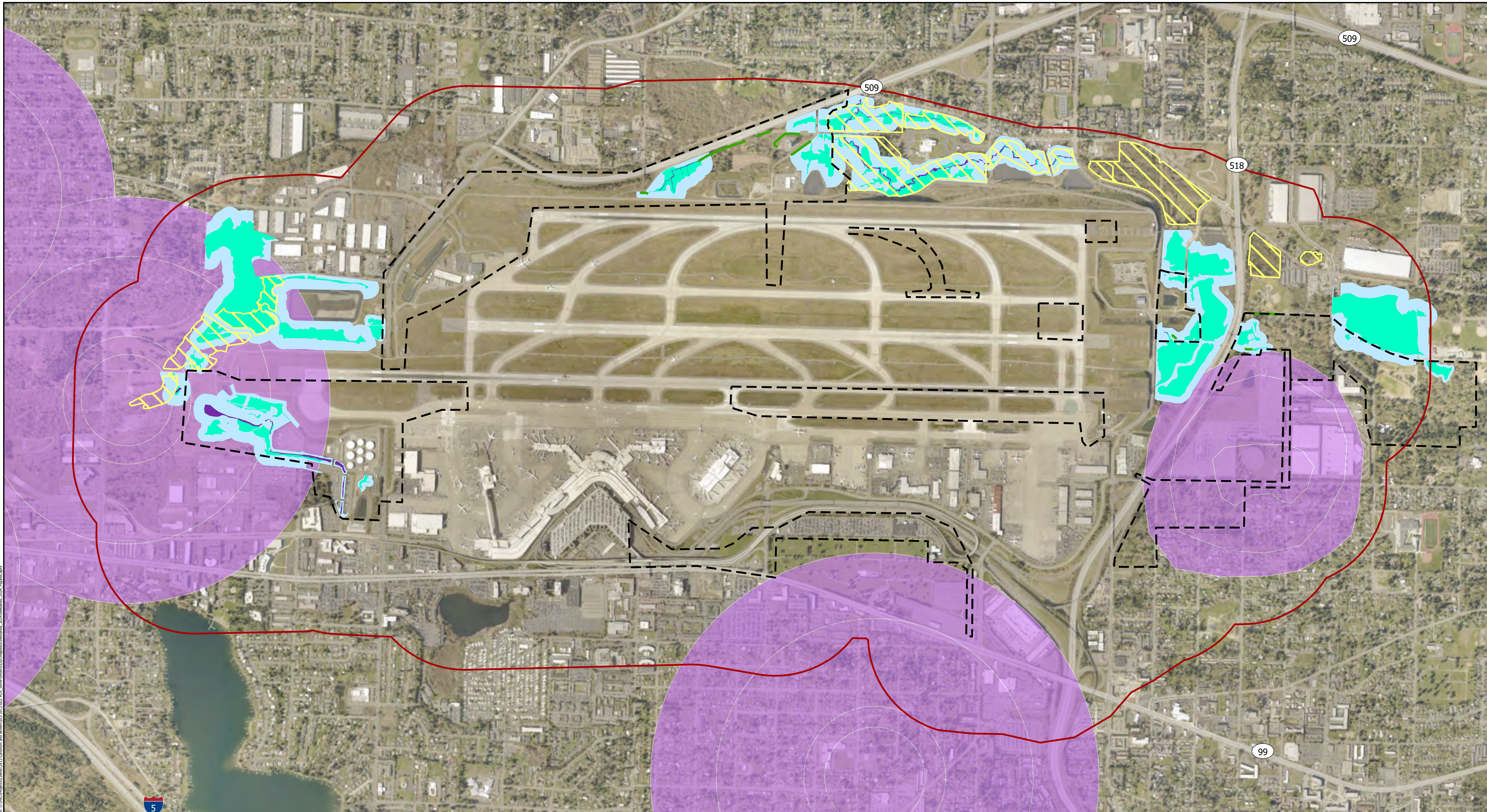
General Study Area
Field Survey Area

Drainage Basins
Des Moines Creek
Gilliam Creek/Lower Green River
Miller Creek/Walker Creek

Study Area Zones
East Zone
North RSA Zone
North Zone
Runway Zone
South RSA Zone
West Zone

Figure 1-1
Vicinity Map
Impact Analysis Memorandum
Seattle-Tacoma International Airport
Sustainable Airport Master Plan (SAMP)

King County, WA



Parametrix

Date: 2/12/2024
Sources: King County, King County Aerial (2021)
Disclaimer: This product is for informational purposes and may not have been prepared for, or be suitable for legal, engineering, or surveying purposes.

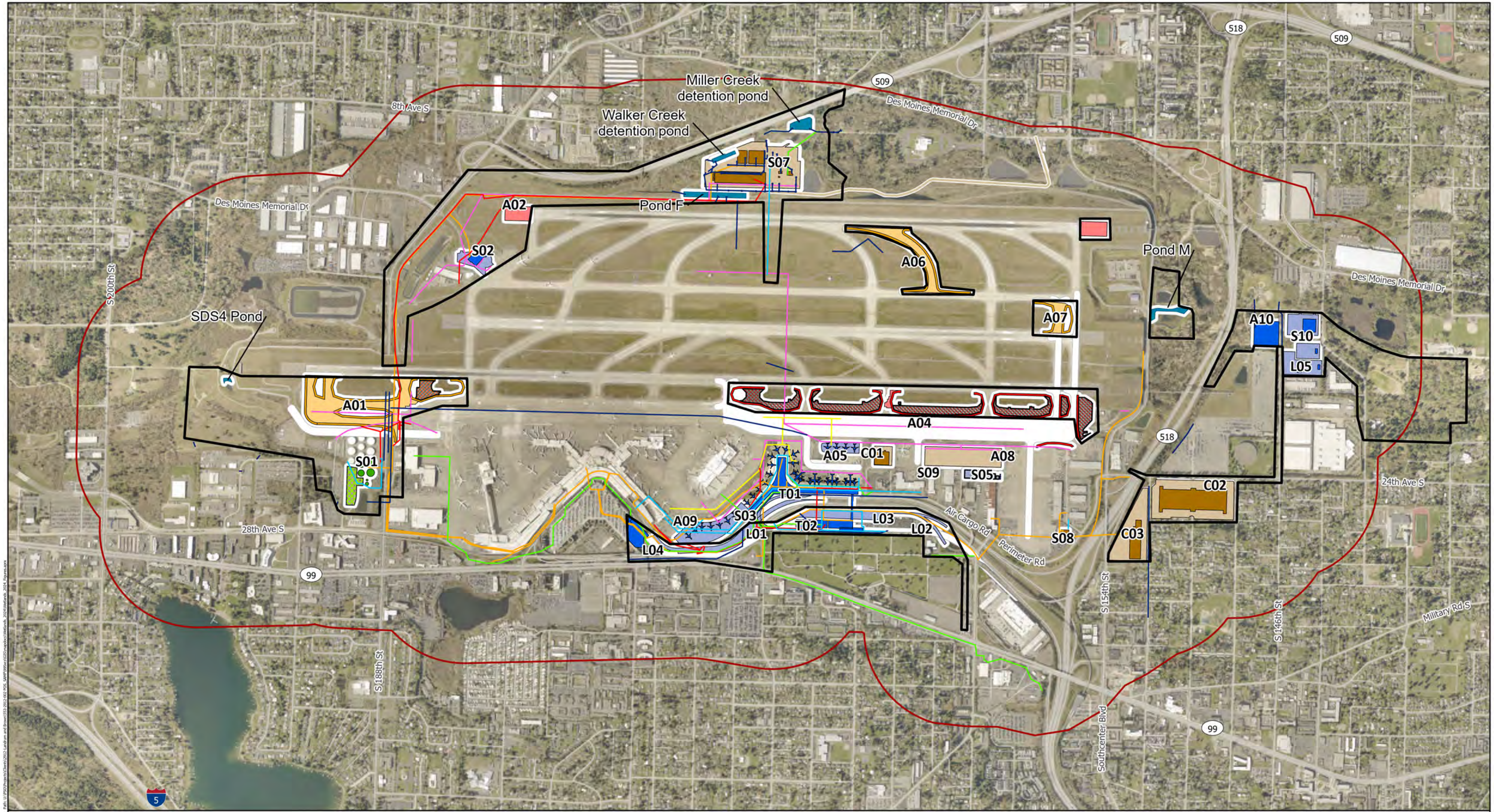
0 0.13 0.25 0.38 0.5 Miles

Tributaries
General Study Area
Field Survey Area
Restrictive Covenant

Critical Area Type
Stream
Wetland
Stream/Wetland Buffer
Wellhead Protection Area

Figure 1-2
Aquatic Critical Areas within the Survey Area
Impact Analysis Memorandum
Seattle-Tacoma International Airport
Sustainable Airport Master Plan (SAMP)

King County, WA



Parametrix

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0 0.13 0.25 0.38 0.5 Miles

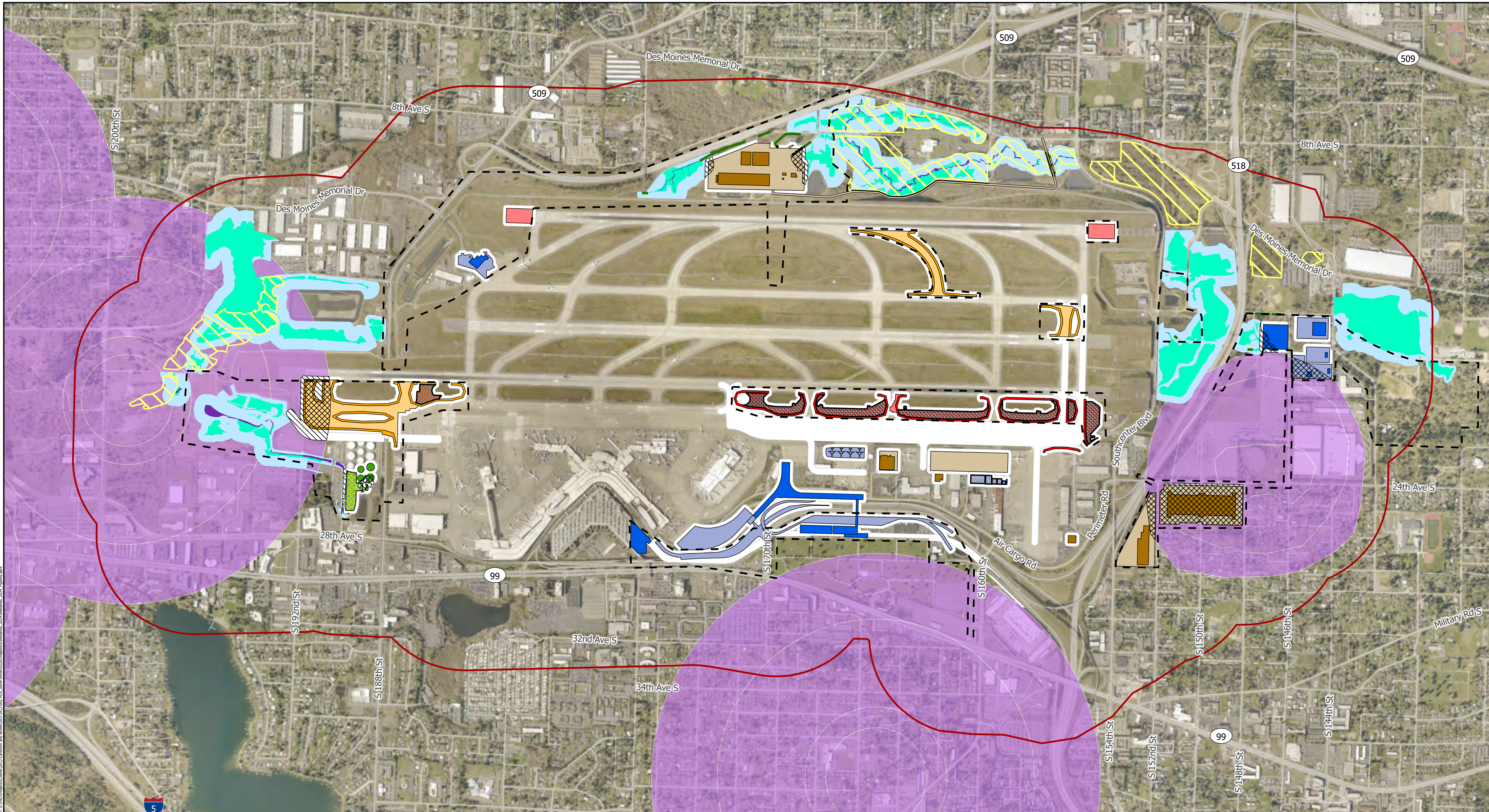
Field Survey Area
General Study Area
Construction Area (50-ft buffer)
Stormwater Pond (UMP Polygon)

Proposed Utilities (UMP Line)
ICT
IWS
Jet Fuel
Power
Sanitary Sewer
Storm
Water

Near Term Project (NTP) Type
Airfield Operational Efficiency Projects
Airfield Operational Efficiency Projects, Structure
Airfield Operational Efficiency Projects, Surface
Airfield Safety/Standards Projects
Airfield Safety/Standards Projects
Airfield Safety/Standards Projects, Structure
Airfield Safety/Standards Projects, Surface
Cargo Expansion Projects, Structure
Cargo Expansion Projects, Surface
North Terminal Projects
North Terminal Projects, Structure
North Terminal Projects, Surface
Sustainable Aviation Fuel Projects
Sustainable Aviation Fuel Projects, Structure

Figure 1-3
Project Elements within the Survey Area
Impact Analysis Memorandum
Seattle-Tacoma International Airport
Sustainable Airport Master Plan (SAMP)

King County, WA



Parametrix

Date: 2/12/2024
Sources: King County, King County Aerial (2021)
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0 0.13 0.25 0.38 0.5 Miles

- Tributaries
- Tributaries Impact
- Permanent Impact Area
- Temporary Impact Area
- Construction Area (50-ft buffer)
- General Study Area
- Field Survey Area
- Restrictive Covenant

Critical Area Type

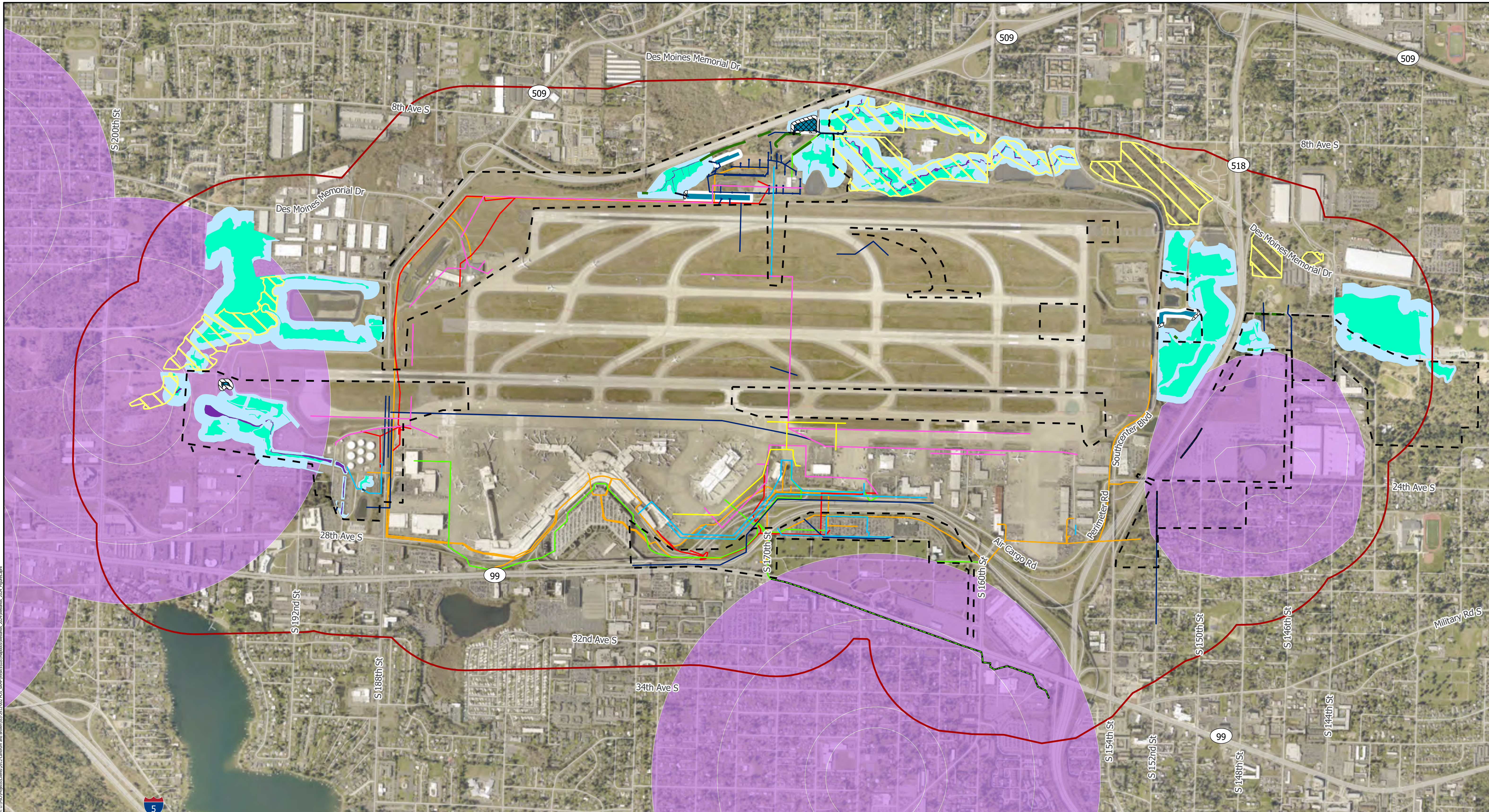
- Stream
- Wetland
- Stream/Wetland Buffer
- Wellhead Protection Area

Near Term Project (NTP) Type

- Airfield Operational Efficiency Projects
- Airfield Operational Efficiency Projects, Structure
- Airfield Operational Efficiency Projects, Surface
- Airfield Safety/Standards Projects
- Airfield Safety/Standards Projects, Structure
- Airfield Safety/Standards Projects, Surface
- Cargo Expansion Projects, Structure
- Cargo Expansion Projects, Surface
- North Terminal Projects
- North Terminal Projects, Structure
- North Terminal Projects, Surface
- Sustainable Aviation Fuel Projects
- Sustainable Aviation Fuel Projects, Structure

Figure 1-4
NTP Impacts to Aquatic Critical Areas within the Survey Area
Impact Analysis Memorandum
Seattle-Tacoma International Airport
Sustainable Airport Master Plan (SAMP)

King County, WA



Parametrix

Date: 2/12/2024
Sources: King County, King County Aerial (2021)
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0 0.13 0.25 0.38 0.5 Miles

- Tributaries
- Tributaries Impact
- Permanent Impact Area
- Temporary Impact Area
- Construction Area (50-ft buffer)
- Field Survey Area
- General Study Area
- Restrictive Covenant

Critical Area Type

- Stream
- Wetland
- Stream/Wetland Buffer
- Wellhead Protection Area

Utility Master Plan (UMP) Type

- ICT
- IWS
- Jet Fuel
- Power
- Sanitary Sewer
- Storm
- Water

Figure 1-5
UMP Impacts to Aquatic Critical Areas within the Survey Area
Impact Analysis Memorandum
Seattle-Tacoma International Airport
Sustainable Airport Master Plan (SAMP)

King County, WA

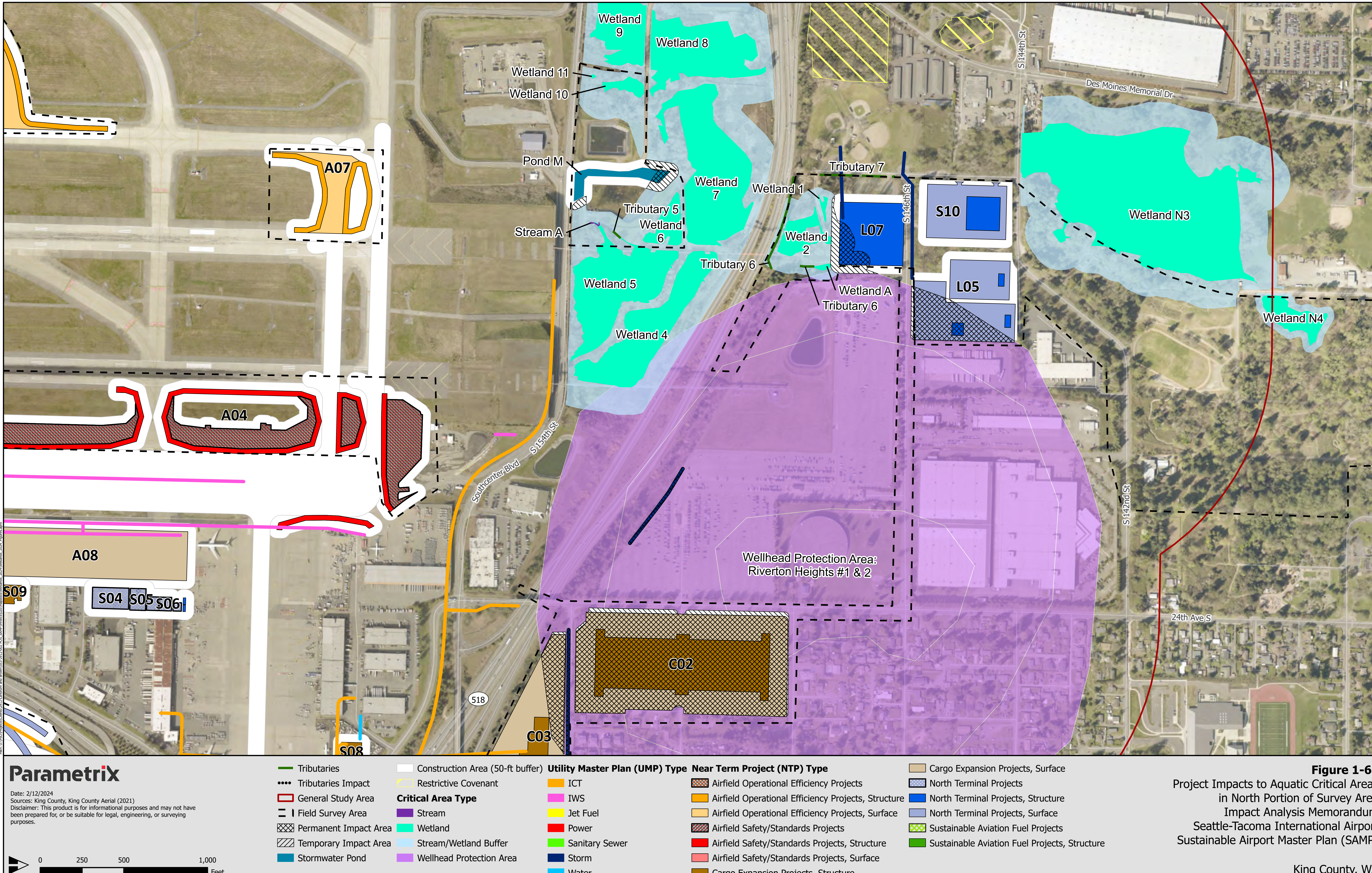
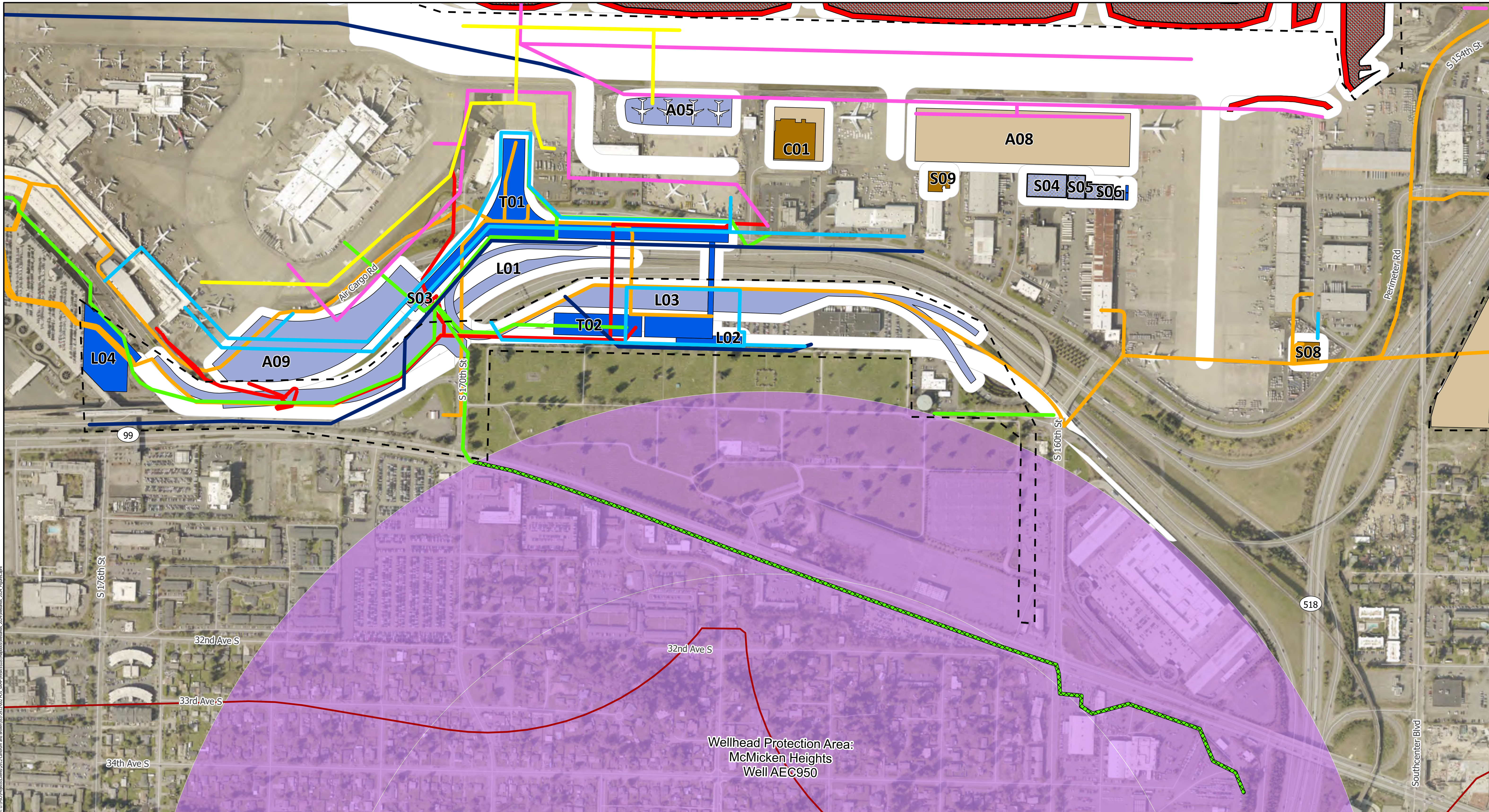


Figure 1-6a
Project Impacts to Aquatic Critical Areas in North Portion of Survey Area
Impact Analysis Memorandum
Seattle-Tacoma International Airport
Sustainable Airport Master Plan (SAMP)

King County, WA



Parametrix

Date: 2/12/2024
Sources: King County, King County Aerial (2021)
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0 250 500 1,000
Feet

- Tributaries
- Tributaries Impact
- General Study Area
- Field Survey Area
- Permanent Impact Area
- Temporary Impact Area
- Stormwater Pond
- Construction Area (50-ft buffer)
- Restrictive Covenant

Critical Area Type

- Stream
- Wetland
- Stream/Wetland Buffer
- Wellhead Protection Area

Utility Master Plan (UMP) Type

- ICT
- IWS
- Jet Fuel
- Power
- Sanitary Sewer
- Storm
- Water

Near Term Project (NTP) Type

- Airfield Operational Efficiency Projects
- Airfield Operational Efficiency Projects, Structure
- Airfield Operational Efficiency Projects, Surface
- Airfield Safety/Standards Projects
- Airfield Safety/Standards Projects, Structure
- Airfield Safety/Standards Projects, Surface
- Cargo Expansion Projects, Structure
- Cargo Expansion Projects, Surface
- North Terminal Projects
- North Terminal Projects, Structure
- North Terminal Projects, Surface
- Sustainable Aviation Fuel Projects
- Sustainable Aviation Fuel Projects, Structure

Figure 1-6b
Project Impacts to Aquatic Critical Areas in North Portion of Survey Area
Impact Analysis Memorandum
Seattle-Tacoma International Airport
Sustainable Airport Master Plan (SAMP)

King County, WA

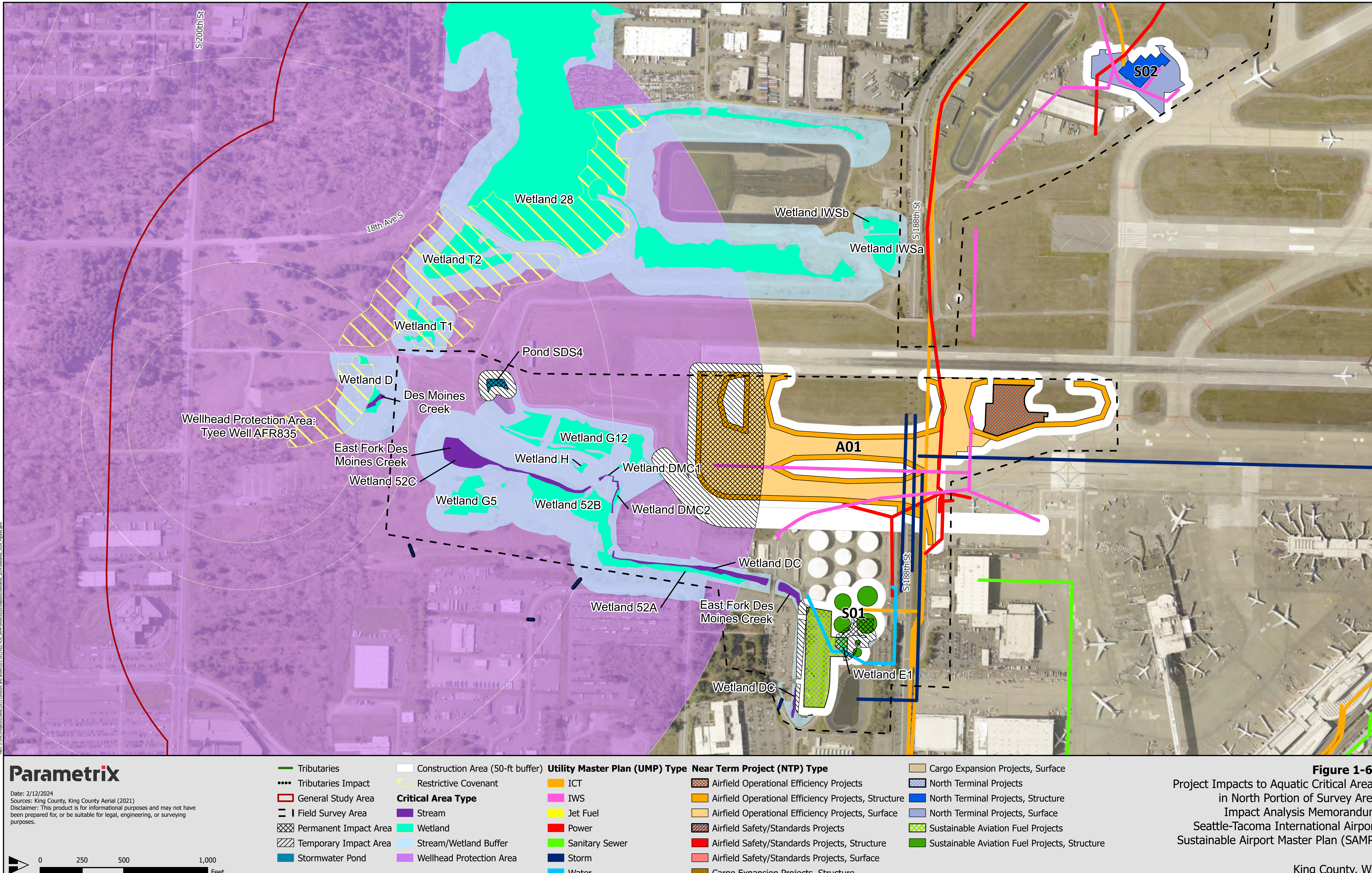
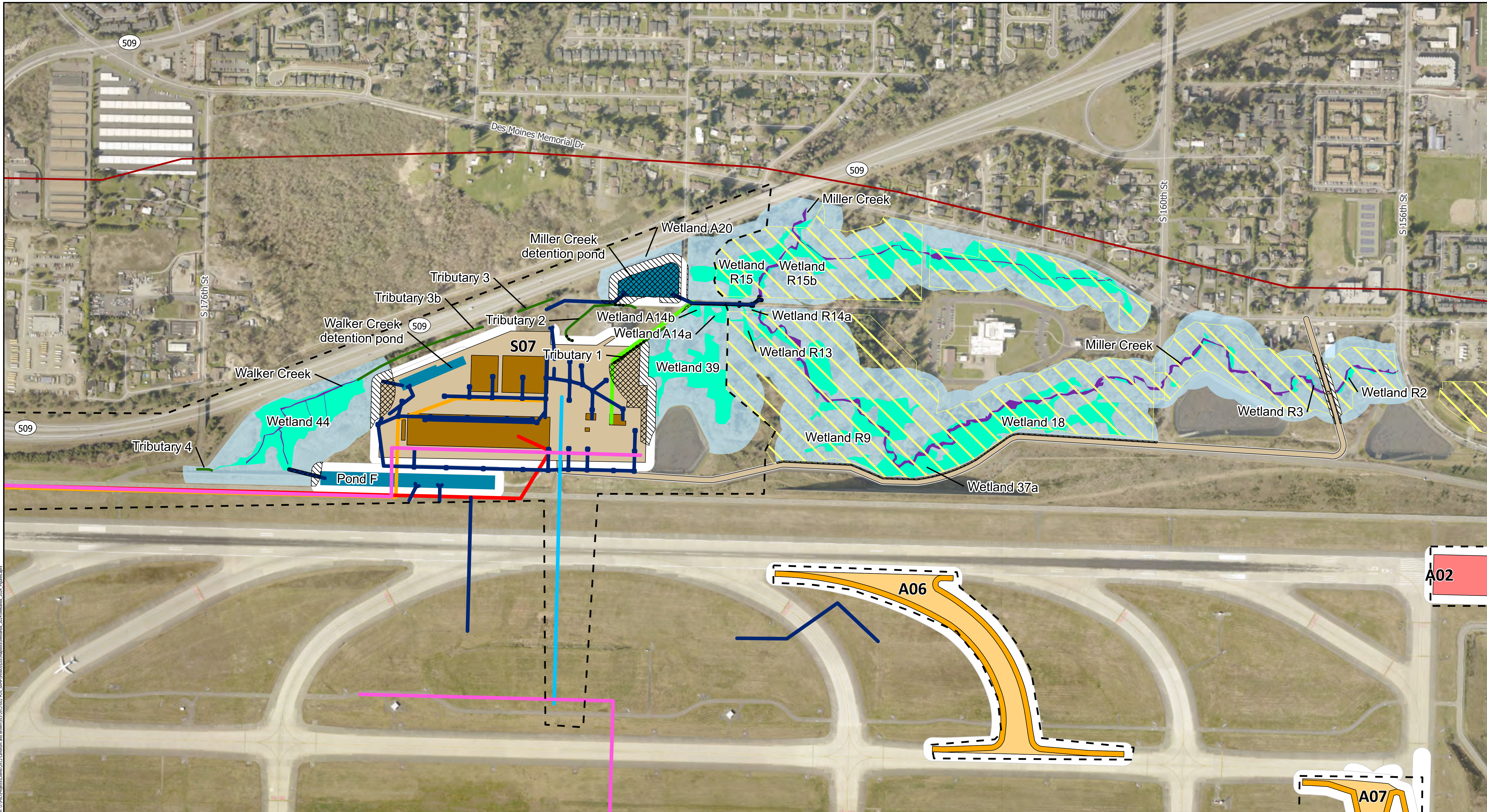


Figure 1-6c
Project Impacts to Aquatic Critical Areas in North Portion of Survey Area
Impact Analysis Memorandum
Seattle-Tacoma International Airport
Sustainable Airport Master Plan (SAMP)

King County, WA



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Date: 2/12/2024
Sources: King County, King County Aerial (2021)
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0 250 500 1,000 Feet

Tributaries
Tributaries Impact
General Study Area
Field Survey Area
Permanent Impact Area
Temporary Impact Area
Stormwater Pond

Construction Area (50-ft buffer)
Restrictive Covenant

Critical Area Type
Stream
Wetland
Stream/Wetland Buffer
Wellhead Protection Area

Utility Master Plan (UMP) Type
ICT
IWS
Jet Fuel
Power
Sanitary Sewer
Storm
Water

Near Term Project (NTP) Type
Airfield Operational Efficiency Projects
Airfield Operational Efficiency Projects, Structure
Airfield Operational Efficiency Projects, Surface
Airfield Safety/Standards Projects
Airfield Safety/Standards Projects, Structure
Airfield Safety/Standards Projects, Surface
Cargo Expansion Projects, Structure
Cargo Expansion Projects, Surface
North Terminal Projects
North Terminal Projects, Structure
North Terminal Projects, Surface
Sustainable Aviation Fuel Projects
Sustainable Aviation Fuel Projects, Structure

Figure 1-6d
Project Impacts to Aquatic Critical Areas
in North Portion of Survey Area
Impact Analysis Memorandum
Seattle-Tacoma International Airport
Sustainable Airport Master Plan (SAMP)

King County, WA

APPENDIX M

Water Resources

Impacts and Mitigation Summary and Proposed Permitting Approach

Parametrix
let's create tomorrow, together

Technical Memorandum

DATE:	May 22, 2024
TO:	Steve Rybolt, Port of Seattle
FROM:	Josh Wozniak, PWS and Kaylee Moser, PWS
SUBJECT:	SAMP Project Impacts and Mitigation Summary and Proposed Permitting Approach
CC:	Jenifer Young
PROJECT NUMBER:	553-2912-002
PROJECT NAME:	Port of Seattle SAMP

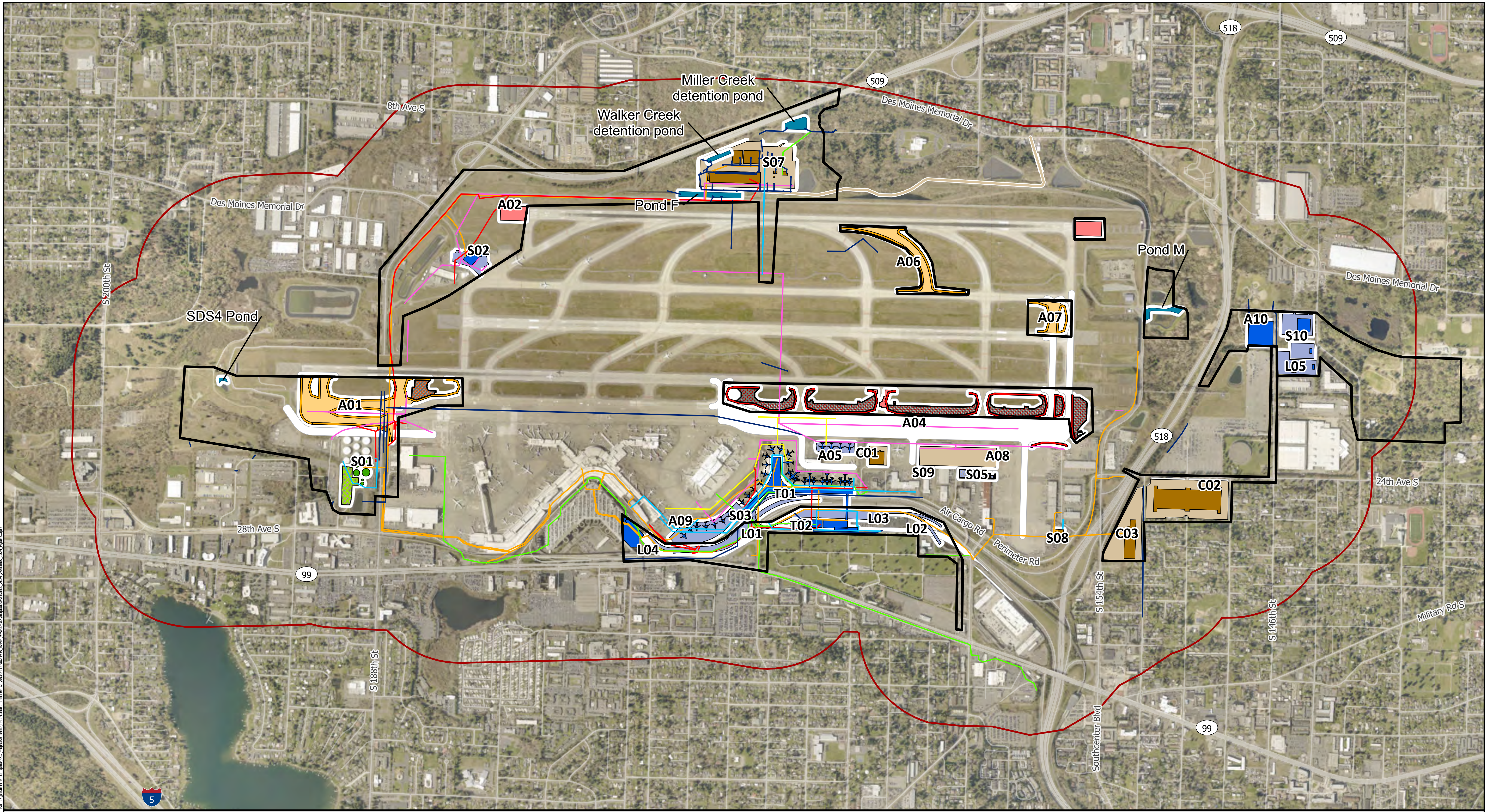
Introduction and Purpose

This memorandum provides a preliminary summary of potential impacts, proposed mitigation for aquatic resources, and permitting approach under the jurisdiction of the U.S. Army Corps of Engineers (Corps) that would be affected by Near-Term Projects (NTP) under the Port of Seattle's (Port) Sustainable Airport Master Plan (SAMP) at Seattle-Tacoma International Airport (SEA). All wetlands included in this memorandum are assumed to be federally jurisdictional by the Corps for the purposes of the Environmental Assessment (EA). A jurisdictional determination will be sought during the permitting phase of the project.

Project Overview

The Port of Seattle (Port) identified a set of NTPs to address the near-term activity levels projected to occur at the Airport. The NTPs include over 30 projects that would improve efficiency, safety, access to SEA, and support facilities for airlines and SEA.

The NTPs are depicted on Figure 1, as well as the proposed utilities and stormwater facilities necessary for NTP implementation. Collectively, the NTPs and the enabling projects are referred to as the Proposed Action. If approved, the Proposed Action is expected to take approximately five years to construct. Those projects that are anticipated to have impacts to aquatic resources under the Corps' jurisdiction—and the subject of this memorandum-- are listed in Table 1.



Parametrix

Date: 3/13/2024
Sources: King County, King County Aerial (2021)
Disclaimer: This product is for informational purposes and may not have been prepared for, or be suitable for legal, engineering, or surveying purposes.

0 0.13 0.25 0.38 0.5 Miles

- Field Survey Area
- General Study Area
- Construction Area (50-ft buffer)
- Stormwater Pond (UMP Polygon)

Proposed Utilities (UMP Line)
- ICT
- IWS
- Jet Fuel
- Power
- Sanitary Sewer
- Storm
- Water

Near Term Project (NTP) Type
- Airfield Operational Efficiency Projects
- Airfield Operational Efficiency Projects, Structure
- Airfield Operational Efficiency Projects, Surface
- Airfield Safety/Standards Projects
- Airfield Safety/Standards Projects
- Airfield Safety/Standards Projects, Structure
- Airfield Safety/Standards Projects, Surface
- Cargo Expansion Projects, Structure
- Cargo Expansion Projects, Surface
- North Terminal Projects
- North Terminal Projects, Structure
- North Terminal Projects, Surface
- Sustainable Aviation Fuel Projects
- Sustainable Aviation Fuel Projects, Structure

Figure 1
Project Elements within the Survey Area
Corps Technical Memorandum
Seattle-Tacoma International Airport
Sustainable Airport Master Plan (SAMP)

King County, WA

Table 1. Proposed Action Elements Anticipated to Impact Aquatic Resources Under Corps Jurisdiction

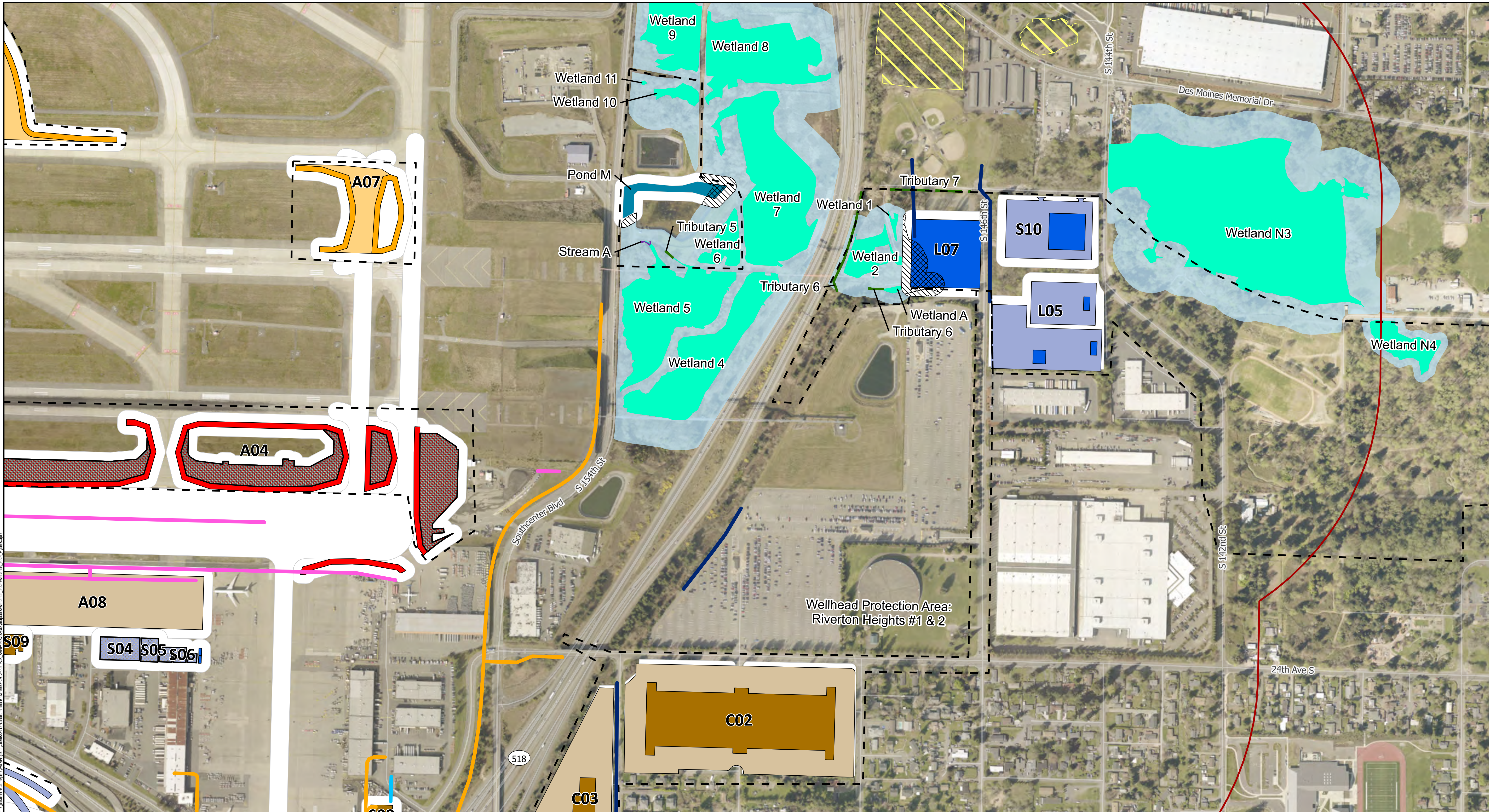
Project Element	SAMP NTP Number	Project Type
Employee Parking Structure	L07	North Terminal Projects, Structure
Fuel Farm Expansion	S01	Sustainable Aviation Fuel Projects, Structure
North Ground Transportation (GT) Holding Lot	L05	North Terminal Projects
Off-site Cargo PH 1 (L-Shape)	C02	Cargo Expansion Projects, Structure
Off-site Cargo PH 2 (L-Shape)	C03	Cargo Expansion Projects, Structure
Taxiway A/B Extension	A01	Airfield Operational Efficiency Projects, Surface
Westside Maintenance Campus	S07	Airfield Operational Efficiency Projects, Surface
Miller Creek Detention Pond	n/a	Stormwater Pond
Pond F Detention Pond	n/a	Stormwater Pond
SDS4 Pond	n/a	Stormwater Pond
Sanitary Sewer Lines	n/a	Utility
Storm Lines	n/a	Utility
Water Lines	n/a	Utility
UMP Line	n/a	Utility

Impact Analysis

Wetlands, streams, and other waters of the US were mapped and documented during site investigations in 2019 and 2020 and wetland and water verification in 2024 (Parametrix 2024). The potential permanent and temporary construction impacts to these aquatic resources from construction of the Proposed Action are summarized in Table 2 and depicted in Figures 2a through 2d. In some instances, designated stream and buffer areas overlap, but for the purpose of this analysis they are reported separately.

Table 2. Summary of Permanent and Temporary Impacts to Aquatic Resources under Corps Jurisdiction

Aquatic Critical Areas and Buffers	Permanent Impacts (acres)	Temporary Impacts (acres)
Stream/Jurisdictional Ditches	**0.02**	**0.08**
Stream Buffer	**0.12**	**0.20**
Wetland	**0.79**	**0.21**
Wetland Buffer	**2.66**	**3.43**



Parametrix

Date: 3/13/2024
Sources: King County, King County Aerial (2021)
Disclaimer: This product is for informational purposes and may not have been prepared for, or be suitable for legal, engineering, or surveying purposes.

0 250 500 1,000 Feet

- Tributaries
- Tributaries Impact
- General Study Area
- Field Survey Area
- Permanent Impact Area
- Temporary Impact Area
- Stormwater Pond
- Construction Area (50-ft buffer)
- Restrictive Covenant

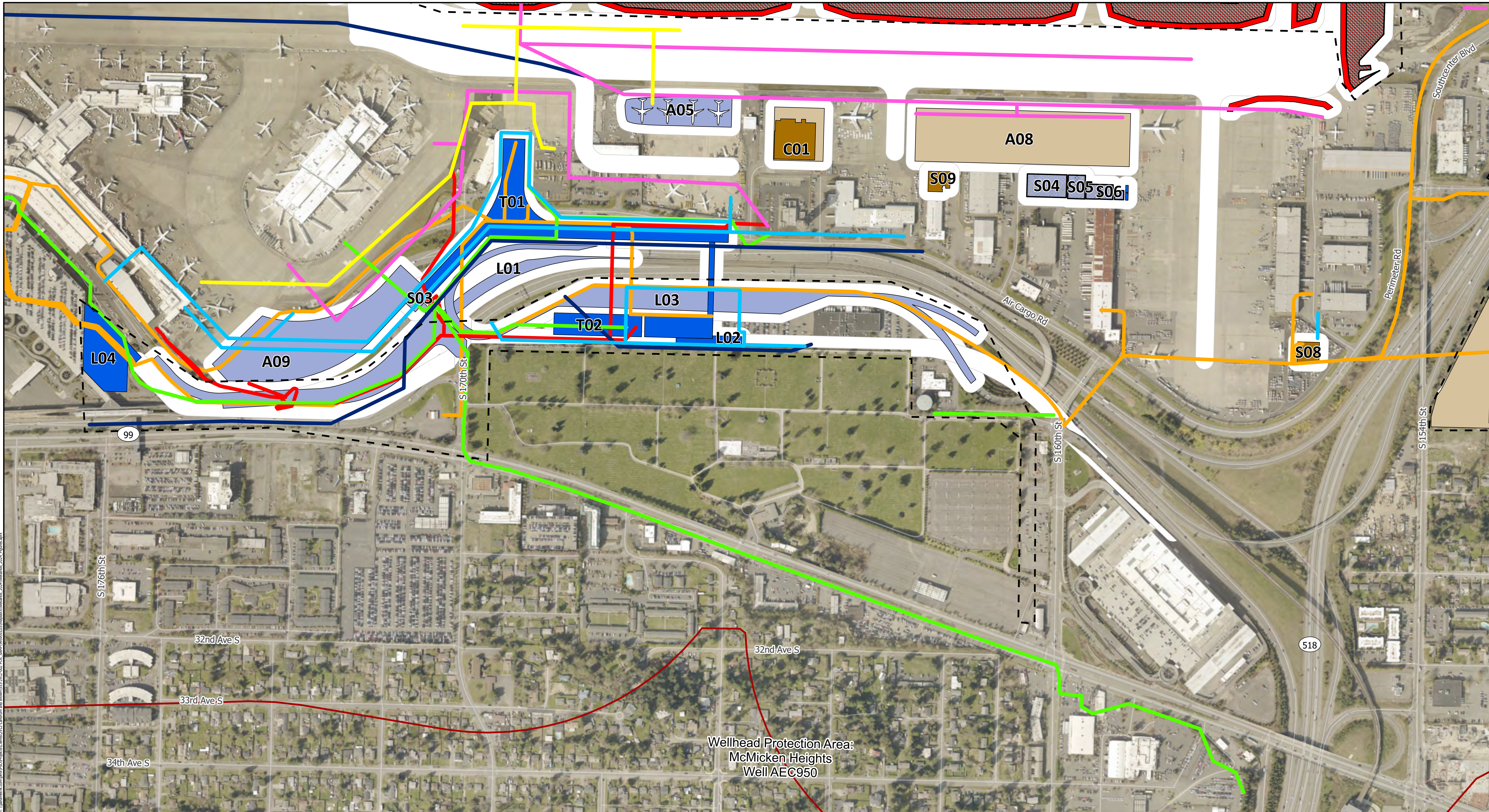
Critical Area Type
- Stream
- Wetland
- Stream/Wetland Buffer

Utility Master Plan (UMP) Type
- ICT
- IWS
- Jet Fuel
- Power
- Sanitary Sewer
- Storm
- Water

Near Term Project (NTP) Type
- Airfield Operational Efficiency Projects
- Airfield Operational Efficiency Projects, Structure
- Airfield Operational Efficiency Projects, Surface
- Airfield Safety/Standards Projects
- Airfield Safety/Standards Projects, Structure
- Airfield Safety/Standards Projects, Surface
- Cargo Expansion Projects, Structure
- Cargo Expansion Projects, Surface
- North Terminal Projects
- North Terminal Projects, Structure
- North Terminal Projects, Surface
- Sustainable Aviation Fuel Projects
- Sustainable Aviation Fuel Projects, Structure

Figure 2a
Project Impacts to Aquatic Critical Areas in North Portion of Survey Area
Corps Technical Memorandum
Seattle-Tacoma International Airport
Sustainable Airport Master Plan (SAMP)

King County, WA



Parametrix

Date: 3/13/2024
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0 250 500 1,000 Feet

- Tributaries
- Tributaries Impact
- General Study Area
- Field Survey Area
- Permanent Impact Area
- Temporary Impact Area
- Stormwater Pond
- Construction Area (50-ft buffer)
- Restrictive Covenant

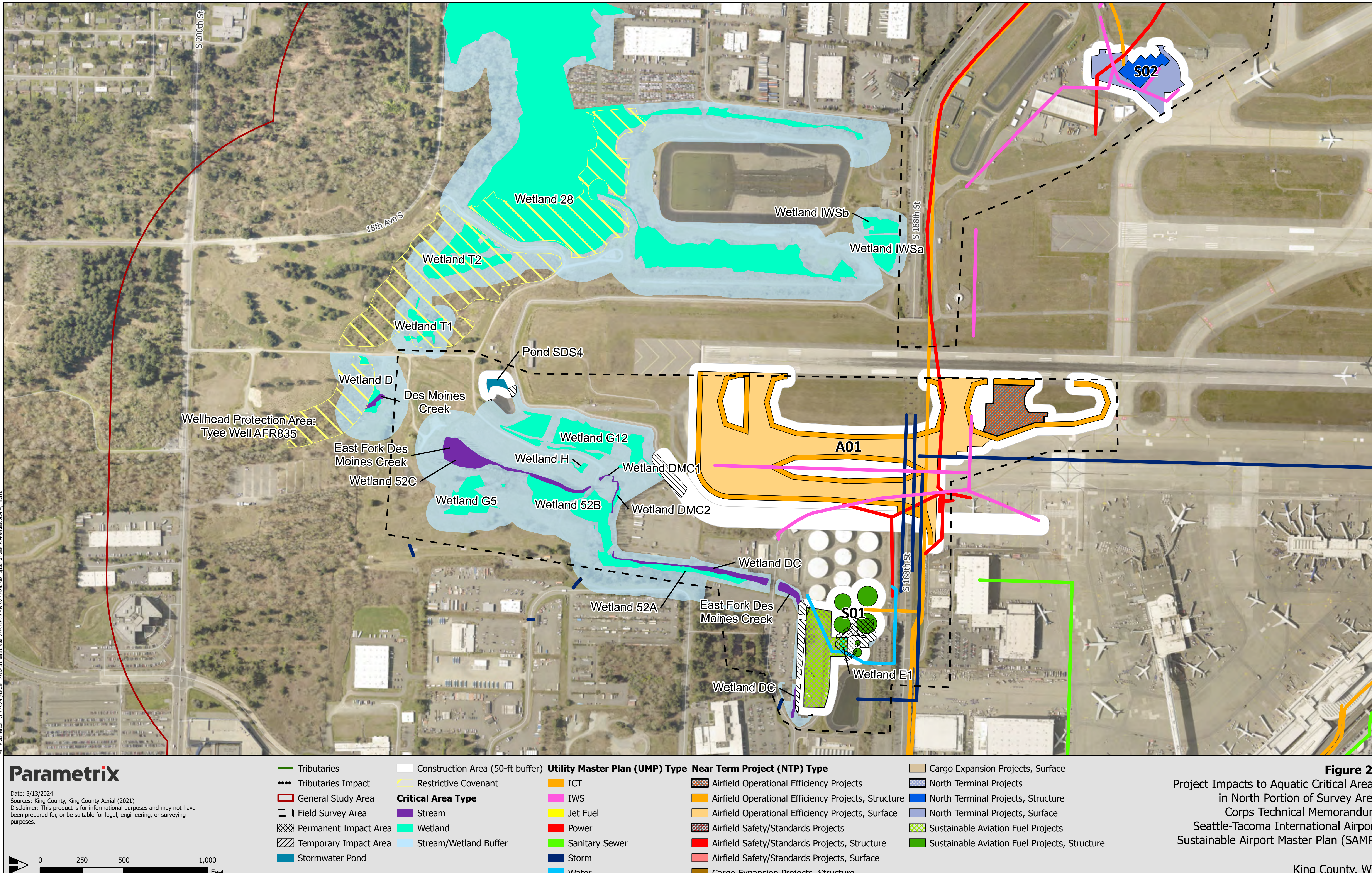
Critical Area Type
- Stream
- Wetland
- Stream/Wetland Buffer

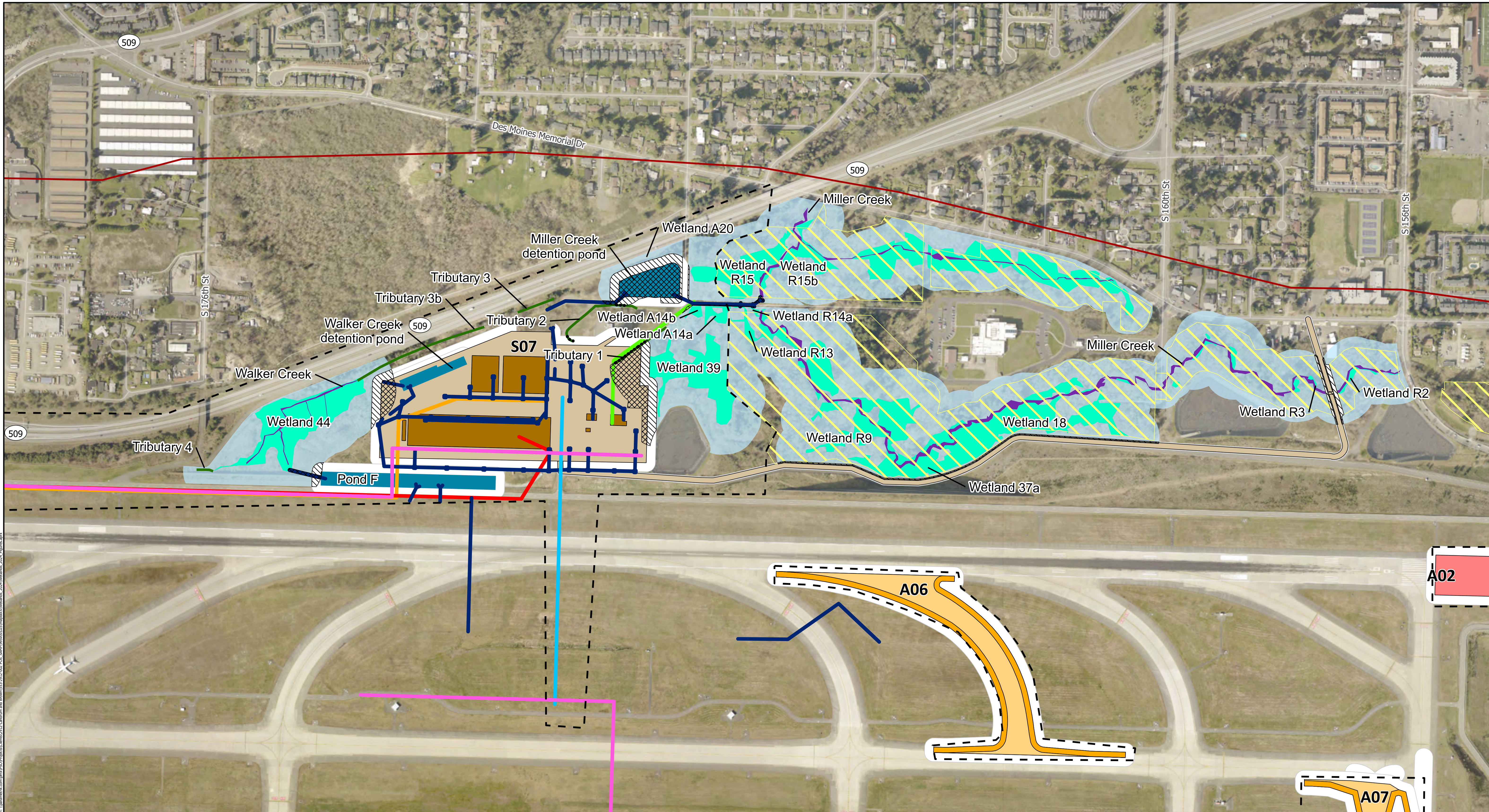
Utility Master Plan (UMP) Type
- ICT
- IWS
- Jet Fuel
- Power
- Sanitary Sewer
- Storm
- Water

Near Term Project (NTP) Type
- Airfield Operational Efficiency Projects
- Airfield Operational Efficiency Projects, Structure
- Airfield Operational Efficiency Projects, Surface
- Airfield Safety/Standards Projects
- Airfield Safety/Standards Projects, Structure
- Airfield Safety/Standards Projects, Surface
- Cargo Expansion Projects, Structure
- Cargo Expansion Projects, Surface
- North Terminal Projects
- North Terminal Projects, Structure
- North Terminal Projects, Surface
- Sustainable Aviation Fuel Projects
- Sustainable Aviation Fuel Projects, Structure

Figure 2b
Project Impacts to Aquatic Critical Areas in North Portion of Survey Area
Corps Technical Memorandum
Seattle-Tacoma International Airport
Sustainable Airport Master Plan (SAMP)

King County, WA


S 200th St
18th Ave S
S 188th St
Wetland 28
Wetland IWSb
Wetland IWSa
Wetland T2
Wetland T1
Pond SDS4
Wetland D
Des Moines
Creek
Wellhead Protection Area:
Tyee Well AFR835
East Fork Des
Moines Creek
Wetland 52C
Wetland G12
Wetland H
Wetland DMC1
Wetland DMC2
Wetland G5
Wetland 52B
Wetland DC
Wetland 52A
East Fork Des
Moines Creek
Wetland E1
Wetland DC
A01
S01
S02
Parametrix
Date: 3/13/2024
Sources: King County, King County Aerial (2021)
Disclaimer: This product is for informational purposes and may not have been prepared for, or be suitable for legal, engineering, or surveying purposes.
0
250
500
1,000
Feet
Tributaries
Tributaries Impact
General Study Area
Field Survey Area
Permanent Impact Area
Temporary Impact Area
Stormwater Pond
Construction Area (50-ft buffer)
Restrictive Covenant
Critical Area Type
Stream
Wetland
Stream/Wetland Buffer
Utility Master Plan (UMP) Type
ICT
IWS
Jet Fuel
Power
Sanitary Sewer
Storm
Water
Near Term Project (NTP) Type
Airfield Operational Efficiency Projects
Airfield Operational Efficiency Projects, Structure
Airfield Operational Efficiency Projects, Surface
Airfield Safety/Standards Projects
Airfield Safety/Standards Projects, Structure
Airfield Safety/Standards Projects, Surface
Cargo Expansion Projects, Structure
Cargo Expansion Projects, Surface
North Terminal Projects
North Terminal Projects, Structure
North Terminal Projects, Surface
Sustainable Aviation Fuel Projects
Sustainable Aviation Fuel Projects, Structure
Figure 2c
Project Impacts to Aquatic Critical Areas
in North Portion of Survey Area
Corps Technical Memorandum
Seattle-Tacoma International Airport
Sustainable Airport Master Plan (SAMP)
King County, WA



Parametrix

Date: 3/13/2024
Sources: King County, King County Aerial (2021)
Disclaimer: This product is for informational purposes and may not have been prepared for, or be suitable for legal, engineering, or surveying purposes.

0 250 500 1,000
Feet

Tributaries
Tributaries Impact
General Study Area
Field Survey Area
Permanent Impact Area
Temporary Impact Area
Stormwater Pond

Construction Area (50-ft buffer)
Restrictive Covenant

Critical Area Type
Stream
Wetland
Stream/Wetland Buffer

Utility Master Plan (UMP) Type
ICT
IWS
Jet Fuel
Power
Sanitary Sewer
Storm
Water

Near Term Project (NTP) Type
Airfield Operational Efficiency Projects
Airfield Operational Efficiency Projects, Structure
Airfield Operational Efficiency Projects, Surface
Airfield Safety/Standards Projects
Airfield Safety/Standards Projects, Structure
Airfield Safety/Standards Projects, Surface
Cargo Expansion Projects, Structure
Cargo Expansion Projects, Surface
North Terminal Projects
North Terminal Projects, Structure
North Terminal Projects, Surface
Sustainable Aviation Fuel Projects
Sustainable Aviation Fuel Projects, Structure

Figure 2d
Project Impacts to Aquatic Critical Areas in North Portion of Survey Area
Corps Technical Memorandum
Seattle-Tacoma International Airport
Sustainable Airport Master Plan (SAMP)

King County, WA

Permanent Impacts

Permanent impacts from implementation of the Proposed Action would result from excavation and fill activities associated with project construction. Permanent impacts for utility lines were calculated based on an assumption of a 20-foot-wide buffer polygon. Table 3 details the permanent impacts to aquatic resources for individual project elements.

Table 3. Permanent Impacts to Aquatic Resources from the Proposed Action

Project Element	Streams/Tributaries (acres)	StreamBuffer (acres)	Wetland (acres)	Wetland Buffer (acres)
Employee Parking Structure	–		0.02	0.60
Fuel Farm Expansion	–	–	0.21	0.01
Taxiway A/B Extension	–	–	–	–
Westside Maintenance Campus	0.01	0.07	<0.01	1.70
NTP Projects Subtotal	*0.01*	*0.07*	*0.23*	*2.31*
Stormwater Pond (Miller Creek detention pond)	–	–	0.55**	–
Stormwater Pond (Pond M)	–	–	–	0.11
Stormwater Pond (Pond F)	–	–	–	<0.01
Stormwater Pond (SDS4 pond)	–	–	–	<0.01
Sanitary Sewer Lines	–	–	–	0.01
Storm Lines	0.01	0.05	0.01	0.23
Water Lines	–	–	–	–
Enabling Projects Subtotal	*0.01*	*0.05*	*0.56*	*0.35*
Total*	*0.02*	*0.12*	*0.79*	*2.66*

* Impacts values in the table are rounded from more detailed calculations. The grand total is rounded from the calculated total, not the sum of the individual rounded values presented in the table.

** Future design may include a vault, reducing or eliminating this impact.

Table 4 summarizes all permanent wetland impacts by project element and Wetland ID. Table 5 summarizes all permanent stream/tributary impacts by project element and Stream/Tributary ID. Table 6 summarizes the wetland and stream resources associated with the permanent buffer impacts per project element. Because the buffers are overlapping in most of the project area, the buffers were dissolved into one layer in GIS so as to not double-count buffer impacts. Therefore, buffer impacts per individual resource are not provided.

Table 4. Permanently Impacted Wetlands

Project Element	Wetland Impact (acre)	Wetland ID	2014 Ecology Rating [a]	Total Wetland Size (acres)
Employee Parking Structure	0.02	Wetland A	III	0.11
Westside Maintenance Campus	<0.01	Wetland 39	III	2.60
Stormwater Pond (Miller Creek detention pond)	0.55**	Wetland A20	III	0.55
Fuel Farm Expansion	0.21	Wetland E1	III	0.21
Storm (UMP Line)	<0.01	Wetland A14	III	0.21
	0.01	Wetland 44	II	3.10
	<0.01	Wetland A20	III	0.55
	<0.01	Wetland R13	II	1.12
	<0.01	Wetland R14a	II	0.06
Total	*0.79*			

[a] Hruby and Yahnke 2023

* Impacts values in the table are rounded from more detailed calculations. The total is rounded from the calculated total, not the sum of theindividual rounded values presented in the table.
** Future design may include a vault, reducing or eliminating this impact.

Table 5. Permanently Impacted Streams/Tributaries

Project Element	Stream Impact (acre)	Stream/Tributary ID	WDNR Classification[a]	SeaTac Stream Class[b]
Westside Maintenance Campus	0.01	Miller Creek	F	2
Storm Lines	0.01	Tributary 2	N/A	N/A
Total	***0.02***			

[a] WDNR FPARS mapping (2024), as mapped within the study area
[b] SMC 15.700.330: The Port of Seattle has adopted SMC 15.700.330 with respect to classification of streams and application of appropriate buffer widths.

Table 6. Permanently Impacted Wetland and Stream Buffer

Wetland Buffer		
Project Element	Buffer Impact per Project Element (acre)	Associated Wetland ID[a]
Employee Parking Structure	0.60	Wetland A, Wetland 1, Wetland 2
Fuel Farm Expansion	0.01	Wetland DC
Westside Maintenance Campus	1.70	Wetland 39, Wetland 44, Wetland R9, Wetland 37a, Wetland 18, Wetland R3, Wetland R2
Stormwater Pond (Pond M)	0.11	Wetland 6, Wetland 7
Stormwater Pond (Pond F)	<0.01	Wetland 44
Stormwater Pond (SDS4 pond)	<0.01	Wetland G12
Sanitary Sewer Lines	0.01	Wetland 39
Storm Lines	0.23	Wetland 44, Wetland 39, Wetland A20, Wetland A14a, Wetland A14b, Wetland 13, Wetland R15, Wetland R15b
Total	***2.66***	
Stream Buffer		
Project Element	**Buffer Impact (acre)**	**Associated Stream ID**
West Side Maintenance Campus	0.07	Miller Creek
Storm Lines	0.05	Walker Creek
Total	**0.12**	

[a] Because the buffers are overlapping in most of the project area, the buffers were dissolved into one layer in GIS so as to not double-count buffer impacts. Therefore, buffer impacts per individual resource would not be accurate.

Temporary Construction Impacts

Temporary construction impacts would occur where aquatic areas or buffers are affected by clearing and ground- disturbing work but are revegetated within a year following construction. These impacts were calculated based on the assumption of a 50-foot buffer polygon applied to NTP footprints and stormwater ponds. The temporary construction impacts for the West Maintenance Campus access road were calculated based on a 5- foot buffer from the edge of the road. At the Miller Creek stream crossing, the temporary construction impacts were extended to meet the boundaries of the restrictive covenant on either side of the road.

Table 7 details the temporary impacts to critical areas and buffers for individual project elements. Only the individual projects that have temporary impacts to critical areas and/or associated buffers are listed in this table.

Table 7. Temporary Impacts to Aquatic Resources from the Proposed Action

Project Element	Stream (acres)	Stream Buffer (acres)	Wetland (acres)	Wetland Buffer (acres)
Employee Parking Structure	--	--	0.04	0.55
Fuel Farm Expansion	0.07	--	0.07	0.35
Taxiway A/B Extension	--	--	--	0.42
Westside Maintenance Campus	0.01	0.20	0.10	1.41
NTP Projects Subtotal	*0.08*	*0.20*	*0.21*	*2.73*
Stormwater Pond (Miller Creek detention pond)	--	--	--	--
Stormwater Pond (Pond F detention pond)	--	--	--	0.11
Stormwater Pond (SDS4 Pond)	--	--	--	0.06
Stormwater Pond buffer (Pond M)	--	--	--	0.53
Infrastructure Improvements Subtotal	*--*	*--*	*--*	*0.70*
Total*	*0.08*	*0.20*	*0.21*	*3.43*

* Impact values in the table are rounded from more detailed calculations. The total is rounded from the calculated total, not the sum of the individual rounded values presented in the table.

Table 8 summarizes all temporary wetland impacts by project element and Wetland ID. Table 9 summarizes all temporary stream/tributary impacts by project element and Stream/Tributary ID. Table 10 summarizes the wetland and stream resources associated with the temporary buffer impacts per project element. Because the buffers are overlapping in most of the project area, the buffers were dissolved into one layer in GIS so as to not double-count buffer impacts. Therefore, buffer impacts per individual resource are not provided.

Table 8. Temporarily Impacted Wetlands

Project Element	Wetland Impact (acre)	Wetland ID	2014 Ecology Rating [a]	Total Wetland Size (acres)
Employee Parking Structure	0.02	Wetland A	III	0.11
	0.02	Wetland 2	III	0.81
Fuel Farm Expansion	0.07	Wetland DC	II	0.54
Westside Maintenance Campus	0.06	Wetland 39	III	2.60
	0.04	Wetland 44	II	3.12
Total*	*0.21*			

[a] Hruby and Yahnke 2023

Table 9. Temporarily Impacted Streams/Tributaries

Project Element	Stream Impact (acre)	Stream/Tributary ID	WDNR Classification[a]	SeaTac Stream Class[b]
Fuel Farm	0.07	East Fork Des Moines Creek	F	2
Westside Maintenance Campus	0.01	Miller Creek	F	2
Total*	*0.08*			

[a] WDNR FPARS mapping (2024), as mapped within the study area

[b] SMC 15.700.330: The Port of Seattle has adopted SMC 15.700.330 with respect to classification of streams and application of appropriate buffer widths.

Table 10. Temporarily Impacted Wetland and Stream Buffer

Wetland Buffer		
Project Element	Buffer Impact per Project Element (acre)	Associated Wetland ID[a]
Employee Parking Structure	0.55	Wetland A, Wetland 1, Wetland 2
Fuel Farm Expansion	0.35	Wetland DC
Taxiway A/B Extension	0.42	Wetland G12
Westside Maintenance Campus	1.41	Wetland 44, Wetland 39, Wetland R9, Wetland 37a, Wetland 18, Wetland R3, Wetland R2
Stormwater Pond (Pond F detention pond)	0.11	Wetland 44
Stormwater Pond (SDS4 Pond)	0.06	Wetland G12
Stormwater Pond buffer (Pond M)	0.53	Wetland 6, Wetland 7
Total	***3.43***	
Stream Buffer		
Project Element	**Buffer Impact (acre)**	**Associated Stream ID**
West Side Maintenance Campus	0.20	Walker Creek, Miller Creek
Total	**0.20**	

[a] Because the buffers are overlapping in most of the project area, the buffers were dissolved into one layer in GIS so as to not double-count buffer impacts. Therefore, buffer impacts per individual resource would not be accurate.

Avoidance And Minimization Measures

The avoidance and minimization of impacts to aquatic resources was a guiding principle for the preliminary project design. Additional avoidance and minimization measures would be implemented, as practical, as the project design continues to develop. The Port is exploring options to reduce permanent wetland and stream impacts associated with utility lines and to minimize buffer impacts. Additional strategies include minimizing vegetation clearing and restoring temporarily affected areas as soon after the initial impact as possible.

The Port would comply with standard specifications, best management practices (BMPs),[1] and applicable federal and state mitigation requirements during design, construction, and post-construction activities. The Port would meet all regulatory requirements and continue to meet or exceed avoidance and minimization measures related to these BMPs in adherence with federal and state regulations.

On Site Restoration

Temporary impacts to wetlands, streams, and buffers would be restored in-kind on site. For the purpose of this assessment, all temporary impacts are assumed to be short term (restored within one year). The amount of on-site restoration would be equal to the areas of temporary impacts identified in Table 7.

[1] BMPs include various methods and devices to control, remove, or reduce pollution, and are listed in the Airport's Stormwater Pollution Prevention Plan (https://www.portseattle.org/file-documents/sea-tac-stormwater-pollution-prevention-plan). BMPs include operational practices (e.g. training and spill prevention), structural controls (e.g. stormwater ponds and oil/water separators), and erosion and sediment controls (e.g. silt fence and filter strips).

Mitigation Approach

Compensatory Mitigation

For unavoidable permanent impacts from elements of the Proposed Action, the Port will develop a compensatory mitigation plan during the permitting phase in accordance with applicable federal and state requirements and guidelines. These guidelines are listed in the U.S. Army Corps of Engineers and EPA's Compensatory Mitigation for Losses of Aquatic Resources,[2] and Ecology's interagency guidance contained in Wetland Mitigation in Washington State: Parts 1 and 2.[3]

The mitigation plan will be developed in cooperation with resource agencies and tribes and will follow a mitigation sequencing approach based on a hierarchy of avoiding and minimizing adverse impacts through careful design, rectifying temporary impacts, and compensating for unavoidable adverse impacts. The specific portfolio of mitigation, including location, design, and timing of permitting and construction would be developed concurrent with the progression of design for elements of the Proposed Action, which will be required to adhere to mitigation sequencing guidelines. To the extent practicable, compensatory mitigation will be designed to replace the functions and values of the impacted resources.

The area needed for compensatory mitigation is dictated by federal and state guidance. For the purpose of this evaluation, we anticipate that the project will comply with the compensatory mitigation ratios recommended by an interagency review committee composed of the Corps, EPA, and Ecology (Ecology, et al 2021). Table 10 provides a summary of the recommended compensatory mitigation ratios.

Table 10. Interagency Recommended Compensatory Mitigation Ratios for Wetland Impacts

Category and Type of Wetland	Creation or Reestablishment	Rehabilitation	Enhancement
Category I: Mature Forested	6:1	12:1	24:1
Category I: Based on Functions	4:1	8:1	16:1
Category II	3:1	6:1	12:1
Category III	2:1	4:1	8:1
Category IV	1.5:1	3:1	6:1

[2] 33 CFR Parts 325 and 332/ 40 CFR Part 230

[3] *Wetland Mitigation in Washington State Part 1: Agency Policies and Guidance* (2021), and *Part 2: Developing Mitigation Plans* (2006)

Table 11 provides a summary of the compensatory wetland mitigation areas that are anticipated to be required based on the current preliminary design.

Table 11. Compensatory Wetland Mitigation Area Calculations

Project Element	Wetland Impact (acre/Rating)	Re-establishment Area Needed (acres)	Rehabilitation Area Needed (acres)	Enhancement Area Needed (acres)
Facilities	0.23/III	0.46	0.92	1.84
UMP Line	0.01/III	0.02	0.04	0.08
Utility Lines	0.01/II	0.03	0.06	0.12
StormwaterPonds	0.55/III	1.10	2.75	4.40
	Total Areas	**1.61**	**3.77**	**6.44**

The requirement to provide compensatory mitigation for buffer impacts is not stated in the regulatory guidelines and is typically evaluated on a case-by-case basis. For the purposes of this evaluation, it is conservatively assumed that all buffer impacts would be mitigated by reestablishing buffer in association with the wetland compensatory mitigation at a 1:1 ratio (impact to reestablishment).

Mitigation Area Need and Availability

Compensatory mitigation for wetland impacts of the NTPs is anticipated to require between 1.61 acres and 6.64 acres of mitigation site area. The lower end of this range assumes a mitigation approach based entirely on wetland re-establishment. The upper end of the range assumes a mitigation approach based entirely on wetland enhancement. Providing additional area to mitigate for buffer impacts at a 1:1 ratio would add 2.66 acres of needed mitigation to each of these ranges. Therefore, the project is anticipated to required mitigation site areas that total between 4.27 and 9.30 acres.

The Port has seven sites within its ownership that have been identified as being suitable for compensatory mitigation. Proposed mitigation approaches have been evaluated and described based on each site's opportunities and potential (Anchor 2019). Six sites are within the airport property and one site is located along the Green River in Auburn. These mitigation sites encompass over total 150 acres and include potential for more than 40 acres of wetland re-establishment, and 11 acres of wetland enhancement (Anchor QEA 2019). Based on these calculations, the mitigation areas identified by the Port have sufficient capacity to provide the needed compensatory mitigation for the anticipated impacts to wetlands and buffers occur due to the proposed action.

In addition to wetland and buffer impacts the project includes a small amount of permanent impacts to steams and jurisdictional tributaries (0.02 acre). Impacts to jurisdictional tributaries are generally mitigated by restoring the function of the impacted drainage system and typically do not require compensatory mitigation. Impacts to streams are not generally mitigated in terms of area. Mitigation is typically proposed to provide a functional uplift to the impacted system. Where there are insufficient opportunities to create functional uplift in the impacts system, it may be necessary to provide mitigation through other mechanisms such as purchasing mitigation credits from banks or in-lieu fee programs. While the project has not progressed to the point where these specific requirements are known, the amount of impact that would need to be mitigated through these programs is small (0.02 acre or less) and the Airport is within the service area of several existing banks and in-lieu fee programs.

Permitting Approach

The Proposed Action elements are in a conceptual phase of development and have not completed detailed designs. During the design process, the Port will confirm existence of regulated wetlands with the Corps to ensure that all waters of the U.S. subject to Corps jurisdiction are properly identified. At this time, all wetlands will be considered jurisdictional as this will be the basis for detailed calculations of impacts and mitigation for advanced project design.

With clarity on potential impacts and additional project design details, the Port will submit permit applications to the Corps and other regulatory agencies, as necessary, in compliance with Clean Water Act requirements, Washington State regulations, and local ordinances. These applications will provide design drawings, refined impact assessments, and detailed mitigation plans.

The permitting approach will be further informed by the location, schedule, and sequencing of individual projects with unavoidable impacts to waters of the U.S. Individual permit applications are expected to be submitted for most or all proposed action elements, but some may be combined into a single permit application, including if the selected mitigation activity to offset wetland/aquatic impacts for more than one proposed action element is combined into a single mitigation site. The decision on the number and timing of permit applications will be determined following further planning and design development.

As shown in the table below, four SAMP NTPs would result in impacts to wetlands, streams and/or their buffers. One of these projects may exceed the impact threshold for an applicable Nationwide Permit (NWP) of 0.5 acre, and would therefore require an Individual Permit from the Corps.

On-site mitigation at the project location is feasible for nearly all wetlands and streams impacted by the SAMP NTPs as land is available within the NTP area to support replacement of lost functions with each mitigation action. However, mitigation for impacts to Wetland E1 within the S01/Fuel Farm Expansion project would need to take place on Port-owned property at SEA or at the Port mitigation site in Auburn due to site constraints at the fuel farm facility.

Each project is planned to be permitted separately with the Corps and other regulatory agencies. If efficiencies are identified to bundle projects that have similar construction timeframes under a single permit, the Port will evaluate this option with regulatory agencies (Table 12).

Table 12. Anticipated Permit and Mitigation Method for SAMP NTPs with Impacts to CWA Jurisdictional Resources

NTP	Section 404 Permit	Mitigation Method	Planned Construction	Notes
A01/ Taxiway A/B Extension	n/a	On-site	2026-2029	Wetland buffer impacts only
L07/ Employee Parking Structure	NWP	On-site	2029-2031	
S01/ Fuel Farm Expansion	NWP	On Port property	2029-2031	On-site capacity is not available to mitigate for wetland impacts at the fuel farm facility.
S07/ Westside Maintenance Campus	Individual	On-site	2025-2027	Wetland impacts may exceed NWP threshold of 0.5 acre, assuming full take of Wetland A20.

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APPENDIX M

Water Resources

Impervious Area Impacts and Mitigation Measures

Gresham Smith

TECHNICAL MEMORANDUM

TO:	Sarah Potter, Landrum and Brown Steve Rybolt, Port of Seattle
FROM:	Gresham Smith
DATE:	June 14, 2024
SUBJECT:	**IMPERVIOUS AREA IMPACTS AND MITIGATION MEASURES SUPPLEMENTAL INFORMATION FOR ENVIRONMENTAL ASSESSMENT SEATTLE-TACOMA INTERNATIONAL AIRPORT SUSTAINABLE AIRPORT MASTER PLAN** Gresham Smith Project No. 42583.04

Gresham Smith prepared this Impervious Surface Analysis Technical Memorandum to analyze the potential impervious area changes resulting from the Sustainable Airport Master Plan (SAMP) Near-Term Projects (NTP). This report also identifies stormwater controls to address these impacts.

Description of the Proposed Action

The Port of Seattle (Port) identified a set of NTPs to address the near-term activity levels projected to occur at the Airport. The NTPs include 31 projects that would improve efficiency, safety, access to the Airport, and support facilities for airlines and the Airport.

In addition to the Proposed Action, the Port also evaluated a Hybrid Terminal Option. The impervious area impacts and stormwater controls described in this memorandum are associated with the Proposed Action and the Hybrid Terminal Option. For the purposes of analyzing changes to impervious surfaces, the Hybrid Terminal Option resulted in no differences from the Proposed Action. The No Action Alternative has no impervious area changes.

Potential Impacts Due to Site Imperviousness

Both the Proposed Action and Hybrid Terminal Option would involve the addition or expansion of impervious areas, as well as the replacement of existing impervious surfaces. Major impervious area changes include the reconfiguration of taxiways to meet safety and operational requirements, expansion of the fuel farm, construction of the westside maintenance campus, and the construction of new cargo and parking facilities on undeveloped sites north of SR 518. The addition of impervious surfaces would be at least partially offset by the demolition of select impervious surfaces along the taxiways and other hard surfaces.

The change in impervious surfaces between pre- and post-development conditions was analyzed in detail by overlaying proposed project footprints with existing airport drainage subbasin boundaries. Each subbasin has a unique drainage infrastructure system that drains to existing stormwater controls before draining to an outfall and leaving the airport. Impervious areas within both the Stormwater Drainage System (SDS) and Industrial Wastewater System (IWS) were included in this analysis. Please refer to **Exhibit 1** for IWS and SDS subbasins and detention facility locations. **Table 1** provides a summary of net impervious area changes within each drainage subbasin. As shown in the table, the total impervious area is expected to increase by about 75 acres.

Without appropriate stormwater quantity controls, this expansion in impervious area would be expected to increase stormwater runoff quantity and impact stormwater quality. A stormwater analysis was performed to evaluate the impacts of the proposed changes on stormwater runoff quantity, as well as the need for new or expanded detention facilities to address these quantity impacts. Table 1 includes a summary of the estimated percent increase in peak runoff rates in each drainage subbasin, upstream of existing and proposed stormwater controls (not accounting for existing and proposed stormwater quantity mitigation).

Proposed development conditions were simulated with existing stormwater controls to determine the need for new or expanded detention facilities to mitigate for stormwater quantity impacts and control stormwater discharges in accordance with local requirements. Impervious area changes within the new development areas north of SR 518 would require the implementation of new stormwater controls. The proposed impervious areas were also compared to existing water quality treatment capacities to determine the need for new or expanded water quality treatment best management practices (BMPs) in accordance with local requirements. Please refer to the Mitigation and Minimization Measures section for stormwater control improvements that are proposed to address the impervious area impacts.

TABLE 1: IMPERVIOUS AREA CHANGE SUMMARY

Drainage Subbasin[1]	Net Change in Impervious Area[2] (acres)	Estimated % Increase in 100 year Peak Runoff Rate Without Mitigation[3]
IWS	-29.20	N/A[5]
SDD05B	+0.42	4%
SDE4 & SDE4X	+34.18	24%
SDN2/3/4	+9.72	21%
SDN3A	+0.85	7%
SDS3 / SDS3A / SDS5	-3.46	N/A[5]
SDS4	+1.82	5%
SDS6-7A	+1.00	2%
SDW1B	+15.84	49%
SDW2	+8.54	61%
MC07	-2.87	N/A[5]
New Development North of SR518[4]	+37.59	82%
TOTAL (Existing + New Development)	**+74.43**	N/A[6]

1. "SDXX" nomenclature refers to drainage subbasin IDs within the storm drain system (SDS). The third character in each drainage subbasin ID (N/E/S/W) indicates the side of the airport where the drainage subbasin is located (north / east / south / west).
2. Although all projects and subbasins were evaluated for impervious area changes, the summary table above excludes subbasins with no net change in impervious area. The total impervious area change is inclusive of all impervious area changes. The net change in impervious area accounts for impervious changes due to development projects (both addition and demolition of paved surfaces), as well as shifts between subbasin boundaries. A positive net change indicates that total impervious area increased, while a negative net change indicates that total impervious area decreased. Impervious area changes were determined through GIS analysis performed by Aspect Consulting in March 2021.
3. The percent increase in peak runoff rates were calculated by WSP based on regression analyses and model-generated flow rates to illustrate the magnitude of the potential impact of development on stormwater quantity. These flow rates were then proportioned to reflect changes in the drainage basins since that analysis was performed. These flow rates do not account for mitigation at existing and proposed detention basins. Proposed improvements to existing detention facilities to address the identified impacts are summarized in Mitigation and Minimization Measures.
4. "New development north of SR 518" refers to isolated projects north of SR 518 that do not fall within existing drainage subbasins. The net change in impervious area represents the total impervious area within those project footprints. These new development areas are not currently served by stormwater controls and increases in impervious areas that would require the implementation of new controls, as described in Section J.3.
5. Reductions in impervious area were not evaluated for peak flow reduction as they do not result in an impact requiring mitigation.
6. Stormwater quantity impacts were evaluated for individual drainage basins with development, as summarized in the rows above.

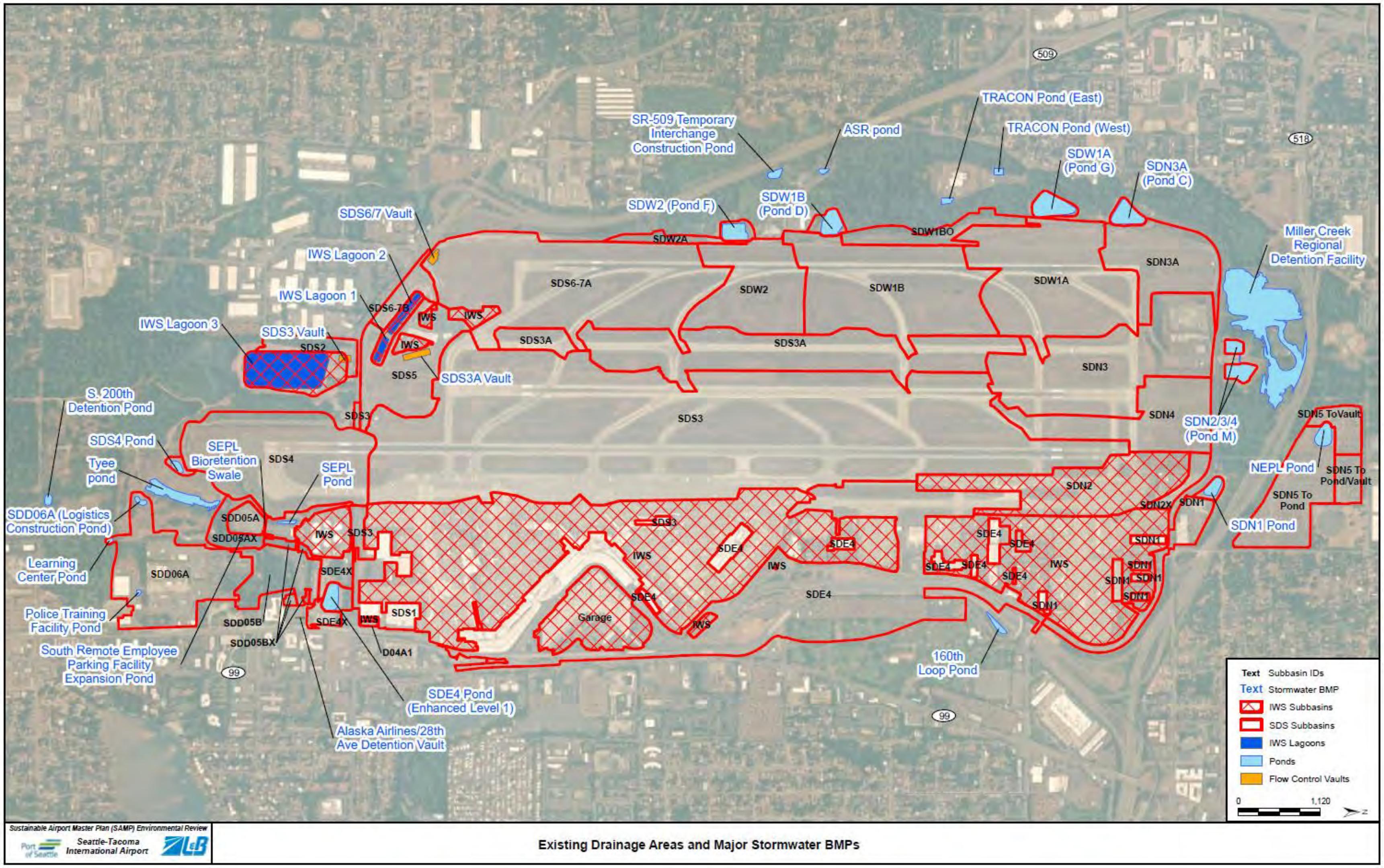


EXHIBIT 1: EXISTING DRAINAGE BASINS AND DETENTION FACILITIES

Mitigation and Minimization Measures

To minimize and mitigate for potential impacts to stormwater runoff quantity and quality associated with expanded impervious surfaces, grading activities, and airport activity areas, the Port would implement stormwater management measures for development projects in accordance with applicable local, state, and federal regulatory requirements. These include post-construction stormwater quantity and quality (treatment) controls, as well as source controls (structural and non-structural), and low-impact development. Proposed stormwater controls that are anticipated to be needed as mitigation and minimization measures for the Proposed Action within the SDS and IWS are described below under the SDS Measures and IWS Measures subsections.

Source Controls

The Airport's SWPPP describes existing non-structural (e.g., good housekeeping, spill response, employee training) and structural source controls (e.g., oil/water separators, containment berms) that are already in place, and the locations where they are implemented to minimize the potential for pollutant runoff from existing activity areas. New facilities may need to implement additional source controls or expand the area where existing controls are implemented, where appropriate, to reduce the risk of pollutants entering the SDS or IWS drainage systems. Specific source controls will be evaluated and selected for individual projects during the design phase based on project features, planned activities, pollutants potentially associated with those activities, and compliance with applicable regulations. The Airport's SWPPP would be updated to reflect any proposed change in facilities, activity areas, tenants, and the application of BMPs and source controls to new activity areas. Additionally, new facilities with qualifying oil storage tanks and equipment would implement appropriate spill response, containment measures, and other source controls in accordance with the Airport's Spill Prevention, Control, and Countermeasure (SPCC) Plan, which would also be updated accordingly.

6PPD / 6PPD-Quinone and Other Emerging Contaminants

During the design of stormwater controls for new projects, the potential for the release of emerging contaminants (e.g., 6PPD and 6PPD-quinone) will be considered where relevant. Available industry guidance such as the Washington State Department of Ecology's *Stormwater Treatment of Tire Contaminants Best Management Practices Effectiveness* (2022) will be referenced to select appropriate source control BMPs and/or flow and treatment BMPs to address these contaminants where applicable and to the extent feasible. These include BMPs that contribute to sediment capture, filtration, sorption, or infiltration. The Port has already implemented a large number of structural and non-structural BMPs, as documented in the Airport's SWPPP, that are likely to be effective at reducing 6PPD and 6PPD-quinone, including:

- Street sweeping
- Runway rubber removal (annual)
- Detention basins
- Constructed wetlands
- Cartridge filters
- Bioswales

- Filter strips
- Oil/water separators
- Industrial Waste Treatment Plant
- Sediment removal from Lagoons 1-3.

The types of post-construction stormwater controls identified to address the Proposed Action, as detailed in Table 2 (including detention basins, oil/water separators, infiltration BMPs, and bioretention) are included among the BMPs in Ecology's 2022 report recommended to address 6PPD and 6PPD-quinone.

Low-Impact Development

Low-impact development techniques and infiltration features would also be considered for implementation where feasible, as described in the SDS Measures subsection. Feasibility of LID would be evaluated during the detailed design phase to take into account the detailed facility layout, space constraints, project runoff characteristics, and site-specific geotechnical / hydrogeologic investigations and infiltration testing that will be performed at that time. This LID feasibility review would follow the process outlined by the Port of Seattle in the *Low Impact Development Guideline Seattle-Tacoma International Airport* (2018) and *Seattle Tacoma International Airport Stormwater Management Manual for Port Aviation Division* (2017), and would account for FAA regulations and competing needs for STIA operations. It would also reference previous studies conducted by the Port regarding technical feasibility of infiltration at STIA, including the *STIA Infiltration Feasibility Assessment* (2016) and *Infiltration Infeasibility Map* (2018).

SDS Measures

The Airport's SDS includes collection, conveyance, detention, and treatment infrastructure to manage stormwater runoff at the Airport. In support of the Utility Master Plan, a detailed analysis was performed to evaluate the impacts of the Proposed Action on stormwater runoff rates and assess the future demand for SDS conveyance infrastructure and stormwater control (i.e., detention and treatment) capacities. This analysis accounted for the remaining capacities of existing stormwater conveyance and controls (some of which had excess capacity to address a portion of the planned development); identified deficiencies in comparison to future demand; and made recommendations for improvements to address those deficiencies. Specific recommendations were identified for each drainage basin and watershed in which development is planned, in accordance with applicable stormwater development standards and regulations. Planned stormwater controls and preliminary sizing estimates are summarized in **Table 2**, as sized to address the anticipated impacts from planned development and impervious surfaces as defined for the Proposed Action. The proposed stormwater control expansions have been evaluated for feasibility based on site constraints, but site-specific layouts were not developed as part of this analysis. As projects are designed, stormwater controls site layouts would be developed and sizes would be adjusted as needed to comply with local, state, and federal stormwater regulations.

TABLE 2: PLANNED STORMWATER CONTROLS BY AREA

Drainage Basin / Area Served[1]	Stormwater Controls to be Added / Modified[2]
SDW1b	• Expand detention volume by 4.4 acre-feet. • Integrate on-site low-impact development techniques as feasible. • Pursue opportunities for shallow / deep infiltration. • Provide source controls where required, including oil/water separator.
SDW2	• Relocate existing detention pond or convert to an underground vault to avoid proposed development. Provide a total storage capacity of 14.3 acre-feet (existing storage plus additional 2.4 acre-feet of storage). • Integrate on-site low-impact development techniques as feasible. • Pursue opportunities for shallow / deep infiltration to offset storage requirements. • Provide source controls where required, including oil/water separator.
SDE4 & SDE4X	• Expand detention volume by 2.0 acre-feet. • Integrate on-site low-impact development techniques as feasible. • Pursue opportunities for shallow / deep infiltration. • Provide source controls where required, including oil/water separators. • Install canister filters for water quality treatment.
SDN2/3/4	• Expand detention volume by up to 4.7 acre-feet. • Integrate on-site low-impact development techniques as feasible. • Pursue opportunities for shallow / deep infiltration at SR 518 pond to offset storage requirements. • Provide source controls where required.
SDS4	• Expand detention volume by 0.1 acre-feet to address development within subbasin only (assuming no diversion from SDS3/5). • Expand bioretention swale footprint by 90 square feet or provide equivalent detention and treatment alternative. • Integrate on-site low-impact development techniques as feasible. • Pursue opportunities for shallow / deep infiltration to offset storage requirements. • Provide source controls where required.
SDD05B	• Expand detention volume by 2.3 acre-feet. • Integrate on-site low-impact development techniques as feasible. • Pursue opportunities for shallow / deep infiltration to offset storage requirements. • Provide source controls where required.
SDD06A	• Expand detention volume by 6.4 acre-feet. • Integrate on-site low-impact development techniques as feasible. • Pursue opportunities for shallow / deep infiltration to offset storage requirements. • Provide source controls where required.

<table>
<tr><td rowspan="4">New Development North of SR 518</td><td colspan="2">• Integrate on-site low-impact development techniques as feasible.
• Pursue opportunities for shallow / deep infiltration to offset storage requirements.
• Provide source controls where required.
• Implement local detention facilities and water quality treatment as follows:</td></tr>
<tr><td>Projects</td><td>Detention and Water Quality Treatment Volume (acre-feet)</td></tr>
<tr><td>Off-site Cargo Phase 1 (C02) and Off-site Cargo Phase 2 (C03)</td><td>14.1</td></tr>
<tr><td>North GT Holding Lot (L05)[3], Employee Parking (L07), and Centralized Rec. & Dist. Center (S10)[4]</td><td>7.7</td></tr>
</table>

1. "SDXX" nomenclature refers to drainage basin IDs within the storm drainage system (SDS). The third character in each drainage basin ID (N/E/S/W) indicates the side of the airport where the drainage basin is located (north / east / south / west).
2. Stormwater control needs summarized above account for available capacity remaining within existing facilities. Drainage areas that experience an increase in impervious area but are not shown in this table were found to have sufficient capacity available within existing stormwater controls. Please refer to Exhibit 1 for existing drainage basin and detention facility locations.
3. "GT" = Ground Transportation
4. "Rec. & Dist." = Receiving and Distribution

Source: Utility Master Plan (UMP): Sewer and Surface Water, HNTB (December 2022)

IWS Measures

The Airport's IWS includes collection, conveyance, detention (three lagoons), and pretreatment infrastructure (Industrial Waste Treatment Plant, or IWTP) to manage runoff from designated industrial activity areas at SEA, including deicing runoff. While the IWTP provides treatment for solids, fuel, petroleum substances, and insoluble metals, additional activity-specific source controls may be necessary to mitigate other potential water quality impacts within the IWS. These will be evaluated and selected during the design of individual projects.

The Port maintains and upgrades the IWS as needed to comply with two associated discharge permits: (1) NPDES permit for discharges to surface water associated with industrial activities, and (2) IWD Permit for discharges to the King County sanitary sewer. Based on the conditions for the current NPDES and IWD permits, wastewater runoff rates associated with the Proposed Action were identified, and the future demand for IWS conveyance infrastructure, storage capacity, snow storage areas, and IWTP infrastructure was assessed. The Airport's NPDES and IWD permits were renewed on 9/1/2021 and 7/2/2021, respectively. There were no changes to the NPDES permit; the renewed IWD permit has two tiers of reduced effluent limits, effective 10/1/22 and 03/31/26.

A concept was developed for IWTP enhancements, including additional storage and treatment capacity and infrastructure upgrades, to meet both tiers of reduced limits. The Port will proceed with the IWTP enhancement improvements as needed to comply with permit requirements in advance of planned development. Final mitigation will be determined once final project designs are completed.

APPENDIX M

Water Resources

References

SEA Stormwater Management Manual, pg 1-8
Port of Seattle Master Specification Section 01 57 13 - Temporary Erosion and Sediment Control Planning and Execution
Section 01 57 23 – Pollution Prevention Planning and Execution
Section 01 59 00 – Construction Water Management System
STIA GWS Phase 1 Report
STIA GWS 2015 Annual Sampling Event

May 2017
Port of Seattle Aviation Environmental Programs

Port of Seattle

Seattle Tacoma International Airport Stormwater Management Manual for Port Aviation Division

Chapter 1
INTRODUCTION

1.1 Objective

The objective of this Manual is to set forth the measures necessary 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. Application of the appropriate minimum requirements and Best Management Practices (BMPs) identified in this manual are necessary but sometime insufficient measure to achieve these objectives.

Water quality standards include:

- Chapter 173-200 of the Washington Administrative Code (WAC), Water Quality Standards for Ground Waters of the State of Washington
- Chapter 173-201A WAC, Water Quality Standards for Surface Waters of the State of Washington
- Chapter 173-204 WAC, Sediment Management Standards

This Manual includes minimum requirements for measures necessary to control stormwater discharges from new development and redevelopment to storm drain systems. This Manual also covers requirements for the discharge of stormwater to the Industrial Waste System (IWS) at Seattle-Tacoma International Airport (STIA).

Volume I of this Manual identifies minimum requirements for development and redevelopment projects of all sizes and provides guidance concerning how to prepare and implement stormwater site plans. These requirements are, in turn, satisfied by the application of Best Management Practices (BMPs) from Volumes II through V. Projects that follow this approach will apply reasonable, technology-based and water-quality-based BMPs to reduce the adverse impacts of stormwater.

The Washington State's (WSDOT) *Aviation Stormwater Design Manual* was also used as guidance when preparing this manual, particularly with respect to the design of flow control and runoff treatment (BMPs) and managing associated wildlife hazards at and around airports.

1.2 Organization of this Manual

1.2.1 Overview of Manual Content

To accomplish the objective described in Section 1.1, the Manual includes the following:

- *Minimum Requirements* that cover a range of issues, such as preparation of Stormwater Site Plans, pollution prevention during the construction phase of a project, control of potential pollutant sources, treatment of runoff, control of stormwater flow volumes, protection of wetlands, and long-term operation and maintenance. The Minimum Requirements applicable to a project vary depending on the type and size of the proposed project.

- *Best Management Practices (BMPs)* that can be used to meet the minimum requirements. BMPs are schedules of activities, prohibitions of practices, maintenance procedures, managerial practices, or structural features that prevent or reduce adverse impacts to waters of Washington State. BMPs are divided into those for short-term control of stormwater from construction sites, and those addressing long-term management of stormwater at developed sites. Long-term BMPs are further subdivided into those covering management of the volume and timing of stormwater flows, prevention of pollution from potential sources, and treatment of runoff to remove sediment and other pollutants.
- *Guidance on how to prepare and implement Stormwater Site Plans.* The Stormwater Site Plan is a comprehensive report that describes existing site conditions, explains development plans, examines potential off-site effects, identifies applicable Minimum Requirements, and proposes stormwater controls for both the construction phase and long-term stormwater management. The project proponent submits the Stormwater Site Plan to the Port, who use the plan to evaluate a proposed project for compliance with stormwater requirements.

1.2.2 Organization of this Manual

Volume I of this Manual serves as an introduction and covers several key elements for developing the Stormwater Site Plan submittal to the Port. Following this introduction, Volume I contains three additional chapters. Chapter 2 identifies the Minimum Requirements for stormwater management at all new development and redevelopment projects. Chapter 3 describes the Stormwater Site Plan and provides step-by-step guidance on how to develop this plan. Chapter 4 describes the process for selecting BMPs for long-term management of stormer flows and quality. Appendices are included to support these topics. Volume I also includes the Glossary for all five volumes of the Manual.

The remaining volumes of this Manual cover BMPs for specific aspects of stormwater management. Volumes II through V are structured as addendums to the corresponding volumes of the Ecology Manual. **Therefore, project proponents should obtain and review all portions of the Ecology Manual that are referenced in this Manual.**
Volumes II through V of this Manual are organized as follows:

- Volume II of this manual is an addendum that adds to or amends Volume II of the Ecology Manual, which covers BMPs for short-term stormwater management at construction sites.
- Volume III is an addendum to Volume III of the Ecology Manual, which covers hydrologic analysis and BMPs to control flow volumes from developed sites.
- Volume IV is an addendum to Volume IV of the Ecology Manual, which addresses BMPs to minimize pollution generated by potential pollution sources at developed sites.

- Volume V is an addendum to Volume V of the Ecology Manual and presents BMPs to treat runoff that contains sediment or other pollutants from developed sites.

1.3 Applicability to Aviation Properties

This Manual is applicable to projects conducted on areas subject to STIA's individual National Pollution Discharge Elimination System (NPDES) Waste Discharge Permit No. WA-002465-1 (STIA NPDES Permit) as well as other projects on Port Aviation Division property consistent with the provisions and procedures of the Port's building permit process and the Interlocal Agreement with the City of SeaTac. It applies to most types of land development, including commercial, industrial, and roads.

This Manual is based on the Department of Ecology's Stormwater Management Manual for Western Washington (Ecology Manual) (Department of Ecology, 2014) and provides guidance on how the Ecology Manual is to be implemented at the STIA. It integrates requirements of STIA's NPDES Permit, the City of SeaTac interlocal agreement (ILA), and the Des Moines Creek Basin Plan. Administering and implementing development in accordance with the Ecology Manual and this Manual complies with associated elements of the Port's NPDES permit.

The Ecology Manual was originally developed in response to a directive of the Puget Sound Water Quality Management Plan (PSWQA 1987 et. seq.). The Puget Sound Water Quality Authority (since replaced by the Puget Sound Partnership, PSP) recognized the need for overall guidance for stormwater quality improvement. It incorporated requirements in its plan to implement a cohesive, integrated stormwater management approach through the development and implementation of programs by local jurisdictions, and the development of rules, permits and guidance by Ecology.

The Puget Sound Water Quality Management Plan included a stormwater element (SW-2.1) requiring Ecology to develop a stormwater technical manual for use by local jurisdictions. The Ecology Manual was originally developed to meet this requirement. Ecology has found that the concepts developed for the Puget Sound Basin are applicable throughout western Washington.

Information describing how this Manual relates to the Puget Sound Water Quality Management Plan (now the Puget Sound Action Agenda) is included in the Ecology Manual.

The Washington State Department of Transportation (WSDOT) Aviation Stormwater Design Manual was also used as guidance when preparing this manual, particularly with respect to managing wildlife hazards near airports.

1.4 STIA NPDES Permit

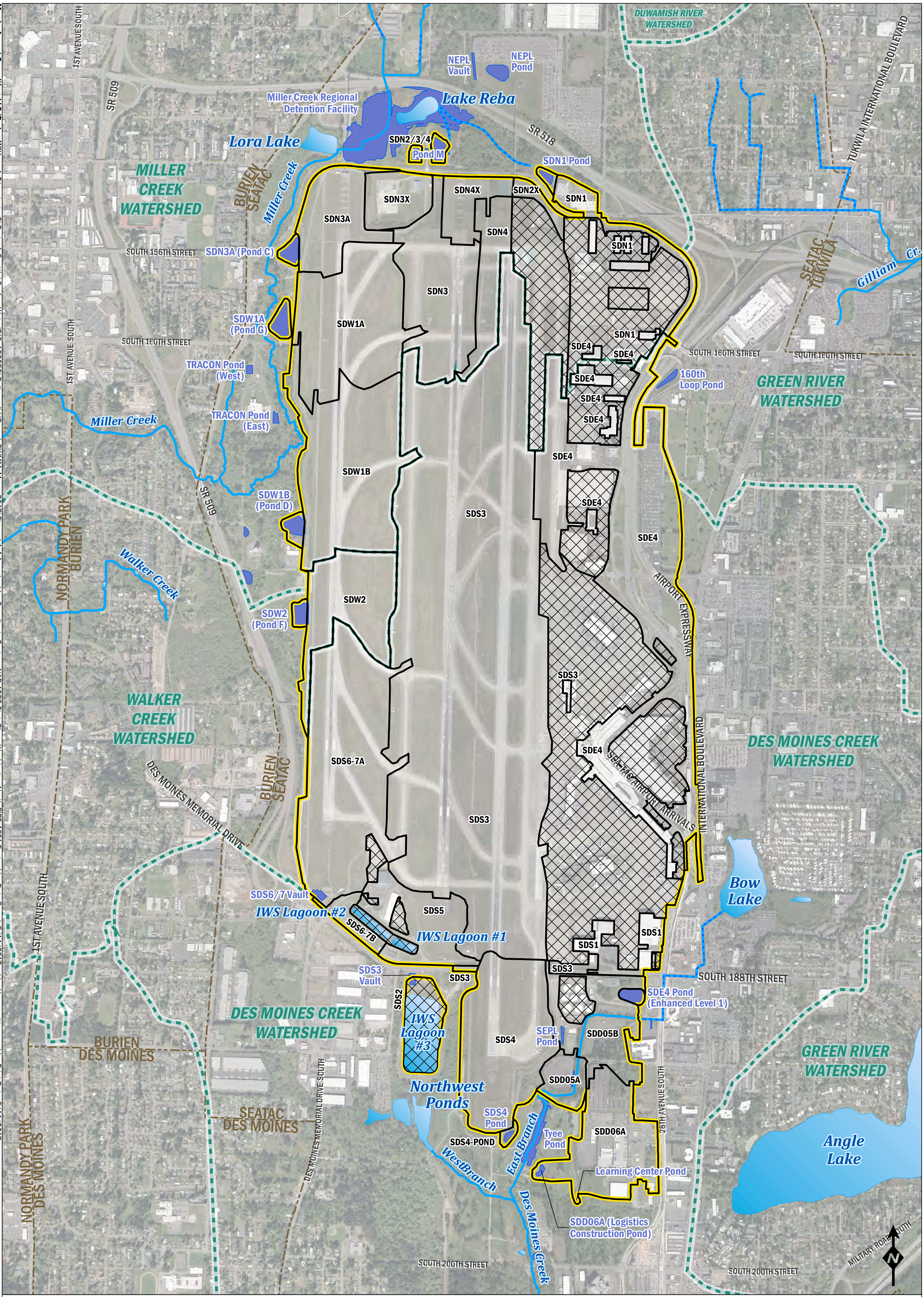
STIA has been regulated under an NPDES permit since 1980. The Port of Seattle's NPDES Permit No. WA-002465-1 regulates stormwater discharges associated with industrial and construction activities at the STIA. The STIA NPDES Permit is reissued every five years. The most recent effective permit can be found on Ecology's website at http://www.ecy.wa.gov/programs/wq/permits/northwest_permits.html. The permit is organized into three sections:

- Part I - applies to Airport Industrial Wastewater System (IWS) discharges to Puget Sound and municipal sewer system.
- Part II - applies to Industrial Stormwater and regulates stormwater from areas associated with airport industrial activities discharging directly or indirectly to Des Moines, Miller, or Walker Creeks, Northwest Pond or Lake Reba.
- Part III - applies to Construction Stormwater, which includes construction stormwater and dewatering water from construction sites that drain to the SDS.

In general, individual NPDES permits authorize discharges from specific outfalls to regulated receiving waters. Therefore, the aerial extent of coverage for each of these parts is determined by the outfalls identified in the permit and their associated subbasins. Every five years when the permit is renewed, the Port and Ecology reexamine the extent of permit coverage and adjust as needed.

The aerial extent of permit coverage as of February 2016 for Parts I and II of the Airport's Individual Permit is shown in Figure I-1.4.1. Because it was not possible to identify construction outfall locations in advance of construction projects, the Port monitors specific stream segments for compliance with construction-related effluent limits (Part III). These segments are specified in the Individual Permit and are illustrated on Figure I-1.4.2 and discussed further in Section 1.7.4.

In addition to authorizing direct discharge to receiving waters, the STIA NPDES permit authorizes the discharge of certain industrial wastewaters to the Midway Sewage Treatment Plant. Authorized discharges to Midway along with monitoring and discharges limitations are described in STIA Permit Part I Condition S1.C.



- NPDES Permit Application Boundary and STIA Retrofit Area
- Storm Drainage Subbasin
- Industrial Waste System (IWS) Area
- Watershed Boundary
- Flow Control Facilities
- Conveyance
- Stream
- Surface Waterbody
- City Limit

FIGURE I-1.4.1

STIA Retrofit Area and Storm Drainage System Subbasins

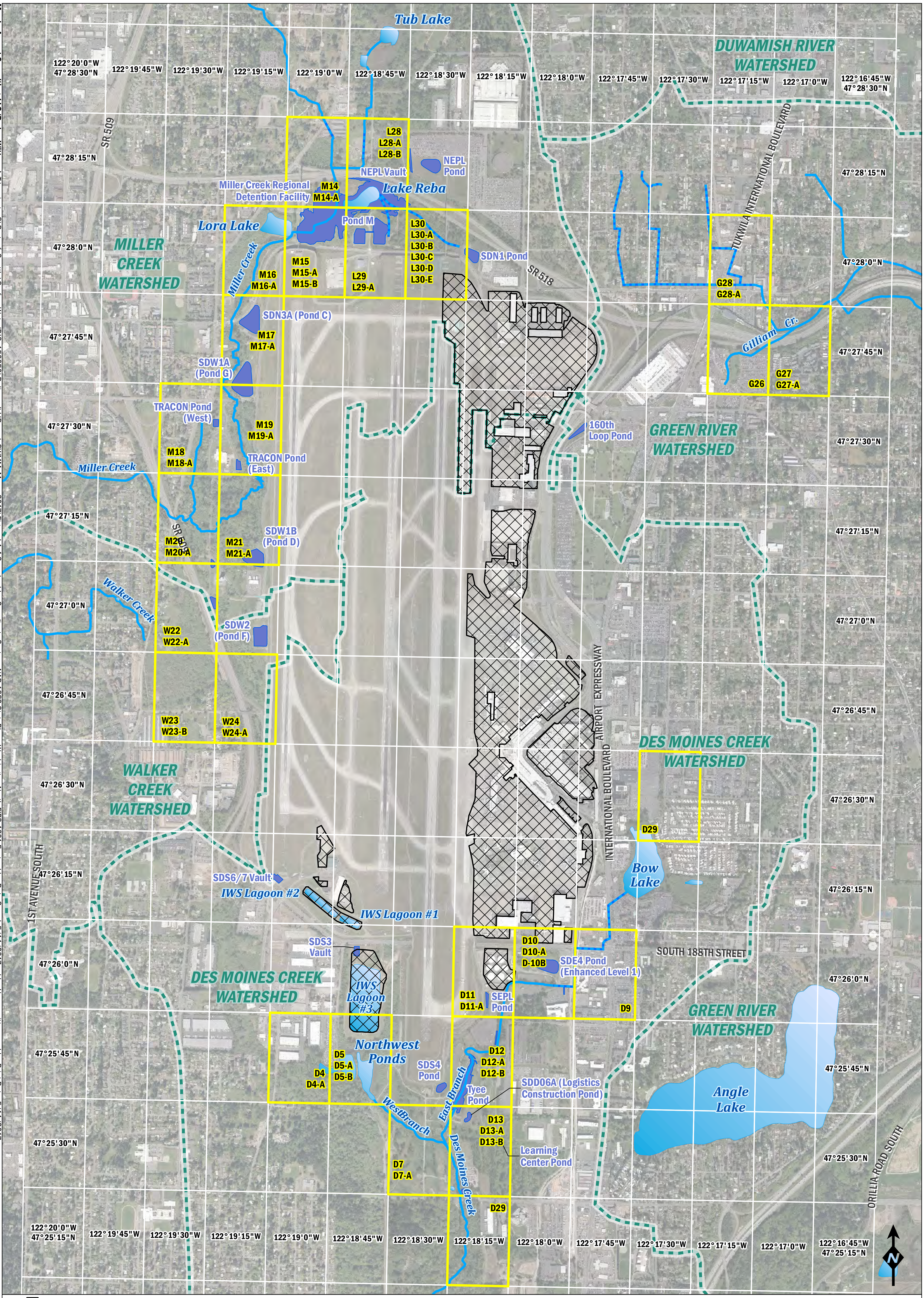
Volume I - Minimum Technical Requirements and Site Planning

0 700 1,400
Feet

MAP BY: Aspect CONSULTING

Port of Seattle

Map by Aspect Consulting, LLC (Parker Wittman): T:\projects_8\Port_of_Seattle\SurfaceWater\DIO_150050\Delivered\LID_and_SWMM_Maps_2017\Figure I-1-4-2.mxd || Coordinate System: NAD 1983 StatePlane Washington North FIPS 4601 Feet || Date Saved: 5/11/2017 || User: pwittman || Print Date: 5/11/2017



Industrial Waste System (IWS) Area
Watershed Boundary
Flow Control Facilities
Surface Waterbody
Conveyance
Stream

122°20'0"W
47°28'30"N

15 Arc-Second Latitude/Longitude Grid
(coordinates represent the center of each cell row/column)

W22
W22-A

Grid Cell with Permitted Outall(s)

FIGURE I-1.4.2
STIA NPDES Construction Permit Coverage

Volume I - Minimum Technical Requirements and Site Planning

0 750 1,500
Feet

MAP BY: Aspect CONSULTING

Port of Seattle

1.5 STIA Stormwater Management Systems

Stormwater at STIA is collected by one of two drainage systems: the stormwater drainage system (SDS) and the IWS. The following paragraphs describes each system and provides the general rules for determining into which system a project must drain. Under some circumstances, the Port may require the stormwater runoff from a site to drain to the sanitary system. The project proponent shall contact the Port's Environmental Program Manager to confirm which system is appropriate for their project.

1.5.1 Industrial Waste System

The IWS consists of a collection and conveyance system, a high and low strength BOD waste stream segregation system, three storage lagoons, an industrial wastewater treatment plant (IWTP) that includes dissolved air flotation, a direct discharge to Puget Sound through the Midway Sewer District's outfall and an alternate discharge to King County's Renton Treatment plant for the high strength BOD waste stream.

IWS flow is runoff collected from the North and South Service Basins which mainly consists of stormwater runoff from terminal air cargo, deicing areas, hangars, and maintenance areas. Due to the nature of activities in these areas, the water collected has variable levels of spilled fuel, de-icing/frost chemicals, and wash water and other minor process water sources. These flows are collected in a drain system and conveyed to the storage lagoons for subsequent treatment in the IWTP.

The IWTP was originally designed and constructed in 1963/1964 for the purpose of capturing and treating fuel spills. Since then, its storage and DAF treatment capacity has been enlarged. Most recently, the high and low strength BOD waste stream segregation system and alternate discharge to King County's Renton Treatment Plant have been added in compliance with AKART for aircraft deicing fluids and associated stormwater. The STIA NPDES Permit Part I defines effluent limits for low strength BOD waste streams discharging to Puget Sound.

The IWS utilizes the Midway Sewer District's Des Moines Creek Wastewater Treatment Plant (WWTP) outfall for low strength BOD discharges to Puget Sound. The outfall is covered under NPDES Waste Discharge Permit No. WA0020958. In 2002 URS prepared an Outfall Modeling Technical Memorandum No. 1 (TM-1) that documented mixing zone and hydraulics analyses performed in support of the Des Moines Creek WWTP Outfall Project for the Midway Sewer District (District) and identified the design criteria established for the new diffuser design. The outfall, now completed and in use, serves both the District and STIA's IWTP.

Subsequent to the preparation of TM-1, the original modeling was updated using the most current dilution modeling software. The September 2006 addendum was prepared to provide an updated mixing zone analysis for the final diffuser configuration to verify compliance with water quality standards in the mixing zone limits in accordance with the requirements of the NPDES discharge permits.

Based on the results of the reasonable potential calculations using the model-derived dilution factors and effluent analysis, the new outfall diffuser was found to provide adequate mixing to meet Washington State water quality standards. The final dilution factors to be applied for the new outfall were determined to be 72 for the acute boundary and 202 for the chronic boundary based on year 2020 District flows and maximum IWTP flows. These dilutions translate to an acute critical effects concentration (ACEC) of 1.4% and a chronic critical effects concentration (CCEC) of 0.50% for whole effluent toxicity (WET) bioassays for both the District and IWTP discharges. Appropriate BMPs for IWS operations are included in STIA's *Stormwater Pollution Prevention Plan* (SWPPP). The most current version of the SWPPP can be downloaded at http://www.portseattle.org/Environmental/Water-Wetlands-Wildlife/Stormwater/Documents/STIA_SWPPP_current.pdf.

1.5.2 Stormwater Drainage System

Part II of the permit covers stormwater associated with approximately 1,200 acres of the stormwater drainage system. Stormwater runoff is from roads, runways, taxiways, airfield, rooftops, cargo operations, flight kitchens, and other areas associated with airport industrial activities. Stormwater runoff is treated using ponds, grass swales, and other passive stormwater treatment methods. Treated stormwater discharges to freshwater streams, wetlands, and lakes around the airport.

The Airport stormwater management system underwent significant modifications over the last 15 years in response to NPDES permit conditions and requirements of a Section 401 Water Quality Certification issued in association with the 1997 Master Plan Update (MPU). A number of studies and planning documents were completed to enable these modifications. Significant studies and planning documents relevant to the current Airport stormwater management system and this Manual are described below.

1.5.2.1 Comprehensive Stormwater Management Plan

The Comprehensive Stormwater Management Plan (CSMP) (Parametrix 2001) provided a management plan of stormwater quantity and quality as required to mitigate potential effects to the environment from the 1997 MPU improvements at STIA.

Two documents were prepared that amend the CSMP: *Proposed Design Refinements to the Comprehensive Stormwater Management Plan Master Plan Update Improvements Seattle-Tacoma International Airport Des Moines Creek Basin* (Parametrix, August 2004) and *Proposed Design Refinements to the Comprehensive Stormwater Management Plan Master Plan Update Improvements Seattle-Tacoma International Airport Miller/Walker Creek Basins* (Parametrix, June 2005).

The Des Moines Creek amendment allowed the use of the Des Moines Creek Basin Plan's Regional Detention Facilities that modified the flow control requirements for the Des Moines Creek basin, refined land use assumptions used for analysis, and provided other design refinements for various other facilities described in the CSMP.

READ THIS FIRST

The Design Engineer shall modify this specification to address project specific needs.

Changes to this specification shall be approved by the Erosion Control / Stormwater Engineer.

This specification is for all Port of Seattle construction including Maritime and Airport projects. Designer to verify with Maritime Environmental or Aviation Environmental groups if there are additional environmental permit requirements.

Maritime projects located within the City of Seattle must comply with City of Seattle Stormwater Code SMC 22.800 – 22.808.

Maritime projects that discharge only to the Port Municipal Separate Storm Sewer System (MS4) must be reviewed by Maritime Environmental.

All Maritime projects must be designed and completed pursuant to City of Seattle Stormwater Code SMC 22.800 – SMC 22.808 as required by the Port of Seattle's Phase I National Pollutant Discharge Elimination System (NPDES) Permit WAR044701. Each project must comply with the City of Seattle Stormwater Code 22.805.020.D Minimum Requirements for Construction Site Stormwater Pollution Prevention Control. Evaluate applicability of best management practices (BMPs) from City of Seattle Stormwater Manual Volume 2 Construction Stormwater Control and Volume 4 Source Control, and include in the Construction Stormwater Control Plan (CSCP) or Pollution Prevention Plan as required.

Note specific requirements related to the amount of new plus replaced hard surface for the project and consider exemptions for pavement maintenance, utility facilities and railroad maintenance.

≥750 square feet: Submit project for Port of Seattle Stormwater Design Review or City of Seattle Drainage Control Review (dependent on project discharge location)

≥1,500 square feet: Complete on-site stormwater management evaluation

≥5,000 square feet: Stormwater treatment BMP required

This Project Spec Document may need additional modifications to suit your project. It is recommended that you proofread each section, paying attention to any "Notes" boxes such as this one--you should remove these "Notes" sections as you go. Also, do a search for all bracket characters " [ ] " as they are used to show you areas containing options or project specific details (you can use Microsoft Word's Find feature {Ctrl-F} to jump to an open bracket " [" character quickly). Again, these bracket characters should be removed.

It is important that every paragraph be numbered to allow for easy referencing. If you use the document's built in styles and formatting your outline should be fine (turn on the formatting toolbar by going to View > Toolbars > Formatting). Most paragraphs will use the style "Numbered Material" and can be promoted (Tab) or demoted (Shift-Tab).

You should not have to manually enter extra spaces, carriage returns or outline characters such as A, B, C, or 1.01, 1.02; the formatting will do this for you. The entire document is 11 pt. Arial. If you paste items in, you may need to reapply the "Numbered Material" format.

PART 1 GENERAL

1.01 SUMMARY OF WORK

A. This item shall consist of planning, installing, inspecting, maintaining, upgrading and removing temporary erosion and sediment control Best Management Practices (BMPs) as shown in the Contract Documents, in the Contractor's Erosion and Sediment Control Plan (CESCP), or as ordered by the Engineer to prevent pollution of air and water, and control, respond to, and manage eroded sediment, turbid water and process water during the life of the contract.

Paragraph B: THIS IS NOT USED OFTEN BUT IS USEFUL FOR PROJECTS INVOLVING A LARGE VOLUME OF PROCESS WATER SUCH AS IN HYDRODEMOLITION. Delete if not needed.

B. This project shall be managed as a no discharge project. All stormwater shall be diverted away from work areas. All project and process water shall be collected, stored and discharged off Port property.

C. This work shall apply to all areas associated with contract work including, but not limited to the following:

1. Work areas
2. Equipment and material storage areas
3. Staging areas
4. Stockpiles
5. Access Roads

1.02 GOVERNING CODES, STANDARDS, AND REFERENCES

A. The following rules, requirements and regulations specified may apply to this work:

1. Surface Water Design Manual, King County, Department of Natural Resources, (Current Edition).
2. Washington State Department of Ecology Stormwater Management Manual for Western Washington (2014), Vol. 2 Washington State Stormwater Quality Standards (WAC 173-201A).
3. National Pollution Discharge Elimination System (NPDES) Waste Discharge Permit No. WA 002465-1.
4. Port of Seattle Regulations for Airport Construction (current edition).
5. Sea-Tac International Airport Rules and Regulations (current edition).

Some Airport Projects- Projects with one or more acres of disturbance may need to obtain this permit. Typically the Port obtains and transfers coverage to the Contractor.

Verify if applicable.

6. Construction General NPDES Permit #[__________]

1.03 SUBMITTALS

A. As part of the required Preconstruction Submittals, Section 01 32 19 - Preconstruction Submittals and before Notice to Proceed is given, the Contractor shall submit the following:

1. Contractor Erosion and Sediment Control Plan (CESCP)

(1) Including CESCL Certification Cards and ECL Qualifications

Add or Remove items to make this section project specific.

B. The following shall be submitted in accordance with Section 01 33 00 – Submittals:

1. Oil Absorbent Pads
2. Silt Fence
3. Straw Wattle
4. Erosion Control Blanket
5. Bonded Fiber Matrix
6. Catch Basin Protection
7. Temporary Piping Connections / Plugs
8. Construction Limits Fencing
9. Wheel Wash
10. Geotextile Fabric Check Dam
11. Plastic Sheeting
12. Temporary Organic Mulch
13. Water Filled Diversion Berm
14. Biofence

PART 2 MATERIALS

2.01 PROJECT INFORMATION

2.02 PREPARATION FOR MATERIALS

2.03 FABRICATION, PRODUCTION, & SUPPLY OF MATERIALS

2.04 MATERIAL REQUIREMENTS

Add/remove items to make this section project specific

A. GENERAL:

A. All products used to construct the Contractor selected BMPs shall be suitable for such use and submitted to the Engineer for approval.

B. OIL ABSORBENT PADS:

A. Oil absorbent pads shall be made of white, 100% polypropylene fabric that absorbs oil-based fluids and repels water-based fluids. Each pad shall be a minimum of 15x19 inches in size and absorb no less than 50 ounces of oil-based fluids.

C. TESC – ASPHALT CURB & ASPHALT BERM:

A. Asphalt curb and asphalt berm shall be constructed as directed by the Engineer. The asphalt concrete shall meet the requirements of Section 32 12 16 – Bituminous Concrete Pavement.

D. SILT FENCE:

A. Geotextile material shall meet the requirements of WSDOT Specification Section 9-33 Table 6. Geotextile material shall be backed by 2”x4” wire mesh and shall be attached to steel “T” posts using wire or zip ties. Dimensions and spacing shall be as detailed on the drawings.

E. STRAW WATTLE:

A. Wattles shall consist of cylinders of biodegradable plant material, such as straw, coir, or compost encased within biodegradable or photodegradable netting. Wattles shall be a minimum of 5 inches in diameter, unless otherwise specified. Encasing material shall be clean, evenly woven, and free of debris or any contaminating material, such as preservative and free of cuts, tears or damage. Compost filler shall meet material requirements specified in WSDOT Section 9-14.4(8) Coarse Compost. Straw filler shall be 100% free of weed seeds.

F. EROSION CONTROL BLANKET:

A. Erosion Control Blanket shall meet the requirements of WSDOT Specification Section 9-14, paragraph 9-14.5(2) “Erosion Control Blanket”. Installation in ditches and swales shall be per WSDOT Standard Plan I-60.20-00 “Erosion Control Blanket Placement in Channel”. Installation on slopes shall be per WSDOT Standard Plan I-60.10-00 “Erosion Control Blanket Placement on Slope”.

G. BONDED FIBER MATRIX SOIL STABILIZATION:

A. Bonded Fiber Matrix soil stabilization shall be labeled as such on the unopened bags furnished by the manufacturer. Bonded fiber matrix shall be installed with seed and fertilizer included in the homogenous mix. Seeding shall be as specified in Section 32 92 19.16 – Hydroseeding for Erosion Control and Landscaping.

H. CATCH BASIN PROTECTION:

A. Catch basin protection shall be designed and installed for the purpose of preventing sediment from entering the storm system. Protection shall:

B. Be constructed of non-woven geotextile fabric with sewn seams;

C. Contain a built-in lifting strap;

D. Have a built-in, high flow bypass;

Be sized such that all water draining to the catch basin flows into the insert and does not flow directly into the storm drain.

E. Catch basin covers shall be 30 mil PVC liner material.

I. TEMPORARY PIPING/CONNECTIONS:

A. Temporary piping shall meet the requirements of the storm drain pipe as specified in Section 33 41 13 – Pipe for Storm Drains and Culverts. Temporary catch basin shall meet the requirements of Section 33 49 13 – Manholes, Catch Basins, Inlets and Inspection Holes.

J. TEMPORARY PIPING PLUGS:

A. Installation in Pipe/Structure to be Demolished/Abandoned. Plug shall be concrete as specified in Section 03 30 00 – Cast-in-Place Concrete.

B. Installation in Pipe/Structure to Remain. Plug shall be a mechanical secured plug.

K. STORMWATER STORAGE TANK:

A. The tank shall be a fixed axle weir tank with a minimum 21,000 gallon.

L. STORMWATER STORAGE TANK PADS:

A. The stormwater storage tank pads shall be as detailed on the drawings.

M. CONSTRUCTION LIMITS FENCING:

A. Fencing material shall be standard size orange plastic mesh construction safety fence. Posts shall be steel “T” posts.

N. ROCK CHECK DAMS:

A. Rock check dams shall be constructed of quarry spalls per the details shown in the project drawings and as specified in Section 31 23 00 - Excavation and Embankment.

O. STABILIZED CONSTRUCTION ENTRANCE

A. Stabilized construction entrance(s) shall be constructed of stabilization geotextile fabric and quarry spalls as specified in Section 31 23 00 – Excavation and Embankment.

P. WHEEL WASH

A. The wheel wash shall be a high water pressure, low water volume system long enough to allow for at least two full tire rotations. Spray nozzles shall be directed at inner and outer side walls for all tires including duals, all treads from two directions, wheel wells and flaps, and truck sides up to the bottom of the windshield. For water line material and construction requirements shall be as specified in Section 33 10 00 – Water Distribution.

Q. GEOTEXTILE FABRIC CHECK DAMS

A. Geotextile check dam shall be a urethane foam core encased on Geotextile material. The minimum length of the unit shall be 7 feet. The foam core shall be a minimum of 8 inches in height, and have a minimum base width of 16 inches. The geotextile material shall overhang the foam by at least 6 inches at each end, and shall have apron type flaps that extend a minimum of 24 inches on each side of the foam core. The geotextile material shall meet the requirements for silt fence.

R. PLASTIC SHEETING

A. Plastic sheeting shall be clear, reinforced, and a minimum of 6 mil thick. Sandbags or other Engineer-approved material shall be used to secure the plastic sheeting in place. Black plastic may be used to cover stockpiles.

S. TEMPORARY ORGANIC MULCH

A. Temporary organic mulch shall consist of straw, wood chips, hog fuel, compost or other material approved by the Engineer.

T. WATER FILLED DIVERSION BERM

A. Berm shall be a minimum 6 inches high and 10 feet long and made of 10 mil polyurethane or 22 oz. PVC.

U. BIOFENCE

A. Biofence shall consist of 7 ounce or heavier uncoated burlap fabric at least 36 inches wide and 100 feet long. Wood stakes dimensions shall be a minimum 1 1/8 x 11/8 inches by 42 inches high.

2.05 MATERIAL HANDLING, DELIVERY, & STORAGE

2.06 DELIVERABLES

2.07 QUALITY ASSURANCE

PART 3 EXECUTION

3.01 PROJECT INFORMATION

A. GENERAL

1. In the event of conflict between these requirements and pollution control laws, rules, or regulations of other Federal, state, or local agencies, the more restrictive laws, rules, or regulations shall apply.

2. No discharge of water shall be allowed that increases volume, velocity, or peak flow rate of receiving water background conditions, or that does not meet state of Washington water quality standards.

3. The Contractor's Erosion and Sediment Control Plan (CESCP) required by this section shall be based upon the Temporary Erosion and Sediment Control (TESC) requirements of the contract but shall specifically phase, adjust, improve and incorporate the TESC requirements into the Contractor's specific schedule and plan for accomplishing the work. The CESCP shall be modified as changes are made to improve, upgrade and repair best management practices used by the Contractor and as the work progresses and TESC needs change.

4. The Contractor shall be wholly responsible for control of water onto and exiting the construction site and/or staging areas, including groundwater, stormwater, and process water. Stormwater from offsite shall be intercepted and conveyed around or through the project and shall not be combined with onsite construction stormwater.

5. Design of, and modifications to, project hydraulic conveyances, detention facilities, and TESC plan sheets shall be stamped by a Professional Engineer (P.E.) licensed by the State of Washington. All other changes to the CESCP shall be signed by the ECL.

B. PROJECT REQUIREMENTS

1. DESCRIPTION OF WORK

a. In order to comply with the requirements of this section, the Contractor shall:

(1) Develop the Stormwater Pollution Prevention Plan (SWPPP) and submit a Contractor's Erosion and Sediment Control Plan (CESCP). The CESCP shall, at a minimum, include and address the following:

(a) Site Description and Drawings

(b) Contractor Erosion and Sediment Control Personnel

(c) Schedule and Sequencing

(d) BMP Installation

(e) BMP Maintenance

(f) BMP Inspection

(g) Record keeping

(h) BMP Removal

(i) Emergency Response

(j) Construction Dewatering

(k) Fugitive Dust Planning

(l) Utilities Planning

(m) Education

(2) Revise and modify the CESCP during the life of the contract and maintain records.

(3) Install, maintain, and upgrade all erosion prevention, containment, and countermeasures BMPs during the life of the contract, and removal at the end of the project.

(4) Contain, cleanup and dispose of all sediment and convey turbid water to existing or proposed detention/treatment facilities.

(5) Perform other work shown on the project drawings, in the Contractor Erosion and Sediment Control Plan, or as directed by the Engineer.

(6) Inspect to verify compliance with the CESCP requirements including BMPs; facilitate, participate in, and implement directed corrective actions resulting from inspections conducted by others including outside Agencies and Port employees/consultants.

(7) Educate all Contractor and sub-contractor staff about environmental compliance issues at weekly meetings and document attendance and content.

2. DEFINITIONS

   a. Process Water: All water including, but not limited to, that used for washing, cleaning, fire proofing and hydrodemolition is defined by the Department of Ecology as “process water” and shall be collected and disposed of in a manner that complies with all local, state and federal regulations. Disposal tickets shall be provided to the Engineer.

      (1) Process water shall not be discharged to the IWS or SDS

3. PERMITS

   a. Work shall be conducted in accordance with NPDES permit No. WA- 002465-1.

When the project requires a Construction General NPDES Permit and the contractor is to be completely responsible for compliance, the Port will obtain the permit and contractor shall have to accept transfer of permit from the Port. Otherwise delete paragraph below.

   b. The Contractor shall accept from the Owner complete transfer of Construction General NPDES Permit #[ ]. The Contractor shall submit a signed Notice of Transfer before Notice to Proceed. The form can be obtained at: http://www.ecy.wa.gov/biblio/ecy02087a.html

4. ADMINISTRATIVE REQUIREMENTS

   a. The provisions of this section shall apply to the Contractor, subcontractors at all tiers, suppliers and all others who may have access to the work site by way of the contractor’s activities.

   b. Failure to install, maintain, and/or remove BMPs shown on the drawings, in the approved Contractor Erosion and Sediment Control Plan and specified herein, or by order of the Engineer; or failure to conduct project operations in accordance with Section 01 57 13 - Temporary Erosion and Sediment Control Planning and Execution will result in the suspension of the Contractor's operations by the Engineer in accordance with Section 00 70 00 - General Conditions.

   c. The Contractor shall be solely responsible for any damages, fines, levies, or judgments incurred as a result of Contractor, subcontractor, or supplier negligence in complying with the requirements of this section.

   d. Any damages, fines, levies, or judgments incurred as a result of Contractor, subcontractor, or supplier negligence in complying with the requirements of this section will be deducted from payment due by Modification.

   e. Any time and material costs incurred by the Port due to damages, fines, levies, or judgments incurred as a result of Contractor, subcontractor, or supplier negligence in complying with the requirements of this section will be deducted from payment due by Modification.

f. The Contractor shall be solely responsible for any schedule impacts from damages, fines, levies, judgments, or stop work orders incurred as a result of Contractor, subcontractor, or supplier negligence in complying with the requirements of this section. The project schedule will not be changed to accommodate the time lost.

Add/remove items to make this section project specific

g. Contractor shall not clear, grub, grade, demolish, or perform any earthwork after Notice to Proceed until the following has been installed per the project drawings, the approved Contractor Erosion and Sediment Control Plan, or as directed by the Engineer:

(1) Silt Fence or other perimeter controls are in place.

(2) Areas not to be disturbed are delineated with construction fence.

(3) Temporary ponds and ditches are installed and vegetated or covered.

(4) Permanent ponds used for sediment control during construction have been installed and vegetated or covered and modified with riser.

(5) Water flows from off site are tight lined and directed away from work area.

(6) All construction entrances are stabilized and wheel wash systems in place and operational.

(7) Catch basin inserts are installed in all catch basins that receive drainage from the Work area and haul roads.

(8) Stormwater storage tanks are located onsite to provide for additional storage volume and/or treatment volume required for treatment by settlement.

(9) Materials on hand, in quantities sufficient to cover all bare soil, divert all flows, contain all sediments, and prevent turbid discharges from the site during all stages of construction. These materials include, but are not limited to the following:

(a) Reinforced 6 mil plastic sheeting

(b) Straw Wattles

(c) 6” pipe

(d) 8” pipe

(e) Sand bags, filled

(f) Wire-backed silt fence

(g) Steel "T" posts

5. AUTHORITY OF ENGINEER

a. The Engineer has the authority to limit the surface area of erodible earth material exposed by clearing, excavation, and fill operations, and to direct the Contractor to provide immediate permanent or temporary pollution control measures to prevent contamination of adjacent streams or other watercourses, lakes, ponds, wetlands or other areas of water impoundment.

b. In the event that temporary erosion and pollution control measures are required due to the Contractor's negligence, carelessness, or failure to install permanent controls as a part of the work as scheduled or are ordered by the Engineer, such work shall be performed by the Contractor at his/her own expense.

c. The Engineer may increase or decrease the area of erodible earth material to be exposed at one time as determined by analysis of project conditions.

d. In the event that areas adjacent to the work area are suffering degradation due to erosion, sediment deposit, water flows, or other causes, the Engineer may stop construction activities until the situation is rectified.

e. In the event that the Washington State Department of Ecology issues an Inspection Report, a Notice of Non-Compliance, Notice of Violation or Enforcement Action, the Engineer may stop all construction activities until it has been determined that the project is in compliance. The Engineer may require the Contractor to send additional staff to successfully complete Contractor Erosion and Sediment Control Lead (CESCL) training before construction activities may begin. The number of working days will not be changed to accommodate the work stoppage. All costs associated with work stoppages, mitigation of the event, and/or training shall be paid by the Contractor.

f. In the event that the Contractor discharges storm water, ground water, or process water to storm drains, ditches, gutters or any conveyance that discharges to a receiving water as defined by the Department of Ecology without prior approval of the Engineer, the Engineer may stop all construction activities and require additional Contractor staff training and may require that all parties involved in the unapproved discharge be removed from the project for a time determined by the Engineer. The project schedule will not be changed to accommodate the time lost. All costs associated with mitigation of the unauthorized discharge, work stoppages, training and/or removal of personnel from the project shall be paid by the Contractor.

6. COORDINATION MEETINGS

a. The Contractor shall be available, at a minimum, for a weekly coordination meeting with the Engineer, other Port Staff and outside agency representatives to review the ongoing contract work for compliance with the provision of this specification.

b. The Contractor's Erosion Control Lead (ECL) shall attend a quarterly environmental staff meeting scheduled by the Erosion Control/Stormwater Engineer to discuss and resolve relevant environmental, stormwater and erosion control issues on Port of Seattle projects.

3.02 PREPARATION FOR EXECUTION OF WORK

A. STORMWATER POLLUTION PREVENTION PLAN (SWPPP)

1. The Contractor shall prepare a Stormwater Pollution Prevention Plan (SWPPP). The contents of a construction SWPPP may vary with the amount of new or replaced impervious surface, acres of land disturbing activity and the classification of water.

2. The Contractor shall prepare a CESCP. The contents of a CESCP may vary with the amount of new or replaced hard surface, acres of land disturbing activity and the classification of water. The CESCP shall comply with the Director's Rules based on the City of Seattle "Stormwater Code", SMC Chapters 22.800 through 22.808, and must contain enough detail to demonstrate controls sufficient to determine compliance with City of Seattle Stormwater Code SMC 22.805.020.D.

> Note to Designer: Verify all conditions of the Seattle Stormwater Code are met with the requirements in this specification. http://www.seattle.gov/dpd/Codes/default.asp#construction Adjust as needed.

3. The SWPPP shall consist of the following documents:

a. Temporary Erosion and Sediment Control Plan sheets in the Contract documents;

b. Section 01 57 13 - Temporary Erosion and Sediment Control Planning and Execution;

c. Section 01 57 23 - Pollution Prevention, Planning and Execution;

d. Contractor's Erosion and Sediment Control Plan (CESCP), submitted by the Contractor;

e. Pollution Prevention Plan per Section 01 57 23, submitted by the Contractor;

> Typically for Airport projects, the Port develops the Storm Water Monitoring Plan. Coordinate with PM and make selection below. If Contractor developed, add this plan to Submittal section and include requirements for plan as 3.02 B

f. Construction Storm Water Monitoring Plan, developed by the [Port] [Contractor].

4. Contractor's Erosion And Sediment Control Plan (CESCP)

In order to comply with these requirements, the Contractor shall include and address the following in the CESCP portion of the SWPPP:

a. Site Description and Drawings

(1) Included in the CESCP shall be a written description of the construction site, including location of staging areas, stockpile areas, material storage areas, natural and constructed drainage systems within the work area and staging areas, and proximity to other construction projects.

(2) Drawings shall be included in the CESCP which show the location of the construction site, including location of staging areas, stockpile areas, material storage areas, natural and constructed drainage systems within the work area and staging areas, and proximity to other construction projects.

(3) The drawings shall show locations of BMPs during each phase of construction as identified by the Contractor in the Project Schedule.

(4) The drawings and written description shall detail temporary stormwater conveyance facilities and other measures proposed by the Contractor to limit the contributing drainage areas to not exceed the capacity of each of the stormwater ponds.

Adjust qualifications depending on the complexity of the project. At a minimum, a ECL is required.

b. Contractor Erosion and Sediment Control Personnel

(1) The Contractor shall designate sufficient employees as the responsible representatives in charge of erosion and sedimentation control. These employees' responsibility will be the oversight of all water and air quality issues.

(2) The designated employees responsible for erosion and sedimentation control as discussed above shall be the Erosion Control Lead(s) (ECL) responsible for developing, maintaining and modifying the CESCP for the life of the Contract and ensuring compliance with all requirements of this section.

(3) An ECL shall be onsite at all times when any work activity is taking place. An ECL shall be required for each shift.

(4) The ECL shall be qualified in the preparation of erosion and sediment control plans, in the installation, inspection, monitoring, maintenance of BMP's, and documentation required for NPDES permits as well as sensitive resource identification, water treatment, and restoration and stabilization of unstable slopes, shorelines, stream banks, and wetlands.

(5) The ECL shall have authority to direct all Contractor and sub-contractor personnel.

(6) The ECL shall have no other duties aside from developing, maintaining, modifying, inspecting, implementing the CESCP and ensuring compliance with all requirements of this section, and, all other environmental regulations, or as directed by the Engineer.

(7) Qualifications of the ECL shall be as follows:

Complex projects may require minimum training at the CPESC level – coordinate with Erosion Control/Stormwater Engineer to determine.

(a) Have successfully completed Contractor Erosion and Sediment Control Lead (CESCL) training given by a Washington State Department of Ecology-approved provider, and have five years experience in construction site erosion and sediment control regulatory requirements and BMPs, erosion and sediment control plan development, and stormwater/water quality monitoring, or

(b) Currently certified as a Certified Professional in Erosion and sediment Control (CPESC) offered by CPESC, Inc. (www.cpesc.org) and have one year experience in state of Washington construction site erosion and sediment control regulatory requirements and BMPs, erosion and sediment control plan development and stormwater monitoring.

(8) The ECL shall also have done the following:

(a) Coordinated, developed, and implemented erosion and sediment control plans for NPDES permit compliance in the State of Washington.

(b) Completed at least two erosion and sediment control plans for earthwork projects.

(c) Developed phased construction work schedules addressing all ground disturbing activities.

(d) Designed temporary and permanent erosion and sediment control measures (BMPs) during clearing, demolition, existing road improvement, and for emergency situations.

(e) Designed excavation dewatering plans.

(f) Designed plans for dust abatement, embankment stabilization, and restoration

(g) The Contractor shall submit for approval all documentation listed above necessary to prove ECL qualifications including but not limited to resumes, certificates, degrees, recommendation letters, and plan examples.

(9) Duties and responsibilities of the ECL shall include:

(a) Maintaining permit file on site at all times which includes the the SWPPP, and any associated permits and plans;

(b) Directing BMP installation, inspection, maintenance, modification, and removal;

(c) Shall be onsite at all times when work is taking place.

(d) Availability 24 hours per day, 7 days per week by telephone throughout the period of construction;

(e) Updating all drawings with changes made to the plan;

(f) Keeping daily logs, one report per ECL is to be submitted;

(g) Prepare and submit for approval a Contractor Erosion and Sediment Control Plan (CESCP) as part of the SWPPP;

(h) Immediately notify the Engineer should any point be identified where storm water runoff potentially leaves the site, is collected in a surface water conveyance system (i.e., road ditch, storm sewer), and enters receiving waters of the State;

(i) If water sheet flows from the site, identify the point at which it becomes concentrated in a collection system.

(j) Inspect CESCP requirements including BMPs as required to ensure adequacy; facilitate, participate in, and take corrective actions resulting from inspections performed by outside agencies, Port employees, and Port consultants.

(k) Set up and maintain a construction stormwater monitoring plan that includes monitoring locations and procedures. At a minimum, the plan will include monitoring points everywhere construction stormwater discharges from the project.

(l) The ECL shall have authority to act on behalf of the Contractor.

(m) The CESCP shall include the name, office and mobile telephone numbers, fax number, and address of the designated ECL and all Contractor personnel responsible for erosion and sediment control.

(n) In addition to the ECL, at a minimum, the Contractor's superintendent, foremen, and lead persons shall have successfully completed "Contractor Erosion and Sediment Control Lead" (CESCL) training given by a Washington State Department of Ecology-approved provider. On matters concerning erosion control, they shall report to the ECL.

c. Schedule and Sequencing

(1) Schedules for accomplishment of temporary and permanent erosion control work, that include as a minimum all specific work items as are applicable for clearing and grubbing; grading; construction; paving; structures at watercourses, sawcutting, and dewatering, underground utilities; Stormwater conveyances, and seeding.

(2) Proposed method of erosion and dust control on haul roads and borrow pits and a plan for disposal of waste materials;

(3) Estimated removal date of all temporary BMPs;

(4) Estimated date of final site stabilization.

(5) Dates of earthwork activities.

(6) Dates when construction activities temporarily or permanently cease on any portion of the site.

(7) Dates when any stabilization measures are installed.

(8) Dates when structural BMPs are initiated.

(9) Dates for all work performed within 200 feet of sensitive environmental areas including wetlands, streams and ponds.

(10) Erosion control work activities consistent with the CECSP shall be included in the Project Schedule for each work area and project activity as shown on the drawings.

d. BMP Installation

(1) The CESCP shall include installation instructions and details for each BMP used during the life of the Project;

(2) To prepare or modify Contractor's Erosion and Sediment Control Plans, use BMPs from the Washington State Department of Ecology, Stormwater Management Manual for Western Washington, Vol. 2, and (Current Version). May be downloaded at: http://www.ecy.wa.gov/programs/wq/stormwater/manual.html

(3) The ECL shall certify that all BMP installers are trained in proper installation procedures.

e. BMP Maintenance

(1) The CESCP shall include a description of the maintenance and inspection procedures to be used for the life of the project.

(2) BMPs shall be maintained for the life of the project, the completion of a work phase and/or until removed by direction of the Engineer;

(3) BMPs shall be maintained during all suspensions of work and all non-work periods;

(4) BMPs shall be maintained and repaired as needed to assure continued performance of their intended function and in accordance with the approved CESCP;

(5) Sediments removed during BMP maintenance shall be placed away from natural and constructed storm water conveyances and permanently stabilized.

(6) All maintenance shall be completed within 24 hours of inspection

f. BMP Inspection

(1) The ECL shall inspect all TESC best management practices daily during workdays and anytime 0.5" of rainfall has occurred within 24 hours on weekends, holidays, and after hours. Rainfall amounts can be determined by contacting the National Weather Service. .

(2) Deficiencies identified during the inspection shall be corrected within 24 hours or as directed by the Engineer.

(3) Observe runoff leaving the site during storms, checking for turbid water;

(4) Implement additional BMPs, if needed, to address site-specific erosion control;

(5) Inspect streets surrounding site for dirt tracking;

(6) Inspect for dust.

(7) The ECL shall visually inspect all stormwater runoff that discharges from the project for petroleum or chemical sheen, or “rainbow”. Occurrences of sheen shall be reported immediately to the Engineer and shall follow procedures specified in Section 01 57 23 – Pollution Prevention, Planning & Execution.

(8) The ECL shall collect samples and test all stormwater runoff that discharges from the project for turbidity using a calibrated turbidimeter, and for pH using test strips that measure from pH 0 - 14. Turbidity that exceeds 25 NTUs or pH that is below 6.5 or above 8.5 shall be reported immediately to the Engineer.

g. Record keeping

(1) Reports summarizing the scope of inspections, the personnel conducting the inspection, the date(s) of the inspection, major observations relating to the implementation of the CESCP, and actions taken as a result of these inspections shall be prepared and retained as a part of the CESCP;

(2) All inspection reports shall be kept on-site during the life of the project and available for review upon request of the Engineer.

(3) Copies of all inspection records and updated CESCP shall be submitted to the Engineer weekly.

(4) The CESCP shall include the Contractor’s inspection form which includes the following:

(a) All best management practices to be inspected and monitored for all work areas and work activities identified in the schedule for the life of the contract.

(b) Inspection time and date.

(c) Weather information including current conditions, total rainfall since last inspection and rainfall in the 24 hours prior to the current inspection.

(d) Locations of BMPs inspected.

(e) Locations of BMPs that need maintenance and reasons why.

(f) Locations of BMPs that failed to operate as designed or intended.

(g) Locations where additional or different BMPs are needed and reasons why.

(h) A description of stormwater discharged from the site. The ECL shall note the presence of suspended sediment, turbid water, discoloration, and/or petroleum sheen.

(i) Any water quality monitoring performed during inspection.

(j) General comments and notes, including a description of any BMP repairs, maintenance or installations made as a result of the inspection.

(k) A statement that, in the judgment of the person conducting the site inspection, the site is either in compliance or out of compliance CESCP. If the site inspection indicates that the site is out of compliance, the inspection report shall include a summary of the remedial actions required to bring the site back into compliance, as well as a schedule of implementation. If the site inspection indicates that the site is out of compliance, the ECL shall notify the Engineer immediately.

(l) Name, title, and signature of the ECL conducting site inspection and the following statement: “I certify that this report is true, accurate, and complete, to the best of my knowledge and belief.”

h. BMP Removal

(1) After cleaning and removal, the drainage system shall not be used for temporary construction stormwater conveyance or storage.

(2) Sediment removed shall be placed away from drainage conveyances and permanently covered with hydro seed or other material as directed by the Engineer.

(3) Stormwater ponds used to contain construction stormwater runoff shall be returned to elevations shown on the plans.

(4) Temporary BMPs shall be removed upon permanent stabilization or as directed by the Engineer.

(5) Areas disturbed during removal of temporary BMPs shall be permanently stabilized.

(6) Permanent stabilization shall occur upon installation of:

(a) Concrete or asphalt pavement.

(b) On grades 3:1 and less, soil is covered by a minimum of 85% grass growth, as determined by the Engineer.

(c) On grades greater than 3:1 soil is covered by an approved erosion control blanket or bonded fiber matrix and a minimum of 85% grass growth, utilizing the “Line Intercept Method”.

(d) All stormwater discharges from the project meet the following criteria:

(i) 0-25 NTUs.

(ii) 6.5-8.5 pH.

(iii) No visible sheen.

(iv) No settleable solids.

(v) Washington State Stormwater Quality Standards (WAC 173-201A) at the receiving water, as determined by the Engineer.

i. Emergency Response

(a) The CESCP shall contain information on how the Contractor shall control and respond to turbid water discharges, sediment movement, and fugitive dust. At a minimum, the Contractor's employee responsible for, or first noticing, the discharges shall take appropriate immediate action to protect the work area, private property, and the environment (e.g., diking to prevent pollution of state waters). Appropriate action includes but is not limited to the following:

(i) Hazard Assessment - assess the source, extent, and quantity of the discharge.

(ii) Securement and Personal Protection - If the discharge cannot be safely and effectively controlled, then immediately notify the ECL and the Engineer. If the discharge can be safely and effectively controlled, proceed immediately with action to protect the work area, private property, and the environment.

(iii) Containment and Elimination of Source - Contain the discharge with silt fence, pipes, sand bags or a soil berm down slope from the affected area. Eliminate the source of the discharge by pumping turbid water to a controlled area, building berms, piping clean water away from the area or other means necessary.

(iv) Cleanup - when containment is complete, remove sediment, stabilize, dispose of contaminated water and prevent future discharge.

(v) Notification - report all discharges immediately to the Engineer.

j. Construction Stormwater Management

Designer to verify specific discharge requirements and modify this section accordingly. In some cases, no construction stormwater discharge is allowed and alternative disposal methods, such as sanitary sewer or trucking off site need to be included.

(1) Storm water and construction dewatering operations shall not discharge to the Storm Drain System (SDS) unless free from pollutants. Before discharge, water shall be measured using a properly calibrated, approved turbidity meter. Discharged water shall not exceed 25 Nephelometric Turbidity Units (NTUs) and pH levels shall be between 6.5 and 8.5.

(2) Storm water and construction dewatering water shall not be discharged to the Industrial Wastewater System (IWS) unless free from pollutants. Before discharge, water shall be measured using a properly calibrated, approved turbidity meter. Discharged water shall not exceed 200 Nephelometric Turbidity Units (NTUs) and pH levels shall be between 6.0 and 9.0. There shall be no discharge to any catch basin without specific approval of the Engineer.

(3) The CESCP shall address how the Contractor plans to manage clean and polluted water during the life of the project. Specific procedures shall be developed and included in the CESCP when work includes excavation within 10 feet of any water, sewer, or storm system. Procedures shall address, at a minimum, locating, protecting, and connecting to existing pipes, as well as response plans for broken pipes.

(4) The Engineer shall be notified before any disposal, hauling, pumping, or treatment of water occurs. Notification shall include location of disposal and methods of treatment. Disposal tickets shall be provided to the Engineer upon request.

(5) Water shall not be pumped into ditches, gutters, drainage conveyance, catch basins, or any area that drains to one of these unless it meets the specifications outlined in this section and with prior approval of the Engineer.

(6) Chlorinated water used for disinfecting water pipes shall not be discharged to the storm drain system.

k. Fugitive Dust Planning:

(1) The CESCP shall detail the Contractor proposed approach to fugitive dust management. The plan shall include the following:

(a) Identification of all fugitive dust sources for each work activity.

(b) Description of the fugitive dust control measures to be used for each source.

(c) Schedule, rate of application and calculations to identify how often, how much, and when the control method is to be used.

(d) Provisions for monitoring and recordkeeping.

(e) Contingency plan in case the first control plan does not work or is inadequate.

(f) Name and telephone number of the person responsible for fugitive dust control.

(g) Source and availability of fugitive dust control materials.

(2) The Contractor shall provide whatever means is necessary to keep fugitive dust on site and at an absolute minimum during working hours, non-working hours and any shut-down periods.

(3) The Contractor's methods for fugitive dust control will be continuously monitored and if the methods are not controlling fugitive dust to the satisfaction of the Port, the Contractor shall improve the methods or utilize new methods at no additional cost.

(4) The Contractor shall maintain as many water trucks on a site during working and non-working hours as required to maintain the site free from fugitive dust.

(5) During time periods of no construction activity, water trucks must be ready with on-site Contractor's personnel available to respond immediately to a dust or debris problem as identified by the Engineer.

(6) At no time shall there be more than a 10 minute response time to calls concerning fugitive dust/debris problems during work hours and a 90 minute response at all other times on a 24 hour basis.

I. Utilities Planning:

(1) The CESCP shall identify when and how all underground utility work will be conducted so that water quality compliance is maintained. At a minimum, the Contractor shall:

(a) Have all shut off valves located and have procured the means to shut off valves within 10 minutes of a water line break.

(b) Before cutting into an existing water line, the Contractor shall verify to the Engineer that the water line is not pressurized.

(c) The Contractor shall not cut into an existing storm drain or connect new stormwater conveyance systems into existing systems until it has been verified to the Engineer there will be no discharge of non-compliant water during and after cutting and connection operations.

(d) The Contractor shall grout all holes, seams, cracks, joints, cast iron rings and grates within 24 hours of installation of each item.

(e) Storm systems to be demolished in place shall be first blocked at the point of connection to existing section to prevent contamination of existing storm system.

(f) Chlorinated water shall be discharged to sanitary sewer or removed from the site.

(g) Air plugs shall not be utilized for more than 24 hours and shall be in new condition with no leaks and monitored daily for proper air pressure.

(h) Mechanical plugs shall not be utilized for more than 5 calendar days and shall be used according to the manufacturer's instructions and engineering parameters. The Contractor shall submit instructions and engineering documentation before use.

(i) When a plug needs to remain in place longer than 5 days, the Contractor shall utilize grout. The grout shall be installed so that the length is one and a half times the diameter of the pipe.

m. Low Impact Development (LID) Protection Planning

(1) The CESCP shall identify how all LID BMPs are to be protected from sedimentation, pollution and compaction.

n. Education:

(1) The Contractor shall provide narrative in the CESCP on how they will educate all personnel including subcontractors. At a minimum, the Contractor shall:

(a) Train staff through regularly scheduled meetings to discuss environmental protection subjects as related to this project. This may be added to any existing weekly meetings (such as safety meetings).

(b) Training shall emphasize water quality compliance, BMP installation and maintenance, sensitive areas, emergency response, spill prevention, and inspections.

(c) Minutes of the meetings detailing attendees and subjects discussed shall be kept and submitted to the Engineer weekly.

(d) Prior to commencing work, all Contractor and subcontractor personnel at any tier shall complete a Port of Seattle Environmental Compliance Orientation given with the required Safety Orientation.

3.03 EXECUTION OF WORK

A. CONSTRUCTION REQUIREMENTS

Remove anything that doesn't apply to work.

1. Saw cutting

a. Saw cut slurry and cuttings shall be vacuumed during cutting operations;

b. Saw cut slurry and cuttings shall not remain on permanent concrete or asphalt pavement overnight;

c. Saw cut slurry and cuttings shall not drain to SDS, IWS, or any other natural or constructed drainage conveyance;

d. Collected slurry and cuttings are the responsibility of the Contractor and shall be disposed of off site in a manner that does not violate groundwater or surface water quality standards.

2. Soil and Construction Debris Stockpiles

a. Soils and construction debris, including broken concrete and asphalt paving, shall be stockpiled within the work site or off site.

b. Stockpiles shall be covered with plastic and secured from blowing wind and/or jet blast.

c. Plastic shall be a minimum thickness of 6 mil.

d. Materials to be stockpiled on pavement shall be placed on plastic and contained within a bermed area.

e. Clean storm water runoff from the plastic covering shall be directed away from bare soil using pipes, sandbags, or other temporary diversion devices.

f. Stockpiles shall be covered so that no soil or debris are visible and shall be covered at the end of each work day, weekends and holidays

g. Stockpiles on the AOA shall not be allowed unless approved by the Engineer.

3. Construction Entrances, Exits and Haul roads

a. Before leaving project site, all trucks and equipment shall be inspected for mud and debris.

b. At no time shall mud, debris, or visible sediment be allowed outside of the project boundaries and on any Port-owned and public roads.

c. Mud and debris shall be removed from pavement by vacuum sweeping and shoveling and transported to a controlled sediment disposal area identified in the CESCP.

d. Mud and debris shall be considered contaminated by fuels, grease, metals or other pollutants and shall be disposed of in accordance with Section 01 57 23 - Pollution Prevention, Planning and Execution.

e. Use of water to wash concrete or asphalt pavement shall be allowed only after sediment has been removed by vacuum sweeping and shoveling, and a Road Wash Plan has been submitted and accepted by the Engineer.

f. Washing pavement, shall first be approved by the Engineer. Wash water shall not drain into the SDS, IWS or any other natural or constructed storm water conveyance and shall be contained and removed from Port property and disposed of off-site in accordance with local, state, and federal regulations. Disposal tickets shall be provided to the Engineer.

g. Power brooms shall not be utilized without prior approval by the Engineer.

h. Contractor shall have sufficient working vacuum sweepers on site at all times work is being performed. All sweepers shall have on-board water spray systems that shall be operating at all times.

i. Vacuum sweepers shall be dedicated to this project and shall not be utilized by any other contract, nor be hired out to another contractor.

j. Sweeper systems shall function per manufacturer specifications, including, but not limited to, spray water systems, blowers, vacuum nozzles, hoses, debris hopper, hydraulics and electrical.

k. At no time shall debris hopper seals leak debris and or liquids.

l. At least one driver shall be assigned to a vacuum sweeper and shall do no other work.

m. Coverage shall be provided during lunch breaks, and during unfilling activities.

n. If, in the Engineer's opinion, the Contractor does not adequately manage the tracking of sediment, the Port may subcontract out the control of sediment tracking at the Contractor's expense.

4. Asphalt Curb and Asphalt berm

a. Asphalt curbs or asphalt berms shall be constructed on project perimeters, when the project is surrounded by impervious surfaces.

b. Asphalt curb and berm shall be a minimum height of four inches.

c. Diesel shall not be used to clean tools and equipment

5. Catch Basin Protection

a. All catch basins within the project limits, and outside the project limits but within the project drainage basin, including haul roads, shall be protected.

b. Catch basin protection shall be installed where shown in the project drawings, in all storm drainage structures within the work area, or as otherwise directed by the Engineer.

6. Concrete Truck and Equipment Washing

a. Concrete truck chutes, concrete pumps, hand tools, screeds, floats, trowels, rollers and all other tools shall be washed out only into Washington State Department of Ecology (WDOE)-approved covered steel containers..

b. All contained concrete waste shall be disposed of offsite in a manner that does not violate groundwater or surface water quality standards.

c. All water used for washing, is defined by the WDOE as "process water" and shall be collected and disposed of in a manner that complies with all local, state and federal regulations.

7. Wheel Washes

a. All haul vehicles exiting the work site to public roads shall pass through a wheel wash system to control sediment tracking. Any required modification, alteration or improvement needed on the existing wheel wash systems or supplemental vehicle washing for the successful control of dirt, debris or sediment tracking beyond the wheel wash, either on Port haul roads or public roads, for the duration of the contract shall be the responsibility of the Contractor.

b. No modifications of the wheel wash system are allowed that alter the design of a contained operation with recycled wash water with no release of sediment laden wash water. The sediment shall be contained and disposed of at an appropriate disposal facility off Port Property.

c. Wheel wash water shall be replaced weekly with fresh, clean water.

d. The wash water is "process water" and shall not be released on site or to the storm drain system and shall be disposed of in accordance with all water quality regulations.

e. Wheel wash water shall not exceed 100 NTU.

f. Contractor shall sample wheel wash water for turbidity 2 hours after start and 2 hours before shutdown of the system. Sampling results shall be entered into Contractor's daily inspection report.

8. Silt Fence

a. Silt fence shall be constructed at the locations shown in the project drawings, in the approved Contractor Erosion and Sediment Control Plan, or otherwise directed by the Engineer.

b. The geotextile shall be attached to the up-slope side of the posts and the wire mesh using staples, wire rings, or in accordance to the manufacturer's recommendations.

c. Where seams are required to join two sections of fence material, the seams shall be taped together, wrapped three times around a 2" steel post and the post driven into the ground. All rips, tears, holes, and other damage to silt fences shall be repaired within 24 hours of locating the damage When sediments deposits reach approximately one-third the height of the silt fence, the deposits shall be removed and disposed of outside Port property.

9. Straw Wattle

a. The installation of straw wattles shall be per WSDOT Standard Plan I-30.30-00 "Wattle Installation on Slope", or as directed by the Engineer.

b. Straw Wattles shall not be installed on impervious surfaces.

10. Bonded Fiber Matrix Soil Stabilization

a. The installation of Bonded Fiber Matrix Soil Stabilization shall be applied at a minimum rate of 3,000 pounds per acre and provide a minimum of 95% soil cover. Seed and fertilizer shall be included.

b. Contractor shall provide all Bonded Fiber Matrix, seed and fertilizer bags to the Engineer upon request.

11. Temporary Organic Mulch

a. Temporary organic mulch shall be applied at a minimum rate of 1.5 tons per acre.

12. Swale Construction
    a. Grass-lined swales shall be constructed to the lines and grades shown on the drawings. The swale includes excavating, grading, placement of topsoil, placement of erosion control blanket, and hydroseeding as detailed on the drawings. Excavated material from the swale construction shall be considered Excess Soil as defined in Section 31 23 00 – Excavation and Embankment.
13. Temporary Piping/Connections
    a. The Contractor shall install temporary piping, catch basins and connections to the existing storm drain system in locations shown on the drawings. At the completion of the work, the piping shall be removed and the temporary connections plugged.
14. Temporary Pipe Plugging
    a. The locations of piping to be temporarily plugged are indicated on the drawings. At the completion of the work, the plugs shall be removed.
15. Construction Stormwater Management
    a. The Contractor shall construct stormwater tank pads in the size, location and as detailed on the drawings.
    b. The Contractor shall install stormwater storage tanks, as specified, in the locations and quantities shown on the drawings.
    c. The Contractor is responsible for conveying construction stormwater within each work area to the stormwater storage tank area shown on the drawings.
    d. Temporary piping, structures and pump facilities required for the conveyance are the responsibility of the Contractor.
    e. The construction stormwater shall be held in the storage tanks until hauled and disposed of by the Contractor on a Force Account basis.
    f. The storage tank facilities including pads, access roads, ramps, temporary structures and piping shall be removed at the completion of the work or as directed by the Engineer
16. Surface Roughening:
    a. All soil shall be roughened, loose and friable, by ripping or with equipment tracks before being permanently stabilized.
17. Water Filled Diversion Berms
    a. Water filled diversion berms shall be installed such that offsite water is prevented from entering the job site and site water is kept within the project boundary.
    b. Berms may be used to prevent contaminants and water from entering catch basins.

c. Berms may be used on impervious surfaces.

18. Biofence

a. Stakes shall be driven into the ground a minimum of 12 inches and be spaced no more than 6 feet apart.

b. Fence ends shall be joined by wrapping ends together around a post 3 times and driven into the ground.

c. Burlap fabric shall be attached to the post in at least 3 places using staples or other method approved by the Engineer.

d. When used as a barrier fence, fabric shall not be trenched into the ground. When used as a silt fence, a minimum 8 inch flap shall be left at the bottom and held in place with straw wattles staked in as detailed in item 9 above.

19. Process Water Collection, Storage and Disposal

a. The Contractor shall provide and install stormwater storage tanks of sufficient size and volume to enable collection of 100% of the process water generated by the project.

b. The Contractor is responsible for conveying process water within each work area to storage tank(s).

c. Temporary piping, structures and pump facilities required for the conveyance are the responsibility of the Contractor.

d. The storage tank facilities including pads, temporary structures and piping shall be removed at the completion of the work or as directed by the Engineer.

e. Contractor shall provide process water disposal locations to the Engineer for review.

20. Low Impact Development (LID) Protection

a. At a minimum, the Contractor shall:

1) At no time shall water exceeding 25 NTUs drain into bioretention, rain garden, or pervious pavement BMPs.

2) At no time shall water exceeding pH range of 6.5 to 8.5 drain into bioretention, rain garden, or pervious pavement BMPs.

3) At no time shall water containing sheen drain into bioretention, rain garden, or pervious pavement BMPs.

4) Upon reaching final grade, native soils below infiltration BMPs shall be maintained such that designed infiltration is not impacted. Areas shall be fenced to prevent vehicle and foot traffic from entering.

5) Pervious pavement BMPs fouled with sediment or debris such that designed infiltration rates are reduced shall be cleaned to the satisfaction of the Engineer, or replaced at the Contractor's expense.

3.04 DELIVERABLES

3.05 QUALITY ASSURANCE

PART 4 MEASUREMENT AND PAYMENT

Replace all of Part 4 language with following only with approval by the Erosion Control/Stormwater Engineer:

No separate measurement or payment will be made for the work required by this section. The cost for this portion of the Work will be considered incidental to, and included in the payments made for the applicable bid items in the Lump Sum price bid for the Project.

Otherwise, review items below, one or more may be used – add/remove to customize for specific project. If all TESC can be defined, Item A can be used independently. Any items where quantities cannot be defined (quantities may vary), select unit price items and/or Force Account to address variances

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4.01 MEASUREMENT

A. Measurement for “TESC – Plan and Execution” will be as a unit.

B. Measurement for “TESC – Bonded Fiber Matrix Soil Stabilization” and “TESC-Temporary Organic Mulch” will be per square yard.

C. Measurement for “TESC – Silt Fence”, “TESC – Straw Wattle”, “TESC – Asphalt Curb”, “TESC – Grass Lined Swale”, TESC-Biofence” , will be per linear foot.

D. Measurement for “TESC – Catch Basin Protection”, “TESC – Temporary Piping/Connections”, “TESC – Temporary Pipe Plug”, “TESC – Construction Roads, Entrances and Exits” , “TESC – Stormwater Storage Tank Pad” and “TESC – Water Filled Diversion Berms” will be per each.

E. Measurement for “TESC – Stormwater Storage Tank” shall be per each per month.

F. Measurement for “TESC – Force Account” and “TESC – Construction Stormwater Hauling” will be on a Force Account basis in accordance with Document 00 70 00 – General Conditions. An estimated amount has been entered in the Schedule of Unit Prices.

4.02 PAYMENT

A. Payment for “TESC – Plan and Execution” will be made at the contract lump sum price as stated in the Schedule of Unit Prices and shall be full compensation for furnishing all labor, equipment, materials and tools to develop, implement and maintain the temporary erosion and sedimentation control plan including implementation of temporary stormwater conveyance facilities either as shown on the drawings or as required to complete the work, dust control, operation, maintenance and modification of wheel wash systems, construction of the stormwater tank pad areas as detailed on the drawings, control of sediment tracking, providing and operating vacuum sweepers and water trucks, and other measures as required as detailed on the drawings and specified herein through the duration of the contract, with the exception of those items measured and paid for separately. Payments will be made as follows:

Payment percentages may be adjusted (ie 20/60/20) to reflect specific project.

1. Upon acceptance of the Contractor's Erosion and Sediment Control Plan (CESCP) 25%.
2. After NTP and before Substantial Completion, 50% will be prorated and paid monthly for compliance with the CESCP. Non-compliance will result in withholding of payment for the month of the non-compliance.
3. After Substantial Completion, 25% for a clean and stabilized site.

B. Payment for “TESC – Silt Fence” will be made at the contract unit price per linear foot as stated in the Schedule of Unit Prices and shall be full compensation for furnishing all labor, equipment, materials and tools necessary to complete the installation of the silt fence as detailed on the drawings or as directed by the Engineer and specified herein. The unit price shall include all maintenance, the removal of silt fencing, and restoration of the area at the completion of the work.

C. Payment for “TESC – Biofence” will be made at the contract unit price per linear foot as stated in the Schedule of Unit Prices and shall be full compensation for furnishing all labor, equipment, materials and tools necessary to complete the installation of the biofence as detailed on the drawings or as directed by the Engineer and specified herein. The unit price shall include all maintenance, the removal of biofence, and restoration of the area at the completion of the work

D. Payment for “TESC – Catch Basin Protection” will be made at the contract unit price per each as stated in the Schedule of Unit Prices and shall be full compensation for all labor, equipment, tools, and materials to install inlet protection or filter on catch basins as shown on the drawings and specified herein. The unit price shall include all maintenance, removal and disposal of sediment material and the removal of the protection at the completion of the work.

E. Payment for “TESC – Straw Wattle” will be made at the contract unit price per linear foot as stated in the Schedule of Unit Prices and shall be full compensation for furnishing all labor, equipment, materials, and tools necessary to install the straw wattles as directed by the Engineer. The unit price shall include all maintenance, removal and disposal of the material at the completion and the restoration of the area at the completion of the work.

F. Payment for “TESC – Asphalt Curb” will be made at the contract unit price linear foot as stated in the Schedule of Unit Prices and shall be full compensation for all labor, materials, tools, and equipment necessary to complete the work to install the asphalt curb or berm as shown on the drawings or directed by the Engineer and specified herein, and remove and dispose of the material at the completion of the work.

G. Payment for “TESC – Bonded Fiber Matrix Soil Stabilization” will be made at the contract unit price per square yard as stated in the Schedule of Unit Prices and shall be full compensation for furnishing all labor, equipment, materials, and tools including site preparation, and installation of the material as described in this section and as detailed on the drawings. The unit price shall be full compensation for multiple applications, in areas as required by the Engineer as the work progresses. The minimum application will be 500 square yards. The unit price shall include mobilization/demobilization for each application required.

H. Payment for "TESC – Temporary Organic Mulch" will be made at the contract unit price per square yard as stated in the Schedule of Unit Prices and shall be full compensation for furnishing all labor, equipment, materials, and tools including site preparation, and installation of the material as described in this section and as detailed on the drawings. The unit price shall be full compensation for multiple applications, in areas as required by the Engineer as the work progresses. The unit price shall include mobilization/demobilization for each application required.

I. Payment for "TESC – Temporary Piping/Connections" will be made at the contract unit price per each as stated in the Schedules of Unit Prices and shall be full compensation for furnishing all labor, equipment, materials, and tools to install the temporary piping of various sizes as shown on the drawings and described in this section, including the site preparation, excavation, hauling and disposal of material, required maintenance, including sediment removal, and removal of the piping and restoration of the area at the completion of the work or as directed by the Engineer. This item shall also include bends, anchors, supports, etc. necessary for a complete and operational system.

J. Payment for "TESC – Temporary Pipe Plug" will be made at the contract unit price per each as stated in the Schedules of Unit Prices and shall be full compensation for furnishing all labor, equipment, materials, and tools to furnish, install, maintain and remove the specified temporary pipe plug in location shown on the drawings or as directed by the Engineer.

K. Payment for "TESC – Construction Roads, Entrances and Exits" will be made at the contract unit price per each as stated in the Schedule of Unit Prices and shall be full compensation for furnishing all labor, materials, equipment, tools to construct the construction entrance, regardless of size, including site prep, grading, furnishing and the installation of quarry spalls, crushed aggregate base, asphalt concrete, piping, as required to construct and maintain the entrances as shown on the drawing and specified herein. The unit price shall include maintenance, removal of the temporary improvement and restoration of the area at the completion of the work.

L. Payment for "TESC – Grass Lined Swale" will be made at the contract unit price per linear foot as stated in the Schedule of Unit Prices and shall be full compensation for furnishing all labor, equipment, materials, and tools to construct the swale as detailed on the drawings, including the required site preparation, excavation, hauling and disposal of excavated material off Port Property, erosion control blanket, seeding and all incidentals to complete the work and the removal the swale and restoration of the area at the completion of work.

M. Payment for "TESC – Stormwater Storage Tank Pad" will be made at the contract unit price per each as stated in the Schedule of Unit Prices and shall be full compensation for furnishing all labor, tools, equipment and material to construct the pad as detailed on the drawings including all excavation, crushed aggregate base, piping, grading, asphalt concrete pavement, maintenance of the pads, removal and restoration of the site at the completion of work or as directed by the Engineer.

N. Payment for "TESC – Stormwater Storage Tank" will be made at the contract unit price per each per month as stated in the Schedule of Unit Prices, and shall be full compensation for furnishing the specified storage tank. The unit price per each per month shall include the cost of mobilization/demobilization, cleaning, hauling and all incidentals for the number of storage tanks required by the Engineer for a minimum of one month through the maximum for the duration of the contract.

O. Payment for “TESC – Water Filled Diversion Berms” will be made at the contract unit price per each per month as stated in the Schedule of Unit Prices, and shall be full compensation for furnishing the specified diversion berms. The unit price per each shall include the cost of mobilization/demobilization, cleaning, hauling and all incidentals for the number of diversion berms required by the Engineer for the duration of the contract.

P. Payment for “TESC – Construction Stormwater Hauling” as stated in the Schedule of Unit Prices will be made on a Force Account basis in accordance with Document 00 70 00 –General Conditions and shall be full compensation to transfer construction stormwater from the stormwater storage tanks to trucks for hauling and disposal in an existing stormwater pond.

Item of Work “TESC – Force Account “will be added to the Schedule of Unit Prices in Specification Section 00 41 00 – Bid Form. The Unit Price and Amount will be set by the Designer along with the Erosion Control / Stormwater Engineer.

Q. Payment for “TESC – Force Account” as stated in the Schedule of Unit Prices will be made on a Force Account basis in accordance with Document 00 70 00 – General Conditions and shall be full compensation to complete only temporary erosion control measures that are not part of the contract work, not covered under existing bid items and are at the specific direction of the Engineer.

End of Section

READ THIS FIRST

This Project Spec Document may need additional modifications to suit your project. It is recommended that you proofread each section, paying attention to any “Notes” boxes such as this one--you should remove these “Notes” sections as you go. Also, do a search for all bracket characters “[ ] “ as they are used to show you areas containing options or project specific details (you can use Microsoft Word’s Find feature {Ctrl-F} to jump to an open bracket “ [“ character quickly). Again, these bracket characters should be removed.

It is important that every paragraph be numbered to allow for easy referencing. If you use the document’s built-in styles and formatting your outline should be fine. Most paragraphs can be promoted (Shift) or demoted (Shift-Tab).

You should not have to manually enter extra spaces, carriage returns or outline characters such as A, B, C, or 1.01, 1.02; the formatting will do this for you. The entire document is 11 pt. Arial. If you paste items in, you may need to ‘format paint’ to reapply the format.

PART 1 GENERAL

1.01 SUMMARY

A. This section consists of planning for and implementing the temporary measures indicated herein, shown on the Contract Documents, or as ordered by the Engineer to prevent pollution of soil and water, and control, respond to, and dispose of potential pollutants or hazardous materials during the life of the Contract.

B. This work shall apply to all areas associated with Work including, but not limited to the following locations:

1. Project Site, including equipment and material storage areas
2. Remote Laydown Staging Areas (LSAs), including Logistics Lots (reference Section 01 50 00 – Temporary Facilities and Control for details and restrictions)
3. Stockpile areas

1.02 DESCRIPTION OF WORK

A. In order to comply with this specification the Contractor shall:

1. Develop and submit a site-specific Pollution Prevention Plan
2. Revise the Pollution Prevention Plan during the life of the Contract
3. Install, maintain, and remove all spill prevention, containment, countermeasures, and pollution prevention Best Management Practices during the life of the Contract
4. Contain, cleanup and dispose of all hazardous materials or potential pollutants
5. Maintain good housekeeping practices at the jobsite and laydown staging areas
6. Perform other work shown on the Contract Documents or as directed by the Engineer

7. Maintain any required Contractor pollution liability insurance including insurance liability for the transportation of hazardous materials for the duration of the Contract

8. Maintain a proper Hazardous Material Endorsement for any driver that is transporting hazardous material in a vehicle that requires the driver to maintain a valid and current Commercial Driver's License in the State of Washington

1.03 POLLUTION PREVENTION PLAN

A. The Contractor shall develop and submit to the Port a site-specific Pollution Prevention Plan. The Pollution Prevention Plan must be a site-specific document that outlines the administrative, operational, and structural Best Management Practices that will be implemented on the project.

B. The Pollution Prevention Plan must, at a minimum, include the following:

1. Site specific description and drawings
2. Contractor pollution prevention contact personnel
3. Known or potential hazardous materials inventory list
4. Safety Data Sheets (SDSs) for hazardous materials identified on the inventory list
5. Hazardous material containers labeling system
6. Hazardous material container storage and handling procedures
7. Hazardous material spill prevention planning and execution
8. Hazardous material spill control and response planning and execution
9. Hazardous material cleanup and disposal planning and execution
10. Pollution Prevention BMP Selection
11. Pollution Prevention BMP Maintenance planning, execution, and inspection
12. Subcontractor's acknowledgment
13. Education

1.04 SUBMITTALS

A. As part of the required Preconstruction Submittals, Section 01 32 19 - Preconstruction Submittals, and before Notice to Proceed is issued, the Contractor shall submit the following information:

1. Pollution Prevention Plan and the required contents.
2. Insurance Endorsements verifying liability coverage for job-site work and any transportation of hazardous materials to or away from the jobsite.
3. Copy of a completed MCS-90 Certificate if required under the Motor Carrier Act of 1980 for transportation of hazardous material which verifies compliance with the financial responsibility requirements of the Act;
4. A list of all drivers who will be hauling hazardous material in a vehicle that requires the driver to maintain a Commercial Driver's License in the State of Washington under RCW 46.25.080. These drivers must show evidence

of a proper Hazardous Material Endorsement in accordance with Washington RCW 46.25.070 and 46.25.085.

1.05 DEFINITIONS

A. Absorbent: Any material capable of absorbing oils, water-based materials, solvents, acids, and other hazardous materials. Absorbent materials include: pads, kitty litter, floor dry, and other commercially available materials.

B. Best Management Practice (BMP): The variety of administrative, operational, and structural measures that will be implemented to prevent and reduce the amount of contaminants in stormwater and the environment. (Examples: covering concentrated galvanized materials and providing secondary containment for liquid storage are BMPs).

C. Container: Any portable device, in which a material is stored, transported, treated, disposed of, or otherwise handled.

D. Dangerous Waste: Solid wastes designated by the State of Washington Under Chapter 173-303 WAC and regulated as Dangerous Waste, Extremely Hazardous Waste, or Mixed Waste. (The State of Washington is authorized to implement Federal Hazardous Waste Regulations - see also Hazardous Waste Definition)

E. Hazardous Material: A substance or material, including a hazardous substance, hazardous waste, marine pollutant, including but not limited to: diesel, gasoline, petroleum products, solvents, paints, acids, lubricants, curing compounds, form release agents, adhesives, sealants, and epoxies. (See also Hazardous Waste definition)

F. Hazardous Material Storage Area: The area used by the Contractor to store hazardous material.

G. Hazardous Material Container Labeling System: The system used by the Contractor for identifying the secondary containers used to store hazardous materials or wastes. Acceptable methods include: Department of Transportation (DOT), Hazardous Material Information System (HMIS); National Fire Protection Association Fire Diamond (NFPA Hazard Rating).

H. Hazardous Waste: Solid wastes designated by 40 CFR Part 261, and regulated as hazardous or mixed waste by the United States EPA.

I. Laydown Staging Area (LSA): Remote office, equipment and materials laydown staging areas, including Logistics Lots 1-5, Radisson Lot 6, Cell Lot, West, and North LSAs.

J. Project Site: The location(s) where the Work will be performed or constructed by the Contractor as set forth in the Drawings and Specifications. Project Site specifically includes areas identified by the Port for Contractor’s logistics or staging but does not include any areas separately secured by the Contractor, a Subcontractor of any tier, or Supplier for use in connection with the Work (e.g. Contractor’s home office, an off-site fabrication plant, etc.).

K. Safety Data Sheet (SDSs): Written or printed material available for each chemical that includes information on: the physical properties, hazards to personnel, fire and explosion potential, safe handling recommendations, health effects, fire-fighting techniques, and reactivity and disposal.

L. Secondary Container: Any container, other than the original container that is used for transferring, holding, storing or otherwise containing hazardous materials or wastes.

M. Secondary Containment: A device designed, installed, or operated to prevent any migration of wastes or accumulated liquid to the soil, ground water, or surface water. The device must, at minimum, hold 110 percent of the volume of the largest container being stored. The device must have the strength to contain a spill and be made of materials that will not be degraded by the wastes or accumulated liquids it is intended to contain.

N. Sorbent: A material used to soak up free liquids by either adsorption or absorption, or both.

O. Storm Drainage System (SDS): Consists of any drain, inlet, catch basin, slot drain, pipe, gully, fissure, ditch, or other form of conveyance that collects and transports stormwater.

1.06 REFERENCES

A. The following rules, requirements and regulations specified may apply to this work:

1. Washington State Dangerous Waste Regulations: Chapter 173-303 WAC, September, 2020 or current edition.

2. National Pollution Discharge Elimination System Waste Discharge Permit No. WA-0024651 (Seattle-Tacoma International Airport).

3. Part C - Hazardous Communication: Chapter 296-62-054 WAC, “Right to Know”.

4. Port of Seattle Regulations for Airport Construction (Current Edition).

5. Puget Sound Stormwater Management Plan, Puget Sound Water Quality Action Team; 1998.

6. Title 40 Code of Federal Regulation Subchapter I - Solid Wastes 261, 262, 263, 265, 268, 273, 279, 370 (Federal Hazardous Waste Regulations).

7. Sea-Tac International Airport Rules and Regulations (Current Edition).

8. Sea-Tac Airport Stormwater Pollution Prevention Plan, as required by NPDES permit No. WA-0024651.

9. Seattle-Tacoma International Airport Programmatic Construction Stormwater Pollution Prevention Plan: NPDES Permit WA0024651, November 2021

10. Seattle-Tacoma International Airport Spill Prevention Control and Countermeasure (SPCC) Plan: January 2021. Gresham Smith

11. Stormwater Management Manual for Western Washington, Department of Ecology; July 2019 (or current edition).

12. Surface Water Design Manual, King County Public Works, September 2021 (or current edition).

13. WAC 173-201 A, Water Quality Standards of the State of Washington.

14. Revised Code of Washington - 46.25.085, 46.25.080, 46.25.070, 46.48.170, 4.24.314.

1.07 PERMITS

Coordinate with PM and POS ENV – add/edit/delete as applicable.

A. Work shall be conducted in accordance with STIA NPDES Permit WA-0024651.

PART 2 PRODUCTS - Not Used

PART 3 EXECUTION

3.01 SITE SPECIFIC DESCRIPTION AND DRAWINGS

A. A written site description shall be included in the Pollution Prevention Plan that addresses the following:

1. Physical description and location of the construction site and staging areas;
2. Construction activities that will involve the use of hazardous materials or generate hazardous waste;
3. Location of material storage areas and project staging areas;
4. Designated fueling areas;
5. Proximity to any natural or manmade drainage conveyance including ditches, catch basins, ponds, wetlands, and pipes;
6. Public areas relating to construction project;
7. Proximity to other construction sites;

B. Drawings shall be included in the Pollution Prevention Plan that show the construction site(s), location of fueling areas, equipment storage areas, catch basins and other man-made and natural drainage conveyances within the work area and storage areas. The drawings shall show locations of Pollution Prevention BMPs during each phase of construction. The drawings may be hand drawn sketches but must include the appropriate spatial information.

3.02 CONTRACTOR POLLUTION PREVENTION CONTACT PERSONNEL

A. The Contractor shall identify in the Pollution Prevention Plan at least one project personnel that will be available 24 hours a day to administer and respond to hazardous materials management requirements of the Contract and provide the following information:

1. Contact Name
2. Contact Phone Number
3. Contact E-mail Address

B. Duties

1. Maintain permit file on site at all times which includes the Pollution Prevention Plan, Contractor Erosion and Sediment Control Plan and any associated permits and plans;
2. Direct BMP installation, inspection, maintenance, modification and removal;

3. Available 24 hours per day, 7 days per week by telephone;
4. Update all drawings with changes made to the Pollution Prevention Plan;
5. Maintain daily logs;
6. Immediately notify the fire department (911) of any hazardous material spill that cannot be contained (see Paragraph 3.08.A.5 for detailed reporting requirements).
7. Immediately notify the Engineer of any and all spills, regardless of size.
8. Inspect for Pollution Prevention Plan requirements including BMPs as required to ensure adequacy. Facilitate, participate in, and take corrective actions within 24 hours resulting from inspections performed by outside agencies, Port employees, and Port designees.

C. Qualifications

1. The Pollution Prevention Plan Inspector shall have the following experience:
   a. Prevention, control and clean-up of construction caused pollution from petroleum, hazardous materials and construction wastes.
   b. Knowledge of basic hazard and risk assessment techniques.
   c. An understanding of basic hazardous materials terms.
   d. Ability to perform basic control, containment or confinement operations within the capabilities of the resources and personnel protective equipment available.
   e. Installation, inspection, maintenance, reporting, record keeping, and removal of Pollution Prevention BMPs.

3.03 HAZARDOUS MATERIAL INVENTORY LIST

A. A complete list of all known or potential hazardous materials or waste to be used or generated during all phases of the construction project shall be included in the Pollution Prevention Plan.

3.04 SAFETY DATA SHEETS (SDSs)

A. A Hazardous Material Inventory List supported by a corresponding SDS for all materials that have an SDS shall be included in the Pollution Prevention Plan.

B. For all hazardous materials not submitted in the original Hazardous Material Inventory List, the Contractor shall provide SDSs to the Engineer prior to bringing the material on site and submit a revised inventory list (or plan if required) within 7 days.

1. Hazardous materials shall be permitted on the work site only with prior written acknowledgement of receipt of SDSs by the Engineer.

3.05 HAZARDOUS MATERIAL CONTAINERS LABELING SYSTEM

A. The Pollution Prevention Plan shall address and the Contractor shall implement the following:

1. Identification of container with a legible label containing the materials product name, as was written on the material’s original container label.

2. Include the name of the material's manufacturer, as was written on the chemicals original container label.

3. Include appropriate hazard warnings, which identify the chemicals associated risks to health, flammability, or reactivity.

4. Contractor shall mark each container with the Contract project number and company owner of the container.

5. The mark shall be permanent, easily identifiable and placed with care to prevent defacing of the marker through abrasion, chemical reaction, or other means that would hinder marker identification.

6. At all times during the Work, the Contractor shall assure that proper and identifiable labels are attached to all hazardous materials and secondary containment

3.06 HAZARDOUS MATERIAL CONTAINER STORAGE AND HANDLING

A. Solid Chemicals, chemical solutions, paints, petroleum products, solvents, acids, caustics solutions, and any waste materials, including used batteries, shall be stored in a manner that will prevent the inadvertent entry of these materials into waters of the state, including groundwater. Storage shall be in a manner that will prevent spills due to overfilling, tipping, or rupture. In addition, the Pollution Prevention Plan shall address and the Contractor shall implement the following specific requirements:

1. All liquid products must be stored on durable, impervious surfaces and within a berm or other means of secondary containment capable of containing 110% of the largest single container volume in the storage area.

2. Waste liquids shall be stored under cover, such as tarps of roofed structures, in addition to secondary containment. Any waste storage areas, whether for waste oil or hazardous waste, shall be clearly designated as such and kept segregated from products to be used on the site.

3. In the event that the Contract Document Drawings designate a hazardous material storage area, the Contractor shall be restricted to storing hazardous materials or waste specific to the Project work to the area designated in the Contract Document Drawings.

4. All hazardous materials and waste containers shall be stored with the container lid secured, to prevent spills or leaking.

5. Upon completion of a specific task for which hazardous material(s) were used, the Contractor shall document in the Daily Report (Form CM03), the amount of hazardous material removed from the site, and the product and manufacturer name(s) of such material(s).

3.07 HAZARDOUS MATERIAL SPILL PREVENTION

A. The Pollution Prevention Plan shall address and the Contractor shall implement the following:

1. Hazardous Material Transfer

a. All hazardous materials shall be transferred from primary to secondary containers using secondary containment with spill kits in close proximity.

2. Vehicle and Equipment Fueling
    a. All equipment fueling operations shall utilize pumps and funnels and absorbent pads and / or drip pans;
    b. Fueling shall not take place within 25 feet of any natural or manmade drainage conveyance including ditches, catch basins, ponds, wetlands, and pipes;
    c. Fueling shall be restricted to designated fueling areas as shown on the Contract Documents or as submitted and accepted by the Engineer as a part of the Pollution Prevention Plan;
    d. A spill kit will be located within 25 feet of the fueling operation;
3. Vehicle and Equipment Maintenance
    a. Engine, transmission, and hydraulic oil may be added, as needed utilizing funnels and drip pans;
    b. Absorbent pads shall be placed to prevent fluid contact with soil;
    c. No fresh or used engine fluids will be stored on the project site;
    d. No vehicle maintenance other than emergency repair shall be performed on the project site.
4. Small Engine Fueling and Maintenance
    a. All fueling operations and engine fluid additions shall utilize funnels and be performed over drip pans.
    b. Absorbent pads shall be placed to prevent fuel and engine fluid contact with soil.
    c. Fueling shall not take place within 25 feet of any natural or manmade drainage conveyance including ditches, catch basins, ponds, wetlands, and pipes.
    d. Contractor shall not drain and replace engine fluids on Port property.
5. Equipment Storage
    a. Drip pans and absorbent padsshall be placed under all large fuel-powered and/or engine/hydraulic oil containing equipment that is unused for more than 4 hours, overnights, weekends, and holidays.
    b. Small fuel powered and/or engine/hydraulic oil containing equipment (i.e. generators, light plants, etc) shall be stored inside properly sized secondary containment at all times.
6. Spill Response Kits
    a. Spill kits shall be stored at designated locations on the project site, at the hazardous material storage areas, and in close proximity to any fueling operation.
    b. The contents of the spill kit must be appropriate to the types and quantities of materials stored and used, and spill kit contents shall

be replaced after use. Spill Kits shall, at a minimum, contain the following:

(1) 1-spill response procedures sheet

(2) 12-oil absorbent pads (17”x19”)

(3) 12-water-based absorbent pads (17”x19”)

(4) 3-oil absorbent socks/booms (3’x4’)

(5) 2-oil absorbent socks/booms (3’x10’)

(6) 1-roll of plastic sheeting

(7) 5-gallons (or ~25 lbs) of loose absorbent material (i.e. kitty litter or floor dry)

(8) 24-heavy duty garbage bags

(9) 1-shovel (non-metallic)

(10) 1-broom

(11) 1-pair splash resistant goggles

(12) 1-water resistant nylon bag

(13) 3-pair nitrile gloves

(14) 10-copies spill report form

3.08 HAZARDOUS MATERIAL SPILL CONTROL AND RESPONSE

A. The Plan shall contain information on how the Contractor shall control and respond to hazardous material spills. At a minimum, the Contractor’s employee responsible for the spill must take appropriate immediate action to protect human health and the environment (e.g., diking to prevent contamination of state waters).

1. Hazard Assessment - assess the source, extent, and quantity of the spill.

2. Containment and personal protection - If the spill cannot be safely and effectively controlled, then evacuate the area and immediately notify outside response services (go to Step 5). If the spill can be safely and effectively controlled, secure the area and proceed immediately with spill control (impacts to waters of the state should be given the highest priority after human health and safety)

3. Containment and elimination of Source - Contain the spill with absorbent materials or a soil berm around the affected area. Eliminate the source of the spill by closing valves, sealing leaks, providing containment, or deactivating pumps.

a. Spill control measures may include damming the spill, covering floor drains, catch basins, or preventing the contaminant from entering water systems. Contaminants include turbidity as well as chemicals.

4. Cleanup - when containment is complete, clean or remove the spill with absorbents or by pumping and containerizing the material for off-site disposal.

5. Notification

a. Report all spills that cannot be contained immediately to the Port of Seattle Fire Department:

(1) Port Phone: 911

(2) External Phone: (206) 787-5380

(3) Provide the following information:

(a) Time spill occurred or was discovered

(b) Location of the spill and equipment involved

(c) Material spilled and estimated quantity

(d) Measures taken to contain the spill and secure the area

b. Report all spills (regardless of size) immediately to the Engineer.

c. Complete spill report form within 24 hours and submit to Engineer.

(1) The report shall include items from 3.08.5.a.3 above

(2) The report shall describe/propose preventative future measures

(3) An example spill report form is provided in the Pollution Prevention Plan template

3.09 HAZARDOUS MATERIAL CLEANUP AND DISPOSAL

A. The Plan shall contain information on how the Contractor shall characterize, cleanup and remove all hazardous material and waste generated from Contractor operations. At a minimum, the Plan shall include or communicate the following:

1. For the purposes of this section, clean shall be defined as the Work site being free of all hazardous material(s), product (or oil) sheen, waste(s) container(s), containment device(s), scrap material(s), used spill pads or absorbent pads, or any other hazardous material debris resulting from the Contractor activities.

2. The Port of Seattle will retain title to all existing hazardous waste on site if encountered during demolition, removal, or excavation. This does not include hazardous materials generated, or left behind by the Contractor, such as used motor oils, paints, lubricants, cleaners, spilled materials, etc. Contractor will be the generator and owner of these wastes and shall clean and dispose of such waste according to the Contract Documents and follow local, State, and Federalregulations. Any contractor materials brought onsite for the construction project that remain unused shall be removed from Port property following completion of the project, unless otherwise specified by the Contract. The Port of Seattle will be shown as the hazardous waste generator and will sign all hazardous waste manifests for non-Contractor generated hazardous wastes. Nothing contained within these Contract Documents shall be construed or interpreted as requiring the Contractor to assume the status of owner or generator of hazardous waste substances for non-Contractor generated hazardous wastes.

3. Hazardous material(s) and other waste(s) shall be disposed in a fully permitted disposal facility with the approvals necessary to accept the waste

materials that are disposed. Use of the Port of Seattle's EPA Identification Number for disposal purposes must be coordinated with the Engineer and all documentation such as manifests, land disposal restriction forms, and profiles must be delivered to the Engineer if the Port of Seattle's EPA Identification number is being used for disposal on the project.

4. Handling of any contaminated soils resulting from a contractor spill shall be coordinated with the Engineer. Contaminated soil stockpiles must be on a plastic liner, covered with plastic, secured and labeled. Contaminated soils from a contractor spill of unknown source must be characterized for disposal purposes. Use of the Airport Environmental Soil Stockpile Facility is prohibited unless authorized by the Engineer.

5. Contaminated materials, such as absorbent materials, rags, containers, gloves, shall be collected, placed into labeled containers and properly disposed

6. Any unanticipated hazardous materials, waste, or contaminated soils encountered during construction that are not generated by the Contractor shall be immediately brought to the Engineer's attention for determination of appropriate action. Contractor shall not disturb such hazardous materials or contaminated soils until directed by the Engineer.

3.10 Pollution Prevention BMP Selection

A. The contractor shall document temporary Pollution Prevention BMPs that will be implemented during the duration of the project. Approved BMPs may be found in the Stormwater Management Manual for Western Washington, Department of Ecology, July 2019, or current edition.

B. At a minimum, the following Pollution Prevention BMPs will be required on the project site and at any LSA utilized by the contractor:

1. Housekeeping – Contractor areas and pavement shall remain free of loose trash/debris (including cigarette butts) and sediment at all times.

2. Concentrated galvanized materials shall not be stored directly on pavement and shall be under cover (or covered and secured with plastic sheeting or tarps) at all times.

3. Products with SDSs and small fuel-powered equipment shall be stored inside properly sized and maintained secondary containment.

4. Lids are required on all dumpsters and/or trash cans, and shall be secured at all times.

3.11 Pollution Prevention BMP Maintenance Planning, Execution and Inspection

A. Planning and execution

1. BMPs shall be maintained for the life of the project, the completion of a work phase and/or until removed by direction of the Engineer.

2. BMPs shall be maintained during all suspensions of work and all non-work periods.

3. BMPs shall be maintained and repaired as needed to assure continued performance of their intended function.

4. Sediments removed during BMP maintenance shall be placed away from natural and constructed storm water conveyances and permanently stabilized or removed from the project site or LSA.

5. All maintenance shall be completed within 24 hours of inspection.

B. Inspection

1. Contractor shall inspect all BMPs daily when work is occurring onsite and anytime 0.5" of rainfall has occurred within 24 hours on non-working days including, but not limited to, weekends, holidays, after hours, and suspension days. Rainfall amounts can be determined by contacting the National Weather Service.

2. Deficiencies identified during inspection shall be corrected within 24 hours or as directed by the Engineer.

3.12 SUBCONTRACTOR ACKNOWLEDGEMENT

A. The requirements of the Pollution Prevention Plan are the responsibility of the Contractor and compliance must be communicated at all tiers of the Contract. The Contractor must provide a written acknowledgement from all subcontractors that they have read, understand, and will comply with the requirements of the Pollution Prevention Plan. This written acknowledgement must be included in the Pollution Prevention Plan as part of the preconstruction submittal. The subcontractor acknowledgement section of the Pollution Prevention Plan must be updated as needed throughout the life of the Contract.

3.13 EDUCATION

A. The Contractor shall provide narrative in the Pollution Prevention Plan on how they will educate all personnel including subcontractors. At a minimum, the Contractor shall train staff through regularly scheduled meetings to discuss environmental protection subjects as related to this project. This may be added to any existing weekly meetings (such as safety meetings). Training content shall emphasize identifying Pollution Prevention team members, pollutant sources, sensitive areas, emergency response, spill prevention and inspections. Keep minutes of the meetings detailing attendees and subjects discussed. Submit the minutes to the Engineer monthly.

PART 4 MEASUREMENT AND PAYMENT

4.01 GENERAL

Based upon unit cost Bid Item "Pollution Prevention Planning and Execution", payments will be made as follows:

A. Upon receipt of the Pollution Prevention Plan 25%

B. After NTP and before Substantial Completion, 50% will be pro-rated and paid monthly for compliance with the Pollution Prevention Plan. Non-compliance will result in withholding of payment for the month of non-compliance.

C. After Substantial Completion, 25% for completion of work onsite.

[OR]

A. No separate measurement or payment will be made for the work required by this Section. The cost for this portion of the Work will be considered incidental to, and included in, the payments made for the applicable bid items in the [Schedule of Unit Prices] or [Lump Sum price] bid for the Project.

End of Section

READ THIS FIRST

This Project Spec Document may need additional modifications to suit your project. It is recommended that you proofread each section, paying attention to any "Notes" boxes such as this one--you should remove these "Notes" sections as you go. Also, do a search for all bracket characters " [ ] " as they are used to show you areas containing options or project specific details (you can use Microsoft Word's Find feature {Ctrl-F} to jump to an open bracket " [" character quickly). Again, these bracket characters should be removed.

It is important that every paragraph be numbered to allow for easy referencing. If you use the document's built in styles and formatting your outline should be fine (turn on the formatting toolbar by going to View > Toolbars > Formatting). Most paragraphs will use the style "Numbered Material" and can be promoted (Tab) or demoted (Shift-Tab).

You should not have to manually enter extra spaces, carriage returns or outline characters such as A, B, C, or 1.01, 1.02; the formatting will do this for you. The entire document is 11 pt. Arial. If you paste items in, you may need to reapply the "Numbered Material" format.

Changes to this specification shall be approved by the Erosion Control / Stormwater Engineer.

This specification is for all Port of Seattle construction including Seaport and Airport projects. Designer to verify with Seaport Environmental or Aviation Environmental groups if there are additional environmental permit requirements.

The Design Engineer shall modify this specification to address project specific needs.

PART 1 GENERAL

1.01 SUMMARY OF WORK

A. This item shall consist of the management of all construction water including collection, conveyance and treatment of onsite stormwater and groundwater, diversion of offsite water away from the project sites, and collection and offsite disposal of process water.

B. The Contractor shall be solely responsible for design, installation, operation and maintenance of all collection, conveyance and treatment systems and shall modify as needed to meet the requirements of this Section. The Contractor shall take full responsibility for fines imposed due to exceeding the discharge limits.

C. The minimum treatment system effluent performance requirements shall include oil/water separation, turbidity reduction, solids removal and pH treatment as required to meet the minimum effluent performance requirements listed in this Section.

D. Any treatment system used shall be approved for use by the Washington State Department of Ecology (Ecology).

E. All components of the construction water management system shall meet the requirements of the Ecology Chemical Treatment Assessment Protocol (CTAPE) and the Stormwater Management Manual for Western Washington (SWMM). At a minimum, the following shall apply:

A. BMP C250 Construction Stormwater Chemical Treatment

B. BMP C251 Construction Stormwater Filtration

C. BMP C252 High pH Neutralization Using CO2

D. BMP C253 pH Controls for High pH Water

1.02 DESCRIPTION OF WORK

A. In order to comply with the requirements of this section, the Contractor shall:

1. Develop and submit a Construction Water Management Plan (CWMP).
2. Install temporary structures, modifications, sumps, piping, by-passes, connections, and pumps to contain and convey stormwater to the treatment facility prior to treatment.
3. Provide any pre-treatment of water using oil/water separation, pH adjustment, or other approved methods as required prior to treatment.
4. Treat stormwater with an approved, Contractor-designed, furnished and installed, Construction Water Treatment and Monitoring System.
5. The operating treatment capacity shall be as specified on the drawings.
6. Discharge all treated water at the location shown on the drawings or as directed by the Engineer.
7. Perform all required monitoring, testing and recordkeeping.
8. Remove all temporary system components and restore the Port's stormwater facilities to their original condition.
9. Clean all Port storm conveyances, structures, vaults and facilities to the satisfaction of the Engineer.

1.03 SUBMITTALS

A. As part of the required Section 01 32 19 - Preconstruction Submittals, the Contractor shall submit the following:

1. Construction Water Management Plan.

1.04 PERMITS

Permit #s below are for Airport projects. Coordinate with PM and POS ENV – add/edit/delete as applicable.

A. Work shall be conducted in accordance with [STIA] NPDES permit number [WA-002465-1].

B. Work shall be conducted in accordance with Stormwater Pollution Prevention Plan, as required by the [STIA] NPDES permit number [WA-002465-1].

PART 2 PRODUCTS

2.01 PRIMARY WATER TREATMENT EQUIPMENT

A. The Contractor shall be solely responsible for the water treatment system design, operation, and maintenance, including full responsibility for fines imposed due to exceeding the discharge effluent limits.

B. The Contractor shall provide a water treatment and monitoring system with the treatment and storage capacity to manage stormwater without causing construction delays.

C. Contractor shall keep on hand, or have immediate access to, spare equipment and/or materials for any breakdown(s).

D. The materials and equipment used for the water treatment system shall be no older than 3 years and suitable for the Work and be maintained in good condition.

E. Contractor shall provide and maintain at all times an ultrasonic totalizing flow meter to record effluent discharge. The flow meter shall display instantaneous flow and record cumulative flow. The Engineer reserves the right to install a redundant flow meter in series with the Contractor meter.

F. Contractor shall choose the type and size of equipment and components needed to accomplish the functions designated.

G. Contractor shall construct the treatment system with sampling ports and the necessary valves as required to collect water treatment samples.

H. The Contractor shall maintain dedicated redundant pumps at the treatment facility to provide immediate back-up pumping capacity at the designed treatment and discharge rates.

2.02 WATER TREATMENT SYSTEM CONTROL

A. Unattended treatment plant operation shall not occur.

B. The Contractor shall provide a notification system to alert the Operator if system experiences conditions that will potentially cause the treatment system to shut down.

C. Contractor shall provide high-level alarms on the tanks to prevent overflow conditions. Alarms may cause automatic actions to relieve the condition or may warn the Operator. Contractor shall also set a dedicated overflow level alarm at an elevation as directed by Engineer and notify Port immediately when the alarm is activated.

D. Contractor shall design the control system to accomplish the functions designated. The control system is subject to review and approval by the Engineer.

E. If an upset condition occurs which may result in a release or non-conformance with the discharge requirements, Contractor shall immediately suspend operation and notify the Engineer.

2.03 STORMWATER STORAGE TANK

A. Storage tanks shall consist of a weir tank with a capacity adequate to contain the volume determined in the Contractor’s analysis. The Port reserves the right to limit the maximum height for tanks and the available location for tank placement. Coordinate with the Engineer for tank placement.

2.04 PUMPING

A. The Contractor is responsible for all pumping and shall identify structures utilized as sumps for pumping locations. These shall be augmented with other on-site pumps utilized for collection of standing water and continuous dewatering of excavations.

B. Pumps shall be sized to provide the minimum conveyance capacity as determined in treatment facility sizing calculations.

2.05 TEMPORARY PIPING

A. Temporary above ground piping shall be PVC/Woven Synthetic Fibers, EPDM, Ductile Iron, or HDPE Pressure Pipe meeting AWWA C901/C906.

B. All above ground piping and fittings shall be sized and pressure rated for their application, water tight, free of leaks or tears, and maintained in working condition.

<u>PART 3 EXECUTION</u>

3.01 GENERAL

A. Design and modifications to conveyances, pumps, sumps, detention facilities and any hydraulic calculations necessary for implementation of this Section shall be stamped by a Professional Engineer licensed in the State of Washington.

B. Damage to any portion of the Construction Water Management System caused by Contractor operations, weather or negligence shall be repaired immediately at sole cost to the Contractor.

C. The system shall be designed to handle the specified maximum peak influent flow rates, treat the water to the minimum specified effluent performance criteria, and discharge the treated water at the specified maximum peak effluent flow rates determined in the treatment sizing calculations.

D. The Contractor shall install elevation gauges in detention facilities.

E. The Contractor shall initiate treatment system operation and pumping immediately after 0.1 inches of rainfall has fallen in the previous 24 hours unless otherwise approved by the Engineer.

F. All system components that require fueling shall be maintained with a minimum of 50% fuel in their tanks.

G. Contractor shall provide all utilities and power required for treatment and water management activities.

3.02 CONSTRUCTION WATER MANAGEMENT PLAN (CWMP)

A. The Contractor shall prepare a CWMP that describes and includes the management of construction stormwater and non-construction stormwater. The plan shall include procedure outlines for start-up, normal operations, process monitoring sampling and analysis, monitoring and control of residual flocculent, control philosophy, alarm conditions and responses, freeze protection, normal shutdown, and decommissioning.

B. This plan shall describe the management of construction stormwater and by what means non-construction stormwater is segregated from the project site. This consists of planning/phasing, installing, onsite collection, conveyance, plugs, pumps, treatment as required, discharge of water and/or collection, infiltration, and disposal of all construction water collected or related to construction activities or as ordered by the Engineer to prevent pollution of water, and control, respond to, and manage turbid water and pH during the life of the Contract.

C. In addition, the CWMP shall include and address, at a minimum, the following:

1. Site Description and Site Drawings
    a. Provide a detailed project description including phasing and schedule for major work activities.
2. Construction Water Management Description and Drawings
    a. Contractor shall provide sufficient detail to show that all site water is managed per the requirements of this Section and to the satisfaction of the Engineer.
    b. Installation layout drawing for treatment systems.
3. Design Calculations
    a. Contractor shall provide product information and/or supporting calculations indicating that their selected pumps and hoses will meet the pump conveyance requirements.
    b. Contractor shall provide calculations demonstrating that their Construction Water Treatment System can meet or exceed the minimum specified operating capacity.
    c. Contractor shall provide design calculations for any additional conveyance utilized in their Construction Water Management Plan or that represent a change to Construction Water Management approach.
    d. All Contractor calculations shall be approved and stamped by a Professional Engineer licensed in the State of Washington.
4. CTAPE Documentation
    a. CTAPE documentation shall meet Department of Ecology requirements.
5. Treatment System Operations Manual
    a. The treatment system operations manual shall meet Department of Ecology requirements, remain onsite and be submitted to the Engineer.
6. Construction Water Management Personnel
    a. Treatment systems shall only be operated by Constructing Water Treatment Operators (Operators) trained and certified by Ecology requirements.
    b. Operators shall have no other duties other than those specified in this section and shall be onsite at all times the system is operating.
    c. Operators shall have a minimum of three (3) years full time documented experience operating Ecology-approved treatment systems.

d. Operators shall be Ecology-certified and current Contractor Erosion and Sediment Control Leads (CESCL).

e. Contractor shall submit resumes and certification documentation.

3.03 EFFLUENT DISCHARGE PERFORMANCE CRITERIA

A. All discharge from the project site shall be treated to meet the minimum effluent performance criteria for oil/water separation, pH, and turbidity as described in Table 1 of this Section.

Measurement Parameter for Treated Water (flow-through)	Monitoring Location	Frequency of Sampling Flow Through Treatment	Frequency of Sampling Batch Treatment	Minimum Performance Criteria
Turbidity	Pre-treatment in detention facility	Every 15 minutes	1 per batch	<500 NTU
Turbidity	Post-treatment Effluent	Every 15 minutes[1]	1 per batch	5 NTU Maximum daily average[2]
pH	Post-treatment Effluent	Every 15 minutes[1]	1 per batch	6.5-8.5
Total Petroleum Hydrocarbon	Detention Facility	4 times per operating day	1 per batch	No visual Sheen. If visual sheen then 5 mg/L.[3]
Flow	Post-treatment Effluent	Every 15 minutes[1]	1 per batch	Report, including maximum discharge rate

TABLE 1- EFFLUENT DISCHARGE PERFORMANCE CRITERIA

3.04 SAMPLING AND CHEMICAL ANALYSIS

A. Sampling and laboratory analysis of effluent discharges shall be performed by the Contractor per Table 1 in this Section.

B. The Contractor shall be responsible for all additional sampling and analysis necessary to monitor system performance and verify compliance with this Section.

C. Residual flocculent testing shall be completed daily

3.05 RECORDKEEPING

A. Daily treatment logs shall be submitted to the Engineer as part of the Contractor Daily Report.

B. At a minimum, the daily treatment logs shall include:

1. CTAPE reporting and record keeping requirements
2. Cumulative inflow volumes using ultrasonic totalizing meter
3. Cumulative discharge volumes using ultrasonic totalizing meter
4. Total hours of system operation
5. Total hours of discharge
6. System maintenance items
7. Test data as specified in this Section
8. Documentation of analysis conducted in Section 3.03

C. The Contractor shall submit a monthly summary report to the Engineer by the 7th of each month. The report shall summarize the following results for the previous month:

1. Minimum and maximum average daily turbidity
2. Minimum and maximum pH
3. Visual sheen and any required test results for TPH.
4. Minimum, maximum and average daily flow
5. Total monthly flow
6. Residual flocculent test results.
7. Electronic format of all records.

D. Reports of non-conformances or upset conditions including releases shall be documented in the Contractor Daily Report.

E. Reports of changes in system configuration or operation due to changing conditions shall be documented in the Contractor Daily Report.

F. All records shall be kept in hard copy and electronic format suitable to the Engineer.

3.06 SYSTEM REMOVAL AND CLEANING

A. The Contractor shall clean, flush, jet and vactor out all sediment accumulated in Port conveyances including, but not limited to, storm pipes, manholes, vaults, ponds and ditches. The cleaning operation shall not flush sediment laden water or debris into the active downstream storm system.

3.07 EMERGENCY RESPONSE

A. The Contractor shall be available 24 hours per day, seven days per week to respond to system emergencies.

B. The Contractor shall respond to system emergencies within one hour of notification by the Engineer.

3.08 DISPOSAL OF OTHER RESIDUALS

A. Contractor shall manage oil and sediment/sludge produced by the treatment system for disposal with excavated soil ensuring that they meet all transportation laws and regulations and the receiving landfill requirements.

B. Contractor shall manage any spent filtration media with excavated soil

3.09 STORMWATER STORAGE

A. It is the responsibility of the Contractor to verify the adequacy of the existing, specified facilities for use with their proposed water treatment system. The Contractor shall supplement the storage of the existing facilities as required with stormwater storage tanks.

B. The Contractor shall install additional stormwater storage tanks, within the allowable stormwater storage and treatment area as required.

C. The Contractor is responsible for conveying construction stormwater within each work area to the specified stormwater storage and treatment area.

D. Temporary piping, structures and pump facilities required for the conveyance are the responsibility of the Contractor.

E. The construction stormwater shall be held in the specified storage until treated, hauled and disposed of by the Contractor.

F. Contractor furnished storage and treatment facilities including pads, access roads, ramps, temporary structures and piping shall be removed at the completion of the work or as directed by the Engineer.

PART 4 MEASUREMENT AND PAYMENT

4.01 GENERAL

Coordinate with Design Engineer and Erosion Control/Stormwater Engineer to estimate the maximum number of gallons that will need to be processed for the specific project. This may also be edited to include an end date for the LS and/or a Force Account for additional gallons.

A. Measurement and Payment for “Construction Water Management System” will be made at the contract lump sum price as stated in the Schedule of Unit Prices and shall be full compensation for furnishing all labor, hardware, equipment, materials, consumables, rentals, and tools to implement and maintain the CWMP to manage up to [____] gallons of water. It includes implementation of temporary stormwater conveyances, storage systems, truckin, discharging, sampling, documentation, and other measures as specified herein through the duration of the Contract, with the exception of those items measured and paid for separately. Payments will be made as follows:

Payment percentages may be adjusted (ie 20/60/20) to reflect specific project.

1. Upon receipt of the Construction Water Management Plan 25%
2. After NTP and before Substantial Completion, 50% will be pro rated and paid monthly for compliance with the CWMP. Non-compliance will result in withholding of payment for the month of non-compliance.

3. After Substantial Completion, 25% for completion.

[OR]

A. No separate measurement or payment will be made for the work required by this Section. The cost for this portion of the Work will be considered incidental to, and included in the payments made for the applicable bid items in the Lump Sum price bid for the Project.

End of Section

Aspect consulting
IN-DEPTH PERSPECTIVE

SEATTLE-TACOMA INTERNATIONAL AIRPORT

Phase 1 Groundwater Study Report

Prepared for: Port of Seattle

Project No. 970016-005-06 • July 25, 2008 Final

Aspect consulting
earth+water

SEATTLE-TACOMA INTERNATIONAL AIRPORT

Phase 1 Groundwater Study Report

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State of Washington
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List of Abbreviations and Acronyms

AAL	Alaska Air Lines
AFS	Aircraft Fueling System
AOMA	Aircraft Operations and Maintenance Area
ASR	Aquifer Storage and Recovery
ASTM	American Society for Testing and Materials
bgs	below ground surface
BTEX	benzene, toluene, ethylbenzene, xylenes
CAD	computer-aided design
cfs	cubic feet per second
COC	contaminant of concern
cm	centimeters
cm/sec	centimeters per second (= 2,835 ft/day)
1,2-DCA	1,2-dichloroethane
1,1-DCE	1,1-dichloroethylene
DEM	digital elevation model
Ecology	Washington State Department of Ecology
EDD	electronic data deliverable
EMIS	Environmental Management Information System
EIS	Environmental Impact Statement
FAA	Federal Aviation Administration
ft	feet
ft/day	feet per day (= 3.527 $\times 10^{-4}$ cm/sec)
GIS	geographic information system
gpd	gallons per day
gpd/ft	gallons per day per foot
gpm	gallons per minute
gpm/ft	gallons per minute per foot (of drawdown)

GWS	Phase I Groundwater Study Report
in	inches
IWS	Industrial Waste System
KCWD	King County Water District
LRSF	Lake Reba Stormwater Management Facility
ma	million years ago
mg/kg	milligrams per kilogram
mg/L	milligrams per liter
mgal	million gallons
mgal/yr	million gallons per year
min	minutes
MS	Microsoft, Inc.
MTCA	Model Toxics Control Act
NFA	No Further Action
NCDC	National Climatic Data Center
NGVD	National Geodetic Vertical Datum
NOAA	National Oceanic and Atmospheric Administration
NWA	Northwest Airlines
NWP	Northwest Ponds
OPL	Olympic Pipeline Company
PAH	Poly-aromatic hydrocarbon
PHC	Petroleum Hydrocarbons
Port or POS	Port of Seattle
ppb	parts per billion
QA/QC	Quality assurance/quality control
Qva	Quaternary Vashon advance glacial outwash
Qvr	Quaternary Vashon recessional glacial outwash
RFI	Request For Information
RMS	root mean square
STEP	South Terminal Expansion Project

STIA	Seattle-Tacoma International Airport
SUL	subsurface utility line
SVOC	semivolatile organic compound
TPH	total petroleum hydrocarbons
TPH-D	total petroleum hydrocarbons as diesel
TPH-G	total petroleum hydrocarbons as gasoline
TPH-O	total petroleum hydrocarbons as heavy oil
TRACON	Terminal Radar Approach Control
USGS	United States Geological Survey
UST	underground storage tank
VOC	volatile organic compound
WAC	Washington Administrative Code
ybp	years before present
USC	United States Code
µg/L	micrograms per liter

Site Acronyms

Agreed Order Sites

BDGLP	Budget Auto Facility
CONHS	Continental Airlines Hydrant System Closure
DELAG	Delta Air Lines Autogas Cluster Tanks
DELFF	Delta Air Lines Fuel Farm
GATB2	Gate B-2 Site
NWBFF	Northwest Airlines Bulk Fuel Farm
NWFHT	Northwest Airlines Former Hangar Tanks
NWHS2	Northwest Airlines Hydrant System Closure (also known as NWA Hydrant System [1997] and NWA Hydrant System Closed; includes South Satellite Baggage Tunnel)
PAFAT	Pan Am Former Avgas Tanks
PAFFF	Pan Am Former Fuel Farm
RACFT	RAC Auto Facility Former Tank

UNFUF/CONFF	United Air Lines Fuel Farm/Continental Airlines Fuel Farm

Other Sites

QTA	QTA Tank Site

Potential Sites

P1	Former Maintenance and Paint Shop
P2	Former Gas Station
P3	Former Lagoon Area
P4	Possible Refueler Tank
P5	Abandoned Hydrant Line
P6	Possible Concourse A Area Fuel Tank
P7	Possible Parking Garage Fuel Tanks
P8	Former Gas Station
P9	Possible Transformer Room Fuel Tank
P10	Abandoned Hydrant Line
P11	Former Maintenance Hangar Tank Area
P12	Possible Air Cargo Area Tanks
P13	Abandoned Hydrant Line (also known as NWA Hydrant System [1976] or NWA Hydrant System Abandoned)

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1 Executive Summary

This report describes an investigation of groundwater aquifers and contaminant migration in the vicinity of Seattle-Tacoma International Airport (STIA) referred to as the STIA Groundwater Study. The study was performed to meet the requirements of an Agreed Order between Washington State Department of Ecology (Ecology) and the Port of Seattle (Port). The report was prepared by Aspect Consulting, LLC in association with S.S. Papadopulos & Associates, Inc. for the Port. S.S. Papadopulos & Associates, Inc. constructed the numerical groundwater model and performed the contaminant fate and transport analyses as a subcontractor to Aspect Consulting, LLC. Port of Seattle Aviation Environmental Programs provided the Fuel Systems Pollution Prevention Report which documents the assessment of fuel storage and distribution systems at STIA.

1.1 Purpose and Scope of Work

Ecology and the Port entered into Model Toxics Control Act (MTCA) Agreed Order #97TC-N122 on May 25, 1999 (Department of Ecology, 1999). Under the Agreed Order, Ecology and the Port agreed that the Port would undertake a study to evaluate specific groundwater conditions in the STIA vicinity.

The principal purposes of the study, as described in the Agreed Order, were:

- To determine whether historical airport operations in the Aircraft Operations and Maintenance Area (AOMA) had significantly impacted the uppermost regional (Qva) aquifer;
- To confirm groundwater flow direction in the Qva aquifer; and
- To provide a more comprehensive understanding of the fate and transport of contaminants originating within the AOMA.

With respect to contamination fate and transport, the study results would identify the potential risk of contamination of groundwater at specific “potential local receptors”: the public drinking water supplies at the City of Seattle Highline Well Field, the Highline Water District Angle Lake, Des Moines and Tyee wells, and King County Water District 54 wellfield; publicly recorded and operational private drinking water wells; and Bow Lake, Des Moines Creek, and Miller Creek.

In order to accomplish the above listed purposes, the Port and Ecology agreed that the Port would undertake the following work:

- Compilation of hydrogeological and environmental data (Agreed Order Task IV.1),
- Monitoring of Qva groundwater levels (Agreed Order Task IV.2),
- Development and evaluation of a numerical model for groundwater flow and contaminant fate and transport analysis (Agreed Order Tasks IV.3 and IV.4),

- Preparation of STIA Groundwater Study Phase I Report (Agreed Order Task IV.5), and
- Assessment of and report on the STIA fuel storage and distribution systems (Agreed Order Tasks IV.6 and IV.7).

Most of the drinking water supply wells named as “potential local receptors” were completed in aquifers below the uppermost Qva aquifer. Evaluation of risk to those potential receptors therefore required an assessment of the hydrogeology of the deeper aquifer systems.

The main study tasks included the following elements:

- Geological interpretations
- Hydrogeological data synthesis
- Assembly of contaminant testing data
- Database development
- Groundwater modeling
- Contaminant fate and transport modeling

The geological interpretations, numerical modeling, and contaminant analysis represent practical simplifications of a very complex hydrogeological environment.

1.2 Study Area

The study area covers about 42 square miles and is approximately coincident with the Des Moines Quadrangle (USGS, 1949). The area of investigation is located between Puget Sound (to the west) and the Duwamish/Green River valley (to the east) and between South 116th Street (on the north) and a line running east from Saltwater State Park (on the south). The study area includes the Des Moines Drift Upland, a topographic high at elevations from 300 to 500 feet. The central area of the upland is drained by four primary creek systems: Miller Creek/Walker Creek, Des Moines Creek, Barnes Creek/Massey Creek, and Gilliam Creek.

The study area is a heavily populated portion of southwestern King County. The area is dominated by residential use, but includes significant commercial and industrial uses. STIA, built in 1942 and expanded since then, represents about 11 percent of the total area. The climate is temperate, with mild winters and cool dry summers. Annual precipitation averages about 38 inches per year.

1.3 Data Management Plan and Database Development

Within the framework of an overall Data Management Plan, the Port developed an Environmental Management Information System (EMIS) to process and store all hydrogeological and environmental data used in the Groundwater Study. The primary storage system in EMIS is a relational database that links each datum to a “system location code” that is uniquely assigned to each well, boring, or “point data”. The database was populated with information from existing geologic and hydrogeologic studies, environmental reports, public records of well logs, and data from public water supply systems. Data from new and continuing STIA projects are added to the EMIS database according to workflow procedures of the Data Management Plan.

1.4 Geology

A part of the southern Puget Sound Lowland, the study area consists of glacial and non-glacial deposits overlying volcanic and sedimentary bedrock. The latter is exposed in the northeast portion of the study area. The contemporary surface morphology was defined by the most recent glacial processes (Vashon glacial advance) and subsequent erosion and deposition.

Subsurface geological conditions were assessed by a review of all available drilling and boring logs with reference to the most recent geological surface mapping. Soils were classified by geologic units and by hydrostratigraphic units. Interpretations were entered into the EMIS database for individual soil borings or well records. The system of hydrostratigraphic units defines a geologic unit as either an aquifer or aquitard. In this study, 14 hydrostratigraphic units were identified above the bedrock. The large number of units reflects the complexity of the geological depositions and represents a significant refinement in the degree of hydrogeologic interpretation in comparison to previous work conducted within the study area.

Eight cross sections of the subsurface geology were prepared for the study area and an additional ten cross sections were constructed that focus on the STIA area.

1.5 Hydrogeology

Available groundwater data have been collected and entered into the Port's EMIS database. These data include well locations, drilling logs, construction details, groundwater elevations, well test results, hydraulic parameters, hydrostratigraphic interpretations, and groundwater quality test results.

Groundwater in the study area includes perched groundwater and regional aquifers. Perched groundwater is found in isolated, laterally discontinuous zones near the surface (e.g., in the upper 50 feet) in otherwise unsaturated soils. This study focused on the regional aquifers, especially the uppermost aquifer in the Vashon glacial advance outwash sediments (Qva, or C1). The Qva aquifer is interpreted to be primarily unconfined, although water levels indicate that the unit is confined in some areas (e.g., Angle Lake). The lower aquifer units are generally confined, with those above sea level (C2 and C3) being exposed at seepage faces along either creek drainages or edges of the upland.

Recharge of the upper aquifers appears to be entirely from precipitation. The lower aquifers may also be recharged by lateral flow from outside the study area, but that possibility cannot be determined from the existing data. The major withdrawals of groundwater from operating public water supply wells were tabulated and those data used in the numerical groundwater flow model. Pumping withdrawals from two irrigation wells located in close proximity to STIA were also included in the modeling effort.

Groundwater elevation contours were created for the upper three aquifers (C1, C2, and C3) based on empirical data. Water levels exhibit a seasonal sensitivity to precipitation. Groundwater flow in all three aquifers appears to be primarily west to Puget Sound and east to the Duwamish/Green Rivers. The flow directions for the C1 and C2 aquifers are locally modified by creek drainages. Within the AOMA, groundwater flow is primarily from east to west. At the south end of the AOMA, the Qva flow direction turns to the south toward Des Moines Creek. Groundwater flow directions for the lowest three aquifers are uncertain due to the small number of wells completed in these aquifer units.

Hydraulic parameter and test data were compiled from existing records and reports. Wherever possible, new calculations for hydraulic parameters were made from well test data. The resulting soil permeability (hydraulic conductivity) data were correlated with aquifer unit. These permeability values were used in developing the numerical groundwater flow model.

1.6 Contamination Sources and Risk Evaluation Criteria

The Agreed Order listed thirteen sites within the AOMA that are known to have impacted groundwater in the Qva aquifer or to have significant soil contamination. Based on a review of historical records, the Port developed a list of an additional thirteen potential sites. One site with recently identified contamination was also added. The history and current status of the sites are discussed in Section 6.

These 27 sites were evaluated for inclusion in the contaminant fate and transport analysis. Six of the Agreed Order sites were rejected for analysis based on the lack of or low frequency of contaminant detection in Qva groundwater. Eight of the potential sites were excluded from further consideration due to observations and data finding “no significant impact” or “minor soil contamination”, during recent STIA construction projects. Contaminant fate and transport analyses were conducted for seven Agreed Order, one recently identified, and three potential sites. Evaluation of the remaining two potential sites relied on modeling data from nearby sites.

Appropriate indicator contaminants of concern (COCs) were identified for each site. Since the sites contain a number of COCs, fate and transport modeling was focused on selected contaminants. Consistent with MTCA, the study eliminated from consideration those substances that contribute a small percentage to the overall risk, i.e., chemicals that exhibit relatively low toxicity, fast degradation, low mobility, low detection frequencies at low concentrations, and lack of hazardous degradation by-products. A risk evaluation then assessed the remaining COCs for relative mobility in the soil/groundwater matrix, rate of degradation in the groundwater environment, and level of toxicity. The indicator COC for each site was the chemical judged to be overall the most mobile, stable, and toxic.

Naphthalene was selected as the indicator COC for sites with elevated levels of total petroleum hydrocarbons in the diesel or Jet A fuel range (TPH-D or TPH-Jet). Two Agreed Order sites and three potential sites fall into this category. For the two sites with total petroleum hydrocarbon contamination that is predominately in the gasoline range (TPH-G), benzene was used as the indicator chemical. Two potential sites located down gradient from the model benzene sources were assessed by comparison to the benzene results. For sites with solvent contamination, 1,1-dichloroethylene (DCE) was used for two sites and 1,2-dichloroethane (DCA) for the third site.

1.7 Groundwater Flow Model and Contaminant Fate and Transport Simulation

Steady state groundwater flow in the study area was modeled using the industry standard United States Geological Survey (USGS) MODFLOW program supplement with specialized RIVER and DRAIN packages.

The model consists of ten active layers (hydrostratigraphic units C1 through F6) plus inactive layers at top and bottom. The top inactive layer accounts for the unsaturated thickness of fill, Vashon recessional outwash, and Vashon till deposits that overlay the C1 (Qva) regional aquifer unit. The bottom inactive layer provides either a no-flow boundary condition (where the F6 layer sits directly on bedrock) or a constant head boundary (where the F6 layer is separated from bedrock by additional sediments).

The north and south limits of the model are defined as no-flow boundaries. On the east and west, the model units are bounded by seepages faces above sea level or river bottom and by constant head conditions below those levels. Recharge of groundwater, for model input, is entirely from precipitation. Horizontal hydraulic conductivity values for the different hydrostratigraphic units were determined from the compilation of existing hydraulic parameter and well test data.

The model was calibrated by adjusting hydraulic parameter and boundary condition values in order to provide acceptable comparison with water level data and with base flows in Miller and Des Moines Creek. The root mean square (RMS) error for water levels in the C1 and C2 hydrostratigraphic units was less than 15 percent and for the C3 unit less than 20 percent. Although a 10 percent error is desirable, the model was limited by the use of data collected over a period of 40 years and by data that, especially for deeper aquifers, were acquired prior to significant pumping of the aquifers.

The numerical model was found to be only moderately sensitive to most parameters, with the exception of vertical hydraulic conductivity values for the aquitard layers. In deeper units, the model was also sensitive to constant head values on the east boundary. Lower values of hydraulic conductivity were required in those cells adjacent to the constant head boundaries; the low values represent resistance to flow by fine grain sediments that cover the faces of aquifer units under Puget Sound and below the Duwamish/Green River valley. Local variations in water levels were achieved by varying conductance in DRAIN and RIVER cells and hydraulic conductivity values in cells adjacent to constant head boundaries. Groundwater elevation contour maps from the flow model output were developed for the C1, C2, and C3 aquifers.

1.8 Contaminant Fate and Transport Simulation

Contaminant fate and transport were simulated with the MT3D99 program. The movement and concentration of contaminants are modeled by the advection-dispersion equation in conjunction with formulas that estimate adsorption onto soil particles and degradation in groundwater. Advection (contaminant movement with flow) is controlled by flow velocity (from the flow model). Dispersion (spreading of the chemical due to small scale variations in velocity) is determined by the dispersivity factors. Adsorption is characterized by organic carbon–water partitioning coefficients and degradation by a chemical's half life. The advection, dispersion, adsorption, and degradation processes eventually come into balance and define the maximum extent of a plume for a specified concentration. The extent of a plume is determined primarily by the degradation rate, while other parameters affect the time required for a plume to develop.

Ten sites were selected for simulation (Table 7-5). A contaminant source concentration and location was determined for each site. Simulations were run for each indicator COC (benzene, 1,1-dicholorethylene, 1,2-dichloroethane, and naphthalene). The benzene and 1,1-dichloroethylene plumes were calibrated by concentrations observed in down gradient wells. The results are presented as concentration contours, which include the MTCA Method B and Method C Groundwater Cleanup Levels. The predicted 30-year contaminant plumes, which are considered fully developed, are presented in Figures 7-20 and 7-21 and discussed briefly below:

- The benzene plume shows a high degree of spreading with co-mingling of plumes from three sites. Peer review of the model suggested that the spreading may be a modeling artifact resulting from numerical dispersion. Further analysis applied an analytical solution to the groundwater flow model's curved flow path. That analysis yielded much narrower plumes.
- The 1,1-dichloroethylene and 1,2-dichlorethane plumes both exhibit long, narrow configurations consistent with a long half life (low degradation rate).
- The simulation for naphthalene shows short plumes that are consistent with a relatively fast degradation rate and high adsorption coefficient.

1.9 Modeling Results and Discussion

A water budget of inflows and outflows in the groundwater flow model was constructed. Calculated stream flows agreed favorably with observed low flows in Miller and Des Moines Creeks.

The groundwater flow model indicates that flows in the AOMA are predominately westerly. Where the F2 aquitard unit is absent (a significant portion of the AOMA and STIA areas), the C1 and C2 aquifers are in contact. The F3 unit appears to be largely continuous and 25 to 100 feet in thickness, thus inhibiting groundwater flow and any contaminant movement into the C3 aquifer.

The modeling analysis, with conservatively slow degradation (long half lives) of COCs, indicate that concentrations above MTCA Method B Groundwater Cleanup Levels do not impact local receptors, nor extend beyond the AOMA. Additional findings include:

- Model results for benzene suggest that the plume could reach wells along Concourse D. Since benzene has not been detected in this area, the benzene plume may be smaller than predicted.
- A slower, and more conservative, degradation rate was used for 1,1-dichloroethylene in order to match observed concentrations. The longer half life may indicate that the

aquifer is aerobic, as 1,1-dichloroethylene degrades more slowly under aerobic conditions.

- The source area for 1,2-dichloroethane was defined by a single well surrounded by wells where the chemical was not detected. Consequently, the source area and the resulting plume for this compound may be smaller than represented in the model.
- The naphthalene plumes are comparatively small due to the limits imposed by relatively high adsorption and fast degradation. The predicted small plume sizes are supported by low concentrations in wells down gradient of two source areas.

In the event Ecology determines that additional monitoring is to be preformed to confirm model results, the Port would propose to monitor individual plumes, rather than the AOMA as a whole. In this approach, the wells would not serve as compliance wells, but would provide verification of the findings of this study. The wells would be sampled in spring and fall for two years. Data inconsistent with model predictions would be evaluated in order to determine risk to potential local receptors, and to inform decisions regarding the necessity or direction of future monitoring.

1.10 Assessment of STIA Fuel Storage and Distribution Systems

The Agreed Order required that the Port and Ecology work together to assess fuel systems and identify and address appropriate pollution prevention activities. Specifically, the Agreed Order required that:

- The Port and Ecology engage ”non-regulated” fuel system owner/operators to identify and implement procedures and equipment that would increase leak prevention and detection capabilities (Agreed Order Task IV.6a),
- Ecology conduct an inspection of regulated underground storage tank (UST) systems at STIA (Agreed Order Task IV.6b),
- The Port create a database for USTs at STIA (Agreed Order Task IV.6c), and
- The Port annually, for a period of five years, request information from all UST owner/operators to identify changes and upgrades and describe leak detection and prevention methods and procedures (Agreed Order Task IV.6d).

The Port’s Aviation Environmental Programs reports that, prior to execution of the Agreed Order, the Port and the airline consortium agreed to construct a state-of-the-art airport-wide aircraft fuel hydrant system (AFS). The AFS is to become operational by mid-2005. As part of this program, the Port purchased the above-ground tank farm and post-storage distribution system of the Olympic Pipeline Company (OPL). The OPL pipelines are being replaced and substantial redesign, modification, and retrofitting of the tank farm is in progress. Four of the five independent fuel systems have terminated operations. The United Air Lines system is scheduled for termination after initiation of the AFS operations. These actions have effectively rendered Task IV.6a moot.

The following actions addressed Tasks IV.6b, c, and d:

- Ecology conducted an inspection of USTs in 2001 and issued a Notice of Correction concerning two tanks. The Port provided a response demonstrating implementation of the required actions.
- The Port developed a UST database as part of the Port's EMIS. This database is updated at least annually.
- From 1999 through 2003, the Port annually requested that owner/operators of USTs provide information requested in the Agreed Order. This information was entered in the UST database.

1.11 Report Structure

The STIA Groundwater Study report is structured as follows:

- **Section 1:** Executive Summary.
- **Section 2:** Presents the legal requirements of the study and details the purposes and the scope of the work.
- **Section 3:** Defines the study area and describes the physiographic, hydrologic, land use, and climatologic features.
- **Section 4:** Gives a full description of the subsurface geology, including explanations of the geologic and hydrostratigraphic units. This section is supplemented by Appendix C.
- **Section 5:** Describes the hydrologic system, conceptually and specifically, and reviews the compilation of hydrogeologic data, the development of groundwater contour elevation maps, and the determinations of hydraulic parameter values.
- **Section 6:** Presents a brief history and current status of the Agreed Order and Potential Sites, explains the selection of sites for contaminant fate and transport analyses, and discusses the choice of indicator contaminants of concern (COC).
- **Section 7:** Describes the numerical groundwater flow model and the contaminant fate and transport simulation, including programs and boundary conditions, hydraulic and soil parameters, and model calibrations. Presents predicted contaminant plumes and discusses contaminant source values, dispersion factors, and degradation rates.
- **Section 8:** Discusses the modeling results and proposes a groundwater monitoring network.
- **Section 9:** Provides a listing of references reviewed for the study.
- **Section 10:** Presents a glossary of terms used in the report.
- **Appendix A:** Describes the Port's Data Management Plan, the Environmental Management Information System (EMIS), and database development.
- **Appendix B:** Presents the Port's Fuel Systems Pollution Prevention Report.
- **Appendix C:** Provides additional detail on the geology and hydrostratigraphy of the study area.

- **Appendix D:** Summarizes hydrogeologic data from wells and borings compiled for the study.
- **Appendix E:** Summarizes hydraulic testing data conducted in groundwater wells
- **Appendix F:** Describes the methodology for the analysis of hydraulic parameters
- **Appendix G:** Presents the Contaminant of Concern supporting data and describes the computation of naphthalene concentration from TPH data.
- **Appendix H:** Documents the peer review of the modeling procedures and results.

2 Introduction

The Washington State Department of Ecology (Ecology) and the Port of Seattle (Port) entered into Model Toxics Control Act (MTCA) Agreed Order #97TC-N122 on May 25, 1999 (Department of Ecology, 1999). Under the Agreed Order, Ecology and the Port agreed that the Port would undertake a study to evaluate specific groundwater conditions in the vicinity of Seattle-Tacoma International Airport (STIA). As expressed in the Agreed Order, the primary scope of the study consisted of:

- Compilation of hydrogeological and environmental data (Agreed Order Task IV.1),
- Monitoring of groundwater levels (Agreed Order Task IV.2),
- Development and evaluation of a numerical model for groundwater flow and contaminant fate and transport analysis (Agreed Order Tasks IV.3 and IV.4),
- Preparation of STIA Groundwater Study Phase I Report (Agreed Order Task IV.5), and
- Assessment of and report on the STIA fuel storage and distribution systems (Agreed Order Tasks IV.6 and IV.7).]

The principal purposes of the study were also described in the Agreed Order:

- To determine whether historical airport operations in the AOMA had significantly impacted the Qva aquifer;
- To confirm the Qva aquifer groundwater flow direction; and
- To provide a more comprehensive understanding of the fate and transport of contaminants originating within the AOMA. The study results would identify the potential risk from identified groundwater contamination to named “potential local receptors” (public drinking water supplies at the City of Seattle Highline Well Field, the Highline Water District Angle Lake and Des Moines wells, and King County Water District 54 wells located south of STIA; publicly recorded and operational private drinking water wells; and Bow Lake, Des Moines Creek, and Miller Creek).

The secondary task of the Agreed Order required Ecology and the Port to cooperatively assess the fuel storage and distribution systems at STIA. Ecology and the Port were to determine whether existing fuel systems pollution prevention activities should be enhanced, and if so, to identify appropriate system modifications if necessary.

2.1 Background

Ecology and the Port entered the Agreed Order after several years of discussion. In 1995, Ecology proposed to the Port that a study be undertaken. Ecology requested Port action that would assist Ecology in addressing concerns expressed to Ecology by members of the public that contamination conditions at STIA were not being appropriately managed, particularly “unknown” contamination. At that time, and since, Ecology acknowledged that the Port (and/or Port tenants as responsible parties) was complying with MTCA with respect to sites where contaminants were known to have been released to the environment. Ecology noted specifically that "*existing information indicates that there does not appear to be significant risk posed by contamination at known MTCA sites at STIA, and the ongoing independent cleanup actions at the sites appear at this time to be adequate*[1]". In addition, Ecology recognized that facility investigations had shown that large areas of the AOMA are uncontaminated.[2]

Nonetheless, Ecology determined that the concerns raised by members of the public about "unknown" contamination at the airport could be addressed by an evaluation of the risk posed by groundwater contamination associated with the STIA AOMA to particular potential receptors.

Ecology and the Port developed a proposed scope of work for a risk evaluation through 1996, and published the resulting Proposed Agreed Order for public comment in spring 1997. Ecology established a 30-day public comment period from May 14 through June 13, 1997. A public meeting was held on May 21, 1997. Extensive public comments were received and resulted in several modifications to the proposed Agreed Order. A Responsiveness Summary was published by Ecology in January 2001. The Port and Ecology executed the Agreed Order on May 25, 1999.

During the period between proposal of the Agreed Order Scope of Work and execution of the Agreed Order, Ecology and the Port agreed that the Port could proceed with certain scoped tasks that were necessary to the study, such as compilation and review of historical and technical data, and development of a database. In anticipation of execution of the Agreed Order, the Port initiated these activities in 1997. The Port's work on the project has proceeded since that time, resulting in, for example, development of a database now containing more than 5,300 data points, production of numerous geological and hydrological maps, etc. The Port has also, since initiation of study work, met with Ecology periodically to provide status updates and to obtain Ecology input. In accordance with the Agreed Order scope of work, and consistent with Ecology instructions and approvals, the Port has submitted ten interim Groundwater Study documents (Table 2-1).

This report compiles the results of the MTCA Agreed Order STIA Groundwater Study, including the review and evaluation of historical records, acquired data, and groundwater flow and fate and transport modeling. The results of the study, as reported here, provide a comprehensive assessment of the risks posed to potential receptors of groundwater associated with, and impacted by operations of the STIA AOMA, consistent with the Agreed Order scope of work.

2.2 Purpose

The purpose of the MTCA Agreed Order STIA Groundwater Study is summarized above and is expressly stated in the text of the Agreed Order. In addition, Ecology provides an expanded discussion of the purpose of the STIA Groundwater Study in the Agreed Order Fact Sheet, and in the Responsiveness Summary (Ecology, 2001). A review of all of these statements and discussions shows clearly that the core purpose of the study is to

[1] Responsiveness Summary (Ecology, 2001) page 13.
[2] Responsiveness Summary (Ecology, 2001) page 12.

identify the risk to potential local receptors posed by the presence of contamination in groundwater in the AOMA of STIA.

The groundwater study tasks conducted under the Agreed Order and described in this report (for example, historical data collection and review, additional data collection, identification of risk parameters, development and execution of groundwater flow and fate and transport models, etc.) were performed with a focus on the ultimate requirement--to evaluate risk. With that in mind, the assumptions, screening factors, and similar study design and evaluation elements were established with a significant degree of conservatism. For example, chemicals of concern selected for fate and transport modeling represent the most toxic and mobile constituents observed at a particular release site. Similarly, the computer modeling was performed, and the model results evaluated, with conservatism appropriate to the assessment of the risk in question and to the purpose of the study.

2.3 Agreed Order Scope of Work

The following section briefly describes the primary scope of work elements required in the Agreed Order for the STIA Groundwater Study, and introduces the Port's performance of each.

2.3.1 Hydrogeological / Environmental Data Compilation

The Agreed Order stipulated that research be conducted to document pertinent information sources to characterize the hydrogeologic and environmental conditions at STIA and the surrounding area. The main purposes of the data compilation effort were to:

- Develop a hydrogeological description and characterization of the aquifer systems beneath STIA and the surrounding area;
- Identify known and potential areas of soil and groundwater contamination within the STIA AOMA and near vicinity and evaluate potential preferred pathways for contaminant transport;
- Develop a database of wells screened across the surface of the Qva aquifer throughout the AOMA and near vicinity (see Section 2.3.2); and,
- Identify any publicly recorded, operational, private drinking water supply wells within one-mile of the AOMA that could potentially be impacted by contaminant sources within the AOMA.

Research was conducted to identify existing hydrogeologic and environmental data for the purpose of constructing a conceptual understanding of the groundwater aquifer systems at STIA and the surrounding area. One focus of data research was the environmental reports that have been completed for 13 sites listed in the Agreed Order: sites within the STIA AOMA that are known to have contaminants of concern present in groundwater and/or to contain significant soil contamination. Publicly recorded logs of wells completed within the study area were obtained from Ecology, Seattle-King County Health Department, King County Department of Natural Resources and the U.S. Geological Survey (USGS). Water supply purveyors (City of Seattle, Highline Water District, Water District 54) were contacted to provide information and technical data regarding their public water supply wells. Regional groundwater, geologic and hydrogeologic studies completed in the study area were obtained. A complete listing of all data sources reviewed for the project is presented in Section 9 of this report.

The Agreed Order required that a database be developed to compile the hydrogeological and environmental data in a usable and understandable format using a computer database system. This task included development of a relational database. The requirement was instrumental in establishment of the Port's Environmental Data Services Program, the primary function of which includes the collection, storage and presentation of the environmental data managed at STIA. Complete details of the data management plan and associated database are presented in Appendix A.

The Port Environmental Data Services Program staff, STIA Environmental Program Managers, and contracted consultants worked closely to effectively incorporate the STIA Groundwater Study requirements into the data management plan. The data management plan identifies sources of data, quality assurance/quality control (QA/QC) check points, data storage location and format, and end users of the data. This plan and the workflow procedures associated with it guided the database design and data collection efforts of the STIA Groundwater Study.

Database Design

The design of the database and establishment of the Environmental Data Services Program augment the Port's enterprise-wide data assets, minimize data redundancy, system maintenance and development costs, maximize data integrity, and provide user friendly data access.

The Port of Seattle Environmental Management Information System (EMIS) database stores the following types of data in a relational format. All data are linked to a geographical location identified by surveyed coordinates in order to facilitate accurate graphical presentation.

- logistical properties (i.e., bore/well data, well construction, survey)
- hydrogeological properties
- water level measurements
- water quality parameters
- laboratory analytical test methods
- laboratory analytical results
- laboratory analytical QA/QC results
- data validation levels and data qualifiers
- field data parameters and collection methods
- source document bibliography

2.3.2 Qva Aquifer Water Level Monitoring

Another primary element of the Agreed Order scope of work required that four quarters of groundwater elevation data be collected from a set of groundwater monitoring wells to evaluate the groundwater flow direction in the Qva aquifer. Ecology and the Port agreed that water level data would be obtained from wells that:

- Were logged and screened in the Qva aquifer.
- Were operational and accessible for the entire September 1999 through June 2000 quarterly water level measurement period.
- Were arrayed to enable development of a representative groundwater contour surface within the AOMA.

Thirteen monitoring wells completed within the AOMA and an additional four wells completed at the northwest area of STIA (near the Third Runway project area) met these criteria and were used for quarterly groundwater level measurements. Six of the monitoring wells were outfitted with pressure transducers that collected water levels at 6 hour intervals for a period of about one year. In addition, quarterly groundwater level measurements were obtained from September 1999 through June 2000 from the selected monitoring well network. Section 5 summarizes the results from this monitoring program.

2.3.3 Groundwater Flow and Contaminant Fate and Transport Model Development

The Agreed Order also required that numerical groundwater flow and contaminant fate and transport models be developed utilizing data obtained from the data compilation effort and water level monitoring activities. The modeling effort would be used to evaluate whether contamination observed at known sites and hypothetical contaminant sources at potential sites could impact the potential local receptors. The primary objectives of the technical modeling effort for the Groundwater Study consisted of the following elements:

- Develop a numerical representation of groundwater flow in the Qva and deeper aquifer systems in the vicinity of STIA;
- Assess potential groundwater transport pathways from known contaminated sites at STIA to downgradient potential local receptors;
- Evaluate contaminant fate and transport in groundwater of the primary contaminants of concern;
- Evaluate the probable impacts to potential local receptors from historic operations with the potential to have had contaminant releases (potential sites), and;
- Support the design of a groundwater monitoring network, as necessary.

To evaluate potential impacts to public water supply wells completed in deep aquifer systems, a multi-layer groundwater flow model was constructed using the computer code MODFLOW developed by the USGS (McDonald and Harbaugh, 1988). The use of MODFLOW has several desirable features which benefit the model objectives of the project, which include:

- Ability to represent three-dimensional steady-state hydrogeologic systems that include a variety of hydrogeologic boundary conditions;
- Ability to accurately incorporate heterogeneous hydrogeologic properties;
- Readily available in the public domain; and
- Verified for this application and well accepted by the groundwater professional community and regulatory agencies.

The numerical computer code MT3D99 developed by S.S. Papadopulos & Associates, Inc. was used to evaluate concentrations of contaminants of concern potentially migrating from known and potential sites at STIA. MT3D99 is an enhancement of the MT3D transport code (Zheng, 1990) and allows for modeling of hydrodynamic dispersion and chemical reactions such as partitioning to aquifer solids and degradation processes. This computer code has been successfully applied at a wide range of contaminated groundwater sites and is widely accepted by regulators and the groundwater consulting and research communities.

Details of the modeling effort are presented in Sections 7 and 8.

2.3.4 STIA Groundwater Study Phase I Report

This report fulfills the requirement to compile and evaluate data from the above tasks (2.3.1, 2.3.2, and 2.3.3).

2.3.5 Fuel Storage and Distribution Systems Assessment

A secondary task of the Agreed Order was an assessment of fuel storage and distribution systems at STIA. This work involved a joint effort between Ecology and the Port to:

- Assess STIA fuel facilities [pipelines, fuel truck filling stations (fuel racks), and underground storage tank (UST) systems] that are deferred or exempt from Washington UST regulations;
- Conduct site inspections of UST systems that are subject to Washington UST regulation; and,
- Develop a database for all UST systems located at STIA.

A report developed by the Port documenting performance and results of the fuel systems assessment is included as Appendix B.

3 Study Area Description

3.1 Introduction

This section provides a brief description of the study area. The study area encompasses approximately 42 square miles in southwestern King County, Washington. The study area boundaries were selected to include the airport and the Potential Local Receptors specified in the Agreed Order (see Section 3.5), and to provide a sufficient basis for defining the sub-surface geological and hydrological characteristics necessary for modeling groundwater flow and contaminant movement.

3.2 Physiographic Description

3.2.1 Location

The study area surrounds STIA and is approximately 9 miles by 7 miles in extent. Major features of the study area are shown in Figure 3-1 and include the airport, highways, surface water bodies and principal public water supply wells. The airport AOMA is indicated, along with ¼-mile and 1-mile buffer zones surrounding the AOMA. Boundaries of the data collection area and the groundwater model are also shown on Figure 3-1.

The study area data collection boundary encompasses:

- Puget Sound on the west;
- South 116th Street on the north;
- The north-south section line coincident with that portion of West Valley Highway (State Route 181) between South 234th and 192nd Streets on the east, and;
- A line running east from Saltwater State Park on the south.

The majority of the data collection area boundary lies within the Des Moines 7.5 minute quadrangle topographic map (USGS, 1995). Portions of the western and southern data collection boundary project on to the Vashon and Poverty Bay 7.5 minute quadrangle maps, respectively (USGS, 1991 and 2003).

The groundwater model boundary defines the lateral extent of the numerical model used to evaluate groundwater flow and contaminant transport (Section 7). The northern and southern portions of the model boundary are roughly coincident to the data collection boundary. The eastern model boundary runs parallel to the intersection of the eastern slope of the Des Moines upland with the Green/Duwamish River valley bottom. The western model boundary runs roughly parallel to the projection of the -300 foot bathymetric contour line in Puget Sound. The extent of the model area was determined by various boundary conditions established for modeling purposes, described in further detail in Section 7.

3.2.2 Surface Morphology

The surface morphology of the study area is shown in a shaded relief map (Figure 3-2) and in a mosaic of U.S. Geological Survey topographic maps for the Des Moines, Vashon and Poverty Bay 7.5-minute quadrangles (Figure 3-3). The study area is within the Puget Sound Lowland between the Olympic and Cascade Mountains. The Puget Sound Lowland consists of glacial and non-glacial sediments that have been shaped into ridges or uplands that trend generally north-south. Troughs that separate the uplands are now occupied by Puget Sound, freshwater lakes, or river-deposited alluvial (fluvial) soils (e.g., the Green/Duwamish River Valley).

The study area lies on the Des Moines Drift Upland (Glaster and Laprade, 1991) at elevations of 300 to 500 feet. The upland drops steeply on the west side into Puget Sound and on the east to the Duwamish River valley. The edges of the upland have been subject to erosion by water and landslides. The Duwamish River valley has been filled to an elevation of about 25 feet with alluvial soils deposited by the White, Green, Cedar, and Duwamish Rivers. Presently, only the Green River feeds the lower Duwamish River section. The White River was diverted in 1906 and the Cedar River was diverted in 1917 (Luzier, 1969). The geology and hydrogeology of the study area are addressed in detail in Section 4 and 5.

3.2.3 Surface Water

Surface water bodies and drainages are identified in Figure 3-4. The steep western and eastern edges of the Des Moines upland are drained by a number of small creeks that are typically 3 to 5 miles in length. The central area of the upland within the study area is drained by four primary creek systems: Miller Creek/Walker Creek, Des Moines Creek, Barnes Creek/Massey Creek and Gilliam Creek. The first three creeks referenced above drain west into Puget Sound. They are incised into troughs previously created by glacial ice and subglacial meltwater processes that eroded through the upper sediment layers (Booth, 1996). Gilliam Creek, located north of STIA, flows to the east into the Green/Duwamish River valley.

Three of these surface water systems, Miller Creek/Walker, Des Moines Creek and Gilliam Greek are receiving waters for STIA stormwater discharges. A brief description of these creeks is presented below.

Miller Creek/Walker Creek

Miller Creek, a perennial watercourse that drains to Puget Sound, has headwaters originating at Arbor, Burien, and Tub Lakes. STIA contributes drainage to the creek through the Lake Reba Stormwater Management Facility (LRSF). Walker Creek begins in the wetlands west of STIA and discharges to Puget Sound near the estuary common to both creeks. The Miller Creek/Walker Creek watershed (Port of Seattle, 2003a) encompasses an area of about 8.1 square miles. STIA covers about 0.4 square miles of the watershed. The groundwater basin contributing discharge to the creeks is substantially larger than the surface water basin. The watershed includes portions of Normandy Park, the City of SeaTac and Burien. Land use in the basin is approximately 62 percent residential, 14 percent commercial (non-airport), 5 percent airport, and the remainder is open space (parks, cemeteries, or forest/wetlands).

Des Moines Creek

The Des Moines Creek watershed (Port of Seattle, 2003a) covers 5.8-square miles near the center of the Seattle-Tacoma metropolitan area, including portions of King County and the cities of Des Moines, Normandy Park, and SeaTac. Most of the upper watershed is heavily urbanized. STIA constitutes 27 percent of the watershed. Des Moines Creek is approximately 3.5 miles long and flows into Puget Sound at Des Moines Creek Beach Park. The creek originates on a low gradient plateau near the southern end of STIA and descends steeply through a ravine before it empties into Puget Sound. The watershed contains two major tributaries: the East Fork and the West Fork of Des Moines Creek, and two major water bodies, Bow Lake and the Northwest Ponds (NWP). The East Fork and the West Fork converge on the Tyee Golf Course south of STIA. The East Fork flows out of Bow Lake, for the first half mile through a series of subsurface pipes, until it surfaces at approximately 26th Avenue South. An instream stormwater detention facility, the Tyee Pond was constructed by King County in the East Fork on the Tyee Golf Course in 1989. The West Fork begins below the outlet of the NWP complex located at the western edge of the Tyee Golf Course. The Des Moines Creek Regional Detention/Retention Facility is currently under construction in the area of the NWP and the West Fork.

Gilliam Creek

Gilliam Creek is located within the Green River drainage basin, and enters the Green River at river mile 12.7. The Gilliam Creek drainage basin is approximately 2.9 square miles (1,835 acres) in extent, of which 84 percent (1,535 acres) lies within the City of Tukwila and the remaining 16 percent (300 acres) is in the City of SeaTac (Herrera, 2001). The historical Gilliam Creek channel has been fragmented by highway and street crossings, residential and commercial development and filling of wetlands. Surface water is conveyed through a combination of underground pipes, drainage ditches and open stream channels. Stormwater generated from northeast landside areas of STIA (engineering yard and taxi yard) are discharged via a City of SeaTac storm drain system into Gilliam Creek.

3.2.4 Land Use

The study area is a heavily populated portion of southwestern King County dominated by residential use, but includes significant commercial and industrial uses. STIA is the most significant of the later uses and represents about 11 percent of the study area land surface area. The majority of the study area is located within the cities of Burien, Tukwila, Normandy Park, SeaTac, Des Moines, and Kent. Continued residential, commercial and industrial growth is expected in the study area according to current regional urban planning studies (King County, 2004).

STIA construction was initiated in 1942 and airport operations began in 1944. Airport facilities were expanded in 1949, primarily with the addition of permanent administration building/terminal and some runway reconfiguration. In 1956, the main runway was extended. Development activities from 1967 through 1973 saw an expansion of the terminal facilities, a passenger subway, access roads, a parking garage, and the addition of a second parallel runway. During the early 1980s, cargo facilities were constructed at the northeast end of the airfield, and during the 1980s and early 90s, miscellaneous terminal and garage improvements occurred.

Construction of airport improvements named in a 1997 master plan began in the late 1990s, and will be completed by late 2008 when a new third parallel runway and its associated taxiways become operational. In addition to the runway/taxiways, these latest improvements include an expanded south terminal, parking garage expansion, new Federal Aviation Administration (FAA) facilities, and expansion or demolition and relocation of several aircraft hangars and maintenance operations.

3.3 Climatology

The Puget Sound climate is temperate, with mild wet winters and cool dry summers conducive to the growth of lush evergreen forests. Winter temperatures are typically in the 40s°F, but can be as low as 5°F. Typical summer temperatures are in the 70s°F, but range up into the 90s°F (Glaster and Laprade, 1991). Annual precipitation, as measured at STIA over the last 58 years, has averaged 38 inches per year. Year-to-year variation is significant, from a minimum of 23 to a maximum of 52 inches per year (Figure 3-5). A graph of the historic monthly precipitation data is presented in Figure 3-6. Monthly precipitation varies from less than an inch during the summer to about six inches per month during the winter (Figure 3-7). Precipitation data from National Oceanic and Atmospheric Administration (NOAA) Station 457473 was used through 1996. Since January 1, 1997, data is from a tipping bucket monitored by Taylor Associates, Inc. The NOAA station was located on the west central side of the airport and the tipping bucket in the northeast portion on top of the Air Cargo 4 building. Since 1931, annual snowfall at STIA has averaged 11.7 inches, with nearly half falling in January (Western Regional Climate Center, 2004). However, rare storms can cause significant, albeit short-lived, accumulations.

3.4 Survey Coordinate System

Survey data for locations in the study area follow the STIA survey system. All horizontal and vertical survey data are presented in feet. Horizontal data are referenced to the unique STIA Grid System. The origin of this coordinate system is located in Puget Sound about 8,000 feet west of Des Moines Beach (Figure 3-1). Vertical data are referenced to National Geodetic Vertical Datum (NGVD) of 1929.

3.5 Potential Local Receptors

Potential Local Receptors are defined in the Agreed Order (see Section II.4.c) as those surface water bodies and drinking water supply wells that could be at risk from contamination originating at the AOMA.

The surface water bodies listed in the Agreed Order as potential local receptors are Bow Lake, Des Moines Creek, and Miller Creek.

The Agreed Order names both public and private drinking water wells as potential local receptors. The public drinking water supply wells are the City of Seattle Highline well field, the Highline Water District wells, and King County Water District No. 54 well field. Private drinking water supply wells are defined as those that are publicly recorded and operational. Approximately 500 private wells were identified within the data collection area and were entered into the EMIS database for use in this study (Ecology, 1997 and USGS, 1997). The operational status of these wells has not been investigated. Given the area's intensive urbanization and development and mandated use of public water supply systems, it is probable that many of these wells have been decommissioned or abandoned and are no longer in use. If warranted by the results of this Groundwater Study, the Port will obtain additional information about the operating status of these wells. The locations of the listed receptors are shown in Figure 3-8.

4 Geologic Setting

4.1 Introduction

This chapter presents a summary of the geology and hydrostratigraphy of the Puget Sound Lowland region and the STIA Groundwater Study area. The regional geology provides the basis for interpreting the subsurface geologic and hydrogeologic conditions within the STIA project study area. This chapter describes:

- The geologic time periods discussed in this report,
- The tectonic processes that determine the underlying bedrock structures,
- The glacial, inter-glacial, and post-glacial periods of sediment deposition and erosion,
- The geologic and hydrostratigraphic terms used, and
- The geologic units as used in this study.

A more comprehensive description of the regional geology, geologic history, and information on the hydrostratigraphic interpretations is included in Appendix C. Relevant technical references are presented in Section 9.2. A Glossary of the geologic and hydrogeologic terms used in this report is presented in Section 10.

The geologic descriptions are supported with a number of figures. A surficial geologic map (USGS 2002) is presented in Figure 4-1. Figure 4-2 plots locations of wells and borings that were used for subsurface interpretation. Figures 4-3 and 4-4 show locations of geologic cross sections for the study area and for the STIA area, respectively. Eight cross sections were developed for the study area (Figures 4-5 through 4-12) and ten cross sections were prepared locally through STIA (Figures 4-13 through 4-21). Table 4-1 correlates different systems used in naming geologic and hydrostratigraphic units.

4.2 Geologic Time Periods

The geologic time periods referred to in this study are the Tertiary, Quaternary, Pleistocene, and Holocene. The Tertiary period is from approximately 66 to 2 million years ago (ma). The Quaternary period is dated from 2 ma to present and is divided into the Pleistocene and Holocene epochs. The Holocene epoch is the most recent and covers time shortly following the end of the last glaciation. Generally, the Holocene refers to the last 11,000 years. However, in the Puget Lowland the last glacial ice retreated about 13,500 years ago and, therefore, local usage of the term Holocene covers a slightly longer period of time than elsewhere.

4.3 Regional Tectonic Processes and Geologic Structures

This section presents an overview of the tectonic processes and the resulting bedrock structures in the Puget Sound Lowland region. The STIA Groundwater Study area lies within this region of tectonically active structures (areas where the earth's crustal blocks are in motion against one another). These active tectonic structures determine the shape and location of regional bedrock high areas and low-lying sedimentary basins (topographically low areas where sediments collect and are preserved). The location of the sedimentary basins and structural high areas imparts a significant control on the type, thickness, and structure of the sedimentary deposits in the study area. The sedimentary deposits, in turn, control the location and thickness of the aquifers and aquitards that compose the hydrostratigraphic model units (see Section 4.5).

Convergence of oceanic and continental crustal plates within the Cascadia subduction zone (an area where one plate sinks below another) creates regional-scale folding and thrusting which produces uplift of the Olympic and Cascade Mountains and subsidence of the Puget Sound trough. The trough, which is known geographically as the Puget Lowland, includes the Tacoma basin, the Seattle basin, and the Everett basin. The region is also subject to a north-south compression that has resulted in north to south shortening and created a series of folds resulting in low and high areas within the trough. The low areas, depressions in the underlying volcanic and sedimentary bedrock, are basins where sediments accumulate within the trough. These depressions in the bedrock are separated by folds and earthquake-producing regional faults. The basins are filled with Late Tertiary (younger than about 35 million years [ma]) sedimentary rock and Quaternary (last 2 ma) sediments.

The groundwater study area lies generally on the flank of the high bedrock area near the middle of the Seattle uplift, a broad upward flexure of basement rocks that separates the Tacoma and Seattle basins. The Seattle uplift terminates abruptly to the north of the project area at the Seattle fault.

The bedrock surface is exposed in the northeast corner of the study area (red areas in Figure 4-1) and dips to the south and to the west in response to folding of the Tertiary strata within the Puget trough and the Seattle uplift. Elevation of the bedrock surface drops from approximately +200 feet in the northeast, to -800 feet in the southeast, and to -1000 feet in the northwest portion of the study area (Cross Sections A-A', B-B', and E-E', Figure 4-5, 4-6, and 4-9, respectively). Several gentle folds and small faults have also been documented (Booth et al., 1999 and Booth et al., 2004) in the sediments in the uplift, which demonstrate that the tectonic forces that formed the basin and bedrock high are still active.

4.4 Geologic History

The Puget Lowland is underlain at depth by volcanic and sedimentary bedrock, and is filled to the present-day land surface with glacial and non-glacial (non-glacial or inter-glacial sediments are those deposited between periods of glaciation) sediments deposited during the Quaternary Period (within the last 2 million years). Only the late Quaternary deposits are exposed at land surface in the majority of the study area.

The Quaternary geologic history of the Puget Sound region is dominated by a succession of at least six dated and named periods of ice sheet glaciations. Global climatic records suggest that there were many more periods capable of producing glaciations in the Puget Sound region that are not directly evidenced in the sediments. During these episodes of cooler mean global temperatures, continental ice sheets originating in Canada flowed south, covering much of low-lying northern North America with glacial ice, in places over one mile thick. In the Puget Lowland, the most recent continental glacier was present as a lobe of ice that reached its maximum extent just south of Olympia during the Vashon stade (a short period of regional glacial advance) of the Fraser glaciation (a major period of regionwide glaciation). The Fraser glaciation locally occurred between about 13,000 and 15,000 years ago. Sediments that were deposited prior to the Vashon glaciation are collectively referred to as “pre-Fraser”.

As the glaciers advanced, the northern end of the Puget Lowland was blocked by glacial ice, trapping the normal northward discharge of the lowland rivers. A large lake formed in the lowland as the ice sheet advanced southward. As the ice sheet advanced, sediment deposited in the lake changed from dominantly non-glacial, to glacially-derived silt and clay, and formed deposits called transition beds. Transition beds are so named because they mark the transition from deposition of non-glacial sediment to deposition of glacial lake sediments (called glaciolacustrine deposits). As the ice sheet advanced farther southward, the supply of sediment to the lake coarsened and sand and gravel, known as advance glacial outwash, filled the lowland. When the ice reached the latitude of the study area, sub-glacial melt water flow (water that flows beneath the glacial ice) and glacial ice scoured into the underlying sediment and rock, reworking and entraining more sediment and carrying it south through a spillway near Olympia. The deposit of glacial sediment that was smeared on the eroded surface is called glacial lodgement till. As the climate warmed, the glaciers melted, depositing their entrained sediment loads over the landscape, forming recessional glacial outwash.

During the Vashon stade, glacial ice was about 3,000 feet thick in the study area (Thorson, 1980). Sediments that were overridden by the glacier are termed glacially overconsolidated. The weight of the ice compacted the underlying sediments to a very dense or hard state. Sediments that were not glacially overridden and thus were not overconsolidated are termed normally consolidated. These sediments, such as recessional glacial outwash and recent alluvium, are typically much less dense or hard.

Each successive glaciation partially eroded the pre-existing ground surface, and then deposited a fresh sequence of sediment over the land. Between glaciations (the non-glacial periods), erosional and depositional processes worked much like they do today, with broad lowland rivers and streams filling the deep glacially-modified channels, and eroding the steep upland slopes.

During glacial cycles, a tremendous amount of sediment was deposited in the lowland. During the non-glacial cycles, some of the glacial sediment deposits were eroded, and the sediments were then re-deposited elsewhere. Due to these cycles of deposition and erosion and re-deposition, there may be gaps in the stratigraphic sequences, and very young deposits may rest on much older deposits. For example, at a particular location, the Vashon age sediments may lie directly on any of the older pre-Fraser glacial or non-glacial sediments, or may be entirely absent.

Geologic processes following the Vashon glaciation are dominated by erosion of the uplands and deposition of recent alluvium and lacustrine deposits in the valleys and water bodies of the Puget lowland. Extensive filling of former wetlands and grading for construction projects has further modified the land surface. Sediments that were deposited after the Vashon stade of the Fraser glaciation (during the Holocene Epoch) are usually termed “recent” to identify their stratigraphic position relative to the older deposits.

4.5 Geologic and Hydrostratigraphic Units and Terms

4.5.1 Geologic and Hydrostratigraphic Units

The subsurface hydrogeological conditions are described for this study in three ways:

1) by logged soil description (e.g. silty sand or sandy gravel) which primarily describes the particle size range;
2) by geologic units; and
3) by hydrostratigraphic units.

The geologic units are packages of sediment, characterized by the origin of the specific soil types encountered in borings and referred to by their geologic deposit names. If sufficient correlating information is available, a geologic unit may also include assignment of that stratum to a particular named, and possibly dated, geologic formation.

Hydrostratigraphic units are bodies of sediments that have been grouped based on their hydrologic behavior. Hydrostratigraphic unit differentiation is characterized primarily by whether the sediments are relatively coarse and permeable (aquifers), or relatively fine and impermeable (aquitards).

4.5.2 Geologic Units

Descriptions of subsurface conditions from the various data sources range from very detailed to very general. In some areas, including the AOMA and Third Runway where there is an abundance of consultant-produced monitoring well and borehole logs, more detailed descriptions of subsurface conditions permit interpretation of the geologic origin of the soils, and division into geologic units. Categorization into geologic units is useful for modeling subsurface conditions. When the stratigraphic position of the unit is known, that knowledge helps to predict the lateral and vertical extent of the unit and its gross hydraulic characteristics.

4.5.3 Hydrostratigraphic Units

The relationship between geologic units and hydrostratigraphic units is presented in Table 4-1 and developed in more detail in Appendix C. All subsurface deposits in the study area have been subdivided into groups based on whether the sediments are primarily fine-grained (silt and clay) or coarse-grained (sand and gravel). This division of subsurface units into fine (F) and coarse (C) units is used in the groundwater model to determine whether the deposits are inferred to be primarily aquifers (water-bearing and transmissive to groundwater flow) or primarily aquitards (generally not water-bearing or non- or poorly-transmissive) which are designated as “F” units for fine-grained.

Soils encountered in all explorations in the groundwater study area have been subdivided into these C and F hydrostratigraphic units. As shown on Table 4-1 and on the study area hydrostratigraphic cross sections (Figures 4-5 through 4-12), the unique C and F unit numbers increase with increasing inferred age (and generally with increasing depth). See Sections 5.2 and 5.3 for a description of the hydrogeologic framework.

4.6 Groundwater Study Area Geology and Hydrostratigraphy

This section describes the location and extent of the major geologic and hydrostratigraphic units, moving up the stratigraphic section, generally from older deposits (deeper) to the younger (shallower) deposits. Both geologic and hydrostratigraphic interpretations are presented on the STIA area cross sections I-I' through S-S' (Figures 4-13 through 4-21). Where fewer data are available or geologic correlations are generally not possible, only hydrostratigraphic interpretations are presented, which is typically the case for the study area cross sections A-A' through H-H' (Figures 4-5 through 4-12).

The use of geologic versus hydrostratigraphic units was determined by the nature of the available data. Description of the subsurface conditions in terms of their geologic unit names requires abundant subsurface information. The majority of the subsurface explorations in the STIA area are shallow, professionally logged, and allow assignment of both geologic and hydrostratigraphic units. Outside of the STIA area, subsurface information is more limited, generally consisting of well driller’s logs, which typically emphasize water production information rather than detailed soil descriptions. Only one boring exceeds 1,000 feet in depth. Due to the scarcity of information at depths greater than about 50 feet below ground surface (bgs), the interpretations of the study area geology use the more generalized hydrostratigraphic units.

Due to the lack of deep data, the modeled hydrostratigraphic layers become much simpler and more sheet-like with depth. However, the actual deposits are believed to be as complex as the shallow units, where the data are complex, as presented on the cross sections.

4.6.1 Bedrock

Bedrock crops out in the northeastern portion of the model area, west of the Duwamish River and north of State Route-518 (Figure 4-1) (Booth and Waldron, 2002). Exposed bedrock consists of Eocene sedimentary and volcanic rocks of the Puget Group. The sedimentary rocks were derived from weathering of continental source areas and are chiefly composed of sandstone, siltstone, and claystone, with minor coal seams. The volcanic rocks are primarily basaltic to andesitic intrusives within the Puget Group.

Well log and test hole descriptions of bedrock encountered beneath Quaternary sediments in the northern portion of the study area suggest that the basement there also consists of Tertiary sedimentary rocks. Borehole logs and geophysical data have been used to estimate the depth to bedrock in the study area (Jones, 1998). Bedrock is generally shallowest or crops out in the northern portion of the study area, nearest the uplifted Seattle fault. Although borehole data in this area are sparse, modeled bedrock contours in the middle and southern portions of the study area undulate between several hundred feet, to over a thousand feet below sea level at the south end. Bedrock has been designated as an aquitard for purposes of this study and is the lowest geologic unit shown on the profiles. Bedrock is identified with the abbreviation “Br” on the profiles (Cross Sections A-A', B-B', and E-E', Figures 4-5, 4-6, and 4-9, respectively).

4.6.2 Pre-Fraser Fine- and Coarse-Grained Units

Pre-Fraser deposits compose the majority of the subsurface sediments in the study area. The locations and extents of these hydrostratigraphic units in the study area are presented on cross sections A-A' through H-H' (see Figures 4.3 through 4.12).

Interconnected deposits of pre-Fraser coarse-grained units (Qpfc) composed primarily of sand, gravel, or silty sand are grouped as coarse-grained model units C2 through C6. Pre-Fraser fine-grained units (Qpff) are composed primarily of silt and clay, and where laterally extensive, are grouped as fine-grained model units F2 through F7. Both F and C model layers contain interbeds of other types of sediments. Modeled contour maps of the top elevation of units C2 through C6 are presented in Figures 7-5 through 7-13).

The distribution of fine- and coarse-grained units F7, C6, F6, C5, and F5 was based on limited deep well and borehole data. These units do not extend throughout the study area due to the intersection of these units on a south and westward dipping bedrock surface. Bedrock is present at the ground surface near the northeast corner of the study area, and dips to 600 to 700 feet below sea level in the central portion and about 1,100 feet in the southern portion. Where units F7 through C5 intersect the sloping bedrock surface, they lap onto the bedrock surface and successively higher stratigraphic units (lower numbered units) extend progressively farther northeastward. Unit F7 terminates at depth on the bedrock surface north of STIA, roughly on a line between Tukwila, Riverton Heights, and Seahurst. Younger units C6, F6, and C5 terminate to the northeast, in the Riverton and Foster neighborhoods, nearer to the existing bedrock outcrops along the Duwamish River. These units are considered continuous within the extent of their boundaries.

The C4, F4, C3, F3, units are not continuous throughout the study area. These units may thin and pinch out between surrounding adjacent units. There is no strongly apparent pattern to the distribution of these units.

Deposits composing the C2 unit are detailed through a number of exploration boreholes, municipal water supply test wells and observation wells. These subsurface units are best detailed on section A-A' (Figure 4-5). The C2 unit is composed of non-glacial sands and silty sands overlain by a thick glacial outwash deposit. The outwash is overlain by more non-glacial sands and silty sands with an intervening laterally discontinuous fine-grained interbed identified as C2F.

The C2 and C2F units are also present in surface exposures and boreholes completed for the Midway Landfill, in the south central portion of the study area. Like some of the older hydrostratigraphic units, the C2 unit is slightly thicker and deeper in the north end of the study area. The top of the unit lies at about the 350-foot elevation in the southern portion, and the 250-foot elevation in the northern portion. The C2F fine-grained interbed occurs at about the 170 foot elevation near Seahurst and the Highline Well Field area (Section A-A' – Figure 4-5), and at about the 210-foot elevation at the south end of the study area (Section B-B' – Figure 4-6).

4.6.3 Transition Beds – Lawton Clay and Pre-Fraser Fine-Grained Deposits

Transition beds (Qtb) are the fine-grained deposits that mark the transition during a glacial advance from non-glacial lake deposition to glacial lake deposition. In the Seattle area, the Vashon advance glaciolacustrine (glacial lake) deposits are known as the Lawton Clay member, and are commonly recognized as a distinctive geologic unit. In this hydrostratigraphic model, the Vashon glaciolacustrine deposits (Lawton Clay) are grouped within the transition beds unit because it is generally not possible to distinguish between Lawton Clay and fine-grained deposits of the Olympia beds in the boring and well logs. The F2 unit may also include some older glacial and non-glacial fine-grained deposits. The F2 unit overlies the C2 and older units.

Fine-grained Olympia bed non-glacial deposits contain silt, clay, and silt-sand mixtures, with scattered to abundant organics and thin interbeds of peat and organic-rich wetland deposits. The non-glacial deposits in the F2 unit are present at elevations of up to about 340 feet. Lawton Clay is composed of hard gray, interbedded silt and clay with thin fine sand interbeds and scattered sand and gravel dropstones (sand or gravel particles that fell into fine-grained sediments after they melted out of floating glacial ice). Lawton Clay does not crop out in the study area (Figure 4-1) but was identified in explorations to the north of STIA in the Seahurst and Highline well field area, shown by unit F2 on section A-A' (Figure 4-5). The Lawton Clay is generally not present above about elevation 260 feet in the study area. The maximum deposit elevation was controlled by the height of a spillway that controlled the elevation of the glacial lake that the sediment was deposited into.

4.6.4 Vashon Glacial Deposits

Sediments deposited during the Vashon glacial advance are collectively termed Vashon Drift. The main components of the Vashon Drift glacial sequence present within the study area are described below from oldest to youngest. These deposits date from the advance of the Vashon ice-sheet glacier about 15,000 years ago to the retreat of the ice about 13,500 years ago. The earliest Vashon deposit, the glaciolacustrine Lawton Clay was described above.

Advance Outwash (Qva) – Advance glaciofluvial (glacial meltwater deposits) deposits of the Vashon Stade are also called Vashon Advance Outwash. A prominent sandy Vashon Advance Outwash unit, known in the Seattle area as the Esperance Sand, occurs widely across the study area. Advance Outwash present in the project area is generally a very dense, brown to gray, homogeneous, clean (no appreciable silt or clay) to slightly silty, fine to medium sand, although some deposits are composed of sand and gravel. Cobbles are present although rare in the gravelly advance outwash. In the study area, this geologic unit forms the C1 aquifer and is present beneath much of the AOMA. The C1 deposit probably exceeds 200 feet in thickness in the northern and central portions of the study area. The unit generally thins toward the south end of the study area.

Vashon Till (Qvt) – This unit consists primarily of lodgement till, a very dense, gray mixture of clay, silt, sand, and gravel with cobbles that was deposited at the base of the Vashon glacier. Interbeds or lenses of water-worked outwash-like sand and gravel are present within the till. The interbeds and lenses commonly range from several inches to about 5 feet thick. Thin lacustrine lenses and boulders are also present in Vashon till.

Vashon Till forms the erosion-resistant cap in much of the study area. In the AOMA where the density of subsurface information is high, Vashon till covers about ¾ of the upland ground surface. The till averages about 10 feet thick and rarely exceeds 30 to 40 feet. Most of the major drainages and ravines have cut through the thin, resistant till cap.

Unweathered till generally exhibits very low permeability and forms an aquitard, hydrostratigraphic unit F1. Where low areas in the till surface are present, groundwater will perch atop this unit. Wetlands commonly occur in enclosed depressions on the till surface. Where Vashon till caps units such as the C1 aquifer, it may form a confining layer. Where the C1 unit is confined and is exposed to the surface through hillside erosion or downcutting by a natural drainage, such as in the Miller Creek drainage, discharge from the C1 unit may occur as seeps or wetlands or springs contributing to surface water baseflow.

Weathered Vashon Till (Qvtw) – Where the upper surface of the till has been weathered, a subunit of the Vashon till, called weathered till (Qvtw) had been identified. Although typically not greater than 5 feet thick, this unit is brown to gray, and is looser and has higher permeability (and transmits water more rapidly) than unweathered till. It is usually grouped with unit F1. Weathered till has been identified in some of the explorations in the AOMA and Third Runway areas. Sections I-I' through S-S' (Figures 4-13 through 4-21) present subsurface conditions in these areas.

Recessional Outwash (Qvr) – Recessional outwash deposits consist of coarse-grained fluvial (river and stream) sediments (Qvr) associated with the retreat of the Vashon ice sheet. The fluvial sediments consist of sand, gravel, and silty sand. Recessional outwash is the only Vashon glacial deposit that was never overridden by glacial ice and compressed, and is therefore substantially less dense and softer than the older deposits.

Recessional outwash occurs as thin deposits on upland areas, typically less than 20 feet thick, and in broad low areas that were former recessional meltwater channels (Figures 4-13 through 4-17). Along the walls and bottoms of most major drainages in the model area, recessional outwash is more continuous and may exceed 30 feet in thickness. Recessional outwash may occur in the same geographic locations as recent alluvium (modern stream and river deposits). It has sedimentary characteristics similar to alluvium, and may be grouped with alluvium on the cross-sections. In upland areas where drainage is poor, recessional outwash commonly forms a perched aquifer. Recessional outwash is included in the C0 hydrostratigraphic unit.

Recessional Lacustrine Deposits (Qvrl) - Fine-grained deposits associated with the recession of the Vashon ice sheet glacier are identified as Recessional Lacustrine deposits (Qvrl). These normally consolidated (not glacially overridden) glacial lake, pond, and kettle (a depression that formed by melting of buried glacial ice) deposits generally consist of silty to clayey sediments with interbedded silty fine sands. They are usually restricted to poorly-drained ice meltout kettles on the uplands, and as thin interbeds within coarse-grained recessional outwash deposits in the low-lying areas. Recessional lacustrine deposits are included in the F0 hydrostratigraphic unit.

4.6.5 Recent (Holocene) Deposits

Holocene sediments are those that been deposited since the disappearance of glacial ice following the last ice age. In the central Puget Lowland, this disappearance of ice occurred approximately 13,500 years ago. The sediments were deposited by non-glacial geologic processes that are largely active today, such as erosion, landslides, streams and rivers, and human activities such as excavating and filling. Because these sediments have not been glacially overridden, they are normally consolidated or slightly over consolidated, and are typically very loose to dense or soft to very stiff. The most extensive Holocene deposits include recent alluvium and fill. Recent deposits are either C0 if coarse-grained, or F0 if fine-grained. There is no stratigraphic order among the recent deposits.

Recent Alluvium (Qal) – Recent alluvium consists of young stream and river (fluvial) sands and gravels and silty sands, commonly containing some interbedded silt and clay and organic matter. Thin ribbons of recent alluvium fill the ravines and creek bottoms that drain the upland, including portions of Miller and Des Moines Creeks. The alluvium thickens where the creeks approach the shoreline of Puget Sound or the wide river valleys on the east side of the model area. Thicker and laterally extensive recent alluvium fills the Duwamish and Green River valleys (Cross Sections C-C', D-D', F-F', G-G', and H-H'). Alluvium in the Green and Duwamish River valleys can exceed several hundred feet in thickness. On the study area cross sections, recent alluvium is included with recessional outwash in the C0 hydrostratigraphic unit (Figures 4-5 through 4-12). On the map of Regional Surficial Geology (Figure 4-1), recent alluvium is identified as Qyal.

Recent Lacustrine Deposits (Ql) – Recent deposits of lake (lacustrine), pond, floodplain and other low-energy or slack water bodies are generally composed of silt, clay, and silty fine sand. These fine-grained deposits commonly contain some organics and wood and may include peat. This geologic unit is included in the F0 hydrostratigraphic group. Lake and pond deposits are not common in the AOMA although some fill covered lake deposits are presented on the north end of Section P-P' (Figure 4-18).

Topsoil (Qts) – Topsoil consists of organic-enriched soil that typically marks the top of native soils or any formerly vegetated older surface. Although typically less than 2 feet thick, topsoil is commonly present below fill soils in the AOMA and is an important marker bed for delineating the thickness and extent of fills that cover the topsoils. Topsoil is identified on most of the sections in the AOMA (Figures 4-13 through 4-21) and is included in the C0 unit on the model area sections (Figures 4-5 through 4-12).

Artificial Fill (Fill) – Fills of various thickness and composition are present throughout the project area resulting from land development. Fills are most common in low-lying areas around drainage bottoms. Thick fills are also present in the STIA area where former wetlands have been developed, and for extension of runways (Figures 4-13 through 4-21). Fills may be composed of any mixture of fine or coarse grained soils. Fills are considered to be water bearing zones if coarse-grained and classified with the C0. Fine grained fills, classified as F0, tend to exhibit poor water bearing capabilities.

5 Hydrogeologic Setting

5.1 Introduction

The hydrogeology of the study area is first discussed conceptually, in Section 5.2, in order to provide a general understanding of groundwater conditions. Section 5.3 describes the system of hydrostratigraphic nomenclature used in the study. An historical context is provided by a review of previous work in Section 5.4. The current understanding of the area's hydrogeology is then presented in three parts. Section 5.5 reports on hydraulic parameter values for the hydrostratigraphic layers, especially estimates of hydraulic conductivity values used for the numerical model. Section 5.6 discusses the water elevation contours and groundwater flow paths as inferred from observed water level data. The effects of variation in precipitation are also covered. Section 5.7 specifies the data used for estimating groundwater recharge and groundwater withdrawals within the study area.

5.2 Conceptual Hydrogeology

5.2.1 Conceptual Hydrogeologic System

The purpose of this subsection is to provide a brief, conceptual description of the hydrogeology of the STIA Groundwater Study area. A general understanding of the hydrogeologic system is necessary for development of conceptual model interpretations, groundwater flow, and contaminant fate and transport prediction.

Historically, the geology in the Puget Lowlands had been described as a "layer-cake" structure of glacial deposits sitting on a bedrock foundation. Aquifers are located in the geologically recent (Holocene) alluvial material and in older coarse-grained glacial or non-glacial layers. The coarse layers are separated by fine layers that retard groundwater flow and serve as aquitards. Two glacial aquifers were defined by Luzier in 1969. By the early 1980s, with additional exploration, the interpretation was expanded to a three glacial aquifer system. Continuing investigations have highlighted the complexity of the glacial depositions—the lateral discontinuity of geologic units, the variability in unit thickness, and the variability in elevation—as well as increased the number of water-bearing coarse grain glacial units.

Based on currently available information, this study proposes a more refined interpretation of the hydrogeology within the Des Moines quadrangle. A total of six glacial and/or non-glacial aquifer units have been defined. The aquifer units are not continuous throughout the study area, but limited in lateral extent. In many places, an aquifer unit is not bounded by low permeability layers (aquitards), but is in direct contact with the aquifer unit above or below. Figure 5-1 shows conceptually how the hydrostratigraphic units may be related.

The study area is primarily on the Des Moines Upland, which does not have the extensive alluvial sediments that are found, for example, in the Duwamish/Green River valley.

Therefore, the alluvial aquifer mentioned above is not encountered. The most shallow groundwater is found as perched groundwater within the most recent glacial deposits or fill soils. Zones of perched water are found on top of relatively impermeable soils within the uppermost deposits (including the F0, C0 and F1 units). Due to the discontinuous nature and limited volumes of perched groundwater, the perched zones are not considered to be aquifers. The most shallow groundwater aquifer is found within the C1 unit (Quaternary Vashon advance outwash [Qva] glacial deposits) and is commonly referred to as the Qva aquifer. Local precipitation within the study area is the primary recharge source for the C1 aquifer. The deeper units probably also receive recharge from lateral migration of groundwater from outside the study area and/or leakage from overlying aquifers.

5.2.2 Groundwater Flow

Precipitation infiltrates directly into the ground, flows along drainages as surface water, evaporates, or is taken up and transpired by vegetation. Precipitation that infiltrates into the soil either recharges the perched groundwater zones or continues infiltrating downward into the upper-most regional aquifer system. A number of possible pathways are identified in Figure 5-1. Infiltration is shown as occurring relatively fast in coarse soils and slow in fine soils. Drainage sands or gravels placed in anthropogenic features such as utility trenches and foundations can also provide preferential pathways for the movement of infiltrating groundwater. Once in the aquifer system, groundwater can move both laterally and vertically.

The velocity of groundwater water movement through saturated soils depends on the driving pressure (head) and the ability of the soil to transmit water (hydraulic conductivity). The hydraulic conductivity, or permeability, is discussed in Section 5.5. Lateral groundwater velocities within the coarse grain aquifer units are expected to be, roughly, on the order of 100 feet per year.

Precipitation retained in surface water bodies (as lakes and marshes) typically provides delayed recharge to groundwater, including both perched zones and deeper aquifers. Groundwater from the upper aquifers in turn provides a component to surface water flow (base flow) where saturated portions of aquifer units are exposed. The C1, C2, and, to a limited extent, C3 appear to be the coarse hydrostratigraphic units exposed in the study area, primarily along creek drainages. The potential for groundwater discharge exists generally in the creek drainages (Section 3.2.3) and on the slopes along both Puget Sound and the Duwamish/Green River valley. Angle Lake, which is underlain by a confined portion of the Qva aquifer, may represent a special case where the C1 aquifer could provide some groundwater discharge to the lake. Surface water bodies in the study area are described in Section 3.2.3.

Contaminants can be carried along flow pathways by infiltrating precipitation and eventually into perched groundwater zones or regional aquifer systems. The pathways for this movement, as indicated in Figure 5-1, can be very complex, reflecting the complexity of glacial depositions and man-made modifications to the environment. Once in an aquifer system, contaminants can move both laterally and vertically, as well as degrade over time. The transport and fate of contaminants within the groundwater system is discussed in the Sections 7 and 8 regarding groundwater flow and contaminant transport modeling.

5.3 Hydrostratigraphic Units

The hydrostratigraphic units used in this study are functional, binary hydrological units–either aquifer or aquitard–based on the geological soil descriptions. Soils were characterized as relatively coarse and permeable (aquifers) or relatively fine and impermeable (aquitards) and assigned to a unit labeled with either “C” or “F”. The assignment of a stratum to a hydrostratigraphic unit was inferred from drilling log information (grain sizes and distribution, stratigraphic position, and any identifying markers) as described in Section 4.5.3. Well test data were not directly used in defining the hydrostratigraphy, but experimental estimations of hydraulic parameters were used in the groundwater model. The system of hydrostratigraphic units is a useful conceptualization of a very complex, multi-layered glacial and non-glacial stratigraphy.

The hydrostratigraphic units are designated as either F# or C# with the numbering sequence starting at the ground surface and increasing with depth. Table 4-1 provides a correlation of the hydrostratigraphic units with the geological units and descriptions used for this study. For comparison purposes, similar systems to define hydrostratigraphic units developed by USGS and South King County Ground Water Management Plan within the study area are also presented in Table 4-1.

The upper, glacially unconsolidated layers are labeled F0 and C0 and do not have a specific stratigraphic order. F1 is Vashon till (Qvt) and C1 is Vashon advance outwash (Qva). Deeper units (F2 and below) are considered undifferentiated, fine or coarse, pre-Fraser deposits (Qpff and Qpfc) that include both glacial and non-glacial soils. The C2 layer likely includes Olympia non-glacial, Possession glacial outwash, and Whidbey non-glacial deposits. In some parts of the study area, the C2 unit also includes a significant low permeability interbed (C2F).

The relationship between geologic units and hydrostratigraphic units is addressed further in Sections 4.5 and 4.6. Note that ice contact deposits, which are highly variable, have not been assigned to any hydrostratigraphic unit. Where well screens were installed in ice contact deposits, the database field “Screened Hydrostratigraphic Unit” (Appendix D) yields the value “n/a”.

5.4 Previous Work

Previous groundwater investigations relevant to the STIA Groundwater Study include three USGS studies and six consultant reports. USGS studies of southwestern King County were conducted by Luzier (1969) and Woodward et al. (1995). A regional groundwater study of Puget Sound was conducted by Vaccaro et al. (1998). The consultant reports include work done for:

- the unconstructed Seahurst Tunnel (Converse Consultants, 1983),
- the City of Seattle’s Highline Well Field (Hart Crowser, 1984),
- the Midway Landfill (AGI Technologies, 1988),

- the South King County groundwater study (South King County Ground Water Advisory Committee, 1989),
- the STIA irrigation system (Osborn Pacific, 1990 and Robinson and Noble, 1989), and
- the Highline Water District (Robinson & Noble, 1998).

This previous work is summarized below in chronological order. For reference, Table 5-1 compares the hydrostratigraphy of the three USGS studies with the more detailed interpretations made in this STIA Groundwater Study Report (the current study) and Section 5.5.3 provides explanations for many of the technical terms used in the summaries (e.g. transmissivity and, storage coefficient).

5.4.1 Luzier

Luzier (1969) performed the first groundwater investigation of southwest King County. His 1961-1963 compilation of soil log and well test data remains a valuable reference. Luzier's records include items from interviews and private records, such as pump test duration, which were not included in the formal records. Luzier determined that production wells were typically completed in either Vashon advance outwash or "Salmon Springs Drift" (a term used at the time for glacial deposits present below the Vashon Drift, most of which have since been determined to be much younger than the true Salmon Springs Drift). Luzier's advance outwash corresponds well with the C1 (Qva) interpretation of this groundwater study, and his interpretation of the extent of the advance outwash in the Des Moines quadrangle is also consistent with the more detailed current work (Figure 7-3). Luzier's "Salmon Springs Drift" appears to correspond to the F2 and C2 units along a transect through, approximately, Three Tree Point and the airport terminal. At the south end of the study area, Luzier's "Salmon Springs" unit may include some of the F3 and C3 units of this study.

5.4.2 Converse Consultants

Converse Consultants (1983) prepared a geotechnical report for a proposed, although never constructed, tunnel for the Renton Effluent Transfer System. The tunnel alignment was along South 146th Street from Tukwila to Seahurst. Explorations for this study included one test well and 16 geotechnical/monitoring wells from 60 to 512 feet in depth. Cross section A-A' (Figure 4-5) includes many of those borings. Offshore seismic reflection and side scan sonar studies were also performed. The study area was generally coincident with the Des Moines Quadrangle.

The aquifer system was described in general terms as complex, non-uniform, and non-isolated. The study defined two aquifer units, a shallow aquifer corresponding to the Qva or C1 unit and a main aquifer in "Salmon Springs" outwash that is coincident with the C2 unit. Analysis of pump test data for the main aquifer indicated a variable transmissivity along the alignment. Transmissivity was highest near the center and dropped by over an order of magnitude towards the edges of the aquifer. A groundwater contour map was presented that is generally consistent with the current Qva or C1 groundwater contour map (Figure 5-7).

5.4.3 Hart Crowser

Hart Crowser (1984) prepared a technical memorandum for the City of Seattle that summarized existing hydrogeologic data and presented a conceptual model for the Highline well field area. The study also reanalyzed test data for the pump test performed by Converse Consultants (1983). The study area covered most of the Des Moines Quadrangle.

The hydrostratigraphy was modeled as a three aquifer system. The aquifers were referred to as shallow (Qva), intermediate or “Salmon Springs”, and deep. The three cross sections presented by Hart Crowser were compared to those of the current study. The interpretations of well logs were different in a number of cases, and therefore a simple correlation could not be made. Based on current information, the shallow, intermediate, and deep aquifers presented by Hart Crowser included, respectively, C1 and C2 units, C2 and C3 units, and C3, C4, and C5 units.

Existing well and test data were collected in Hart Crowser Tables 1 and 2. These tables primarily report specific capacity data, but also appear to be the first compilation of hydraulic parameter values within the Des Moines Quadrangle. Transmissivity was reported for four wells, storage coefficient for two of the four, and hydraulic conductivity for three other wells.

Groundwater maps were presented for the shallow and intermediate aquifers. Both groundwater maps appear consistent with the present interpretations for the C1 and C2 hydrostratigraphic units.

5.4.4 South King County Ground Water Advisory Committee

The South King County Ground Water Advisory Committee undertook a major review of groundwater resources in South King County (1989). The work was performed by Economic and Engineering Services, Inc. in association with Hart Crowser, Inc., Pacific Groundwater Group, and Robinson & Noble, Inc. The consultants developed a hydrogeologic database that contained and expanded on the existing USGS database. For the Des Moines Upland, the study identified three aquifers that were labeled Qva, Qc(3), and Qc(4), respectively. Maps of aquifer extent were prepared, but are on a scale too coarse to make meaningful comparisons with the current study. The study noted long term declines in water levels of one foot per year within the Des Moines Upland. The aquifers were characterized and recommendations made for monitoring of future impacts on the groundwater resource.

5.4.5 Osborne Pacific and Robinson & Noble

Robinson & Noble (1989) prepared a hydrogeologic study that was included as an appendix to a review of the STIA irrigation system conducted by Osborn Pacific (1990). The Robinson & Noble report outlines the presence of five aquifer layers (Zones 1 through 5). Correlations with the hydrostratigraphic units of the STIA study could not be reliably inferred due to the brief descriptions of the zones and the absence of the cross sections and hydrogeological data that were used in preparing the report.

5.4.6 AGI Technologies

AGI Technologies (1995) prepared a hydrogeological report for the Port of Seattle as a response to comments on the Port's 1995 Draft Environmental Impact Statement (EIS) for the Master Plan update. The purposes of the report were to characterize subsurface geology, identify aquifers and aquitards, characterize the water balance, evaluate impact of proposed development on the groundwater, and identify mitigation measures.

The study area for the AGI report was a three by seven mile area centered on STIA and representing about one-third of the Des Moines Quadrangle. The AGI study used the three part aquifer interpretation and used the nomenclature--Qva, Qc(3), and Qc(4)--developed by the South King County Ground Water Management Plan (South King County Ground Water Advisory Committee, 1989). The AGI report and the SKCGWMP system were criticized for not incorporating the most recent geological interpretations (Associated Earth Sciences, 1995).

A transmissivity range of over an order of magnitude was reported for both the intermediate Qc(3) and deep Qc(4) aquifers. Groundwater maps were presented for the shallow and intermediate aquifers. The maps are consistent with the C1 and C2 hydrostratigraphic units, respectively. However, the contours of the intermediate aquifer do not show the upstream inflections at Miller and Des Moines Creeks as in the current C2 interpretation. A groundwater balance was also presented for the study area.

5.4.7 Woodward et al.

A recent USGS investigation (Woodward et al., 1995) expanded on Luzier's work and also presented data on hydraulic parameters. The boundaries used to define southwest King County were somewhat modified from those used by Luzier. The subject area of the STIA Groundwater Study represents about 20 percent of Woodward's study area. Woodward et al. (1995) presented contour maps of Qva, Q(A)c, and Q(B)c units. The Qva map compares favorably with the C1 map (Figure 7-3) developed for the current study. The Q(A)c and C2 maps are similar, although there are several areas in this interpretation (Figure 7-5) that are from 50 to 300 feet higher in elevation than shown in the current study. The differences are probably attributable to the finer scale of the current study. The elevations of the Q(B)c layer, typically at about -100 feet, appear to be most similar with those of the C4 unit (Figure 7-9). However, in the Lake Burien area, the lower elevation values of the Q(B)c layer compare best with the C5 unit (Figure 7-11).

A north-south trending zone of direct contact between Qva (C1) and Q(A)c (C2) units is identified by Woodward et al. (1995) with the south end of the 4000 foot wide (east-west) zone positioned just off the northeast corner of STIA. This zone extends about 12,000 feet northward, encompassing about 700 acres. The zone is intersected by cross sections A-A', D-D', and E-E' in Township 23N/Range 4E/Sections 15, 16, 21, and 22. Direct C1-C2 contact is inferred by the current study only at the north end of section D-D'.

The cross sections of the current study inferred a number of C1-C2 contacts, primarily near STIA, but also at Arrow Lake and the south end of the study area on section B-B'. The lateral extent and continuity of these C1-C2 contacts is uncertain, but the geologic interpretations suggest that the pattern is complex. The model assumes continuity between most of the identified points of C1-C2 contact and projects a large area of contact underlying STIA. This area can be seen as the absence of the F2 unit at STIA in Figure 7-4.

5.4.8 Vaccaro et al.

Vaccaro et al. (1998) analyzed and modeled the hydrology of the Puget Sound Lowland on a regional scale. The regional hydrologic stratigraphy of Vaccaro et al. (1998) is three part: river valley aquifers, Fraser Aquifer, and Puget Aquifer. The Fraser Aquifer corresponds to the C1 (Qva) aquifer. The alternating sequence of fine and coarse sediments within the Puget Aquifer is acknowledged, but those layers are not differentiated in the regional analysis. The authors surmise that significant regional flows are not present, but that the Puget Sound aquifer system contains isolated, subregional flow systems. This conclusion is consistent with our interpretations of limited lateral extent of aquifer units and connections between aquifer units within the STIA study area.

5.4.9 Robinson & Noble

For the Highline Water District, Robinson & Noble (1998) performed an evaluation of the regional groundwater system and ranked options for increasing the District's production capacity. The work thus addressed both hydrology and water rights. In their report, Robinson & Noble used the three aquifer system developed by Woodward et al. (1995) to defining the area's hydrology. They note that the Q(A)c and Q(B)c layers may contain entire glacial sequences, including a discontinuous fine till layer. The presence of intervening fine layers appears consistent with the finer subdivisions defined by the current study (Tables 4-1 and 5-1).

5.5 Hydraulic Properties

5.5.1 Scope

This portion of the study reports collection and calculation of hydraulic parameter data from previously compiled records, reports, and well test data. Where sufficient information was available, the study made new estimates of parameters (transmissivity and conductivity) from well performance data (i.e., specific capacity). The hydraulic parameter data were then correlated with the hydrostratigraphic units.

A spreadsheet was developed to compile, calculate, and compare the hydraulic parameter data. The required hydraulic parameter, well construction, and hydrostratigraphic unit information was extracted by query from the Port's database (Port of Seattle, 2003b). An average value of conductivity was calculated for each well and also for each individual test type. All averages were calculated geometrically (Bouwer, 1978). The horizontal hydraulic conductivity data were then condensed in several ways. The spreadsheet and the calculated averages were provided as a range of input parameters for the groundwater modeling process (Section 7).

Well behavior was assumed to be the same for both perforated casing and well screen designs. No open-end wells were identified in the data set.

The following subsections:

- review the data sources,
- define the hydraulic parameters,
- define the types of aquifer tests and analyses,
- describe the estimation of transmissivity values from specific capacity data,
- compare slug test results with other tests,
- review the results of laboratory tests, and
- compare the hydraulic conductivity results with previous work.

Appendix D lists identifying and location information, construction details, screened hydrostratigraphic units, and water level data for wells used in the analysis. Appendix E lists the hydraulic conductivity and storage coefficient data for each test type performed on each well. As noted previously, data are geometrically averaged where there were more than one test of a given type on a well. The wells are sorted by the screened hydrostratigraphic unit. Table 5-2 summarizes the hydraulic conductivity data. Results for each hydrostratigraphic unit are presented as an average by well and an average weighted by test type. The average for each test type within each unit is also given.

5.5.2 Data Sources

Hydraulic parameter data and all data used to generate hydraulic parameters for the STIA Groundwater Study were entered into the Environmental Management Information System (EMIS) administered by the Port of Seattle (2003). The data used for the hydrological interpretations of this section include well construction details, well test results, and hydrostratigraphic interpretations as well as previously reported hydraulic parameters.

The primary data sources of drillers' logs and well reports were compiled from a study of southwestern King County groundwater resources by Luzier (1969), USGS well database records (U.S. Geological Survey, 1997), a summary of groundwater data by the South King County Ground Water Advisory Committee (1991), the collection of water well reports held by the Washington Department of Ecology (2003), and numerous reports prepared by consultants for STIA environmental investigations and for public water districts. After information from those sources was entered into the EMIS database, well data from Seattle and King County Public Health (2001a and 2001b) and the Washington State Department of Health (2002) were compared to entries in the database. No additional wells were found as a result of this review process. Public Health data for Group A[3] wells were used to improve well locations (14 records) and refine well status,

[3] Group A wells are defined as public water systems that regularly serve 15 or more residential connections or 25 or more people/day for 60 or more days/year (Washington State Department of Health, 2004).

owner name, and/or depth information (26 records). Review of Department of Health data on Group A and Group B[4] wells resulted in minimal changes to EMIS data.

In a number of cases, different test types and/or test analyses were available for a single well. For some wells, consultants had previously calculated hydraulic parameter values. All tests and results were included in the compilation as they were originally reported. In addition, new calculations for transmissivity were made from all available specific capacity data.

Hydrostratigraphic units, which define the particular aquifer screened by a well, were developed during this study (Section 4) and entered into the EMIS database.

5.5.3 Definitions of Hydraulic Parameters

The hydraulic parameters used to characterize aquifer systems include transmissivity, hydraulic conductivity (or permeability), specific capacity, and storage coefficient.

<u>Transmissivity</u> (T) is a measure of an aquifer's ability to produce flow. Specifically, transmissivity is the flow rate from a unit width of the aquifer under a unit hydraulic gradient. Transmissivity values will increase with aquifer thickness (assuming identical soils). Measurements units are gallons per day per foot of water (gpd/ft).

<u>Hydraulic conductivity</u> (K), or permeability, is a measure of a soil's ability to transmit flow. The conductivity relates the driving pressure (head) to the flow. For a given head, a higher conductivity results in a greater flow rate. Measurement units used in this study are centimeters per second (1 cm/sec = 0.0328 ft/sec = 2835 ft/day).

Hydraulic conductivity is related to transmissivity by the aquifer thickness (b):

$$K = \frac{T}{b}$$

An appropriate value of aquifer thickness must be selected for calculation of hydraulic conductivity. The selection of appropriate values of aquifer thickness is discussed in Appendix F.

Hydraulic conductivity can vary in both the horizontal and vertical dimensions. All reported values are horizontal conductivity. The small-scale horizontal layering observed in glacial tills and sedimentary deposits preferentially hinders vertical flow. Vertical conductivity for glacial aquifers is typically assumed to be about one-tenth the horizontal conductivity (e.g. Vaccaro et al., 1998).

<u>Specific capacity</u> is a measure of a well's productivity and is calculated as the flow rate divided by the drawdown. Transmissivity may be directly calculated from specific capacity when the test duration and well radius are also known.

The <u>storage coefficient</u> (S) is a dimensionless measure of the relationship between the volume of water removed from or added to an aquifer, and the change in head. Storage coefficient is calculated as the volume of water withdrawn per amount of drawdown per

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[4] Group B wells are defined as public water systems that serves less than 15 or more residential connections and less than 25 people/day or 25 or more people/day during fewer than 60 days/year (Washington State Department of Health, 2004).

unit aquifer area. For unconfined (water table) aquifers, the value of S will be high, 0.01 to 0.3 (Driscoll, 1986), and reflects the porosity of the soil structure. For confined (artesian) aquifers, S will be in the range 1 x 10^{-3} to 1 x 10^{-5}. In confined aquifers, the release of water observed with a drop in head is due to the slight expansion of the confined water and the compression of the soil structure when pressure in the aquifer is relieved during pumping (Driscoll, 1986).

5.5.4 Types of Aquifer Tests and Analyses

Transmissivity values are obtainable from four types of tests: well performance tests, pump tests, slug tests, and laboratory analyses.

A well performance test is a simple test of a well's production capacity. Water is withdrawn, by pumping or bailing, at a constant rate for a period of time and the drawdown recorded at the end of the test. The tests reviewed in this study averaged 14 hours, but ranged from a fraction of an hour up to seven days in duration. Well performance testing is typically performed at the time of well installation by the drilling contractor.

The simplest estimate of transmissivity is made from the well's specific capacity. Analysis requires that pump rate, drawdown, test duration, effective radius, and storage coefficient be known. A value of the storage coefficient must be assumed. Where aquifer thickness is known, the results may also be corrected for partial penetration. When a step test (variable flow rate) has been conducted, a correction for well loss may also be made. Appendix F gives the equations used by this study for the calculation of transmissivity from specific capacity.

Pump tests draw water from the aquifer at a high, but sustainable, rate for an extended period of time while recording the water level during the test. Data from either the pumped well or from a nearby observation well may be analyzed. Analyses generate a transmissivity value, from which hydraulic conductivity may be calculated.

For the pumped well, an analysis is performed of the water level drawdown during the test and/or the recovery of water level after the pumping is discontinued. The data is compared to the theoretical Theis curve or modifications thereof (Driscoll, 1986). In reviewing the data, the investigator may decide that an emphasis on a particular portion of the drawdown curve is appropriate. Thus, the analysis may be referred to as "early-time" or as "late-time". Analysis of recovery data also requires the test to have been conducted at a constant flow rate. Transmissivity calculated from recovery data is considered superior to that from drawdown data.

Where an observation well (located at a distance from the pumped well) was monitored, both drawdown and recovery data may be analyzed in a similar fashion as referred to above. In addition, the storage coefficient may also be calculated. If multiple observation wells are monitored, a distance drawdown analysis can also be performed. Data from observation wells are of particular value since the effects of pumping are measured over a larger distance.

A slug test suddenly raises, or lowers, the water level in a well. The behavior of the water level as the well returns to its pre-test static condition is analyzed. Depending on the recovery behavior, a number of different analytic methods may be employed (Butler, 1998). This test is relatively fast (test duration is typically measured in minutes) and therefore provides information about soils that are close to the well screen. The test estimates hydraulic conductivity, from which a transmissivity value is typically calculated. Conductivity, transmissivity, and analytic methods are usually reported.

In comparison to pump tests, slug tests tend to yield lower estimates of permeability. Thus, the slug tests should be regarded as providing a lower bound for permeability.

Laboratory tests for conductivity included Hazen's approximation using grain size distribution, other (unspecified) grain size analyses, constant head permeability tests (American Society for Testing and Materials [ASTM] D-2434), falling head permeability tests, and triaxial permeability tests.

5.5.5 Calculation of Transmissivity from Specific Capacity

For this study, transmissivity values were calculated from specific capacity for each well where sufficient data were available. This calculation was made using the Cooper-Jacob approximation of the Theis equation (Driscoll, 1986).

The Cooper-Jacob equation assumes full penetration of the aquifer by the well screen, a condition generally not met by wells in the study area. The results were therefore corrected for partial penetration using two methods. These were the Ferris modification of the Theis equation (Bradbury and Rothschild, 1985) and the Kozeny equation (Driscoll, 1986). Both methods gave similar results. The resulting conductivity calculations compared best when (1) the full aquifer thickness was used for data corrected for partial penetration, (2) the full aquifer thickness was used for cases with partial penetration greater than 50 percent and (3) twice the screen length was used for uncorrected data with partial penetration less than 50 percent. Equations and further detail on the analytic methods are provided in Appendix F.

In five cases, the specific capacity was also corrected for well loss (Driscoll, 1986). Well loss was calculated from step test data for four wells and reported for one well. For three wells, the hydraulic conductivity values increased by a factor of about two; for the other two wells, the increases were insignificant (0 percent and 14 percent).

In this study, the calculation of transmissivity from specific capacity data required assumption of a value for the storage coefficient. In cases where a value for the storage coefficient was presented in a report, that value was used for computations. Otherwise, the aquifer was assumed to be confined and a storage coefficient of 1×10^{-4} was used. Woodward et al. (1995) selected a similar value of 1.5×10^{-5}. That difference in values would affect the calculation of hydraulic conductivity from specific capacity by only about 5 percent. That value is not significant since the estimations of conductivity values are at best accurate to a factor of three. However, the C1 unit appears to be primarily unconfined within the study area. In this case, a value of 0.01 to 0.3 for the storage coefficient would be more appropriate (Driscoll, 1986). Treating the unconfined aquifer as confined raised the hydraulic conductivity value by a factor of about 1.7. This value is within the estimated accuracy range of the parameter.

No attempt was made to correlate transmissivity values obtained from specific capacity with values derived from other, presumably more accurate, methods. Razack and Huntley (1991) analyzed a set of 215 data pairs and found that subsets of 10 pairs provided no useful prediction of transmissivity. This study's data set did not meet even that minimal condition. The most tested aquifer unit, C2, had only seven wells with correlating transmissivity data from other analytical methods.

5.5.6 Comparison of Slug and Pump Tests

As expected, slug tests results yielded lower estimates of hydraulic conductivity than well performance or pump tests. The difference in conductivity between slug tests and well or pump tests (on different wells) within an aquifer unit was typically an order of magnitude for the wells reviewed (Table 5-3).

There are two possible contributions to the difference. Both are due to the fact that pump tests were usually performed on production wells, while all slug tests were conducted on monitoring wells. First, the most permeable portion of the soil column encountered in a production well boring would be screened, while monitoring wells are not subject to that constraint. Second, the development of production wells is generally superior to that of monitoring wells. Selection of the most permeable zones in production wells could bias conductivity values (of a coarse grain unit) on the high side, whereas a lesser degree of development in monitoring wells would bias results lower than actual conditions. The combination of these two effects may explain the difference in conductivity values observed between pump tests and slug tests.

Hydrostratigraphic unit C1 (Qva) was an exception. Conductivity values were similar for both slug and well performance tests. The lack of a difference between test types may reflect small sample size (three) and poor performance. Two of the three pumped wells had specific capacities of only 0.5 gpm/ft. Areal distribution could also be significant. The ten slug tests were conducted within the AOMA (8 wells) and south of Lora Lake (2 wells), whereas the three pump test wells were located away from the airport at one mile east of Bow Lake, north of Gilliam Creek, and in the northwest corner of the study area, respectively.

5.5.7 Results of Laboratory Tests

Results of the laboratory tests varied by a factor of 1000, both higher and lower, from the respective slug test results for a boring. Laboratory test results, averaged by well, are reported in Appendix E, but those conductivity values were not included in the summary averages due to the large differences with *in situ* test results.

5.5.8 Hydraulic Conductivity Values

The average conductivity values generated in the current study were about 6×10^{-3} for C1 and 2×10^{-2} for the deeper aquifers (Table 5-2). The lower permeability of C1, relative to other coarse units, is consistent with the tighter formations of fine and medium sand that dominate the C1 unit, although both gravelly and silty zones were also present.

The similarity of values among the lower aquifers is consistent with the similarity of the gravel-dominated soil types for the lower coarse units. Higher conductivity values for units C2 and below, relative to unit C1, are expected for the coarser soil types. Those conductivity values may represent an upper limit for the deeper aquifers, since the most permeable zones would have been preferentially selected for the screen locations of production wells and thus bias the data upward.

The C2 and deeper aquifers also appear to have a significant range of grain sizes within units. A large range in grain sizes would imply a large range in hydraulic conductivity values within a given unit. The range of grain sizes may be due to the categorization of multiple geologic units (glacial and non-glacial) together.

5.5.8.1 Comparison with Previous Estimates

Woodward et al. (1995) calculated hydraulic conductivity values from specific capacity data for wells in southwestern King County. In order to make a comparison with the current study, we averaged the hydraulic conductivity values of wells in the Woodward study that were located within the Des Moines Quadrangle. Those and other averages of hydraulic conductivity were all calculated geometrically following recommendations by Bouwer (1978).

For the Qva (C1) unit in Woodward et al. (1995), an average conductivity of 1.7 x 10^{-2} cm/sec was obtained for four wells. For the Q(A)c unit, data from 21 wells averaged at 1.2 x 10^{-2} cm/sec. The Q(A)c unit appears to include both C2 and C3 units. Woodward et al. also concluded that conductivity decreased with depth (from recent alluvial deposits Qal, to Qva, and to the Q(A)c and A(B)c units). Neither well data nor analytical techniques were reported.

The values of hydraulic conductivity from the current study compare reasonably well with the results from Woodward et al. (1995). The differences between the two studies are less than a factor of three and therefore within the accuracy of the test data. The current study indicates that the lower coarse units are relatively more permeable than the C1 (Qva) unit. Woodward et al.'s observation of a decrease of conductivity with depth was not supported. A more refined comparison would require an examination of the unreported data and analytic techniques used by Woodward et al. (1995).

5.6 Groundwater Occurrence and Flow

5.6.1 Water Elevation Data

Observed static water level data have been used to create elevation contour maps for hydrostratigraphic units C1, C2, and C3 (Figures 5-2, 5-3, and 5-4). Data were insufficient to develop maps for the deeper aquifer units (C4, C5 and C6).

These elevation contours represent either the top of the water table (unconfined aquifers) or the potentiometric surface (confined aquifers). For an unconfined or water table aquifer, the water surface is in direct communication with the atmosphere at the point of measurement. The elevation contours thus represent the actual water surface. For a confined aquifer, the top of the aquifer unit is locally covered by a fine grained aquitard that limits the movement of water, but allows water to be under pressure at the point of measurement. Elevation contours for a confined aquifer define the potentiometric surface, which represents the hydraulic pressure, not the actual level of water.

Several considerations are important for interpretation of the elevation contour data:

- An aquifer can be confined in one location and unconfined in another. For example, the C2 unit (on Cross Section A-A', see Figure 4-5) is primarily confined and the hydraulic pressure is above the top of the actual hydrostratigraphic unit. However, the C2 aquifer becomes unconfined at the west end of the section, where the unit outcrops on the slope.
- Aquifers can be in direct contact. As an example, there are multiple contacts between units C1 and C2 in the study area. Lower units show fewer connections, but the geological information also becomes sparser with depth, and the hydrostratigraphic interpretations are more generalized. Where in contact, two aquifers will exhibit small differences in static water level.
- Although the contours are based on observed water levels, the contours are generated by a best fit approximation. Thus, the elevation contours are an interpretation of the data.
- The water level measurements used to generate the contours were taken over a wide time period. Therefore, the elevation contours as presented represent a temporal generalization and no inferences about long term changes may be made from the figures.
- In general, the degree of confidence in the hydrogeologic interpretations decreases with depth. Given the size of the study area, there are relatively few deep well logs available to characterize the hydrostratigraphy of the deep aquifer zones.
- With the exception of shallow geotechnical borings near the airport, much of the soil data was not logged by geologists or geologic engineers. Non-standard soil descriptions can be difficult to interpret.

5.6.2 Groundwater Elevation Contours and Flow Paths

Groundwater movement is described in terms of groundwater elevations (the water table of unconfined units or the piezometric surface of confined aquifers) and flow paths. Groundwater elevations are presented as contours of the measured heads. This analysis assumes for each aquifer, or coarse hydrostratigraphic unit, that flows always move from areas of high head to areas of low heads. Flow directions are always perpendicular to the contours.

5.6.2.1 Perched Groundwater

Perched groundwater exists within the upper C0, F0, and F1 layers in places where relatively impermeable soils retard infiltration and allow the retention of water. The geologic conditions conducive to perching are complex, variable, and site specific. Perched groundwater zones appear to vary from a single saturated area of about 1 acre in extent (United Air Lines Fuel Farm/Continental Airlines Fuel Farm [UNFUF/CONFF] site) to a discontinuous zone of variable saturation (Northwest Airlines Bulk Fuel Farm [NWBFF] site) (Aspect Consulting, 2003).

On the scale of the airport, flow of perched groundwater is primarily vertical, downward. On the scale of the Agreed Order sites, flow can also be lateral (Figure 5-1). Anthropogenic infrastructure, including foundations and subsurface utility lines (SUL), can potentially affect the natural flow paths by providing low permeability paths for either vertical or lateral flow. Extensive lateral flow, such as from the AOMA to the 3rd Runway area, via SUL preferential pathways, appears unlikely (AESI, 2001 and Aspect Consulting, 2003).

5.6.2.2 C1, C2 and C3 Groundwater Aquifers

Groundwater elevation contours were developed from observed water levels. Water level data were used from wells that were screened only in the single unit of interest. Wells completed in multiple units were excluded from contouring. For static water levels, values recorded at-time-of-drilling were used only if no other data were available. Otherwise, the median value of all other water level records for a well was calculated, thus mitigating the effect of data outliers. The C1, C2, and C3 groundwater contours were based on approximately 150, 98, and 42 wells, respectively. For the C1 unit, additional contour control points along Miller, Walker, Des Moines, and Gilliam Creeks were used to define the water surface. These control points forced the contours to the level of the stream in those areas where the stream had eroded into the C1 unit, allowing for groundwater to discharge to the surface water body.

The potentiometric groundwater contours were computer generated using the program Surfer® (Golden Software, 2002), and then adjusted where necessary to run parallel with seepage faces in the study area. The contours were cropped to the model unit boundary and queried in zones without data.

Groundwater contour maps were developed for the C1, C2, and C3 hydrostratigraphic units (Figures 5-2, 5-3, and 5-4). All three maps exhibit a general north-south groundwater divide. The C1 and C2 contours also show a groundwater ridge located between the Miller Creek and Des Moines Creek basins. On the scale of the study area, the C1 unit is typically unconfined except in the topographic low area around Angle Lake, where a comparison of water levels with top-of-unit C1 elevations indicate that the unit is confined. The C2 aquifer appears confined except at seepage faces along creek drainages and the west and east sides of the Des Moines Upland. The C3 unit is confined except at seepages faces along the edges of the Upland.

The potentiometric surface of the C1 aquifer varies from highs at 300 to 375 feet (elevation NGVD 29) to lows along the east and west side of the study area at about 250 feet. For the C2 unit, the highs are at roughly 300 to 325 feet and lows are about 150 feet on the west and 75 feet on the east. In the C3 aquifer, highs are at 250 to 275 feet with lows at 25 to 50 feet along the sides of the Upland. Along the drainage faces on sides of the Des Moines Upland, the local confined heads (i.e., the head above the top of a unit) appear to drop to low values, probably as a result of seepage.

Groundwater flow for all three units appears generally east and west from the predominately north-south divides, into the Duwamish/Green River valley or into Puget Sound, respectively. The flow directions are locally modified where drainages are incised into the C1 and C2 units. The drainages of Miller and Des Moines Creeks noticeably affect the contours for both C1 and C2 units and the Gilliam Creek drainage additionally affects C1.

Within the AOMA, groundwater flow in the C1 and C2 units appears to be primarily from east to west. Both Figures 5-2 and 5-3 suggest weak groundwater ridges running east-west through the center of the main terminal complex. North of the respective ridges, groundwater flows toward the headwaters of Walker Creek. South of those ridges, groundwater flows west and then turns south toward both forks of Des Moines Creek.

The changes in flow direction at the south end of the AOMA are difficult to precisely locate at the scale of the study area. The interpretation of observed water levels in Figure 5-2 suggest that, south of South Satellite Terminal, the westerly flow turns south before reaching the west boundary of the AOMA. A previous report (Aspect Consulting, 2003) estimated southerly to south-westerly flow throughout that south end of the AOMA boundary. On the other hand, the model contours (Figure 7-14) suggest that the flow turns only slightly south of west while within the AOMA. Additional review of the geology, water level data, and control points in the southern AOMA and upper Des Moines Creek area would help clarify, but may not fully determine, the most likely flow paths.

Groundwater flow directions are uncertain for the C4, C5, and C6 aquifers. Available groundwater level data are too limited for development of an accurate groundwater flow map. Rising bedrock at the north and northeast portions of the study area would limit deep groundwater flow in those areas. Below sea level, subsurface loses are expected west into Puget Sound. Along the east and west study area boundaries, there appears to be a continuous connection, and thus possible flows, for the aquifers below sea level.

5.6.3 Seasonal Effects

A detailed interpretation of the C1 water table was made for a full water year in a one square mile area at the south end of airport (AESI, August 1, 2000). This study evaluated Qva groundwater flow in the AOMA and its near vicinity in fulfillment of Agreed Order Task IV-2. Thirteen wells representative of the AOMA and vicinity, and four wells in the Third Runway area, were selected for observation. Six of the wells were equipped with data loggers. The groundwater elevation contours (Figures 5-5, 5-6, 5-7, and 5-8) show a small water level increase of about 1 foot at the southeast corner of the airport as a result of winter precipitation. The down gradient head west of the AOMA remained stable throughout the year. The groundwater contours exhibited directions of flow slightly north of west and were consistent during the period of monitoring.

Longer term effects are shown in hydrographs for selected wells in the study area for data collected water years 1983 through 2003. The locations and screened hydrostratigraphic units for the wells are shown in Figure 5-9. The uneven distribution of wells reflects the availability of data from previous work at specific sites.

Hydrographs for select wells completed in the C1 (Qva) aquifer are presented in Figure 5-10 and, at a finer scale, in Figure 5-11. Most of the data were collected near the airport and indicate the general level of the C1 water table at about 310-foot elevation in the airport vicinity. The water level of IWSLG_MW-104 at about 285 feet is coincident with the lower ground surface south of the runways. Well 3RDRW_A3-B9 has a water level elevation slightly above 230 feet. The well is located about 2,000 feet from the Des Moines Creek drainage where the geologic interpretation shows the C1 unit exposed on the side slope. The relatively low water level is probably due to both the lower elevation of the C1 unit and groundwater flow from the unit into the Des Moines Creek drainage.

The multi-year history of C1 data at STIA indicates that groundwater elevation does respond to changes in precipitation. Figure 5-11 plots the cumulative precipitation departure for water years 1987 through 2003 along with the C1 hydrographs. The graph shows 4- to 7-foot variations in C1 water levels that correlate with the cumulative departure curve. Seasonal variations, on the order of 1 foot, are evident for wells with at least monthly recording intervals.

Hydrographs for wells in the C2, C3, and C4 units are presented in Figure 5-12. The data indicate that seasonal sensitivity to precipitation varies in the range of one to nine feet and suggest that the variation may increase with depth. The hydrographs are insufficient to show any long term trends.

5.7 Water Budget Components

5.7.1 Precipitation Recharge

Precipitation is considered to be the primary source of recharge for aquifers in the study area. Infiltration occurs primarily in areas that have not been covered with impermeable surfaces. Precipitation initially infiltrates into and through the uppermost soils (typically C0, FO, and F1 units) and, where conditions dictate, is sometimes retained as perched groundwater. The infiltration path continues downward, recharging the highest aquifer unit. Deeper aquifer zones are recharged via seepage through fine soils or directly from an overlying aquifer where the units are in contact. The lower aquifer units are also probably recharged by lateral migration of groundwater from outside the study area. The rate and direction of infiltration are strongly dependent on specific geologic conditions and on soil moisture levels.

Recharge for the study site has been estimated for the Miller and Des Moines Creek basins (Parametrix, 2001) and, more generally, for south King County (Woodward et al., 1995). A precipitation recharge map (Figure 5-16) for the study area was generated using the basin recharge estimates supplemented by the King County data.

5.7.2 Groundwater Resource Development

5.7.2.1 Beneficial Use of Groundwater

Washington State Department of Ecology records indicate that over 250 water supply wells and over 375 monitoring wells have been completed within the boundaries of the groundwater study area. The majority of the private water supply wells are probably no longer used because most residences and businesses obtain their water from one of the three municipal water purveyors that service the area. These three suppliers are the City of Seattle, the Highline Water District, and the King County Water District #54. Two significant irrigation wells in the study area are the Old Tyee Golf Course Well and the Washington Memorial Well. Figure 3-1 illustrates the locations of the water supply and the irrigation wells. Well location, construction, and pumpage data are summarized in Table 5-3 and described in further detail below.

5.7.2.2 City of Seattle, Highline Well Field

The City of Seattle operates three extraction/injection wells (Boulevard Park No. 1 and Riverton Heights No. 1 and No. 2) on an as needed basis to supplement water supply, typically during peak demand in the summer. Data regarding well location and construction are summarized in Table 5-3. All three of the City of Seattle wells are completed in the C2 aquifer and are located 0.5 to 2 miles from the north end of the airport runways. The city has used this well field for an Aquifer Storage and Recovery (ASR) program in an attempt to avoid excessive drawdown of water levels in the aquifer. The City of Seattle has periodically injected surface water into the wells in the winter following summer extraction periods, if water levels did not rise to pre-pumping conditions at the end of the wet season in May of any year (Dally Environmental, 1997). Monthly and annual total pumpage data for water years 1990 through 2003 are plotted on Figure 5-13. Negative values represent injection as part of the ASR program; positive values represent withdrawal. Annual groundwater extraction from the Boulevard Park well averaged 84 million gallons (mgal) during the 1990 to 2003 period. For the same period, the combined production of Riverton Heights Nos. 1 and 2 averaged 229 mgal.

5.7.2.3 Highline Water District

The Highline Water District operates two extraction wells (Des Moines and Angle Lake) on a year-round basis. Well data are shown in Table 5-3. Both wells are completed in the C4 aquifer and are located approximately 1 mile south of the runways (Figure 3-1). Annual groundwater extraction averaged 165 and 125 mgal for the Des Moines and Angle Lake wells, respectively, for water years 1997 through 2002 (Figure 5-14). The Highline Water District recently constructed a third water supply well, the Tyee Well, on the Tyee Golf Course, approximately 1/2 mile south of the runways. (The Tyee Well should not to be confused with the Old Tyee Golf Course Well, which is located about 350 feet to the southeast of the Tyee Well.) The Tyee Well has a water right for 600 acre-feet (196 mgal) of groundwater per year according to Robinson & Noble (2001). It appears that the Highline Water District intends to use the Tyee Well to supplement existing supply during summer peak demand. Robinson & Noble (2001) reported that the well is capable of producing 830 gallons per minute (gpm) for a period of 100 days before the water level in the aquifer is drawn down to the pump intake.

5.7.2.4 King County Water District #54

The King County Water District #54 operates three extraction wells (#4, #5, and #6) on a year-round basis in a single well field located approximately 1-3/4 miles south-southwest of the runways (Figure 3-1). Well data are shown in Table 5-3. Wells #5 and #6 are completed in the C4 and C5 aquifers, respectively, while #4 is completed in a clayey gravel horizon (F5 unit). Monthly and annual total pumpage data for water years 1997 through 2000 are given in Figure 5-15. Annual groundwater extraction averaged 34, 83, and 32 mgal for wells #4, #5, and #6, respectively, during that period.

5.7.2.5 Irrigation Wells

Two significant irrigation wells were identified in the groundwater study area. These are the Old Tyee Golf Course Well (screened in C2, C3, and C5) and the Washington Memorial Park Well No. 2 (completed in C1). The former well is located south of the airport (cross section B-B’, see Figure 4-6) and the later well is located near the east edge of the airport and Highway 99 (cross sections B-B' and H-H', see Figures 4-6 and 4-12). No measurements of the volume of water being pumped from these wells were available. The groundwater model used annual water rights to calculate withdrawals for the irrigation wells.

The Old Tyee Golf Course Well has an annual water right of 182 mgal. The Port has filed an application requesting that the use of the Old Tyee Golf Course Well be changed from domestic to irrigation (Port of Seattle, 2004 and Segerson, 2004). Based on power records and assumed system performance parameters, the highest annual water use from the Old Tyee Golf Course Well between 1992 and 2002 was estimated at 30 million gallons (91 acre-feet). The average annual estimate was 22 mgal (68 acre-feet). Using an alternate method, based on irrigation requirements, annual use was estimated as 48 mgal (149 acre-feet).

The water right for the Washington Memorial well is 42 mgal/yr. A usage estimate of 63 mgal/yr, based on the weekly application of one inch of water on 89 acres for a period of 6 months, suggests that the full water right may be used.

6 Contamination Sources and Risk Evaluation Criteria

The Agreed Order requires the Port to identify known and potential areas of groundwater contamination within the AOMA and its near vicinity. The overall purpose of this evaluation is to determine the known and potential sites at STIA appropriate for consideration of groundwater flow and contaminant fate and transport modeling.

Known sites consist of those facilities or operations within the AOMA that have contaminants present in groundwater and/or significant soil contamination. The Agreed Order lists the known sites as identified as of January 1999 (Ecology, 1999; see Agreed Order Appendix 1). An additional known site, Rental Car Quick Turnaround Area (QTA Tank Area) facility, has recently been identified as impacting soil and groundwater in the AOMA and has been added for evaluation under this study. A potential site list has also been developed by the Port which includes those sites that, based on historical operations, may have impacted groundwater. Figure 6-1 shows the general location within STIA of the known Agreed Order sites and the potential sites evaluated for this study. Additional details on the known and potential sites are presented in the following sections.

6.1 Identified Spills and Releases

6.1.1 Agreed Order Sites

The thirteen sites located within the STIA AOMA that are known to have contaminants present in groundwater or contain significant soil contamination are listed in the Agreed Order. Environmental investigations identifying the nature and extent of contamination have been conducted at these facilities by either the responsible airline or other tenant or the Port. Data from these investigations were used as the basis in evaluating the current impact to the Qva aquifer and developing subsequent contaminant modeling predictions. Table 6-1 presents a summary matrix of the environmental conditions associated with the Agreed Order sites. Section 9 presents a reference list of reports for each of the Agreed Order sites. These reports represent the details of the environmental investigations, remedial actions and long term monitoring completed at each of the Agreed Order sites. A brief summary of the 13 sites follows.

Budget Auto Facility

The Budget Auto Facility (BDGLP) site is located in the central portion of the AOMA adjacent to the STIA parking structure (Figure 6-1). An automotive fuel (gasoline) pipeline leak was first identified by a loss of fuel inventory in 1990. The leak was repaired. The associated UST system was removed in 1993. Soil borings completed as monitoring wells have been used during multiple investigations of the pipeline leak site to evaluate the presence of gasoline hydrocarbons in soil and Qva groundwater. Free product was identified on the Qva aquifer groundwater surface at approximately 40 feet bgs in two wells at the site. A groundwater and liquid phase hydrocarbon recovery system and vapor extraction system were installed in 1990 before the tanks were removed, and were operated until 1994. An expanded vapor extraction system was operated from 1997 until mid 2004. Dissolved gasoline hydrocarbon compounds including benzene, ethylbenzene, and xylene have been detected at concentrations above MTCA Method A Cleanup Levels. The results of groundwater monitoring show a decrease in gasoline hydrocarbon concentrations in several wells at the site, and an absence of free product since 1995. Perched groundwater was not identified during investigations of the site.

Concourse B/Gate B-2

The Concourse B/Gate B-2 site is located on the south side of Concourse B in the north-central portion of the AOMA (Figure 6-1). Petroleum hydrocarbons (PHC) (Jet A) were first detected adjacent to underground jet fuel hydrant pipelines at Gate B-2 during a geotechnical study conducted in 1991 (Shannon & Wilson 1991). Monitoring wells and/or soil borings were completed during multiple environmental investigations conducted between 1991 through 1993 and in 1998 to evaluate the presence of petroleum hydrocarbons and benzene, toluene, ethylbenzene, and xylene (BTEX) in soil and groundwater.

Petroleum hydrocarbons and BTEX compounds were detected in soil from approximately 10 feet to approximately 80 feet bgs at concentrations above MTCA Method A Cleanup Levels. The lateral extent of soil contamination is estimated to be limited to soils east of and beneath Concourse B and in close proximity to Gate B-2. Petroleum contamination was detected in Qva aquifer groundwater west and down gradient of Gate B-2. Petroleum hydrocarbon compounds and xylene were detected at concentrations at or below MTCA Method A Groundwater Cleanup Levels in groundwater east of Concourse B. Neither free product nor perched groundwater was observed during site investigations. Periodic groundwater monitoring has demonstrated stable contaminant levels in the Qva groundwater. Removal of impacted soil during the 2001 through 2004 capital improvement project construction reduced the source area at the site, however, soil removal actions were limited by logistical constraints at the site.

Continental Airlines Hydrant System

The former Continental Airlines Hydrant System was located adjacent to Concourse C on the northwestern portion of the AOMA (Figure 6-1). The former Continental Hydrant System distributed jet fuel (Jet A) from the Continental fuel farm to aircraft at Concourse C. The hydrant system consisted of approximately 4,000 feet of underground piping and 16 hydrant valve pits. The system was operated between 1973 and 1991. In March 1994, an initial site closure assessment was conducted along the entire length of the hydrant system. Characterization of environmental conditions associated with the Continental hydrant system was completed in September 1999. Soil borings were completed at 100-foot intervals along the fuel pipeline and at 50-foot intervals adjacent to hydrant valve pits to evaluate soil conditions. Jet fuel concentrations in soil above the MTCA Method A Cleanup Levels were detected in 16 locations. The lateral extent of jet fuel contamination appears localized to specific hydrant valve pits, low points drains, and a high point vent. Groundwater was not encountered in the borings completed along the hydrant pipeline during the site investigation. Based on a site-specific TPH as Jet A soil cleanup level, Ecology granted MTCA No Further Action (NFA) status for the hydrant system in October 2003.

Delta Airlines Auto Gas Tank Cluster

The former Delta Auto Gas Tank Cluster site is located in the southeastern portion of the AOMA and adjacent to the western side of the former Delta south hangar (Figure 6-1). The site formerly contained five USTs providing storage for gasoline, mineral spirits, ethylene glycol, and waste oil. A release of petroleum hydrocarbons (gasoline) was first identified at the site based on results of a site assessment that was conducted in 1989. The site USTs were removed in 1992. Subsequent investigations of the site included installation of additional groundwater monitoring wells and groundwater sampling and analysis to evaluate the extent of groundwater contamination.

Volatile organic compounds (VOCs) were detected in soils to approximately 30 feet deep at concentrations below MTCA standards in borings during the site assessment conducted in 1989. Gasoline contamination in soil was limited to the area immediately adjacent to the former UST location. Some impacted soil was removed and treated during UST excavation and removal activities in 1992. Excavation activities associated with the 2000 through 2001 capital improvement projects removed all or nearly all remaining impacted soil and the perched groundwater around the former tank area.

Petroleum hydrocarbon compounds and VOCs were detected at the site in perched groundwater at between 18 and 23 feet bgs. Free product was measured in two monitoring wells installed in shallow perched groundwater adjacent to the south side of the former location of the USTs. In 2000, the free product was effectively removed during the excavation of the impacted soil in the vicinity of the former tank area. Low levels of VOCs were detected in monitoring wells installed in the Qva aquifer during groundwater monitoring activities completed through 1998.

Delta Airlines Fuel Farm

The former Delta Air Lines Fuel Farm is located in the southeast portion of the AOMA adjacent to the former Northwest Airlines Fuel Farm (Figure 6-1). The former Delta Fuel Farm consisted of three jet fuel USTs and associated pumps, filters, and piping that provided fuel to the former Delta Hydrant System located at Concourse B. A release of petroleum hydrocarbons was first identified during a site assessment conducted in 1989. The tanks and associated pipeline system were leak tested in 1993 and 1995 and no leaks were detected in the system. Soil borings and monitoring wells were used in multiple investigations of the site to evaluate the extent of soil and groundwater contamination.

Borings were drilled to the Qva aquifer, at depths between 50 and 57 feet bgs. Petroleum hydrocarbon compounds including toluene, ethylbenzene, and xylene were detected in soil in close proximity to the USTs, from the surface to 30 feet bgs. The petroleum hydrocarbon concentration in shallow soil in several locations was above the MTCA Method A Cleanup Levels. Toluene, ethylbenzene, and xylene were detected in soil samples collected from soil borings adjacent to the USTs at depths between 50 and 57 feet bgs at concentrations well below MTCA Method A Cleanup Levels. Free product was detected in 1991 and 1992 in wells installed in perched groundwater at depths less than 20 feet bgs. Removal of free product was initiated as a remedial action. Delta Air

Lines decommissioned the tank farm by removal of its tanks in 1999, and conducted site remediation. Significant excavation of impacted soil occurred during the 2001 through 2004 STIA capital improvement project construction. Based on a site-specific TPH as Jet A soil cleanup level, Ecology granted a MTCA no further action status for both the fuel farm and the associated hydrant system in March 2004.

Northwest Airlines Hangar Tanks

The former Northwest Airlines Hangar Tanks site was located in the southeastern portion of the AOMA (Figure 6-1). The site was located adjacent to the east side of the former Northwest Airlines hangar before the hangar was demolished as part to the South Terminal Expansion Project (STEP). The site formerly contained five USTs that provided storage for mineral spirits, used oil, and fuel oil. A release to soil and groundwater from the USTs was first discovered during a site assessment conducted in 1990. The USTs were removed from four separate excavations later in 1990. During the removal of three USTs (mineral spirits, used mineral spirits, and used oil USTs) from two excavations, visible signs of product release were observed. Soil borings and monitoring wells have been used during multiple site investigations to evaluate the nature and extent of contaminants at the site. Interim remedial activities were performed at the site including soil excavation, soil vapor extraction, bioventing, and product removal. Additional soil was removed at the site during capital improvement construction projects during 2001 through 2004. A chlorinated solvent plume has been detected in the Qva aquifer with a source attributable to the former hangar tanks.

Northwest Airlines Fuel Farm

The former Northwest Airlines Fuel Farm was located in the southeast portion of the AOMA (Figure 6-1). The fuel farm consisted of 14 jet fuel USTs and associated pumps, filters, and piping that supplied fuel to the former Northwest hydrant system (both the "abandoned" and "closed" systems, see below).

Petroleum hydrocarbon contamination was first identified in soil east of the fuel farm in 1985 during a geotechnical investigation. Multiple environmental investigations have been completed to evaluate the extent of soil and groundwater contamination. Operation of the fuel farm was suspended in 1996 and UST removal and closure of the fuel farm was completed in 1998. Bioventing in the tank backfill area was performed, following tank removal, between 1999 through 2000. Excavations associated with capital improvement projects between 2001 through 2004 removed additional impacted soil.

Petroleum hydrocarbon contamination was detected in perched and Qva aquifer groundwater at the site. Historically, free product has been measured in perched groundwater at approximately 25 feet bgs in two wells directly adjacent to the UST location. Free product has not been observed in Qva groundwater. Analytical results of Qva groundwater at approximately 60 feet bgs and adjacent to the tank farm reported petroleum hydrocarbons at concentrations above the MTCA Method A Cleanup Levels.

In addition, two leaks from Northwest Airlines Hydrant System pipelines located just outside the Northwest Fuel Farm released Jet A fuel to soil below Air Cargo Road. The first leak occurred in 1990, the second leak occurred in July 1992. Soil removal activities (limited by subsurface utilities) were conducted and additional soil borings and monitoring wells were completed to evaluate potential groundwater impacts caused by the hydrant system failure. Significant excavation of impacted soil in these locations was performed during 2001-2004 capital project construction.

Northwest Airlines Hydrant "Closed" System (also known as NWA Hydrant System [1997]

The former Northwest Airlines Hydrant System was removed from service in 1997. The hydrant system is located in the south central portion of the AOMA and extends from the former Northwest Fuel Farm to the South Satellite. The hydrant system consists of a trunk line that provided fuel to two hydrants loops. The older hydrant loop, referred to as the "abandoned" system, was taken out of service in 1976. The trunk line and the newer loop are referred to as the "closed" system, which was taken out of service in 1997.

Repeated pipeline failures have historically been documented with the closed system including releases near Air Cargo road in 1990 and 1992 and a release near the South Satellite Baggage Tunnel in 1993. Additional information about system effects to groundwater was discovered during the 1997 hydrant line characterization.

During modifications to the hydrant system laterals, five separate trenches were excavated to expose the pipeline. Soil samples were collected from the excavations to evaluate the presence of petroleum hydrocarbons. Groundwater was not encountered in the trench excavations.

Soil samples collected from several of the trench excavations contained petroleum hydrocarbons above the MTCA Method A Soil Cleanup Level. Petroleum contamination appeared to be associated with hydrant system pipelines and pipeline backfill. Additional excavation was conducted to remove petroleum contaminated soil. However, excavations were limited by the presence of the hydrant system pipelines and site pavement. The horizontal extent of petroleum hydrocarbon contamination was estimated to be limited to soils adjacent to the hydrant system laterals.

An additional focused investigation was conducted in 1997 associated with system closure. Two temporary groundwater monitoring wells were completed as part of this investigation in the Qva aquifer. Samples were reported to contain elevated levels of TPH as jet fuel.

During 2001-2004 capital project construction, significant excavation of impacted soil was performed in some of the areas where the Northwest "Closed" Hydrant system had been located.

South Satellite Baggage Tunnel (associated with the Northwest Airlines Hydrant Closed System site)

The South Satellite Baggage Tunnel site is located in the southwest portion of the AOMA near the South Satellite terminal (Figure 6-1). The site was first investigated in 1992 in response to discovery of Jet A fuel seeping into the South Satellite baggage tunnel, the result of a release from a Northwest Airlines Hydrant Closed System (1997) pipe leak. An emergency vacuum-enhanced fuel collection system was installed in the backfill material surrounding the baggage tunnel complex. The failed portion of the Northwest Airlines Hydrant System (1997) was permanently removed from service shortly after identification of the release. Northwest Airlines closed operations of the remainder of their fuel system in 1998, and sections of the Northwest Airlines Hydrant System have been removed in association with area construction projects since that time. Impacted soil has also been removed in conjunction with collocated construction projects.

Multiple investigations have been conducted since 1992 to evaluate soil and groundwater quality. Monitoring wells were installed to evaluate water quality in the Qva aquifer, which was encountered at the site at approximately 60 feet below grade. A program of groundwater monitoring and free product removal was initiated. Groundwater sampling results indicate that dissolved concentrations of TPH and xylenes at concentrations that exceed the MTCA Method A Cleanup Levels are localized. Perched groundwater was not encountered at the site.

Pan Am Airlines Avgas Tanks Site

The former Pan Am Former Avgas Tanks Site was located in the central portion of the AOMA, adjacent to the south end of the former Concourse A. The site contained six USTs that stored automotive gasoline, ethylene glycol, kerosene, diesel, mineral spirits, and waste oil. These six USTs were removed in 1991. Petroleum contaminated soil was observed in site soils during tank removal. Four 20,000-gallon "Avgas Tanks", for which the Pan Am site is named, contained avgas early in their operations, but for the most part were used for storage and transmission of Jet A fuel. Two of these USTs were removed in 1991 and 1992; the remaining two tanks were abandoned in-place at that time to assure the stability of adjacent buildings. The remaining two USTs, ancillary piping, and four Pan Am fuel lines (two 6-inch and two 8-inch) were removed prior to Pan Am Hangar demolition in March 2001. Extensive removal of impacted soil occurred during the 2001 and 2004 capital improvement project construction.

Soil borings and monitoring wells were installed during multiple investigations of the site to evaluate the nature and extent of soil and groundwater contamination. Jet A fuel was detected in soils at various depths between 10 and 60 feet bgs at concentrations above the MTCA Method A Soil Cleanup Level. Impacted soil was present adjacent to the USTs and associated fuel hydrant lines. Free product was detected on perched and shallow Qva aquifer groundwater at the site. The occurrence of free product in perched groundwater was restricted to wells adjacent to the southwest corner of the former USTs location. Measurable free product was also observed in three wells installed in the Qva aquifer in the vicinity of the former USTs location. A program of free product removal and groundwater monitoring was conducted through 1996.

Dissolved petroleum hydrocarbons were detected in perched groundwater southwest of the former USTs location at concentrations above the MTCA Method A Groundwater Cleanup Level. Dissolved petroleum hydrocarbons were not detected in Qva aquifer groundwater west of the former USTs location at concentrations above the MTCA Method A Cleanup Level, however, monitoring has confirmed that this site contains co-mingled chlorinated solvents originating from the upgradient Northwest Airlines Former Hangar Tank site.

Pan Am Airlines Fuel Farm

Pan Am bankruptcy resulted in Port completion of the removal of the former Pan Am Fuel Farm (PAFFF) and associated soil remediation in the early 1990s. The former Pan Am Fuel Farm was located in the southwestern portion of the AOMA. The fuel farm facility consisted of two constructed-in-place concrete USTs that were used to store Jet A fuel. The tanks were partially removed in 1990, with the concrete pavement beneath the former tanks and two sidewalls left in place to ensure stability of the adjacent roadway. Soil borings and monitoring wells were used in multiple investigations of the site to evaluate the presence of petroleum hydrocarbons in soil and groundwater (Dames & Moore, 1993b). A 5-year program of groundwater monitoring was conducted by the Port up through 1998.

Petroleum hydrocarbons were detected in soil at depths between 3 and 25 feet bgs. Soil with contaminant concentrations above the MTCA Method A Soil Cleanup Level were detected in soil at less than 10 feet deep and directly adjacent to the former UST locations. Soil contamination was identified to be limited to soil adjacent to the former tank locations and within the boundary of the former fuel farm. Some impacted soil remains in place due to site constraint issues.

Qva aquifer groundwater is present at approximately 50 feet bgs at the former Pan Am Fuel Farm site. Groundwater analyses indicate that at the conclusion of the groundwater monitoring period petroleum hydrocarbons were present in only one down gradient monitoring well installed in the shallow Qva aquifer, at concentrations slightly above the MTCA Method A Groundwater Cleanup Level. Neither free product nor perched groundwater were observed during investigations of the site.

RAC Auto Facility

The RAC Auto Facility site is located in the east central portion of the AOMA adjacent to the toll booths for the STIA parking facilities (Figure 6-1). The site previously contained three gasoline USTs and associated fuel dispensing piping that were used by the Hertz, Avis, and National rental car agencies. The USTs and associated piping were removed in 1993. Samples collected during removal indicated a release of petroleum hydrocarbons. Monitoring wells and/or soil borings were installed during multiple investigations to evaluate the extent of petroleum hydrocarbon contamination.

Petroleum hydrocarbon compounds were detected at concentrations in soil above the MTCA Method A Soil Cleanup Level from approximately 10 feet bgs to the Qva aquifer water table at approximately 45 feet bgs directly adjacent to the former USTs fill ports. Outside of the immediate vicinity of the former fill ports, petroleum hydrocarbon compounds were not detected in soils above the depth of 42 feet. The presence of petroleum hydrocarbons in soil at the water table was likely associated with dissolved-phase constituents in groundwater (i.e., smear zone).

Petroleum hydrocarbon compounds are present in Qva aquifer groundwater above MTCA Method A Groundwater Cleanup Levels in a pattern radiating westerly from the former fueling facility location. Free product was also measured in two monitoring wells adjacent to the former fill port locations. Perched ground-water was not identified during site investigation activities.

United Airlines Fuel Farm/Continental Airlines Fuel Farm

The United Air Lines Fuel Farm consists of an operating facility[5] and an adjacent closed facility. The closed portion of the United Fuel Farm and the former Continental Airlines Fuel Farm are located adjacent to one another on the northeastern portion of the AOMA (Figure 6-1). Multiple investigations have been conducted at both sites to evaluate soil and groundwater quality. Since 1996, the two facilities have been considered as a single environmental management site. Soil and groundwater remediation have been conducted at the sites.

The closed portion of the United Fuel Farm contained 3 USTs and associated equipment. The tanks were used to store waste Jet A fuel and glycol deicers when last in service, and gasoline at an earlier time. A site assessment was conducted in 1988. Petroleum impacted soils were detected from the surface to a depth of 30 feet bgs. Free product was detected on perched groundwater. Tanks in the closed portion of the United Fuel Farm were removed in 1993. United’s facility drainage control sump system was located adjacent to the closed portion of the fuel farm, and was determined to be potentially partially responsible for site conditions. The sump system was removed as part of remedial construction in 1996.

The former Continental tank farm consisted of one waste jet fuel tank and four USTs and associated pumps, filters, and piping that supplied jet fuel (Jet A) to the Continental hydrant system. During upgrading of the UST system in 1988 petroleum hydrocarbon impacted soils and free product on the perched groundwater surface were identified. A site assessment was conducted at the Continental fuel farm in 1992 when the USTs were removed. Petroleum impacted soil and free product were present in the excavation during UST removal. Free product was measured in existing monitoring wells during the site assessment and free product recovery was initiated at the site.

Soil and groundwater remedial activities were conducted at the individual sites, and since 1996, at the combined fuel sites. The most contaminated soil has been excavated and removed. A soil vapor extraction system operated at the site from 1997 until 2000.

With one exception, the groundwater monitoring wells installed at this site were completed in the perched water bearing zone. One well completed in the Qva aquifer (MWE-1), installed west and downgradient of the fuel farm, has shown low levels of benzene and jet fuel range TPH in 1995. Additional samples collected at MWE-1 through 2004 have been at non-detect levels for benzene and TPH. These data indicate that operations at this facility do not constitute an impact to the Qva aquifer above MTCA Method A Cleanup Levels.

[5] Termination of operations of the active United tank farm and implementation of regulatory closure and any appropriate environmental management is expected to begin in mid-2005, following initiation of Aircraft Fueling System (AFS) operations. Pre-closure hydrant line characterization was performed in 2002-03, and will be supplemented by additional information obtained during collocated AFS construction in 2004-05. Neither of these elements of the United fuel system are included in the United/Continental site.

6.1.2 Additional Known Site

QTA Tank Area

The Rental Car Quick Turn Around Area (QTA Tank Area) is located at the north end of the STIA parking garage structure. The QTA site was constructed in 1991 and is currently used by five rental car companies (tenants) for fueling and vehicle washing. Five 12,000 gallon double-contained, fiberglass underground storage tanks, nine fueling dispensing islands and approximately 3,500 lineal feet of product and vapor recovery piping are installed at the facility.

Prior to QTA construction, one monitoring well (QTAL5_MW-1) was installed in 1991 in the Qva aquifer as part of site characterization work. Groundwater samples collected from this monitoring well in 1991 were non-detect for benzene, toluene, ethylbenzene, and xylenes (BTEX). Total petroleum hydrocarbons in the gasoline range were reported at 45 parts per billion (ppb) or micrograms per liter (µg/L) by Method 5030.

In 2004, the Port commissioned an environmental investigation of the QTA facility to document baseline soil and groundwater conditions as part of due diligence for long-term lease of the facility with the facility tenants. The baseline environmental investigation consisted of resampling of the existing monitoring well installed in 1991, completing 23 soil borings and conducting soil sampling. Three soil borings indicated levels of BTEX and total petroleum hydrocarbons in the gasoline range at concentrations above the MTCA Method A Soil Cleanup Levels. Groundwater samples that were collected from the existing monitoring well and at one soil boring location contained elevated levels of total petroleum in the gasoline range and BTEX above the MTCA Method A Groundwater Cleanup Levels. Free product was measured at 0.03 feet in MW-1 in March 2004.

A Phase II Assessment was conducted in July 2004 which included the completion of eight soil borings with six of the borings completed as groundwater monitoring wells in the Qva aquifer. Free product was measured in two wells, MW-1 and QMW-5 at 0.02 feet and 2.05 feet thick, respectively. Groundwater sampling occurred in five monitoring wells that did not contain free product with elevated levels of BTEX and TPH in the gasoline range detected above the MTCA Method A Groundwater Cleanup Level. Free product bail down testing and UST integrity testing has been conducted. Groundwater monitoring and product removal are ongoing, and expansion of the well network is under consideration.

6.1.3 Potential Sites

The Agreed Order required the Port to identify potential sites where, based on a review of historical operations, groundwater may have become contaminated. The Port performed an in-depth review of historical records and developed a list containing 13 potential sites (identified as P1 through P13). In general, operations at these sites were discontinued prior to the development of current MTCA regulations. Table 6-2 provides the final potential site list submitted to Ecology in February 2003 (Port of Seattle, 2003c) in fulfillment of the Agreed Order requirement. The general locations of the potential sites at STIA are shown on Figure 6-1.

Eight of the thirteen potential sites were excluded from further modeling analysis. After those potential sites were placed on the list, data collected from subsequent environmental investigations and/or construction monitoring observations demonstrated that no apparent release of contaminants to soil or groundwater had occurred (Table 6-2). Two of the thirteen potential sites, P7 – Possible Parking Garage Fuel Tanks and P9 – Possible Transformer Room Fuel Tanks, are located in the near vicinity of the known Budget, RAC, and QTA release sites. Contaminant transport model predictions for the benzene plume from the Budget and RAC facilities were used to provide an estimate of the possible contaminant flow pathway from P7 and P9. The remaining three potential sites were included for contaminant transport modeling and are briefly described below.

P3 – Former Lagoon Area

The Former Lagoon Area is associated with a historic wastewater lagoon that was located in the vicinity of the current Alaska Air Lines (AAL) access road intersection with South 188th Street at the south end of STIA. The lagoon was constructed some time between 1948 and 1953 and functioned as an oil/water separator for wastewater discharges from several airline hangars (Lovely, 2002). Discharges to the lagoon were discontinued in 1963 when the current Industrial Waste System (IWS) was constructed. The lagoon was removed in about 1966 or 1967 for construction of the AAL access road. During construction of the access road, portions of the lagoon dike were regraded in the area southwest of the lagoon. Construction of the South Duct Bank in 2000 encountered contaminated soils in a trench excavated north of South 188th Street in the vicinity of the former lagoon. Soil samples collected during construction in September 2000 indicated total petroleum hydrocarbon of heavy oil (TPH-O) and diesel range at 8,510 parts per million (ppm) or milligrams per kilogram (mg/kg) and 6,870 ppm, respectively, lead at 1,840 ppm and low levels of polychlorinated biphenyls (PCBs) at 3.37 ppm (Lovely, 2002). Additional soil sampling using hand augers was conducted to further define the extent of impacted soils in the vicinity of the former lagoon. Field observations indicated a 6- to 18-inch layer of soil with petroleum hydrocarbon staining and odor. TPH in the diesel range was measured as high as 1,900 ppm at a depth of about 4 feet. No solvents were detected in the soil samples collected during the investigation.

P12 – Possible Air Cargo Area Tanks

The Port has identified historic 1968 construction drawings that indicate a 2,000-gallon fuel tank and pump and a 500-gallon gas tank might have been located in the northwestern portion of the AOMA. No further information regarding this site has been identified that confirms the initial installation of the drawn tanks, or the current status.

P13 – Abandoned Hydrant Line (also known as NWA Hydrant System [1976])

Potential site P13 – Abandoned Hydrant Line is a segment of the Northwest Airlines (NWA) fuel hydrant line system that was abandoned in 1976. The site is located between the former NWA Fuel Farm and the former NWA Hangar (Figure 6-1). In 1997 and 1998, NWA conducted site investigations along the abandoned fuel hydrant line. Construction during May 2001 through April 2002 required significant soil excavation in the P13 area. Construction work in these areas included the removal of concrete and asphalt pavement, removal of sections of the abandoned NWA fuel lines and fuel hydrants, and mass excavation (Lovely, 2003). Approximately 58,603 tons of petroleum impacted soil associated with NWA hydrant line were removed for off site thermal treatment and disposal. Soil associated with the Northwest hydrant line that was excavated for STEP construction contained concentrations of TPH in the Jet A or diesel range measured at up to 1,320 ppm in Area 8, and 13,000 ppm in Area D (Lovely, 2003). Confirmation soil samples collected from the excavation floor and sidewalls indicated that some petroleum impacted soil remains in some portions of the STEP project area. The highest residual concentrations are about 4,600 ppm TPH in the Jet A or diesel range, located in STEP Area D.

6.2 Contaminants of Concern

Contaminants of concern (COC) at each of the Agreed Order sites have been selected for contaminant transport modeling purposes based on the assessment of overall threat to human health and the environment. In order to accurately evaluate threat, the frequency of detection (from the Port of Seattle's EMIS database) and relative toxicological characteristics (from MTCA) were assembled, and relevant summary-level statistical data calculated, for all compounds analyzed at each of the Agreed Order sites that impact the Qva aquifer. The resulting report (Appendix G) shows the frequency of detection as well as frequency of detection at concentrations above the MTCA clean up levels published in the Ecology document, *Cleanup Levels and Risk Calculations* (*Clarc) Version 3.1* (Ecology, 2001). The substances identified by the statistical frequencies were evaluated to identify the contaminant of concern to be modeled for each Agreed Order site. For the purpose of this study–evaluation of the potential risk to downgradient local receptors–the most toxic and most mobile chemicals were selected for transport modeling analysis.

6.2.1 Selection of Indicator Contaminants of Concern for Modeling Purposes

Indicator COCs have been selected in accordance with the criteria established in MTCA (Ecology, 1991, see MTCA Washington Administrative Code [WAC] 173-340-703). The selection process for this study identified appropriate indicator chemicals for predictive contaminant transport modeling. The selection process eliminates those chemicals that contribute a small percentage of the overall risk to human health and the environment. The criteria used in the indicator COC screening include:

- Detection frequency: Chemicals that have a low frequency of detection were eliminated from the screening process.
- Chemical concentration: Chemicals with concentrations either below or marginally above relevant cleanup levels may not be important in consideration of the overall hazard and risk and were eliminated from further consideration.
- Toxicity: Chemicals were rated based on toxicity; compounds with low toxicity (or, conversely, high cleanup levels) were candidates for exclusion.
- Environmental fate: Chemicals that degrade easily in the environment may not be important to the overall hazard or risk.
- Mobility and potential exposure: Modeling was focused on chemicals that move readily in groundwater.

- Degradation byproducts: Chemicals that degrade into low toxicity compounds were excluded.

The EMIS database was used to identify the chemicals analyzed in groundwater in the Qva aquifer at specific sites. A summary matrix identifying those chemicals is presented in Table 6-3. Appendix G contains the results of the summary statistics for each compound analyzed and includes additional detail on the individual compounds detected at each site. Table 6-4 presents a summary of detections and MTCA cleanup level exceedances.

6.2.2 Computation of Naphthalene Concentration from TPH Data

Several STIA Groundwater Study sites are listed in the Agreed Order, or have been identified as potential sites, due to reported or suspected elevated levels of total petroleum hydrocarbons. Table 6-5 provides a summary of specific TPH compounds reported to exceed MTCA Method A Cleanup Levels in the Qva aquifer at Agreed Order sites. The transport analysis for these sites uses naphthalene as an indicator chemical to predict the extent of contamination that could be present in groundwater from these sites. Analytical data for some of these Agreed Order sites showed the presence of total petroleum hydrocarbons as diesel (TPH-D) or jet fuel concentrations rather than naphthalene concentrations. To facilitate fate and transport modeling, site-specific equivalent hypothetical groundwater naphthalene concentrations were calculated from groundwater TPH data. In addition, at two potential sites (P3 and P12), no groundwater analytical data were available. The computation of naphthalene concentration in groundwater for these sites was based on the reported concentration of TPH-D in soil. Details on the methodology used to compute naphthalene concentration in groundwater from TPH-D data in soil or groundwater is presented in Appendix G.

6.3 Risk Evaluation Criteria

Several parameters are used to predict a chemical's relative mobility and interaction with the aquifer matrix, and therefore, the likelihood that a particular chemical of concern will migrate in groundwater to a potential local receptor (i.e. surface water body or drinking water well). Three parameters used in this study to predict a chemical's relative mobility include the chemical's organic carbon–water partitioning coefficient (K_{oc}), degradation half life, and toxicity.

The partitioning coefficient, K_{oc}, provides a measure of the extent to which a chemical in groundwater will become attached to organic carbon in the soil matrix. A higher K_{oc} value indicates that a chemical is more likely to adsorb onto soil and therefore less able to migrate in the groundwater system. A low K_{oc} value indicates that a compound could be readily transported in groundwater. The amount of chemical adsorbed is equal to the product of the partitioning coefficient, the soil density, and the percentage of organic carbon.

The degradation half life is the period of time required for natural degradation processes to reduce a chemical concentration by one-half. The unit of measurement is years. The half life quantifies the persistence of a chemical in the environment.

The toxicity of a chemical is reflected in the MTCA Groundwater Cleanup Level for that chemical. In general, a low cleanup level indicates that a particular chemical is more toxic than one with a higher cleanup level.

Table 6-6 provides evaluation parameter values for the primary volatile organic compounds (VOCs), including BTEX, and naphthalene that have been detected in Qva groundwater at Agreed Order sites. VOCs[6] are a large class of chemicals that typically exhibit high rates of volatilization (vaporization). VOCs include several compounds (BTEX) associated with petroleum products. VOCs also include the chlorinated solvents (such as perchlorethene, trichlorethene and their associated break-down products dichloroethene, vinyl chloride, etc.).

TPH[7] is a complex mixture of chemical constituents. Benzene and naphthalene represent the most soluble constituents of gasoline and diesel fuel, respectively, and are the COCs used for contaminant transport modeling to evaluate TPH fate and transport from the rental car fueling sites and Jet A fuel release sites.

Two known solvent sites are present in the AOMA, the Delta Air Lines Autogas Cluster Tanks (DELAG) and the Northwest Airlines Former Hangar Tanks. COCs selected as indicator chemicals in the fate and transport model for these sites are as follows: 1,2-dichlorethane (1,2-DCA) from the DELAG site and 1,1-dichloroethylene (1,1-DCE) from the NWFHT site.

[6]VOCs typically show a greater tendency to dissolve in water than some other classes of organic compounds (e.g., semivolatile organic compounds [SVOC]), but are seldom found in surface water because of their high volatilization rate. Once dissolved in groundwater, they generally are not as easily retarded by the soil matrix as other classes of compounds and certain VOCs can be migrate in groundwater quite readily.

[7] TPH is a mixture of alkanes (straight chain carbon molecules with a single bond between carbon atoms), alkenes (straight chain hydrocarbons with a double bond between carbon atoms) and aromatics (ring hydrocarbons with alternating single and double bonds between carbon atoms). Refined products, such as gasoline, contain C4 to C12 alkanes (compounds consisting of 4 to 12 carbon atoms linked by a single bond between carbon atoms) and monoaromatic compounds such as BTEX. Medium range distillates such as Jet A fuel, kerosene and diesel fuel contain alkanes ranging from C10 to C24, in addition to monoaromatics (BTEX) in low concentrations, slightly soluble poly-aromatic hydrocarbons (PAHs) such as naphthalenes, anthracenes, a few metals and select additives.

7 Numerical Model Development

7.1 Groundwater Flow Modeling

7.1.1 Computer Code Description

Groundwater flow simulations were conducted using the USGS MODFLOW code (McDonald and Harbaugh, 1988). This model code is the industry standard and most widely used code for simulating groundwater flow. MODFLOW is a three-dimensional finite-difference groundwater flow model capable of simulating steady and transient flow in an irregularly shaped flow system in which aquifer layers can be confined, unconfined, or a combination of both.

7.1.2 Model Grid and Model Layers

MODFLOW is applied by determining the geographic area and hydrostratigraphic units to be simulated by the code. The geographic area is subdivided into cells and the hydrostratigraphic units are divided among model layers. The code then solves the continuity equation for groundwater flow among the model cells and layers.

The Groundwater Study model grid is shown in Figure 7-1. The grid covers roughly the area of the Des Moines quadrangle. Model grid dimensions vary from 400 feet in the outer areas of the model area (domain) to 100 feet in the immediate vicinity of STIA. The model layers for each hydrostratigraphic unit are one cell thick; the cell height is thus equal to the hydrostratigraphic unit thickness. Model cross sections are presented in Figures 7-2 and 7-3. Model boundaries were established based on wellhead protection and capture area information published by the water purveyors for municipal drinking water production wells in the vicinity of STIA. The model domain includes the production wells and their capture areas.

The hydrostratigraphic units included in the model include all the regional aquifers in the model domain and the confining units between aquifers. The uppermost aquifer is the Qva, or C1, aquifer. The deepest aquifer is the Qu, or Qcu, aquifer and referred to in this report as the C5 aquifer. A schematic description of the aquifers and aquitards included in the model is shown in Table 5-1. The hydrostratigraphic units are represented by 10 model layers. In addition, one layer was added to the top of the model to account for the thickness of fill and/or Qvr (F0 and C0) and/or Qvt (F1) units, which were not simulated in the model. This layer was added for convenience to allow ground surface elevation to be used as the top of the model. A layer was also added to the bottom of the model to provide a bottom boundary condition to the model. Groundwater flow in the top and bottom layers was not simulated, as the top layer is inactive and the bottom layer is set as an impermeable no-flow boundary in areas where bedrock is present and a constant head boundary in areas where bedrock is deeper than the bottom of the model.

The elevation and thickness of model layers were determined from top of unit and unit thickness information (see Section 5.2). Data were provided as grid files showing top elevation and thickness of each unit over the model domain. These grid files were then interpolated onto the irregular model grid using a kriging algorithm.

The resulting top of unit and unit thickness grids indicated that units vary considerably over the model domain both in elevation and thickness. In addition, most units are not continuous over the entire model domain. Areas where units are discontinuous were determined by several factors:

- Units missing in boring logs (unit has zero thickness in the thickness grid);
- Bottom of unit interpolated above ground surface;
- Top of unit interpolated as below bedrock; and
- Top of upper unit lower than top of deeper unit.

Where a unit was absent due to any of the above reasons, the model layers were adjusted to account for the missing unit. The adjustment varied depending on the factor as described in Table 7-1. Areas where confining layers are missing were assigned hydraulic conductivity values from the adjacent layers. This procedure provides a means of simulating transport pathways between aquifers in areas where confining units are missing.

Adjustments for absent units resulted in very irregular and discontinuous model units as shown in model cross sections (Figures 7-2 and 7-3). The model area and ground surface topography and bathymetry are shown in Figure 7-4. The extent of different model units and the elevation contours of the top of the units are shown in Figures 7-5 through Figure 7-15.

7.1.3 Boundary Conditions

Boundary conditions define the inflows, outflows, and/or heads at model boundaries. Model boundaries include:

- Puget Sound: Defined as a seepage face for aquifers above sea level and constant head for aquifers below sea level. The constant head for Puget Sound was set at zero.
- Green/Duwamish River valley: Defined as a seepage face for aquifers above the valley floor and constant head for aquifers below the valley floor. The constant head for the Green/Duwamish River valley was set at 20 feet based on water level data from wells located in the valley east of the model area.
- North and south limits of the model domain: Defined as no-flow boundaries. Flow is primarily westerly to Puget Sound or easterly to the Green/Duwamish River valley. Therefore, northerly or southerly components of flow along these boundaries are weak and not significant.
- Recharge: Surface recharge from precipitation.
- Streams: Inflow and/or outflow of groundwater to or from streams such as Miller and Des Moines Creeks. Handled as RIVER cell in MODFLOW.

- Seepage: Drainage of units when truncated by topography. Treated as DRAIN cell in MODFLOW.
- Bedrock: Treated as a no-flow boundary.

Recharge: Recharge of groundwater from precipitation was analyzed in two different ways. Comprehensive stormwater modeling was conducted on Miller and Des Moines basins (Parametrix, 2001). The surface water modeling predicted stream runoff and losses to groundwater which in turn were used as recharge in the MODFLOW model. The groundwater recharge for each subbasin simulated in the Miller and Des Moines models was allocated to the MODFLOW cells that fell in the footprint of the subbasin. This analysis provided recharge for much of the model domain.

Recharge from areas outside those simulated with the Miller and Des Moines Creek models was determined from the USGS hydrologic study of south King County (Woodward et al., 1995). The USGS data were not available electronically. Consequently, recharge was digitized from the USGS report and mapped onto those cells that are not within the Miller or Des Moines creek basins. Figure 5-16 presents map showing the recharge values that were used for model input.

Streams: Streams are simulated using the MODFLOW RIVER package. In the RIVER package, flow between groundwater and a stream is defined by the difference between the groundwater level and the stream stage and by a conductance term, which represents the flow resistance between groundwater and the stream. Each stream may be either a gaining or losing stream depending on the head difference between the stream and the aquifer. For this study, stream locations and elevations were digitized. The digitized elevations were assumed to be the bottom of the stream and the depth of water for all streams was assumed to be one foot (because all the streams within the model domain are relatively small).

Seepage: Areas where hydrostratigraphic units are truncated by topography indicate the possible location of seepage faces. These seepage faces are simulated using the MODFLOW DRAIN package. This model package is similar to the RIVER package except that, while groundwater may flow to a drain, a drain does not allow inflow to the aquifer. Like the RIVER package, flow is defined by the difference between ground-water level and the seepage face elevation and a conductance term, which represents the flow resistance between groundwater and the seepage face. The primary locations of these seepage faces are in coarse-grain units above constant head elevations in Puget Sound and the Green/Duwamish River valley, and in bluffs adjacent to Miller, Des Moines, Barnes, and Massey Creeks.

7.1.4 Hydraulic Parameters

Hydraulic parameters used in groundwater flow models include vertical and horizontal conductivities and storage parameters. However, because the model for this study was operated on a steady-state basis, storage parameters were not needed.

Horizontal hydraulic conductivity values are available within the model area from a number of aquifer tests done in the area (see Section 5.5.1). The range of hydraulic parameters derived from the data and the hydraulic parameters used in the model are provided in Table 7-2.

7.1.5 Calibration and Sensitivity Analysis Procedures

Model calibration was conducted by modifying hydraulic parameters and boundary conditions to provide an acceptable comparison between model results and observations. Observations primarily consisted of water level data, as well as base flows in Miller and Des Moines Creek. The goodness of fit between model results and data is measured by a number of statistical parameters. The statistical parameters used in this study are the mean of the residual and the RMS error of the residual, where the residual is the difference between the model results and water level data. RMS is a measure of the range or scatter in the residuals. In a perfect calibration, the mean and RMS would both be equal to zero.

Calibration targets for water level data include the average error between observed and simulated water levels as well as the RMS error. RMS is a measure of the deviation about the mean. A typical target for RMS is within 10 percent of the range of values observed in the data. However, that standard is not appropriate for the modeled data set, because the data used in calibration were collected by independent sources on an irregular basis over a period of more than 40 years. Some data, particularly for wells in deeper aquifers, predate significant public supply well pumping of the aquifers. The calibration achieved RMS values less than 15 percent of the range in the data in C1 and C2 and less than 20 percent of the range in the data in C3. These RMS values are considered appropriate for the study data set. Model calibration statistics are shown in Table 7-3 and a graph of the model-calculated heads to the observed heads is shown in Figure 7-16.

During model calibration we observed changes in model results with changes in model parameters. These changes provide a means of assessing the sensitivity of the model to different model parameters. The model was found to be only moderately sensitive to most parameters, with the exception of the vertical hydraulic conductivity of the fine grain aquitard layers. Vertical conductance determines the overall head difference between layers. Water level data show an average head of 308 feet in C1, 267 feet in C2, 163 feet in C3, 95 feet in C4, and 32 feet in C5. The water level gradient across the aquitards and between the aquifer layers is considerable and is due primarily to the low vertical conductivity of the aquitard layers. In the absence of those low hydraulic conductivity units, water levels in all aquifers would be less than 100 feet and the C1 and C2 aquifers would be largely dry.

In deeper units, the model was also sensitive to constant head values used along the east side of the model and to the hydraulic conductivity values applied to constant head cells along both east and west sides. Lower values of hydraulic conductivity were required at constant head boundaries than were used in the aquifers. The lower values represent resistance to flow from sediments that cover the otherwise exposed faces of the aquifer units terminated by the Puget Sound basin and the Duwamish River paleo-channel, the latter now filled with alluvium.

Local variation in modeled water levels was achieved by varying DRAIN and RIVER conductance and hydraulic conductivity adjacent to constant head boundaries.

7.1.6 Flow Model Results

Groundwater levels from the model simulation are shown on Figures 7-17 to 7-19 for aquifers C1, C2, and C3, respectively. These three aquifers show a similar flow pattern with higher heads east of the AOMA and a general flow pattern toward Puget Sound. The flow is complicated by Miller and Des Moines Creeks, which intercept groundwater flow from the C1, C2 and C3 aquifers before it reaches Puget Sound. Groundwater flow within the AOMA is predominately in a westerly direction.

7.2 Contaminant Transport Modeling

7.2.1 Computer Code Description

Contaminant transport simulation was conducted using the groundwater transport simulation code MT3D99 (SSPA, 2000). This code is the latest version of the MT3D series of codes, which include both proprietary and public domain codes (SSPA, 1990; USACE, 1999). The MT3D family of codes is the most widely used code for simulation of contaminant transport in groundwater.

The model simulates contaminant transport in groundwater by applying the advection-dispersion equation to flow rates generated by a separate groundwater flow model (i.e., MODFLOW). Advection is the movement of contaminant caused by the flow of groundwater and is controlled by the fluid velocity as obtained from the groundwater flow model. Dispersion refers to the spreading of a contaminant caused by small-scale variations in velocity from the average value. Dispersion is described by dispersivity parameters, which are discussed in Section 7.2.2.2. The model includes additional processes that affect contaminant concentration. Degradation processes simulate the breakdown of complex compounds to simpler chemicals. Degradation processes can be simulated as simple first-order degradation or more complex biodegradation processes with nutrient inhibition. For most applications, the first-order degradation process is adequate and is used in this simulation. The model also includes interaction between contaminants and aquifer material. This interaction may be represented as a linear (used here) or non-linear adsorption reaction between dissolved contaminants and contaminants attached to the aquifer matrix. Adsorption (or sorption) has the effect of slowing the migration of contaminants. Degradation rates and sorption coefficients are discussed in Section 7.2.2.3.

In addition, several sites were further analyzed using a combination of analytical modeling and particle tracking procedures to address the spreading of benzene plumes as a result of numerical dispersion that is an artifact of using the MT3D code. Subsection 7.2.4 provides detail on the alternative modeling procedures to address numerical dispersion.

7.2.2 Input Parameters and Boundary Conditions

The groundwater transport model requires specific inputs in order to simulate contaminant transport at a specific site. These parameters include:

- Groundwater flow rates,
- Groundwater inflows and outflows,

- Aquifer delineation, including top and bottom elevation of aquifers and porosity,
- Initial concentration distribution and definition of source areas,
- Dispersion coefficient, and
- Reaction rate parameters including degradation rates and sorption coefficients.

The groundwater inflows, outflows, and flow rates are passed from the MODFLOW flow model to MT3D in an output file generated by MODFLOW versions that support MT3D. Aquifer delineations are the same as those used to construct and implement the MODFLOW model.

Porosity was taken as 0.25 for all aquifers, which is a reasonable value for the types of material that comprise the aquifers in the study area. The remaining parameters are defined in more detail below.

7.2.2.1 Initial Concentration and Definition of Source Areas

MT3D simulations begin with an initial estimate of concentration of a specific contaminant within the model area. For this study, specific source areas were identified in the MTCA Agreed Order. In addition, a number of potential sites were identified by the Port and Ecology after the Agreed Order was executed. Agreed Order specified sites and potential sites have been analyzed to identify the COCs to be modeled for each. A summary of all sites, including the indicator COC or the basis for not modeling, is presented in Table 7-4.

Once modeling COCs were established for each Agreed Order and potential site, each of the sites was reviewed for contaminant transport modeling. Certain sites located upgradient of sites with the same COCs and similar or lesser concentration characteristics were excluded from modeling because they represented less conservative modeling input. Similarly, sites with potential contamination located adjacent to sites with known concentrations of the same COC were excluded from contaminant modeling. Sites with data records demonstrating low initial COC concentrations and a long-term decline to non-detect concentrations also were not modeled. See detailed site discussions below.

For incorporation in the model, the COC concentration and areal distribution associated with each model source is identified. The source area and source area concentrations are then used as inputs to the transport model to evaluate the migration of the COCs from each site. The following is a discussion of the source area analysis for each site. In all cases, the source areas were simulated as a constant source of contamination over a 30-year simulation period.

The source area for each modeled site is one cell, 100 feet by 100 feet in lateral extent based on the model grid sized used for this study. All the observed data and model source concentration values discussed below are for groundwater, except where noted. Contaminant concentrations in soil are used to estimate equivalent groundwater concentrations for some sites modeled with naphthalene.

The predicted 30-year[8] contaminant plume boundaries are shown in Figure 7-20. Figure 7-21 presents these plumes in relation to the AOMA and most of named potential local receptors.

7.2.2.1.1 Gasoline Sites

Budget Auto and RAC Auto Facilities

The model COC for Budget Auto and RAC Auto facility sites is benzene. Contamination from gasoline was identified in the Qva at each site (Figure 7-20). Historic benzene concentrations have ranged from non-detect to 6,200 and 22,000 parts per billion (ppb) at the RAC and Budget facilities, respectively. Cleanup actions at the Budget site have resulted in declining benzene concentrations over time. Samples from the Budget facility wells have shown declines in concentration, in the range of 1,000 ppb to less than 5 ppb at several wells, presumably resulting from the effectiveness of remedial actions. Historically, concentrations at the RAC site were not as high as the Budget site, but concentrations at some RAC wells have not declined as dramatically as at the Budget site.

The most recent benzene data range from non-detect to 2,100 ppb at the RAC site and non-detect to 56 ppb at the Budget site. The most recent data are from 2001 and 2000 at the RAC and Budget sites, respectively. The RAC source area is defined by the highest concentrations at the RAC site. These concentrations were interpolated to a source area located at RAC wells RACFT_HZ-5, RACFT_HZ-6, and RACFT_HZ-9 with a source area concentration of 1,400 ppb. A second source area with a concentration of 56 ppb was included to represent the Budget site based on the highest concentration detected in the November 2000 sampling event.

QTA Tank Area

The model COC for the QTA Tank Area site is benzene. Groundwater in the Qva aquifer has been impacted by a release of gasoline. Free product has been measured on the Qva water table and benzene concentrations in monitoring wells have ranged between 551 ppb to 23,700 ppb. The source concentration was set at 12,000 ppb, which represents an average concentration observed downgradient of wells QMW-6 and QMW-7 based on groundwater quality measurements collected in July 2004.

7.2.2.1.2 Solvent Sites

Delta Auto Gas Cluster Tanks

The model COC for the Delta Auto Gas Cluster Tanks site is 1,2-DCA. This compound was detected at one well at the site. Samples from other wells were non-detect and, therefore, limit the source area to a small area in the vicinity of one well (Figure 7-20). Consequently, the source is defined as a single location corresponding to monitoring well DELAG_AGC-5 in which 1,2-DCA was detected. The source concentration was set at 8.3 ppb based on the most recent sampling completed at that well in 1998.

[8] A 30-year simulation period was chosen based on break-through analysis of the plumes over time and distance which showed that the plume lengths became stable within the 30-year time period.

NWA Hangar Tanks, Gate B-2 and Pan Am Avgas Tanks

The former NWA Hangar Tanks site is identified as a source of 1,1-DCE. Gate B-2 and Pan Am Avgas Tanks sites are located downgradient of the NWA Hangar Tanks site and also have low levels of 1,1-DCE detected in some wells (Figure 7-20). Gate B-2 is located downgradient from the 1,1-DCE source area. The Pan Am Avgas Tank site is not considered a source of 1,1-DCE, but is located in the plume emanating from the former NWA Hangar Tanks area. Three wells with elevated sample levels of 1,1-DCE located in the vicinity of the former NWA hangar define the 1,1-DCE source. Interpolation over the wells used to monitor 1,1-DCE yields a source concentration of 43 ppb located 100 feet northwest of the former NWA hangar.

7.2.2.1.3 Jet-A and TPH-D (Naphthalene) Sites

Several sites have been associated with releases of jet fuel as indicated by detection of Jet-A and/or TPH-D. These sites include four Agreed Order sites and three potential sites:

- NWA Fuel Farm,
- Pan Am Fuel Farm,
- South Satellite Baggage Tunnel,
- NWA Hydrant System Closure (also NWA Hydrant System [1997]),
- Former Lagoon Area (P3),
- Abandoned Hydrant Line (also P13 or NWA Hydrant System [1976]), and
- Possible Air Cargo Area Tanks (P12).

Since Jet-A and TPH-D are mixtures of a large number of compounds, contaminant migration from these sites was simulated using naphthalene as an indicator chemical. Naphthalene was selected for the transport analysis because it is more mobile than most Jet-A and TPH-D chemical components and a naphthalene MTCA Method A Cleanup Level has been published. The following provides a description of how these source areas were incorporated into the model.

NWA Fuel Farm: Groundwater samples analyzed from this site for TPH-D had values above MTCA Method A Cleanup Levels. This site is located adjacent to potential site P13 (NWA Hydrant System [1976]) and upgradient of the NWA Hydrant System (1997), and South Satellite Baggage Tunnel leak sites. The NWA Fuel Farm site was not included as a source area in the model. Potential site P13, located north of the NWA Fuel Farm, had much higher naphthalene source concentration values than would be calculated for the fuel farm site. Therefore, P13 was chosen for modeling naphthalene in this area of the AOMA.

Pan Am Fuel Farm: This site is located at the southwest edge of the AOMA. Groundwater from this site was analyzed for TPH-D. The highest historical concentration of TPH-D detected at the site was 840 ppb. The most recent sampling data report non-detect levels of TPH-D at detection limits between 100 and 250 ppb. Given the low historic concentration of TPH-D at this site and the declining concentration with time to non-detect levels, this site is not a continuing long-term source of contamination and was not included in the model as a source area.

<u>South Satellite Baggage Tunnel leak site</u>: This site is located downgradient from the NWA Fuel Farm, Abandoned Hydrant Line (NWA Hydrant System [1976]) and NWA Hydrant System Closure (NWA Hydrant System [1997]) sites. It overlaps the NWA Hydrant Closure site east of the South Satellite terminal building. Naphthalene was detected in several wells at concentrations below MTCA Method B. The highest naphthalene concentrations in the area of this site were associated with sampling conducted for the NWA Hydrant System Closure (NWA Hydrant System [1997]). Consequently, contaminant transport from the South Satellite site was simulated using naphthalene concentrations computed for the NWA Hydrant System Closure (NWA Hydrant System [1997]) site as a discussed below.

<u>NWA Hydrant System Closure (also known as NWA Hydrant System [1997])</u>: Releases from this site are located between the South Satellite terminal building and the NWA Fuel Farm. Samples from two temporary wells located east of the South Satellite building reported elevated levels of TPH as jet fuel. The jet fuel concentrations were converted to naphthalene concentrations (see Appendix G). This computation produced concentrations above MTCA Method B at one well. A source area east of the South Satellite building was incorporated in the model with a naphthalene concentration of 1,040 ppb based on this analysis.

<u>Former Lagoon Area (P3)</u>: This potential site is located south of the former Alaska Air Lines hangar on the south end of the AOMA. It has been identified on the basis of soil samples with elevated concentration of TPH-D. The highest concentration of TPH-D in soil was 1,900 ppm. This TPH-D soil concentration was converted to a soil naphthalene concentration and then to a groundwater naphthalene concentration based on soil-groundwater partitioning parameters in MTCA (see Appendix G). This calculation produced a groundwater naphthalene source area concentration of 6,060 ppb for this site.

<u>Abandoned Hydrant Line (also known as P13 or NWA Hydrant System [1976])</u>: The NWA Hydrant System (1976) is a potential site located west of the NWA Fuel Farm extending along the footprint of the former Concourse A. Elevated levels of total petroleum hydrocarbons as gasoline (TPH-G), TPH-D, and TPH-Jet have been detected in soils during construction monitoring activities associated with capital construction in the area between the former NWA Flight Kitchen building and former NWA Hangar. It should be noted however that the detection of TPH-G is in question and may be a result of laboratory interference. Soil concentrations for TPH-D or TPH-Jet ranged from non-detect to 13,000 ppm. The data indicated three areas with elevated soil concentrations: directly east of the former NWA Flight Kitchen building, northeast of the building, and directly north of the building. The soil concentrations in each of these areas were averaged to produce an areal average soil concentration. TPH-D soil concentrations from each of the three areas were converted to soil naphthalene concentrations and then to groundwater naphthalene concentrations based on soil-groundwater partitioning parameters in MTCA (see Appendix G). Conversion calculations produced three separate source areas with concentrations ranging from 5,900 to 15,500 ppb. Because of the grid resolution of the groundwater model, these three source areas are located in three adjacent cells east, northeast, and north of the Former NWA Flight Kitchen building.

<u>Possible Air Cargo Area Tanks (P12)</u>: This potential site is located just outside the northern part of the AOMA. The site was identified based on historical Port facility drawings (not as-built drawings). No information is available on the usage of the tanks and no environmental data for soils or groundwater are available for this site. The source area for this site was modeled using initial naphthalene concentrations from other source areas in the AOMA. To be conservative, the highest source area concentration developed for the other AOMA sites was applied to this source area. Consequently, the source area at this site was given a naphthalene concentration of 15,500 ppb.

7.2.2.1.4 Source Area Summary

Based on the analyses discussed above, location and concentration for the various source areas were developed for the model. A summary of the source area evaluation for the modeled sites is presented in Table 7-5.

7.2.2.2 Dispersion Coefficients

Dispersion represents the spreading of contaminants with distance from the source area. Non-uniform flow velocities in the aquifer cause contaminants to move faster in some pore spaces than others and result in movement generally across the primary flow direction. Dispersion is described by three dispersivity parameters that represent dispersion in the direction of flow (longitudinal), horizontally crosswise to the flow direction (horizontal transverse), and vertically (vertical transverse).

Following the analysis of Gelhar et al. (1992), longitudinal dispersivity values for highly reliable data fall within the range of 1 foot to 11 feet. Horizontally transverse dispersivity values with high reliability fall within the range of 0.06 to 0.3 feet and vertical transverse dispersivity is on the order of 0.006 feet. The range of values for transverse dispersivity is consistent with the rule of thumb that horizontal transverse dispersivity is on the order of 10 percent of longitudinal dispersivity and vertical transverse dispersivity is on the order of 1 percent of longitudinal dispersivity (Zheng and Bennett, 1995). The present analysis was conducted using 1.0, 0.1, and 0.01 feet for longitudinal, horizontal transverse, and vertical transverse dispersivity, respectively.

7.2.2.3 Reaction Parameters

Reaction parameters in the MT3D model are of two types: sorption coefficients and degradation rates. Sorption for most organic compounds is related to the fraction of organic carbon in the aquifer material. Consequently, sorption is simulated in the model using the organic carbon concentration in the soil and the organic carbon – water partitioning coefficient (K_{oc}) of the chemical. For the COCs included in the transport analysis, the K_{oc} values were taken from Table 747-1 of MTCA Chapter 173-340 WAC. The organic carbon concentration was taken as the default MTCA value of 0.1 percent, which is consistent with fraction organic carbon data from the C1 aquifer. The model also uses the bulk density and the porosity of the aquifer for sorption calculations. A porosity of 0.25 and bulk density of 1.6 were used in the transport analysis.

Degradation rates were taken from the literature (Mackay et al., 2000; Suarez and Rifai, 1999; Massman, 2004) for the COCs included in the transport analysis. Degradation rate information is provided in Table 7-6.

The degradation rate for benzene and naphthalene were taken from Mackay et al. and are reasonably conservative values well above the mean degradation rates in the literature. The degradation rate for 1,1-DCE was developed by calibrating the model to 1,1-DCE concentrations in wells downgradient from the 1,1-DCE source area. The calibrated 1,1-DCE degradation rate is considerably lower than the mean value from the literature. The degradation rate for 1,1-DCE was also applied to 1,2-DCA because both of these compounds have similar degradation pathways and more readily degrade in anaerobic environments.

7.2.3 Calibration and Sensitivity Analysis Procedures

In this study, the benzene and 1,1-DCE plumes can be calibrated based on the extent of the plume observed in downgradient wells. The primary calibration parameter affecting the extent of the plume is the degradation rate. Other parameters such as dispersivity, porosity, and sorption coefficient affect the time required for a plume to develop, but do not limit the extent of the plume. Degradation rate directly affects the extent of a plume as the concentration in the plume is being reduced by degradation processes with distance from the source. Eventually, an equilibrium develops due to the combined effects of advection, dispersion, sorption and degradation, which limits further expansion of the plume. The extent of the plume is then defined by selection of a contaminant concentration value. For this study we have used MTCA Method B and Method C Groundwater Cleanup Levels to represent the leading edge of the plumes.

Model sensitivity was conducted for the benzene degradation rate. Benzene has the highest exceedance ratio (ratio between on-site concentration and the MTCA cleanup level) of all COCs. The benzene plume is the most extensive and the only plume predicted to reach the C2 aquifer at concentrations above the cleanup level. With respect to the flow and transport parameters in the model, the extent of the plume is primarily dependent on the degradation rate. Therefore, the benzene degradation rate is an appropriate parameter for conducting a sensitivity analysis of the model. For the sensitivity test, the benzene half-life was increased by a factor of three. Numerical modeling results showed a larger benzene plume and higher benzene concentrations in the C2 aquifer, but the plume did not propagate outside the AOMA at concentrations above the MTCA Method B cleanup level. The more conservative analytical-particle tracking analysis predicted a longer plume length which extended beyond the AOMA boundary but did not propagate beyond the airport boundary at concentrations above MTCA Method B. The analytical-particle tracking analysis is very conservative as it does not account for vertical dispersion or mixing of groundwater between the C1 and C2 aquifers downgradient of the AOMA.

Further sensitivity analyses are not warranted as the model was constructed from an extensive array of actual data and efforts were made throughout the modeling process to conservatively over-predict concentrations. The model results presented in this report represent a reasonable worst case condition for designing a monitoring network for COCs in the AOMA.

7.2.4 Transport Model Results

The transport model was implemented to simulate each source area. Individual simulations were conducted for each COC. The benzene simulation included all three benzene source areas, which provides a means of assessing the interaction and potential co-mingling of plumes from the different source areas. Similarly, the naphthalene simulation included all naphthalene source areas in a single simulation.

In each case, the simulation period was 30 years. The model generates concentration distributions both horizontally and vertically over time. The extent of each plume at the end of the thirty-year simulation period is presented in Figure 7-20. Figure 7-21 presents a small-scale view of the plume boundaries in relation to the locations of potential local receptors. The 1,1-DCE and 1,2-DCA plumes show a long, narrow configuration consistent with a long half life (low degradation rate). The naphthalene simulation show short plumes consistent with a relatively high degradation rate and higher sorption. A compound with a high degradation and high sorption will degrade faster than it is transported resulting in short plume lengths.

The benzene plume shows a high degree of spreading with a co-mingling of the plumes from the three source areas. An independent peer reviewer[9] of the modeling study raised a concern that the spreading shown in the benzene results may be an artifact of numerical modeling known as numerical dispersion. Numerical dispersion is most likely to occur when flow and transport pathways are approximately 45 degrees to the grid layout. This is the situation in the area of the benzene plumes, where groundwater is flowing north-westerly at approximately 45 degrees with respect to the model grid.

Based on comments from the independent peer reviewer, the benzene plumes were further analyzed using a combination of analytical modeling and particle tracking (see Appendix H regarding model peer review). An analytical model is a purely mathematical model that is not subject to numerical dispersion. However, the mathematical model cannot incorporate complex hydrogeology and therefore has limitations. One limitation is that the groundwater flow does not change with time or distance from the source area. This means that the plumes are always straight rather than following irregular flow pathways.

To identify the flow pathway, particle tracking can be used. In particle tracking, particles are placed in the flow model and allowed to move with time based on groundwater flow rate and direction as determined by the numerical flow model. The analytical solution and the particle tracking analysis are then merged with the plume orientation defined by the particle tracking and the plume concentration defined by the analytical model. For this combined analytical-particle tracking analysis, the ATRANS analytical model (Zheng and Bennett, 1995) and the PATH3D particle-tracking program (SSPA, 2001) were used.

[9]The Port of Seattle contracted with Pacific Groundwater Group (PGG) and Joel Massmann of Keta Waters to conduct an independent peer review of the groundwater flow and contaminant model process and results. Appendix H contains the review comments and response to comments.

The results of the analytical-particle tracking analysis are presented in Figure 7-20 along with the results of the numerical simulation. The analytical-particle tracking analysis was only applied to the RAC and QTA sites as these are the dominant benzene sources affected by numerical dispersion. The analytical solution indicates that the benzene plumes do not co-mingle and are much narrower than indicated by the numerical model. The width of the plume is important in the development of a monitoring network to ensure that monitoring wells are located within the plume.

8 Modeling Findings and Discussion

This section of the report provides a summary of the modeling results and provides recommendations for a future groundwater monitoring effort that could be implemented, if Ecology determined additional monitoring was appropriate, to verify the conclusions of this study and the limits of selected contaminant plumes. Groundwater monitoring results may be compared to predict groundwater concentration presented in this study, however, variability noted in the direct comparison between field data and modeling results may be dependent on several factors including screen length and placement, aquifer thickness, and other hydrogeological site specific conditions.

8.1 Groundwater Flow Modeling

8.1.1 Water Budget Analysis

Groundwater flow was analyzed through a flow budget analysis of model output. Groundwater enters the model area primarily as surface recharge. Some inflow occurs at depth from constant head boundaries at the bottom of the model and adjacent to the Duwamish River valley. Discharge occurs along the bluffs above the Duwamish River valley and Puget Sound, at slopes along Miller, Walker, Des Moines, Barnes and other creeks in the model area, directly to the creeks as base flow, and as seepage to Puget Sound. The results of this analysis are shown in Table 8-1.

Direct seepage to Des Moines and Miller/Walker Creeks produces a base flow of 5 cubic feet per second (cfs) and 3 cfs, respectively. However, this flow may be augmented considerably in Miller Creek with seepage in areas where the C1 and C2 aquifers are incised by the creek valley. This seepage flow is computed at 11 cfs. However, only a fraction of it would contribute to stream flow as much of it likely discharges to wetlands where considerable evaporation and transpiration would occur. The stream flows agree favorably with observed low flows at the mouth of Miller and Des Moines Creek. Average low flows in Miller Creek varied from 3.0 to 10.4 cfs from 1991 to 1996 and low flows in Des Moines Creek varied from 2.5 to 5.8 cfs from 1992 to 1996 (Parametrix, 2001).

8.2 Transport Pathway Identification

8.2.1 Flow Paths from Potential Contaminated Sites

Groundwater in the C1 aquifer in the vicinity of the AOMA flows primarily west toward the area where the F2 aquitard is missing. Where the F2 is present, contaminant transport between C1 and C2 aquifers is impeded. However, where F2 is missing, there is a direct connection between the two aquifers. This reduces contaminant concentration in the C1 aquifer as contaminants are diluted by the flow in the C2 aquifer. Benzene is the only COC predicted to reach the C2 aquifer. However, benzene does not propagate outside the AOMA at concentrations above the MTCA Method B cleanup level in either the C1 or C2 aquifers. The benzene plume was also simulated with a significantly higher degradation half-life (see Section 7.2.3). With the higher half-life, benzene concentrations in the C2 aquifer increased, but declined to below the MTCA Method B cleanup level before reaching the boundary of the AOMA.

In the C2 aquifer, groundwater in the vicinity of the AOMA flows primarily west toward Puget Sound and Miller and Walker Creeks. Toward the south end of the AOMA, there is a flow divide between the Miller/Walker Creek watershed and the Des Moines Creek watershed.

The F3 aquitard is extensive and intact varying in thickness from approximately 25 feet to over 100 feet in the vicinity of the AOMA. Boring logs that penetrate the F3 aquitard identify it as a blue clay or silt. Consequently, it is reasonable to expect that the F3 aquitard has a very low hydraulic conductivity. This low conductivity layer inhibits groundwater movement to the C3 aquifer. Consequently, contaminant transport from the C2 aquifer to the C3 aquifer is unlikely.

8.2.2 Receptors to Groundwater from Potential Contaminated Sites

The Agreed Order identified a number of potential local receptors to groundwater flowing beneath the AOMA. The potential local receptors are public drinking water supply wells; publicly recorded and operational local private drinking water supply wells; Bow Lake; Des Moines Creek; and Miller Creek. No operational private drinking water supply wells have been identified downgradient from the AOMA.

Relative to the groundwater flow directions described in this report, the primary receptors in the vicinity of the AOMA are Miller, Walker, and Des Moines Creeks, the Highline Water District Tyee Well and the Old Tyee Golf Course (irrigation) Well. The wells draw from the C2 and C3 aquifers, but are located in an area where the F2 fine-grained unit is missing. Consequently, they also draw water from the C1 aquifer. As the Highline Water District well is used for water supply, potential receptors include humans using drinking water in addition to aquatic organisms impacted by seepage into creeks.

8.3 Contaminant Transport Modeling

8.3.1 Potential Exposure Concentrations at Local Receptors

The contaminant fate and transport modeling indicates that exposure concentrations to human or aquatic receptors will be less than applicable water quality criteria for all COCs modeled. The modeling analysis, with conservatively low values for degradation (high half life) of COCs, indicates that concentrations above MTCA Method B Cleanup Levels do not extend beyond the AOMA. The conservative approach (Section 7.2.2.1) taken in the modeling does not include the effects of mitigation activities, such as soil removal or in-situ remediation, which would lower or eliminate a contaminant source and reduce predicted COC concentrations.

The predicted benzene plume from the RAC and QTA sites migrates in a northwesterly direction under Concourse D (see Figure 7-20). This flow direction in the C1 unit is due to the absence of the F2 confining unit along the northwest side of Concourse D (Figure 7-4), which influences the local C1 groundwater contours by direct infiltration from the

C1 aquifer into the C2 aquifer. The bend of the QTA analytical plume from northwest to west indicates a transition of that contaminant plume from the C1 model layer into the more westerly flow of the C2 layer. Model results suggest that the plume could reach several shallow monitoring wells located along the northwest side of Concourse D. These wells are in suitable locations for monitoring and could be used to verify model results.

The predicted 1,1-DCE plume extends from the source area to the east of and below the former NWA hangar in a westerly direction past monitoring well NWFHT_MW-8 (Figure 7-20). A 1,1-DCE concentration of 5.2 ppb was detected at this well in 2001. A relatively slow degradation rate compared to most literature values was used to provide a favorable match between the model and the observed 1,1-DCE concentration at monitoring well NWFHT_MW-8. The slower degradation rate represents a considerably higher degradation half life for this compound. The longer half life possibly indicates that the aquifer is aerobic as 1,1-DCE degrades more slowly under aerobic conditions.

The predicted 1,2-DCA plume extends westerly from the source area (Figure 7-20). The 1,2-DCA source area is defined by one well, which is almost surrounded by wells where 1,2-DCA was not detected. Consequently, it is likely that the source area for this compound is smaller than represented in the model, which would result in a smaller plume configuration as well.

Four naphthalene source areas and plumes are shown on Figure 7-20. In each case, the modeled naphthalene plume does not migrate significantly from the source area. This is due to the high sorption rate for naphthalene in soil, especially relative to other COCs in this study. The higher sorption rate results in longer transport times, which give degradation processes more time to break down the naphthalene. Consequently, naphthalene plumes are more compact than those of other modeled COCs, even though the naphthalene source areas have higher concentrations than the source areas of other COCs. The small plume size of naphthalene is supported by data from the Northwest Airlines Hydrant System Closure (NWHS2) wells north of the South Satellite building. All of these wells have low concentrations of naphthalene even though the NWHS2 (NWA Hydrant System [1997]) and the Abandoned Hydrant Line (P13 or NWA Hydrant System [1976]) source areas are located upgradient from these wells.

8.4 Groundwater Monitoring Network Design Recommendations

Groundwater Study modeling results suggest that groundwater contamination at STIA does not threaten groundwater quality at potential local receptors. However, Ecology has determined that additional monitoring is required to verify model preditions. The additional monitoring will focus on specific contamination plumes identified in this study, rather than monitoring the AOMA as a whole. Plume-specific monitoring would allow confirmation that contaminant plumes from sources in the AOMA are sufficiently defined and that the contaminants in the plumes pose no risk now, or in the future, to potential local receptors.

Site specific monitoring strategies are summarized in Table 8-2. The monitoring strategies will focus on selected wells near the edge of plumes. These wells were positioned based on the centerline of the plume as defined by both modeling results and empirical field data (i.e., groundwater flow direction, groundwater chemistry, etc.). The selected well locations and the associated monitoring objectives are as follows (see Figure 8-1):

- UNFHS_CMW-5, UNFHS_CMW-7, and UNHYD_MW-1 to monitor the benzene plume in the C1 aquifer from the RAC Auto Facility and QTA Tank Area sites.
- A new monitoring well, to monitor benzene in the C1 aquifer, positioned along the centerline of the analytical plume from the RAC site and located on the northwest side of Concourse D.
- UNFHS_CMW-8 to monitor the benzene plume in the C2 aquifer from the QTA and RAC sites.
- A new monitoring well to monitor the 1,1-DCE plume in the C1 aquifer from the former NWA Hangar Tanks site. This well would be located near the centerline of the modeled 1,1-DCE plume, but at a position determined by the logistics of aircraft operation.
- Wells NWHS2_SSW-9 and NWHS2_SSW-2 to monitor petroleum hydrocarbons associated with the South Satellite Baggage Tunnel leak site and Northwest Airlines Hydrant Closure (NWA Hydrant System [1997]) sites.
- A new monitoring well located approximately 500 feet north of the northeast corner of the South Satellite to monitor Potential Site P13 (Abandoned Hydrant Line or NWA Hydrant System [1976]) site.
- A new monitoring well, located south of the Delta Auto Gas Cluster Tanks site near South 188th Street, to monitor 1,2-DCA from the Delta Air Lines Autogas Cluster Tanks (DELAG) site.
- A new monitoring well, located about 250 feet west of Potential Site P3, to monitor naphthalene from site P3 and 1,2-DCA from the DELAG site

The Port will sample these wells annually for 5 years. Data will be evaluated at the conclusion of the 5-year monitoring period. Wells at inactive sites that demonstrate stable or contracting COC plume conditions will not be monitored further. Well data from inactive sites suggesting an increasing trend will by monitored biannually for 6 additional years. Active sites with concentration above MTCA Method A will continue to be monitored. A decision matrix for determining future monitoring requirements, for both inactive and active sites, is presented in Table 8-2.

In addition to the 5-yr monitoring program, three active sites (RAC Auto Facility, Budget Auto Facility, and QTA Tank Area) will continue to be monitored by the respective parties under existing monitoring plans.

9 References

References are divided into the following sections:

- Reports listed by Agreed Order site and associated with Potential sites,
- Technical and scientific literature including references cited in the text of this report, and
- Reports, maps, and presentation materials.

9.1 Reports Listed by Agreed Order Site

This reference section is broken out into separate groupings by the Agreed Order sites. The Agreed Order sites are sorted alphabetically by the Port's identifying acronym. The reports are presented alphabetically by author within the applicable Agreed Order site(s). If a report references more than one Agreed Order Site, it is listed within each applicable site along with a note identifying the other sites referenced in the report. In addition, specific reports associated with Potential sites are listed at the end of this section.

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CONFF - Continental Former Fuel Farm

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10 Glossary

Agreed Order	A legally binding, administrative order issued by Ecology and agreed to by the potentially liable party regarding cleanup action of a contaminated site. An agreed order describes the site activities that must occur for Ecology to agree not to take enforcement action for that phase of work.
Alluvium	Sediment deposited by streams or rivers during recent times.
Andesite	A type of volcanic rock often formed by large, cone-shaped mountain volcanoes. Common in the Cascade Range and associated areas of the Pacific Northwest.
Aquifer	A geologic formation, group of formations, or part of a formation capable of producing groundwater in wells or springs.
Aquitard	A geologic formation, group of formations, or part of a formation through which virtually no water moves.
Basalt	A type of dark-colored, fine-grained, rock formed by the rapid cooling of lava. Often originally created on ocean floors.
Boulder	Sediment having a median dimension greater than 12 inches.
Casing (well)	A solid piece of pipe, typically steel or PVC plastic, used to keep a well open in either unconsolidated materials or unstable rock.
Clay	Sediment passing through a No. 200 sieve and consisting of silicate minerals exhibiting plasticity.
Claystone	A type of sedimentary rock formed through the burial and compaction of clay.
Cobble	Sediment having a median dimension of greater than 3 inches, but less than 12 inches.
Consolidated (over-consolidated)	With respect to soils, glacially overridden and therefore with a high density.

Dispersion	The spreading of contaminants with distance from the source area due to non-uniform flow velocities in an aquifer.
Drift (glacial)	Any material laid down directly by ice or deposited in lakes, oceans, or streams as result of glacial activity.
Eocene	The geologic epoch of time from 58 to 36 million years ago.
Epoch	A unit of geologic time that is a division of a period.
Esperance Sand	Quaternary Vashon advance outwash found in the Puget Lowland.
Fill	Any human-emplaced fine or course-grained soil resulting from land development.
Fluvial	Pertaining to or deposited by rivers or streams.
Fore-arc	The region of a subduction zone between the offshore trench and the associated volcanic arc.
Fraser	The most recent, region-wide glaciation that occurred in the Puget Lowland between about 15,000 and 13,000 years ago. Also used to describe sediment deposited during this time.
Glaciation	The formation, advance, and recession of glaciers or ice sheets.
Glaciofluvial	Silty sand to well-sorted sand and gravel that was deposited by glacial outwash rivers and streams and subglacial meltwater flow.
Glaciolacustrine	Pertaining to, derived from, or deposited in glacial lakes. Glaciolacustrine sediment is generally silt and clay
Gravel	Sediment having a median dimension of greater than ¼ inch, but less than 3 inches.
Groundwater	The water contained in interconnected pores beneath the ground surface.
Head (hydraulic)	Energy contained in a water mass, produced by elevation, pressure or velocity. The level to which water will rise in a well.
Holocene	The most recent geologic epoch, from the present to 11,000 years before present.

Hydraulic conductivity	The ability of a soil to transmit flow. Used interchangeably with permeability.
Hydrogeology	The branch of geology that deals with the occurrence, distribution, and effect of ground water.
Hydrograph	A graph showing groundwater head or surface water flow over time.
Hydrology	The branch of geology dealing with water on the earth.
Hydrostratigraphy	A method for grouping bodies of sediment based on their hydrogeologic behavior.
Ice-contact (deposit)	Sediment deposited under direct contact with ice. These deposits are generally unsorted and consist of a wide variety of grain sizes.
Interbed	In stratigraphy, a laterally discontinuous layer lithologically distinct from the more major unit containing it.
Kettle	A topographic depression formed by the melting of buried glacial ice.
Kriging	A geostatistical gridding method used to contour irregularly spaced data points.
Lacustrine	Pertaining to or deposited in lakes.
Lahar	A mudflow or landslide of eruptive debris on the flanks of a volcano.
Lawton Clay	Quaternary Vashon advance glaciolacustrine deposit found in the Puget Lowland.
Local receptor	A surface water body or drinking water supply well that could be at risk from contamination originating at the STIA AOMA.
Lodgement till	Till deposited at the base and then overridden and consolidated by a moving glacier deposit of glacial sediment that was smeared on the eroded surface
MODFLOW	A computer program developed by the USGS for modeling groundwater flow.
MT3D	A family of computer codes widely used to simulate contaminant transport in groundwater.
Olympia	The non-glacial period from 60,000 to 16,000 years before present (ybp) and the sediments deposited

	during that time.
Outwash (glacial)	Sediment deposited by meltwater streams beyond active glacier ice. Outwash can be either advance or recessional, depending on how the associated glacier is behaving at the time of deposition. Vashon recessional outwash is noteworthy in that it is the oldest sediment in the Puget Lowland that has not been glacially consolidated.
Paleomagnetic	A dating method that relies on the identification of sediments deposited during geologic time periods of reversed magnetic polarization.
Paleosol	A buried soil horizon of the geologic past.
Perched (groundwater)	Unconfined groundwater separated from the underlying water table by an unsaturated zone.
Period	A subdivision of geologic time consisting of multiple epochs.
Permeability	See hydraulic conductivity
Pleistocene	The epoch of geologic time from 2 million years ago to 11,000 ybp.
Plume	The volume of contaminated groundwater.
Possession	The glacial period from 80,000 to 60,000 ybp and the sediments deposited during that time.
Potentiometric surface	A surface that represents the head over an entire aquifer.
Pumice	Volcanic glass containing numerous distinct cells of gas.
Pump test	A test of aquifer properties conducted by pumping a test well and measuring how the water level changes both in the test well and in other nearby wells.
Quaternary	The period of geologic time from the present to 2 million years ago.
Radiocarbon dating	A dating method for organic material based on the decay rate of the naturally occurring isotope C^{14}.
Salmon Springs	The non-glacial period from 16,000 to 60,000 ybp and the sediments deposited during that time.
Sand	Sediment that passes through a No. 4 sieve, but is

	retained on a No. 200 sieve.
Sandstone	A type of sedimentary rock composed of cemented or otherwise compacted sand grains.
Screen (Well)	A tubular device with either slots, holes, gauze, or continuous-wire wrap; used at the end of a well casing to complete a well. The water enters the well through the well screen.
Sedimentary	Descriptive term for rock formed through the compaction and consolidation of rock fragments or through the precipitation of dissolved minerals.
Silt	Non-plastic sediment passing through a No. 200 sieve.
Siltstone	A fine-grained sedimentary rock composed of cemented or otherwise compacted silt grains.
Slug test	A test of aquifer properties conducted by displacing an amount of water for a well in static equilibrium and observing how the water level recovers in that well.
Smear Zone	The region of the subsurface adjacent to the water table containing liquid-phase contaminants due to fluctuations of the water table.
Specific capacity	A measure of a well's productivity, calculated as the flow rate divided by the drawdown.
Stade	Time represented by glacial deposits. A major, regional glaciation, persistent over time, can sometimes be broken into distinct stades.
STIA Grid System	A horizontal coordinate system with origin located in Puget Sound about 8,000 feet west of Des Moines Beach.
Storage coefficient	A dimensionless measure of the relationship between the volume of water removed from or added to an aquifer, and the change in head.
Stratified	A descriptive term for layered sediment lying in distinct beds.
Stratigraphy	A method for grouping bodies of sediment based on their composition or geologic origin.
Subduction zone	An elongate area in which an oceanic crustal block is pushed beneath a continental crustal block.

Tectonic	Of, pertaining to, or designating the rock structure and external forms resulting from the deformation of the earth's crust.
Tertiary	The period of geologic time from 2 to 66 million years ago.
Till	Unsorted and unstratified glacial drift, deposited directly by and underneath a glacier without subsequent reworking by water. Consists of a heterogeneous mixture of clay, silt, sand, gravel, and boulders varying widely in size and shape.
Transition beds	Sediments deposited during the transition from a non-glacial to a glacial environment or from a glacial to a non-glacial environment.
Transmissivity	A measure of an aquifer's ability to produce flow.
Vashon	The glacial period from 11,000 to 16,000 ybp and the sediments deposited during that time.
Volcanic	Having to do with volcanoes.
Whidbey	The non-glacial period from 80,000 to 100,000 ybp and the sediments deposited during that time.

Limitations

Work for this project was performed and this report prepared in accordance with generally accepted professional practices for the nature and conditions of work completed in the same or similar localities, at the time the work was performed. It is intended for the exclusive use of the Port of Seattle for specific application to the referenced property. This report does not represent a legal opinion. No other warranty, expressed or implied, is made.

July 20, 2015
Project 101.00145.00010

Mr. Ching-Pi Wang
Washington Department of Ecology
3190 – 160th Avenue SE
Bellevue, Washington 98008

Re: SeaTac International Airport Groundwater Study

Dear Mr. Wang:

On behalf of Delta Air Lines, Inc., the Port of Seattle, Avis Budget Car Rental, LLC, Hertz Corporation, and Vanguard Car Rental USA, LLC (the Groundwater Monitoring PRP Group), SLR International Corporation (SLR) is submitting the attached report that describes the field activities and presents the results of the 2015 annual groundwater sampling event at SeaTac International Airport (STIA).

In June 2015, the fifth annual groundwater sampling event was conducted, and the sample analytical results showed that only one sample contained a detectable contaminant of concern (COC; naphthalene) concentration, and that concentration (0.051 µg/L) only slightly exceeded the method reporting limit (MRL; 0.05 µg/L) and it was below the MTCA Method B cleanup level (160 µg/L). All of the other samples collected in 2015 did not contain COC concentrations greater than the MRLs. During the 2011, 2012, 2013, and 2014 groundwater sampling events, none of the samples contained COC concentrations that exceeded the MRLs. Based on the groundwater model predictions and the results of the five annual groundwater sampling events, the downgradient extents of the all of the modeled contaminant plumes have been sufficiently delineated, and the contaminants of concern in the plumes will not reach any potential local receptors (surface water bodies or drinking water supply wells), nor extend beyond the Aircraft Operations and Maintenance Area. Therefore, the Groundwater Monitoring PRP Group has discontinued the groundwater monitoring program, and considers this project closed.

If you have any questions regarding the 2015 annual sampling event or the attached report, please contact me at (425) 402-8800.

Sincerely,

SLR International Corporation

Michael D. Staton, L.G.
Principal Geologist

cc: Chris Lough, Delta Air Lines
Don Robbins, Port of Seattle
Rose Pelino, Avis Budget Car Rental, LLC
Tim Egan, Hertz Corporation
Brittany Hrgich, Enterprise Holdings, Inc.
Jeffrey Endsley, Enterprise Holdings, Inc.
Michelle Keen, Enterprise Holdings, Inc.

Attachment: Groundwater Sampling Report – 2015 Annual Event

July 20, 2015
Project 101.00145.00010

Mr. Ching-Pi Wang
Washington Department of Ecology
3190 – 160th Avenue SE
Bellevue, Washington 98008

Re: Groundwater Sampling Report – 2015 Annual Event, SeaTac International Airport Groundwater Study

Dear Mr. Wang:

On behalf of Delta Air Lines, Inc. (Delta), the Port of Seattle (Port), Avis Budget Car Rental, LLC, Hertz Corporation, and Vanguard Car Rental USA, LLC (the Groundwater Monitoring PRP Group), SLR International Corporation (SLR) has prepared this report to describe the field activities and present the results of the 2015 annual groundwater sampling event at SeaTac International Airport (STIA). The location of the airport is shown on Figure 1.

On May 25, 1999, the Port entered into a Model Toxics Control Act (MTCA) Agreed Order (#97TC-N122) with the Washington Department of Ecology (Ecology) to conduct an assessment of groundwater aquifers and contaminant migration in the vicinity of the STIA (referred to as the STIA Groundwater Study). From 1999 through 2008, the Port's consultants constructed a numerical groundwater model and performed contaminant fate and transport analyses. The results of the modeling analysis, with conservatively slow degradation (long half lives) of the contaminants of concern (COCs) at the STIA, predicted that concentrations above MTCA Method B groundwater cleanup levels will not impact local receptors (surface water bodies or drinking water supply wells), nor extend beyond the Aircraft Operations and Maintenance Area (AOMA) [Aspect Consulting, Inc, (Aspect), 2008]. The AOMA is shown on Figure 1. After reviewing the modeling results, Ecology stated that they approved of the work and that the terms of the Agreed Order were completed (Ecology, 2008). Although not required to complete the Agreed Order, Ecology recommended that the Port implement a groundwater monitoring plan to verify the model results.

To provide the data necessary to verify the groundwater model predictions, the Groundwater Monitoring PRP Group has been implementing the groundwater monitoring program presented in SLR's Work Plan for Groundwater Monitoring (SLR, 2011a), which is in accordance with Section 8.4 (Groundwater Monitoring Network Design Recommendations) of Aspect's Final Phase I Groundwater Study Report (Aspect, 2008). The contaminant plume-specific monitoring results will determine if the plumes have been sufficiently defined and if the contaminants in the plumes pose no risk to potential local receptors. The first four annual groundwater sampling events of the five-year-long monitoring program were conducted in 2011, 2012, 2013, and 2014.

GENERAL INFORMATION ABOUT CONTAMINANT PLUMES

There are 14 sites located within the AOMA that are known to have contaminants present in groundwater or contain significant soil contamination (Aspect, 2008). Environmental investigations that identified the nature and extent of contamination were conducted at these sites by either the responsible airline or other tenant, or the Port. For the STIA Groundwater Study, the data from these investigations were used by the Port's consultants as the basis to evaluate impacts to the Qva aquifer (the shallowest aquifer beneath the STIA) and to develop contaminant modeling predictions. Of the 14 known contaminated sites, 8 sites were selected for the groundwater model. In addition, two sites where known soil contamination could have potentially impacted the Qva aquifer (identified as potential sites) were also selected for the groundwater model.

In accordance with Section 8.4 of the Final Phase 1 Groundwater Study Report (Aspect, 2008), the groundwater monitoring program described in this report assesses the groundwater conditions near the edges of the contaminant plumes (primarily hydraulically downgradient) from the eight known groundwater contamination sites and the two potential sites that were included in the groundwater model. The eight known groundwater contamination sites are the Rental Car Quick Turnaround Area (QTA Tank Area), RAC Auto Facility, Budget Auto Facility, Delta Auto Gas Tank Cluster, Northwest Airlines (NWA) Hangar Tanks, PanAm Airlines (PanAm) Avgas Tanks, NWA Closed Hydrant System, and the South Satellite Baggage Tunnel Leak. The two potential sites are the Former Lagoon Area (designated Potential Site P3) and the NWA Abandoned Hydrant System (designated Potential Site P13). The locations of the modeled contaminant sources for each of these known or potential contamination sites are shown on Figure 2.

Known Groundwater Contamination Sites

The contaminant source areas at the QTA Tank Area, RAC Auto Facility, and Budget Auto Facility are located at the east-central part of the AOMA, near the airport parking garage (see Figure 2). Gasoline was previously released at all three of these areas, and the results of previous investigation activities have indicated that the gasoline at each area has impacted the Qva aquifer (Aspect, 2008). The modeled COC from each of these areas was benzene.

The Delta Auto Gas Tank Cluster was located near the southeast corner of the AOMA, near the current Delta hangar (see Figure 2). Gasoline and volatile organic compounds (VOCs) were released from the underground storage tank (UST) area and low levels of VOCs were detected in the Qva aquifer (Aspect, 2008). The modeled COC from this area was 1,2-dichloroethane (1,2-DCA).

The NWA Hangar Tanks were located in the east-central portion of the AOMA, near the current Concourse A terminal (see Figure 2). Chlorinated solvents were released at the area and have been detected in the Qva aquifer (Aspect, 2008). The modeled COC from this area was 1,1-dichloroethylene (1,1-DCE).

The PanAm Avgas Tanks were located in the east-central portion of the AOMA, near the NWA Hangar Tanks area (see Figure 2). Previous investigation results showed that Jet A was released from the tank area, and that petroleum free product was present in Qva aquifer monitoring wells (Aspect, 2008). Low levels of 1,1-DCE were also present in the Qva aquifer and appear to be due to the previous solvent releases at the NWA Hangar Tanks. Due to the co-mingled chlorinated solvents plume, the modeled COC from this area (and the NWA Hangar Tanks area) was 1,1-DCE.

The NWA Closed Hydrant System was located in the south-central part of the AOMA and extended from the former NWA fuel farm to the South Satellite Terminal. The modeled source area was located near the northeast corner of the South Satellite Terminal (see Figure 2). The results of previous investigations showed that two temporary monitoring wells in the Qva aquifer contained elevated concentrations of total petroleum hydrocarbons (TPH) as Jet A. The modeled COC from this area was naphthalene.

In 1992, Jet A fuel was discovered seeping into the South Satellite Baggage Tunnel, at a location near the northeast corner of the South Satellite Terminal (the South Satellite Baggage Tunnel Leak site; see Figure 2). The release was from an underground fuel hydrant system that has been decommissioned. Jet A free product is present on the Qva aquifer in this area. The modeled COC from this area was naphthalene.

Potential Groundwater Contamination Sites

The contaminant source at the Former Lagoon Area (Potential Site P3) is a historic wastewater lagoon that was located in the vicinity of the current Alaska Airlines hangar access road from South 188th Street, at the south end of the airport (see Figure 2). Soil samples from the area contained elevated TPH as diesel (TPH-D) and TPH as heavy oil (TPH-O) concentrations (Aspect, 2008). The Qva aquifer beneath the source area has not been assessed. The modeled COC from this area was naphthalene.

The modeled source area of the NWA Abandoned Hydrant System (Potential Site P13) is a segment of the former hydrant system located in the southeastern portion of the AOMA, near the southern end of the current Concourse A terminal (see Figure 2). During Port construction activities in 2001 and 2002, excavated soil from the area contained TPH as Jet A or TPH-D concentrations up to 13,000 milligrams per kilogram (mg/kg), and the highest TPH concentrations in the remaining soil were up to 4,600 mg/kg (Aspect, 2008). The Qva aquifer beneath the source area has not been assessed. The modeled COC from this area was naphthalene.

Site Hydrogeology

The STIA is underlain by a thick sequence of glacial and non-glacial deposits, and man-made fill materials. Deposits include silt, sand, and gravel fill; silty to clayey and peaty lacustrine deposits; silty, sandy and gravelly fluvial deposits; silty and gravelly sandy glacial till; sandy and gravelly glacial outwash; and silty and clayey glaciolacustrine transition beds. Six major aquifers associated with distinct stratigraphic units have been identified in the airport area (Aspect Consulting, 2008). Discontinuous fine-grained units of low to moderate permeability locally restrict vertical groundwater flow between each of the aquifers. The shallowest aquifer beneath the airport area is the Qva aquifer (Vashon Advance Outwash), which occurs at depths ranging from approximately 60 feet below ground surface (bgs) beneath the southern portion of the AOMA to approximately 95 feet bgs beneath the northern portion of the AOMA. Beneath the airport, the general flow direction of the Qva aquifer is to the west. The Qva aquifer (also designated as the C1 aquifer) is the primary focus of the groundwater monitoring activities described in this report; however, one of the existing monitoring wells (UNFHS_CMW-8) included in the groundwater monitoring program is screened within the deeper C2 aquifer (at a location where the Qva aquifer and the underlying C2 aquifer are directly connected).

GROUNDWATER MONITORING PROGRAM

To collect the groundwater data needed to test the previous groundwater model predictions, the STIA groundwater monitoring program was initially planned to be conducted at six existing and five new groundwater monitoring wells, as described in Section 8.4 of the Final Phase 1 Groundwater Study Report (Aspect, 2008); however, based on an inspection of the existing wells by SLR, the Port, and Ecology in March 2011, one of the Qva aquifer wells (UNFHS_CMW-5) that was part of the monitoring program could not be found, and appeared to have been destroyed (covered by a concrete pad). To allow for the monitoring of several of the groundwater contaminant plumes, a total of six groundwater monitoring wells (designated AWGM-1 through AWGM-6) were installed at the STIA in May 2011 (SLR, 2011b). Well AWGM-1 replaced former well UNFHS_CMW-5. The locations of the wells are shown on Figure 2.

In accordance with Section 8.4 of the Final Phase 1 Groundwater Study Report (Aspect, 2008), groundwater sampling events were conducted on an annual basis for five years. The groundwater monitoring program for each of the modeled known and potential contamination sites includes the following monitoring wells, which are shown on Figure 2:

QTA Tank Area, RAC Auto Facility, and Budget Auto Facility

- Wells UNHYD_MW-1, UNFHS_CMW-7, UNFHS_CMW-8, AWGM-1 and AWGM-2

NWA Hangar Tanks and PanAm Avgas Tanks

- Well AWGM-3

NWA Closed Hydrant System and South Satellite Baggage Tunnel Leak

- Wells NWHS2_SSW-2 and NWHS2_SSW-9

Potential Site P13

- Well AWGM-4

Delta Auto Gas Tank Cluster

- Wells AWGM-5 and AWGM-6

Potential Site P3

- Well AWGM-6

Except for well AWGM-5, all of the monitoring wells are positioned based on the centerline of each modeled contaminant plume. Figure 8-1 ("Proposed Groundwater Monitoring Network") of the Final Phase 1 Groundwater Study Report, which shows the modeled plumes and the well locations, is presented in Appendix A.

Results of Previous Annual Groundwater Sampling Events

SLR personnel conducted the first four annual groundwater sampling events in May and/or June of 2011, 2012, 2013, and 2014. The groundwater sample analytical results from each sampling event showed that the samples did not contain COC concentrations greater than the method reporting limits (MRLs) (SLR, 2011b; SLR, 2012; SLR, 2013; and SLR, 2014). The 2011 and 2013 samples from well NWHS2_SSW-9 contained TPH as Jet A concentrations [760 and 570 micrograms per liter (µg/L), respectively] that exceeded the MTCA Method A groundwater cleanup level (500 µg/L), and the 2014 sample from well UNHYD_MW-1 contained a TPH as gasoline (TPH-G) concentration (1,300 µg/L) that exceeded the Method A groundwater cleanup level (800 µg/L) (SLR, 2011b; SLR, 2013; and SLR, 2014). However, TPH as Jet A and TPH-G are not groundwater COCs.

2015 GROUNDWATER SAMPLING EVENT

SLR personnel conducted the fifth annual groundwater sampling event from June 1 through 4, 2015. The work was conducted in accordance with SLR's *Work Plan for Groundwater Monitoring, SeaTac International Airport,* dated April 15, 2011. Prior to sampling each well, SLR measured the depth to groundwater and free product, if present, by using an electronic oil/water interface probe. The depths to groundwater in the wells ranged from 38.16 to 87.52 feet. The depth to groundwater in well AWGM-5 (38.16 feet) was approximately 9.8 feet above the top of the well screen, and it appears that the depth to groundwater was affected by a shallower perched groundwater zone at that location. The depths of the Qva aquifer in the wells located along Concourse D (AWGM-1, AWGM-2, UNHYD_MW-1, and UNFHS_CMW-7) ranged from 82.66 to 87.52 feet. The depths of the Qva aquifer in the wells located near the South Satellite Terminal and the southern end of the AOMA (AWGM-3, AWGM-4, AWGM-6, NWHS2_SSW-2, and

NWHS2_SSW-9) ranged from 53.96 to 62.78 feet. The depth to groundwater in the C2 aquifer well (UNFHS_CMW-8) was 87.06 feet. The depth to groundwater measurements were converted to groundwater elevations by using the results of the previous well elevation surveys. The depths to groundwater and groundwater elevations are presented in Table 1. Free product was not present in any of the wells.

Except for wells AWGM-5 and UNFHS_CMW-8, a minimum of three well casing volumes of groundwater were purged from each well by using a disposable bailer attached to a nylon cord. Well AWGM-5 was bailed dry prior to removing the third well casing volume of groundwater, and was subsequently sampled after a sufficient quantity of groundwater recharged into the well. Because UNFHS_CMW-8 is a 4-inch-diameter well that contained approximately 160 feet of groundwater, SLR applied low-flow sampling techniques to purge that well. The pH, temperature, and conductivity of the purge water were measured to determine when the groundwater conditions in each well had stabilized. After the groundwater conditions had stabilized, the samples were collected and submitted to Friedman & Bruya, Inc., in Seattle, Washington, for analysis. The purge water is temporarily stored at the airport in properly labeled, 55-gallon drums, pending disposal in the airport's industrial wastewater system.

As recommended in the Final Phase I Groundwater Study Report (Aspect, 2008), the groundwater samples were analyzed for the following parameters:

- To monitor the benzene plumes from the Budget Auto Facility, the RAC Auto Facility and the QTA Tank Area, the samples from wells AWGM-1, AWGM-2, UNHYD_MW-1, UNFHS_CMW-7, and UNFHS_CMW-8 were analyzed for benzene by EPA Method 8021B and for TPH-G by Ecology Method NWTPH-Gx. A duplicate sample (designated AWGM-16-0615) was collected from UNHYD_MW-1, and analyzed for benzene and TPH-G.

- To monitor the co-mingled 1,1-DCE plume from the NWA Hangar Tanks site and the PanAm Avgas Tanks site, the sample from well AWGM-3 was analyzed for 1,1-DCE by EPA Method 8260C. To monitor TPH from the PanAm Avgas Tanks site, the sample from AWGM-3 was also analyzed for TPH as Jet A by Ecology Method NWTPH-Dx (after silica gel cleanup and calibrated to a Jet A standard) and for TPH-G.

- To monitor the naphthalene plume from the NWA Closed Hydrant System site and the South Satellite Baggage Tunnel Leak site, the samples from wells NWHS2_SSW-2 and NWHS2_SSW-9 were analyzed for naphthalene by EPA Method 8270D SIM and for TPH as Jet A.

- To monitor the naphthalene plume from Potential Site P13, the sample from well AWGM-4 was analyzed for naphthalene and TPH as Jet A.

- To monitor the 1,2-DCA plume from the Delta Auto Gas Tank Cluster site, the samples from wells AWGM-5 and AWGM-6 were analyzed for 1,2-DCA by EPA Method 8260C. Due to the known gasoline releases at the site, the samples were also analyzed for TPH-G. To monitor the naphthalene plume from Potential Site P3, the sample from AWGM-6 was also analyzed for naphthalene, and for TPH-D and TPH-O by Ecology Method NWTPH-Dx (after silica gel cleanup).

The groundwater sample analytical results showed that sample NWHS2_SSW-2 contained a naphthalene concentration (0.051 μg/L) that was below the MTCA Method B groundwater cleanup level (160 μg/L). None of the other samples contained COC concentrations greater than the MRLs. The samples from well UNHYD_MW-1 (including duplicate sample AWGM-16-0615) contained a TPH-G concentration (340 μg/L for both samples) that was below the MTCA Method A cleanup level, and the sample from well NWHS2_SSW-2 contained a TPH as Jet A concentration (120 μg/L) that was below the Method A groundwater cleanup level. It is important to note that TPH-G and TPH as Jet A are not groundwater COCs. The groundwater sample analytical results are presented in Table 2, and copies of the laboratory reports are presented in Appendix B.

CONCLUSIONS

From 2011 through 2015, SLR has conducted annual groundwater sampling events in accordance with the STIA groundwater monitoring program to provide the data necessary to verify the previous groundwater model predictions. In June 2015, the fifth annual groundwater sampling event was conducted, and the sample analytical results showed that only one sample contained a detectable COC (naphthalene) concentration, and that concentration (0.051 μg/L) only slightly exceeded the MRL (0.05 μg/L) and it was below the MTCA Method B groundwater cleanup level (160 μg/L). During the 2011, 2012, 2013, and 2014 groundwater sampling events, none of the samples contained COC concentrations that exceeded the MRLs.

The STIA groundwater monitoring plan in the Final Phase I Groundwater Study Report (Aspect, 2008) stated that annual groundwater sampling would be conducted for a period of at least five years to establish any trends in the groundwater data and to evaluate the previous groundwater modeling results. Based on the results of the five annual groundwater sampling events, the downgradient extents of all of the modeled contaminant plumes have been sufficiently delineated (and are smaller than predicted by the model), and the contaminants in the plumes will not impact potential local receptors (surface water bodies or drinking water supply wells), nor extend beyond the AOMA. Since the COCs have not been detected at concentrations greater than the MRLs, except in one sample, SLR and the Groundwater Monitoring PRP Group believe that additional groundwater data are not necessary to further verify the groundwater model predictions. Therefore, the groundwater monitoring program will be discontinued, and the project is considered closed.

If you have any questions, please contact me at (425) 402-8800.

Sincerely,

SLR International Corporation

Michael D. Staton, L.G.
Principal Geologist

cc: Chris Lough, Delta Air Lines
Don Robbins, Port of Seattle
Rose Pelino, Avis Budget Car Rental, LLC
Tim Egan, Hertz Corporation
Brittany Hrgich, Enterprise Holdings, Inc.
Jeffrey Endsley, Enterprise Holdings, Inc.
Michelle Keen, Enterprise Holdings, Inc.

Attachments: Limitations
References
Tables 1 and 2
Figures 1 and 2
Appendix A – Figure 8-1 of Aspect Report
Appendix B – Laboratory Reports

LIMITATIONS

The services described in this report were performed consistent with generally accepted professional consulting principles and practices. No other warranty, express or implied, is made. These services were performed consistent with our agreement with our client. This report is solely for the use and information of our client unless otherwise noted. Any reliance on this report by a third party is at such party's sole risk. Opinions and recommendations contained in this report apply to conditions existing when services were performed and are intended only for the client, purposes, locations, time frames, and project parameters indicated. We are not responsible for the impacts of any changes in environmental standards, practices, or regulations subsequent to performance of services. We do not warrant the accuracy of information supplied by others, or the use of segregated portions of this report.

REFERENCES

Aspect Consulting. 2008. *Seattle-Tacoma International Airport Phase 1 Groundwater Study Report.* July.

SLR International Corporation. 2011a. *Work Plan for Groundwater Monitoring, SeaTac International Airport.* April.

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Washington Department of Ecology. 2008. Letter to Paul Agid of Port of Seattle, Completion of Agreed Order #97TC-N122, Sea-Tac International Airport, Ground-Water Study. September 3.

TABLES

Table 1
Groundwater Monitoring Data
STIA Groundwater Study
SeaTac International Airport

Well Number	Top of Casing Elevation[a] (feet)	Approximate Depth of Well Screen (feet)	Date Measured	Depth to Groundwater (feet)	Groundwater Elevation (feet)	Comments
AWGM-1	392.95	80.1 to 94.7	06/02/11	87.37	305.58	
			06/19/12	86.53	306.42	
			06/06/13	87.01	305.94	
			06/10/14	87.48	305.47	
			06/03/15	87.52	305.43	
AWGM-2	389.92	80.0 to 94.6	06/02/11	84.47	305.45	
			06/20/12	83.68	306.24	
			06/05/13	84.10	305.82	
			06/11/14	84.55	305.37	
			06/03/15	84.42	305.50	
AWGM-3	375.58	54.9 to 69.5	06/01/11	61.93	313.65	
			06/19/12	61.78	313.80	
			06/05/13	61.78	313.80	
			06/13/14	62.79	312.79	
			06/03/15	62.78	312.80	
AWGM-4	357.57	53.0 to 67.6	06/01/11	56.93	300.64	
			06/18/12	57.00	300.57	
			06/04/13	56.83	300.74	
			06/09/14	56.76	300.81	
			06/02/15	56.82	300.75	
AWGM-5	368.13	48.0 to 62.6	05/31/11	37.44	330.69	Depths to groundwater in well affected by shallower perched groundwater during all monitoring events.
			06/18/12	37.10	331.03	
			06/04/13	36.61	331.52	
			06/09/14	37.81	330.32	
			06/03/15	38.16	329.97	
AWGM-6	359.74	47.0 to 61.6	06/02/11	52.81	306.93	
			06/18/12	54.85	304.89	
			06/04/13	54.30	305.44	
			06/09/14	54.14	305.60	
			06/02/15	53.96	305.78	

Table 1
Groundwater Monitoring Data
STIA Groundwater Study
SeaTac International Airport

Well Number	Top of Casing Elevation[a] (feet)	Approximate Depth of Well Screen (feet)	Date Measured	Depth to Groundwater (feet)	Groundwater Elevation (feet)	Comments
UNHYD_MW-1	378.14	77.0 to 92.0	05/31/11	82.54	295.60	
			06/20/12	81.74	296.40	
			06/06/13	82.27	295.87	
			06/10/14	82.58	295.56	
			06/01/15	82.66	295.48	
UNFHS_CMW-7	391.93	80.5 to 100.5	06/01/11	86.55	305.38	
			06/19/12	85.75	306.18	
			06/05/13	86.16	305.77	
			06/11/14	86.63	305.3	
			06/02/15	86.72	305.21	
UNFHS_CMW-8	392.22	227.5 to 247.5	06/02/11	87.13	305.09	
			06/20/12	85.73	306.49	
			06/03/13	86.55	305.67	
			06/11/14	87.05	305.17	
			06/01/15	87.06	305.16	
NWHS2_SSW-2	375.18	52.0 to 71.5	05/31/11	58.34	316.84	
			06/18/12	58.18	317.00	
			06/03/13	58.21	316.97	
			06/10/14	58.23	316.95	
			06/04/15	58.28	316.90	
NWHS2_SSW-9	374.95	55.0 to 64.5	06/01/11	60.03	314.92	
			06/19/12	59.80	315.15	
			06/04/13	59.79	315.16	
			06/10/14	59.87	315.08	
			06/02/15	59.85	315.10	

Notes:
[a] Top of well casing elevations were surveyed relative to a known elevation above mean sea level.

Table 2
Groundwater Sample Analytical Results
STIA Groundwater Study
SeaTac International Airport

Sample Location	Sample Name	Sample Date	Benzene[a] (µg/L)	Naphthalene[b] (µg/L)	1,1-DCE[c] (µg/L)	1,2-DCA[c] (µg/L)	TPH-G[d] (µg/L)	TPH-D[e] (µg/L)	TPH-O[e] (µg/L)	TPH as Jet A[f] (µg/L)
	MTCA Groundwater Cleanup Levels[g]		0.80[h]	160[h]	400[h]	0.48[h]	800[i]	500[i]	500[i]	500[i]
AWGM-1	AWGM-1-0611	06/02/11	<0.04 E	NA	NA	NA	<100	NA	NA	NA
	AWGM-1-0612	06/19/12	<0.04 E	NA	NA	NA	<100	NA	NA	NA
	AWGM-1-0613	06/06/13	<0.8	NA	NA	NA	<100	NA	NA	NA
	AWGM-1-0614	06/10/14	<0.8	NA	NA	NA	<100	NA	NA	NA
	AWGM-1-0615	06/03/15	<0.8	NA	NA	NA	<100	NA	NA	NA
AWGM-2	AWGM-2-0611	06/02/11	<0.04 E	NA	NA	NA	<100	NA	NA	NA
	AWGM-2-0612	06/20/12	<0.04 E	NA	NA	NA	<100	NA	NA	NA
	AWGM-2-0613	06/05/13	<0.8	NA	NA	NA	<100	NA	NA	NA
	AWGM-17-0613 (dup.)	06/05/13	<0.8	NA	NA	NA	<100	NA	NA	NA
	AMGM-2-0614	06/11/14	<0.8	NA	NA	NA	<100	NA	NA	NA
	AWGM-2-0615	06/03/15	<0.8	NA	NA	NA	<100	NA	NA	NA
AWGM-3	AWGM-3-0611	06/01/11	NA	NA	<0.48 E	NA	<100	NA	NA	<50
	AWGM-3-0612	06/19/12	NA	NA	<0.48 E	NA	<100	NA	NA	<50
	AWGM-3-0613	06/05/13	NA	NA	<0.48	NA	110 x	NA	NA	<50
	AWGM-3-06/14	06/13/14	NA	NA	<0.48	NA	<100	NA	NA	<50
	AWGM-3-0615	06/03/15	NA	NA	<0.48	NA	<100	NA	NA	<55
AWGM-4	AWGM-4-0611	06/01/11	NA	<0.1	NA	NA	NA	NA	NA	<50
	AWGM-4-0612	06/18/12	NA	<0.1	NA	NA	NA	NA	NA	<50
	AWGM-4-0613	06/04/13	NA	<0.1	NA	NA	NA	NA	NA	<50
	AWGM-4-0614	06/09/14	NA	<0.05	NA	NA	NA	NA	NA	<50
	AWGM-4-0615	06/02/15	NA	<0.05	NA	NA	NA	NA	NA	<50
AWGM-5	AWGM-5-0511	05/31/11	NA	NA	NA	<0.48 E	<100	NA	NA	NA
	AWGM-5-0612	06/18/12	NA	NA	NA	<0.48 E	<100[j]	NA	NA	NA
	AWGM-5-0613	06/04/13	NA	NA	NA	<0.48	<100	NA	NA	NA
	AWGM-5-0614	06/09/14	NA	NA	NA	<0.48	<100	NA	NA	NA
	AWGM-5-0615	06/03/15	NA	NA	NA	<0.48	<100	NA	NA	NA
AWGM-6	AWGM-6-0611	06/02/11	NA	<0.1	NA	<0.48 E	<100	<50	<250	NA
	AWGM-16-0611 (dup.)	06/02/11	NA	<0.1	NA	<0.48 E	<100	<50	<250	NA
	AWGM-6-0612	06/18/12	NA	<0.1	NA	<0.48 E	<100[j]	<50	<250	NA
	AWGM-6-0613	06/04/13	NA	<0.1	NA	<0.48	<100	<50	<250	NA
	AWGM-6-0614	06/09/14	NA	<0.05	NA	<0.48	<100	<50	<250	NA
	AWGM-6-0615	06/02/15	NA	<0.05	NA	<0.48	<100	<50	<250	NA

Table 2
Groundwater Sample Analytical Results
STIA Groundwater Study
SeaTac International Airport

Sample Location	Sample Name	Sample Date	Benzene[a] (µg/L)	Naphthalene[b] (µg/L)	1,1-DCE[c] (µg/L)	1,2-DCA[c] (µg/L)	TPH-G[d] (µg/L)	TPH-D[e] (µg/L)	TPH-O[e] (µg/L)	TPH as Jet A[f] (µg/L)
MTCA Groundwater Cleanup Levels[g]			**0.80[h]**	**160[h]**	**400[h]**	**0.48[h]**	**800[i]**	**500[i]**	**500[i]**	**500[i]**
UNHYD_MW-1	UNHYD_MW-1-0511	05/31/11	<0.04 E	NA	NA	NA	<100	NA	NA	NA
	UNHYD_MW-1-0612	06/20/12	<0.04 E	NA	NA	NA	130	NA	NA	NA
	UNHYD_MW-1-0613	06/05/13	<0.8	NA	NA	NA	170	NA	NA	NA
	UNHYD_MW-1-0614	06/10/14	<0.8	NA	NA	NA	**1,300**	NA	NA	NA
	UNHYD_MW-1-0615	06/02/15	<0.8	NA	NA	NA	340	NA	NA	NA
	AWGM-16-0615 (dup.)	06/02/15	<0.8	NA	NA	NA	340	NA	NA	NA
UNFHS_CMW-7	UNFHS_CMW-7-0611	06/01/11	<0.04 E	NA	NA	NA	<100	NA	NA	NA
	UNFHS_CMW-7-0612	06/19/12	<0.04 E	NA	NA	NA	<100	NA	NA	NA
	UNFHS_CMW-7-0613	06/05/13	<0.8	NA	NA	NA	<100	NA	NA	NA
	UNFHS_CMW-7-0614	06/10/14	<0.8	NA	NA	NA	<100	NA	NA	NA
	UNFHS_CMW-7-0615	06/02/15	<0.8	NA	NA	NA	<100	NA	NA	NA
UNFHS_CMW-8	UNFHS_CMW-8-0611	06/02/11	<0.04 E	NA	NA	NA	<100	NA	NA	NA
	UNFHS_CMW-8-0612	06/20/12	<0.04 E	NA	NA	NA	<100	NA	NA	NA
	UNFHS_CMW-8-0613	06/03/13	<0.8	NA	NA	NA	<100	NA	NA	NA
	UNFHS_CMW-8-0614	06/10/14	<0.8	NA	NA	NA	<100	NA	NA	NA
	UNFHS_CMW-8-0615	06/01/15	<0.8	NA	NA	NA	<100	NA	NA	NA
NWHS2-SSW-2	NWHS2_SSW-2-0511	05/31/11	NA	<0.1	NA	NA	NA	NA	NA	<50
	NWHS2_SSW-2-0612	06/18/12	NA	<0.1	NA	NA	NA	NA	NA	110
	NWHS2_SSW-2-0613	06/04/13	NA	<0.1	NA	NA	NA	NA	NA	**570**
	NWHS2_SSW-2-0614	06/10/14	NA	<0.05	NA	NA	NA	NA	NA	110
	AWGM-16-0614 (dup.)	06/10/14	NA	<0.05	NA	NA	NA	NA	NA	140
	NWHS2-SSW-2-0615	06/04/15	NA	0.051	NA	NA	NA	NA	NA	120
NWHS2-SSW-9	NWHS2_SSW-9-0611	06/01/11	NA	<0.1	NA	NA	NA	NA	NA	**760**
	NWHS2_SSW-9-0612	06/19/12	NA	<0.1	NA	NA	NA	NA	NA	<50
	AWGM-16-0612 (dup.)	06/19/12	NA	0.19	NA	NA	NA	NA	NA	<50
	NWHS2_SSW-9-0613	06/04/13	NA	<0.1	NA	NA	NA	NA	NA	<50
	NWHS2_SSW-9-0614	06/10/14	NA	<0.05	NA	NA	NA	NA	NA	150
	NWHS2_SSW-9-0615	06/03/15	NA	<0.05	NA	NA	NA	NA	NA	<60

Table 2
Groundwater Sample Analytical Results
STIA Groundwater Study
SeaTac International Airport

Sample Location	Sample Name	Sample Date	Benzene[a] (µg/L)	Naphthalene[b] (µg/L)	1,1-DCE[c] (µg/L)	1,2-DCA[c] (µg/L)	TPH-G[d] (µg/L)	TPH-D[e] (µg/L)	TPH-O[e] (µg/L)	TPH as Jet A[f] (µg/L)
MTCA Groundwater Cleanup Levels[g]			**0.80[h]**	**160[h]**	**400[h]**	**0.48[h]**	**800[i]**	**500[i]**	**500[i]**	**500[i]**

Notes:

µg/L = micrograms per liter.

NA = not analyzed.

Concentration in **bold** exceeds Model Toxics Control Act (MTCA) groundwater cleanup level.

E = The laboratory report stated that the value is an estimate because it is below the normal method reporting limits.

x = The laboratory report stated that the sample chromatographic pattern does not resemble the fuel standard used for quantification.

[a] Benzene by EPA Method 8021B.

[b] Naphthalene by EPA Method 8270D SIM.

[c] 1,1-Dichloroethene (1,1-DCE) and 1,2-Dichloroethane (1,2-DCA) by EPA Method 8260C.

[d] Total petroleum hydrocarbons (TPH) as gasoline (TPH-G) by Ecology Method NWTPH-Gx.

[e] TPH as diesel (TPH-D) and as oil (TPH-O) by Ecology Method NWTPH-Dx (after silica gel cleanup).

[f] TPH as Jet A by Ecology Method NWTPH-Dx (after silica gel cleanup).

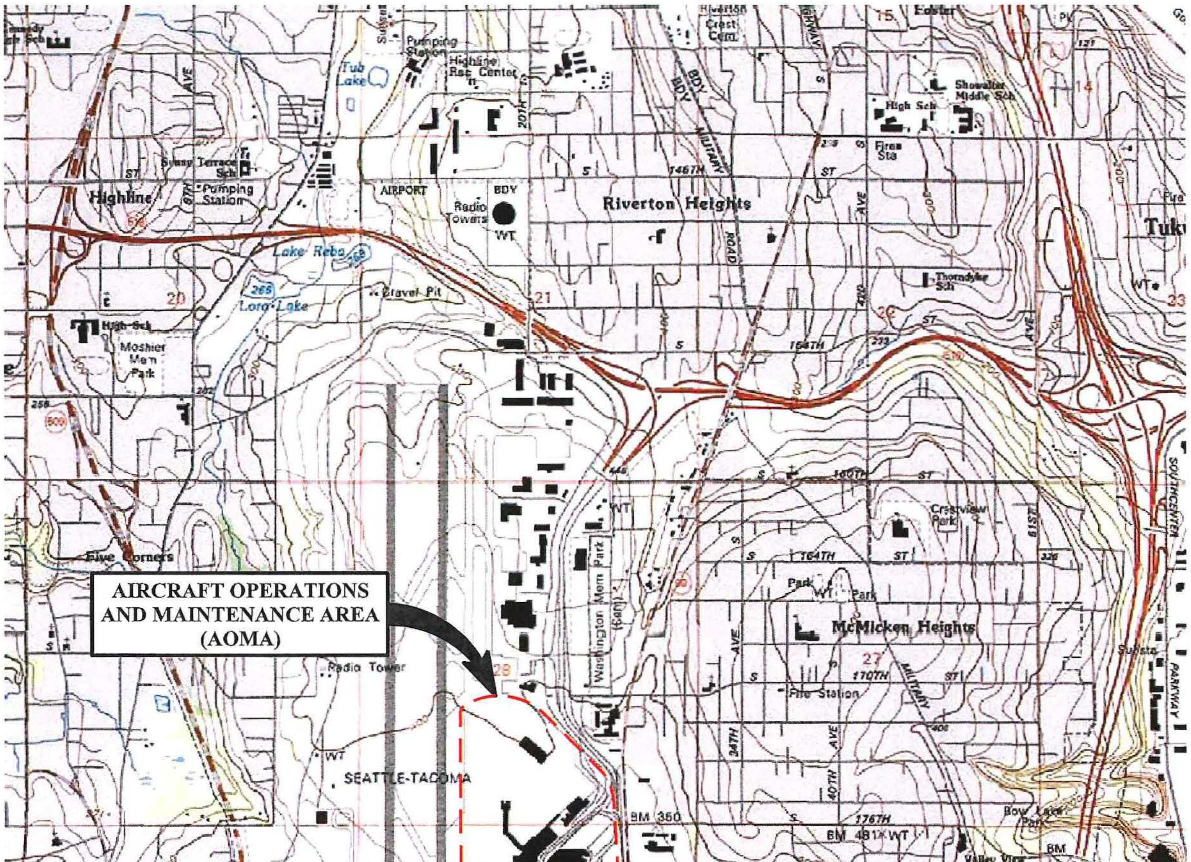
[g] Chapter 173-340 WAC, "Model Toxics Control Act Cleanup Regulation." Amended February 12, 2001.

[h] Method B groundwater cleanup level.

[i] Method A groundwater cleanup level was applied because site-specific data to calculate a Method B cleanup level is not available.

[j] Analysis was performed a few hours outside of the method holding time requirement.

FIGURES



Base map prepared from USGS 7.5-minute quadrangle of DES MOINES,WA (1995)

0 3000 6000

SCALE IN FEET

SLR

22118 20th AVE SE
BLDG. G, SUITE 202
BOTHELL, WA 98021

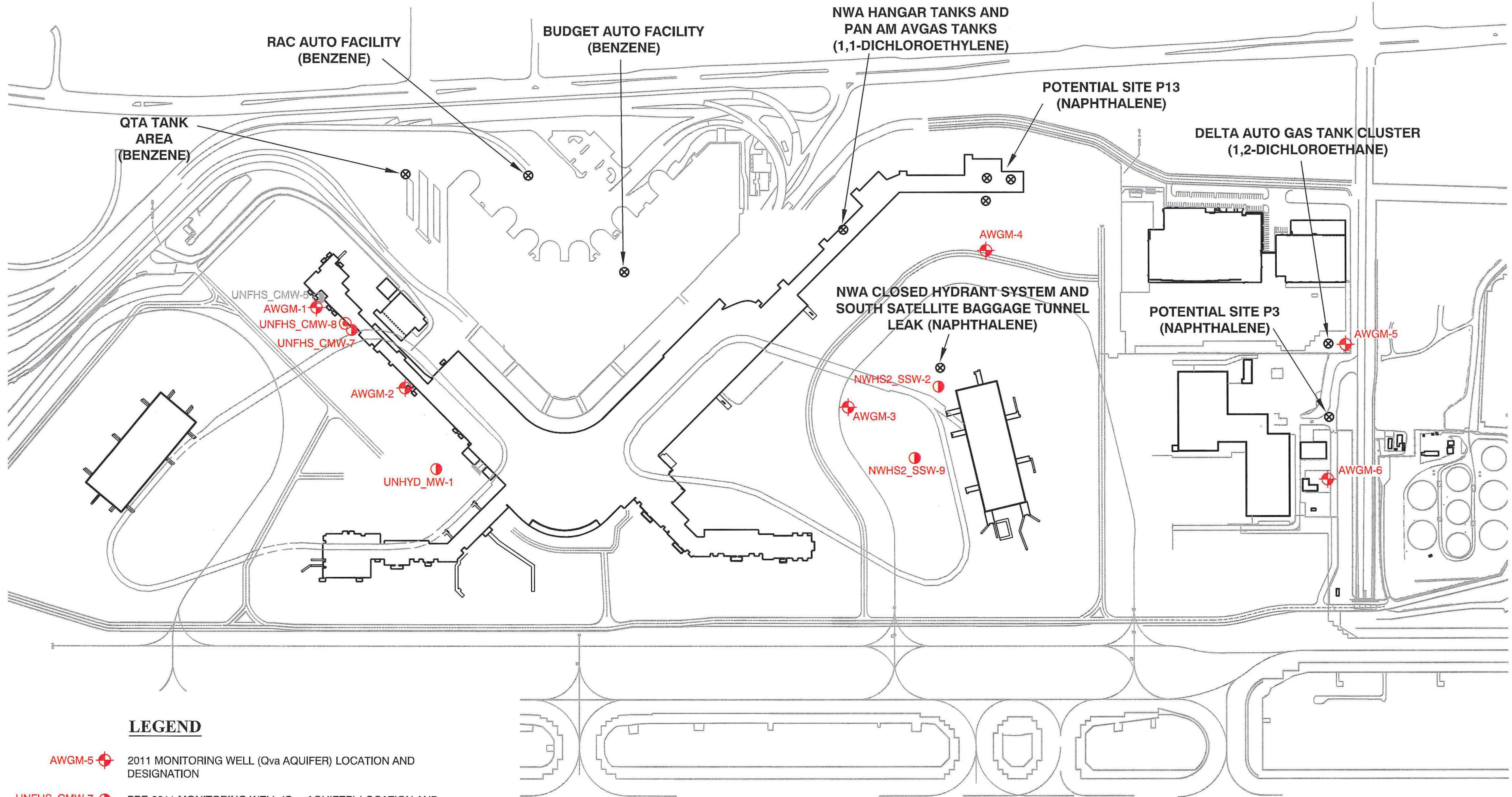
T: 425-402-8800
F: 425-402-8488

DATE 04/11
DWN. BDT
APPR.
REVIS.
PROJECT NO.
101.00145.00010

FIGURE 1
GROUNDWATER MONITORING
SEATAC INTERNATIONAL AIRPORT

SEATAC INTERNATIONAL AIRPORT
LOCATION MAP

C:\DRIVE_E\Clients\SLR\101\101.00145.00010\02-01.dwg, 4/12/2011 7:52:12 PM, BDT



LEGEND

AWGM-5 — 2011 MONITORING WELL (Qva AQUIFER) LOCATION AND DESIGNATION

UNFHS_CMW-7 — PRE-2011 MONITORING WELL (Qva AQUIFER) LOCATION AND DESIGNATION

UNFHS_CMW-8 — PRE-2011 MONITORING WELL (C2 AQUIFER) LOCATION AND DESIGNATION

UNFHS_CMW-5 — DESTORYED MONITORING WELL LOCATION AND DESIGNATION

⊗ MODELED CONTAMINANT SOURCE LOCATION

NOTE: PRE-2011WELL LOCATIONS, PLUME NAMES AND SOURCES, AND CONTAMINANTS OF CONCERN ARE FROM ASPECT CONSULTING'S FIGURE 8-1 "PROPOSED GROUNDWATER MONITORING NETWORK", DATED FEBRUARY 2005.

0 400 800
SCALE IN FEET

SLR
22118 20th AVE SE
BLDG. G, SUITE 202
BOTHELL, WA 98021
T: 425-402-8800
F: 425-402-8488

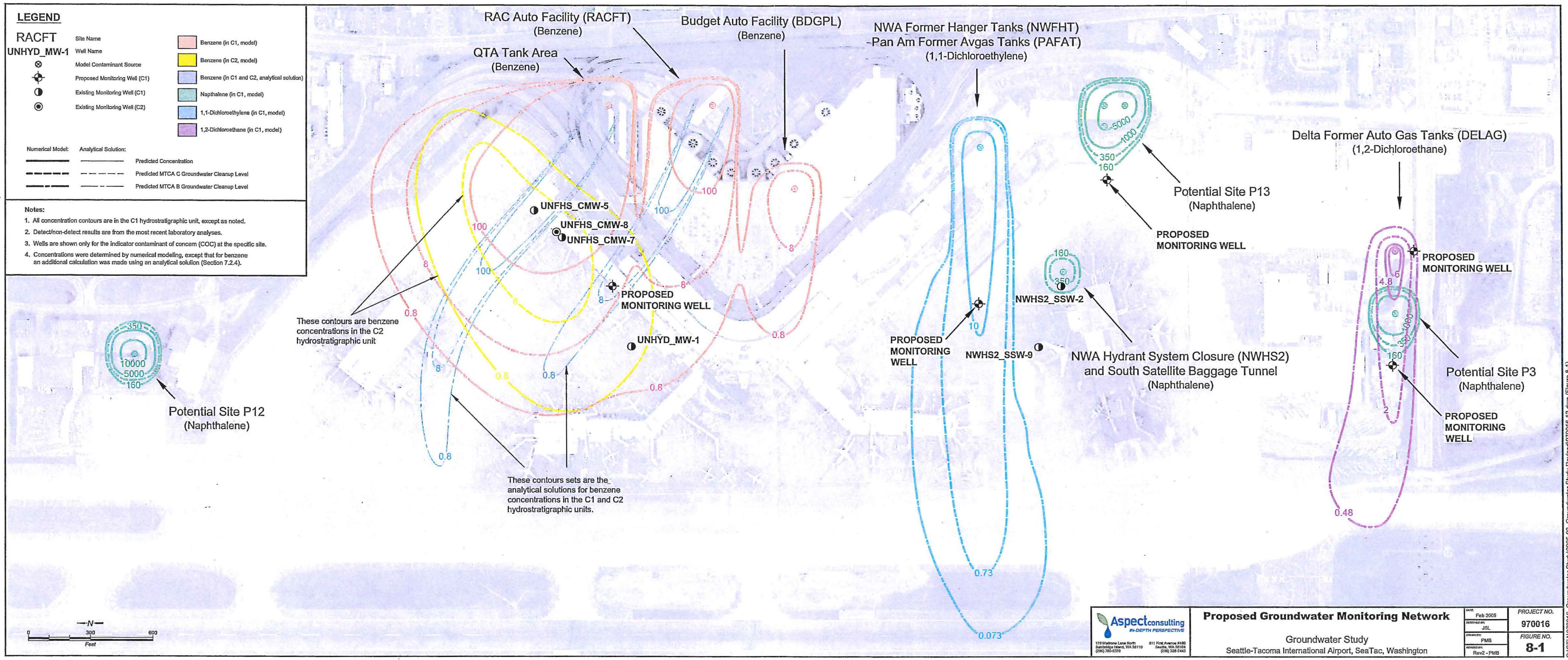
DATE 07/11
DWN. BDT
APPR.
REVIS.
PROJECT NO.
101.00145.00010

FIGURE 2
GROUNDWATER MONITORING STUDY
SEATAC INTERNATIONAL AIRPORT

GROUNDWATER MONITORING WELL LOCATIONS

APPENDIX A

FIGURE 8-1 OF ASPECT REPORT



LEGEND
RACFT Site Name
UNHYD_MW-1 Well Name
Model Contaminant Source
Proposed Monitoring Well (C1)
Existing Monitoring Well (C1)
Existing Monitoring Well (C2)
Benzene (in C1, model)
Benzene (in C2, model)
Benzene (in C1 and C2, analytical solution)
Napthalene (in C1, model)
1,1-Dichloroethylene (in C1, model)
1,2-Dichloroethane (in C1, model)
Numerical Model:
Analytical Solution:
Predicted Concentration
Predicted MTCA C Groundwater Cleanup Level
Predicted MTCA B Groundwater Cleanup Level
Notes:
1. All concentration contours are in the C1 hydrostratigraphic unit, except as noted.
2. Detect/non-detect results are from the most recent laboratory analyses.
3. Wells are shown only for the indicator contaminant of concern (COC) at the specific site.
4. Concentrations were determined by numerical modeling, except that for benzene an additional calculation was made using an analytical solution (Section 7.2.4).
RAC Auto Facility (RACFT)
(Benzene)
QTA Tank Area
(Benzene)
Budget Auto Facility (BDGPL)
(Benzene)
NWA Former Hanger Tanks (NWFHT)
Pan Am Former Avgas Tanks (PAFAT)
(1,1-Dichloroethylene)
Potential Site P13
(Naphthalene)
PROPOSED MONITORING WELL
Delta Former Auto Gas Tanks (DELAG)
(1,2-Dichloroethane)
PROPOSED MONITORING WELL
UNFHS_CMW-5
UNFHS_CMW-8
UNFHS_CMW-7
PROPOSED MONITORING WELL
UNHYD_MW-1
These contours are benzene concentrations in the C2 hydrostratigraphic unit
These contours sets are the analytical solutions for benzene concentrations in the C1 and C2 hydrostratigraphic units.
Potential Site P12
(Naphthalene)
NWHS2_SSW-2
PROPOSED MONITORING WELL
NWHS2_SSW-9
NWA Hydrant System Closure (NWHS2)
and South Satellite Baggage Tunnel
(Naphthalene)
Potential Site P3
(Naphthalene)
PROPOSED MONITORING WELL
N
0 300 600
Feet
Aspect consulting
IN-DEPTH PERSPECTIVE
179 Madrone Lane North
Bainbridge Island, WA 98110
(206) 780-9370
811 First Avenue #480
Seattle, WA 98104
(206) 328-7443
Proposed Groundwater Monitoring Network
Groundwater Study
Seattle-Tacoma International Airport, SeaTac, Washington
DATE: Feb 2005
DESIGNED BY: JSL
DRAWN BY: PMB
REVISED BY: Rev2 - PMB
PROJECT NO. 970016
FIGURE NO. 8-1