APPENDIX A – SECTION 9

GROUNDWATER AND SOIL QUALITY

A. INTRODUCTION

This section presents available geologic, soil, and groundwater data at and in the general vicinity of Seattle-Tacoma International Airport between 1997 and 2019, identifies changes in soil and groundwater quality during this time frame, and provides an evaluation of those identified changes due to potential effects from airport operations and/or the results of remediation conducted by Seattle-Tacoma International Airport on soil and groundwater conditions.

Specifically, the consultant team reviewed available airport and off-airport groundwater and soil analytical data for the noted time frame (focusing on the years of 1997, 2009, and 2019 or as close to those years as the data sets allow), looking for trends in analytical concentrations over time and evaluating whether chemical concentrations increased, decreased, or remained stable. If concentrations increased, the analysis included an evaluation whether the effects were caused directly by airport operations, attributed to other non-airport point sources, and/or caused by percolation of contaminants from stormwater runoff (airport or general urban runoff) percolating into soil and groundwater. If concentrations decreased, the analysis included an evaluation regarding the effectiveness of the airport's subsurface remediation efforts, related natural attenuation, and the airport's stormwater treatment system.

This section describes the data collected and reviewed by the consultant team including:

- Technical reports provided by the Port of Seattle.
- Databases, technical studies and GIS information provided by the study area cities.
- Geologic/hydrogeologic framework at the airport and within the study Area.
- Airport-related sites/sources of contamination and primary chemicals of interest (COIs).
- The agreed order between the Washington Department of Ecology (Ecology) and the Port of Seattle.
- Groundwater analytical data and remediation conducted at the airport sites.
- Non-airport-related sites/sources of contamination and groundwater analytical data at those non-airport-related sites.

This section also provides an evaluation regarding potential groundwater effects at off-airport sites and if they originated from airport operations; whether airport-related groundwater effects have migrated off-property; and preliminarily addresses concerned citizens' issues of black soot observed on their private property. The section closes with the identification of any data gaps and provides recommendations for specific follow-up analysis.

B. DATA COLLECTION PROCESS

To obtain Seattle-Tacoma International Airport and study area data, and in particular, data on known affected airport and non-airport sites within the study area, the consultant team requested and/or obtained information from the following sources:

- The Port of Seattle public website and documents provided by the Port of Seattle
- City of Burien public website and documents provided by the city
- City of Des Moines public website and documents provided by the city
- City of Federal Way public website and documents provided by the city
- City of Normandy Park public website and documents provided by the city
- City of SeaTac public website and documents provided by the city
- City of Tukwila public website and documents provided by the city
- Ecology Toxic Cleanup Program (TCP) public website: lists and individual site details for sites within the TCP: spills and cleanups; active and inactive underground storage tanks (USTs), and leaking underground storage tanks (LUSTs).
- Washington Department of Ecology's Permitting and Reporting Information System (PARIS) public database containing water quality permits, inspections, enforcement actions and discharge monitoring reports (DMRs) for both federal National Pollutant Discharge Elimination System (NPDES) and state waste discharge permits.
- Washington Department of Ecology's Environmental Information Management (EIM) public database containing groundwater and soil analytical data (which also contains King County data).
- Information from concerned citizens acquired during the two project public meetings.
- Online searches for Seattle-Tacoma International Airport-specific or other airport-vicinity soil studies/technical articles.
- A subcontract with Environmental Data Resources (EDR) to conduct online data searches to identify affected, potentially affected, or suspected affected sites at Seattle-Tacoma International Airport and properties within a one-mile radius of Seattle-Tacoma International Airport.

For this portion of the project (soil and groundwater quality), the Port provided the pertinent documents:

- 1996 Seattle-Tacoma International Airport Master Plan Final EIS.
- 1997 Seattle-Tacoma International Airport Master Plan Final Supplemental EIS.
- 2007 Seattle-Tacoma International Airport Comprehensive Development Plan (CDP) Final EIS.
- 2008 Seattle-Tacoma International Airport Groundwater Study.
- 2015 Seattle-Tacoma International Airport Groundwater Study Update (Annual Groundwater Sampling 2011-2015).

The study area cities provided available GIS shape files, databases, and environmental technical reports from their files. They predominantly had periodic surface water quality data, stream quality reports, and critical areas maps but did not have groundwater or soil analytical data.

The study area cities and the Port of Seattle referred the consultant team to the King County Hydrologic Information Center and Industrial Wastewater Permit websites and to Ecology's PARIS website. Although these particular websites have large amounts of surface water and stormwater analytical data but not groundwater or soil analytical data, review of these websites proved valuable to help identify primary chemicals of concern that could affect soil and/or groundwater.

Supplementing city and agency databases/information and the Port-supplied reports listed above, the consultant team obtained and reviewed these additional documents:

- 2003 State Route 509: Corridor Completion/IH-5/South Access Road Final EIS.
- 2018 Seattle-Tacoma International Airport Sustainable Airport Master Plan (SAMP) – Technical Memorandum No. 8, Environmental Overview.
- 2019 Request for Ecology's Opinion Regarding Completed Remedial Action, Former Continental-Olympic-United Fuel Farm Area, Facility/Site #2294, VCP #NW2300, Seattle-Tacoma International Airport.

Study area topographic/soil/geologic framework

Information for this subsection was obtained from the 2007 CDP Final EIS (prepared by CH2MHill, now Jacobs) and from the 2008 Seattle-Tacoma International Airport Groundwater Study prepared by Aspect Consulting (Aspect).

Ground surface elevations at Seattle-Tacoma International Airport range from approximately 360 to 440 feet above mean sea level (AMSL). Most of the runway and the airport's aircraft operations and maintenance area (AOMA) – terminal/gates/passenger concourses, various airline hangars, and former aircraft fueling operations predominantly located along the east-central to southeast portions of the airport property elevations – are approximately 400 feet AMSL. Beyond the airport boundaries, ground surface elevations remain at approximately 400 to 440 feet AMSL north of the airport (north of State Route 518), drop to approximately 200 feet AMSL to the east (approaching IH-5), drop to the west (down to 0 feet AMSL at Puget Sound), and drop to the south (ranging between 200 to 300 feet AMSL but with lower elevations along Des Moines Creek). Overall, ground surfaces drop to the west (towards Puget Sound).

A surface soil map is provided in Figure 9.1, and a surface geologic map is provided in Figure 9.2 (reproduced from Figure 4-1 of Aspect's groundwater study). As shown on both figures, much (if not all) of the airport property is graded and/or artificial fill with pavement in the AOMA and building areas, and along the aircraft taxiways/runways with bare ground in between the paved taxiways/runways. Native surface soils in the vicinity of the airport (to depths of approximately 20 inches) belong to the Alderwood Association and are moderately well-drained soils in undulating to hilly topography positions. From depths of 20 to 40 inches, soils are dense, very slow permeable glacial till (consistent with local geologic conditions).

The study area is situated in the Puget Sound Lowland with the Vashon Stade of the regionwide Fraser period glaciation dominating the landscape and geologic framework. The Fraser glaciation locally occurred between approximately 13,000 and 15,000 years ago. Sediments deposited prior to the Vashon glaciation are collectively referred to as "pre-Fraser."

As shown on Figure 9.2, the study area is primarily composed of Vashon Stade glacial Vashon Till (Qvt; dense to very dense, sub-rounded to well-rounded clasts in a massive, silt- or sand-rich matrix with sporadic clay lenses) and lesser amounts of overlying recessional outwash deposits (Qvr; stratified, moderately to well-sorted sand and gravel with lenses of silty sand and silt) and underlying advance outwash deposits (well-bedded sand and gravel nearly devoid or silt or clay). In general, the dense to very dense Vashon Till (in particular, the fine-grained silt and clay fractions) retards migration of potential contamination in the subsurface.

Figure 9.1
Surface Soil Map

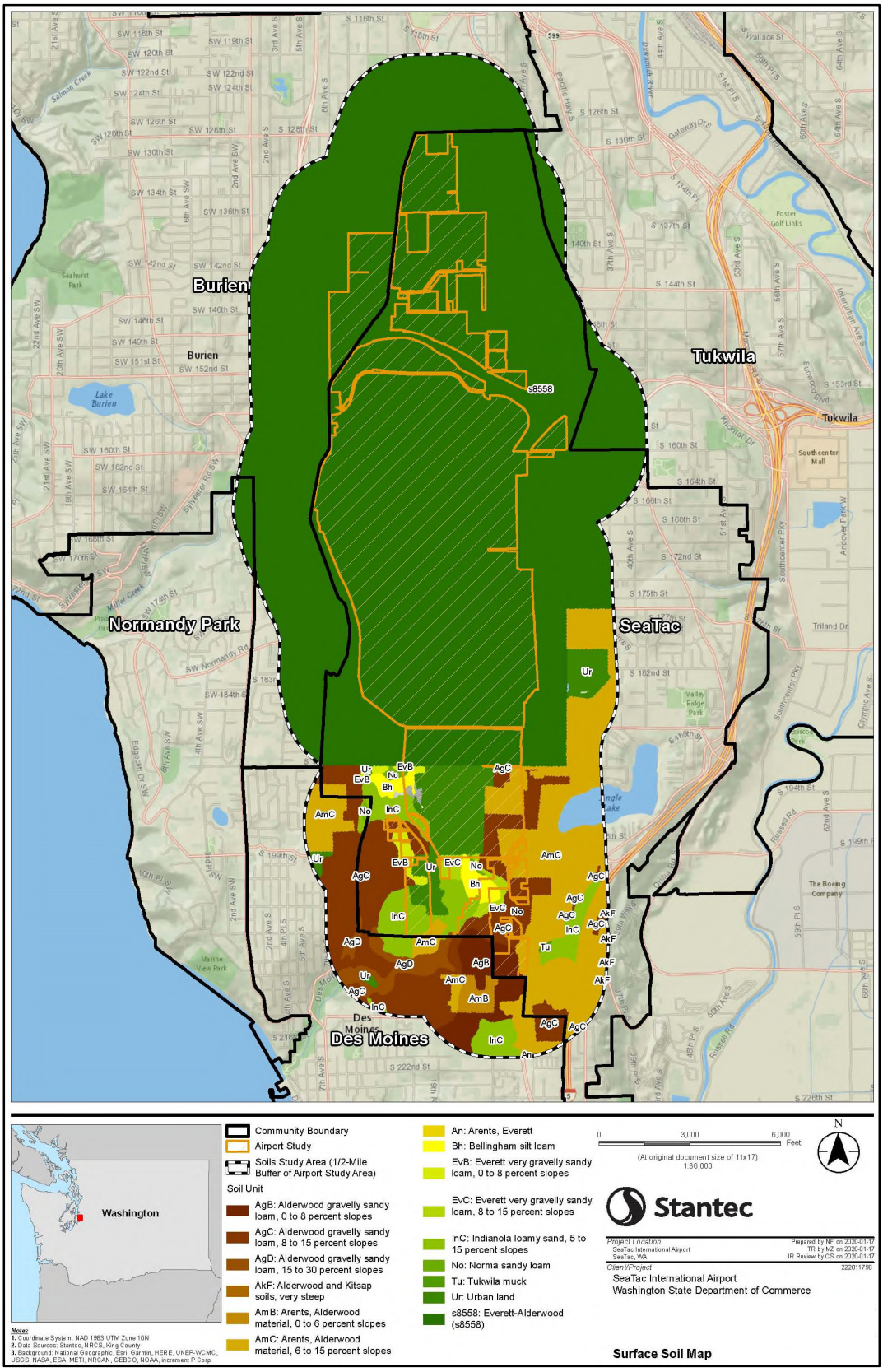
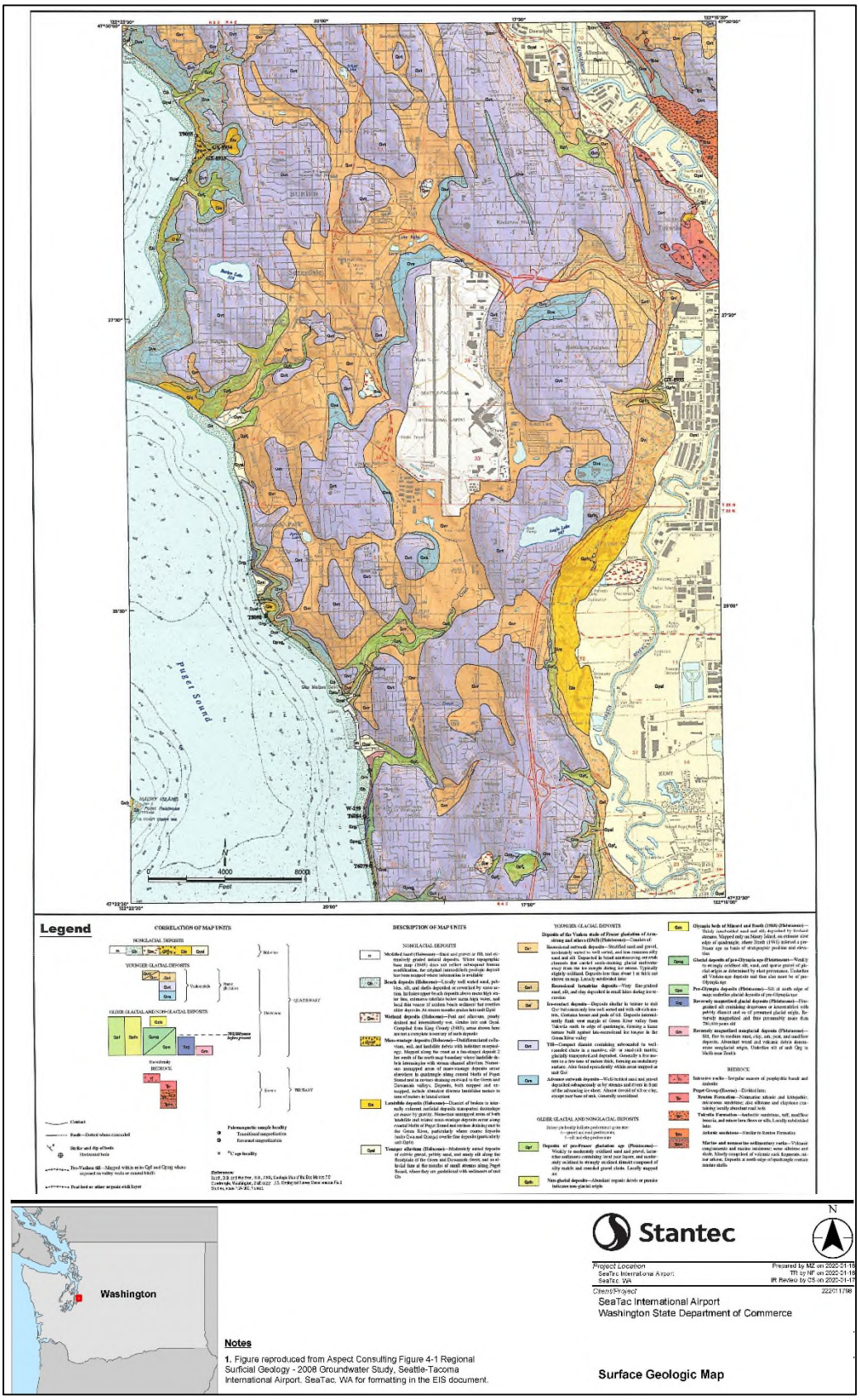


Figure 9.2
Surface Geologic Map



Except for grading activities/new development/redeveloped areas at Seattle-Tacoma International Airport and beyond the airport boundaries (but still within the study area) where new artificial fill or wetlands have been generated or created, the topographic/soil/geologic framework has not changed from 1997 to the present time.

Agreed Order #97tc-N122, environmental database, and groundwater study

In 1995, discussions between Ecology and the Port began regarding an airport-wide groundwater monitoring program that resulted in the initiation of the airport's groundwater study. Part of the requirements of the groundwater study tasked the Port of Seattle to compile and convert existing hardcopy data into a computer database. Compilation of this preliminary database began in 1995 with work being performed by Black and Veatch (Tacoma, WA).

In 1996, the Port of Seattle determined the need for the overall management of environmental data, which led to its environmental management information system (EMIS). Earthsoft's EQUIS environmental data management software was initially used (1997 to 2000), then moved to a customized Microsoft-based database program (2001 to the present). The consultant team understands that this is a proprietary Port-generated and Port-owned database.

By 1997, preparation of the Agreed Order between Ecology and the Port of Seattle was in progress. Agreed Order #97TC-N122 was finalized May 25, 1999 with the requirement that the groundwater study be completed to the satisfaction of and acceptance by Ecology. Primary tasks required by the groundwater study included: a detailed geologic and hydrogeologic characterization of the airport and the nearby vicinity of the airport; identification of water-bearing units; groundwater quality; identification and extent of chemical effects in groundwater at the airport's AOMA; and groundwater modeling to predict future contaminant migration.

In 2003, Aspect submitted a preliminary groundwater study that was finalized in 2008 (dated July 25, 2008). The 2008 groundwater study addressed the required items and included summaries of soil and groundwater remediation conducted by the Port. The 2008 Groundwater Study was deemed complete and was accepted by Ecology in its letter dated Sept. 17, 2008.

As part of continuing work, Ecology required an additional five years of groundwater monitoring and sampling at the AOMA groundwater wells with the analysis of eight key parameters. Based on the results of the five years of monitoring and sampling, either additional monitoring and sampling would be required (in the event that chemical concentrations in groundwater remained above Ecology's Model Toxic Control Act [MTCA] cleanup levels [CULs] and/or showed increasing trends) or no further monitoring and sampling would be required (in the event that chemical concentrations in groundwater were below CULs).

As documented at the end of five years of monitoring and sampling in 2015, no further monitoring or sampling was deemed necessary.

Study area geologic/hydrologic units and water supply wells

Information in this subsection was primarily obtained from Aspect's 2008 Seattle-Tacoma International Airport Groundwater Study, which provided a detailed breakdown of the Seattle-Tacoma International Airport and the study area's geologic and hydrogeologic units. Aspect used the Port's EMIS to complete its detailed hydrogeologic characterization, built a complete geologic/hydrologic conceptual site model (CSM), and performed hydrogeologic computer modeling to estimate affected groundwater plume migration rates. The hydrogeologic characterization and CSM were for the study area as a whole, whereas the computer modeling focused on Seattle-Tacoma International Airport.

Aspect took prior geologic/hydrologic designations and broke them down into smaller, identifiable units based on study area's detailed boring logs, well construction details, groundwater levels, permeability, and other criteria. Coarse-grained, permeable units (aquifers) were given a "C" prefix and fine-grained, very low to impermeable units were given an "F" prefix (aquitards). The units were then assigned numeric suffix with the shallow or uppermost units given a "0" designation and increasing numbers with increasing depth. The upper glacially unconsolidated layers have been designated C0 and F0 with deeper units identified C1, F1, C2, F2, C3, F3, etc.

In summary, the uppermost groundwater in the study area (in particular, beneath Seattle-Tacoma International Airport) is a perched unconfined zone with several thin discontinuous water-bearing zones present from ground surface to depths of approximately 40 feet below ground surface (BGS); it is identified as Unit "C0". Beneath perched groundwater zone Unit C0, the next three water-bearing zones (with increasing depth) are Units C1 (represented by Qva, Vashon advance outwash), C2, and C3 which are individually separated by very low to impermeable F1 (represented by Qvt, Vashon Till), F2, and F3 units. Figure 9.3 (reproduced from Aspect's Groundwater Study) shows the identified units within the study area and beneath Seattle-Tacoma International Airport.

As documented in the 2008 groundwater study, affected groundwater beneath the airport's AOMA has been detected in shallow perched groundwater Unit C0 and in the next lower water-bearing zone Unit C1/Qva. Effects have not been detected in the deeper water-bearing zone, Unit C2.

There are six water supply well locations within the study area and within approximately two miles of the Seattle-Tacoma International Airport boundary; however, none is located on the airport itself. From north to south, the well locations are identified as follows:

- Riverton Heights Wells (a cluster of two wells)
- Washington Memorial Park Well
- Tyee Well and Old Tyee Golf Course Well (two wells)
- Des Moines Well
- Angle Lake Well
- King County Water District #54 Well Field (a cluster of three wells).

The locations of these water supply wells relative to the airport's AOMA where contamination has been detected are shown on Figure 9.4 (reproduced from Aspect's groundwater study). The AOMA location is shown within the dashed redline area and buffer zones surrounding the AOMA are shown in different colors: 0.25-mile buffer in orange and 1-mile buffer in yellow. Well screen intervals and the identification of the water-bearing units for these wells are shown (reproduced from Aspect's groundwater study). Most of these wells are screened and completed at much greater depths than affected groundwater at the airport.

Results of the groundwater modeling show that effects are essentially restricted to the AOMA. Three small areas extend a short distance beyond the AOMA but still well within the 0.25-buffer and within the airport boundary. Two small lobes extend a short distance west of the AOMA (beneath the easternmost runway), and one small area is immediately north of the AOMA.

Figure 9.3
Summary of Study Area Geologic and Hydrologic Units

Geologic Group	Geologic Unit Name	Geologic Unit Abbr.[1]	Geologic & Sedimentologic Characteristics	Hydro-Stratigraphic Unit		Model Condition	South King Co. Groundwater Mgmt. Plan Unit	USGS[2]
Post-Glacial Deposits	Fill	Fill	All man-placed fill and extensively graded areas.	C0/F0	Order is variable	Perched Water Bearing Zones and Aquitards[3]	Qal and Qvr	m
	Topsoil	Qts	Topsoil.	C0				
	Recent Alluvium	Qal	Sand and gravel deposited by streams and rivers.	C0				Qyal
	Recent Lacustrine Deposits	Ql	Clay, silt, and peat deposited in lakes, ponds and wetlands.	F0				
Fraser Glacial Deposits (Vashon Drift)	Recessional Lacustrine Deposits	Qvrl	Silt and clay deposited in quiet water recessional glacial environments including lakes, ponds, floodplains, and kettles.	F0				Qvrl
	Recessional Outwash	Qvr	Sandy to gravelly recessional glacial stream and river deposits.	C0				Qvr
	All deposits above are normally consolidated. All deposits below are glacially overconsolidated.							
	Weathered Vashon Glacial Till	Qvtw	Weathered till.	F1		Aquitard[3]	Qvt	Qvt
	Vashon Glacial Till	Qvt	Glacial lodgement till composed of poorly-sorted clay, silt, sand and gravel. Includes interbeds of outwash and glaciolacustrine sediments.					
	Vashon Advance Outwash	Qva	Pro-glacial outwash composed primarily of silty sand, sand, and sand-gravel mixtures. (Known in the Seattle area as Esperance Sand.)	C1		Aquifer	Qva "Shallow Aquifer"	Qva
Pre-Fraser Glacial & Non-Glacial Deposits	Transition Beds	Qtb	Includes both Vashon glaciolacustrine silt and clay deposits (Lawton Clay) and pre-Fraser fine-grained non-glacial deposits.	F2		Aquitard	Qvl and Qf(1)	Qpf
	Pre-Fraser Fine-Grained Deposits	Qpff	Undifferentiated pre-Fraser fine-grained deposits.					
	Pre-Fraser Coarse-Grained Deposits	Qpfc	Uppermost extensive coarse-grained deposit below Vashon Drift. Chiefly sand and gravel. Likely includes Olympia non-glacial beds, Possession glacial outwash, and Whidbey non-glacial deposits. Includes a discontinuous fine-grained interbed (C2F).	C2		Aquifer	Qc(3) "Intermediate Aquifer"	Qpfc
				C2F				Qpf
				C2				Qpfc
	Pre-Fraser Fine-Grained Deposits	Qpff	Older undifferentiated fine-grained deposits.	F3		Aquitard	Qf(3)	Qpf
	Pre-Fraser Coarse-Grained Deposits	Qpfc	Older undifferentiated coarse-grained deposits.	C3		Aquifer	Qc(4) "Deep Aquifer"	Qpfc
	Pre-Fraser Fine-Grained Deposits	Qpff	Older undifferentiated fine-grained deposits.	F4		Aquitard	Qf(4)	Qpf
	Pre-Fraser Coarse-Grained Deposits	Qpfc	Older undifferentiated coarse-grained deposits.	C4		Aquifer		Qpfc
	Pre-Fraser Fine-Grained Deposits	Qpff	Older undifferentiated fine-grained deposits.	F5		Aquitard		Qpf
	Pre-Fraser Coarse-Grained Deposits	Qpfc	Older undifferentiated coarse-grained deposits.	C5		Aquifer		Qpfc
	Pre-Fraser Fine-Grained Deposits	Qpff	Older undifferentiated fine-grained deposits.	F6		Aquitard		Qpf
	Pre-Fraser Coarse-Grained Deposits	Qpfc	Older undifferentiated coarse-grained deposits.	C6		Aquifer		Qpfc
Bedrock	Tertiary Bedrock	Br	Siltstone, sandstone and shale with minor coal seams. Includes basaltic and andesitic intrusives.	Br		Aquitard	Tbr	Ti, Tpr, Tpt, Tpta, and Tptm

Notes:

1. The Geologic Unit Abbreviations are those used in this report.
2. USGS designations are those used in the *Geologic Map of the Des Moines 7.5' Quadrangle, Washington* (Booth and Waldron, 2002).
3. The hydrostratigraphic units C0, F0, and F1 were combined into a single layer for the groundwater model.

Figure 9.4
Water Supply Well Construction Details

Owner's Well Name	EMIS Name	EMIS Database Identifier	X Coord. (feet)	Y Coord. (feet)	Ground Surface Elevation (feet)	Screened Interval (feet bgs)	Screened Hydrostratigraphic Unit	Approximate Annual Pumpage[1] (million gallons)	Model Pumpage Rate (cubic feet/day)
City of Seattle, Highline Well Field									
Boulevard Park	23N4E16D3	A_PW205	13695	29774	358	216 - 295	C2	157[2]	57,501
Riverton Heights No. 1	23N4E21C1	A_PW261	14685	23323	436	275 - 355	C2	448[2,3]	164,079
Riverton Heights No. 2	23N4E21C12	A_PW264	14653	23779	431	280 - 385	C2		
Highline Water District									
Des Moines	22N4E8A2	A_PW128	10907	3121	197	312-358	C4	168	61,530
Angle Lake	22N4E9A4	A_PW145	16597	2620	334	412.5 - 481.7	C4	106	38,822
Tyee Well	22N4E4F4	A_PW108	14155	6255	242	93 - 149	C2	196[4]	71,785
King County Water District No. 54									
No. 4	22N4E8K7	A_PW138	10706	-273	166	305 - 328	F5-C5	33	12,086
No. 5	22N4E8K8	A_PW139	10823	-287	148	212.6 - 218 223 - 234.3	C3	85	31,131
No. 6	22N4E8K11	A_PW132	10247	123	141	336 - 351	C5	33	12,086
Port of Seattle									
Old Tyee Golf Course Well[5]	22N4E4F1	A_PW106	14340	5950	238	72 - 160 190 - 243 511 - 541	C2-F3, F3-C3, & C5	182[6]	66,657
Washington Memorial Park									
Well No. 2[5]	23N4E28H2	A_PW337	17050	17520	382	127 - 136	C1	42[7]	15,382

Notes:
1. Based on data obtainec from purveyors except where noted
2. Average for 1990 through 1994 water years
3. Data only available for the combined extraction from Riverton Heights No. 1 and No. 2
4. Well placed in production during 2004. Pumpage based on water right certificate 2191-A (Robinson and Noble, 1998
5. Wells used only for irrigation
6. Groundwater use not metered. Pumpage based on water right certificate 2369-A dated October 18, 195
7. Groundwater use not metered. Pumpage based on water right certificate 3929-A dated June 21, 1961

C. AIRPORT SOURCES OF CONTAMINATION AND LOCATIONS

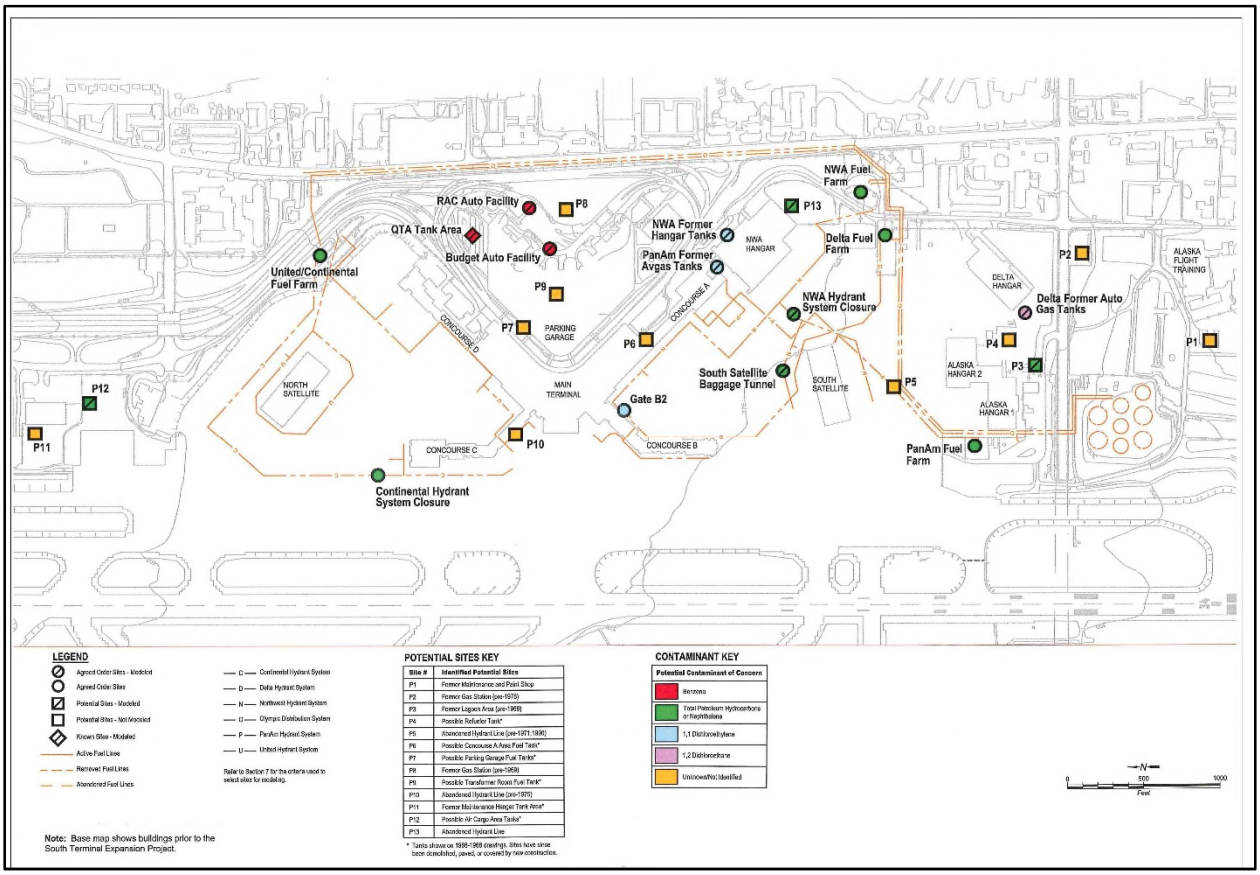
As identified in the Agreed Order #97TC-N122 and as summarized in Aspect's 2008 Groundwater Study, there are 13 contaminated sites at Seattle-Tacoma International Airport that have been investigated as required by Ecology. These 13 sites (listed below) are located within the airport's AOMA and shown on Figure 9.5 (reproduced from Aspect's groundwater study). Figure 9.5 also shows the primary contaminant at each of the 13 sites.

- **Budget Auto Facility**
  Automotive gasoline release from former UST; affected soil and groundwater in Unit C1 (no perched zone C0 present); central portion of AOMA adjacent to Seattle-Tacoma International Airport's parking structure.

- **Concourse B/Gate B**
  Jet A fuel release near jet fuel hydrant pipelines; affected soil and groundwater in Unit C1 (no perched zone C0 present); north-central portion of AOMA.

- **Continental Airlines hydrant system**
  Jet A fuel release along the length of a hydrant pipeline with extent of effects limited to several locations along the pipeline (specific hydrant valve pits, low drain points, and a high point vent; affected soil only; northwest portion of AOMA. No Further Action (NFA) granted by Ecology after investigation and based on site-specific total petroleum hydrocarbons (TPH) as Jet A fuel soil cleanup level.

Figure 9.5
Known and Suspected Affected Sites at Seattle-Tacoma International Airport



- **Delta Airlines auto gas tank cluster**
  Gasoline and volatile organic compound (VOC) releases from a former five-tank UST cluster; affected soil, shallow perched groundwater (Unit C0) and minor effects to deeper groundwater (Unit C1); southeast portion of AOMA.

- **Delta Airlines fuel farm**
  Jet fuel releases from former USTs; affected soil and shallow perched groundwater (Unit C0); southeast portion of AOMA.

- **Northwest Airlines hangar tanks**
  Mineral spirits and oil releases from five former USTs located in four separate excavations; affected soil, shallow perched groundwater (Unit C0), and deeper groundwater (Unit C1 at approximately 60 feet BGS); southeast portion of AOMA.

- **Northwest Airlines fuel farm**
  Former jet fuel UST tank farm (14 former USTs); affected soil, shallow perched groundwater, and deeper groundwater (Units C0 and C1); southeast portion of AOMA.

- **Northwest Airlines hydrant systems**
  Two former hydrant fuel delivery loop systems (an older loop identified as "abandoned" and unused as of 1976, and a second loop identified as "closed" and taken out of service in 1997); affected soil, perched groundwater, and deeper groundwater (Units C0 and C1); south-central to southwest portions of AOMA.

- **South Satellite baggage tunnel**
  Associated with the "closed" Northwest Airlines hydrant loop described above; affected soil and deeper groundwater (no perched groundwater identified); southwest portion of AOMA.

- **Pan Am Airlines Avgas (aviation gas) tanks**
  Up to 10 former USTs (four USTs primarily containing Jet A fuel but originally containing Aviation Gas [lending the name for this location], and six USTs containing automotive gas, ethylene glycol, kerosene, diesel, mineral spirits, and waste oil); affected soil, shallow perched groundwater, and deeper groundwater (Units C0 and C1); central portion of AOMA.

- **Pan Am Airlines fuel farm**
  Two constructed-in-place Jet A fuel concrete USTs, partially removed with concrete pavement beneath the former USTs and in two sidewalls left in place to support the adjacent roadway; affected soil but with only minor effects to deeper groundwater (Unit C1 at approximately 50 feet BGS) in one well; no perched groundwater at this location; southwest portion of AOMA.

- **Consolidated rental car facility**
  Three former gasoline USTs and dispensing pumps near Seattle-Tacoma International Airport parking facility toll booths that were used by Hertz, Avis, and National rental car agencies; affected soil and deeper groundwater (Unit C1 at approximately 45 feet BGS); no perched groundwater at this location; east-central portion of AOMA.

- **United Air Lines (UAL) fuel farm/Continental Airlines fuel farm**
  A total of eight former USTs at these two nearby facilities (three at UAL containing waste Jet A fuel and glycol deicers, and five at Continental containing Jet A fuel and waste jet fuel); affected soil and perched shallow groundwater (Unit C0 at approximately 30 feet BGS); northeast portion of AOMA.

Additional information and status for the 13 agreed order sites at the airport are provided in Figure 9.6 (reproduced from Aspect's groundwater study). Numerous soil borings and groundwater monitoring wells have been drilled at each of these 13 areas.

In addition to the 13 agreed order sites, there is another rental car former fueling and vehicle wash area that was located at the north end of the Seattle-Tacoma International Airport parking garage structure. This area has been identified as the Rental Car Quick Turn Around (QTA) Tank Area where five fuel USTs and nine dispenser islands were formerly located and where affected soil and slightly affected deeper groundwater (Unit C1) have been detected (no mention of the presence of perched shallow groundwater at this location).

There are also up to 13 other airport potential sources of contamination within the AOMA. These other sites range from former gas stations, possible other fuel tanks scattered around the AOMA, a maintenance hangar fuel tank, possible hydrant lines, and a former maintenance and paint shop. Additional information is provided in Figure 9.7 (reproduced from Aspect's groundwater study). These sites were shown on old airport drawings.

Figure 9.6
Summary of Known Affected Sites at Seattle-Tacoma International Airport

Site (Sites Listed in Ecology Agreed Order)	Release Observation Date	Release Source	Contaminant Type	Affected Media (Confirmed)				Investigation Summary	Remediation Summary	Current Project Status (Project Lead)
				Soil	Perched Groundwater	Regional Groundwater (Qva or C1 aquifer)	Free Product			
Budget Auto Facility	1990	Underground gasoline lines	Petroleum - gasoline	Yes	No (perched groundwater not identified)	Yes	Yes	Gasoline line failure resulted in soil and groundwater contamination. Several site studies have been conducted since 1990. Groundwater compliance monitoring is ongoing.	Free product recovery and vapor extraction, followed in 1997 by soil vapor extraction system with product wicking to remove additional free product. Vapor extraction was discontinued in 2002 and system removed in June 2004 due to low contaminant recovery rates.	Active. Ongoing remediation and groundwater monitoring. (Budget)
Concourse B/ Gate B-2	1991	Underground aircraft fuel hydrant system (suspected)	Petroleum - Jet A	Yes	No (perched groundwater not identified)	Yes (minimal)	No	Contamination related to fuel system releases, initially identified in 1991. Site environmental investigtions conducted 1991-1993, and 1998.	Periodic monitoring demonstrated stable, non mobile conditions. Excavation of impacted soil during 2001-2004 capital construction.	Closed (Port of Seattle)
Continental Airlines Hydrant System	1994	Underground aircraft fuel hydrant system	Petroleum - Jet A	Yes	No	No	No	Investigations conducted in 1994 and 1999 identified petroleum in shallow soil at some locations along the hydrant line, but no soil impact at depth.	None appropriate.	Closed. Continental obtained an Ecology NFA, 10/10/03.
Delta Airlines Auto Gas Tank Cluster	1987	Underground storage tanks	Petroleum - gasoline; solvent	Yes	Yes	Yes (minimal)	Yes (in tank-area perched groundwater zone)	Site investigation in 1987 and 1995. Groundwater monitoring through 1998.	Tanks removed in 1992. Significant excavation of impacted soil during 2000-2001 capital construction removed all impacted soil and tank area perching zone.	Inactive, anticipate monitoring or closure pending completion of MTCA Ground Water Study. (Delta)
Delta Airlines Fuel Farm	1989	Underground storage tanks; fuel farm operations	Petroleum - Jet A	Yes	Yes	No	Yes (in perched groundwater zone)	Site investigation in 1989 and 1995. Groundwater monitoring through 1997.	Tanks removed and system closed in compliance with closure regulations in 1999. Significant excavation of impacted soil during 2001-2004 capital construction.	Closed. Delta obtained an Ecology NFA, 3/20/04.
Northwest Airlines Former Hangar Tanks	1990	Underground storage tanks	Petroleum, Solvent	Yes	Yes	Yes	Yes (in perched groundwater zone)	Several site studies of the area around the former tanks have been conducted since 1990. Groundwater monitored through 2001.	Tanks removed in 1990. Vapor extraction conducted in 1995, and bioventing performed in 2000-2001 for free product removal. Significant excavation of impacted soil during 2001-2004 capital construction.	Inactive, anticipate monitoring or closure pending completion of MTCA Ground Water Study. (Northwest)
Northwest Airlines Fuel Farm	1985 (earliest observation)	Underground storage tanks; fuel farm operations	Petroleum - Jet A	Yes	Yes	Yes (minimal)	No	Various studies since 1985 have identified petroleum impacted soil associated with facility operations and releases from nearby hydrant lines.	Tanks removed and system closed in compliance with closure regulations in 1998. Bioventing in tank backfill area 1999-2000. Significant excavation of impacted soil during 2001-2004 capital construction.	Inactive, anticipate monitoring or closure pending completion of MTCA Ground Water Study. (Northwest)
Northwest Airlines Hydrant System Closure (See a, b & c below)	---	---	---	---	---	---	---	---	---	---
(a) Northwest "Abandoned" Hydrant System, removed from service 1976	1981 (earliest observation)	Underground aircraft fuel hydrant system	Petroleum - Jet A	Yes	Yes	Yes	No	Several early studies. System closure investigation completed in 1998.	System closed in compliance with closure regulations in 1998. Significant excavation of impacted soil during 2001-2004 capital construction.	Inactive, anticipate monitoring or closure pending completion of MTCA Ground Water Study. (Northwest)
(b) Northwest "Closed" Hydrant System, removed from service 1997	1985 (earliest observation)	Underground aircraft fuel hydrant system	Petroleum - Jet A	Yes	Yes	Yes	Yes	Several early studies. System closure investigation completed in 1997. Also see South Satellite.	System closed in compliance with closure regulations in 1997. Significant excavation of impacted soil during 2001-2004 capital construction. Also see South Satellite.	Inactive, anticipate monitoring or closure pending completion of MTCA Ground Water Study. (Northwest. See also South Satellite.)
(c) Northwest Airlines South Satellite Baggage Tunnel (Included in Northwest Airlines "Closed" Hydrant System, above)	1992	Underground aircraft fuel hydrant system	Petroleum - Jet A	Yes	No (perched groundwater not identified)	Yes	Yes	Various studies since 1992 have identified petroleum soil associated with releases from hydrant lines.	Closure of hydrant system occurred in 1997. Free product recovery and some specific excavation has occurred in areas of specific releases.	Active. Groundwater monitoring. (Northwest)
Pan Am Airlines "Avgas" Tanks Site	1991	Underground storage tanks	Petroleum - Jet A	Yes	Yes	Yes	Yes	Several site investigations characterizing releases from tanks, have been conducted since 1991.	Tanks removed in 1992 and 2001. Free product recovery thorugh 1996. Significant excavation of impacted soil during 2001-2004 capital construction.	Inactive, anticipate monitoring or closure pending completion of MTCA Ground Water Study.
Pan Am Airlines Fuel Farm	1990	Underground storage tanks; fuel farm operations	Petroleum - Jet A	Yes	No (perched groundwater not identified)	Yes (minimal)	No	Investigation conducted in 1991 and 1993. Semiannual monitoring groundwater monitoring conducted through 1998.	Tanks and soil removed in 1990. Facility closed in compliance with closure regulations in 1993. Some impacted soil remains in place due to site access conditions.	Closed in accordance with Ecology agreement (pre-dates VCP NFA.) (Port)
RAC Auto Facility	1993	Tanks and associated operations	Petroleum - gasoline	Yes	Yes	Yes	Yes	Several site investigations characterizing soil and groundwater conditions conducted since 1993. Ongoing groundwater monitoring.	Tanks and some impacted soil removed.	Active. Ongoing groundwater monitoring. (RAC)
United Airlines Fuel Farm/ Continental Airlines Fuel Farm	1988	Underground storage tanks; fuel farm operations	Petroleum - Jet A	Yes	Yes	No	Yes	Numerous site studies of contaminaiton associated with fuel farm operations have been conducted since 1988. Additional investigation phases are planned. Groundwater compliance monitoring is ongoing.	Past site remediation includes tank removal, soil excavatrion, free product recovery and vapor extraction.	Active. Ongoing groundwater monitoring. Additional remediation planned. (United, Continental, Olympic Pipeline Company, Port of Seattle)

Figure 9.7
Summary of Suspected Affected Sites at Seattle-Tacoma International Airport

The following are sites identifed as having the potential for environmental impacts based on historical operations. Generally, operations at these sites were discontinued prior to the development of current environmental regulations. Sites P1 - P12 were identified in the original Potential Sites List, 12/99. Data generated since 12/99 results in the addition of one new potential site, P13, and the exclusion of eight of the original sites, as noted below.

Site #	Identified Potential Sites	Description	New Data	In Model	Rationale	Reference
P1	Former Maintenance and Paint Shop	Potential historical release of minor amounts of maintenance materials.	Yes	No	Recent data indicates no significant impacts.	*Environmental Assessment, Former Maintenance and Paint Shop* , Aspect Consulting, 6/03
P2	Former Gas Station	Gas station demolished about 1978. Three gasoline tanks were removed and two oil tanks were filled with gravel and sealed.	Yes	No	Construction related tank removal indicated minor soil contamination.	Onsite POS observations during construction by others. Report status unknown.
P3	Former Lagoon Area	Former oil "lagoon" or "sump" demolished in 1966 construction.	Yes	Yes	New soil data will be used to predict potential groundwater concentrations, using MTCA. Groundwater Study model will use predicted values.	*Former South End Oil Lagoon Site/ Summary of Construction Data Review* , Lovely Consulting, Inc., 9/02.
P4	Possible Refueler Tank	3 - 20,000 gallon fuel tanks shown on 1966-8 drawings. No information on tanks status.	Yes	No	Construction related tank removal indicated minor soil contamination.	*Tank Removal Report, Alaska Airlines Maintenance Hangar Area,* Maul Foster & Alongi, 1/03
P5	Abandoned Hydrant Line	Segment of hydrant line abandoned pre-1990 between former fuel farm and Concourse A.	Yes	No	Recent data indicates no significant impacts.	*Draft Pan Am Fuel Hydrant System Investigation System Report* , Landau Associates, 1/03.
P6	Possible Concourse A Area Fuel Tank	500 gallon fuel tank shown on 1966-8 drawings. No information on tank status.	Yes	No	Construction excavations found no tank or indication of former tank presence.	Onsite POS observations during POS construction. No tank or contamination present. No report.
P7	Possible Parking Garage Fuel Tanks	2 - 4,000 gallon fuel tanks shown on 1966-8 drawings. Tanks reportedly filled in place.	No	Yes	Model will rely on data from nearby contaminated sites (Budget and RAC) to predict fate and transport.	---
P8	Former Gas Station	Gas station removed in 1969.	Yes - area	No	Nearby construction excavations found no indication of former tank impact. Also in area with known sites, on which model can rely.	Onsite POS observations of adjacent area during POS construction. No contamination present. No report.
P9	Possible Transformer Room Fuel Tank	Fuel tank shown on 1966-8 drawings. No information on tank status.	No	Yes	Model will rely on data from nearby contaminated sites (Budget and RAC) to predict fate and transport.	---
P10	Abandoned Hydrant Line	Segment of hydrant line abandoned pre-1975 near Concourse C.	Yes	No	Recent data indicates no significant impacts.	*Subsurface Investigation Report United Airlines Fuel Hydrant System* , Enviro-Sciences, Inc., 9/02. Ecology NFA 11/22/05
P11	Former Maintenance Hangar Tank Area	1968 drawing indicates 7 fuel/oil USTs and two drywells in the vicinity of demolished hangar. No information on status.	Yes	No	Construction excavations found no tank or indication of former tank presence.	Onsite POS observations during POS construction. No tank or contamination present. No report.
P12	Possible Air Cargo Area Tanks	1968 drawing indicates 2,000 gallon fuel tank and pump and a 500 gallon gas tank. No information on status.	No	Yes	Typical tank site conditions will be used in model.	---
P13	Abandoned Hydrant Line	Segment of hydrant line abandoned pre-1975 between NWA former fuel farm and NWA former hangar.	Yes	Yes	New soil data will be used to predict potential groundwater concentrations, using MTCA. Groundwater Study model will use predicted values.	*Northwest Airlines Former Fuel Hydrant System, Summary of Construction Data Review* , Lovely, 1/03

Airport-related chemicals of interest

Former and ongoing airport operations include, but are not limited to: aircraft maintenance and repair; airport services support-vehicle maintenance and repair; aircraft and airport services support-vehicle fueling; fueling system maintenance and repairs; aircraft de-icing (as needed during the winter months); aircraft washing; telecommunication system maintenance and repair; airport pavement maintenance and repair; stormwater system maintenance and repair; and temporary storage of wastes generated or associated with these operations.

Based on operations, the following primary chemicals of concern (COIs) have been identified at Seattle-Tacoma International Airport:

- Various total petroleum hydrocarbons (TPH): aviation gas (Avgas); Jet F fuel (Jet A); gasoline (TPHg/gasoline range organics [GRO]); as diesel (TPHd/diesel range organics [DRO]; as oil (TPHo/oil range organics); and mineral spirits.
- Fuel-related aromatic hydrocarbons (volatile organic compounds [VOCs]): benzene, toluene, ethylbenzene, and total xylenes (collectively known as BTEX).
- Gasoline-related additives (VOCs and metallic) normally associated with gasoline: methyl-tertiary-butyl-ether (MTBE); tertiary-amyl-methyl-ether (TAME); tertiary butyl alcohol (TBA); ethyl-tertiary-butyl-ether (ETBE); ethylene dibromide (EDB); ethylene dichloride (EDC, also known as 1,2-dichloroethane [1,2-DCA]), and lead/
- Semi-VOCs associated with fuels and oils: naphthalene, 1-methyl naphthalene, and 2-methyl naphthalene.
- Metals associated with aircraft and vehicle bodies, and batteries: lead, aluminum, iron, magnesium, vanadium, lithium, copper, zinc, mercury, and chromium.
- Deicing compounds (VOCs; ethylene glycol and propylene glycol) and solvents (chlorinated VOCs: 1, 1-dichloroethene (1,1-DCE) and/or its breakdown products such as cis-1,2-DCE, trans-1,2-DCE, 1,1-DCA, or vinyl chloride.

Based on compounds detected in normal urban stormwater runoff, the airport's NPDES permit monitoring requirements, and/or on long-term surface water quality exceedances detected in Miller and Des Moines Creeks, the following compounds are also considered COIs (and previously listed above) – copper and zinc (metals), and ethylene glycol and propylene glycol (VOCs).

D. AIRPORT ANALYTICAL DATA, ECOLOGY COMMUNICATION, AND REMEDIATION

As discussed above in Subsections F and G, numerous soil borings and groundwater monitoring wells have been drilled at AOMA- affected sites with vertical and lateral extent of effects defined to non-detected concentrations or sufficiently well-defined as required and accepted by Ecology. A summary table of Unit C1 groundwater sample data showing the number of detected and non-detected compounds at the various AOMA sites is provided herein as Figure 9.8 (reproduced from Aspect's groundwater study).

As shown in Figure 9.8, most of the detected compounds belong to one of following categories (listed in order of decreasing frequency):

- TPH – gasoline and diesel range (detected at 9 of the 10 areas)
- BTEX (detected at 5 of the 10 areas)
- Chlorinated solvents (detected at 2 of the 10 areas)
- Naphthalene (detected in 1 of the 10 areas).

Comparison of the detected compounds/categories matches well to the identified COIs based on airport operations. Other COIs were not detected. Statistical information in Figure 9.8 shows the actual numbers and percentages of groundwater samples and wells where compounds exceeded Ecology's Model Toxic Control Act (MTCA) cleanup levels (CULs).

In accordance with Ecology's Sept. 17, 2008 letter, the airport was mandated to conduct five years of annual groundwater monitoring and sampling for eight key parameters at the AOMA sites. The key parameters included: TPHg, TPHd, TPHo, TPH as Jet A fuel, benzene, naphthalene, 1,1-DCE, and 1,2-DCA. Five years of groundwater monitoring and sampling were conducted: 2011 through 2015.

At the end of five years, groundwater concentrations showed decreased effects and conformed to MTCA CULs. On behalf of the Port, SLR (Bothell, Washington) prepared an update to the groundwater study. The report (dated July 20, 2015) was submitted to Ecology, stating that further monitoring or sampling was no longer necessary and requesting that specific wells be abandoned. In an email dated Feb. 24, 2016, Ecology approved the requested well abandonments.

As documented in prior environmental reports, remediation has been conducted at the AOMA sites in an effort to clean up the sites and to remove the sources of contamination (i.e., the UST systems and the affected soil). Remediation was performed using the following methods:

- Soil excavation to depths extending to and beyond shallow perched groundwater
- Soil vapor extraction
- Bioventing
- Free product removal.

Figure 9.8
Summary of Groundwater Effects at Seattle-Tacoma International Airport

		# Non-Detects	# Detects	% Detects	# Samples Exceeding MTCA Cleanup Levels[1]	% Samples Exceed MTCA Cleanup Levels[1]	# Wells Exceeding MTCA Cleanup Levels[1]	% Wells Sampled Exceeding MTCA Cleanup Levels[1]
Budget Auto Facility								
TPH	Total Petroleum Hydrocarbons - Oil Range	0	1	100%	1	100%	1	13%
TPH	Total Petroleum Hydrocarbons - Gasoline Range	26	61	70%	52	60%	7	88%
VOCs	Benzene	26	58	69%	57	68%	7	88%
VOCs	Ethylbenzene	34	50	60%	19	23%	4	50%
VOCs	Toluene	27	57	68%	25	30%	5	63%
VOCs	Total Xylenes	19	37	66%	1	2%	1	13%
Delta Auto Gas Cluster Tanks								
VOCs	1,2-DCA	21	2	9%	2	9%	2	33%
VOCs	Dichloromethane	19	4	17%	2	9%	2	33%
Gate B-2 Site								
TPH	Total Petroleum Hydrocarbons - Diesel Range	10	6	38%	4	25%	3	50%
TPH	Total Petroleum Hydrocarbons - Oil	0	1	100%	1	100%	1	17%
VOCs	1,1-DCE	13	1	7%	1	7%	1	17%
NWA Fuel Farm								
TPH	Total Petroleum Hydrocarbons - Diesel Range	71	53	43%	34	27%	4	67%
NWA Hangar Tanks								
TPH	Total Petroleum Hydrocarbons - Diesel Range	12	2	14%	1	7%	1	25%
VOCs	Vinyl Chloride	36	4	10%	4	10%	1	20%
VOCs	1,1-DCE	12	29	71%	29	71%	4	80%
VOCs	Carbon Tetrachloride	38	2	5%	2	5%	2	40%
VOCs	1,2-DCA	32	8	20%	8	20%	1	20%
VOCs	1,1,2-TCA	36	4	10%	4	10%	1	20%
VOCs	Benzene	40	1	2%	1	2%	1	20%
VOCs	Tetrachloroethene	37	3	8%	3	8%	3	60%
VOCs	Trichloroethylene	34	6	15%	1	3%	1	20%
VOCs	Dichloromethane	34	6	15%	3	8%	1	20%
VOCs	cis-1,2-dichloroethene	15	19	56%	7	21%	1	20%
VOCs	1,1-DCA	1	41	98%	4	10%	1	20%
South Satellite Baggage Tunnel / Northwest Airlines Hydrant System Closure								
SVOC	Naphthalene	5	5	50%	0	0%	0	0%
TPH	Total Petroleum Hydrocarbons - Diesel Range	49	59	55%	37	34%	9	90%
VOCs	Benzene	107	7	6%	1	1%	1	13%
PANAM Avgas Tanks								
SVOC	Naphthalene	38	8	17%	0	0%	0	0%
TPH	Total Petroleum Hydrocarbons - Diesel Range	75	22	23%	16	16%	8	73%
TPH	Total Petroleum Hydrocarbons - Gasoline Range	9	28	76%	12	32%	6	67%
VOCs	1,2-dibromo-3-chloropropane	39	1	3%	1	3%	1	14%
VOCs	1,1-DCE	27	13	33%	13	33%	2	29%
VOCs	Carbon Tetrachloride	39	1	3%	1	3%	1	14%
VOCs	Tetrachloroethene	34	6	15%	6	15%	4	57%
PANAM Fuel Farm								
TPH	Total Petroleum Hydrocarbons - Diesel Range	43	13	23%	4	7%	1	25%
RAC Auto Facility								
TPH	Total Petroleum Hydrocarbons - Gasoline Range	39	46	54%	41	48%	9	64%
VOCs	Benzene	40	45	53%	44	52%	13	93%
VOCs	Ethylbenzene	36	49	58%	15	18%	4	29%
VOCs	Toluene	36	49	58%	16	19%	4	29%
QTA Tank Area								
TPH	Total Petroleum Hydrocarbons - Diesel Range	0	8	100%	6	75%	4	67%
TPH	Total Petroleum Hydrocarbons - Gasoline Range	0	8	100%	7	88%	6	100%
VOCs	Benzene	1	7	88%	7	88%	6	100%
VOCs	Ethylbenzene	1	7	88%	5	63%	4	67%
VOCs	Toluene	1	7	88%	6	75%	5	83%
VOCs	Total Xylenes	1	7	88%	1	13%	1	17%
United/Continental Fuel Farms		Only 1 well completed in Qva Aquifer						
Continental Airlines Hydrant System Closure		No wells completed in Qva Aquifer						
Delta Airlines Fuel Farm		No wells completed in Qva Aquifer						

[1]MTCA Method A Cleanup Levels used for TPH; All other analytes are evaluated against MTCA Method B Cleanup Levels.

All of these methods are typically and extensively used in the environmental industry to clean up affected sites and have been successfully implemented at Seattle-Tacoma International Airport. Most of the heavily affected materials have been removed, allowing remaining effects to naturally attenuate over time with decreased levels of effects. As noted above, demonstration of reduced effects at Seattle-Tacoma International Airport is evident in the results of the 2011 - 2015 annual groundwater monitoring and sampling events, during which groundwater effects decreased primarily to non-detect or less than MTCA CULs.

One affected airport site immediately north of the AOMA and not part of the agreed order is the former Continental-Olympic-United Fuel Farm. As detailed in SLR's March 2019 technical report, the consultant team understands that the airport is not the responsible party (RP) for this site, but the RP is the Continental-Olympic-United Fuel Facility Environmental Committee (FFEC) whose current project manager is a United representative. SLR's March 2019 technical report documents pre-2011 remediation consisting of soil over-excavation, free product recovery wells, soil vapor extraction, and air sparging (again, all widely used remediation methods). From 2011 to 2016, a dual-phase extraction system operated. 2017 groundwater analytical data reveal overall decreased chemical concentrations in groundwater but with several wells showing persistent effects. It appears that discussions between FFEC and Ecology with the acceptable solution is to implement institutional controls for these remaining residual effects.

E. NON-AIRPORT-RELATED, STUDY AREA SOURCES OF CONTAMINATION

To identify off-airport, non-airport-related study area sources of contamination and affected sites, the consultant team subcontracted to Environmental Data Resources (EDR of Shelton, Connecticut) to search multiple federal, state, local, and tribal databases/lists of known and suspect affected sites. The environmental industry standard for such database searches normally covers a one-mile radius from a particular site or parcel of land.

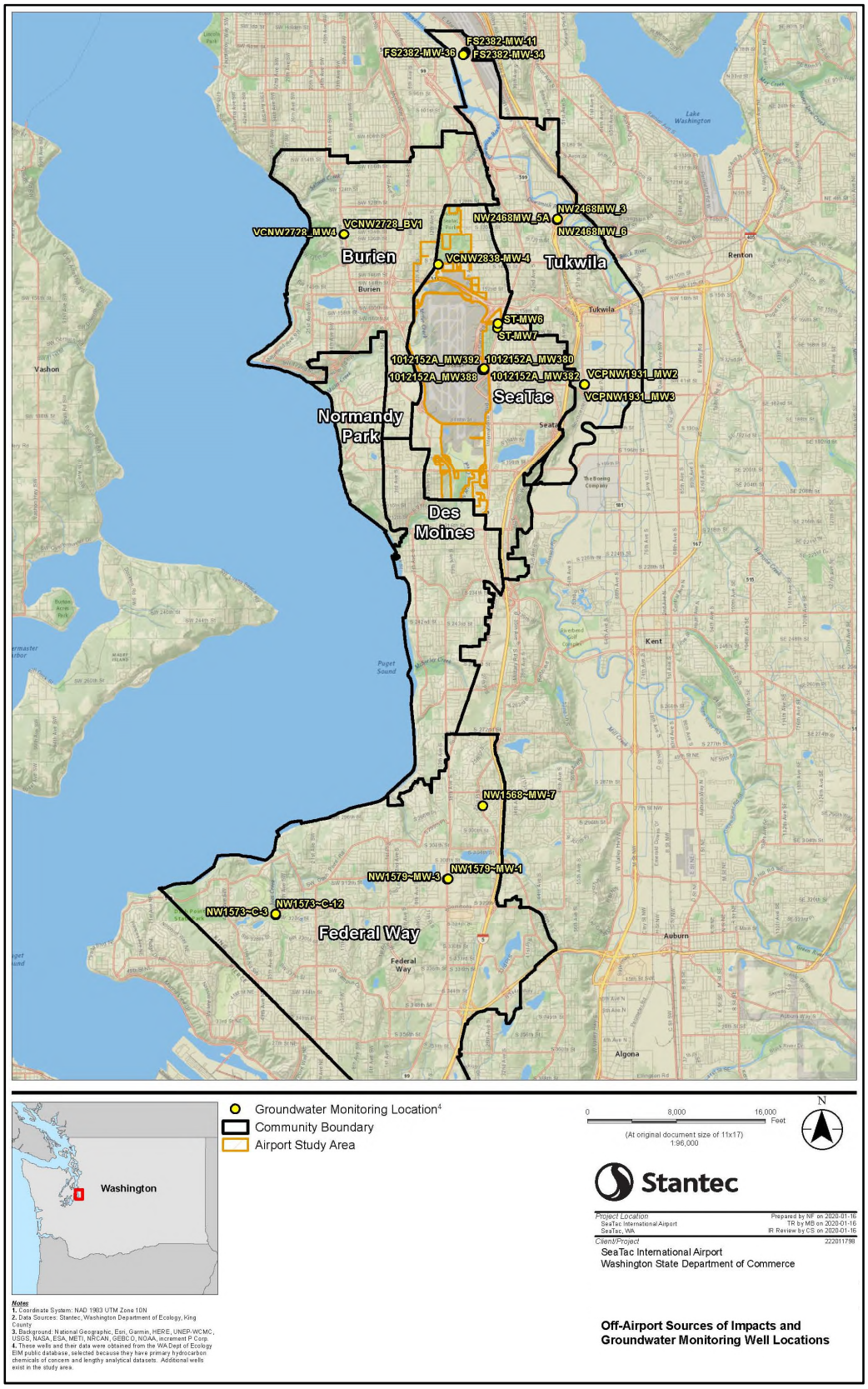
For this project, the consultant team adhered to the one-mile radius coverage as measured from the Seattle-Tacoma International Airport boundary. This research also updates similar database reviews conducted by Shapiro and Associates in 1995, a copy of whose April 1995 database report titled "Environmental Site Assessment" was included as Appendix L of the Port's 1996 Seattle-Tacoma International Airport Master Plan Final EIS.

As detailed in EDR's October 2019 report, there are numerous sites within a one-half mile radius of the airport boundary that are primarily tribal- and state-listed UST or LUST sites, sites with documented or suspect spills or releases, and hazardous waste generators (small or large-quantity generators but not meaning that a release has occurred). There are also several active and former dry cleaner sites with documented or suspect releases.

Non-airport-related, known contaminated sites

Based on review of the EDR report and Ecology's TCP public website, the consultant team went into Ecology's EIM public database and downloaded soil and groundwater analytical data for affected sites within the study area. Using the airport's COIs as a guide, the consultant team filtered the database to identify sites that could have similar COIs (potentially indicating effects originating from the airport) and then re-filtered the data to identify sites that had multiple years of analytical data (10 years or greater) that could be graphed in order to observe historical data trends. The COIs included: TPHg/GRO, TPHd/DRO, benzene, naphthalene, copper, zinc, and 1,1-DCE.

Figure 9.9
Off-Airport Sources of Effects and Groundwater Well Monitoring Locations



As shown on Figure 9.9, 10 sites (with groundwater wells) were identified. The sites are listed below based on Ecology's database nomenclature; the consultant team then used Google EarthPro™ to further identify the site name or use, and then its approximate location within a given jurisdiction city. Figure 9.10 describes these 10 sites.

Figure 9.10
Groundwater Monitoring Wells

Monitoring Well	Description
FS2382	Jorgensen Forge industrial property (northern Tukwila)
NW2468	Peterson's Diesel Fueling (central to east-central Tukwila)
ST-MW-7/ ST-MW-6	Master Park Lot C (eastern SeaTac; close to Airport). This site is further identified by Ecology as SeaTac Development (Facility Site #38258847; Cleanup Site #5994) with numerous environmental reports and technical documents on Ecology's TCP website. This site was operated by various business, "some of which utilized fuel products and USTs. Scarsella Bros. Inc. once owned the property and operated a construction yard on the property until the 1970s. This site is not related to the Seattle-Tacoma International Airport or Sea-Tac Ground Water Study." (reference: Ecology's Site Summary Page, SeaTac Development; public website accessed by the Consultant team on January 17, 2020)
1012152A	On-Airport property; this is Continental-Olympic-United FFEC site described above
VCPNW1931	Ashley Furniture Warehouse (former UST) (southern Tukwila)
NW1568	Former Chevron Station #9-8473 (northeastern Federal Way)
NW1579	Chevron Station #9-8538 (northeastern Federal Way)
NW1573	Chevron Station #9-9624 (northwestern Federal Way)
VCNW2728	ARCO Station #0409 (central to west-central Burien)
VCNW2838	AA Asphalt SeaTac Yard (northern SeaTac)

The 10 properties listed above have/have had known releases that are directly linked to their own particular USTs/former USTs with no discernable connection to airport groundwater data or airport operations. Most of the groundwater data show decreasing concentrations. In fact, VCPNW1931 received a No Further Action (NFA) determination from Ecology dated Jan. 28, 2014.

Evaluation of soil quality at these sites was not possible as soil borings are typically not drilled multiple times at the same locations. At affected sites, soil borings are drilled in a lateral, "step-out" manner to assess the lateral and vertical extent of effects originating from a point source.

One additional well-known and well-documented source of regional soil effects is the former Asarco Tacoma Smelter. According to Ecology's Site Summary Page, "For almost 100 years, the Asarco Company operated a copper smelter in Tacoma. Air pollution from the smelter settled on the surface soil over more than 1,000 square miles of the Puget Sound basin. Arsenic, lead, and other heavy metals are still in the soil as a result of this pollution" (public website accessed by the consultant team on Jan. 17, 2020).

F. WHAT WE HEARD FROM THE PUBLIC

During both public workshops (July and November 2019), a study area resident raised concern regarding polluted soil in his daughter's garden with the soil believed to have been affected by air pollution originated from nearby overhead aircraft emissions.

The consultant team understands that the citizen had been working with the University of Arizona (UA) and, due to increasing concern of air and soil pollution, the resident collected or was provided with samples of "filters, soil, plant material, teeth and bone chip."

The consultant team further understands that the samples were analyzed for a series of metals using industry-standard inductively coupled plasma mass spectrometry (ICP-MS) test methods with the results reported and provided back to the citizen by UA. The consultant team did not independently review the sample collection methods, sample handling procedures, and sample locations. It is recommended that a qualified third-party entity independently review the sample collection/handling/location information.

G. GROUNDWATER AND SOIL EFFECTS ATTRIBUTABLE TO AVIATION ACTIVTY

Positive effects on groundwater and soil

The Port of Seattle has remediated known listed polluted and contaminated sites, including leaking underground storage tanks.

Neutral effects on groundwater and soil

There are no known neutral effects on the groundwater and soil systems, with no changes to the soil or geological framework during the study period (1997 to 2019).

Negative effects on groundwater and soil

Known negative effects include:

- Known on-airport contaminated sites include Budget Auto Facility, Concourse B/Gate B, Continental Airlines Hydrant System, Delta Airlines Auto Gas Tank Cluster, Delta Airlines Fuel Farm, Northwest Airlines Hangar Tanks, Northwest Airlines Fuel Farm, Northwest Airlines Hydrant Systems, South Satellite Baggage Tunnel, Pan Am Airlines Avgas (Aviation Gas) Tanks, Pan Am Airlines Fuel Farm, Consolidated Rental Car Facility, and United Air Lines (UAL) Fuel Farm/Continental Airlines Fuel Farm.
- Surface water quality exceedances detected in Miller and Des Moines Creeks and several sites within airport property that have chemicals of concern.

Negative effects are not attributable to Seattle-Tacoma International Airport include:

- Several underground storage tanks not on airport property were noted to be leaking, according to the Department of Ecology's database.
- There may be long-term effects that were also associated with the operation of the former Asarco Tacoma Smelter (opened in 1917, closed in 1985).

Some citizens raised concerns regarding the effect on soils, gardens, and landscaping from "black soot" that they believe is the result of air pollution associated with aircraft. The composition of the reported "black soot" has not been confirmed by the 2020 study. It requires study and analysis by an independent testing laboratory before its source can be attributed.

Summary of groundwater and soil effects attributable to aviation activity

The graphs and tables in this section present various aspects of the effects on groundwater and soils in the study area, including magnitude and intensity. However, Figure 9.11 presents a general assessment of groundwater and soil effects attributable to aviation activity, categorized into four effect types:

- Positive effect attributable to aviation activity
- Negative effect attributable to aviation activity
- Neutral or no effect attributable to aviation activity
- Inconclusive data/needs additional study.

Figure 9.11
Summary of Groundwater and Soil Effects Directly Attributable to Aviation Activity – 1997 to 2019

■ Positive effect attributable to aviation activity
■ Neutral/no effect attributable to aviation activity
■ Negative effect attributable to aviation activity
○ Inconclusive data/needs additional study

GROUNDWATER and SOIL METRIC	STUDY AREA CITY																	
	Burien			Des Moines			Federal Way			Normandy Park			SeaTac			Tukwila		
	1997	2009	2019	1997	2009	2019	1997	2009	2019	1997	2009	2019	1997	2009	2019	1997	2009	2019
Groundwater	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Soil	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■

As detailed above, the Port of Seattle has addressed and remediated facilities on airport property, while there are remaining non-airport sites that require remediation. In general, the Port of Seattle (on-airport) has addressed aviation-related groundwater and soil concerns. Ongoing monitoring and sampling is still required to ensure the long-term safety and integrity of the groundwater and soil systems.

H. RECOMMENDATIONS

Following a review of documents and websites associated with groundwater and soil quality (see References. Following), the consultant team has identified no significant data gaps regarding soil or groundwater quality. To date, Seattle-Tacoma International Airport has conducted subsurface investigations in accordance with Ecology's regulations under Ecology's direction and supervision, and the airport has performed remediation to clean up affected soil and groundwater to the satisfaction of and acceptance by Ecology. The consultant team is unaware of any non-Ecology-mandatory performed by the Port of Seattle.

As a "good neighbor" and for the long-term protection of groundwater, the following are recommended.

- **Groundwater Recommendation #1 – Conduct independent testing of "black soot"**
  The consultant team heard numerous concerns from study area citizens regarding particulate matter and "black soot" that settles on horizontal surfaces (rooftops, cars, decks, pools, etc.), as well as effects to gardens and landscaping. Therefore, it is recommended that this material be tested by an independent third-party laboratory to determine the chemical composition of the material in question and potential sources.

- **Groundwater Recommendation #2 – Conduct ongoing monitoring and sampling**
  The Port of Seattle should conduct ongoing groundwater monitoring, sampling, and analysis in several remaining AOMA Unit C1 groundwater monitoring wells for key indicator parameters, to be performed on a three-year cycle. Results should be reviewed with groundwater data from the study area municipal water wells.

  It is noted that the Port of Seattle's 2008 Groundwater Study and five years of annual monitoring demonstrated that there are no existing groundwater contaminant plumes that migrate off airport property. The Port of Seattle has stated that if any new sites are identified in the future, they will be characterized and monitored according to applicable and relevant environmental regulations.

- **Groundwater Recommendation #3 – Coordinate with Study Area Comprehensive Plans**
  Natural systems such as groundwater and soils do not begin or end at city or airport borders. It is recommended that the Port of Seattle cooperatively work with surrounding communities to ensure the ongoing health and preservation of groundwater and soil areas. Similarly, it is recommended that as study area cities update their individual specific comprehensive plans that they coordinate these efforts with the Port of Seattle to ensure all parties are adopting plans and policies that do not harm that local and regional environment.

I. THE FUTURE

As with surface water, ongoing growth and urbanization are concerns for the integrity of any developed region's groundwater and soil systems and habitats. As the region and the study area continue to grow, care must be taken to ensure these systems are not affected.

The increasing reliance on low-impact design (LID) and sustainable and green building practices – for both residential and commercial applications – holds promise that increasing urbanization does not have to come at the cost of natural systems. And improvements to the natural environment should also have parallel benefits to human health, property values, and other quality of life metrics.

J. SUMMARY

Many of the sites of concern occur on airport property. The Port of Seattle is appropriately monitoring and addressing these areas of interest. Similarly, there are some off-airport sites of concern – some of which are due to other sources (such as industrial or dry cleaner operations.)

Citizens in the study area also raised concerns about effects to homes, gardens, and landscaping. While those effects could not be independently verified, there should be follow-up monitoring and/or testing to ensure that there are no areas of concern that have not yet been reported.

K. REFERENCES

Asian Journal of Atmospheric Environment. Volume 6-2, June 2012. "The Effect of Aircraft Traffic Emissions on the Soil Surface Contamination Analysis around the International Airport in Delhi, India".

Austin, Elena, Jianbang Xiang, Tim Gould, Jeffry Shirai, Sukyong Yun, Michael Yost, Timothy Larson, and Edmund Seto. 2019. Mobile Observations of Ultrafine Particles (MOV-UP) Study Final Report. Report, Seattle: University of Washington.

City of Burien, Washington. https://burienwa.gov.

City of Des Moines, Washington. http://www.desmoineswa.gov.

City of Federal Way, Washington. https://www.cityoffederalway.com.

City of Normandy Park, Washington. https://normandyparkwa.gov.

City of SeaTac, Washington. https://www.seatacwa.gov.

City of Tukwila, Washington. https://www.tukwilawa.gov.

Eastern Research Group, Inc. 2019. 2017 National Emissions Inventory: Aviation Component.

Environmental Data Resources (Shelton, CT). Corridor Report, October 15, 2019. "Search requirements of EPA's Standards and Practices for All Appropriate Inquiries (40 CFR Part 312), the ASTM Standard Practice for Environmental Site Assessments (E 1527-13), the ASTM Standard Practice for Environmental Site Assessments for Forestland or Rural Property (E 2247-16), the ASTM Standard Practice for Limited Environmental Due Diligence: Transaction Screen Process (E 1528-14) or custom requirements developed for the evaluation of environmental risk associated with a parcel of real estate."

Kolodziej, E.P. 2019. Personal Communication, RE: Miller and Walker Creek stream data. September 24, 2019. Environmental Science and Pollution Research, October 2017. "Signs for Secondary Buildup of heavy metals in soils at the periphery of Athens International Airport, Greece"

Port of Seattle. 1996 Seattle-Tacoma International Airport Master Plan Final Environmental Impact Statement.

Port of Seattle. 1997 Seattle-Tacoma International Airport Master Plan Final Supplemental Environmental Impact Statement.

Port of Seattle. 2003 State Route 509: Corridor Completion/IH-5/South Access Road Final Environmental Impact Statement.

Port of Seattle. 2007 Seattle-Tacoma International Airport Comprehensive Development Plan Final Environmental Impact Statement.

Port of Seattle. 2008 Seattle-Tacoma International Airport Groundwater Study.

Port of Seattle. 2018 Seattle-Tacoma International Airport Groundwater Study Update (Annual Groundwater Sampling 2011-2015).

Port of Seattle. 2018 Seattle-Tacoma International Airport Sustainable Airport Master Plan – Technical Memorandum No. 8 Environmental Overview.

Port of Seattle. 2019 Seattle-Tacoma International Airport Request for Department of Ecology's Opinion Regarding Completed Remedial Action, Former Continental-Olympic-United Fuel Farm Area, Facility/Site #2294, VCP #NW2300.

Port of Seattle. April 2003. Groundwater Chemistry Summary by Site. Agreed Order and Supplemental Groundwater Study Sites

Staton, Michael D. (Principal Geologist, SLR, Bothell, WA). Letter report dated July 20, 2015 to Ching-Pi Wang (Washington Department of Ecology) regarding the Airport Groundwater Study.

Transportation Research Record 1517. "Evaluating Particulate Emissions from Jet Engines: Analysis of Chemical and Physical Characteristics and Potential Impacts on Coastal Environments and Human Health"

Washington Department of Ecology (https://ecology.wa.gov) databases: Toxic Cleanup Program; Underground Storage Tanks; Leaking Underground Storage Tanks; Environmental Information Management; and Permitting and Reporting Information System (PARIS). Accessed 2019.

Washington Department of Ecology. Seattle-Tacoma International Airport-specific letter dated September 17, 2008.