U.S. Army Corps of Engineers

Final Baseline Risk Assessment Report
Former Naval Auxiliary Air Station Quillayute
DERP-FUDS Site No. F10WA012102
Quillayute, Washington

U.S. Army Corps of Engineers
Kansas City District

December 2013

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U.S. Army Corps of Engineers – Kansas City District
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CONTRACTOR STATEMENT OF INDEPENDENT TECHNICAL REVIEW

Notice is hereby given that an Independent Technical Review (ITR) has been conducted on the Final Baseline Risk Assessment Report for the former Naval Auxiliary Air Station Quillayute, which is appropriate to the level of risk and complexity inherent in the project. During the ITR, compliance with established policy, principles, and procedures was verified. This included review of procedures to be used to create a product that meets the customer's needs, consistent with law and existing U.S. Army Corps of Engineers (USACE) policy.

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Significant concerns and the explanation of the resolution are as follows:

None.

As noted above, all concerns resulting from the independent technical review of the document have been considered.

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ACRONYMS AND ABBREVIATIONS

◦F	Fahrenheit
amsl	above mean sea level
AST	above-ground storage tank
ATSDR	Agency for Toxic Substances and Disease Registry
BaP-Eq	equivalent concentration of benzo(a)pyrene
BERA	baseline ecological risk assessment
bgs	below ground surface
BHHRA	baseline human health risk assessment
BLRA	baseline risk assessment
Cal-EPA	California Environmental Protection Agency
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CLARC	Cleanup Levels and Risk Calculations
COC	chemical of concern
CON/HTRW	Containerized Hazardous, Toxic, and Radioactive Waste
COPC	chemical of potential concern
CPEC	chemical of potential ecological concern
CSM	conceptual site model
CTE	Central Tendency Exposure
DoD	Department of Defense
Eco-SSL	Ecological Soil Screening Level
EPC	exposure point concentration
FUDS	Formerly Used Defense Sites
GEO	GEO Consultants, LLC
HI	hazard index
HQ	hazard quotient
HTRW	Hazardous, Toxic, and Radioactive Waste
ILCR	incremental lifetime cancer risk
IRIS	Integrated Risk Information System
kg	kilogram
L	liter
MCL	maximum contaminant level
MMRP	Military Munitions Response Program
MTBE	methyl tert-butyl ether
MTCA	Model Toxics Control Act
m	meter
mg	milligram
NAAS	Naval Auxiliary Air Station
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
NHD	National Hydrography Dataset
NOAA	National Oceanic and Atmospheric Administration
NWI	National Wetlands Inventory
PAH	polynuclear aromatic hydrocarbon
PCB	polychlorinated biphenyl
PCE	tetrachloroethene
RAGS	Risk Assessment Guidance for Superfund
RCRA	Resource Conservation and Recovery Act
RfC	reference concentration
RfD	reference dose
RI	Remedial Investigation

RME	Reasonable Maximum Exposure
RSL	Regional Screening Level
SARA	Superfund Amendments and Reauthorization Act
SVOC	semi-volatile organic compound
TEF	toxicity equivalency factor
TPH	total petroleum hydrocarbon
UCL	upper confidence limit
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
USACE	U.S. Army Corps of Engineers
USEPA	U.S. Environmental Protection Agency
UST	underground storage tank
VAF	vapor attenuation factor
VI	vapor intrusion
VOC	volatile organic compound
WAC	Washington Administrative Code
WDOE	Washington Department of Ecology
µg	microgram

EXECUTIVE SUMMARY

This baseline risk assessment (BLRA) report for the former Naval Auxiliary Air Station (NAAS) Quillayute, Washington has been prepared for the U.S. Army Corps of Engineers (USACE)-Kansas City and Seattle Districts by GEO Consultants, LLC (GEO) under Contract No. W912DQ-10-D-3012, Delivery Order No. 0005. The BLRA includes a baseline human health risk assessment (BHHRA) and a baseline ecological risk assessment (BERA). The BLRA was completed in accordance with the requirements of the National Oil and Hazardous Substances Pollution Contingency Plan (NCP), and the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), as amended by the Superfund Amendments and Reauthorization Act (SARA). The objectives of the BLRA are (1) to evaluate risks and hazards to human health and the environment from exposure to residual contamination present at the former NAAS Quillayute in the event that no action is taken to remove contaminants or stop them from migrating, and (2) to formulate preliminary remediation goals. The BLRA described in this report is based on the results of a Remedial Investigation (RI) that included field sampling from March 2009 through December 2011 (Shannon and Wilson 2012). The RI and the BLRA are part of the USACE's effort under the Department of Defense (DoD) Formerly Used Defense Sites (FUDS) Hazardous, Toxic and Radioactive Waste (HTRW) program to evaluate and address potential environmental impacts from DoD's historical use of the site.

The site is located along Quillayute Road in Clallam County, Washington, approximately 15 miles west of the City of Forks and approximately four miles east of the Pacific Ocean. The majority of the site is located north of Quillayute Road and includes two runways. The northwest-southeast trending Runway (Runway #1) has been closed since 1977 while Runway #2 is still open and is part of the Quillayute Airport primarily used by recreational fliers.

The 1202-acre property was acquired by the War Department in the early 1940's and was developed as an auxiliary air station for joint U.S. Army and U.S. Navy use (Shannon and Wilson 2012). In June 1946, the property was declared excess and was transferred to the General Services Administration for disposal without restriction. The portion of the site currently occupied by the Quillayute Airport is owned and operated by the City of Forks, while the parcels that comprise the remainder of the site are either owned by the State of Washington or private individuals. Portions of the site outside Quillayute Airport are currently either occupied by residences or undeveloped. The area surrounding the site consists of parcels zoned by Clallam County for commercial forest use where residential density is restricted to one dwelling for every 80 acres (Clallam County 2012a, 2012b).

Several investigations have been conducted at the site to determine whether past DoD use of the site had led to impacts on the environment. The most recent field sampling efforts consist of groundwater investigations in 2004 and 2006 and the RI in 2009-2011. During the 2004 and 2006 groundwater investigations, monitoring wells were installed and these wells, along with a number of water supply wells within the site, were sampled (URS 2004, URS 2007). The RI field sampling conducted between March 2009 and December 2011 consisted of soil sampling from areas of potential concern within the former NAAS Quillayute where historical operations may have involved handling of hazardous materials. Installation of monitoring wells, sampling of existing and newly installed monitoring wells, sampling of water supply wells, as well as soil gas and air sampling to concerns regarding vapor intrusion were conducted. Validated analytical data collected during the RI were provided by USACE-Seattle District to GEO to serve as a database for the BLRA. Groundwater data from the 2006 URS investigation, which were included as in appendix in the RI report (Shannon and Wilson 2012), were used in the BLRA to supplement the groundwater data collected during the RI. An ecological reconnaissance of the site was conducted by GEO in March 19-20, 2012. The purpose of the ecological reconnaissance was to collect data regarding habitats and species to support the ecological assessment. The ecological reconnaissance

was focused on the areas of potential concern that had been sampled during the RI and which were mostly located in the western portion of the Industrial Complex Area.

Baseline Human Health Risk Assessment

The BHHRA evaluated risks and hazards to site receptors from exposure to residual contamination at the site under baseline conditions. Chemical analyses of soil, groundwater, soil gas and air samples collected during the RI (Shannon and Wilson 2012) and groundwater analyses from a previous investigation (URS 2007) were compared to risk-screening criteria to identify chemicals of potential concern (COPCs) that were carried forward into a quantitative risk assessment. The screening levels consisted of the minimum of risk-based screening criteria from the U.S. Environmental Protection Agency (USEPA) Regional Screening Levels (May 2013) and from the State of Washington's Model Toxics Control Act (MTCA) Method B criteria (WDOE 2007) downloaded from the State of Washington Cleanup Levels and Risk Calculations (CLARC) database in July 2012. For metals, MTCA Method A criteria was used because they accounted for regional background concentrations. Chemicals that were detected at concentrations that exceeded the screening levels were identified as COPCs and carried forward into the quantitative risk assessment.

Soil Summary

The chemicals that were identified as COPCs in soil were: benzo(a)pyrene and other carcinogenic polynuclear aromatic hydrocarbons (PAHs), pentachlorophenol and naphthalene. There were no volatile organic compounds (VOCs) or polychlorinated biphenyls (PCBs) identified as COPCs in soil. Risks and hazards for site receptors from exposure to soil COPCs were calculated using standard methods provided in USEPA guidance for conducting risk assessments. Based on current land use and Clallam County zoning laws, the site receptors include the resident adult/child, visitor/recreationist adult/child, excavation/construction worker, indoor worker, and outdoor worker (i.e., airport maintenance crew and operators). The highest carcinogenic risks from exposure to soil were found to be associated with soils at B5 (a former NAAS Quillayute Transportation Maintenance building) with an estimated risk for the potential future resident adult of $1x10^{-5}$ which is within the target risk range of 10^{-6} to 10^{-4} of the NCP. Benzo(a)pyrene and other carcinogenic PAHs contributed the most to the overall risk. There are no hazards associated with exposure to soil at the site based on estimated hazard indices below 1 for all the areas of potential concern that were sampled during the RI.

In summary, using the target NCP risk range of 10^{-6} to 10^{-4}, there are no locations within the site where soils contain levels of contamination requiring remediation to protect human receptors.

Groundwater Summary

The chemicals that were identified as COPCs in groundwater were bis(2-ethylhexyl)phthalate and carbon tetrachloride. No COPCs were identified in groundwater underlying the Industrial Complex Area occupied by the Quillayute Airport. Risks and hazards from exposure to groundwater were calculated for groundwater exposure units (EUs) that were defined as the West Parcels Area Groundwater EU, the Industrial Complex Area in the vicinity of B44 Groundwater EU (former Dry Cleaner where dry cleaning solvents may have been used), and the Industrial Complex Area in the vicinity of NI well Groundwater EU. The NI well is a former DoD water supply well where carbon tetrachloride was first detected during sampling by the City of Forks in 2000 (Shannon and Wilson 2012). The definition of these groundwater EUs was based on the hydrogeological and contaminant distribution data collected during the RI and land use at the site. Carcinogenic risk within the West Parcels Area Groundwater EU is below 10^{-6} for all site receptors. Estimated risks are within the NCP target range of 10^{-6} to 10^{-4} for all receptors in the Industrial Complex Area in the vicinity of the B44 slab and the NI well.

Vapor Intrusion Summary

Concerns regarding vapor intrusion at the former location of the B44 slab and the vicinity of the NI well were addressed during the RI through the collection of soil gas and crawl space air samples. The latter were collected from the open space under the residential structure which consists of a mobile home located on the concrete slab from the former B44 building. The concentrations of VOCs detected in the crawl space and soil gas samples were compared to screening levels that were calculating by dividing indoor air screening levels by vapor attenuation factors (VAFs) recommended by USEPA (2012b) for crawl space-to-indoor air and soil gas-to-indoor air pathways. VOC concentrations in the soil gas samples from the vicinity of the NI well were below the soil gas screening levels. VOC concentrations in the soil gas samples collected from the vicinity of B44 exceeded screening levels. VOC concentrations in the crawl space air samples at the B44 slab were above the indoor air screening criteria in 2011, but those concentrations were comparable to the ambient air sample collected during the same sampling event. Benzene, carbon tetrachloride, and 1,2-dichloroethane concentrations exceeded screening levels in the crawl space air samples, while carbon tetrachloride and tetrachloroethene (PCE) concentrations in soil gas samples (2010) exceeded the soil gas screening criteria. These four chemicals were then carried forward into a quantitative risk assessment. Exposure point concentrations (EPCs) for indoor air in the residential structure occupying the former location of B44 were set to the average of the crawl space concentrations multiplied by 0.9, the 95% VAF factor provided by USEPA (2012b) for estimating indoor air concentrations from crawl space data. EPCs were estimated for the soil gas data however the EPCs from the crawl space data are considered more relevant since these are based on conditions closest to the receptor of interest, i.e., the residents in the mobile home occupying the B44 concrete slab (DoD 2009). Estimated risks calculated from the crawl space data were within the NCP target range of 10^{-6} to 10^{-4} for residential receptors. VOC concentrations in the crawl space air samples are comparable to the concentrations of these chemicals in the ambient air sample collected during the same sampling event. This observation suggests that the VOCs in the crawl space air samples may be from sources other than vapor intrusion from the subsurface. Shannon and Wilson (2012) mentioned the possibility of household cleaners.

Baseline Ecological Risk Assessment

The BERA included a literature survey of sensitive species that may be present at the site as well as an ecological reconnaissance visit in March 19-20, 2012 during which species and habitats within the site where observed and documented. The ecological reconnaissance focused on the area within the western portion of the Industrial Complex Area where a majority of the areas of potential concern are located. The literature survey indicated the potential presence of projected federally and state listed species for Clallum County, Washington. However none of these listed species were observed during the site visit and are unlikely to inhabit the project area. The results of the ecological reconnaissance were documented and maps of habitat and biodiversity types are presented in the BLRA report.

The BERA evaluated risks and hazards to site receptors from exposure to contaminants at the site. Chemical analysis of soil, groundwater, soil gas and air samples collected during the RI (Shannon and Wilson 2012) and groundwater analyses from a previous investigation (URS 2007) were compared to risk-screening criteria to identify chemicals of potential ecological concern (CPECs). Based on review and past discussions with USACE-Seattle District, the screening levels consisted of ecological indicator soil concentrations listed in the Washington State MTCA guidance which were used to further analyze site data. Ecological Soil Screening Levels were used as these values are presumed to provide adequate protection of terrestrial ecosystems. Documented CPECs were limited to soil concentrations because existing data consist primarily of soil analyses. Surface water and sediment were not sampled (except for a surface water sample from the pond outside the project boundaries) and groundwater samples were only collected from existing monitoring and drinking water wells.

Soil Summary

Soil sampling [3 to 6 inches below ground surface (bgs)] was conducted for PCBs, Semi-volatile organic compounds (including PAHs) and silver. Results of data analysis initially identified one exceedance along the perimeter of B12 in soil samples (3 to 6 inches bgs) for silver; therefore silver was carried forward as a CPEC. Subsurface soil sampling detected methylene chloride and PCE at 25 feet bgs and for barium, chromium, copper, iron, manganese and mercury at 17 and 18 feet bgs. No ecological indicator soil concentration screening levels (Table 749-3 MTCA Guidance) are available for methylene chloride or PCE. At these depths, it is unlikely that excavation or disturbance of these areas will occur and no ecological impacts are expected from exposure of soils at these depths; therefore, these contaminants are not carried forward as CPECs.

Groundwater Summary

Groundwater sampling from residential wells and existing monitoring wells did not identify contaminants of concern that could be associated with DoD use of the facility, with the possible exception of carbon tetrachloride that has been detected in the western portion of the Industrial Complex Area. Carbon tetrachloride was detected at 6.8 µg/L in the NI well which exceeds risk based screening criteria. Carbon tetrachloride is considered a CPEC because it was detected in a drinking water well however, it was not detected in the man-made pond on the Neilson Property, the only surface water sampled.

During the 95% upper confidence limit (UCL) calculation process, the single exceedance for silver was determined to be an outlier and was removed from the dataset; therefore silver was removed as a CPEC. Results of this BERA determined that no CPECs exist in the Western portion of the Industrial Complex Area, no potential risks exist for ecological receptors, and no remediation activities are recommended.

1. INTRODUCTION

This baseline risk assessment (BLRA) report for the former Naval Auxiliary Air Station (NAAS) Quillayute, Washington has been prepared for the U.S. Army Corps of Engineers (USACE)-Kansas City and Seattle Districts by GEO Consultants, LLC (GEO) under Contract No. W912DQ-10-D-3012, Delivery Order No. 0005. The BLRA includes a baseline human health risk assessment (BHHRA) and a baseline ecological risk assessment (BERA). The BLRA was completed in accordance with the requirements of the National Oil and Hazardous Substances Pollution Contingency Plan (NCP), and the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), as amended by the Superfund Amendments and Reauthorization Act (SARA). In addition, the BLRA follows the guidance and policy outlined in *Management Guidance for the Defense Environmental Restoration Program* (Office of the Deputy Under Secretary of Defense 2001) and *Environmental Quality: Formerly Used Defense Sites Program Policy* (Engineer Regulation, ER 200-3-1, 10 May 2004). The lead regulatory agency is the Washington Department of Ecology (WDOE).

1.1 PROJECT OBJECTIVES

The objectives of the BLRA are (1) to evaluate risks and hazards to human health and the environment from exposure to residual contamination present at the site in the event that no action is taken to remove contaminants or stop them from migrating, and (2) to formulate preliminary remediation goals. The BHHRA was performed following the U.S. Environmental Protection Agency (USEPA) *Risk Assessment Guidance for Superfund* (RAGS; e.g., USEPA 1989, 2004, 2009) and the State of Washington's *Model Toxics Control Act* (MTCA, 173-340 Washington Administrative Code [WAC], WDOE 2007). The BERA was performed following USEPA guidance as published in *Guidelines for Ecological Risk Assessment* (EPA/630/R-95/002F, USEPA 1998) as well as requirements for ecological assessments in the State of Washington's MTCA.

The BLRA described in this report is based on the results of a Remedial Investigation (RI) that included field sampling from March 2009 through December 2011 (Shannon and Wilson 2012). The RI and the BLRA are part of the USACE's effort under the Department of Defense (DoD) Formerly Used Defense Sites (FUDS) program to evaluate and address potential environmental impacts from DoD's historical use of the site. The long-term objectives of the USACE for the site are to:

- Assess whether DoD occupation of the site resulted in the presence of contaminants in environmental media at levels exceeding regulatory or risk-based criteria.
- Identify potential downgradient receptors that may be at risk of exposure.
- Protect human health and the environment from hazards associated with the historical operations of the former NAAS Quillayute by acquiring data to evaluate the potential exposures and risks of past, current, and future site activities.
- Attain project closeout, as measured by remedy-in-place or response complete, by fiscal year 2020. Remedy-in-place, defined as the end date of the construction portion of remedial action, signifies that the construction is complete, all testing has been done, and that the remedy will function properly.
- Carry out project closeout activities using funding authorized under the FUDS appropriation.

The RI (Shannon and Wilson 2012) and the BLRA presented in this report were conducted under DoD FUDS Hazardous, Toxic and Radioactive Waste (HTRW) projects. The following categories of activities or materials at the former NAAS Quillayute are not eligible for inclusion in FUDS HTRW projects, and were therefore not evaluated in the RI and BLRA.

- Underground storage tanks (USTs), above-ground storage tanks (ASTs), and their associated ancillary equipment. These are addressed under a Containerized HTRW (CON/HTRW) program. A CON/HTRW program at the site was completed in 2005 and regulatory concurrence on no further DoD action was indicated (Shannon and Wilson 2012).
- Munitions and pyrotechnics. Munitions and pyrotechnics stored at the former NAAS Quillayute are being addressed under DoD's Military Munitions Response Program (MMRP). This MMRP project will address residuals from activities at the skeet range.
- Asbestos-containing building material and lead-based paint. Concerns regarding these materials will be addressed through a Building Demolition/Debris Removal project.

1.2 REPORT ORGANIZATION

- Section 1 – Introduction. The Introduction contains the project objectives and outlines the report organization.
- Section 2 – Site Background. This section provides site location, property history, and current status for the former NAAS Quillayute.
- Section 3 – Physical Setting. This section describes the physical characteristics of the site include climate, topography and surface waters, geology and hydrogeology, current land use, and the ecological and environmental setting.
- Section 4 – Summary of Previous Investigations. This section discusses previous investigations that have been conducted at the site.
- Section 5 – Baseline Human Health Risk Assessment. This section presents the methods and results of the BHHRA including risk screening, exposure assessment, toxicity assessment, risk characterization and uncertainty.
- Section 6 – Baseline Ecological Risk Assessment. – This section presents the BERA methods and results including risk screening, exposure assessment, toxicity assessment, risk characterization and uncertainty.
- Section 7 – Summary and Conclusions. This section summarizes the BHHRA and BERA results as well as presents Preliminary Remediation Goals.
- Section 8 – References. This section contains a list of references that were cited in the report.

All the report figures and tables are provided at the end of the report before the appendices.

The following supplementary resources have been included as appendices.

- Appendix A – Photographs from the ecological reconnaissance, March 19-20, 2012
- Appendix B – Data from Remedial Investigation (Shannon and Wilson 2012)
- Appendix C – Baseline Risk Assessment Equations for Estimating Exposure
- Appendix D – ProUCL 4.1.01 results and Kaplan Meier calculations for benzo(a)pyrene equivalent concentrations
- Appendix E – Human Health Risk calculations
- Appendix F – Toxicological Profiles for Chemicals of Potential Concern (COPCs) (to be included in Final report)
- Appendix G – Geographic Information Systems data (to be included in Final report)

The BLRA described in this report is based on environmental data collected during previous investigations at the former NAAS Quillayute site. Environmental samples were analyzed for a suite of analytes including lead and total petroleum hydrocarbons (TPHs). The results for lead and TPH analyses were presented in the RI report (Shannon and Wilson 2012) however the BLRA described herein does not include an evaluation of the lead and TPH data because environmental impacts from these chemicals are not actionable under the FUDS HTRW program. Lead at the site may be from lead-based paint and petroleum hydrocarbons are excluded from regulation under CERCLA.

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2. SITE BACKGROUND

2.1 SITE LOCATION

The former NAAS Quillayute is located along Quillayute Road in Clallam County, Washington approximately 15 miles west of the City of Forks, Washington and approximately four miles east of the Pacific Ocean (Figure 2-1). The 1202-acre property is located in Sections 12 and 13 of Township 28 North, Range 15 West, and Sections 7, 8 and 18 of Township 28 North, Range 14 West, Willamette Meridian.

The majority of the site is located north of Quillayute Road and includes two runways (Figure 2-2). The northwest-southeast trending Runway #1 has been closed since 1977 while Runway #2 is still open and is part of the Quillayute Airport.

2.2 SITE HISTORY

The 1202-acre property was acquired by the War Department in the early 1940's and was developed as an auxiliary air station for joint U.S. Army and U.S. Navy use (Shannon and Wilson 2012). During World War II, the facility was used for practice B-24 bombing missions[1], P-38 fighter aircraft missions, and deployment of surveillance blimps (Shannon and Wilson 2012). Jurisdiction over the facility was fully transferred to the U.S. Navy in 1944 when it was officially commissioned 'NAAS Quillayute'. In June 1946, the property was declared excess and was transferred to the General Services Administration for disposal without restriction.

A majority of the property was acquired by the State of Washington in 1962 for use as an emergency landing field while the rest of the property was sold to the Quillayute Prairie School District or to private individuals. The site was used as a clubhouse and campsite for a flying club from 1964 to 1975 (Shannon and Wilson 2012).

The portion of the site occupied by the Quillayute Airport is currently owned and operated by the City of Forks. The Quillayute Airport is primarily used by recreational fliers. A more detailed description of historical land use and the current status of the site are presented in Section 2.3.

2.3 HISTORICAL LAND USE AND CURRENT STATUS

For the purpose of the RI, Shannon and Wilson (2012) subdivided the former NAAS Quillayute into six areas generally corresponding to the DoD operations conducted at the facility. These six areas include (Figure 2-3):

- Administration and Operations Area,
- Army Cantonments/HOMOJA Housing Area,
- East Parcels Area,
- Industrial Complex Area (designated as western and eastern portions in this report),
- West Parcels Area, and
- Runway Approach Zones.

[1] No mention of the presence of practice bombing ranges at the site in the RI Report (Shannon and Wilson 2012).

A brief description of each area's historical use and current status are provided below. The following includes a discussion of the areas of potential concern with respect to environmental impacts that were identified based on previous reviews of the former NAAS Quillayute historical records (Hart Crowser 2002, Shannon and Wilson 2007). Unless otherwise noted, the historical and current uses of the areas described below were obtained from the RI report (Shannon and Wilson 2012). Observations made during an ecological reconnaissance visit[2] conducted in March 2012 in preparation for the BLRA are presented. Photographs from the ecological site visit are presented in Appendix A.

2.3.1 Administration and Operations Area

This area (yellow area in Figure 2-3 and 2-4) included the two runways (4700 feet and 5000 feet long), parking aprons, taxiways and fueling pits[3]. Shannon and Wilson (2012) note that the USTs and piping associated with these fueling pits were removed in 2004.

A potable water supply well, referred to as the 'Airport Well', is located near the southern end of Runway #1 (Figure 2-4). This water supply well was originally installed as part of the former NAAS Quillayute facility potable water supply and is still being used to supply water to the National Oceanic and Atmospheric Administration (NOAA) weather observation station currently occupying one of the former NAAS Quillayute buildings (B14, in the Industrial Complex Area described in Section 2.3.4).

Two areas of potential concern located within the Administration and Operations Area were identified during a preliminary assessment of the site (Hart Crowser 2002). These areas include a cluster of four borrow pits located north of Runway #2 and a suspected liquid disposal area (Figure 2-4). The borrow pits, which were shown on a 1946 site layout map, were likely used as a source for fill material during construction of the facility and no documentation was found in the historical records regarding the use of the borrow pits for refuse disposal (Shannon and Wilson 2012). The suspected liquid disposal area is located at the southwestern end of Runway #2 (Figure 2-4). This area was identified during the preliminary assessment by an anonymous caller who indicated that liquid wastes from aircraft were disposed of to the ground surface in an area off to the southwest end of Runway #2 (Hart Crowser 2002).

The outlines of the borrow pits shown in Figure 2-4 are based on a map in the RI report prepared by Shannon and Wilson (2012) and are presumed to be derived from historical site layout maps for the site. As shown in Figure 2-4, the borrow pits are each approximately 400 to 500 feet across and are described by Shannon and Wilson (2012) as being 50 feet deep. The borrow pits are covered by heavy vegetation as seen in the 2012 aerial photograph in Figure 2-4 and confirmed during the ecological reconnaissance visit conducted in March 2012.

According to Clallam County property records, the portion of the Administration and Operations Area that includes Runway #2 is currently owned by the City of Forks while the remaining portions of the area, including Runway #1, are owned by the State of Washington. Runway #2 was upgraded by the City of Forks in 2002 and is the main operational runway of the Quillayute Airport. Runway #2 is listed by the Federal Aviation Administration as an active runway and Runway #1 is described as being in poor condition (http://www.airnav.com/airport/KUIL).

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[2] The ecological reconnaissance was conducted by EnviroScience, Inc. GEO staff were present during the site visit and made the observations regarding the current status of the areas noted in Section 2.3.

[3] Shannon and Wilson (2012) describe the fueling pits as being located "east of the warming apron between Taxiway # 1 and 2, and west of the warming apron along Taxiway No. 2, adjacent to Aircraft Tied-down Area # 2 and 3".

2.3.2 West Parcels Area

This area located northwest of the Administration and Operations Area (see blue areas in Figure 2-3 and 2-4) contained aircraft tie-downs; storage magazines for explosives, pyrotechnics, and small arms; a trap shooting area; historic gravel borrow areas; and fueling systems including underground storage tanks, piping, and fueling pits. USTs and associated piping in the fueling pits were removed in 2004 (Cherokee General Corporation 2005). The aboveground structures associated with the military operations were demolished prior to transfer to private ownership.

This area has been subdivided into multiple parcels with residential home sites (Figure 2-4). Potable water for these residential homes is provided by four multi-residence water supply wells and up to eight individual water wells (Shannon and Wilson 2012).

2.3.3 East Parcels Area

This area is located northeast of the Administration and Operations Area (dark yellow area in Figures 2-3 and 2-5), and contained taxiways; aircraft tie-downs; a radio building and a generator building; and fueling systems (USTs, piping, and fueling pits). The aboveground structures associated with the military operations were demolished prior to transfer to private ownership.

The area of potential concern in the East Parcels Area consists of buildings B101 and B102 (Figure 2-5). B101 was reportedly used for radio communications and B102 housed the generators that supplied power to B101. Both buildings were reportedly removed in the 1960s.

The East Parcels has been subdivided and now consists of a mix of residential home sites and undeveloped lots (Figure 2-5). The parcel where B101 and B102 were formerly located is privately owned according to Clallam County assessor records, vacant and undeveloped as of 2012 (Google Earth 2012).

2.3.4 Industrial Complex Area

The Industrial Complex consisted of two non-contiguous areas (see purple areas in Figure 2-3), with all of the areas of potential concern located within the western portion of the Industrial Complex Area (Figure 2-6). The portion of the Industrial Complex Area located north of Quillayute Road is within the fenced-in area of the Quillayute Airport and includes the following areas of potential concern (listed west to east as shown in Figure 2-6 as red polygons):

- B20, Hangar. This hangar building is still present at the site and is reportedly being leased by the City of Forks to a private individual (Shannon and Wilson 2012). The control tower attached to this building was destroyed by a fire in November 2007 although the hangar building itself was not damaged (Dickerson 2007). The fire-damaged structures were no longer present during the ecological reconnaissance visit in March 2012.

- B7 and B11, Transformer Vault and Radar/Radio Building. These buildings were located east of B20 (Figure 2-6).

- B12, Class “C” Overhaul Shop. This building located east of B20 (Figure 2-6) was observed to be in major disrepair during the ecological reconnaissance visit in March 2012.

- B14, NOAA Weather Station. This building is east of B12 and currently occupied by a NOAA Weather Station (Figure 2-6). The Airport Well supplies water to this building; this

well was sampled as part of the RI and several analytes were detected (Sections 4.2.2 and 4.3.3).

- B10, Gunnery Training. This building was located south-southeast of B7, B11, and B12 next to Quillayute Road (Figure 2-6). This building has been demolished however the concrete building slab is still present. The area surrounding the slab was observed to be covered by heavy vegetation during the ecological reconnaissance visit in March 2012.

- B18 and B19, Paint Shops. These buildings were located northeast of and adjacent to the former locations for B7 and B11 (Figure 2-6), directly behind the NOAA Weather Station.

- B5, Transportation Maintenance and B17 Wash Rack and Shelter. These buildings were located northeast of B10 next to Quillayute Road (Figure 2-6). The buildings have been demolished; however the building foundation slabs are still present and were observed to be covered by heavy vegetation during the ecological reconnaissance visit in March 2012. Deteriorated asphalt pavement was observed in some areas in the vicinity of the building slabs.

- B29, Photography Laboratory. This building was located northeast of B5 and B17 (Figure 2-6).

- B65, Auxiliary Generator. This building housed a generator and was located next to and northeast of B29 (Figure 2-6).

- Suspected Tetraethyl Lead Disposal Area (Sludge Disposal Area). According to a preliminary assessment (Hart Crowser 2002), two 100,000 gallon ASTs were decommissioned in 1963 and the sludge from the bottom of the tanks was spread on the ground, burned, then buried south of the former ASTs. The former ASTs and the suspected sludge disposal area were located approximately 500 feet northeast of B65 (Figure 2-6).

The portion of the Industrial Complex Area south of Quillayute Road contained two former DoD wells; these wells are shown in Figure 2-6 and are designated as the 'NI well' [4] and 'ST well'[5] in this BLRA report. These wells together with the Airport Well in the Administration and Operations Area (Figure 2-4) were the main sources of water supply for the former NAAS Quillayute. Carbon tetrachloride has been detected at concentrations slightly above the maximum contaminant level (MCL) of 5 micrograms (µg) per liter (L) in water samples collected from the NI well during previous investigations (see Section 4 for more details on previous investigation results). The parcel containing the NI well is privately owned and the owner lives on-site in a residence located approximately 650 feet southeast of the NI well partially on the footprint of B33 (former Barracks, Figure 2-6). B30, B58, and B31 were located on this property. The NI well was being used to supply water to this residence until early 2011 when a new well was installed by the parcel owner (see well labeled 'NNW' in Figure 2-7 presented in Section 2.3.7). The ST well has never been sampled due to inaccessibility and it does not appear to be in use (Shannon and Wilson 2012).

In addition to the former DoD wells, the portion of the Industrial Complex Area south of Quillayute Road contained the following areas of potential concern (listed west to east, shown as red polygons in Figure 2-6):

[4] The NI well is referred to as the 'Nielsen well' and the 'Pumphouse No. 1' well in previous reports (Shannon and Wilson 2012).
[5] The ST well is referred to as the 'Stout well' in previous report (Shannon and Wilson 2012).

- B41, Boiler and Generator. This building was located next to Quillayute Road in the western portion of the Industrial Complex Area (Figure 2-6). Two 10,000 gallon USTs from the vicinity of this former building were reportedly closed in place according to a Tank Closure Report (Farallon Consulting 2005). During the ecological reconnaissance visit in March 2012, remnants of this building (consisting of brick walls) were observed. Fragments of coal on the ground surface next to the former building location was noted. According to Clallam County assessor records, the former location for B41 is in the northwest corner of the parcel that contains the B44 slab described below.

- B44, Dry Cleaner. This building was located approximately 240 feet south of Quillayute Road and B41 (Figure 2-6). Dry cleaning equipment was reportedly present in this dry cleaning facility (Shannon and Wilson 2012). Operations in this building were considered a potential source for carbon tetrachloride detected in the NI well because this chemical could have been used for dry cleaning (Shannon and Wilson 2012). B44 has been demolished; however the foundation slab remains and is currently occupied by a mobile home.

- E120, Fire Station. This building was located approximately 200 feet west of the NI well (Figure 2-6). Operations in this building were considered a potential source for carbon tetrachloride detected in the NI well because this chemical was reportedly a component of older model fire extinguishers that are typical of the era of the building usage (Shannon and Wilson 2012). The building has been demolished and the footprint is currently unoccupied. The building location is within the same parcel that contains the NI well and the residence formerly supplied by water from the NI well (B33 in Figure 2-6).

- B49, Auxiliary Generator. This building housed a generator and was located next to the NI well (Figure 2-6). The footprint of this building is currently occupied by an unpaved driveway.

- B6, Fire Station. This building is located approximately 350 feet northeast of the NI well (Figure 2-6). This former fire station was considered a potential source for carbon tetrachloride in groundwater from the NI well (Shannon and Wilson 2012). The building has been demolished however the foundation slab is still present and was observed to be surrounded by heavy vegetation during the ecological reconnaissance visit in March 2012. According to Clallam County assessor records, the former building is located in an unoccupied/undeveloped parcel that includes B4, B9, B119 and B119A (described below).

- B4, Public Works Shop. This building was located next to Quillayute Road approximately 500 feet northeast of B6 (Figure 2-6). During the ecological reconnaissance visit in March 2012, remnants of this building were observed to consist of concrete columns and wood beams. According to Clallam County assessor records, the former building is located on a privately owned parcel that contains B6, B9, B119 and B119A. During the March 2012 ecological reconnaissance visit, the parcel was unoccupied and covered with heavy vegetation.

- B9, Blacksmith. This building was located immediately south of B4 (Figure 2-6). The building has been demolished and only the slab remains as observed during the March 2012 ecological reconnaissance visit.

- B119 and B119A. These buildings were paint shops located immediately south of B4 and southwest of B9 (Figure 2-6). As noted previously, the parcel containing these buildings, B6,

B4 and B9 is unoccupied and covered by heavy vegetation during the March 2012 ecological reconnaissance visit.

Three former NAAS Quillayute buildings (B31, B33, and B40) are highlighted blue in Figure 2-6 because investigative soil borings and/or monitoring wells were drilled next to these former buildings during the RI (Shannon and Wilson 2012). Specifically, a monitoring well (MW-17) was installed next to the former location of B31, soil borings for soil sampling and soil gas sampling were drilled next to the former location of B33, and a monitoring well (MW-15) was installed next to the former location of B40. These monitoring well locations were chosen to determine if there were additional carbon tetrachloride detections between B44 and the NI well. The RI sampling activities and results are discussed in greater detail in Section 4.

2.3.5 Army Cantonment/HOMOJA Housing Area

The Army Cantonment/HOMOJA Housing Area was located in the northeast corner of the site (green area in Figure 2-3) and contained military housing structures. There were no areas of potential concern identified for this area. According to the Clallam County assessor records, the parcel containing this area is privately owned.

2.3.6 Runway Approach Zones

Access to areas south and north of Runway # 1 was controlled as runway approach zones when the former NAAS Quillayute was an active facility (Shannon and Wilson 2012). According to the Clallam County assessor records, the parcels comprising the south and north runway approach zones are owned by the City of Forks and the State of Washington, respectively. There were no areas of potential concern identified in the runway approach zones.

2.3.7 Summary of Areas of Potential Concern and RI Sampling Locations

In summary, areas of potential concern have been identified at the site based on previous historical research (Hart Crowser 2002, Shannon and Wilson 2007). These areas of potential concern consist of four borrow pits and a suspected liquid disposal area in the Administration and Operations Area (Figure 2-4), a radio and an associated generator building (B101 and B102, Figure 2-5) in the East Parcels Area, a suspected tetraethyl lead disposal area (sludge disposal area) and multiple former NAAS Quillayute building located in the western portion of the Industrial Complex Area (Figure 2-6). No areas of potential concern were identified in the Army Cantonment/HOMOJA Housing, the Industrial Complex Area-East, Runway Approach, and the West Parcel Areas. However, previous investigations have included the installation of monitoring wells and sampling of water supply wells located in the West Parcels area to determine whether groundwater has been impacted by the borrow pits in the Administration and Operations Area.

Figure 2-7 is an overview of monitoring and water supply wells that were sampled during previous investigations (URS 2004, URS 2007, Shannon and Wilson 2012). The figure shows the three former DoD wells (NI, ST and Airport Wells) as well as a number of domestic water supply wells within the West Parcel Area and the residential area south of Quillayute Road in the western portion of the Industrial Complex Area. Note that the ST well is shown on the map for reference; this well has never been sampled during previous investigations due to access problems.

There are a total of 15 monitoring wells present at the site (monitoring wells MW-1 through MW-3 and MW-6 through MW-17, Figure 2-7, Table 2-1). The groundwater data collected from these monitoring wells as well as the water supply wells are presented in Section 4 of this report and were used to determine exposure concentrations and quantify risks in the BHHRA (see Section 5).

With the exception of monitoring well MW-12, all the monitoring wells have depths ranging from 83 to 144 feet below ground surface (bgs) and were designed to probe the same aquifer unit tapped by the surrounding water supply wells. Monitoring well MW-12 has a total depth of 17 feet because it is located in an area that is approximately 90 feet lower in elevation (see description of topography in Section 3.2). Monitoring wells MW-1, MW-2, MW-3, MW-12, MW-14, MW-15, MW-16 and MW-17 (Figure 2-7) are located within the residential portion of the Industrial Complex Area located south of Quillayute Road. Monitoring wells MW-11 and MW-13 are in the western portion of the Industrial Complex Area but they are located within the fenced area of the Quillayute Airport. These wells were installed primarily to evaluate the source and fate/transport of carbon tetrachloride first measured in the NI well by the City of Forks in 2000 (Shannon and Wilson 2012). Monitoring well MW-9 is located within Quillayute Airport and was installed adjacent to the suspected liquid disposal area on the southwestern end of Runway #2 (Figure 2-4). Monitoring wells MW-6, MW-7, MW-8 and MW-10 (Figure 2-7) encircle the borrow pits in the Administration and Operations Area (Figure 2-4).

In addition to monitoring and well sampling locations, Figure 2-7 shows the locations where soil samples were collected from the areas of potential concern during the RI (Shannon and Wilson 2012). The soil sample analysis results are presented in Section 4 following a description of site physical characteristics in Section 3. The soil analyses were used to determine exposure concentrations and quantify risks from exposure to soil to human and ecological receptors as described in Sections 5 and 6 respectively.

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3. PHYSICAL SETTING

3.1 CLIMATE

The former NAAS Quillayute is located in the West Olympic-Coastal area of Washington where climate is heavily influenced by the Pacific Ocean that bounds the area to the west and the Olympic Mountains to the east. Annual precipitation ranges from 70 to 100 inches over the Coastal Plains to 150 inches or more along the windward slopes of the Olympic Mountains (WRCC 2012a). At the NOAA weather station located within the Quillayute Airport (WRCC 2012b), the average annual precipitation for the period from 1981 to 2010 is 99.54 inches with most of the precipitation occurring in the winter-spring months (Figure 3-1, part a). Average temperatures range from a high of 60 degrees Fahrenheit (°F) in July-August to a low of 40°F in December-January (Figure 3-1b).

3.2 TOPOGRAPHY AND SURFACE HYDROLOGY

The former NAAS Quillayute, labeled as the 'Quillayute State Airport' in the U.S. Geological Survey (USGS) Quillayute Prairie topographic map (USGS 1982) shown in Figure 3-2a, is located within the Quillayute Prairie, a broad plain between the Dickey River and the Sol Duc River (also known as the Soleduck River). There is very little topographic relief within the main area of the site, especially within the western portion of the Industrial Complex Area in the vicinity of the RI soil sampling locations that are almost all clustered at the southwest corner of the site within 500 feet of Quillayute Road (Figure 3-2b). Surface elevations at the RI soil sampling locations range from approximately 175 to 185 feet above mean sea level (amsl) (Shannon and Wilson 2012).

A prominent topographic feature in the vicinity of the site is a terrace immediately south of Quillayute Road (Figure 3-2b, historical oblique aerial photograph in Figure 3-3). Ground surface elevations drop from approximately 180 feet at monitoring well MW-03 to approximately 90 feet in the vicinity of monitoring well MW-12 over a distance of 200 feet based on top of casing elevation surveys for these monitoring wells (see Figure 3-2b for well locations). At the bottom of the terrace, the land surface stays relatively flat over the two mile distance to Sol Duc River (Figure 3-2a). Topography on the northern section of the site towards Dickey River is more rugged and incised by perennial tributaries. These tributaries are mapped in the National Hydrography Dataset (NHD) maintained by the USGS. Other NHD-mapped features in the vicinity of the site include Dickey River, Coal Creek, Colby Creek and Franklin Creek all located north of the site. Sol Duc River is located approximately 1.5 miles southeast of the site. The confluence of the Sol Duc River with the Bogachiel River approximately two miles south of the site forms the Quillayute River which flows west approximately four miles before discharging into the Pacific Ocean.

The site is situated within the Hoh-Quillayute watershed (HUC 17100101), which occupies the low-lying plain between the Olympic Mountains and the Pacific Ocean. The sub-watershed map in Figure 3-4 shows that a majority of the RI soil sampling locations are near the boundaries between three sub-watersheds: the Quillayute River, Gunderson Creek-Sol Duc River and Coal Creek-Dickey River. Thus, surface runoff from the vicinity of the RI soil sampling locations can flow into any of the receiving waters for these sub-watersheds. However, as noted earlier, the topography near the RI soil sampling locations is relatively flat (Figure 3-2b) such that most of the precipitation likely infiltrates into the subsurface. There are no surface features on the site to indicate movement of surface water into adjacent streams.

Site drainage features within the western portion of the Industrial Complex Area observed during the ecological reconnaissance in March 2012 are shown in Figure 3-5a. These drainage features include upland roadside ditches, a storm water diversion channel fed by a 36-inch diameter culvert [Figure 3-5b,

Photograph (a)], and a vegetated drainage swale area which may be the source for the water in the man-made ponds [Figure 3-5b, Photograph (b)]. During the ecological reconnaissance visit in March 2012, the storm water diversion channel did not contain any flowing water. None of the site drainage features were observed to go off-site or connect to the streams.

3.3 GEOLOGY AND HYDROGEOLOGY

A map of regional surface geology shows the site underlain by outwash terraces, consisting mainly of stratified sand and gravel with a mantle of loess [Figure 3-6, adapted from Othberg and Korzendorfer (1977)]. This regional description of surficial geology is consistent with the boring logs for the 25-foot deep boreholes drilled during the RI (Appendix A of Shannon and Wilson 2012). A majority of the boring logs, which were mostly collected in the western portion of the Industrial Complex Area, show a 10 to 15-foot layer of clay to clayey silt overlying a layer of sand or gravel. The silt and gravel layers were described in the RI boring logs as "weathered till". The deeper boring logs installed for monitoring wells MW-14, MW-15, MW-16 and MW-17 (depths of 120 to 130 feet, Appendix A of Shannon and Wilson 2012) show lithologies ranging from clayey silt to silty gravel. The presence of natural organic matter within the top 5 feet of the soil was noted in most of the boring logs. A description of every soil sample collected in April, May, and November 2009 are included in Tables 3 and 4 of Appendix A in the RI Report (Shannon and Wilson 2012). A majority of the surface soil samples were described as containing high organic content.

Water levels in the nearby monitoring wells (with the exception of MW-12) ranged from approximately 76 to 106 feet bgs in measurements conducted between 2009 and 2011 (Shannon and Wilson 2012). Because monitoring well MW-12 is located in an area where elevations are lower by 90 feet, the groundwater level in this well has been measured at approximately 6 to 7 feet bgs. Between April 2009 and April 2010, water levels in selected monitoring wells were logged continuously during a hydrogeological investigation conducted as part of the RI (Shannon and Wilson 2012; hydrographs reproduced in Figure 3-7a). The monitoring wells selected for continuous monitoring included monitoring wells MW-6, MW-7 and MW-10 located north of Runway #2 and MW-13, MW-2, and MW-3 located south of Runway #2 (see well map in Figure 3-7b). Groundwater elevations in these wells (Figure 3-7a) clearly show the monitoring wells to be responding similarly to seasonal changes and precipitation events. Furthermore, response to precipitation events is relatively rapid as shown by the steep increases in water elevations in late October/early November 2009 and mid-December 2009 in response to the highest amounts of weekly precipitation. Water levels are observed to be higher in the monitoring wells area north of Runway #2 by at least 20 feet (Figure 3-7a). Shannon and Wilson (2012) inferred groundwater flow directions using data collected in November 2009 and January 2010 for monitoring wells north of Runway #2 (Figure 3-7c). The inferred groundwater flow direction during both days is to the west, with a higher southwestern component in November 2009. This flow direction matches the presumed southwestern direction of regional groundwater flow towards Quillayute River. The westerly direction of groundwater flow is illustrated in graph (a) of Figure 3-7d, where groundwater elevations in the monitoring wells north of Runway #2 are plotted against the easting coordinates of these wells.

The groundwater flow direction south of Runway #2 in the western portion of the Industrial Complex Area was inferred by Shannon and Wilson (2012) to be directed east-northeast (Figure 3-7b) based on water level measurements collected in December 2011. There appears to be a relatively steep decline in water levels between the group of wells consisting of monitoring wells MW-16, MW-14 and MW-15 and the monitoring wells east of this group, as shown graph (b) of Figure 3-7d where groundwater elevations are plotted against the easting coordinates of the monitoring wells. For example, on December 13, 2011, water levels in monitoring wells MW-16, MW-14, and MW-15 were at elevations ranging from 96.5 to 97 feet amsl, but the water level was at 82 feet amsl in monitoring well MW-17. Shannon and Wilson (2012) note the presence of a small stream near monitoring wells MW-14 and MW-

15 that may be causing localized mounding in this area. The boring logs for these wells (in Appendix A of Shannon and Wilson 2012) were inspected for any lithologic differences that may account at least partially for the difference in water elevation. The only difference that can be observed was the presence of a "clayey silt/silty clay" layer in monitoring wells MW-14, MW-15, and MW-16 at the bottom of these wells where the wells were screened; this layer was not present in MW-17. In addition to changes in geological characteristics, the proximity of the terrace edge to these monitoring wells may be influencing groundwater flow at the site especially south of Quillayute Road where monitoring wells MW-14 through MW-17 and MW-1 through MW-3 are located.

Perched groundwater was observed during the installation of monitoring wells MW-2 (16 and 110 feet bgs), MW-3 (83 feet bgs) and MW-11(from 14 to 22 feet bgs) in previous investigations; however, during the RI perched groundwater was only observed in one borehole drilled in the vicinity of B20 (the hangar building). The presence and lateral extent of perched groundwater at the site may be highly variable (Shannon and Wilson 2012).

Water supply wells present within the site (see locations in Figure 2-7) were sampled during the RI and a previous investigation (URS 2007). These water supply wells reportedly derive water from sand and gravel lenses typically between 5 and 20 feet thick within thick glacial till deposits; water well records show these wells drawing water from depths between 90 to 140 feet bgs (Shannon and Wilson 2012). Thus, the on-site monitoring wells which have depths ranging from 83.1 to 144 feet bgs [depths in Table 2 Appendix A of Shannon and Wilson (2012)] are probing the same aquifer being tapped by the water supply wells.

3.4 CURRENT AND FUTURE LAND USE

As noted in Section 2.3, where the current status of the former NAAS Quillayute areas was discussed, the Administration and Operations Area are mostly within the Quillayute Airport and the parcels that comprise this area are owned by the City of Forks and the State of Washington. The western portion of the Industrial Complex Area portion north of Quillayute Road is within the fenced in area of the Quillayute Airport, while the portion south of Quillayute Road is now comprised of privately owned parcels. Some of which are undeveloped while others are occupied by residential structures. The West Parcels Area is comprised of residential properties, while the eastern portion of the Industrial Complex Area, and the East Parcels areas are composed of a mix of residential and undeveloped land.

The observed land use of the former NAAS Quillayute areas is consistent with the Clallam County land use zones (Clallam County 2012a) shown in Figure 3-8. The Administration and Operations Areas, the Industrial Complex Area, and the Runway Approach zones are all designated as 'Western Region Rural Center' zone. The Western Region Rural Center zone is a land use classification intended for areas with a mixture of land uses, including commercial, residential and industrial (Clallam County 2012b). The maximum residential density for this land use zone is one dwelling unit per 0.5 acres.

The West Parcels Area, East Parcels Area and the Army Cantonment Area are all within the 'Western Region Rural Low zone'. The purpose of the Western Region Rural Low zone is to provide home sites in rural forestry areas with limited encroachment of commercial and industrial activities (Clallam County 2012b). The maximum residential density for this land use zone is one dwelling unit per 4.8 acres.

Figure 3-8 shows that the site is surrounded by land designated as 'Commercial Forest'. The purpose of the Commercial Forest zone is to protect large forest land parcels from encroachment of uses which threaten effective forest management practices. Single-unit dwellings are allowed however the maximum residential density is one dwelling unit per eighty acres (Clallam County 2012b). Based on Clallam County zoning laws, the area surrounding the site is likely to stay sparsely populated in the near future.

3.5 ECOLOGY AND ENVIRONMENTAL SETTING

An ecological site assessment of the site was conducted to provide the ecological data required for the BERA. The ecological site assessment consisted of a literature review to identify documented environmental resources at the site and an ecological reconnaissance visit on March 19-20, 2012. The entire former NAAS Quillayute site was investigated during the site visit to generally document terrestrial habitat types; however, since the areas of potential concern and RI soil samples were mostly located in the western portion of the Industrial Complex Area (Figure 2-6 and 2-7) the site visit focused primarily on this area. Results of the literature review and site setting as observed during the ecological reconnaissance site visit are discussed below. Data gathered from the ecological site assessment are used in the BERA which is presented in Section 6.

3.5.1 Literature Review

Prior to conducting the ecological reconnaissance visit, a desktop review of publically available resources was performed to identify any known wetlands, streams and other significant ecological resources. These resources included a review of the USGS topographic map for the area (USGS 1982, shown in Figures 3-2a and 3-2b), USGS National Hydrography Dataset (USGS 2012), U.S. Fish and Wildlife Service (USFWS) National Wetlands Inventory (NWI) maps (USFWS 2012a, shown in Figure 3-9) and USFWS federally protected listed species (USFWS 2012b). A detailed description of document reviews and the ecological resources identified are provided below. Features identified within these resources may or may not be current and are considered supplemental to field efforts. Any resources not identified during the ecological reconnaissance site visit are noted below.

3.5.1.1 USGS Topographic Map

The USGS Quillayute Prairie topographic map (Figures 3-2a and 3-2b) does not depict any streams in the western portion of the Industrial Complex Area. The topographic map shows the Dickey River at the boundary between the site and the northern Runway Approach Area and approximately 1.2 miles north of the western portion of the Industrial Complex Area (Figure 3-2a). The location of Dickey River was verified during the ecological reconnaissance visit. The Sol Duc River is depicted approximately 1 to 1.5 miles southeast of the western portion of the Industrial Complex Area and is outside of the site.

3.5.1.2 USGS National Hydrography Dataset

The USGS NHD was reviewed for data on surface water features within the area of the site (USGS 2012). There are no NHD-mapped streams within the western portion of the Industrial Complex Area. However, there are several unnamed NHD-mapped tributaries within the West Parcels, East Parcels and Administration and Operations Area; all the tributaries drain into Dickey River. The streams depicted within the northeast corner of the West Parcel Area and the northern portion of the Administration and Operations Area were searched for during the ecological reconnaissance visit. A ravine is located in the northeast corner of the West Parcel Area where the stream is depicted, although it appears to begin off-site outside of the West Parcels Area and did not appear to exhibit any stream characteristics. The stream depicted in the northern portion of the Administrations and Operations Area was not identified during the ecological reconnaissance visit. The other areas where streams are depicted were inaccessible due to thick vegetation or prohibited access.

3.5.1.3 USFWS NWI Map

The NWI map (Figure 3-9) (USFWS 2012a) does not depict any wetland systems within the western portion of the Industrial Complex Area. Five wetland systems are depicted on the site. The NWI map shows four wetlands (two PEM1A, one PSS1C, and one PFO4C) within the Administration and

Operations Area. The PEM1A wetland system is defined as palustrine emergent, persistent, and temporary flooded. The PSS1C wetland system is defined as palustrine scrub-shrub, broad-leaved deciduous, and seasonally flooded. The PFO4C wetland is defined as palustrine forested, needle-leaved evergreen, and seasonally flooded. One PFO4A wetland is depicted in the northern portion of the East Parcels Area; this wetland type is defined as palustrine forested, needle-leaved evergreen, and temporarily flooded. Wetlands depicted on NWI maps are based on aerial photograph analysis and were not field verified.

3.5.1.4 USFWS/Washington Fish and Wildlife Office

The USFWS/Washington Department Fish and Wildlife database was searched for known federally protected species within Clallam County, Washington (USFWS 2012b). Table 3-1 shows the federally protected species and their habitats identified by the USFWS/Washington Fish and Wildlife Office as being present in Clallam County. Only federally listed species with the potential to exist within the project are discussed in this section. Potential impacts to these species from residual contamination at the site are discussed in detail in the BERA (Section 6).

Northern spotted owl *(Strix occidentalis caurina)* – Habitat for this federal threatened species consists of dense forest and deep wooded canyons, generally in mature stands or old growth and requires cool summer roost. The northern spotted owl nests on broken tree tops, cliff edges, in natural tree cavity or in trees on stick platforms, in abandoned nest of hawks or mammals and in caves (NatureServe 2011). Portions of woodland habitat exist within the Industrial Complex Area, but no dense mature forest exists; therefore, it is very unlikely this species would utilize the study area.

Bull trout *(Salvelinus confluentus)* – Habitat for this federal threatened species consists of bottom of deep pools in cold rivers and large tributary streams and large coldwater lakes and reservoirs (NatureServe 2011). Habitat does not exist within the Industrial Complex Area and therefore this species does not exist within the study area.

Marbled murrelet *(Brachyramphus marmoratus)* – Habitat for this federal threatened species consists primarily of ocean, but come inland to nest. Nesting habitat consists of old-growth forests with large trees and multiple canopy layers and moderate to high canopy closure (NatureServe 2011). Habitat does not exist within the Industrial Complex Area; therefore, it is very unlikely this species would utilize the study area.

Taylor's checkerspot *(Euphydryas editha taylori)* – Habitat for this federal candidate consists of dry prairies or prairie-like native grassland in Puget Sound, Willamette portions of range, maritime meadows within Garry oak ecosystems in Canada (NatureServe 2011). No prairie or prairie-like habitat exists within the Industrial Complex Area; therefore, it is very unlikely this species would utilize the study area.

Olympic pocket gopher *(Thomomys mazama ssp. Melanops)* – Habitat for this federal candidate species consists of glacial outwash prairies in western Washington (NatureServe 2011). No prairie or prairie-like habitat exists within the Industrial Complex Area; therefore, it is very unlikely this species would utilize the study area.

3.5.2 Site Setting

The purpose of the ecological reconnaissance was to characterize layout, topography and site drainage, document any signs of contamination, characterize existing aquatic, terrestrial and wetland habitat types, identify any potential sensitive environments and/or threatened and endangered species and

record any observations or signs of wildlife within the western portion of the Industrial Complex Area. Terrestrial habitat types within the remainder of the site were noted. Accessible areas were assessed by walking the site. Areas where access was limited were reviewed via a "windshield" survey. These inaccessible areas included habitat south of Quillayute Road where steep topographical drops exist and residential/commercial areas within and adjacent to the western portion of the Industrial Complex Area. where access was prohibited.

Data gathered during the ecological assessment were compiled and the observed terrestrial habitats are qualitatively described in the following subsections following a description of the ecological setting. The description of the terrestrial habitats includes details regarding dominant and representative species, current land use, and any other attributes observed. Based on the biodiversity of species observed, a qualitative rating (low, moderately-low, moderate, moderately-high, high) was assigned to each terrestrial habitat type and represents its ecological value. Figure 3-10 depicts terrestrial habitat types, while Figure 3-11 depicts plant biodiversity ratings of each terrestrial habitat type. Photographs of terrestrial habitat types area presented in Appendix A.

3.5.2.1 Ecological Conditions

The site is located on the Quillayute prairie in the coastal uplands ecoregion of western Washington (USEPA 2011b). The coastal uplands ecoregion extends to an elevation of approximately 500 feet. The climate of this ecoregion is marine-influenced with an extended wintery rainy season, enough fog during the summer dry season to reduce vegetal moisture stress, and a lack of seasonal temperature extremes. This ecoregion roughly corresponds with the historic distribution of Sitka spruce. The extent of the original forest has been greatly reduced due to logging (USEPA 2011b). Natural vegetation in undisturbed areas of this ecoregion include Sitka spruce, western hemlock, or western red cedar. Land use and land cover in this ecoregion consists primarily of Douglas-fir/western hemlock/Sitka spruce/western red cedar forests, rural residential development and recreation. More natural and diverse habitats are located within the vicinity of the site. However, habitat within the western portion of the Industrial Complex Area has been disturbed due to clearing activities over the years, thus reducing diversity of plant and animal species. Furthermore, although the western portion of the Industrial Complex Area is identified as located within the Quillayute Prairie, prairie habitat no longer exists on-site. As mentioned previously, the site is situated within the Hoh-Quillayute watershed (HUC 17100101), which occupies the low-lying plain between the Olympic Mountains and the Pacific Ocean. Subwatersheds located within the vicinity of the site are Coal Creek-Dickey River, Gunderson Creek-Sol Duc River and Quillayute River (Figure 3-4). The Hoh-Quillayute watershed region receives extensive rainfall (the average precipitation measured at the NOAA weather station is 99.54 inches per year, WRCC 2012b), which supports nearby perennial rivers and wetlands.

The closest major natural surface water body to the site is the Dickey River, located approximately 1/4 to 1/2 mile north of the end of Runway #1 and approximately 1.2 miles north of the western portion of the Industrial Complex Area. (Figure 3-2a). The Sol Duc River is located approximately 1 to 1.5 miles south of the site and the western portion of the Industrial Complex Area (Figure 3-2a). Both rivers eventually join the Quillayute River which discharges to the Pacific Ocean approximately 3 miles downstream of the site.

Dickey River is located along the boundary between the Runway Approach Area and the northern boundary of the site. However, it is not located near the western portion of the Industrial Complex Area. No surface water runoff or drainages that connect to Dickey River were identified during the ecological reconnaissance. A ravine was identified adjacent to the north of the West Parcels Area; however, this ravine did not exhibit stream characteristics. Furthermore, the topography in this portion of the site is undulating (Figure 3-2b) and it does not appear Dickey River directly receives runoff from the site.

Sol Duc River is located approximately 1 to 1.5 miles southeast of the western portion of the Industrial Complex Area. Connections to this surface water were searched for within the western portion of the Industrial Complex Area and surrounding area during the ecological reconnaissance. Prior to conducting the site reconnaissance, secondary resource maps were reviewed to determine if any surface water connections may exist. The Quillayute Prairie quadrangle of the USGS topographic map and the USGS NHD (Figures 3-2a and 3-4a) do not identify any surface waters within the western portion of the Industrial Complex Area or surrounding area to the south. A linear ditch was identified in the Administrations and Operations Area and is connected via culverts to roadside ditches along Quillayute Road. However, no hydrologic connections were observed that would convey drainage offsite towards the Sol Duc River. Furthermore, the ecological reconnaissance was conducted during the rainy season and roadside ditches along Quillayute Road were observed dry indicating there is most likely very little site runoff. Precipitation most likely percolates through the subsurface and enters groundwater.

As previously mentioned, water levels in the on-site monitoring wells (with the exception of monitoring well MW-12) ranged from approximately 76 and 106 feet bgs in measurements conducted between 2009 and 2011 (see Section 3.3). Within the study area, the primary unconsolidated strata consist of glacial deposits. Groundwater flow in the West Parcels Area north of Runway #2 was inferred to be directed west-southwest while groundwater flow south of Runway #2 in the vicinity of the western portion of the Industrial Complex Area was inferred to be directed east (Figure 3-7b). Water levels in selected monitoring wells were logged continuously from April 2009 through April 2010 during a hydrogeological investigation conducted as part of the RI (Shannon and Wilson 2012). The monitoring data showed water levels in wells both in the West Parcels and western portion of the Industrial Complex Area responded relatively rapidly to precipitation events (Shannon and Wilson 2012, data reproduced in Figure 3-7a).

Many common wildlife species are known to inhabit forested and undeveloped habitats in the vicinity of the site. Animal species observed during the ecological reconnaissance are documented in Table 3-2. Terrestrial habitat types located within the western portion of the Industrial Complex Area were identified during the ecological reconnaissance and are discussed in detail below. Plant species observed during the site visit are documented in Table 3-3 by terrestrial habitat type. Terrestrial habitat types identified by windshield survey within the remainder of the site primarily consist of deciduous/coniferous forest, scrub-shrub, old field, new field and urban (residential/commercial) with some herbaceous wetland habitat. These habitat types are not discussed further since no chemicals of potential ecological concern (CPECs) were identified in these areas.

3.5.2.2 Terrestrial Habitat Classifications

Terrestrial habitat types identified within the western portion of the Industrial Complex Area are discussed in detail below and are identified on Figure 3-10. The biodiversity of each terrestrial habitat type is rated as either low, moderately low, moderate, moderately high and high and represents a qualitative rating of ecological value. Biodiversity classification is based on the number of native species present as well as the presence of Eurasian and weedy species. The biodiversity of terrestrial habitat types are identified on Figure 3-11.

Urban (Maintained/Residential/Commercial)

The portion of the western portion of the Industrial Complex Area located within the Quillayute Airport along the north side of Quillayute Road is surrounded by a maintained tree lawn/Eurasian meadow community (Figure 3-10). The area appears to consist of occasionally mowed grassland. Presently, this occasionally maintained Eurasian meadow is dominated by *Festuca arundinacea, Poa pratensis, Elytrigia repens, Dactylus glomerata* and *Daucus carota.* Around several of the buildings within the airport are large native trees that include *Alnus rubra, Pinus contorta* and *Picea sitchensis.*

Several tolerant introduced species have grown amongst the buildings that include *Plantago lanceolata, Trifolium repens, Rubus laciniatus* and *Hedera helix* ssp. *hibernica.* Urban maintained development prevents this area from developing naturally into a more native and biodiverse community. Furthermore, the number of non-native Eurasian species present reduces the amount of native species present and reduces the biodiversity in these areas. Therefore, this habitat is characterized as low biodiversity (Figure 3-11).

Residential areas are located along the south side of Quillayute Road (Figure 3-10). These properties contain mowed maintained lawn and clusters of trees with varying tree densities. Due to property owner modifications, the scrub layer is often missing. Overstory trees observed in these areas were *Picea sitchensis, Tsuga heterophylla, Pseudotsuga mentziesii, Thuja plicata* and *Pinus monticola*. Lawn areas were typically dominated by bluegrasses like *Poa annua,* and *Poa pratensis* with *Taraxacum officinale*, and *Trifolium repens*. Urban maintained development prevents these areas from developing naturally into a more native and biodiverse community. Furthermore, the presence of non-native Eurasian species and weedy species reduces the amount of native species present and reduces the biodiversity in these areas. Therefore, this habitat is characterized as low biodiversity (Figure 3-11).

Forested (Mixed Deciduous/Coniferous)

The site is located in an area that was historically the *Picea sitchensis* zone of the western coniferous forest, a long narrow zone that stretches from Oregon to Alaska. This habitat type consists of mature coniferous forests with lush understory of herbs, deciduous shrubs, and terrestrial and epiphytic mosses, ferns and lichens. This habitat type exists outside the site and would have been the dominant community within the site. However, logging and urban development have changed the landscape.

Forested terrestrial habitat is located in patches throughout the western portion of the Industrial Complex Area (Figure 3-10) and consists of a mixture of younger, secondary growth, *Picea sitchensis* forest and deciduous/coniferous forest mixture. Deciduous/coniferous forest communities were observed only along the south side of Quillayute Road to the east and around B4 and B9 (see Figure 2-6 for former building locations). Dominant deciduous species consisted of *Alnus rubra* and *Acer macrophyllum* with scattered coniferous tree species *Picea sitchensis* and *Tsuga heterophylla*. The understory was a mix of sparse, low deciduous shrubs and herbaceous species. Characteristic species included *Oemleria cerasiformis, Ribes sanguineum, Anthroxanthum odoratum, Rubus spectabilis* and *Polystichum munitum*. The remainder of the forested habitat identified within the western portion of the Industrial Complex Area consisted of coniferous forest communities. Dominant species within the coniferous forest community consisted of *Picea sitchensis, Tsuga heterophylla, Thuja plicata and Abies amabilis.* Commonly observed understory species in this community included *Vaccinium parvifolium, Gaultheria shallon, Viola sempervirens, Oxalis oregona, Blechnum spicant, Polystichum munitum* and *Vaccinium ovatum*. Based on the presence of a greater number of native species and an increased diversity of overstory and understory species, the forested habitat in the western portion of the Industrial Complex Area is characterized as moderately-high biodiversity (Figure 3-11).

Cleared

Cleared areas identified in the southeast and eastern portions of the western portion of the Industrial Complex Area appear to have been recently cleared based on review of aerial photography (Figure 3-10). These areas have most likely been cleared for logging. Due to the lack of vegetation in these areas, biodiversity is rated as low (Figure 3-11).

Old field

The old field habitat type was identified within the western portion of the Industrial Complex Area along the north side of Quillayute Road (Figure 3-10). These old field areas are in a successional state from a once maintained Eurasian meadow community. Therefore, these areas contain many of the same Eurasian grass species identified in the Eurasian meadow community documented in the Urban habitat. The shrub community is dominated by *Rubus laciniatus, Rubus armeniacus, Spiraea douglasii* var. *menziesii* along with young *Alnus rubra* and *Acer macrophyllum.* The two blackberry species form large, five to seven-foot high, dense, nearly impassible patches. Other species growing in less shrubby, blackberry-dominated areas included *Cytisus scoparius, Polystichum munitum, Rosa nootkana, Pteridium aquilinum* var. *pubescens* and the Eurasian grasses. *Cytisus scoparius* and *Rubus armeniacus* are not only Eurasian species but are also listed invasive species for the State of Washington (WSRCO 2012). These invasive species are known to crowd out native species and negatively impact wildlife habitat and diversity (WSRCO 2012). The presence of non-native Eurasian species and weedy species reduces the amount of native species present and reduces the biodiversity in these areas. Therefore, this habitat is characterized as low biodiversity (Figure 3-11).

Scrub-shrub

The scrub-shrub habitat types were identified within the western portion of the Industrial Complex Area along the north and south sides of Quillayute Road near the airport and residential areas (Figure 3-10). This is an extremely variable community type due to patchiness. As opposed to the old field community, this does not have the strong Eurasian grass influence and exhibits lower density of *Rubus* species. These are transitional communities typically named after their dominate species. Typical dominants include *Gaultheria shallon, Polystichum munitum* and *Vaccinium parvifolium*. *Cytisus scoparius*, a state listed invasive species, also exists and is a highly aggressive species that will often take over this community. Small trees of *Malus* and *Alnus rubra* were often observed in these areas. Herbaceous species found within these areas are *Fragaria vesca* var. *crinita, Rubus spectabilis, Blechnum spicant* and *Viola sempervirens*. A lower density of Eurasian species and *Rubus,* and increased native species exist. However, due to the presence of *Cytisus scoparius*, a highly invasive species, this terrestrial habitat is characterized as moderately-low biodiversity (Figure 3-11).

Man-made Ponds and Wetland Fringe

Several small wetland areas were observed in the southern portion of the western portion of the Industrial Complex Area below the terrace edge on the south side of Quillayute Road (Figure 3-10; photographs in Figure 3-5b and Appendix A). These wetlands surround man-made ponds and hydrology appears to be a hillside vegetated drainage swale. These areas were either small patches of *Carex* species and *Juncus effusus* that were found in seasonal wetland depressions or small forested vegetated drainage swale -driven systems. These vegetated drainage swale -driven communities were typified by *Picea sitchensis* and *Populus balsamifera* ssp. *trichocarpa* with an herbaceous understory dominated by *Lysichiton americanus*. The man-made ponds are characterized as low biodiversity and the wetland habitat is characterized as moderately-low biodiversity.

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4. SUMMARY OF PREVIOUS INVESTIGATIONS

4.1 PREVIOUS INVESTIGATIONS PRIOR TO THE REMEDIAL INVESTIGATION

Several investigations have been conducted at the site. Brief summaries of the investigations prior to the RI are summarized below, while the sampling approach and results of the RI are presented in Section 4.2 and 4.3. Note that the BLRA is based on the data collected during the RI supplemented by groundwater data collected during the 2006 groundwater investigation described below.

4.1.1 Sampling Activities from 1992 to 2002

In 1992, USACE conducted a site inspection to determine if potential hazardous wastes existed at the site. The results of this site inspection indicated that no such potential existed and no further investigation was warranted (USACE 1992).

In 1999, WDOE conducted an investigation and determined that soil contamination from polynuclear aromatic hydrocarbons (PAHs) was present (WDOE 1999).

In May 2000, the City of Forks collected a water sample from a tap that was supplied by a former DoD well (the NI well, well location is shown in Figure 2-6 and Figure 2-7). Carbon tetrachloride was detected in this sample at a concentration of 5.4 µg/L. Coliform bacteria were present in the initial sample, but not detected in a subsequent sample (Hart Crowser 2002).

In December 2000, a preliminary site investigation was conducted by USACE to follow-up on the 1999 WDOE study (Hart and Crower 2001). PAHs in surface soil samples exceeded screening criteria. Groundwater samples from former DoD wells were collected (the NI well and the Airport well, see Figure 2-7 for well locations). Carbon tetrachloride, chloroform and bromodichloromethane were detected at concentrations of 3.6 µg/L, 13 µg/L, and 0.38 µg/L, respectively, in the water sample from the NI well, but there were no detections in the Airport well.

In 2002, a preliminary assessment was conducted by USACE to evaluate the potential for release of hazardous substances as a result of military operations at the former NAAS Quillayute (Hart Crowser 2002). The assessment consisted of interviews, literature and agency record searches, and a site reconnaissance. The preliminary assessment report recommended additional investigations of the NI well, the fuel tank sludge burning area, a suspected liquid disposal area, and borrow pit sites [which were investigated during the RI by Shannon and Wilson (2012)].

4.1.2 Groundwater Site Investigations

In 2004, a limited site investigation was conducted by URS to evaluate water quality in the former DoD wells (the NI well, the Airport well, and the ST well; see Figure 2-7 for well locations). Water samples were collected from the Airport well and the NI well however the ST well was inactive and inaccessible. Carbon tetrachloride was detected in the NI well but was not detected in the Airport Well. Based on these results, URS installed three monitoring wells (MW-1, MW-2 and MW-3) at locations surrounding the NI well (see Figure 2-7 for well locations). Carbon tetrachloride was detected in the NI well, MW-1, MW-2 and MW-3 at concentrations ranging from 0.8 to 5.4 µg/L (URS 2005).

In 2006, URS conducted an expanded groundwater investigation that included the installation of eight additional monitoring wells (MW-6 through MW-13) as well as sampling of water supply wells located within the site. The analytical data from this groundwater investigation were included in Appendix F of the RI report (Shannon and Wilson 2012). Four monitoring wells (MW-6, MW-7, MW-8

and MW-10) were installed at locations surrounding the borrow pits (see Figure 2-7 for well locations). MW-9 was installed in the vicinity of the suspected liquid disposal area. Monitoring well MW-11 was installed north of the NI well at a location within the airport and monitoring well MW-13 was installed within the airport northeast of monitoring well MW-1. Monitoring well MW-12 was installed south of MW-3 (see Figure 2-7 for well locations). The water supply wells sampled during this study were the NI well, the Airport well, water supply wells in the western portion of the Industrial Complex Area (P-12A/12B and P-13, see Figure 2-7 for well locations) and water supply wells in the West Parcels Area (B14, B21, water supply well, see Figure 2-7 for well locations). An additional well located in the area was reportedly sampled but the location for this well was not found in the RI report (Shannon and Wilson 2012) and the original report for this investigation (URS 2007) was not available for review. The groundwater samples were analyzed for volatile organic compounds (VOCs), semi-volatile organic compounds (SVOCs), PAHs, explosives and total Resource Conservation and Recovery Act (RCRA) metals. The primary results of this investigation are as follows:

- Carbon tetrachloride was detected in the NI well and three monitoring wells (MW-1, MW-2, and MW-3) at concentrations ranging from 1 to 3.6 µg/L; these concentrations are above the current MTCA Method B criterion for this chemical (0.63 µg/L), but are below the USEPA MCL (5 µg/L). Carbon tetrachloride was not detected in any of the other monitoring wells or water supply wells sampled during this study.
- The only other VOC detected in the groundwater samples was methylene chloride and it was only detected in monitoring well MW-8 (located north of Runway #2, Figure 2-7). The detected concentration of methylene chloride (0.3 µg/L) is below the current MTCA Method B criterion for this chemical (5.8 µg/L) and below the USEPA MCL (5 µg/L).
- Bis(2-ethylhexyl)phthalate was detected in monitoring wells MW-8, MW-10, and the water supply well at concentrations of 36, 1.2 and 1.2 µg/L respectively. MW-8 and MW-10 are located north of Runway #2 and next to Runway #1 (Figure 2-7). Based on water level measurements performed during the RI, MW-8 is upgradient, while MW-10 is downgradient of the borrow pits (Figure 3-7c). The exact location for the water supply well was not specified however this well is described as being located in the West Parcels Area (Shannon and Wilson 2012). The concentration measured in the water sample from MW-8 (36 µg/L) exceeds the MTCA Method B criterion (6.3 µg/L) and MCL (6 µg/L) for this chemical. Bis(2-ethylhexyl)phthalate was not detected in any of the other monitoring wells and in any of the water supply wells. No other SVOCs were detected in the groundwater samples collected during the 2006 investigation.
- PAHs were detected in the Airport well at concentrations well below MTCA Method B criteria. Acenaphthene, fluorene and phenanthrene were detected at concentrations of 0.15, 0.10 and 0.10 µg/L, respectively. These concentrations are significantly lower than the MTCA Method B criteria of 960 µg/L for acenaphthene, and 640 µg/L for both fluorene and phenanthrene. There are no MCLs for these chemicals. There were no other PAHs detected in the Airport well or in any of the other water supply or monitoring wells sampled during the 2006 investigation.
- The chemical 1,3-dinitrobenezene was detected at a concentration 0.2 µg/L in monitoring well MW-1. This concentration is significantly lower than the MTCA Method B criterion of 32 µg/L for this chemical. No other explosives were detected in MW-1 or in any of the other monitoring wells or water supply wells sampled during this study.
- Total arsenic was detected in monitoring wells MW-8 and MW-10 at concentrations of 0.6 and 0.2 µg/L, respectively. These concentrations are above the MTCA Method B criterion of 0.058 µg/L but are below the MTCA Method A criterion of 5 µg/L and MCL of 10 µg/L.

Note that the MTCA Method A criterion of 5 µg/L for arsenic is based on background concentrations for the State of Washington (note "b" in MTCA Table 720-1). Thus the arsenic detections in MW-8 and MW-10 are below regional background values.

4.2 REMEDIAL INVESTIGATION FIELD SAMPLING

The RI field sampling activities were conducted between March 2009 and December 2011. A final RI report (Shannon and Wilson 2012) was submitted to USACE-Kansas City District in September 2012. The field sampling consisted of the following activities:

- surface and subsurface soil sampling from the areas of potential concern which were located in the western portion of the Industrial Complex Area, the East Parcels West Area, and the Administration and Operations Area;
- a hydrogeological investigation where water levels were continuously logged in selected monitoring wells from April 2009 to April 2010;
- installation of four new monitoring wells in the western portion of the Industrial Complex Area (MW-14, MW-15, MW-16, and MW-17);
- collection of groundwater samples from the new and existing monitoring wells, as well as from water supply wells in the western portion of the Industrial Complex Area and West Parcels Areas;
- sampling from a pond on the residential property where the NI well is located, as well as from sumps in the vicinity of areas of potential concern; and
- soil gas, crawl space, and ambient air sampling at locations where vapor intrusion (VI) was a concern.

4.2.1 RI Soil Sampling

The soil samples were collected from 3 to 6 inches bgs at 30-foot spacing intervals around the perimeter of the buildings and/or former building locations (see Figure 4-1a through Figure 4-1e for soil sample locations). The first set of soil samples were collected in late March/early April 2009. A second set of soil samples were collected in November 2009 based on a review of analytical results from the first sampling event. During the second sampling event, step-out sampling was conducted at a number of areas of potential concern to verify and better delineate elevated PAH concentrations measured in soil samples collected during the first sampling event. In addition to step-out sampling, soil samples from 6 to 9 inches bgs were collected from selected locations where elevated PAHs were detected in soil samples collected from 3 to 6 inches bgs. The soil sampling locations collected from 6 to 9 inches bgs are shown in Figure 4-1d and Figure 4-1e. A comparison of the results from these co-located samples provided insight into the distribution of PAHs at the site (see Section 4.3.2 for additional discussion of the results).

Subsurface soil samples were collected from the areas of potential concern in the western portion of the Industrial Complex Area (Figure 4-2a and Figure 4-2b) and from the only area of potential concern in the Administration and Operations Area (suspected liquid disposal, Figure 4-2c). A majority of the subsurface soil samples were collected from boreholes that were 25 feet bgs (Figure 4-2a, Figure 4-2b, and Figure 4-2c). Deeper subsurface soil samples (up to 110 feet bgs) were collected from the boreholes that were drilled to install new monitoring wells MW-14, MW-15, MW-16 and MW-17 (Figures 4-2b).

Table 4-1 presents a summary of the soil sample analyses which includes the types of samples collected from each area of concern (i.e., 3 to 6 inches bgs, 6 to 9 inches bgs, and subsurface soil) as well as the analyses that were performed on the soil samples. The analyses performed on the soil samples were

determined based on the historical operations conducted within each area of potential concern (Shannon and Wilson 2012). For example, polychlorinated biphenyl (PCB) analysis was only performed on the 3 to 6 and 6 to 9 inch bgs soil samples from areas of potential concern associated with former buildings that contained generators and transformers (B7, B11, B41, B65 in Figure 4-1a and 4-1d; B49 in Figure 4-1b and 4-1e; and B101/B102 in Figure 4-1c). All of the 3 to 6 and 6 to 9 inch bgs soil samples shown in Figures 4-1a through 4-1e were analyzed for PAHs. All of the 3 to 6 and 6 to 9 inch bgs soil samples, except for the samples associated with the transformer and generator buildings were analyzed for SVOCs, and silver. Table 4-2 shows the methods used to analyze the soil samples.

All subsurface soil samples collected during the RI were analyzed for VOCs. The subsurface soil samples were collected from the areas of potential concern/former NAAS Quillayute buildings where solvents may have been used for painting (B119/119A, B18, B19; Figure 4-2a), maintenance (B20 , B12; Figure 4-2a), photography (B29; Figure 4-2a), dry cleaning (B44; Figure 4-2b), or in fire extinguishers (B6 in Figure 4-2a and E120 in Figure 4-2b). Subsurface soil samples for VOC analysis were collected from the vicinity of the NI well (Figure 4-2b) where carbon tetrachloride is present in groundwater, and from boreholes that were drilled to install monitoring wells MW-14, MW-15, MW-16 and MW-17 (Figure 4-2b). Subsurface soil samples for VOC analysis were collected from the tetraethyl lead disposal area (sludge disposal area)l (Figure 4-2a) and from the suspected liquid disposal area (Figure 4-2c). The subsurface soil samples from the tetraethyl lead disposal area (sludge disposal area) and suspected liquid disposal area were analyzed for SVOCs, PAHs, and silver. The subsurface soil samples from the MW-9 borehole (Figure 4-2c) were analyzed for the same suite of chemicals except the soil samples were analyzed for RCRA metals.

4.2.2 RI Groundwater and Pond Sampling

Groundwater samples were collected from the monitoring wells and water supply wells shown in Figure 2-7 (presented in Section 2.3). As mentioned previously, the ST well (a former DoD water supply well) was not sampled during the RI or in any previous investigations due to inaccessibility; this water supply well appears to be inactive and unused (Shannon and Wilson 2012). Table 4-3 summarizes the analyses performed on the groundwater samples, where the wells are grouped in the following categories:

- Wells located in the vicinity of the West Parcels Area (in the vicinity of the borrow pits).
- Wells within Quillayute Airport portion of the Industrial Complex Area.
- Wells closet to the B44 slab (monitoring wells MW-14, MW-15, and MW-16, water supply wells near these monitoring wells).
- Wells in the vicinity of the NI well (monitoring well MW-17, water supply well designated NNW, and other wells east of these wells).

As shown in Table 4-3, all groundwater samples collected during the RI were analyzed for VOCs, SVOCs, PAHs, and silver. Groundwater samples from some of wells in the West Parcels Area in the vicinity of the borrow pits were analyzed for metals including arsenic, barium, cadmium, chromium, mercury, iron, manganese, and selenium. Groundwater samples from the new wells installed as part of the RI (monitoring wells MW-14 through MW-17), as well as a new water supply well (designated NNW) installed by the owner of the NI well, were sampled for metals. The methods used to analyze the samples are presented in Table 4-4.

The RI field sampling included collection of water samples from sumps near to B10, B20, B41, and B4. The analysis results for these samples are not discussed in this BLRA report because risks from exposure to these sumps are considered minimal. The results of these analyses are presented in the RI report (Shannon and Wilson 2012). As noted in Section 3.2 (Topography and Surface Hydrology) the

only surface water bodies observed near the areas of potential concern are the man-made ponds found below the terrace edge on the property containing the NI and NNW wells (Figure 3-5b, photograph b). A sample from one of the man-made ponds was taken as part of the RI field sampling and analyzed for VOCs. The results of the pond sample analysis were included in the data set evaluated in this BLRA.

4.2.3 Soil Gas, Crawl Space, and Ambient Air Sampling

Sampling was conducted as part of the RI to address VI at the former locations of B44 and at B33 (in the vicinity of the NI and NNW wells). In November 2010, 24-hour air samples were collected from two soil gas probes with soil gas samplers at 6, 13, and 18 feet bgs at locations adjacent to the B44 slab (B44:SV-1 and B44:SV-2 in Figure 4-3a). At the same time, an ambient air sample was collected at the B44:AM location.

In December 2011, 24-hour air samples were collected from the crawl space beneath the mobile home occupying the B44 foundation slab (B44:UT-1 in Figure 4-3a). At the same time as the crawl space air samples, an ambient air sample was collected at the B44:AM-1 location. At this time, soil gas probes with samplers at 6 feet bgs were installed next to the NI well (NI-SV1 in Figure 4-3b) and next to the residence located at the former location of B33 (NR-SV1). Twenty-four hour soil gas samples were collected from these samplers. Details regarding the collection of the soil gas and air samples can be found in the RI report (Shannon and Wilson 2012). The soil gas, ambient air and crawl space air samples were analyzed for VOCs using USEPA Method TO-15 SIM.

4.2.4 Data Validation

The analytical data from the RI were subjected to data validation and quality assurance review by a third party reviewer. The dataset received by GEO for use as a database for the BLRA contained laboratory results as well as validation qualifiers. The data that were rejected by the data validator ("R"-qualified in the data set) were excluded from the database used for the BLRA. The number of rejected data points is included in the data summaries presented in Section 4.3. Even after the rejected data were removed from the database, the remaining numbers of data points were deemed to be adequate as a basis for evaluating the overall presence or absence of an analyte in the samples.

4.3 REMEDIAL INVESTIGATION RESULTS: CONTAMINANT DISTRIBUTION AND HUMAN HEALTH RISK SCREENING

4.3.1 Risk Screening Criteria

The screening criteria used in the RI report (Shannon and Wilson 2012) consisted of criteria from the State of Washington MTCA Method A criteria from WDOE Publication 94-02 (February 2001), MTCA Method B criteria downloaded January 2008 from the WDOE website Cleanup Levels and Risk Calculations (CLARC) website, and USEPA Regional Screening Levels (RSLs) (2012 values). For this BLRA report, the screening levels used to identify COPCs were based on MTCA Method A and Method B risk-based criteria downloaded from the WDOE CLARC website in July 2012 and the USEPA RSLs dated May 2013 for residential soil and tap water. Use of more up to date screening criteria will ensure that the risk screening will incorporate the latest toxicity values published by USEPA. Note that the risk screening described in this subsection focuses on human health; the ecological risk screening process and results are discussed in the section on the BERA (Section 6).

Table 4-5a through 4-5d present screening levels used in the BLRA to identify COPCs in soil for VOCs (Table 4-5a), SVOCs and PAHs (Table 4-5b), PCBs (Table 4-5c) and metals (Table 4-5d). The tables contain the MTCA Method A criterion, the risk-based screening criteria from MTCA Method B (both carcinogenic and non-carcinogenic), and USEPA RSL for residential soil for each chemical. In

general, the minimum of the risk-based screening levels (i.e., MTCA Method B or USEPA RSL) was selected as the comparison value used to determine whether an analyte detected in RI soil samples is a COPC to be carried through the quantitative risk assessment (presented in Section 5). For metals in soil (Table 4-5d), the MTCA Method A criteria and the previously established background concentrations for metals in soil in the Puget Sound Area (San Juan 1994) are given precedence over MTCA Method B and USEPA RSLs. For example, the minimum risk-based screening level for arsenic in soil is 0.39 milligrams (mg) per kilogram (kg), however the 90th percentile for Puget Sound (which includes Clallam County) is 7 mg/kg and the Method A MTCA criterion for this metal in soil is 20 mg/kg which is based on risk from direct contact and protection of groundwater for drinking water use adjusted for natural background for soil (WDOE 2007, note "b" in Table 740-1 of MTCA). As such, the MTCA Method A and Puget Sound background values were used to determine whether arsenic in soil at the site is a COPC.

Table 4-6a through 4-6d present screening levels used in the BLRA to identify COPCs in groundwater for VOCs (Table 4-6a), SVOCs (Table 4-6b), PAHs (Table 4-6c), and metals (Table 4-6d). In general, the minimum of the risk-based criteria (MTCA Method B and USEPA RSL for tap water) was used as a comparison value for determining whether a detected chemical in on-site groundwater samples is a COPC. However, similar to the approach used for soil, MTCA Method A criteria for groundwater were used for metals if the MTCA Method A criteria is based on natural background conditions and is higher than the risk-based criteria. For example, the MTCA Method A screening criterion for arsenic in groundwater of 5 µg/L, (based on background concentrations in the State of Washington, WDOE 2007) was used to evaluate the site RI data for groundwater instead of the minimum risk-based level of 0.045 µg/L.

Table 4-7 presents screening levels used in the BLRA to identify COPCs in indoor air and evaluate risks from VI. Since the RI VI data consist of soil gas and crawl space air data rather than indoor air concentrations, the indoor air screening levels were adjusted using vapor attenuation factors (VAF) provided in USEPA (2012b) using the following equation:

$$SL_{SG} = \frac{SL_{IA}}{VAF_{SS}} \tag{1}$$

$$SL_{CS} = \frac{SL_{IA}}{VAF_{CS}} \tag{2}$$

SL_{SG} and SL_{CS} are the screening levels used to evaluate the soil gas and crawl space air samples, respectively. VAF_{SS} (0.03) and VAF_{CS} (0.9) are the 95% sub-slab soil gas-to-indoor air and crawl space-to-indoor air attenuation factors derived from a VI database compiled by USEPA (2012b).

4.3.2 Identification of Chemicals of Potential Concern in Soil

The screening process to identify COPCs for soil using the data collected during the RI (Shannon and Wilson 2012) was conducted in two phases. In the first phase, the data from the entire site were evaluated as a site-wide data set and the maximum detected concentrations were compared against the screening criteria presented in Table 4-5a through Table 4-5d for soil to determine preliminary COPCs. Preliminary COPCs from the first phase were aggregated by area of potential concern in the second phase. If the maximum detected concentration of the preliminary COPC exceeded the screening levels for an area of potential concern, the chemical was considered a COPC and a quantitative risk assessment was performed for each COPC per area of potential concern (Section 5).

Chemicals that were detected with a frequency of less than 5% in the site-wide data sets were eliminated from further consideration as a COPC.

The site-wide data summaries shown in Tables 4-8a through 4-8e provide the following information for each chemical: the screening levels (from Tables 4-5a through 4-5d), analytical limits (range of detection and quantitation limits reported for the RI analytical results), and summary data. The number of rejected analytical results is presented in these tables as an indicator of the overall reliability of the analyses. The last two columns of the data summary tables provide the results of the site-wide data screening; these columns indicate whether a chemical was determined to be a preliminary COPC and a brief note regarding the rationale for the COPC determination. Each of the soil data summary tables are discussed below. The RI data are provided electronically in Appendix B.

4.3.2.1 Volatile Organic Compounds in Soil

Two VOCs detected in the RI soil samples exceeded the MTCA screening criteria (Table 4-8a); these were methylene chloride (25J µg/kg) and PCE (200J µg/kg). These were measured in a soil sample collected from 25 feet bgs in a borehole near B44. Methylene chloride was not detected (detection limit <5 µg/kg) while PCE concentrations ranged from non-detect to 10 µg/kg in the other soil samples from B44 (data in Appendix B). Methylene chloride and PCE were therefore ruled out as COPCs for soil at the former NAAS Quillayute. Other than PCE and methylene chloride, no other detected VOCs exceeded the screening criteria (Table 4-8a).

The most frequently detected VOCs were toluene (153 out of 211 analysis results, with a maximum concentration of 3.7 µg/kg), benzene (78 out of 211 analysis results, with a maximum concentration of 2.8 µg/kg), and methyl tert-butyl ether [(MTBE), 62 out of 211 analysis results; with a maximum concentration of 3.1 µg/kg]. The presence of MTBE in the soils cannot be attributed to historical DoD because MTBE is a fuel additive that was first used as an octane-enhancing replacement for lead additives in gasoline in 1979 (USEPA 2008). MTBE can be released into the subsurface through leaking gasoline USTs (WDOE 2000) or non-point sources such as storm water runoff. The presence of toluene and benzene, which are also gasoline components, in the soil samples can be from the same non-point sources as MTBE.

Carbon tetrachloride measured in the RI soil samples is of interest because one of the objectives of the RI (Shannon and Wilson 2012) was to identify sources for the detections of this chemical in groundwater at the site. Carbon tetrachloride was detected in 23 out of 211 soil samples at a maximum concentration of 38J µg/kg in subsurface soil samples collected in the vicinity of B12, B18/B19, B20, B41, and B44 (Table 4-9, Figure 4-4). At B44, carbon tetrachloride was detected in soil samples collected from two boreholes drilled at the southeast corner of the former building, up to a depth of 70 feet bgs with detections ranging from 0.64J to 38J µg/kg (Table 4-9). Tetrachloroethene (PCE) was detected in the soil samples collected from the southeast corner of the B44 slab in the same samples from this area of potential concern where carbon tetrachloride was detected (Table 4-9). Benzene, toluene, and/or MTBE were detected in every subsurface soil sample where carbon tetrachloride and PCE was detected (Table 4-9).

4.3.2.2 Semi-volatile Organic Compounds VOCs in Soil

Two SVOCs, naphthalene and pentachlorophenol, were identified as COPCs based on the site-wide screening presented in Table 4-8b. An inspection of individual naphthalene soil concentrations grouped by area of potential concern shows that naphthalene is only a COPC for B5 (Table 4-10).

Pentachlorophenol was determined to be a COPC at B4, B5, B17, and B20 (Table 4-10). Pentachlorophenol was detected in multiple samples from B4, with concentrations that ranged from 30 to

1600 µg/kg. The screening level (890 µg/kg) was exceeded in four samples from three locations (one sample was a field duplicate; Table 4-10). At B5, B17, and B20 pentachlorophenol was not detected however the practical quantitation limit for pentachlorophenol exceeded the screening level. For example, at B5, pentachlorophenol was not detected in any of the samples; however, the reported values for the non-detects (corresponding to the practical quantitation limit) ranged from 2500 to 5000 µg/kg, which are greater than the screening level of 890 µg/kg. Since it was not possible to reliably establish that this chemical was not present above the screening level at B5, B17, and B20, pentachlorophenol was identified as a COPC for these areas of potential concern.

Dimethyl phthalate was the most frequently detected SVOCs in the soil samples (89 out of 169 samples, maximum detection of 1900 µg/kg), followed by bis(2-ethylhexyl)phthalate (79 out of 169 samples, maximum detection of 410 µg/kg). The maximum detection concentration of bis(2-ethylhexyl)phthalate is significantly lower than the risk-based screening level (35,000 µg/kg). At B5, the SVOC measured at elevated levels was dimethyl phthalate with concentrations that ranged from 160 to 1200 µg/kg. There are no available risk-based screening levels for dimethyl phthalate. Dimethyl phthalate is used in solid rocket propellants, lacquers, plastics, safety glasses, rubber coating agents, molding powders, insect repellants and pesticides (USEPA 2000). Bis(2-ethylhexyl)phthalate is used as a plasticizer (ATSDR 2002). It is also known to be present in airport deicers (USEPA 2000).

4.3.2.3 Polynuclear Aromatic Hydrocarbons in Soil

A number of PAHs were detected in the soil samples at concentrations that exceeded screening levels including benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, dibenz(a,h)anthracene and indeno(1,2,3-cd)pyrene (Table 4-8c). The maximum concentration for chrysene (4500 µg/kg) did not exceed its screening level (15,000 µg/kg), but it is considered a COPC in accordance with MTCA requirements which state that mixtures of carcinogenic PAHs shall be considered as a single hazardous substance [WDOE 2007, MTCA 173-340-708(e)]. The carcinogenic PAHs are listed in MTCA Table 708-2 and include benzo(a)pyrene, benzo(a)anthracene, benzo(b)fluoranthene, benzo(k)flouranthene, chrysene, dibenz(a,h)anthracene, and indeno(1,2,3-cd)pyrene. For the risk screening by area of potential concern, the total toxic equivalent concentration of benzo(a)pyrene (BaP-Eq) for each soil sample was calculated. BaP-Eq was calculated by summing the products of the concentrations of carcinogenic PAHs with their respective toxicity equivalency factors (TEFs) published by USEPA (1993a, reproduced in Table 4-11). The Kaplan-Meier method for summing censored data presented by Helsel (2012) was for calculating BaP-Eq from data with non-detects (see calculations in Appendix D). The calculations were performed using a public domain Kaplan-Meier spreadsheet file, published by Helsel (undated). BaP-Eq concentrations for the former NAAS Quillayute soil samples are shown in Table 4-12.

Areas of potential concern where carcinogenic PAHs, represented by BaP-Eq, were determined to be COPCs include B4, B5, B7, B9, B10, B11, B12, B17, B20, B41, B49, and B101/102. This determination was based on a comparison of BaP-Eq concentrations from each area of potential concern with the minimum risk-based screening level of 15 µg/kg. This approach is more conservative than using the MTCA Method A value of 100 µg/kg. In some areas of potential concern, carcinogenic PAHs were ruled out as COPCs for that area if the maximum concentration was considered an isolated elevated value when compared to the rest of the analysis even though the maximum BaP-Eq concentration was greater than 15 µg/kg. This rationale was used to rule out carcinogenic PAHs as COPCs for B29 and B119/B119A.

Figure 4-5 illustrates the wide-spread distribution of benzo(a)pyrene in soil samples collected from 3 to 6 inches bgs during the RI (Shannon and Wilson 2012), with many of the detected concentrations below 100 µg/kg. The concentrations that exceed 100 µg/kg are located near B5 and B17 (Figure 4-5), with the exception of one isolated location at B29. These samples were taken adjacent to deteriorated

asphalt and therefore the results are reflective of the nature of where the samples were collected. The elevated levels of PAHs appear to be limited to the upper 6-inches of soil (Shannon and Wilson 2012), based on a comparison benzo(a)pyrene concentrations in co-located soil samples collected from 3 to 6 inches and 6 to 9 inches bgs during the RI (Table 4-13). For example, the maximum detected benzo(a)pyrene concentration was 3700 µg/kg at location B5:SS-5. A sample collected from 6 to 9 inches bgs from the same location contains benzo(a)pyrene at a concentration of 35 µg/kg. As discussed in Section 2.3.4, deteriorated asphalt was observed in the vicinity of B5 and B17 and may be a potential source for elevated PAHs in this area. The soil samples that are considered likely to have been impacted by deteriorated asphalt are marked in Table 4-12. The low levels of PAHs in soil samples throughout the site (see Figure 4-5) may have been introduced into the environment via natural and anthropogenic combustion processes. Forest or grass fires are among the major sources of naturally produced PAHs. Anthropogenic activities have dramatically increased the quantity of PAHs in the environment with the majority emitted from incomplete combustion of fossil fuel, such as automobiles, planes, lawn mowers, or manufacturing facilities or of wood or solid wastes. PAHs are ubiquitous and humans are exposed to these chemicals every day.

4.3.2.4 Polychlorinated Biphenyls in Soil

The site-wide data summary of PCBs in the RI soil samples shows that PCBs were either not detected or were detected below the screening levels (Table 4-8d). The PCB mixture was evaluated as required by WAC 173-340-708(8) and the maximum PCB mixture concentration was below the screening levels. PCBs were detected in soil samples from former building locations where transformers may have been present including B101/B102 (Radar and Generator Buildings), B7 (Transformer Vault), and B41 (Power Generator Building). Since all the PCB detections were below the screening criteria PCBs are not considered COPCs for the site.

4.3.2.5 Metals in Soil

The site-wide data summary of metals in the RI soil samples shows that none of the metals were identified as COPCs (Table 4-8e). Arsenic concentrations (maximum of 6050 µg/kg) exceeded the risk-based screening level of 390 µg/kg but were below the Puget Sound background value (7000 µg/kg) and MTCA Method A criterion (20000 µg/kg).

4.3.2.6 Summary of Chemicals of Potential Concern in Soil

In summary, the identified COPCs in soil were:

- Naphthalene at B5;
- Pentachlorophenol at B4, B5, B17, and B20;
- Benzo(a)pyrene and other carcinogenic PAHs at B4, B5, B7, B9, B10, B11, B12, B17, B20, B41, B49, and B101/B102.

There were no VOCs or PCBs identified as COPCs. There were no COPCs in soil identified in the following areas of potential concern: B6, B18/B19, B29, B40, B44, B65, B119/B119A, E120, the suspected liquid disposal area, and the tetraethyl lead disposal area (sludge disposal area). The COPCs for each area of potential concern are included in Table 4-1, where the soil analyses performed for each area was presented earlier in this section.

Section 5 of this BLRA report presents estimates for human health risk from exposure to naphthalene, pentachlorophenol, benzo(a)pyrene and other carcinogenic PAHs in soil at the site.

4.3.3 Identification of Chemicals of Potential Concern in Groundwater

The screening process to identify COPCs in groundwater using the data collected during the RI (Shannon and Wilson 2012) was conducted in two phases following the approach used to identify COPCs in soil. In the first phase, the data from all the monitoring wells and residential wells were evaluated as a site-wide data set and the maximum detected concentrations were compared against the groundwater screening criteria that were presented in Table 4-6a through Table 4-6d. Preliminary COPCs from the first phase were individually compared against the screening criteria for each monitoring well and water supply well.

The site-wide groundwater data summaries are presented in Tables 4-14a through 4-14d, and the results are discussed for each class of compounds in the following subsections.

4.3.3.1 Volatile Organic Compounds in Groundwater and in the Man-made Pond on NI Well Property

The only VOC identified as a COPC in groundwater is carbon tetrachloride based on the maximum detected concentration of 6.8 µg/L in the NI well. Table 4-15 shows carbon tetrachloride data from both the 2006 groundwater investigation (URS 2007) and the RI sampling (Shannon and Wilson 2012). The tables present data from monitoring and water supply wells grouped by location (see Figure 4-6). Table 4-15, part (a) shows monitoring and water supply wells that are generally located within the residential areas north of Runway #2. Table 4-15, part (b) shows wells that are located within Quillayute Airport portion of the Industrial Complex Area south of Runway #2 and north of Quillayute Road. Table 4-15, part (c) includes wells that are closest to the B44 slab, while Table 4-15, part (d) shows wells that are closest to the NI well.

Carbon tetrachloride was not detected in any of the wells located in the West Parcels Area Groundwater exposure unit (EU) [Table 4-15, part (a)], or in any of the wells within the Industrial Complex-Quillayute Airport Groundwater EU [Table 4-15, part (b)]. In the vicinity of the B44 slab [Table 4-15, part (c)], carbon tetrachloride was only detected in monitoring well MW-16 at a concentration of 0.6 µg/L, higher than the risk-based screening level of 0.39 µg/L but an order of magnitude below the MCL of 5 µg/L. Carbon tetrachloride concentrations were higher in the vicinity of NI well [Table 4-15, part (d)] and one sample exceeded the MCL. Since the detected concentrations are greater than the risk-based screening level of 0.39 µg/L, carbon tetrachloride was identified as a COPC and was carried through the quantitative risk assessment described in Section 5.

Vinyl chloride was detected at a concentration of 0.28 µg/L in a tap water sample from the NI well collected during the RI. Shannon and Wilson (2012) indicated that this sample was collected after a carbon filtration system, and that an unfiltered tap water sample collected during the same sampling event did not contain any detectable levels of vinyl chloride. Although the detected concentration in the filtered sample exceeds the risk-based screening level of 0.2 µg/L, vinyl chloride was not considered a COPC based on the conclusion (Shannon and Wilson 2012) that vinyl chloride in the filtered sample was either introduced by the carbon filtration system or the sampling and analysis process.

PCE was detected at a concentration of 0.21 µg/L in monitoring well MW-16. This concentration is below the risk-based screening level of 9.7 µg/L and the MCL of 5 µg/L.

Trichloroethene was detected in monitoring well MW-3 and B21 at concentrations of 0.29 and 0.25 µg/L, both lower than the risk-based screening level of 0.44 µg/L and the MCL of 5 µg/L. Other VOCs detected were acetone, carbon disulfide, chloroform, chloromethane, and toluene all at concentrations less than the risk-based screening levels.

The sample from the man-made pond on the NI well property did not contain any detectable VOCs, however, MW-12 near the pond had a carbon tetrachloride concentration of 0.14 µg/L.

4.3.3.2 Semi-volatile Organic Compounds in Groundwater

The site-wide data summary for SVOCs in groundwater samples (Table 4-14b) shows that bis(2-ethylhexyl)phthalate is the only SVOC COPC in groundwater. Tables 4-16, parts a through d show the bis(2-ethylhexyl)phthalate data from both the 2006 groundwater investigation (URS 2007) and the RI sampling (Shannon and Wilson 2012). The tables present data from monitoring and water supply wells grouped "groundwater EUs" as shown in Figure 4-6. Table 4-16, part (a) shows monitoring and water supply wells in the West Parcels Area Groundwater EU; these wells are mostly located in the West Parcels Area but include MW-10 and MW-7 which are in the Administration and Operations Area, and MW-8 which is in the East Parcels Area (Figure 4-6). Table 4-16, part (b) shows wells that are located within the Industrial Complex-Quillayute Airport Groundwater EU which includes MW-11 and MW-13 located in the portion of the Industrial Complex Area occupied by the Quillayute Airport as well as MW-9 and the Airport Well which are located within the Administration and Operations Area but are within Quillayute Airport. Table 4-16, part (c) shows wells from the Industrial Complex Area in the vicinity of B44 Groundwater EU, while Table 4-16, part (d) shows wells in the Industrial Complex Area in the vicinity of the NI well Groundwater EU.

During the RI, the maximum concentration of bis(2-ethylhexyl)phthalate was 24 µg/L measured in a sample collected in April 2009 from B21, a water supply well located in the West Parcels Area (see Figure 2-7 for well location). This concentration is higher than the risk-based screening level of 4.8 µg/L and the MCL of 6 µg/L. Note that during the 2006 groundwater investigation, the sample collected from this well did not contain any detectable levels of this chemical (Table 4-16, part a). During the 2006 investigation, bis(2-ethylhexyl)phthalate was detected at an elevated concentration in a groundwater sample collected from monitoring well MW-8 (36 µg/L, Table 4-16, part a). Bis(2-ethylhexyl)phthalate was significantly lower in the sample collected from monitoring well MW-8 in April 2009 (0.51 µg/L). The data suggests that the elevated levels of bis(2-ethylhexyl)phthalate are not persistent. In monitoring and water supply wells located in the other areas within the site, bis(2-ethylhexyl)phthalate was either not detected or detected at concentrations generally below 1 µg/L which is below the risk-based screening level of 4.8 µg/L and the MCL of 6 µg/L (Table 4-16, parts b through d).

Another frequently detected SVOC was diethyl phthalate which was detected in multiple wells, but the maximum measured concentration (0.96 µg/L) is significantly less than the risk-based screening level of 11,000 µg/L. Other SVOCs detected were at concentrations well below the screening levels and were ruled out as COPCs.

4.3.3.3 Polynuclear Aromatic Hydrocarbons in Groundwater

PAHs were detected in one monitoring well MW-11 and in some water supply wells which are all located in north of Runway #2 (Table 4-14c, Figure 2-7). There were no COPCs identified; all PAH detections were below the screening levels.

4.3.3.4 Metals in Groundwater

None of the metals detected in the groundwater samples were identified as a COPC (see Table 4-14d). Arsenic concentrations (maximum of 4.6 µg/L) were above the risk-based screening level of 0.045 µg/L but were below the MTCA Method A criterion 5 µg/L which considers background conditions in the State of Washington. Many of the highest metal concentrations (Table 4-14d) were detected in the groundwater sample from monitoring well MW-10 which was highly turbid (3926 Nephelometric

Turbidity Units). The high solids content of this sample is further supported by the elevated iron concentration (40,800 µg/L) which is likely from iron oxide particulates in the groundwater sample.

4.3.3.5 Summary of Chemicals of Potential Concern in Groundwater

In summary, the COPCs in groundwater based in the RI groundwater data are carbon tetrachloride and bis(2-ethylhexyl)phthalate. These two chemicals are carried forward through the quantitative risk assessment in Section 5. Table 4-3 (presented earlier in this section) indicates which wells contained bis(2-ethylhexyl)phthalate and/or carbon tetrachloride at levels that exceeded the screening criteria.

4.3.4 Identification of Chemicals of Potential Concern in Air

Data to evaluate VI at the site consist of soil gas samples and crawl space air samples. To identify a preliminary set of COPCs, the maximum detected concentrations in the soil gas and crawl space air samples were compared with screening levels for indoor air (see Table 4-17). Several VOCs detected in the soil gas samples were eliminated from further consideration because the concentrations were below indoor air screening levels. The preliminary COPCs identified in Table 4-17 are 1,1,2,2-tetrachloroethane, 1,2-dichloroethane, benzene, carbon tetrachloride, PCE, and trichloroethene. Table 4-18 contains the concentrations of these VOCs in all the soil gas, crawl space air and ambient air samples collected as part of the RI. No analytes were detected in the ambient air sample collected in 2010 (at the same time as the soil gas samples); however, VOCs were detected in the ambient air sample collected in 2011 (at the same time as the crawl space air sample). This apparent discrepancy may be due to the higher detection limits in the ambient air sample from 2010, which precluded the detection of VOCs at the levels that were reported in 2011. For example, the carbon tetrachloride concentration in the 2011 ambient air sample was 0.4 $\mu g/m^3$, which is below the detection limit of 3.1 $\mu g/m^3$ in the 2010 ambient air sample. Another factor behind the variability between the ambient air concentrations may reflect the presence of other sources other than soil gas. One of the property owners had indicated to USACE during one of the sampling events that he had used carbon tetrachloride outside as a cleaner.

Using the data in Table 4-18, the final COPCs were identified by comparing the crawl space and soil gas samples to screening levels calculated from the indoor air screening levels by dividing these criteria by factors of 0.9, which is the 95% crawl space-to-indoor air VAF in USEPA (2012b), and 0.03, which is the 95% sub-slab soil gas-to-indoor air VAF in USEPA (2012b). The concentrations of 1,2-dichloroethane and benzene in the crawl space samples exceeded the crawl space screening levels for these compounds. With respect to the soil gas samples from the vicinity of the B44 slab, carbon tetrachloride and PCE exceeded soil gas screening levels calculated from the indoor air screening criteria and a VAF of 0.03. Based on the crawl space and soil gas data, 1,2-dichloroethane, benzene, carbon tetrachloride and PCE are considered as COPCs with respect to VI at the B44 slab and were carried forward into a quantitative risk assessment (Section 5). The concentrations of these compounds as well as the other VOCs are comparable with the concentrations measured in the ambient air sample collected on the same date (Table 4-18 for data).

The soil gas concentrations for carbon tetrachloride and PCE from the vicinity of the NI well and the residence located at the former location of B33 were below the screening levels; thus, there are no COPCs for this area.

5. BASELINE HUMAN HEALTH RISK ASSESSMENT

One of the objectives of the BHHRA is to evaluate potential human health risks resulting from exposure to residual contamination in environmental media if no remedial action is taken and to derive preliminary remediation goals. This section presents the methods and results for the BHHRA, which was performed based on information regarding current land use (Section 2), site physical characteristics (Section 3), and field investigations conducted previously at the site (Section 4). The five major components of the BHHRA process are as follows:

- Risk Screening (Section 5.1) – The first step in a BHHRA is to identify COPCs that are to be carried through the quantitative risk assessment. The risk screening is described in detail in Section 4.3. In Section 5.1, the sources of the screening levels used to identify COPCs and the results of the screening process are summarized.
- Exposure Assessment (Section 5.2) – The second step identifies the site receptors considered in the BHHRA. It includes an evaluation of pathways by which receptors may be exposed to site contaminants, and quantifies exposure estimates for each site receptor.
- Toxicity Assessment (Section 5.3) – The third step identifies the carcinogenic and non-carcinogenic toxicity values obtained from the hierarchy of sources recommended by USEPA.
- Risk Characterization (Section 5.4) – The fourth step involves quantification of potential cancer risks and non-cancer health effects derived from the integration of contaminant exposure assessment and toxicity values.
- Uncertainty Analysis (Section 5.5) – This final step is an assessment of site-specific factors that lead to uncertainties in the risk assessment and the overall impact of these uncertainties on the estimated risks and hazards.

5.1 RISK SCREENING

Previous investigations have shown that historical operations at the former NAAS Quillayute may have resulted in environmental impacts in areas of potential concern where hazardous materials may have been stored and used during historical military operations. These areas of potential concern include former NAAS Quillayute buildings, suspected liquid disposal area, and tetraethyl lead disposal area (sludge disposal area) (Figure 2-6).

In Section 4.3 of this BLRA report, the analytical data collected during the RI is compared to screening levels that were obtained from the following sources.

- MTCA Method A criteria for soil and groundwater (WDOE 2007; downloaded from the WDOE CLARC website in July 2012).
- MTCA Method B risk-based criteria for residential soil, groundwater, and residential indoor air (downloaded from the WDOE CLARC website in July 2012).
- USEPA RSLs (USEPA 2013).

The criteria are presented in Table 4-5a through Table 4-5d for soil, Table 4-6a through Table 4-6d for groundwater, and Table 4-7 for indoor air. In general, the minimum of the risk-based criteria (MTCA Method B and USEPA RSL) is used as the comparison value to determine whether a chemical is considered a COPC. However, for naturally occurring compounds like metals, the MTCA Method A

values based on background values for the State of Washington took precedence over the risk-based criteria.

The risk screening process identified the following COPCs for each environmental medium of concern at the site.

- Soil: naphthalene, pentachlorophenol, benzo(a)pyrene and other carcinogenic PAHs. The COPCs specific to each area of potential concern are listed in Table 4-1 (presented previously in Section 4).
- Groundwater: bis(2-ethylhexyl)phthalate and carbon tetrachloride. The COPCs specific to each well are shown in Table 4-3 (presented previously in Section 4).
- Indoor air: 1,2-dichloroethane, benzene, carbon tetrachloride and PCE for the mobile home currently occupying the former location for the B44 building.

5.2 EXPOSURE ASSESSMENT

5.2.1 Exposure Pathways and Conceptual Site Models

The former NAAS Quillayute site was subdivided for the purpose of the RI (Shannon and Wilson 2012) into areas based on historical operations (Figure 2-3). These areas include the Administration and Operations Area, the West Parcels Area, the East Parcels Area, the Industrial Complex Area, the Army Cantonment/HOMOJA Housing Area, and the Runway Approach Zones. Since there were no areas of potential concern identified by the historical research in the eastern portion of the Industrial Complex Area, the Army Cantonment/HOMOJA Housing Area or the Runway Approach Zones, these areas were not investigated during the RI and are not considered in this BLRA. Within the Administration and Operations Area, analytical results for soil samples collected from the suspected liquid disposal area did not indicate any residual contamination at this location (Figure 2-7). There was no evidence found during the RI that supported the anonymous report of liquid disposal in this area (Shannon and Wilson 2012).

Conceptual site models (CSMs) shown in Figure 5-1a through Figure 5-1f were developed based on current land use (Section 2.3), Clallam county zoning laws (Section 3.4), the RI results, and the risk screening (Section 4.3). A CSM for the Administration and Operations Area was not developed because the suspected liquid disposal was ruled out as a contamination source based on the RI sampling results.

The applicable areas for the CSMs generally align with the former NAAS Quillayute areas designated in the RI except for the Industrial Complex Area which was further divided to reflect land use. Figure 5-1a shows the CSM for the Quillayute Airport portion of the Industrial Complex Area. This zone includes all the areas of potential concern north of Quillayute Road that are within the fenced in area of the Quillayute Airport where COPCs were present.

- B5, Transportation Maintenance,
- B10, Gunnery Training
- B11, Radio and Radar Building and B7 Transformer Vault
- B12, Class “C” Overhaul Shop (located approximately 100 feet from the NOAA facility/B14)
- B17, Wash Rack and Shelter
- B20, Hangar

The CSM in Figure 5-1a applies to the Quillayute Airport portion of the Industrial Complex Area Groundwater EU (Figure 4-6).

The current receptors for this zone include indoor and outdoor workers (e.g., airport operators and maintenance workers) and visitors/recreationists (e.g., airport users). Potential receptors include residents and excavation/construction workers. The Clallam County zoning code designates the Quillayute Airport portion of the Industrial Complex Area as being part of the Western Region Rural Center that consists of a mixed commercial/residential/industrial zone ("WRC" in Figure 3-8). Based on the zoning code, the residential receptors are considered potential receptors even though this is unlikely given that the airport has been in place for more than sixty years. The primary sources identified in the CSM for this zone (Figure 5-1a) includes the former NAAS Quillayute historical operations at the former buildings listed above as well as deteriorating pavement, and ongoing airport operations [i.e., use of deicers which potentially contain phthalates (USEPA 2000)]. The CSM for the Quillayute Airport portion of the Industrial Complex Area does not show surface runoff as a viable contaminant transport pathway given the relatively flat topography of this area and the absence of surface water bodies in close proximity to the areas of potential concern within this zone (Section 3.2). Indoor air is not considered a complete pathway based on the minimal detections of VOCs in the subsurface soil samples collected from within the Quillayute Airport portion of the Industrial Complex Area, the depth of the water table (greater than 70 feet bgs) and the absence of detectable VOCs in the monitoring and water supply wells located in the Quillayute Airport portion of the Industrial Complex Area (monitoring wells MW-9, MW-11, MW-13, Airport Well, see Figure 2-7 and 4-6 for location of these wells). Exposure to groundwater is assumed to occur through existing and future water supply wells and all site receptors may be exposed to groundwater through this route through direct ingestion. Only the residential receptors were assumed to have exposure through significant dermal contact (i.e., showering) and inhalation. SVOCs, PAHs and metals were detected in these wells although SVOCs and PAH concentrations were below screening criteria and the metals were either below criteria or when elevated were associated with very turbid groundwater samples (see Section 4.3.3 for screening of groundwater concentrations).

The CSM in Figure 5-1b applies to the Undeveloped Area south of the Industrial Complex Area located south of Quillayute Road. There are two areas of potential concern located in this zone where COPCs are present.

- B4 Public Works Shop
- B9 Blacksmith Shop

B6 and B119/119A are located in this zone but RI data did not indicate the presence of COPCs in the vicinity of these former buildings. The potential receptors include residents, indoor and outdoor workers, excavation/construction workers and visitors/recreationists. The CSM does not include current receptors given that this zone is undeveloped and covered by heavy vegetation however development and construction of a residence is possible in the near future. Groundwater is not part of the CSM in Figure 5-1b since previous investigations have not shown the potential for groundwater contamination.

The CSM in Figure 5-1c applies to the vicinity of the NI well portion of the Industrial Complex Area which includes B49 and E120. This CSM applies to the Groundwater EU in the vicinity of the NI well shown previously in Figure 4-6. The receptors for this CSM are residential receptors given its current land use and excavation/construction workers. The NI well, B49, E120, B30, B58 and B31 are all located on the same residential parcel; the parcel owner resides in a home located partially on former B33. The potential sources in this zone include former NAAS Quillayute operations. As noted previously, the widespread distribution of PAHs in surface soil at the site (including B49 located in this zone) may be partially from vehicle emissions and other diffuse sources. The CSM includes the potential pathway from groundwater to surface water based on the observed vegetated drainage swale in the vicinity of the man-

made pond (Figure 3-5b). Carbon tetrachloride was detected in MW-12 located next to the pond however the groundwater to surface water is shown as incomplete based on the absence of VOCs in a sample collected from the man-made pond during the RI. The VI pathway is shown in the CSM as incomplete based on the soil gas VOC data collected from this zone which did not indicate the potential for VI (Section 4.3.4, Table 4-18).

The CSM in Figure 5-1d applies to the vicinity of the B44 slab within the Industrial Complex Area. This CSM applies to the Groundwater EU in the vicinity of B44 shown previously in Figure 4-6. The receptors for this CSM are residential receptors given current land use of the area surrounding former B44 building as well as former B43; excavation/construction workers are potential receptors. The zone represented by the CSM in Figure 5-1d includes B41 which is located on the same residential property occupied by the B44 slab. The potential sources in this zone include the former NAAS Quillayute operations. COPCs were identified in soil gas samples from the vicinity of the B44 slab (Section 4.3.4, Table 4-18). This pathway is marked as complete in the CSM and was considered in the quantitative risk evaluation.

The CSM in Figure 5-1e applies to the West Parcels Area. The primary contamination sources are the borrow pits (although no documentation exists for historical disposal of hazardous materials) and past/ongoing airport operations. The detections of bis(2-ethylhexyl)phthalate may be from the use of deicers known to contain these chemicals (USEPA 2000). The only receptors for this CSM are residential receptors given its current land use as well as the Clallam County zoning designation for this area as "Rural Low-Western Region" zone ("RW5" in Figure 3-8), which is intended to provide home sites in rural forestry areas (Section 3.4). The only exposure medium shown in the CSM for the West Parcels Area is groundwater because direct contact with surface soil within the borrow pits is considered unlikely given their depths (50 feet). The VI pathway is shown as incomplete because, in addition to the depth to groundwater (>70 feet bgs), there were no VOCs detected at levels of concern in the monitoring and water supply wells in this area.

The CSM in Figure 5-1f applies to the East Parcels Area. The primary contamination source in this area where PAHs were identified as COPCs in surface soil samples may be historical operations in B101/B102. Since the land is undeveloped, there are no current receptors. Potential receptors include residents, indoor and outdoor workers, excavation/construction workers and visitors/recreationists. Groundwater is not shown in this CSM because PAHs, the only COPC identified for B101/B102, have low solubilities and tend to sorb to soil particles; therefore are unlikely to migrate vertically to groundwater.

In summary, CSMs have been developed for zones within the former NAAS Quillayute that reflect land use, the contaminant distribution based on information gathered during previous investigations, and risk screening of the RI soil and groundwater data. The rest of the section presents the methods used and results for estimating risks for the receptors identified in the CSMs from exposure to surface soil in the areas of potential concern where COPCs were identified, exposure to groundwater, and exposure to indoor air in the vicinity of the B44 slab.

5.2.2 Quantification of Exposure

Standard equations from USEPA RAGS documents including USEPA 1991a, 1991b, 1993a, 2004, and 2009 were used to estimate the chemical intake of site receptors from exposure to contaminated soil, groundwater, and indoor air through direct ingestion (for soil and groundwater), dermal contact (for soil and groundwater) and inhalation. For example, the chemical intake from direct ingestion of soil is given by the following equation:

$$Chemical_Intake\left(\frac{mg}{kg-day}\right)=\frac{C_S \times IR_S \times EF \times ED \times FI}{BW \times AT} \quad (2)$$

where:

C_s	=	chemical concentration in soil (mg/kg)
IR_s	=	ingestion rate (kg/day)
EF	=	exposure frequency (days/year)
ED	=	exposure duration (years)
FI	=	fraction ingested (assumed value of 1, unitless)
BW	=	body weight (kg)
AT	=	averaging time (days) for carcinogens or non-carcinogens

Other equations for calculating chemical intake are provided in Appendix C. The exposure parameters used in the intake equations from exposure to soil are shown in Table 5-1a through Table 5-1d for resident child/adult receptors, visitor child/adult receptors, indoor and outdoor worker receptors, and the excavation/construction worker receptors. Standard values for the exposure parameters representing a Reasonable Maximum Exposure (RME) scenario were taken from USEPA sources, as shown in the tables. In addition to the RME scenario, risks were calculated for the residential receptors under a Central Tendency Exposure (CTE) scenario. In the CTE scenario, the soil ingestion rates for resident adult and child were set to 50 and 100 mg/day, respectively (compared to 100 and 200 mg/day in the RME scenario). The lower values were obtained from the Exposure Factors Handbook (USEPA 2011a) which reported that the "general population central tendency" daily soil and dust ingestion rates are 50 mg/day for adults and 100 mg/day for age group of 1 to <6 years. Other than the daily soil ingestion rate, the same values were used for the RME and CTE exposure parameters (Table 5-1a).

For the visitor adult/child, the daily ingestion rates (50 and 100 mg/day, Table 5-1b) were set to half the values used for the resident adult/child. It was assumed that a visitor would be exposed to the soil for 4 hours per day for 75 days a year. Standard exposure parameters from USEPA sources were used for the indoor worker and outdoor worker (Table 5-1c). For the excavation/construction worker (Table 5-1d), the exposure frequency was set to 120 days per year (8 hours per day) and the exposure duration was set to 1 year. The particulate emission factor for the excavation/construction worker (a parameter used to estimate chemical intake from inhalation of dust) was set to $1x10^6$ m^3/kg (Cal-DTSC 2011). This is approximately 3 orders of magnitude higher than the default value of 1.36 x 10^9 m^3/kg (USEPA 2002b) to account for higher soil disturbance and dust generation during excavation work.

Table 5-2a through Table 5-2d present the exposure parameters used to calculate chemical intake from groundwater for the resident adult/child, visitor adult/child, indoor and outdoor worker, and excavation/construction worker, respectively. Standard values for the exposure parameters representing a RME scenario were taken from USEPA sources, as shown in the tables. In addition to the RME scenario, risks were calculated for the residential receptors under a CTE scenario. In the CTE scenario, the resident child drinking water ingestion rate was set to 0.327 liters/day which is the reported mean drinking water ingestion rate for the age group of 3 to <6 years in the Exposure Factors Handbook (USEPA 2011a). The residential adult drinking water ingestion rate for the CTE scenario was set to 1.04 liters/day which is the reported value for the age group of ≥21 years. Other than the drinking water ingestion rate, the same values were used for the RME and CTE exposure parameters (Table 5-2a).

For the visitor/recreationist adult/child, the daily drinking water ingestion rates (0.5 and 1 liters/day, Table 5-2b) were set to half the values used for the resident adult/child. The direct ingestion exposure parameters are provided for the visitor/recreationist adult/child because this is assumed to be the only viable pathway for these receptors (Figure 5-1a). It was assumed that a visitor would visit the site for 75

days per year. Standard exposure parameters from USEPA sources were used for the indoor worker and outdoor worker (Table 5-2c). For the excavation/construction worker (Table 5-2d), the exposure frequency was set to 120 days per year and the exposure duration was set to 1 year.

Exposure parameters for inhalation of indoor air pathway are presented in Table 5-3. Exposure parameters for the resident adult/child receptor are provided because residents at the B44 slab are the only likely receptors at the site for which VI is a concern (Figure 5-1d). Standard exposure parameters from USEPA sources were used for the RME scenario. In the CTE scenario, the exposure time for the CTE scenario was set to 18.5 hours/day and 20 hours/day for the resident child and adult respectively. These values were taken from the Exposure Factors Handbook (USEPA 2011a) and correspond to the mean time spent indoors (at residence) for the age group of birth to <1year and age group of >65 years. The times for these age groups were chosen because these age groups had the maximum times indoors reported among the child (<6 years) and adult age groups.

The risk screening presented in Section 4.3 and summarized in Section 5.1 identified carcinogenic PAHs (represented by BaP-Eq concentrations), pentachlorophenol, and naphthalene as COPCs in soil, bis(2-ethylhexyl)phthalate and carbon tetrachloride in groundwater, and carbon tetrachloride and PCE in indoor air at the B44 slab. Methylene chloride and PCE in duplicate soil samples from 25 feet bgs from a borehole drilled near B44 exceeded MTCA criteria however these were isolated occurrences (see Section 4.4.3 for details) such that these chemicals were ruled out as COPCs. The standard chemical intake equations (Appendix C) require an exposure point concentration (EPC) which corresponds to a representative concentration of the COPC in the environmental medium of concern within an EU.

For the purpose of estimating risks from exposure to soil, each area of potential concern (e.g., B10, B5, etc.) was assumed to correspond to an EU. In some cases, adjacent buildings were considered as one EU due to their proximity to each other. The EPC for a COPC in an area of potential concern/EU was derived from the concentrations measured in soil samples collected from the area of potential concern during the RI. Specifically, the EPC was set to the 95% upper confidence limit (UCL) of the mean calculated from the RI soil data using ProUCL 4.1.01 (USEPA 2010). The EPCs are presented in Table 5-4 along with other statistical parameters for the RI soil data sets from each area of potential concern. For B5 and B17, soil samples which were likely impacted by deteriorated asphalt (marked in Table 4-12) were not included in data set when calculating the EPCs for these areas. After the asphalt-impacted results were removed, outlier tests were performed on all the data sets using ProUCL 4.1.01; values that were considered outliers at a 1% significance level were removed from the data set prior to calculating EPCs. The outliers removed are shown in Table 5-4. ProUCL 4.1.01 data are located in Appendix D.

Risks were calculated from exposure to groundwater for the Groundwater EUs shown in Figure 4-6 and used in screening groundwater data in Section 4.3.3. The Groundwater EUs with identified COPCs include the West Parcels Area (Industrial Complex-B44 and Industrial Complex-NI well). No COPCs were identified in the Quillayute Airport Groundwater EU (see Section 4.3.3). The delineation of these Groundwater EUs is based on hydrogeological and contaminant distribution data collected during the RI, and land use at the site. The West Parcels Area was defined as a Groundwater EU because the groundwater system in this area northwest of Runway #2 appears to be separate from the groundwater system south/southeast of Quillayute Road, (Section 3.3 and Figure 4-6). The groundwater in the vicinity of the B44 slab was considered as a separate EU from the groundwater in the vicinity of the NI well based on the distribution of carbon tetrachloride and groundwater levels. Grouping of the wells in the Quillayute Airport Groundwater EU was based on land use and the observation that carbon tetrachloride detected in the Industrial Complex wells south of Quillayute Road has not been detected in any wells located in the Quillayute Airport portion of the Industrial Complex Area.

Groundwater EPCs for each of the Groundwater EUs were derived from the carbon tetrachloride and bis(2-ethylhexyl)phthalate groundwater data collected during the 2006 groundwater investigation and the RI (Tables 4-15 and Table 4-16). Specifically, if there were more than two detections, the EPC was set to the median of the detected concentrations; however, if there were only two detections the EPC was set to the average. Table 5-5 presents the selected EPCs as well as statistical information regarding the data set used to derive the EPC for each Groundwater EU.

Table 5-6 shows the indoor air EPCs for the residential home at the B44 slab used in the risk calculations. Several sets of indoor air EPCs were calculated from the RI data. These include:

(1) EPCs calculated from crawl space data collected in 2011 and a VAF of 0.9, which is the 95% crawl space-to-indoor air attenuation factor in the vVI database compiled by USEPA (2012b).

(2) EPCs calculated from the ambient air data collected in 2011 and the same VAF of 0.9 used for the crawl space data. Inclusion of this EPC is to assess risks from ambient air.

(3) EPCs calculated from the soil gas data collected in 2010 from a depth of 6 feet bgs and a VAF of 0.3, which is the 95% soil gas-to-indoor air attenuation factor in a VIdatabase compiled by USEPA (2012b).

(4) EPCs calculated from the soil gas data collected in 2010 from depths of 6 to 18 feet bgs and a VAF of 0.3 (USEPA 2012b).

The DoD VI Handbook (DoD 2009) states that, in general, data collected closer to the receptor are considered more relevant than data collected further from the receptor. Thus, the EPC and estimated risks derived from the crawl space data are more relevant than the EPC and estimated risks from the soil gas data for the current configuration of the residence at B44 (i.e., a mobile home on the B44 concrete slab). The risks from the soil gas data may be more relevant for a potential future scenario consisting of a residence with a basement.

5.3 TOXICITY ASSESSMENT

In accordance with guidance from USEPA, toxicity values for the COPCs were obtained from the following three-tiered hierarchy:

- Tier 1 – USEPA's Integrated Risk Information System (IRIS) (http://www.epa.gov/IRIS/)
- Tier 2 – USEPA Provisional Peer Reviewed Toxicity Values
- Tier 3 – Other toxicity values from additional USEPA and non-USEPA sources, including California Environmental Protection Agency (Cal-EPA), Agency for Toxic Substances and Disease Registry (ATSDR) minimum risk levels, and USEPA's Health Effects Assessment Summary Tables

Table 5-7 and Table 5-8 present the carcinogenic and non-carcinogenic toxicity values for the COPCs at the site. The values were obtained either from the online IRIS or Cal-EPA sources and are current for August 2012.

5.4 RISK CHARACTERIZATION

5.4.1 Method for Quantifying Potential Cancer Risk and Health Hazards

For carcinogens, risk is expressed as the probability that an individual will develop cancer over a lifetime as a result of exposure to the carcinogen. Cancer risk from exposure to contamination is expressed as the incremental lifetime cancer risk (ILCR), or the increased chance of cancer above the normal background rate of cancer. In the U.S., the background chance of contracting cancer will be a little more than three in 10, or 3×10^{-1}. The calculated ILCRs will be compared to the target range specified in the NCP of 10^{-6} to 10^{-4} or 1-in-1,000,000 to 1-in-10,000 exposed persons developing an excess cancer.

The ILCR for each medium/carcinogenic COPC was calculated using one of the equations below (USEPA 1989, USEPA 2009):

$$ILCR = I_C \times CSF \tag{3}$$

$$ILCR = IUR \times EC \tag{4}$$

Where:

I_C	=	chronic daily intake or dermal adsorbed dose for carcinogenic effects calculated in the exposure assessment averaged over the receptor's lifetime (mg/kg-day)
EC	=	exposure concentration (mg /m^3)
IUR	=	inhalalation unit risk $(mg/m^3)^{-1}$
CSF	=	cancer slope factor $(mg/kg\text{-}day)^{-1}$

For a given exposure pathway, the total risk to a receptor exposed to several carcinogenic COPCs is the sum of the ILCRs for each carcinogen, as shown below:

$$ILCR_{total} = \Sigma ILCR_i \tag{5}$$

Where:

$ILCR_{total}$	=	total probability of cancer incidence associated with all carcinogenic COPCs
$ILCR_i$	=	ILCR for the ith COPC

In addition to summing risks across all carcinogenic COPCs, risks were summed across all exposure pathways for a given environmental medium (e.g., ingestion, inhalation, and dermal contact with surface soil). It should be noted that that ILCR is an upper bound estimate of the cancer risk that may occur as a result of the exposure; the "true" cancer risk, especially for chemicals where the slope factor is based on animal data, is likely to be less and may even be zero.

In addition to developing cancer from exposure to contaminants, an individual may experience other toxic effects. The term "toxic effects" is used here to describe a wide variety of systemic effects ranging from minor irritations, such as eye irritation and headaches, to more substantial effects, such as kidney or liver disease and neurological damage. The risks associated with toxic (i.e., non-carcinogenic) chemicals were evaluated by comparing an estimated exposure (i.e., intake or dose) from site media to an acceptable exposure expressed as a reference dose (RfD) for daily oral exposure or reference concentration (RfC) for inhalation exposure. The RfD and RfC are threshold levels below which no toxic effects are expected to occur in a population, including sensitive subpopulations. The ratio of intake over the RfD or RfC is the hazard quotient (HQ) (USEPA 1989) and was calculated using one of the equations below:

$$HQ = {I_{NC}}/{RfD} \tag{6}$$

$$HQ = {EC}/{RfC} \tag{7}$$

Where:

I_{NC}	=	daily intake or dermally absorbed dose of a COPC for non-carcinogenic effects averaged over the exposure duration (mg/kg-day)
EC	=	exposure concentration (mg/m^3)
RfD	=	reference dose (mg/kg-day)
RfC	=	reference concentration (mg/m^3).

The HQs for each pathway will be summed to obtain a Hazard Index (HI) for each COPC:

$$HI = \Sigma HQ_i \tag{8}$$

Where:

HI	=	hazard index for all toxic effects
HQ_i	=	hazard quotient for the ith pathway (ingestion, dermal contact, inhalation)

An HI greater than one has been defined as the level of concern for potential adverse non-carcinogenic health effects (USEPA 1989). This approach differs from the probabilistic approach used to evaluate carcinogens. An HQ of 0.01 does not imply a 1-in-100 chance of an adverse effect, but indicates only that the estimated intake will be 100 times less than the threshold level at which adverse health effects may occur. An HI of 1 or less indicates that adverse non-cancer health effects are considered to be extremely unlikely, even if the exposure occurs over a lifetime.

The results of the risk and hazard calculations are presented in the following sections.

5.4.2 Risk and Hazard Estimates

5.4.2.1 Risks and Hazards from Exposure to Soil at the Site

The calculated carcinogenic risks from exposure to soil in the areas of potential concern are presented in Table 5-9 and 5-10, for the RME and CTE scenarios respectively. Risks are calculated for all the possible receptors within the site even though at B41 (located on the same property as the B44 slab), the only site receptors are the residential receptors given current land use. The highest carcinogenic risks are associated with soils at B5 with an ILCR of $1x10^{-5}$ for the resident adult under the RME scenario (Table 5-9) and $8x10^{-6}$ under the CTE scenario (Table 5-10). Of the three COPCs in soil at B5, the largest contribution to risk comes from carcinogenic PAHs represented by BaP-Eq. The risk from pentachlorophenol ($2x10^{-6}$) contributes less than 20% to the total risk from exposure to soil at B5. For a number of areas of potential concern, the calculated risks exceed the lower limit, but are within the target NCP risk range (10^{-6} to 10^{-4}). According to the MTCA, the target risk for exposure to soil is one in one hundred thousand (10^{-5}); this target is not exceeded in any of the areas of potential concern where COPCs in soil are present (Table 5-9 and Table 5-10).

Hazards from exposure to soil are presented in Table 5-11 and Table 5-12 for the RME and CTE scenarios, respectively. For many of the areas of potential concern, HI values cannot be calculated because there are no available non-carcinogenic toxicity values for benzo(a)pyrene or other carcinogenic

PAHs. Using available non-carcinogenic toxicity values for pentachlorophenol and naphthalene, the resulting HI from exposure to these chemicals were below 1 under both the RME and CTE scenarios.

5.4.2.2 Risks and Hazards from Exposure to Groundwater at the Site

The calculated carcinogenic risks from exposure to groundwater are presented in Table 5-13 and Table 5-14, for the RME and CTE scenarios respectively. Carcinogenic risks within the West Parcels Groundwater EU are below 10^{-6} for all site receptors for both RME and CTE scenarios. Estimated risks exceed 10^{-6} but are still below 10^{-4} (the upper range of the NCP target risk range) for the resident adult receptor in the vicinity of the B44 slab, and for both the resident adult and child receptors in the vicinity of the NI well under the RME scenario (Table 5-11). None of the calculated risks exceed the MTCA target risk of 10^{-5}.

Hazards from exposure to groundwater are presented in Table 5-15 and Table 5-16 for the RME and CTE scenarios, respectively. The hazard indices for all Groundwater EUs are below 1.

5.4.2.3 Risks and Hazards from Exposure to Indoor Air at the B44 Slab

The calculated carcinogenic risks from exposure to indoor air at the B44 slab are presented in Table 5-17 and Table 5-18 for the RME and CTE scenarios, respectively. No indoor air samples were collected during the RI; as such the risks were calculated from the crawl space and soil gas data using attenuation factors published by USEPA (2012b). Furthermore, the estimated risks from the crawl space data are considered more relevant than the risks estimated from the soil gas data for the current configuration of the residence at B44. The soil gas data are less relevant because these were collected further away from the current receptor (DoD 2009). Risks from the soil gas data may be appropriate for evaluating a potential future scenario consisting of a residence with a basement.

The estimated carcinogenic risks from the crawl space data for the resident child are at or below the NCP target risk range (10^{-6} to 10^{-4}) for both the RME and CTE scenarios, while the estimated risks based on the soil gas data exceed 10^{-4}. The estimated carcinogenic risks for the resident adult based on the soil gas data exceed exceed 10^{-4}, however, as noted previously, the risks estimated from the crawl space data are considered more reliable because the air measurements were collected closer to the receptor (DoD 2009). The estimated carcinogenic risks for the resident adult from the crawl space data are both approximately $3x10^{-6}$ for the RME and CTE scenarios, respectively. These exceed the lower limit but are below the upper limit of the NCP target risk range, and are below the MTCA target risk of 10^{-5}. All four indoor air COPCs were detected at comparable concentrations between the crawl space and ambient air samples (Table 4-18, estimated risks from ambient air are shown in Tables 5-17 and 5-18). Thus if these COPCs were present in the residence on the B44 slab, a possible source for these COPCs would be ambient air in addition to, or rather than, subsurface contamination in the vicinity of the B44 slab.

Hazard indices from exposure to indoor air are presented in Table 5-19 and Table 5-20 for the RME and CTE scenarios, respectively. Similar to the carcinogenic risk estimates, the hazard indices are calculated using indoor air EPCs estimated from the crawl space and soil gas data. The hazard indices are below 1 based on the crawl space data; the hazard indices exceeded 1 based on the soil gas data.

5.5 UNCERTAINTY ANALYSIS

Site-specific factors that contribute to uncertainty need to be considered when using the risk and hazard calculations for decisions regarding remedial actions at the site. These factors are discussed below.

5.5.1 Uncertainties in Land Use

There is some uncertainty regarding future land use in portions of the site that are currently undeveloped, i.e., the East Parcels area (B101/B102 area of potential concern) and the Industrial Complex area south/southeast of Quillayute Road in the vicinity of B4 and B9. However, the estimated risks for residential receptors from exposure to soil in these undeveloped areas are below 10^{-6} (Table 5-9). Thus, even if the undeveloped land were developed for residential use, residual contamination in surface soil is not anticipated to pose unacceptable risks to future residents.

Within the Quillayute Airport portion of the Industrial Complex Area, the risks for residential receptors from exposure to soil at B5 were within the target NCP risk range but found to exceed the target MTCA risk of 10^{-5} (Table 5-9); risks were at or below the MTCA target for the current receptors including on-site indoor and outdoor workers, excavation/construction workers and visitors. The likelihood of the airport property being developed in the future to a residential area must be considered when evaluating and selecting a remedy for addressing contaminated soil at B5. The comparison of PAHs in soil samples collected from 3 to 6 inches and 6 to 9 inches indicates a significant decrease in PAH concentrations in soil samples collected from 6 to 9 inches. The area surrounding B5 is currently covered by heavy vegetation which will have to be removed if this area were used for either residential or airport/commercial purposes. Removal of the heavy vegetation during re-development will likely result in the removal of PAH-contaminated soil from the area.

With regards to groundwater underlying the site, there are several water supply wells within the site that draw water from the same depths where COPCs carbon tetrachloride and bis(2-ethylhexyl)phthalate were detected in monitoring wells. Based on this known groundwater use, risks from exposure to groundwater in the residential areas (Industrial Complex Area in the vicinity of the B44 slab, Industrial Complex Area in the vicinity of the NI well, and West Parcels Area) were evaluated for residential receptors (Table 5-13 and Table 5-14). Using residential screening criteria, no COPCs were identified in the groundwater underlying the Quillayute Airport portion of the Industrial Complex Area which indicates there are no unacceptable risks from exposure to groundwater in this area under both commercial and residential use.

5.5.2 Uncertainties in Exposure Point Concentrations

The EPCs for soil in the areas of potential concern were based on soil samples collected from the vicinity of the buildings. For some of the areas of potential concern (B20 and B49, Table 5-4), only four data points were available from which to derive EPCs. To compensate for this uncertainty, the maximum concentrations in the small data sets from B20 and B49 were used as the EPCs. A relatively high number of sample points (16) were available from B5, the most contaminated area of potential concern.

There is a high level of uncertainty in the EPCs used for pentachlorophenol in B5, B17, and B20; pentachlorophenol was not detected in any of the soil samples from these areas of potential concern however this chemical was identified as a COPC because practical quantitation limit for the samples were higher than the screening level (Table 4-10). Even with this conservative approach, the resulting total risks for residential receptors at B17 and B20 were below the MTCA target range of $1x10^{-5}$ (Table 5-9). At B5, the total risks for residential receptors exceed $1x10^{-5}$ however pentachlorophenol contributes approximately 10% to the overall risk. Thus, the overall impact of the uncertainty in the pentachlorophenol EPC appears to be minimal. Pentachlorophenol was formerly a widely used biocide but its use is currently restricted and it is no longer available to the general public. When used as a wood preservative, pentachlorophenol is either applied through a pressure-treating process in a wood treatment facility or by non-pressurized means such as spraying, brushing or dipping. The non-pressurized process is often applied for short-term protection in construction (Fisher 1991). Pressure-treated wood may have

been used to construct buildings at the former NAAS Quillayute; however, regular use for maintenance operations is considered unlikely.

The EPCs for groundwater at each EU (Table 5-5) were based on the median/average of the detected concentrations of bis(2-ethylhexyl)phthalate and carbon tetrachloride in groundwater samples collected from each Groundwater EU (Table 4-15 and Table 4-16). For bis(2-ethylhexyl)phthalate in the West Parcels Area (Table 4-18), the EPC was set to the median of the detected concentrations (0.5 µg/L), which is approximately an order of magnitude lower than the highest detections of this chemical of 36 and 24 µg/L in monitoring well MW-8 and B21, respectively. As such, the resulting estimated risk using the EPC of 0.48 µg/L may be underestimated. In both monitoring well MW-8 and B21, subsequent analyses showed levels of bis(2-ethylhexyl)phthalate that are lower (0.51 and 0.48 µg/L, see Table 4-18) and comparable to the selected EPC.

There is uncertainty for EPCs used to estimate indoor air concentrations at the B44 slab (Table 5-6). The VAF used in deriving indoor air EPCs from crawl space concentrations are based on studies in structures with enclosed basements (USEPA 2012b) whereas the residential structure on the concrete slab of former B44 building is a mobile home with a partially enclosed crawl space between the structure's floor and the slab.

The levels of 1,2-dichloroethane, benzene, carbon tetrachloride and PCE in the crawl space air samples are comparable to the levels detected in the ambient sample collected during the same sampling event in December 2011 (Table 4-18). The results of the 2011 ambient air analysis are different from the results of the 2010 ambient air sampling in that no analytes were detected in 2010. This discrepancy may be due to the higher detection limits in the 2010 analyses which would have precluded the detection of the chemicals at the levels measured in 2011. Different locations of the ambient air sample may have influenced the concentrations detected as the owner of the mobile home indicated to USACE during one of the sampling events that he has used carbon tetrachloride outside as a cleaner. Oscar is the resident of the property/residence where vapor intrusion was evaluated.

Carbon tetrachloride is known to be ubiquitous in the atmosphere because it is relatively resistant to degradation with a residence time of 30 to 50 years (ATSDR 2005, WDOE 2008). The reported average concentration of carbon tetrachloride in six monitoring sites in Bellingham (located near Seattle, Washington) during 2001-2002 was 0.67 $\mu g/m^3$ (WDOE 2008), which is comparable to the concentrations detected in the crawl space and ambient air samples. Thus, the carbon tetrachloride and other VOCs detected in the crawl space air samples may be representative of background conditions rather than reflecting an impact from subsurface contamination.

6. BASELINE ECOLOGICAL RISK ASSESSMENT

The BERA presented in this section is an integration of the findings during the ecological reconnaissance performed in March 2012 and the analytical results from the RI (Shannon and Wilson 2012). The ecological reconnaissance and documentation/analysis focus on the western portion of the Industrial Complex Area since the majority of areas of potential concern identified by previous historical research are located in this former NAAS Quillayute area. The observations from the ecological reconnaissance are presented in Section 3.5; this section describes the approach and results of ecological risk estimates.

The ecological reconnaissance, documentation of findings and analysis follows MTCA (WAC 173-340, WDOE 2007), USEPA guidance published in Guidelines for Ecological Risk Assessment (EPA/630/R-95/002F) (USEPA 1998), USEPA Ecological Risk Assessment Guidance for Superfund (USEPA 1997a) and USEPA Region 10 Supplemental Ecological Risk Assessment Guidance for Superfund (USEPA 1997b).

6.1 SUMMARY OF RISK SCREENING

As part of analysis conducted during the RI (Shannon and Wilson 2012) and the BHHRA (Section 5), analytical results were compared to screening limits and regulatory criteria for soil, water, soil gas and ambient air. This included comparison of soil and groundwater data to Washington MTCA regulatory criteria (WAC 173-340, WDOE 2007). As part of the BERA, additional screening of soil and groundwater analytical results documented in the draft versions of the RI report (Shannon and Wilson 2010, 2012) was conducted using ecological criteria. Based on review and past discussions with USACE-Seattle District, ecological indicator soil concentrations listed in the Washington State MTCA guidance were used to further analyze site data. Ecological Soil Screening Levels (Eco-SSLs) were used as these values are presumed to provide adequate protection of terrestrial ecosystems. Detected hazardous substances and their ecological soil screening limits [MTCA Tables 749-2 and 749-3in WDOE (2007); USEPA Eco-SSLs in USEPA (2012c)] were compared to existing chemical data documented at the site during the RI. Hazardous substances for which maximum detected concentrations exceeded soil limits were identified as CPECs. Documented CPECs were limited to soil concentrations because existing data consist primarily of soil analyses. Surface water and sediment data were not available and groundwater samples were only collected from existing monitoring wells.

The Runway Approach Zones, Army Cantonment/HOMOJA Housing Area, Administration and Operations Area, West Parcels Area, East Parcels Area and the eastern part of the Industrial Complex Area were excluded from the ecological reconnaissance because there were no CPECs in these areas based on a review of the RI data. A majority of the areas of potential concern are located in the western portion of the Industrial Complex Area.

Soil sampling was conducted for PCBs, SVOCs (including PAHs), and silver; elevated concentrations of silver were detected near B12. PCBs (PCB-Aroclor 1262 and PCB 1268) were detected at B41; however, the detections were below risk based screening criteria. The detection of silver was between 3 and 6 feet bgs. Ecological indicator soil concentration screening levels (Table 749-3 MTCA guidance) are available for silver and therefore silver is carried forward as a CPEC in this BERA.

Subsurface soil sampling was conducted for VOCs and identified one location with elevated concentrations of contaminants of concern near the B44 slab. The detection of VOCs (methylene chloride and PCE) was at 25 feet bgs and is well below the biotic zone at a depth that will unlikely be excavated. No ecological indicator soil concentration screening levels (Table 749-3 MTCA guidance) are available

for methylene chloride or PCE. Subsurface soil detections above screening levels for metals were documented at depths of 17 and 18 feet for barium, chromium, copper, iron, manganese and mercury in samples taken during the installation of monitoring wells MW-14, MW-15, and MW-17. At these depths, it is unlikely that excavation or disturbance of these areas will occur and no ecological impacts are expected from exposure to soils at these depths.

Groundwater sampling from residential wells and existing monitoring wells did not identify contaminants of concern that could be associated with DoD use of the facility, with the possible exception of carbon tetrachloride that has been detected in the western portion of the Industrial Complex Area. Carbon tetrachloride was detected at 6.8 ug/L in the NI well which exceeds risk based screening criteria. However, carbon tetrachloride is not considered a CPEC because it is present in groundwater (i.e., below the ground surface) and was not detected in the man-made pond on the Neilson Property (the only surface water present on-site). Vinyl chloride was detected in the NI well above risk based screening criteria after a carbon filtration system. Because the sample collected before the filter did not contain vinyl chloride, the detection above screening levels was deemed to be introduced by the filtration system. Other detections below risk based screening criteria included carbon tetrachloride, chloroform, and bromodichloromethane at the NI well; carbon tetrachloride, 1,3-dinitrobenzene, bromodichloromethane and chloroform at MW-1; arsenic and carbon tetrachloride at MW-2; and carbon tetrachloride at MW-12. No evidence of contamination was found in the suspected liquid disposal area or the tetraethyl lead disposal area (sludge disposal area). Monitoring well and residential water supply wells sampled indicate the borrow pits are not a source of downgradient groundwater contamination (Shannon and Wilson 2012).

6.2 PROBLEM FORMULATION

This section includes discussion of development and refinement of CPECs,, selection of assessment endpoints, literature survey findings and development of risk hypotheses for each assessment endpoint.

6.2.1 Chemicals of Potential Ecological Concern

Analogous to COPCs for human health risk calculations described in Section 5, CPECs are chemicals that are deemed to be present in environmental media at high enough levels to warrant quantification of ecological risks. For this BERA, a preliminary screening of the data was performed followed by selection of CPECs based on refined criteria as described below.

6.2.2 Preliminary Screening and Selection of Chemicals of Potential Ecological Concern

Based on the review of existing chemical data in the RI (Shannon and Wilson 2012), it was determined that surface water and sediment data were not available and groundwater samples were only collected from existing monitoring wells. Therefore, documented CPECs were limited to soil concentrations because existing data consist primarily of soil analyses (Table 6-1).

All chemicals measured at concentrations exceeding laboratory detection limits within soil were subjected to a screening based on comparisons of detected concentrations to conservative ecological indicator soil concentrations documented in the Washington State MTCA guidance (Table 749-3, MTCA, Chapter 173-340-WAC). This initial screening identified silver as a CPEC within the western portion of the Industrial Complex Area (Table 6-1).

6.2.3 Refinement

Selection of preliminary CPECs was based on conservative assumptions that contaminants exceeding ecological screening limits may impact the environment. Refinement of CPECs is based comparison of preliminary CPECs with site-specific information. Reevaluation of CPECs will be based on comparisons

with the following data: 95% UCL calculations, HQ calculations, wildlife exposure parameter calculations, and a literature survey of natural and anthropogenic background concentrations.

6.2.3.1 95% Upper Confidence Limit Exposure Concentrations

Following the ecological reconnaissance, the 95% UCL process was initiated to refine CPECs using statistical software, ProUCL 4.1.01, published by the USEPA (2010). However, the single silver detection above screening was eliminated from the data set during the outlier analysis and therefore the 95% UCL calculation was not completed. Furthermore, there are no CPECs to be carried forward further in this ecological risk assessment process and no ecological conceptual site model was developed.

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7. SUMMARY AND CONCLUSIONS

7.1 HUMAN HEALTH RISK ASSESSMENT

7.1.1 Summary of Baseline Human Health Risk Assessment

The BHHRA evaluated risks and hazards to site receptors from exposure to residual contamination at the site under baseline conditions. Chemical analyses of soil, groundwater, soil gas and crawl space air samples collected during the RI (Shannon and Wilson 2012) and groundwater analyses from a previous investigation (URS 2007) were compared to risk-screening criteria to identify COPCs that were carried forward into the quantitative risk assessment. The screening levels consisted of the minimum of risk-based screening criteria from MTCA Method B (WDOE 2007, downloaded from the State of Washington CLARC database in July 2012) and USEPA RSLs (USEPA 2013). For metals, MTCA Method A criteria were used because these levels accounted for regional background concentrations. Chemicals that were detected at concentrations that exceeded the screening levels were identified as COPCs and carried forward into the quantitative risk assessment.

The chemicals that were identified as COPCs in soil were: benzo(a)pyrene and other carcinogenic PAHs, pentachlorophenol and naphthalene. VOCs and PCBs were not identified as COPCs. Risks and hazards for site receptors were calculated for soil COPCs using standard methods provided in USEPA guidance for conducting risk assessments. Based on current land use and Clallam County zoning laws, the site receptors include the indoor and outdoor worker (i.e., airport maintenance and operators), excavation/construction worker, visitor/recreationist adult/child and resident adult/child. The highest carcinogenic risks are associated with soils at B5 (a former transportation maintenance building) with an estimated risk of 1.2×10^{-5} for the resident adult under the RME scenario and 7.8×10^{-6} under the CTE scenario; the largest risk was contributed by carcinogenic PAHs. None of the estimated risks from exposure to soil at NAAS Quillayute exceeds the target risk range of 10^{-6} to 10^{-4}. All of the HIs associated with exposure to soil were below 1.

The chemicals that were identified as COPCs in groundwater were bis(2-ethylhexyl)phthalate and carbon tetrachloride. Risks and hazards from exposure to groundwater were calculated for groundwater underlying the West Parcels Area, the vicinity of the B44 slab within the Industrial Complex Area, and the vicinity of the NI well within the Industrial Complex Area. No COPCs were identified for groundwater underlying the Quillayute Airport portion of the Industrial Complex Area. The delineation of these Groundwater EUs is based on the observed hydrogeological characteristics, contaminant distribution, and land use at the site. Carcinogenic risks within the West Parcels Groundwater EUs are below 10^{-6} (low end of the NCP target range) for all site receptors. Estimated risks exceed 10^{-6} for the resident adult receptor in the vicinity of the B44 slab within the Industrial Complex Area, and for both the resident adult and child receptors in the vicinity of the NI well within the Industrial Complex Area l, with all of the risks from carbon tetrachloride. The estimated risks are within the NCP target risk range of 10^{-6} to 10^{-4} and are below the MTCA target risk of 10^{-5} for all site receptors at all Groundwater EUs.

Concerns regarding VI at the location of the B44 slab and the vicinity of the NI well were addressed during the RI through the collection of soil gas, crawl space, and ambient air samples. The concentrations of VOCs detected in these samples were compared to indoor air screening levels converted by VAFs provided by USEPA (2012b). VOC concentrations in the soil gas samples from the vicinity of the NI well were below the soil gas screening. Benzene, carbon tetrachloride, and 1,2-dichloroethane concentrations in the crawl space air samples from the B44 slab were above the crawl space criteria; although, comparable concentrations were measured in the ambient air sample. Carbon tetrachloride and PCE

concentrations in soil gas samples exceeded the soil gas screening criteria. These four chemicals were then carried forward into a quantitative risk assessment.

EPCs for indoor air were estimated using the crawl space and soil gas data collected in 2011 and 2010, respectively. EPCs for indoor air estimated from the crawl space data were set to the average of the crawl space air concentrations multiplied by 0.9, the VAF factor provided by USEPA (2012b) for attenuation from crawl space to indoor air. EPCs for indoor air estimated from the soil gas data were set to the average of the soil gas concentrations multiplied by an attenuation factor of 0.3 (USEPA 2012b). The estimated risks from VI based on the crawl space data were below the target NCP risk range of 10^{-6} to 10^{-4} for the resident child, but the estimated risks for the resident adult was above the lower range and below the upper limit of the NCP risk range. Risks estimated from the soil gas data were higher than the estimated risks from the crawl space air concentrations. For the current configuration of the residence at B44, the risks estimated from the crawl space data are more relevant than the risks from the soil gas data because the crawl space data represent conditions closest to the current receptor. The risks from the soil gas data may be more appropriate to consider for a potential future scenario of a residence with a basement.

The concentrations of VOCs in the crawl space air sample were comparable to the concentrations of these chemicals in the ambient air sample collected during the same sampling event in 2011. This observation suggests that the VOCs in these air samples may be from sources other than VI from the subsurface. Shannon and Wilson (2012) mentioned the possibility of household cleaners. The calculated HI values from exposure to indoor air COPCs are below 1 for EPC based on the crawl space air concentrations, however the HI values are greater than 1 for EPCs based on the soil gas data. The EPCs and risks calculated from the crawl space data are more representative of current conditions while the risks from the soil gas data are appropriate for a potential future residence with a basement.

7.1.2 Conclusions of Human Health Risk Assessment

The BHHRA results indicate that risks are within the target NCP risk range of 10^{-6} and 10^{-4} from exposure to soil. The highest risk (1.2×10^{-5}) was calculated for residential exposure to soils at B5 (former Transportation Maintenance Building) but estimated risk are below 10^{-5} for current and other potential receptors at B5 (including indoor and outdoor workers, visitors, excavation/construction workers). Data collected during the RI indicated that benzo(a)pyrene and other carcinogenic PAHs, which contributed the most to the risk at B5, was only present at elevated levels up to a depth of six inches. The area surrounding B5 is currently covered by heavy vegetation which will have to be removed if this area was used in the future either for residential or airport/commercial purposes. Removal of the heavy vegetation as well as earthwork during re-development may result in the removal of PAH-contaminated soil from the area. Risks associated with soils from the other areas of potential concern at the site are below 10^{-5}.

Estimated risks from exposure to groundwater underlying the Industrial Complex Area-B44 slab and the Industrial Complex Area-NI well exceed the lower limit of the target NCP range, 10^{-6}, but are below 10^{-5}. The only chemical contributing to risk at these Groundwater EUs is carbon tetrachloride. No COPCs were identified in groundwater underlying the Quillayute Airport portion of the Industrial Complex Area. In the West Parcels Area, the only COPC based on existing groundwater data is bis(2-ethylhexyl)phthalate and the estimated risks from exposure to this chemical in groundwater are below 10^{-6}.

The concentrations in the crawl space air samples at the B44 slab being comparable to concentrations in the ambient air sample collected in 2011, suggesting that risks from exposure to VI from the subsurface may be no different than when compared to risks from the diffuse presence of these VOCs in the ambient air.

Chemicals of concern (COCs) are COPCs for which associated risks exceed the lower range of the NCP target risk level of 10^{-6} and hazards exceed 1. Based on the results of the BHHRA, the COCs for each medium under residential land use at the former NAAS are as follows:

- Soil: Benzo(a)pyrene and other carcinogenic PAHs; pentachlorophenol.
- Groundwater: Carbon tetrachloride.
- Indoor Air: None (estimated risks for each constituent are at or below 10^{-6} based on crawl space data). Based on soil gas data, carbon tetrachloride, benzene, and PCE are COPCs with associated risks that exceed 10^{-6} and/or hazards that exceed 1.

7.2 ECOLOGICAL RISK ASSESSMENT

7.2.1 Summary of Ecological Risk Assessment

The BERA included a literature survey of sensitive species that may be present at the site as well as an ecological reconnaissance visit in March 19-20, 2012 during which species and habitats within the site where observed and documented. The ecological reconnaissance focused on the western portion of the Industrial Complex Area where a majority of the areas of potential concern were located. The literature survey reviewed indicated the potential presence of federally listed species. However, none of these species were observed during the site visit and do not have critical habitat within the study area. The results of the ecological reconnaissance were documented and maps of habitat and biodiversity types are presented in the BLRA report.

The BERA evaluated risks and hazards to site receptors from exposure to contaminants at the site. Chemical analysis of soil, groundwater, soil gas and air samples collected during the RI (Shannon and Wilson 2012) and groundwater analyses from a previous investigation (URS 2007) were compared to risk-screening criteria to identify CPECs. Based on review and past discussions with USACE-Seattle District, the screening levels consisted of ecological indicator soil concentrations listed in the Washington State MTCA guidance were used to further analyze site data. Eco-SSLs were used as these values are presumed to provide adequate protection of terrestrial ecosystems. Documented CPECs were limited to soil concentrations because existing data consist primarily of soil analyses. Surface water and sediment data were not available and groundwater samples were only collected from existing monitoring wells.

The chemicals initially identified as CPECs in soil were silver. However, the single exceedance of silver was removed from the dataset during the 95% UCL calculation process; therefore silver was removed as a CPEC. No risks or hazards for site receptors were calculated for silver as silver was not carried forward in through the risk assessment portion of this BERA.

7.2.2 Conclusions of Ecological Risk Assessment

The western portion of the Industrial Complex Area is located in a rural urban area and only common species were identified during the site investigation. Results of the BERA determined that no CPECs exist in the western portion of the Industrial Area Complex-West, therefore no potential risks exist for ecological receptors and no remediation activities are recommended.

7.3 PRELIMINARY REMEDIATION GOALS

For portions of the site that are in the Industrial Complex Area but are outside the Quillayute Airport portion, use of the MTCA Method A and Method B clean-up criteria as Preliminary Remediation Goals is appropriate given that these areas are either currently occupied by residences, or may be occupied by

residences in the future. For the areas of potential concern in the Quillayute Airport portion of the Industrial Complex Area, use of MTCA Method C (for industrial use areas) may be appropriate. Table 7-1 lists the proposed preliminary remediation goals for the former NAAS Quillayute for the COCs in soil and groundwater.

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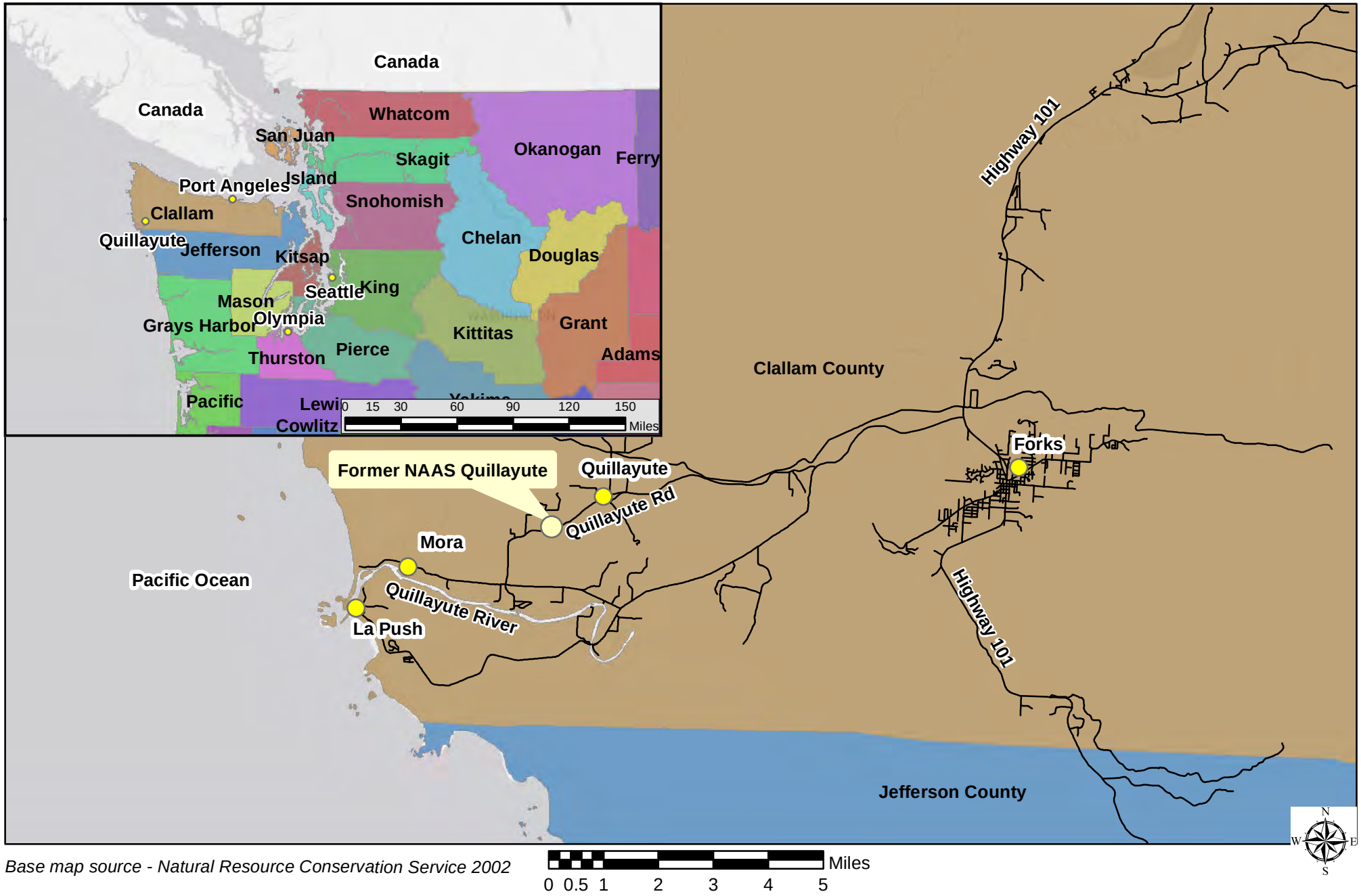

Base map source - Natural Resource Conservation Service 2002

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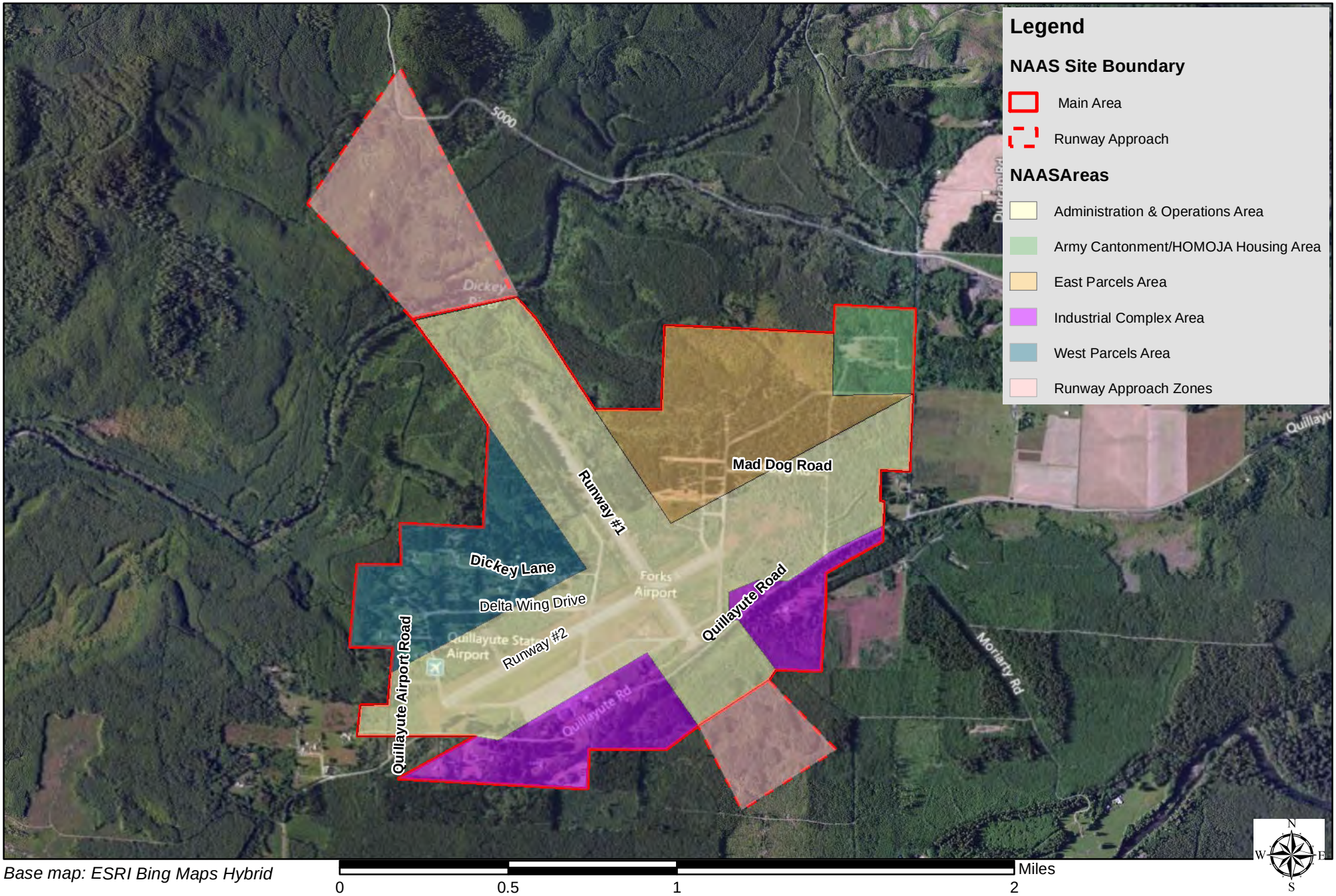
U.S. Army Corps of Engineers	**Figure 2-1. Former NAAS Quillayute Site Location Map**	**Former Naval Auxiliary Air Station Quillayute Quillayute, Washington**

Base map: ESRI Bing Maps Hybrid

U.S. Army Corps of Engineers

Figure 2-2. Site Vicinity Map

Former Naval Auxillary Air Station Quillayute Quillayute, Washington

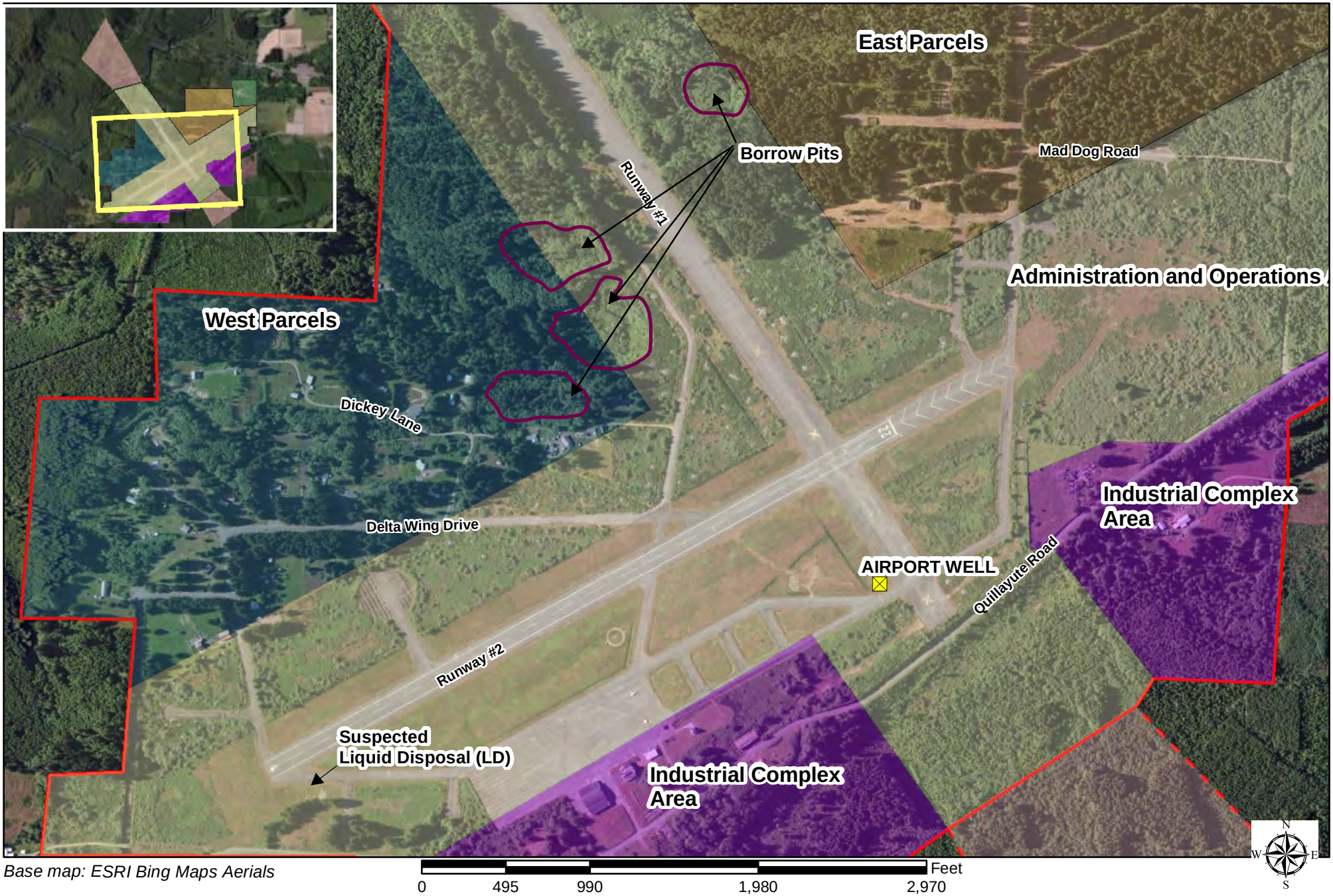


Base map: ESRI Bing Maps Hybrid

U.S. Army Corps of Engineers

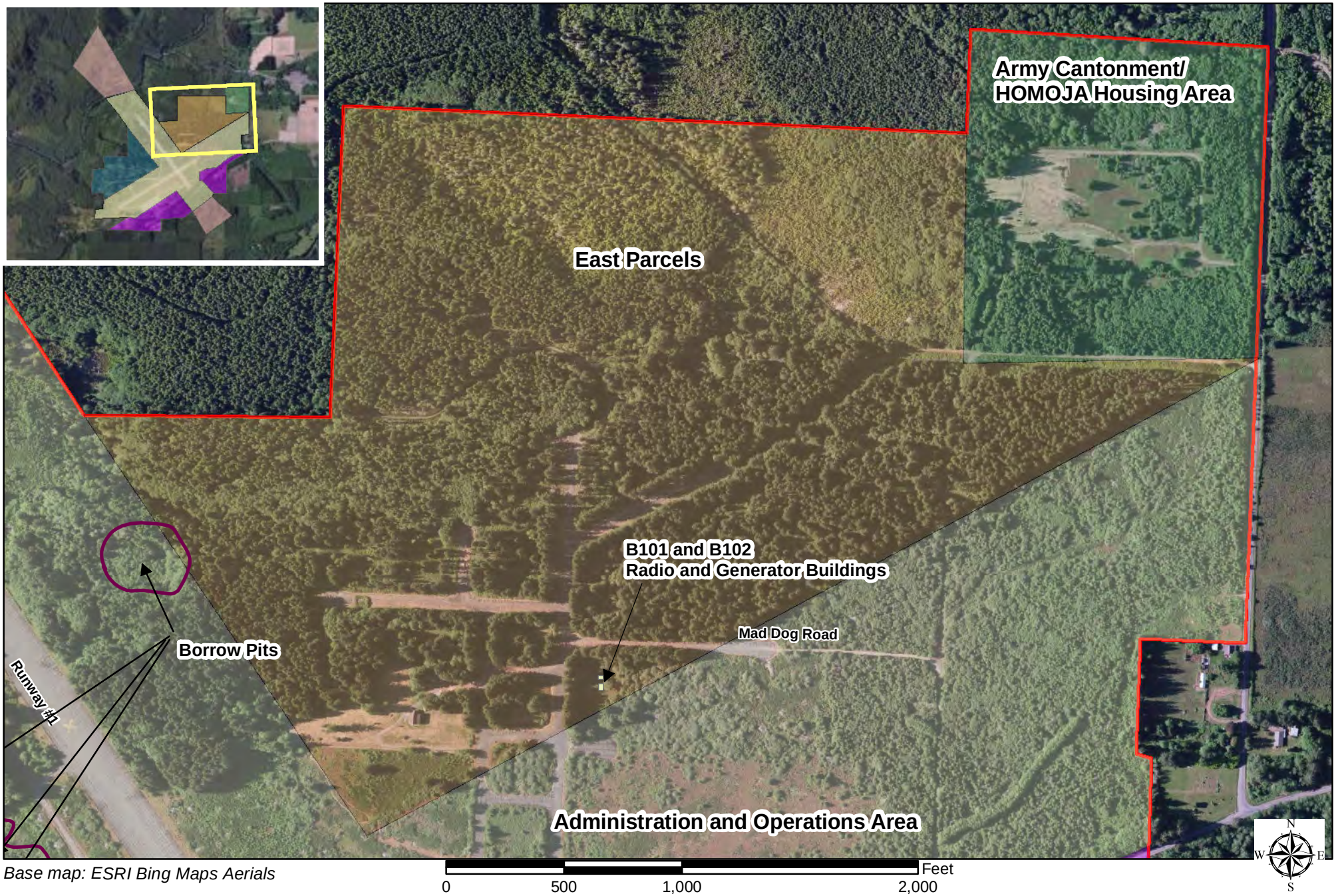
Figure 2-3. Former NAAS Quillayute Areas

Former Naval Auxillary Air Station Quillayute Quillayute, Washington



Base map: ESRI Bing Maps Aerials

U.S. Army Corps of Engineers	**Figure 2-4. Site Features and Areas of Potential Concern in the Administration and Operations Area and West Parcels Area (March 2012)**	**Former Naval Auxillary Air Station Quillayute Quillayute, Washington**

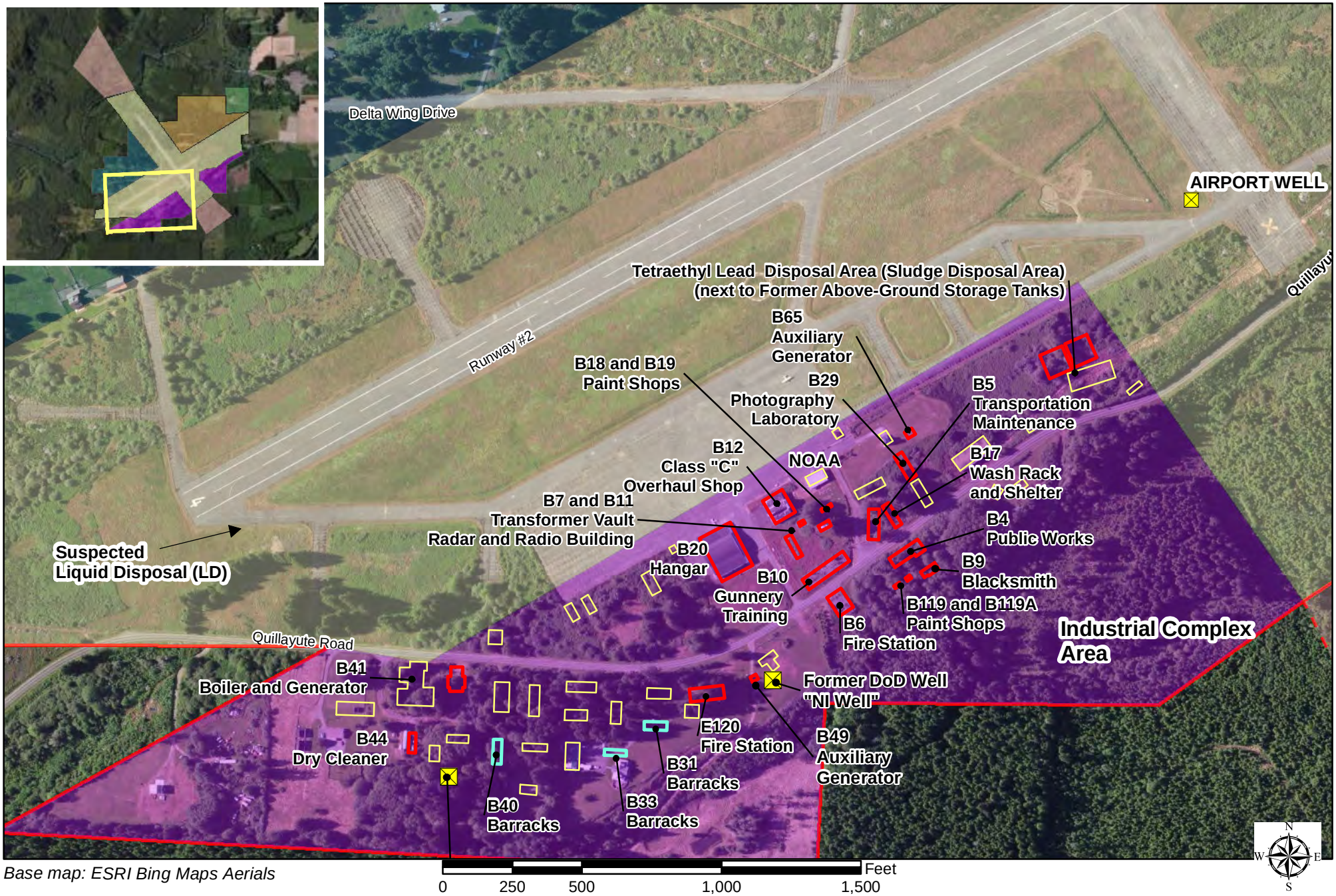


Base map: ESRI Bing Maps Aerials

U.S. Army Corps of Engineers

Figure 2-5. Site Features and Areas of Potential Concern in the East Parcels Area

Former Naval Auxillary Air Station Quillayute Quillayute, Washington

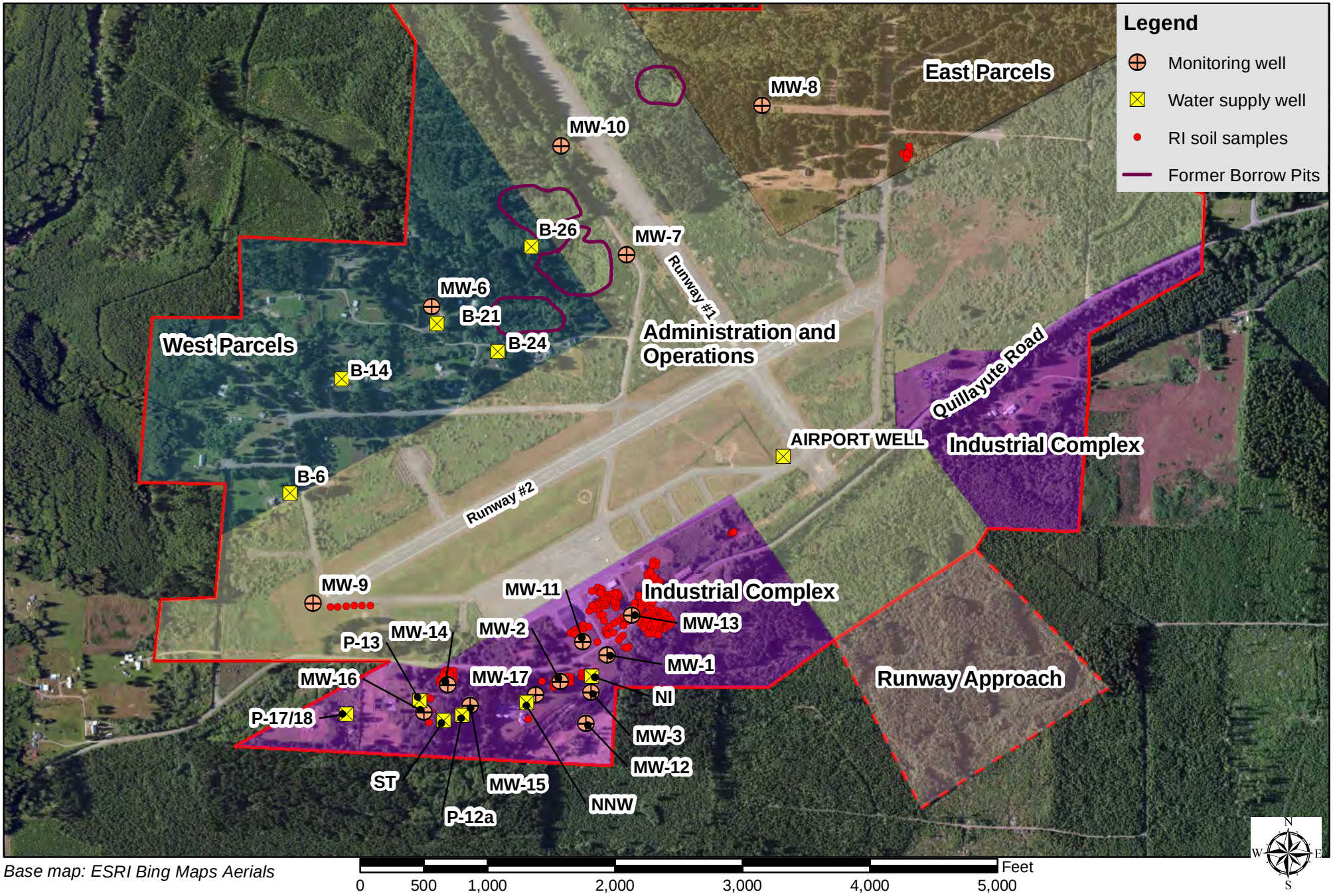


Base map: ESRI Bing Maps Aerials

U.S. Army Corps of Engineers

Figure 2-6. Site Features and Areas of Potential Concern in the Western Portion of the Industrial Complex Area

Former Naval Auxillary Air Station Quillayute Quillayute, Washington



Base map: ESRI Bing Maps Aerials

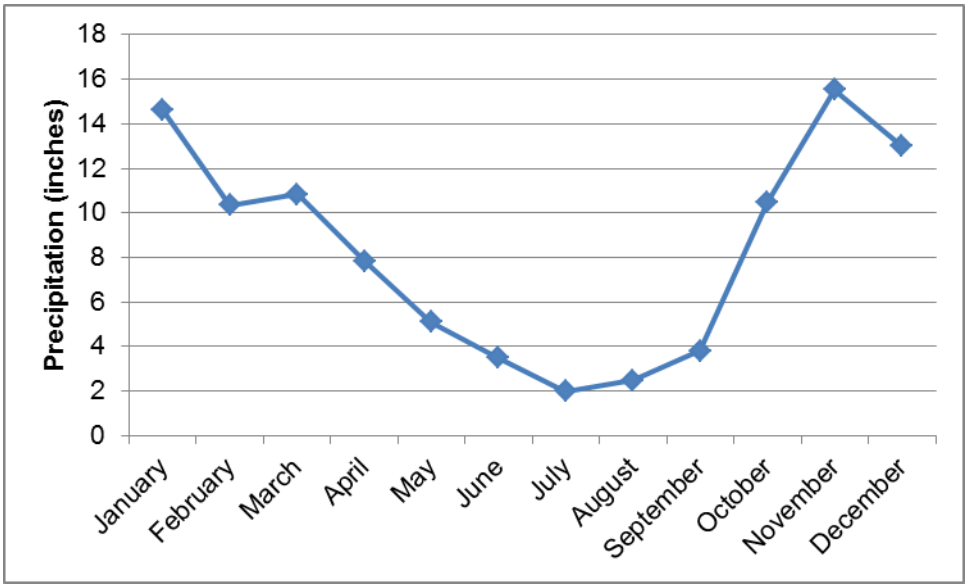
U.S. Army Corps of Engineers

Figure 2-7. Overview Map Showing Sampling Locations from Previous Investigations

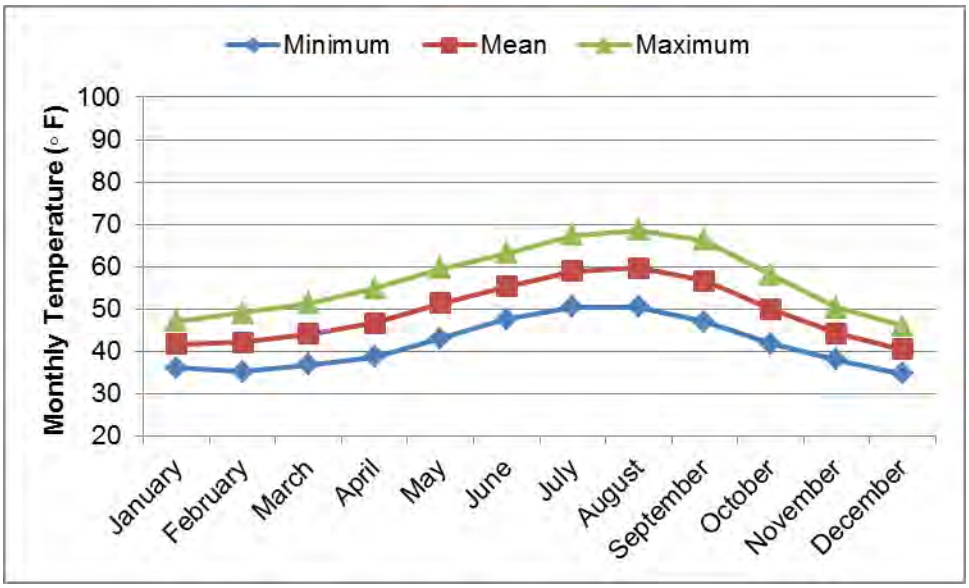
Note: The ST well has never been sampled due to problems with access. It is shown on the map for reference.

Former Naval Auxillary Air Station Quillayute Quillayute, Washington

(a)

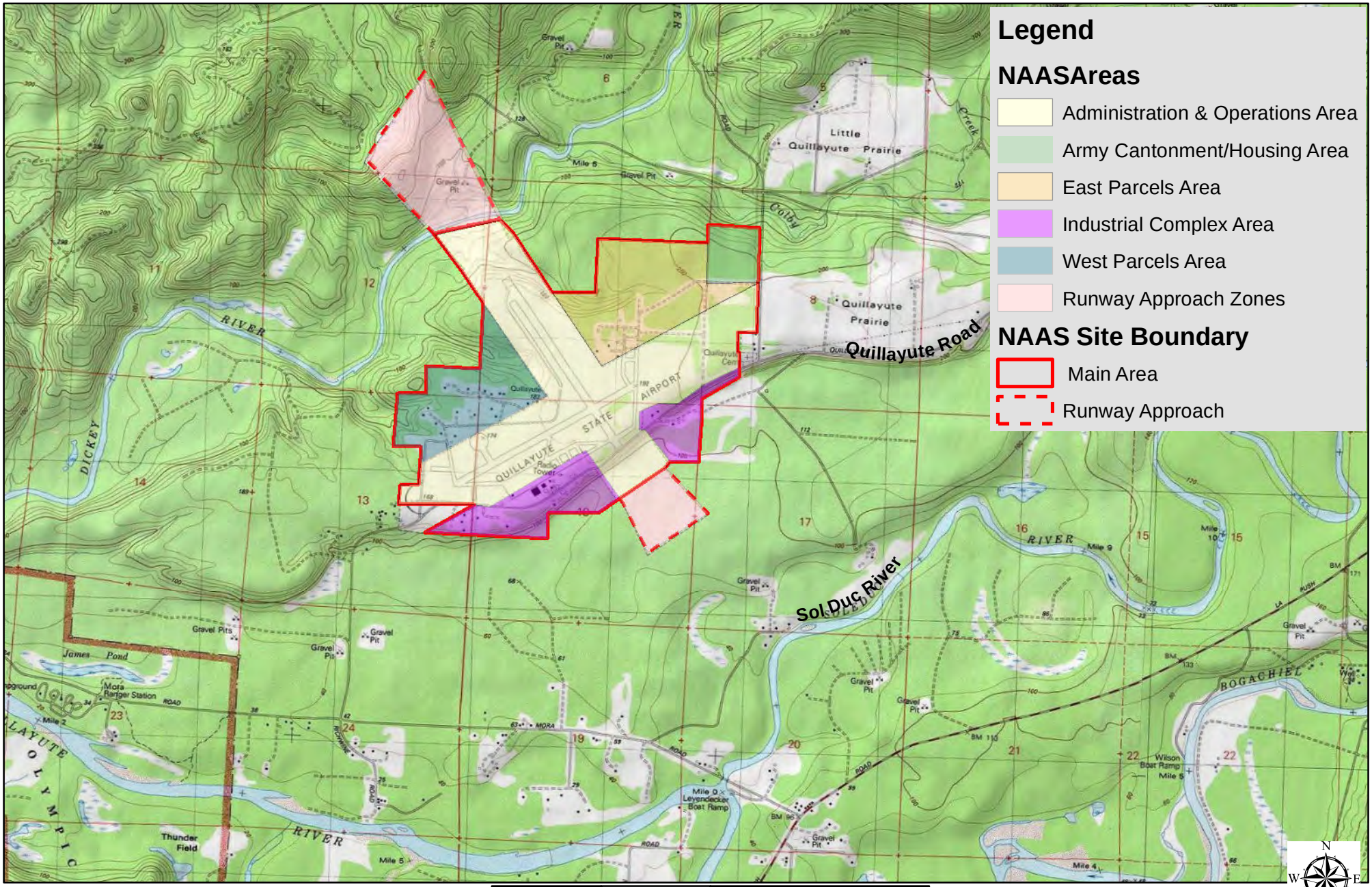


(b)



Data source: Western Regional Climate Center, http://www.wrcc.dri.edu/cgi-bin/cliMAIN.pl?wa6858

U.S. Army Corps of Engineers	**Figure 3-1. Average Monthly Precipitation (a) and Minimum, Average and Maximum Temperatures (b) for Period of Record from 1981 to 2010, Quillayute Weather Station, Washington**	**Former Naval Auxiliary Air Station Quillayute Quillayute, Washington**



Base map: ESRI USA Topo Maps

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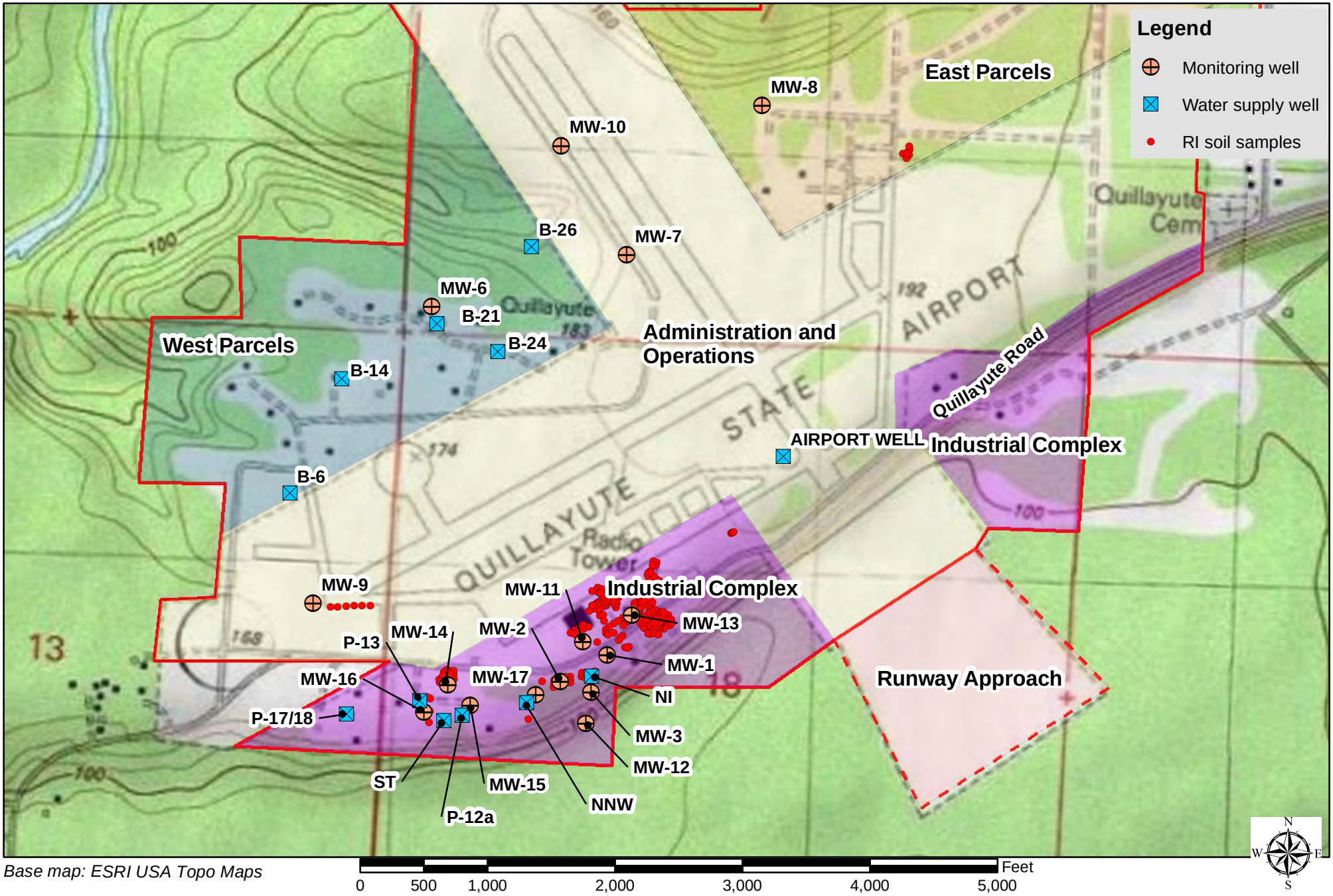
U.S. Army Corps of Engineers

Figure 3-2a. Regional Topography

Former Naval Auxillary Air Station Quillayute Quillayute, Washington



Base map: ESRI USA Topo Maps

0 500 1,000 2,000 3,000 4,000 5,000 Feet

U.S. Army Corps of Engineers

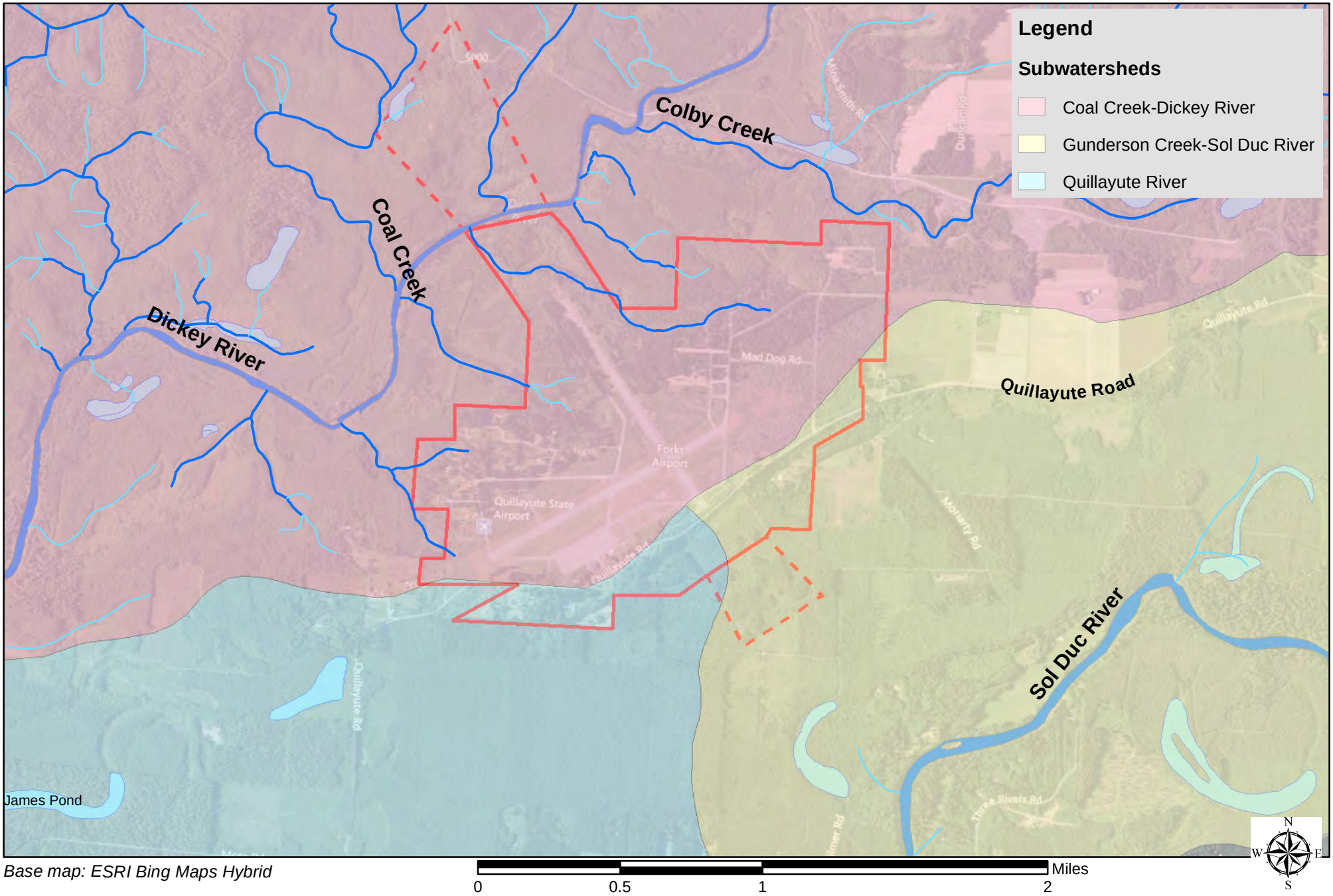
Figure 3-2b. Site Topography in the Vicinity of the RI Groundwater and Soil Sampling Locations

Note: The ST well has never been sampled due to access problems.
It is shown on the map for reference.

Former Naval Auxillary Air Station Quillayute Quillayute, Washington

From the Collection of the Forks Timber Museum, PO Box 873, Forks, Washington

U.S. Army Corps of Engineers	**Figure 3-3. Historical Oblique Aerial Photograph (Looking East) of the Former NAAS Quillayute (1945)**	**Former Naval Auxiliary Air Station Quillayute Quillayute, Washington**



Base map: ESRI Bing Maps Hybrid

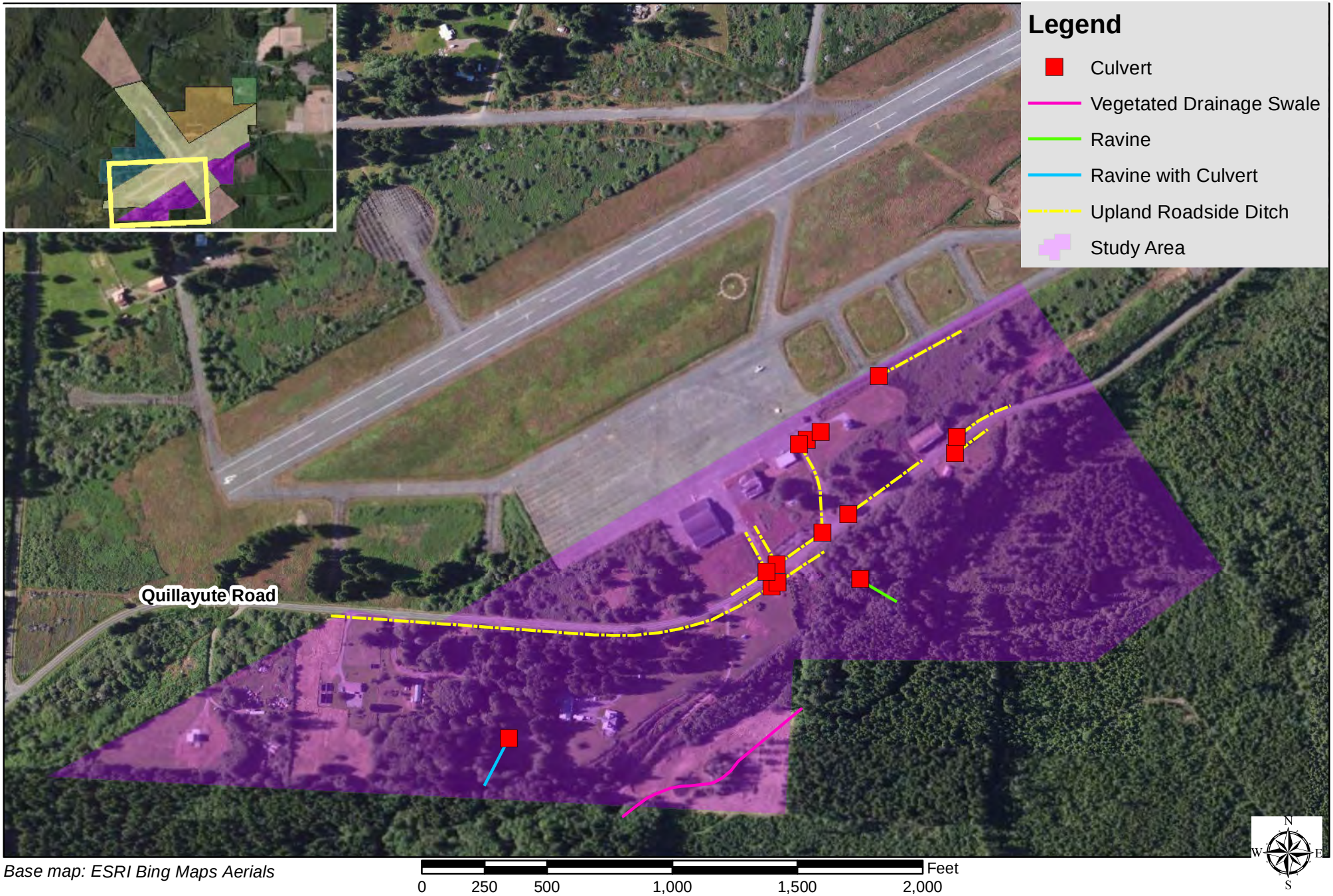
0 0.5 1 2 Miles

U.S. Army Corps of Engineers

Figure 3-4. Subwatersheds in the Vicinity of the Former NAAS Quillayute

Surface water features obtained from the USGS National Hydrography Dataset.

Former Naval Auxillary Air Station Quillayute Quillayute, Washington

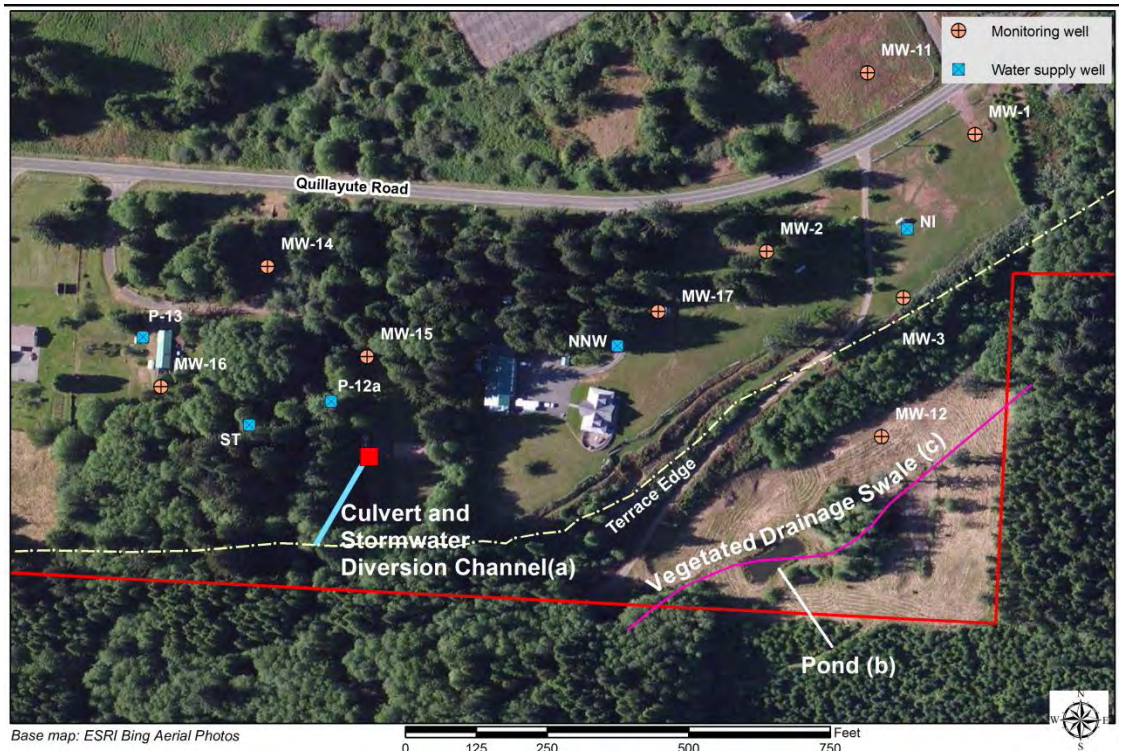


Base map: ESRI Bing Maps Aerials

U.S. Army Corps of Engineers

Figure 3-5a. Drainage Features Observed During the Ecological Reconnaissance (March 19, 2012) at the Western Portion of the Industrial Complex Area

Former Naval Auxillary Air Station Quillayute Quillayute, Washington

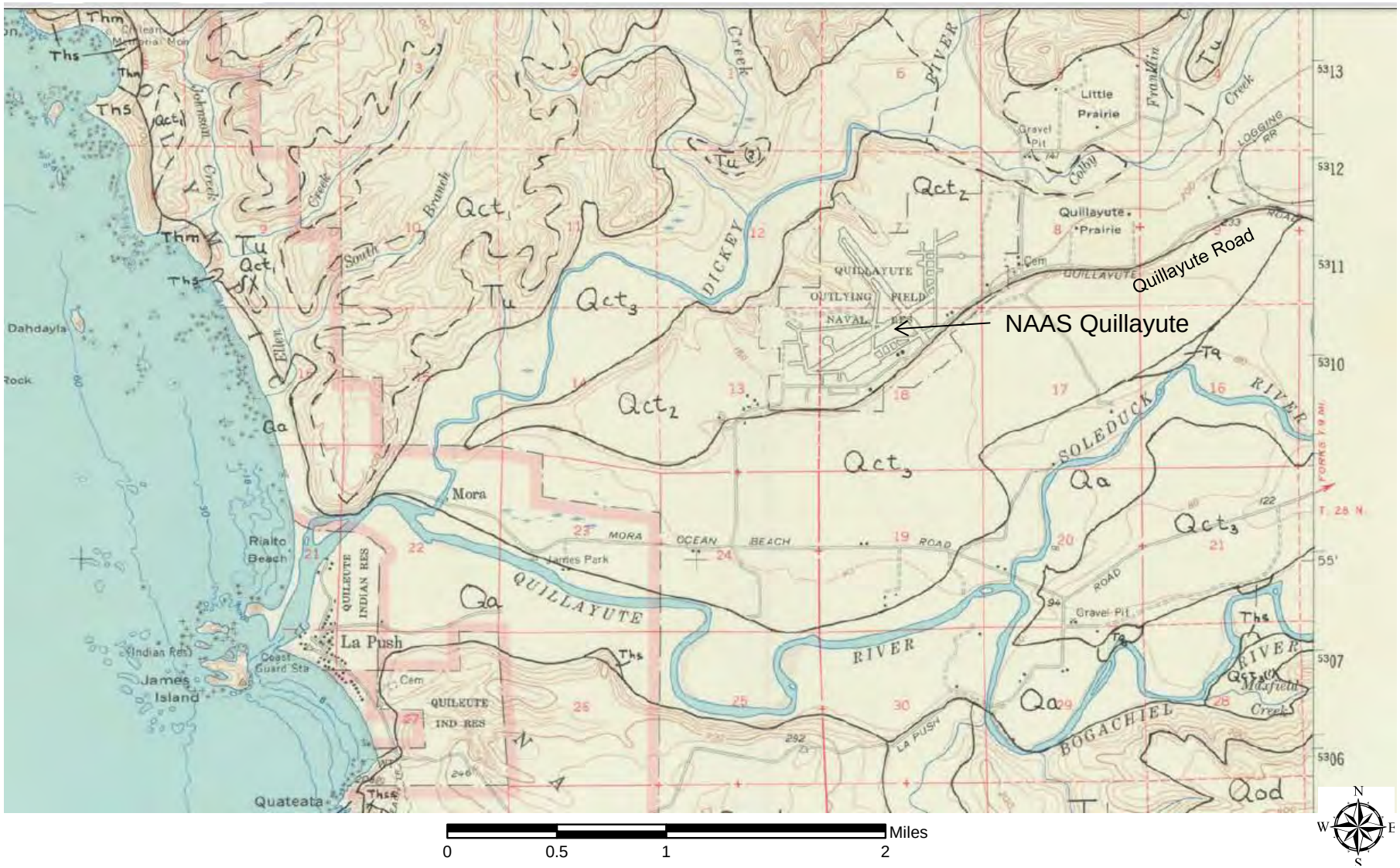


(a) Culvert (~36-inch) and storm water diversion channel

(b) Pond below terrace edge (looking southeast)

(c) Skunk cabbage growing in vegetated drainage swale area

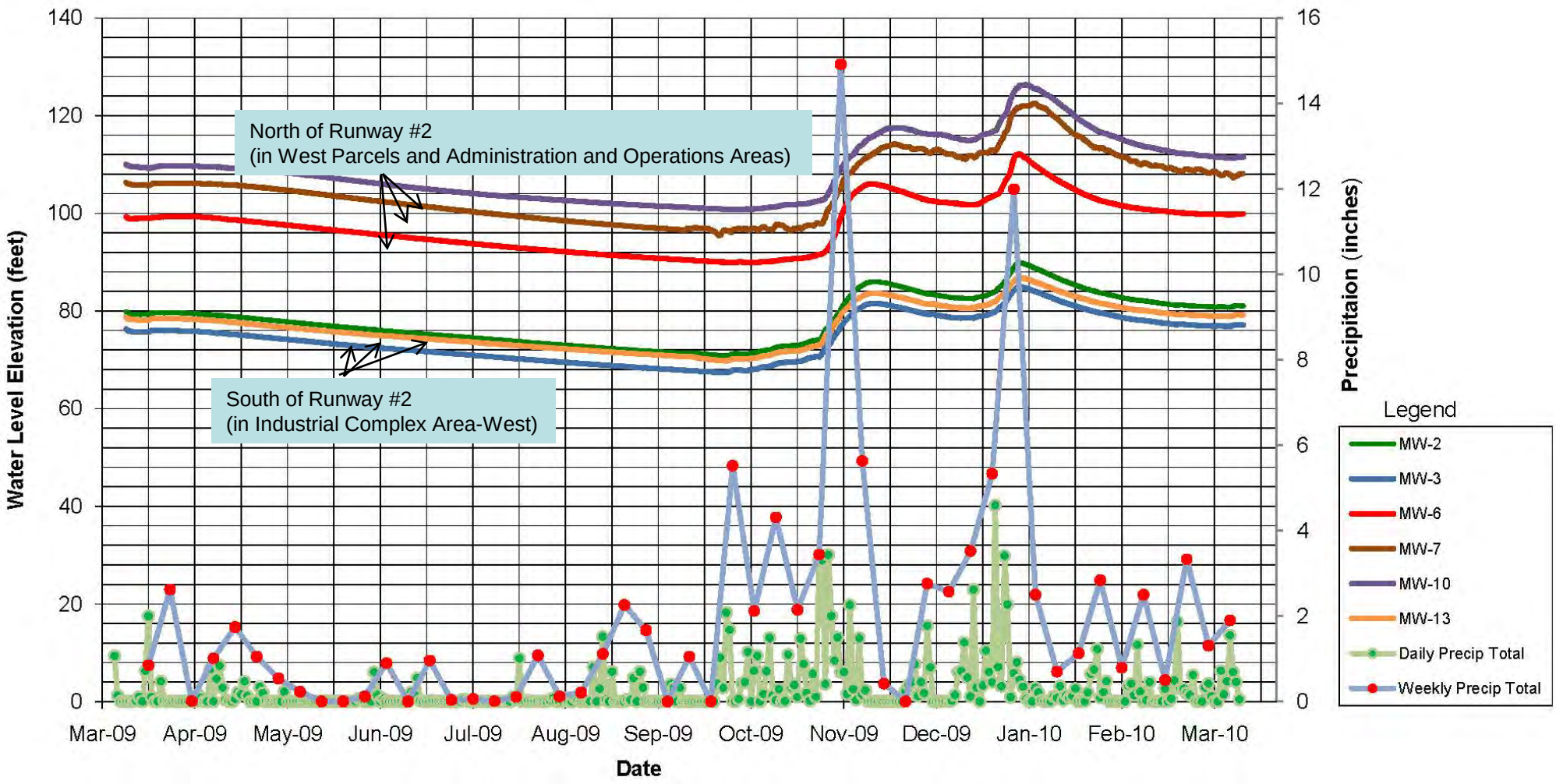
U.S. Army Corps of Engineers	**Figure 3-5b. Photographs of Site Drainage Features taken During the Ecological Reconnaissance (March 19-20, 2012)**	**Former Naval Auxiliary Air Station Quillayute Quillayute, Washington**



Qa Alluvium deposited by modern streams
Qct3 Outwash terraces formed by the latest Juan de Fuca lobe meltwaters. Mainly stratified sand and gravel
Qct2 Outwash terraces that are older than Qct3 but younger than Qct1. Mainly stratified sand and gravel with a mantle of loess.
Qct1 Outwash terraces that are older than Qct2. Mainly stratified sand and gravel with a mantle of loess.

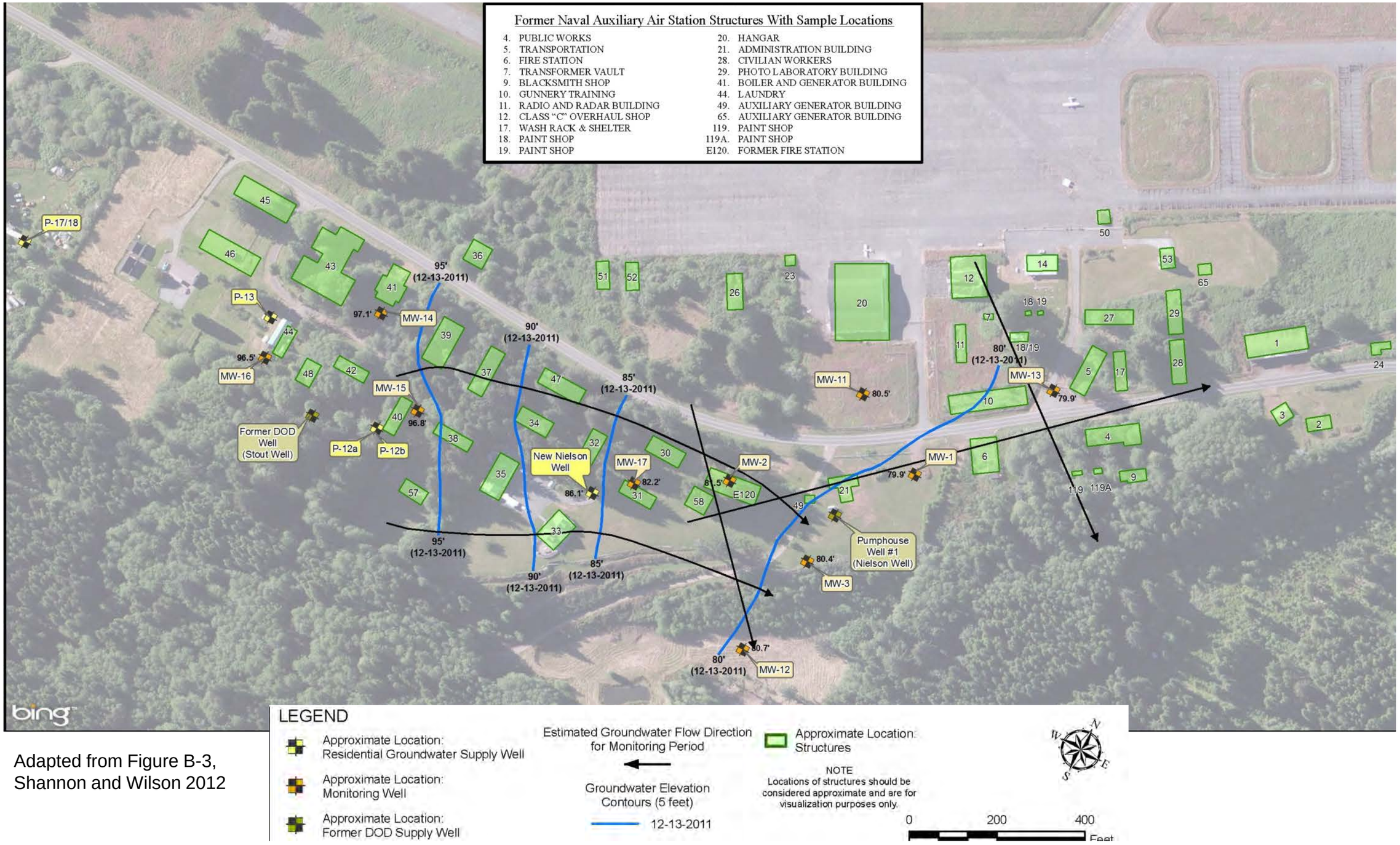
Adapted from: Othberg K. L. and D. Korzendorfer. 1977. Reconnaissance Surficial Geologic Map of Clallam County in the Forks and La Push Quadrangles. Department of Natural Resources, Geology and Earth Resources, Olympia, Washington, 98504.

U.S. Army Corps of Engineers	**Figure 3-6. Surficial Geology in the Vicinity of the Former NAAS Quillayute**	**Former Naval Auxiliary Air Station Quillayute Quillayute, Washington**



Adapted from Shannon and Wilson (2002)

U.S. Army Corps of Engineers	**Figure 3-7a. Hydrographs from Selected Monitoring Wells at the Former NAAS Quillayute**	**Former Naval Auxiliary Air Station Quillayute Quillayute, Washington**

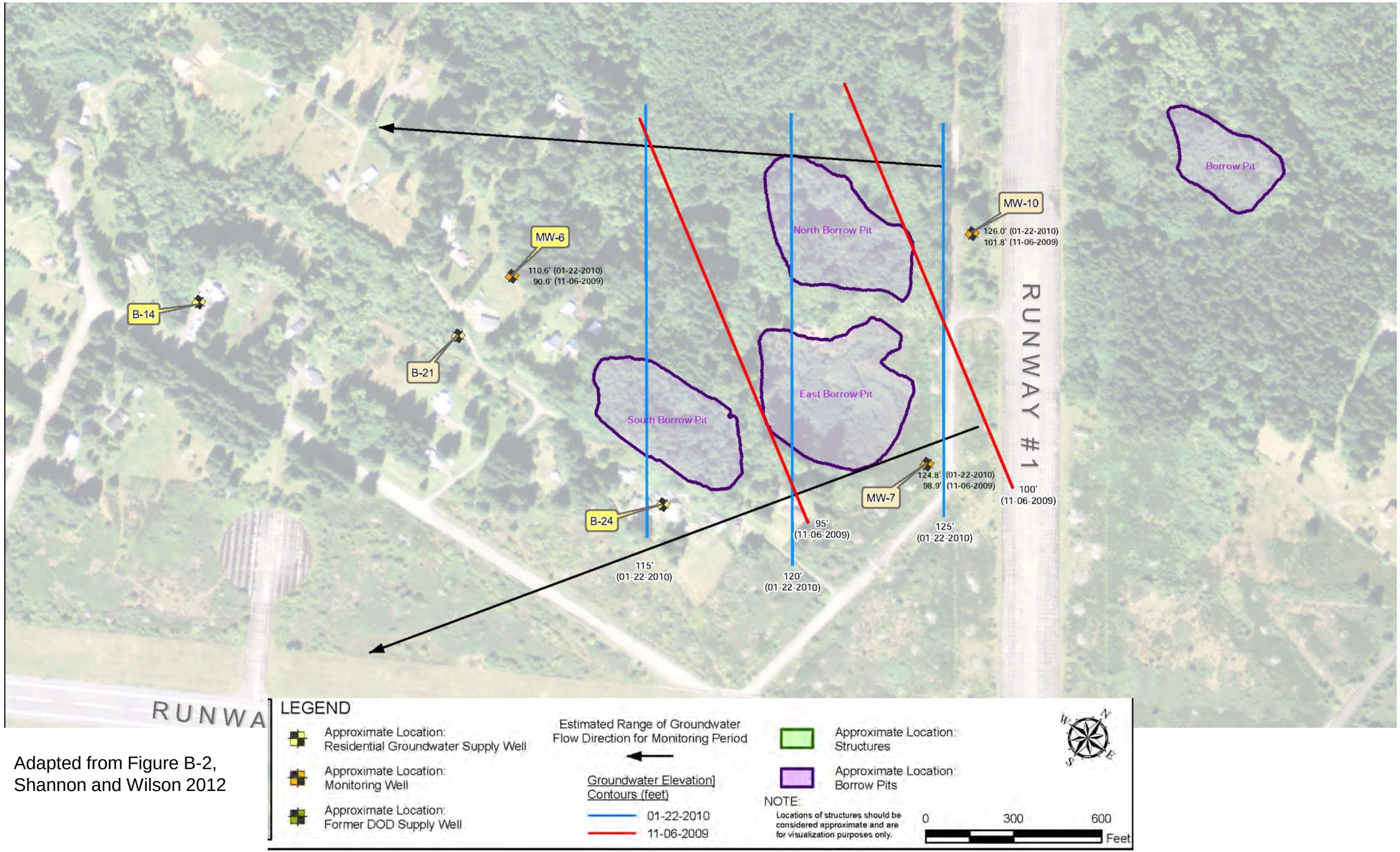


Adapted from Figure B-3, Shannon and Wilson 2012

U.S. Army Corps of Engineers

Figure 3-7b. Groundwater Flow Directions at the Former NAAS Quillayute south of Runway #2

Former Naval Auxiliary Air Station Quillayute Quillayute, Washington



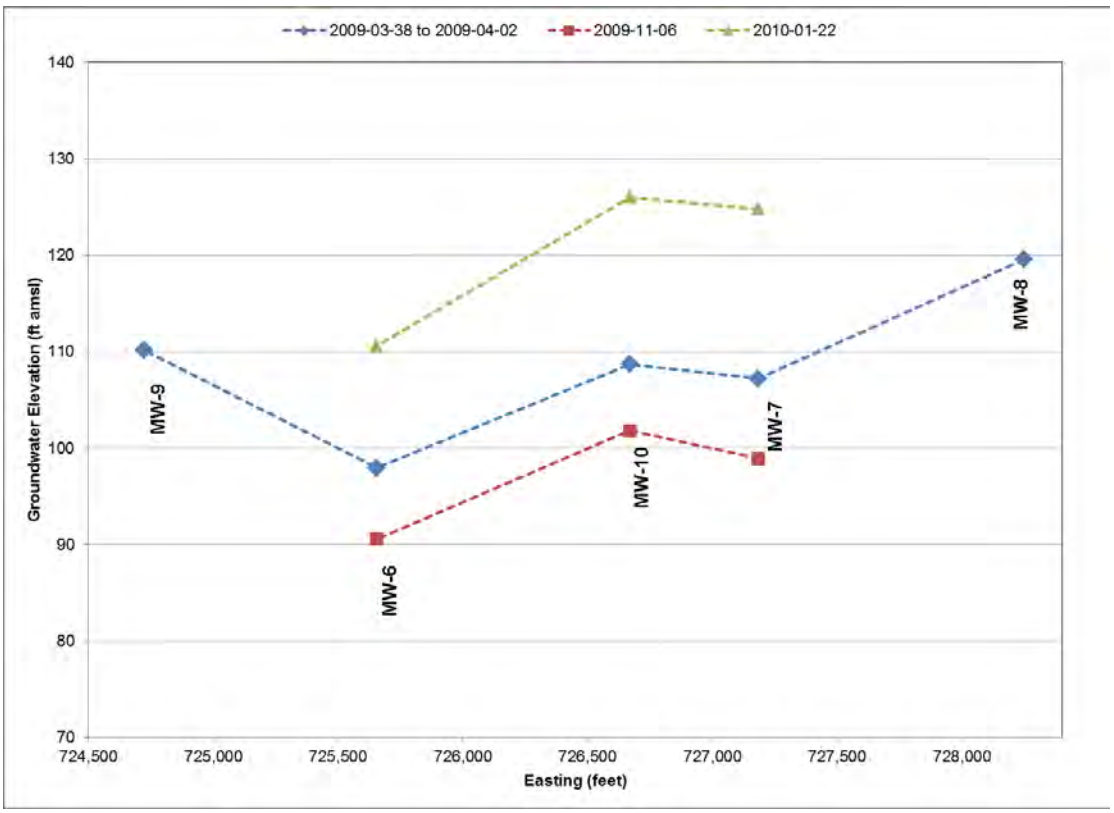
Adapted from Figure B-2, Shannon and Wilson 2012

U.S. Army Corps of Engineers

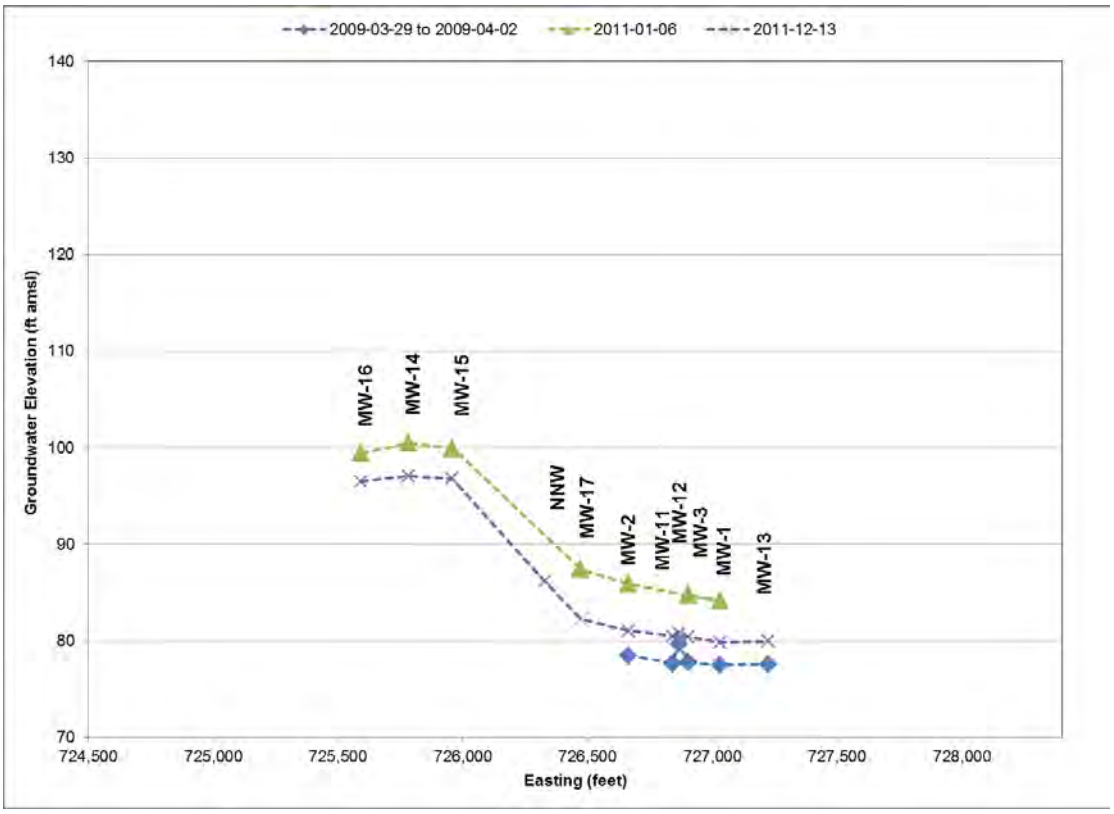
Figure 3-7c. Groundwater Flow Directions at the Former NAAS Quillayute north of Runway #2

Former Naval Auxiliary Air Station Quillayute Quillayute, Washington

(a)

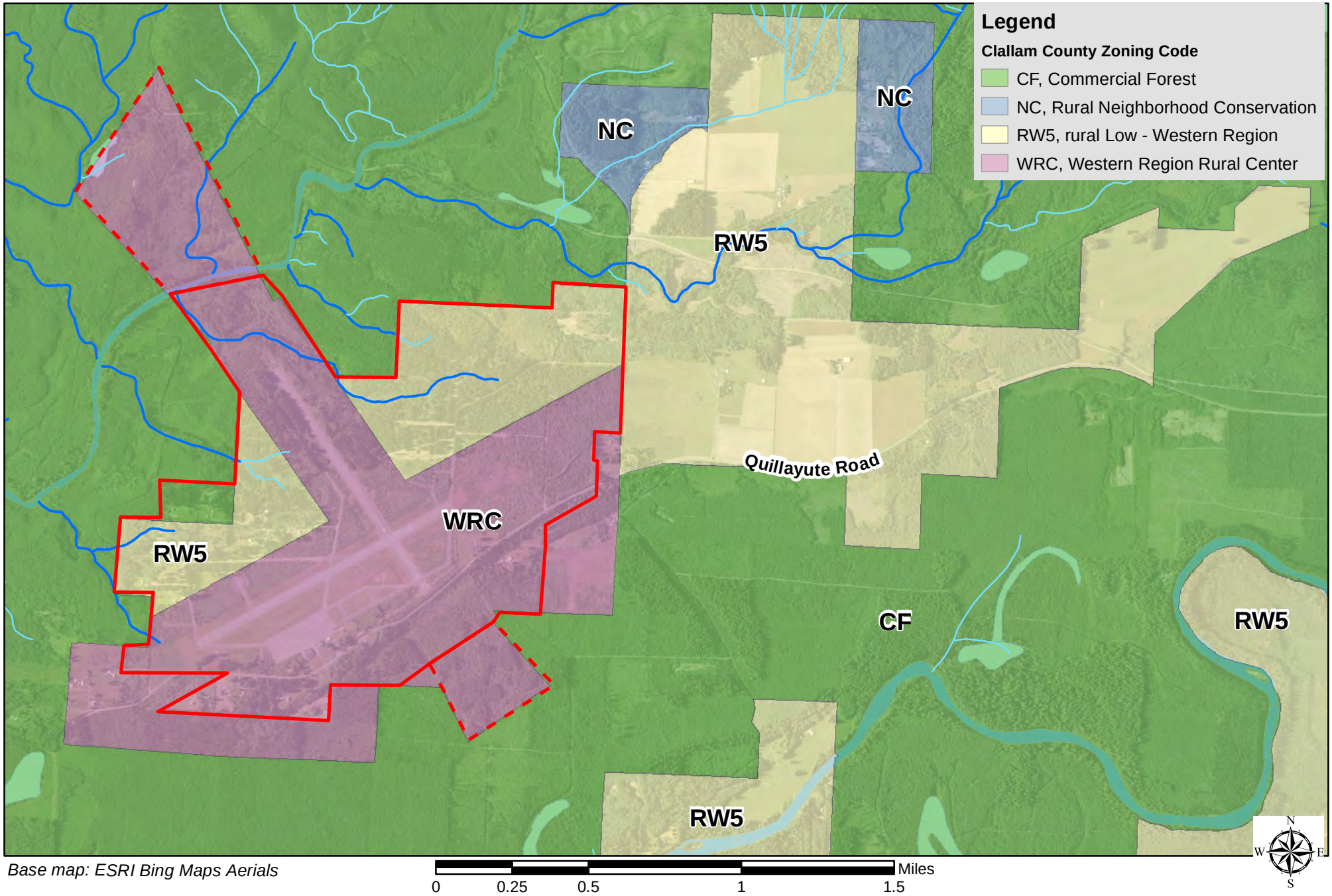


(b)



See Figure 3-7b for well location map.

U.S. Army Corps of Engineers	**Figure 3-7d. Groundwater Elevations Plotted Against Easting Locations of the Monitoring Wells Located North (a) and South (b) of Runway #2**	**Former Naval Auxiliary Air Station Quillayute Quillayute, Washington**



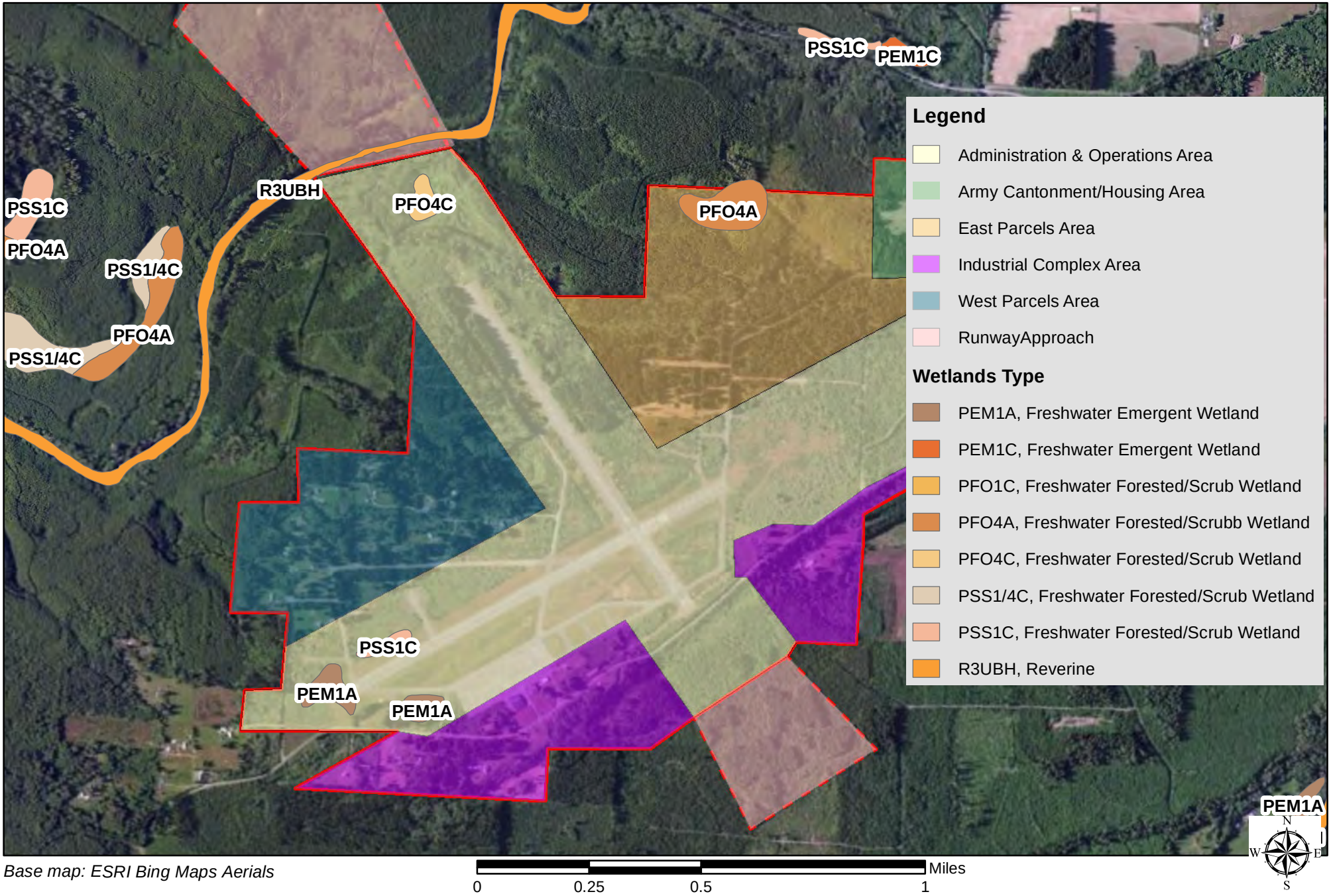
Base map: ESRI Bing Maps Aerials

U.S. Army Corps of Engineers

Figure 3-8. Clallam County Land Use Zones in the Vicinity of Former NAAS Quillayute

Zoning data from Cllalam County, WA
http://www.clallam.net/Maps/zoning.html

Former Naval Auxillary Air Station Quillayute Quillayute, Washington



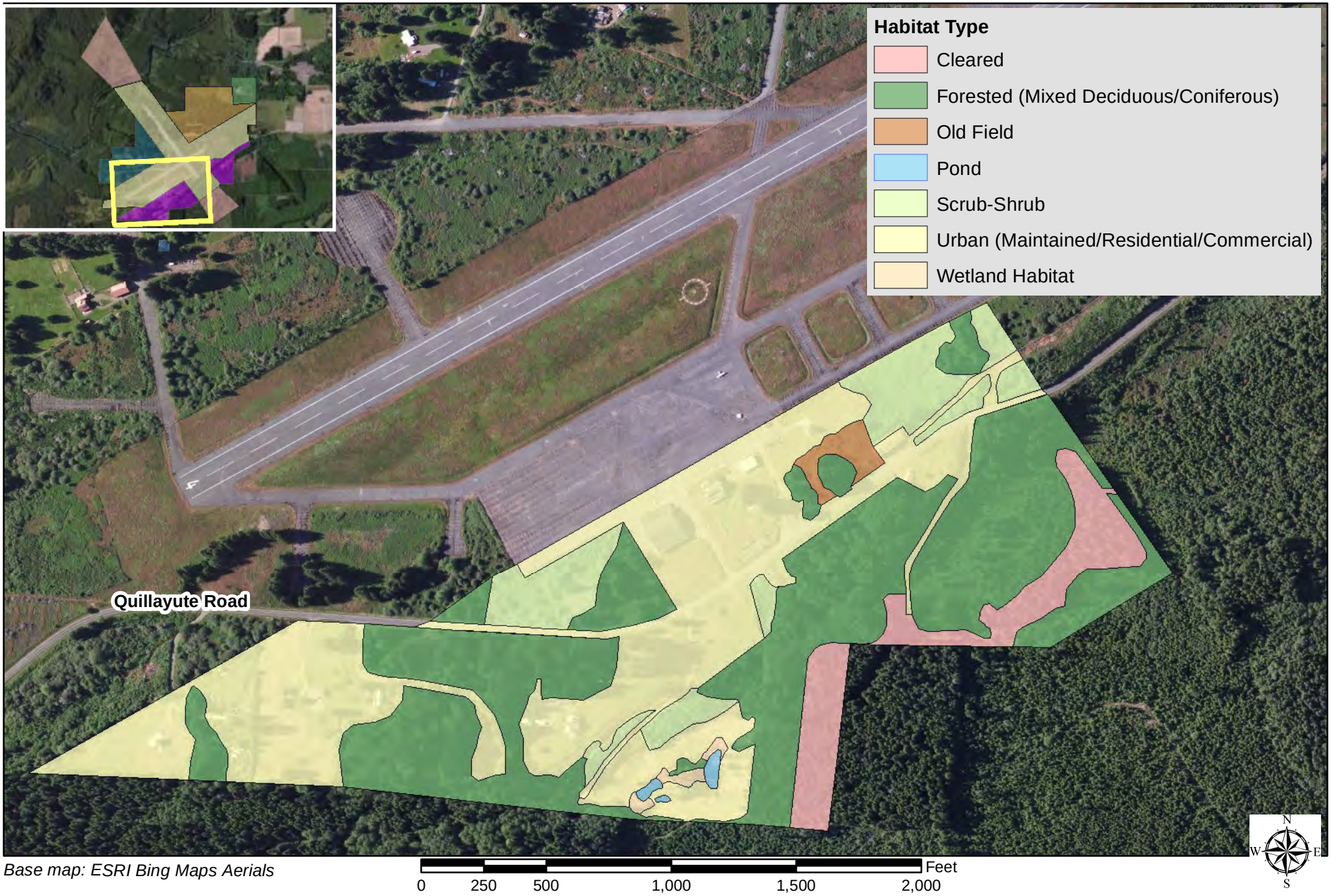
Base map: ESRI Bing Maps Aerials

U.S. Army Corps of Engineers

Figure 3-9. Wetlands in the Vicinity of the Former NAAS Quillayute

Wetlands data obtained from the USFWS National Wetlands Inventory.

Former Naval Auxillary Air Station Quillayute Quillayute, Washington

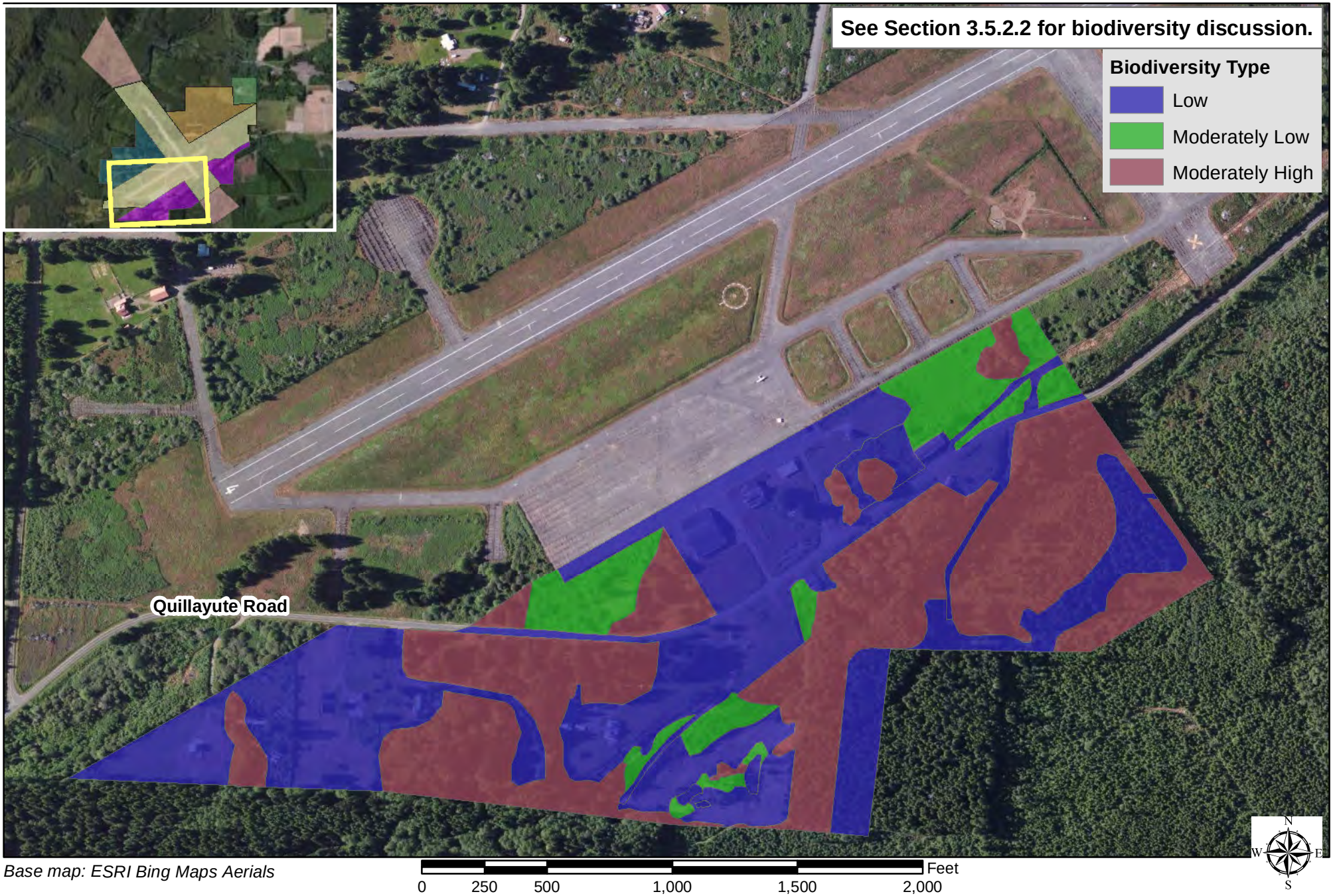


Base map: ESRI Bing Maps Aerials

U.S. Army Corps of Engineers

Figure 3-10. Terrestrial Habitat Map for the Western Portion of the Industrial Complex Area

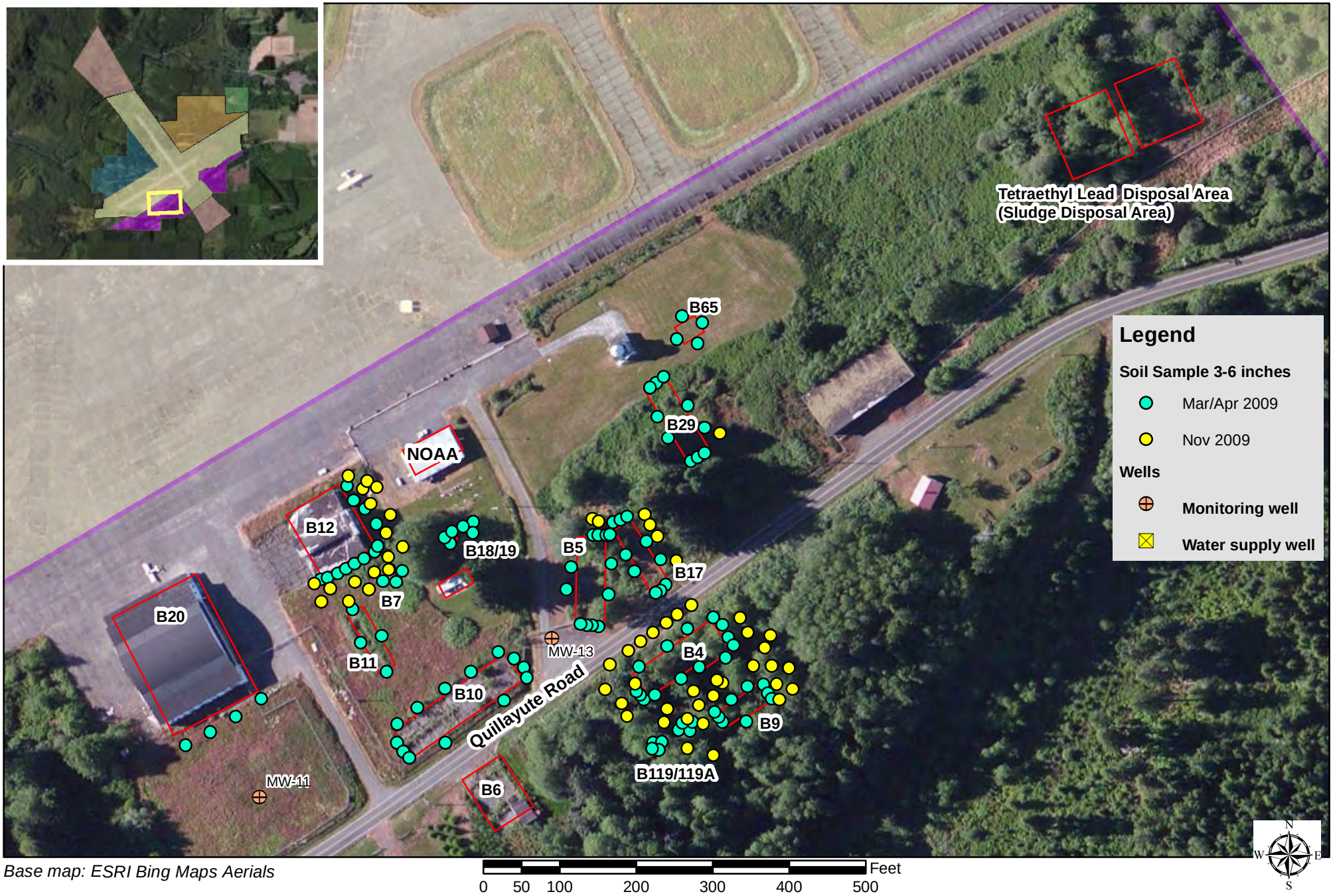
Former Naval Auxillary Air Station Quillayute Quillayute, Washington



U.S. Army Corps of Engineers

Figure 3-11. Plant Biodiversity Types for the Western Portion of the Industrial Complex Area

Former Naval Auxillary Air Station Quillayute Quillayute, Washington



Base map: ESRI Bing Maps Aerials

U.S. Army Corps of Engineers

Figure 4-1a. Soil Sampling Locations (3 to 6 inches) for the Western Portion of the Industrial Complex Area (Quillayute Airport and Undeveloped Area South of Quillayute Road)

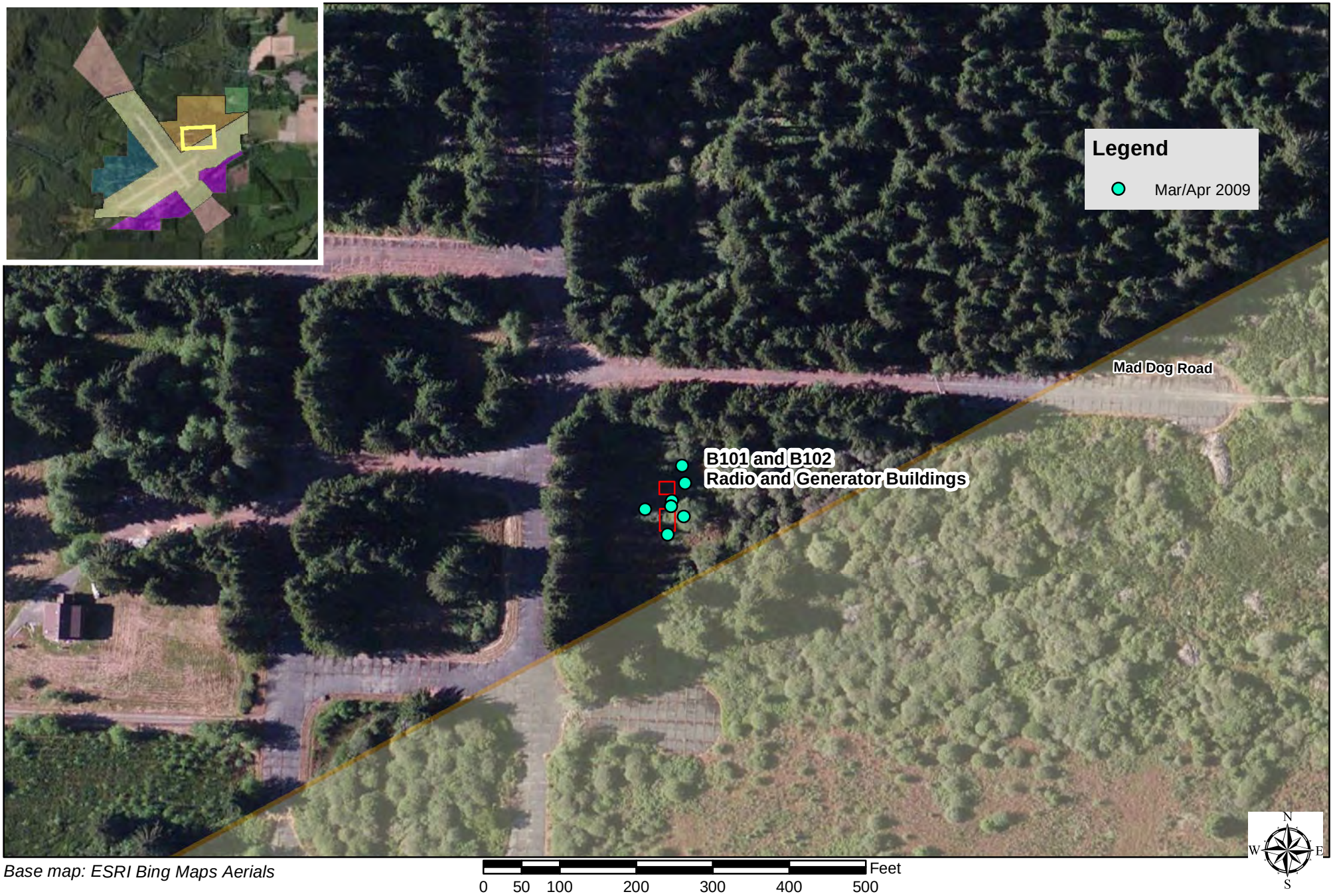
Former Naval Auxillary Air Station Quillayute Quillayute, Washington

Base map: ESRI Bing Maps Aerials

U.S. Army Corps of Engineers

Figure 4-1b. Soil Sampling Locations (3 to 6 inches) for the Western Portion of the Industrial Complex Area (Residential Area South of Quillayute Road)

Former Naval Auxillary Air Station Quillayute Quillayute, Washington

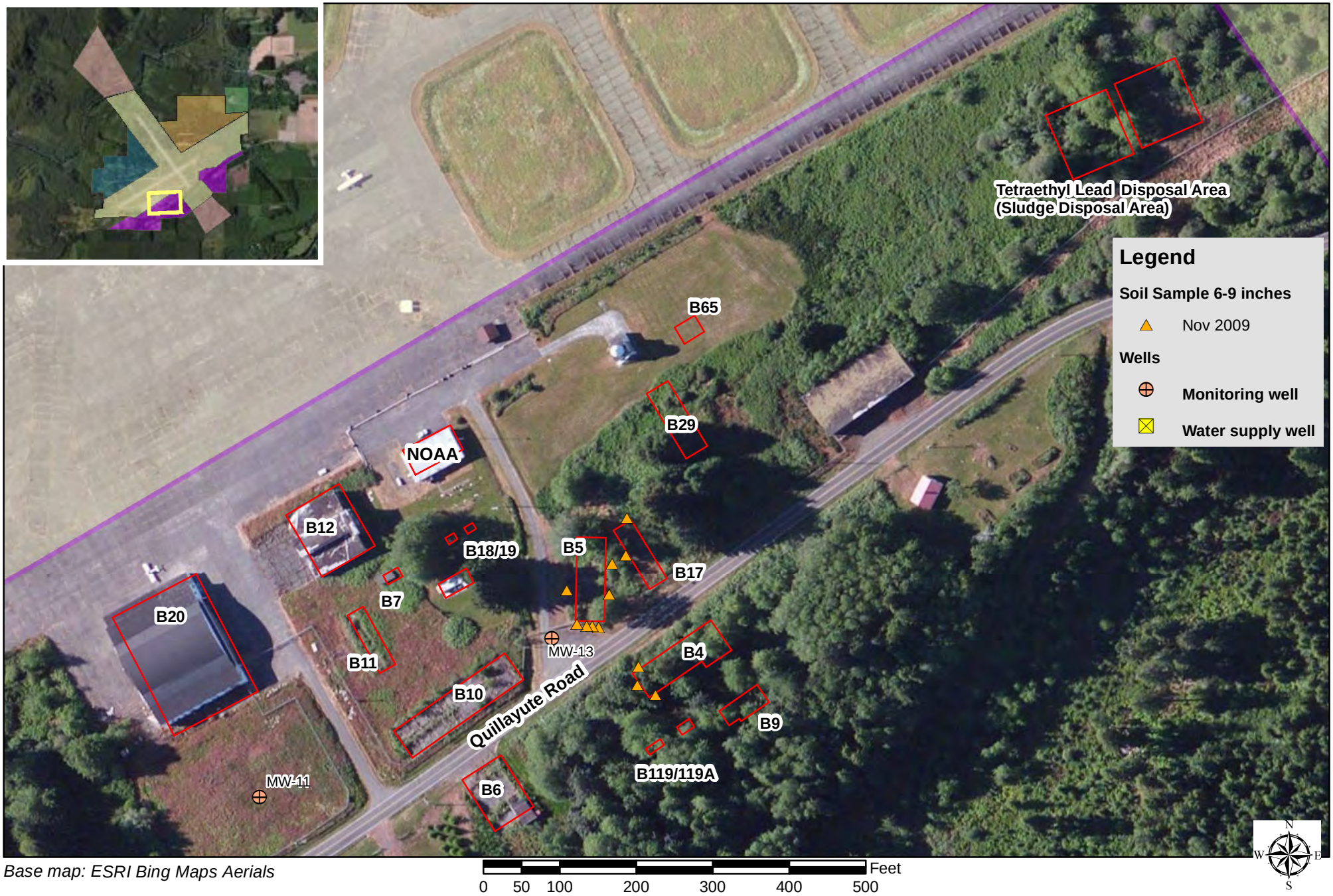


Base map: ESRI Bing Maps Aerials

U.S. Army Corps of Engineers

Figure 4-1c. Soil Sampling Locations (3 to 6 inches) for the East Parcels Area

Former Naval Auxillary Air Station Quillayute Quillayute, Washington

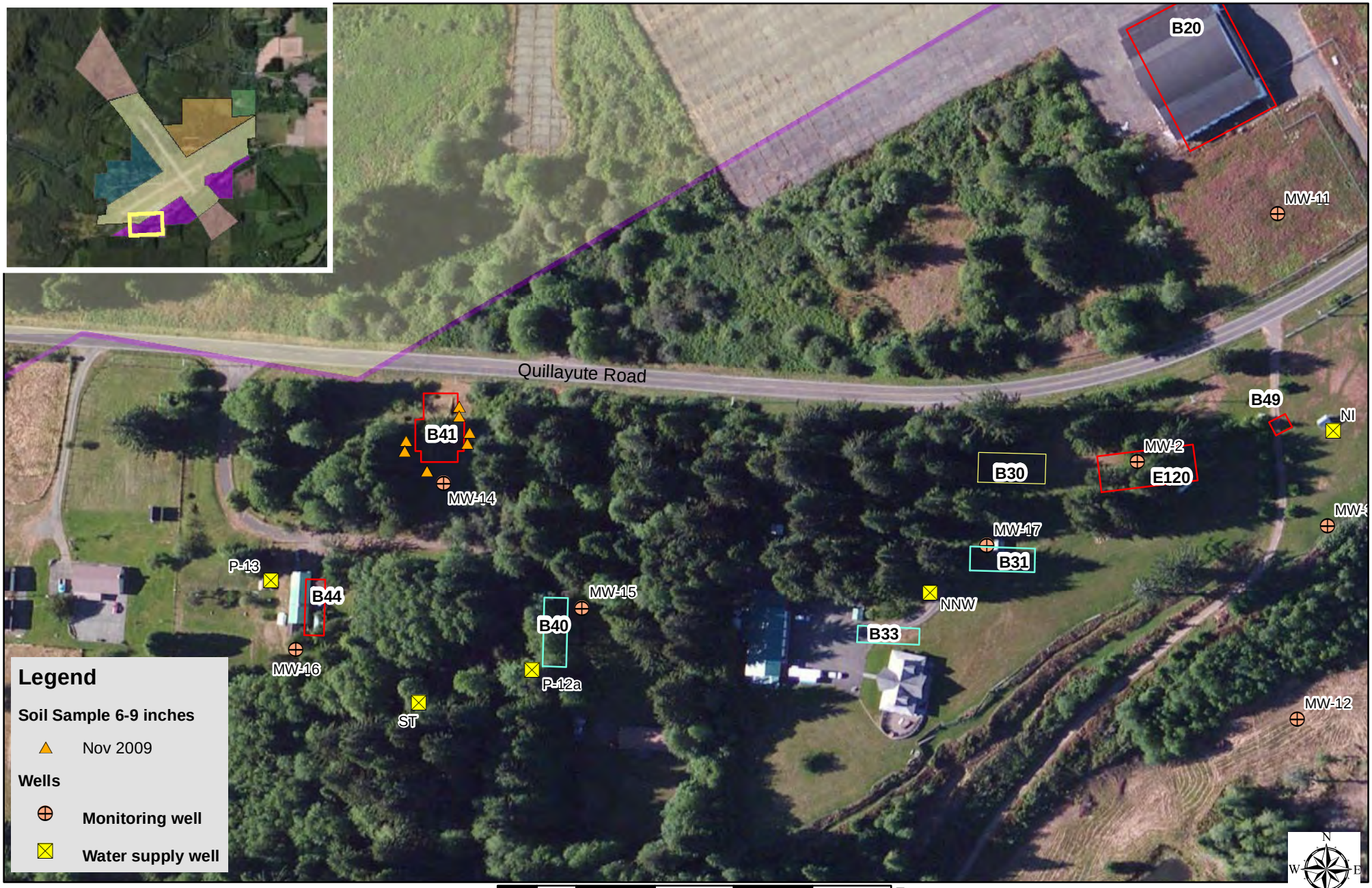


Base map: ESRI Bing Maps Aerials

U.S. Army Corps of Engineers

Figure 4-1d. Soil Sampling Locations (6 to 9 inches) for the Western Portion of the Industrial Complex Area (Quillayute Airport and Undeveloped Area South of Quillayute Road)

Former Naval Auxillary Air Station Quillayute Quillayute, Washington

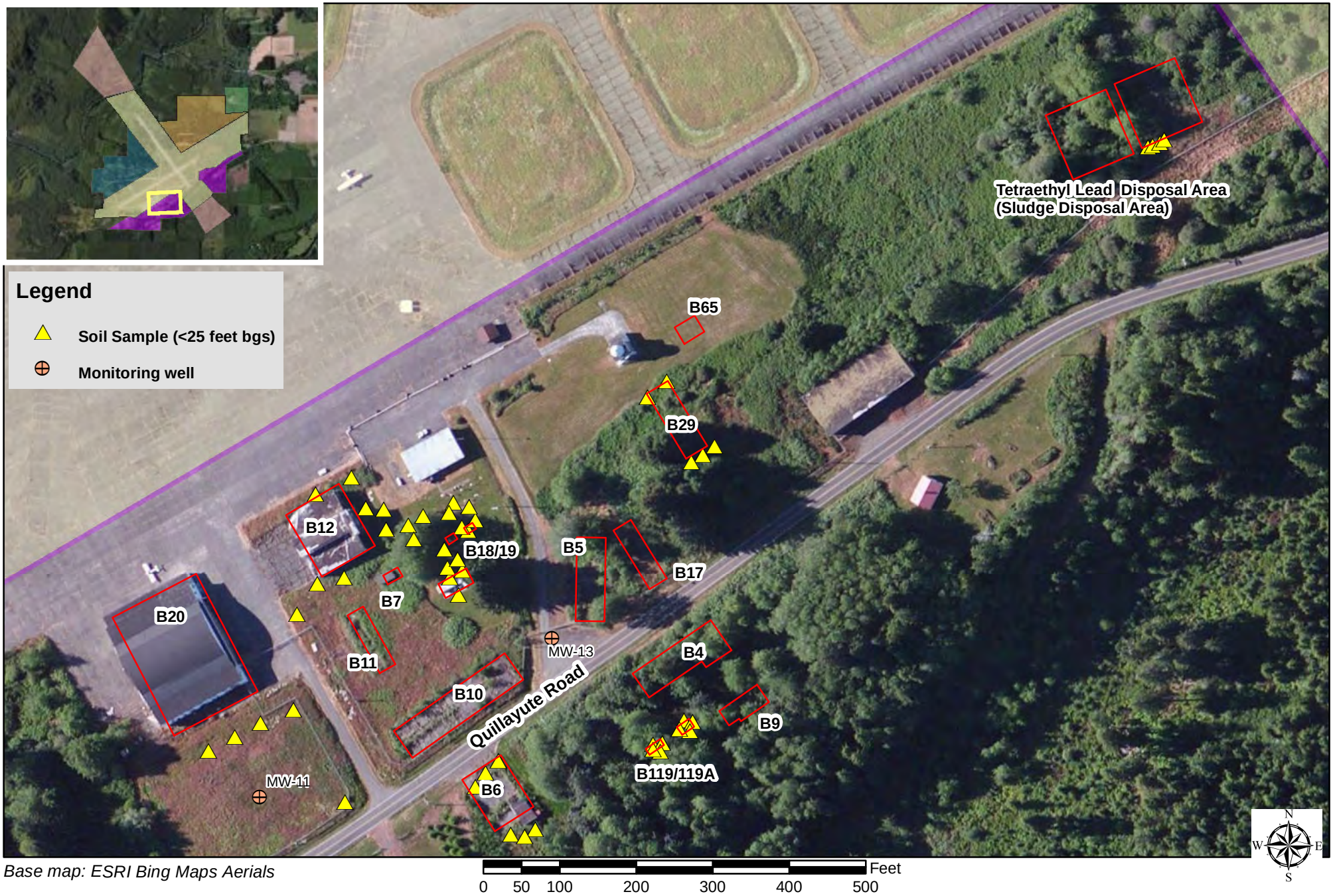


Base map: ESRI Bing Maps Aerials

U.S. Army Corps of Engineers

Figure 4-1e. Soil Sampling Locations (6 to 9 inches) for the Western Portion of the Industrial Complex Area (Residential Area South of Quillayute Road)

Former Naval Auxillary Air Station Quillayute Quillayute, Washington

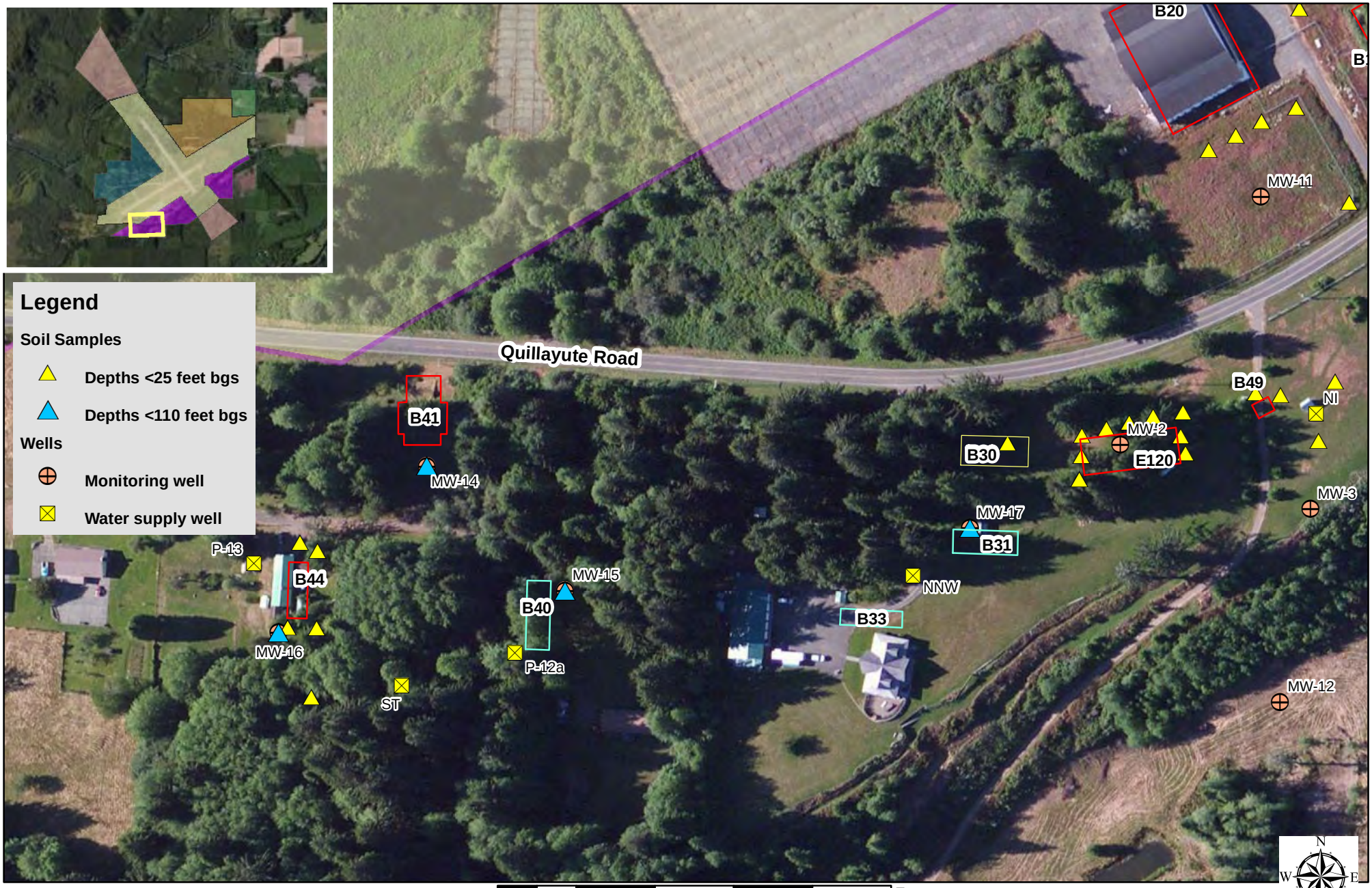


Base map: ESRI Bing Maps Aerials

U.S. Army Corps of Engineers

Figure 4-2a.Subsurface Soil Sampling Locations (<25 feet) for the Western Portion of the Industrial Complex Area (Quillayute Airport and Undeveloped Area South of Quillayute Road)

Former Naval Auxillary Air Station Quillayute Quillayute, Washington

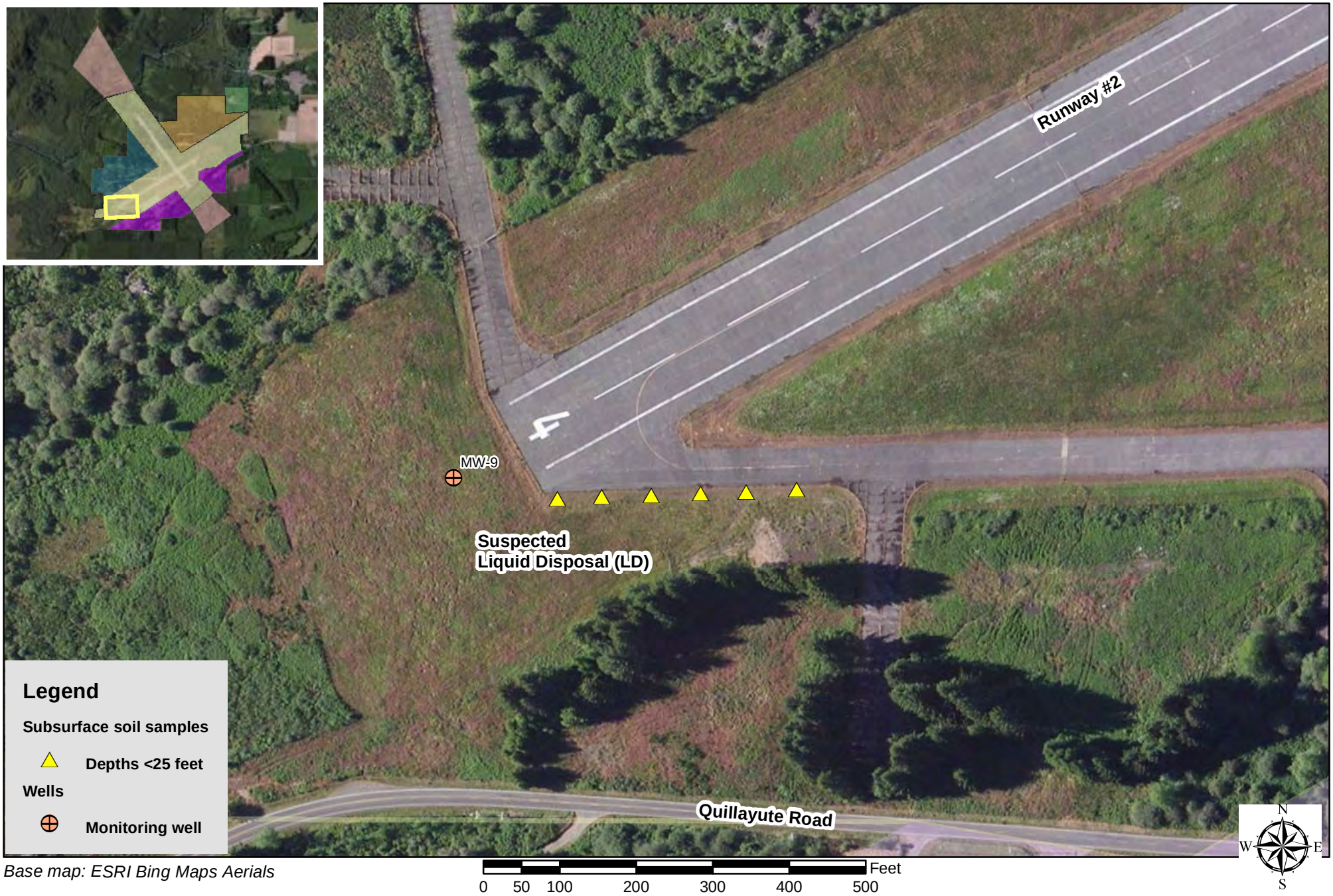


Base map: ESRI Bing Maps Aerials

U.S. Army Corps of Engineers

Figure 4-2b. RI Subsurface Soil Sampling Locations for the Western Portion of the Industrial Complex Area (Residential Area South of Quillayute Road)

Former Naval Auxillary Air Station Quillayute Quillayute, Washington



Base map: ESRI Bing Maps Aerials

U.S. Army Corps of Engineers

Figure 4-2c. Subsurface Soil Sampling Locations (<25 feet) for the Administration and Operations Area

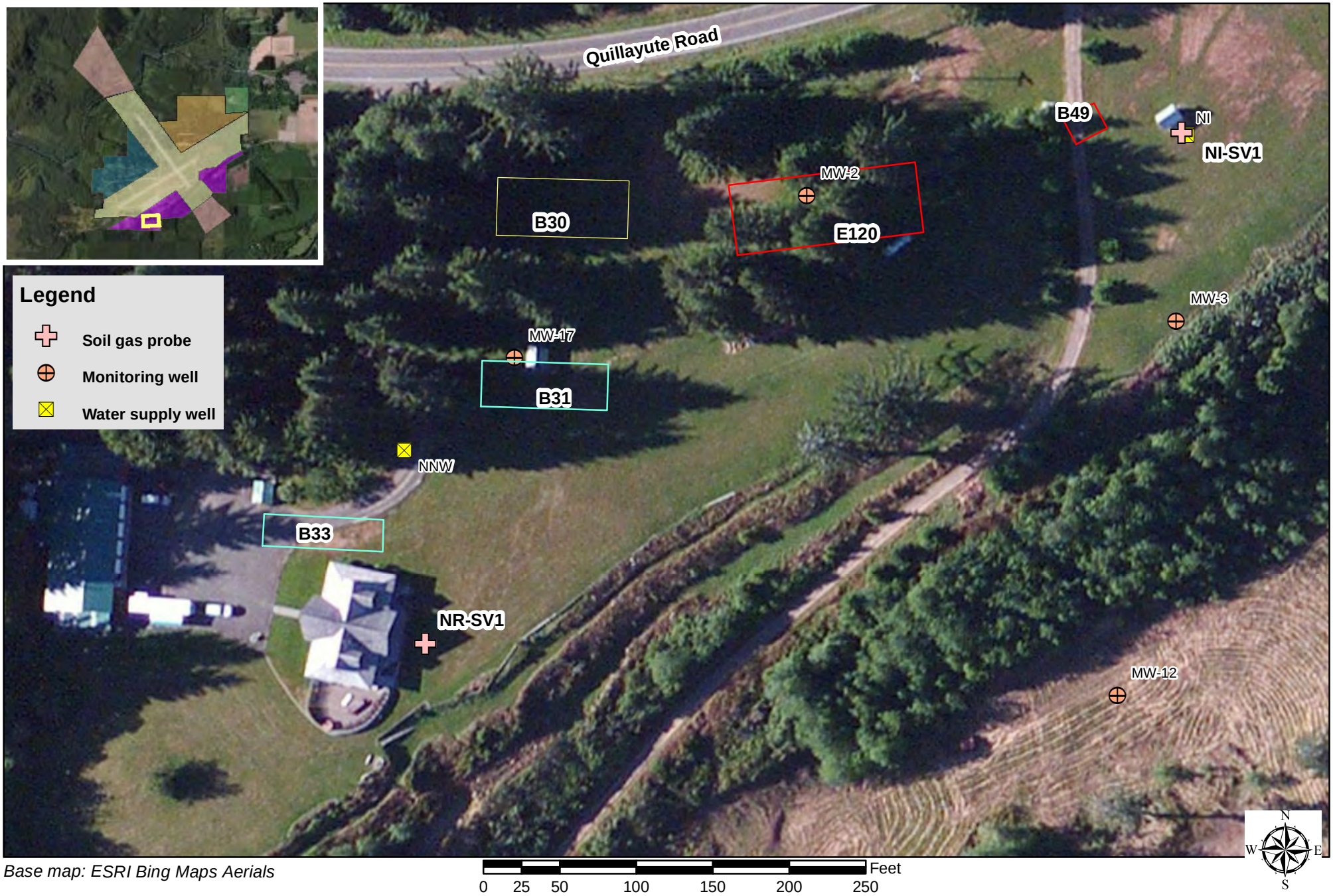
Former Naval Auxillary Air Station Quillayute Quillayute, Washington

Base map: ESRI Bing Maps Aerials

U.S. Army Corps of Engineers

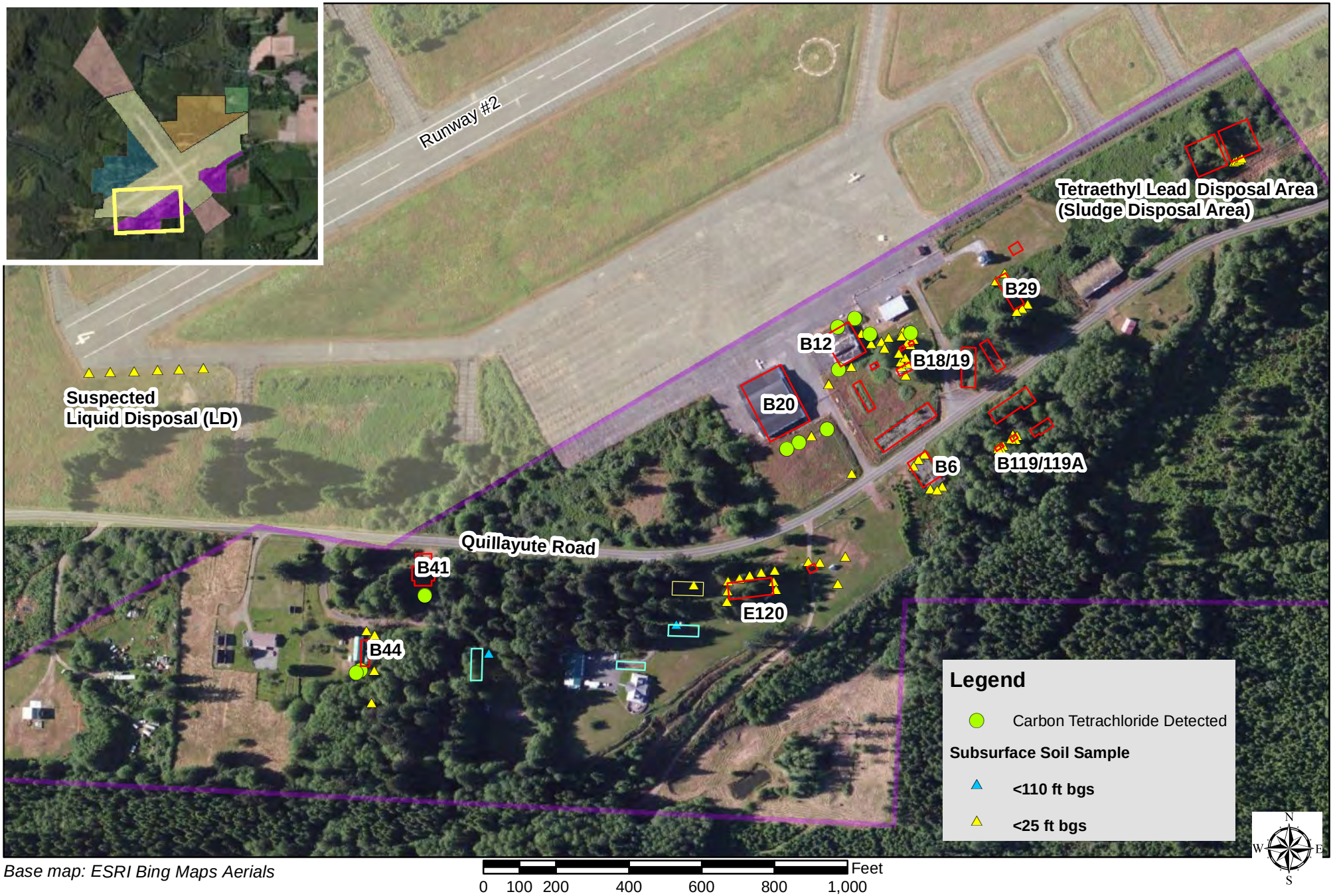
Figure 4-3a. Soil Gas, Ambient Air and Crawl Space Air Samples from the Vicinity of B44 Slab

Former Naval Auxillary Air Station Quillayute Quillayute, Washington



Base map: ESRI Bing Maps Aerials

U.S. Army Corps of Engineers	**Figure 4-3b. Soil Gas Samples from the Vicinity of the NI well (NI-SV-1) and Nearby Residence (NR-SV-1)**	**Former Naval Auxillary Air Station Quillayute Quillayute, Washington**

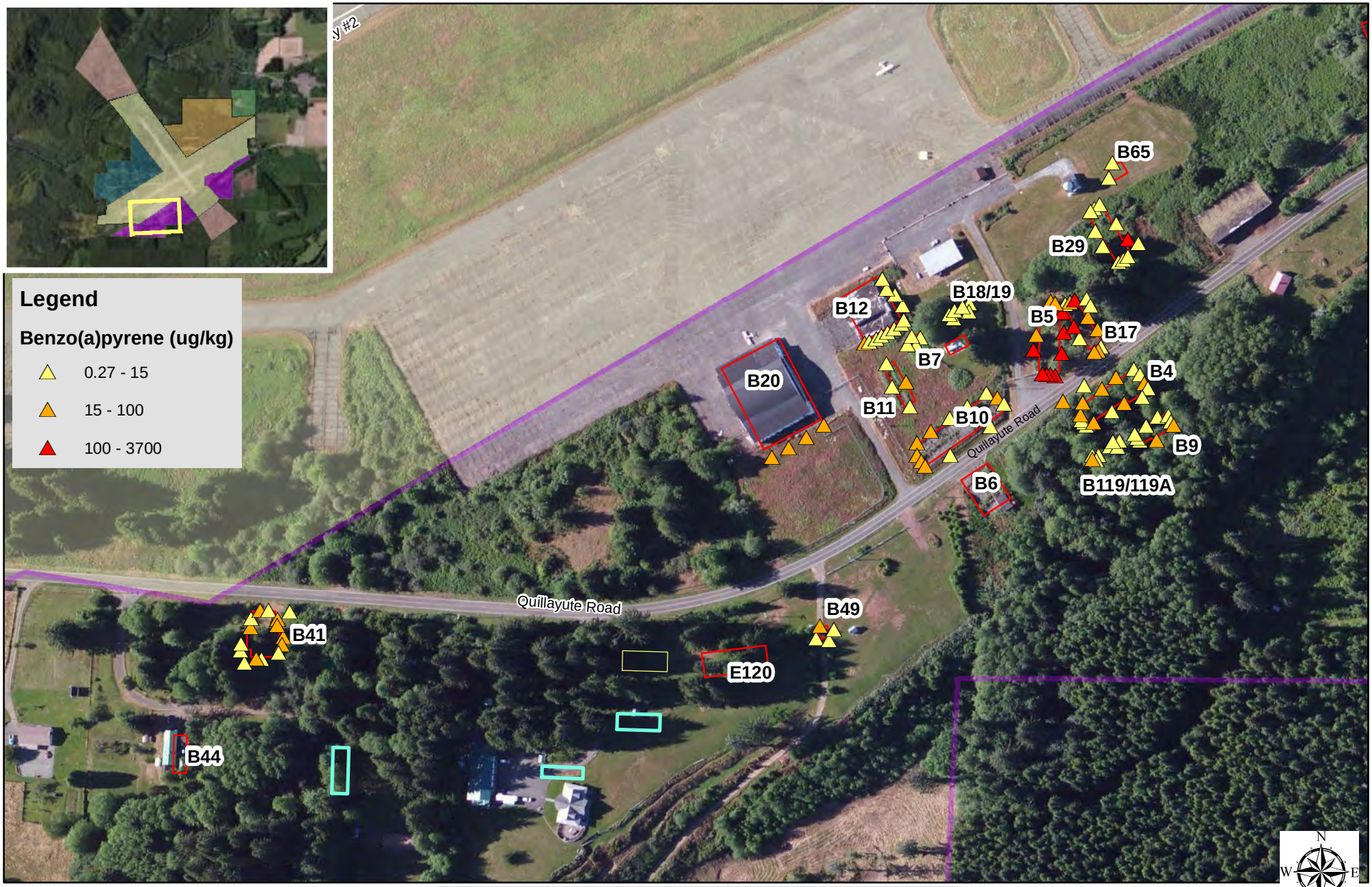


Base map: ESRI Bing Maps Aerials

U.S. Army Corps of Engineers

Figure 4-4. Carbon Tetrachloride Detections in Subsurface Soil Samples

Former Naval Auxillary Air Station Quillayute Quillayute, Washington

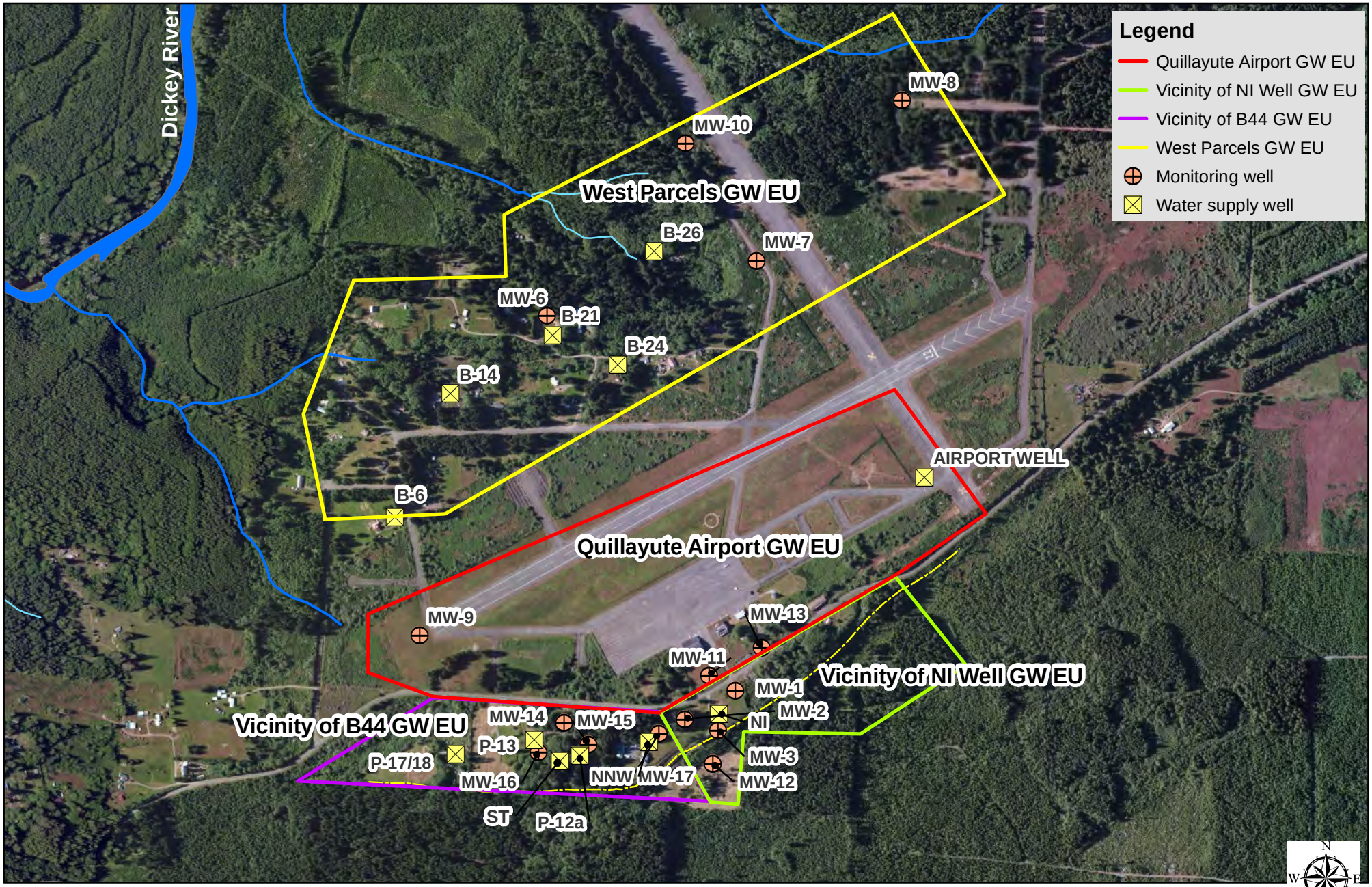


Base map: ESRI Bing Maps Aerials

U.S. Army Corps of Engineers

Figure 4-5. Distribution of Benzo(a)pyrene in Soil Samples (3 to 6 inches)

Former Naval Auxillary Air Station Quillayute Quillayute, Washington



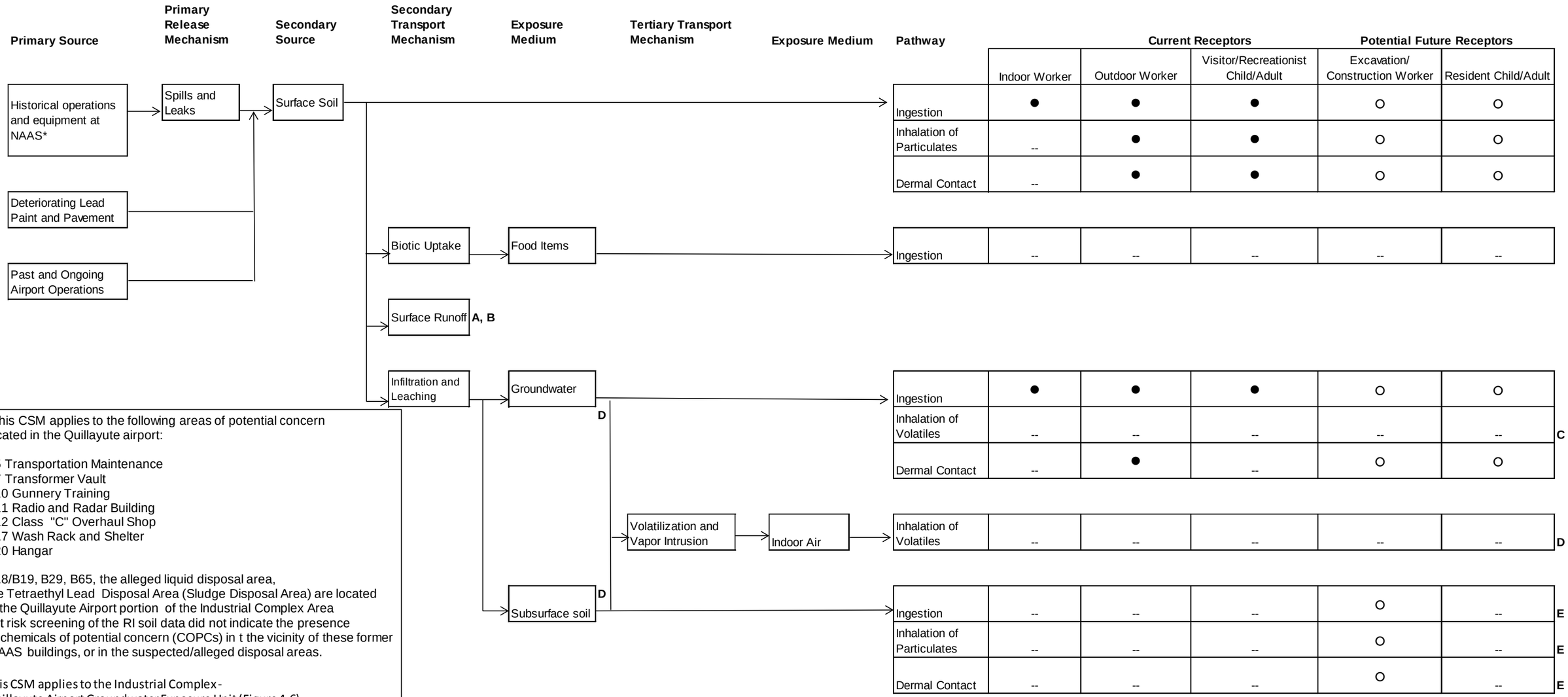
Base map: ESRI Bing Maps Aerials

0 500 1,000 2,000 3,000 4,000 5,000 Feet

U.S. Army Corps of Engineers

Figure 4-6. Groundwater Exposure Units

Former Naval Auxillary Air Station Quillayute Quillayute, Washington



*This CSM applies to the following areas of potential concern located in the Quillayute airport:

B5 Transportation Maintenance
B7 Transformer Vault
B10 Gunnery Training
B11 Radio and Radar Building
B12 Class "C" Overhaul Shop
B17 Wash Rack and Shelter
B20 Hangar

B18/B19, B29, B65, the alleged liquid disposal area, the Tetraethyl Lead Disposal Area (Sludge Disposal Area) are located in the Quillayute Airport portion of the Industrial Complex Area but risk screening of the RI soil data did not indicate the presence of chemicals of potential concern (COPCs) in t the vicinity of these former NAAS buildings, or in the suspected/alleged disposal areas.

This CSM applies to the Industrial Complex-Quillayute Airport Groundwater Exposure Unit (Figure 4-6).

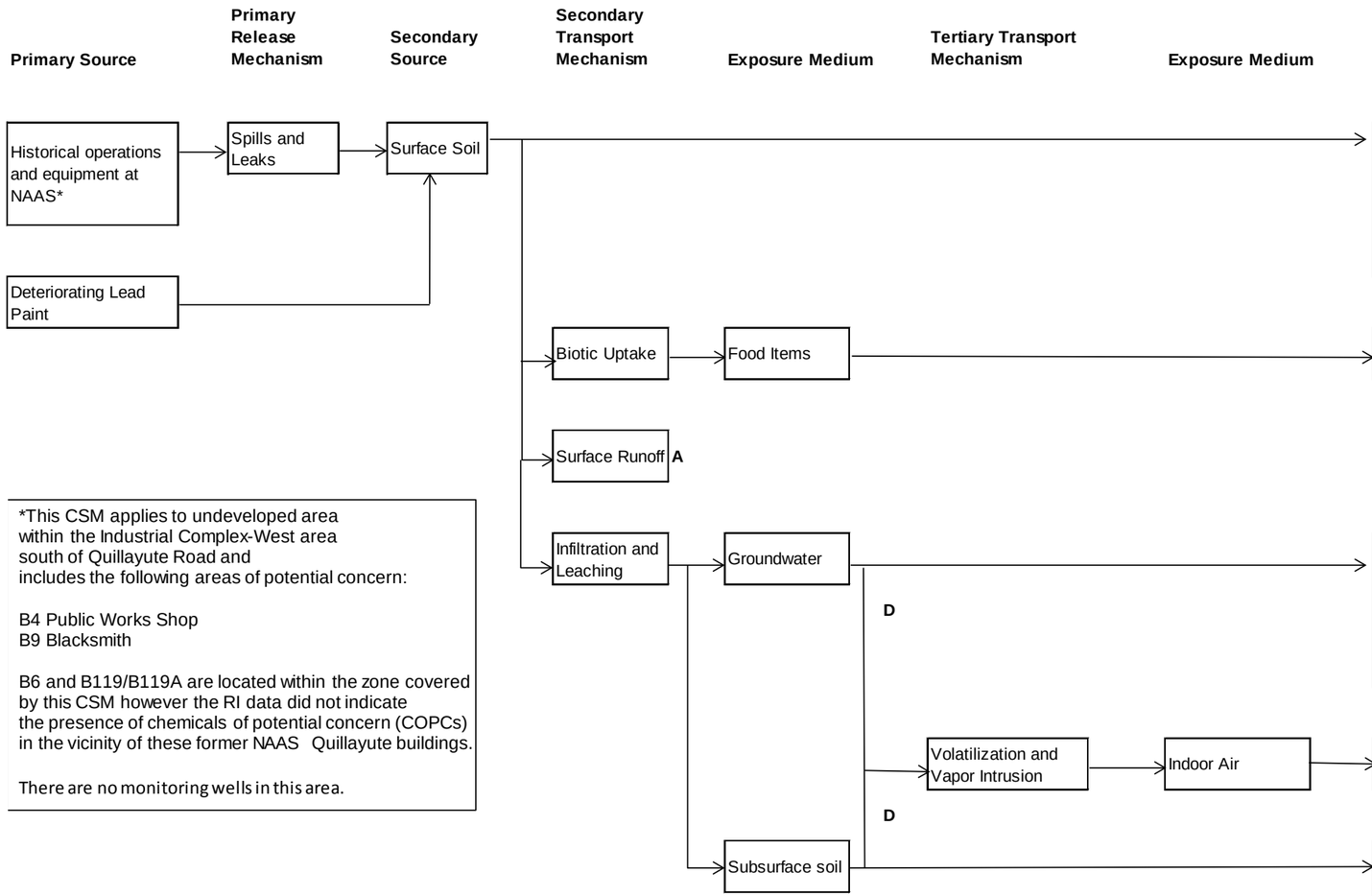
A Surface runoff from this area likely to be minimal because of level topography.
B No surface water bodies in close proximity to these areas.
C No VOCs detected in monitoring wells and water supply well located within the Quillayute Airport.
D Vapor intrusion from groundwater considered unlikely because of the depth to groundwater (> 70 ft bgs) and VOCs were not detected in monitoring wells and the water supply well located within the airport. Vapor intrusion from soil due to detections of VOCs (e.g., benzene) considered unlikely due to low levels (<1 ug/kg).
E Exposure to subsurface soil considered unlikely for receptors other than the excavation/construction worker.

●	Complete pathway for current receptor
O	Complete pathway for potential receptor
--	Incomplete pathway

U.S. Army Corps of Engineers

Figure 5-1a. Conceptual Site Model for the Quillayute Airport within the Western Portion of the Industrial Complex Area

Former Naval Auxiliary Air Station Quillayute Quillayute, Washington



Pathway	Resident Child/Adult*	Indoor Worker	Outdoor Worker	Excavation/ Construction Worker	Visitor/Recreationist Child/Adult	
Ingestion	O	O	O	O	O	
Inhalation of Particulates	O	--	O	O	O	
Dermal Contact	O	--	O	O	O	
Ingestion	--	--	--	--	--	
Ingestion	O	O	O	O	O	
Inhalation of Volatiles	O	--	--	--	--	B
Dermal Contact	O	--	O	--	--	C
Inhalation of Volatiles	--	--	--	--	--	D
Ingestion	--	--	--	O	--	E
Inhalation of Volatiles	--	--	--	O	--	E
Dermal Contact	--	--	--	O	--	E

*This CSM applies to undeveloped area within the Industrial Complex-West area south of Quillayute Road and includes the following areas of potential concern:

B4 Public Works Shop
B9 Blacksmith

B6 and B119/B119A are located within the zone covered by this CSM however the RI data did not indicate the presence of chemicals of potential concern (COPCs) in the vicinity of these former NAAS Quillayute buildings.

There are no monitoring wells in this area.

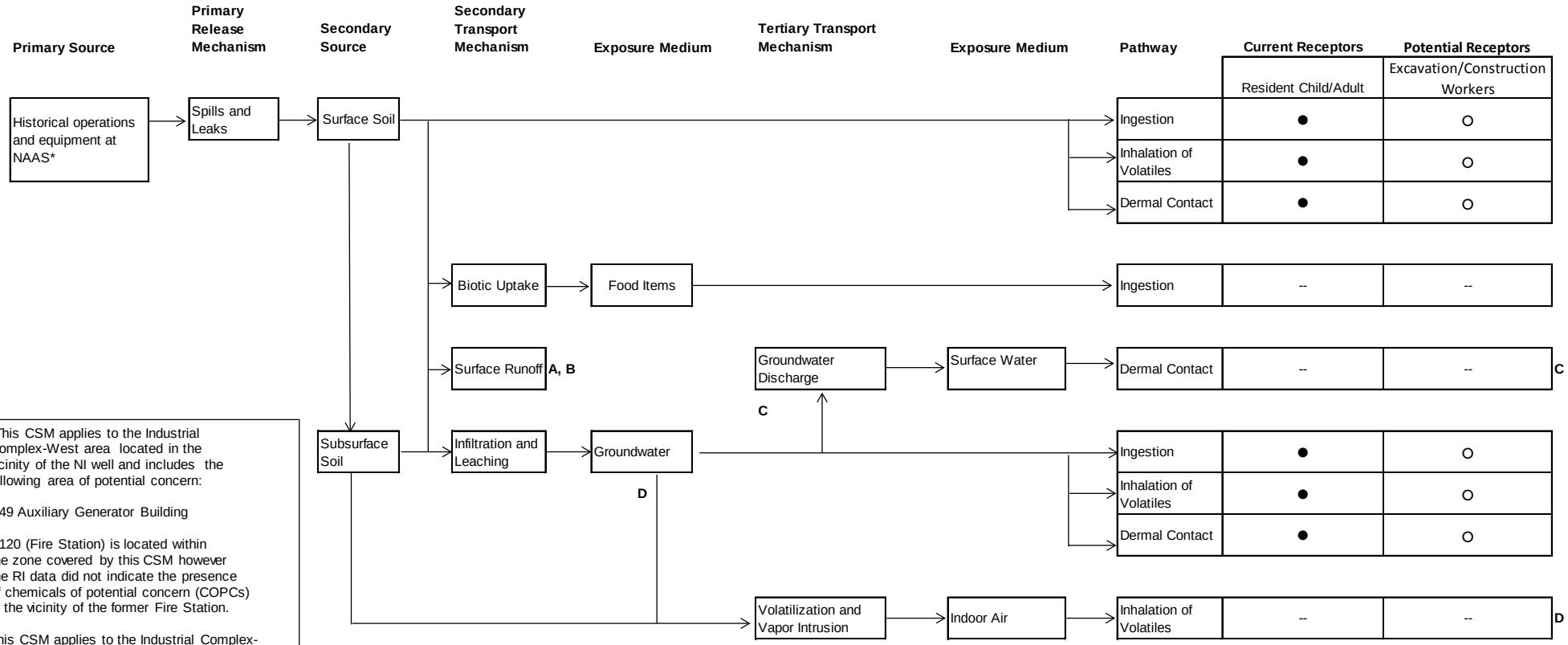
A Surface runoff from this area likely to be minimal because of level topography.
B Inhalation of volatiles from groundwater used as tap water by receptors other than residents considered to be minimal.
C Dermal contact with groundwater as tap water (i.e., during showering) considered unlikley for the visitor/recreationist receptor and excavation/construction worker.
D Vapor intrusion from groundwater considered unlikely because of depth to groundwater (> 70 ft bgs) and low concentrations in groundwater upgradient from this zone. VOC analyses of subsurface soil samples at B6 and B119/119A did not indicate the potential for vapor intrusion.
E Exposure to subsurface soil considered unlikely for receptors other than the excavation/construction worker.
* A residence may be constructed in this area in the near future.

O	Complete pathway for potential receptors
--	Incomplete pathway

U.S. Army Corps of Engineers

Figure 5-1b. Conceptual Site Model for the Undeveloped Area South of Quillayute Road within the Western Portion of the Industrial Complex Area

Former Naval Auxiliary Air Station Quillayute Quillayute, Washington



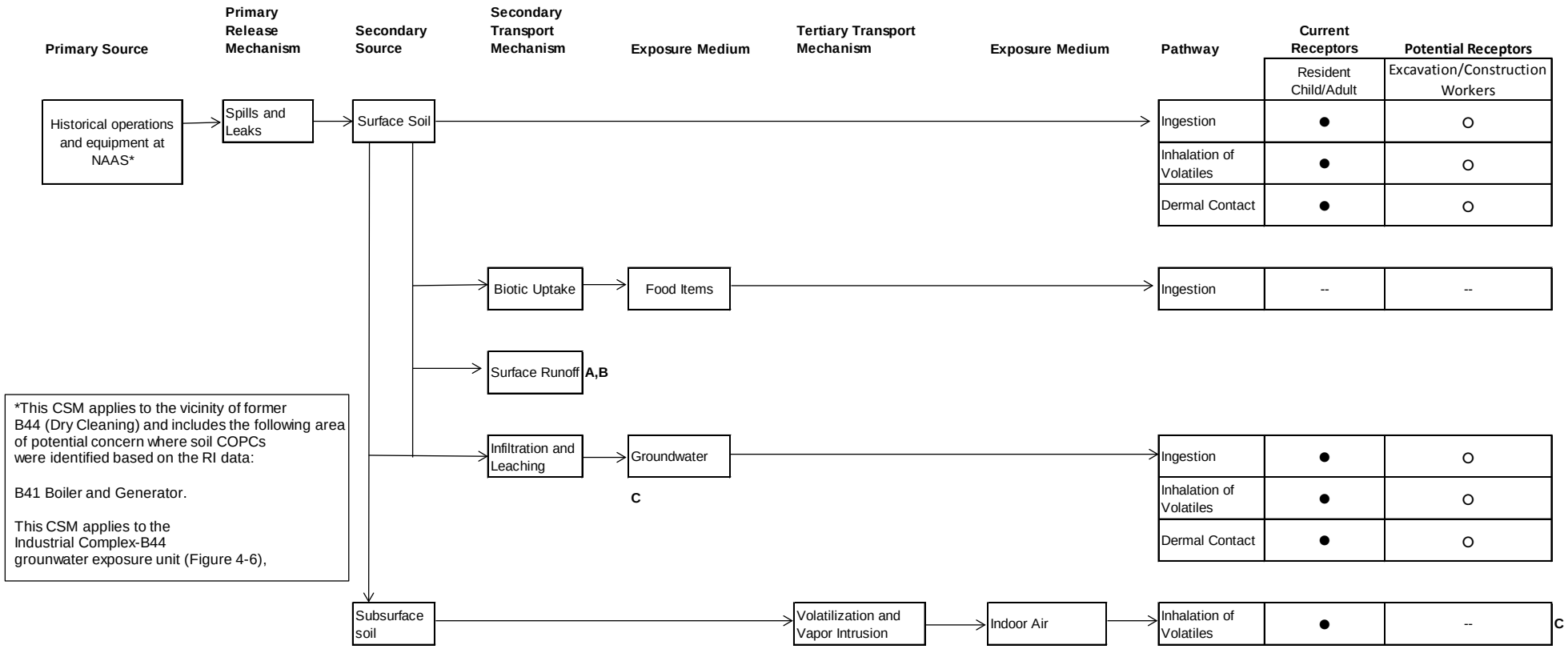
A	Surface runoff from this area likely to be minimal because of level topography.	
B	No surface water bodies in the vicinity of this zone except for the pond on the NI property that appears to be an area of groundwater discharge.	
C	The pond at the NI property may be fed by discharging groundwater however no VOCs were detected in the pond sample.	
D	Vapor intrusion from groundwater considered unlikely because of depth to groundwater (> 70 ft bgs) and low VOC concentrations in groundwater. Soil gas samples did not contain VOCs at levels that indicate potential for vapor intrusion.	

○	Complete pathway for potential receptor
●	Complete pathway for current receptor
--	Incomplete pathway

U.S. Army Corps of Engineers

Figure 5-1c. Conceptual Site Model for the Vicinity of the NI well within the Western Portion of the Industrial Complex Area

Former Naval Auxiliary Air Station Quillayute Quillayute, Washington



A Surface runoff from this area likely to be minimal because of level topography.

B No surface water bodies in this zone.

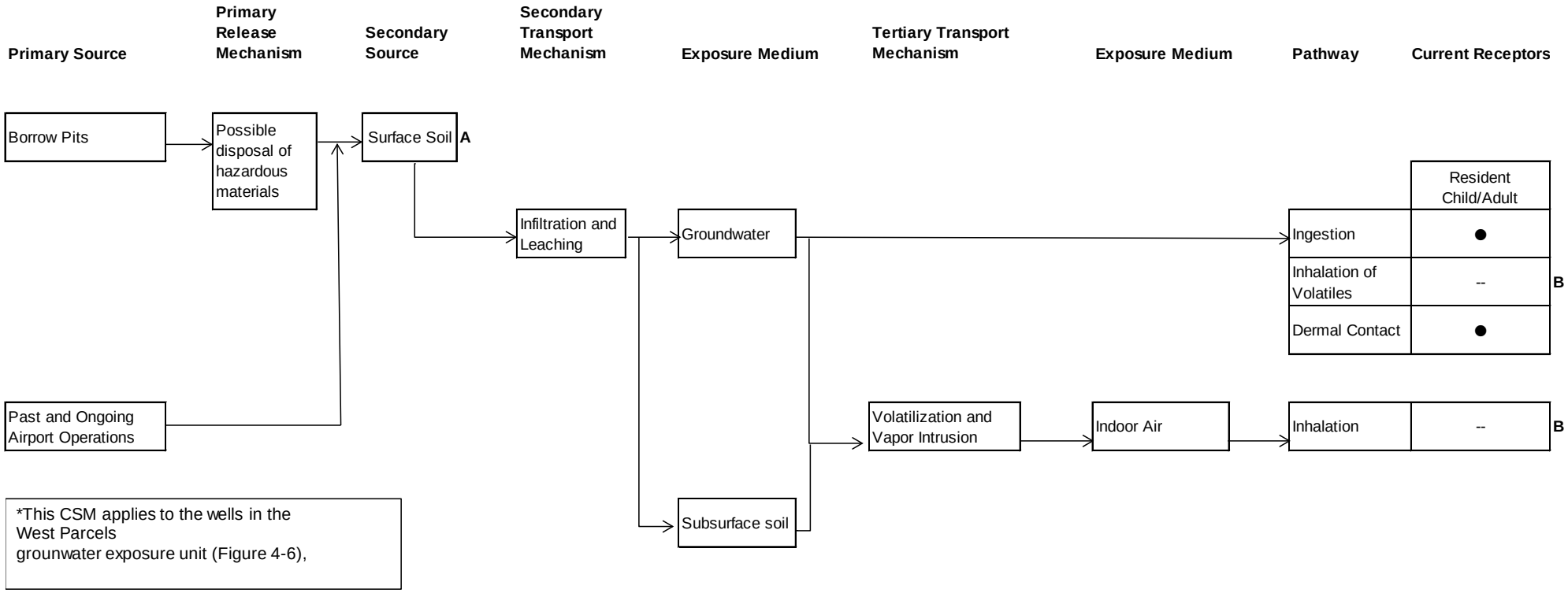
C Vapor intrusion from groundwater considered unlikely because of depth to groundwater (> 70 ft bgs) and low VOC concentrations in groundwater. Vapor intrusion potential from both groundwater and subsurface soil evaluated using soil gas and under trailer air samples.

●	Complete pathway
--	Incomplete pathway

U.S. Army Corps of Engineers

Figure 5-1d. Conceptual Site Model for the Vicinity of the B44 Slab within the Western Portion of the Industrial Complex Area

Former Naval Auxiliary Air Station Quillayute Quillayute, Washington



●	Complete pathway
--	Incomplete pathway

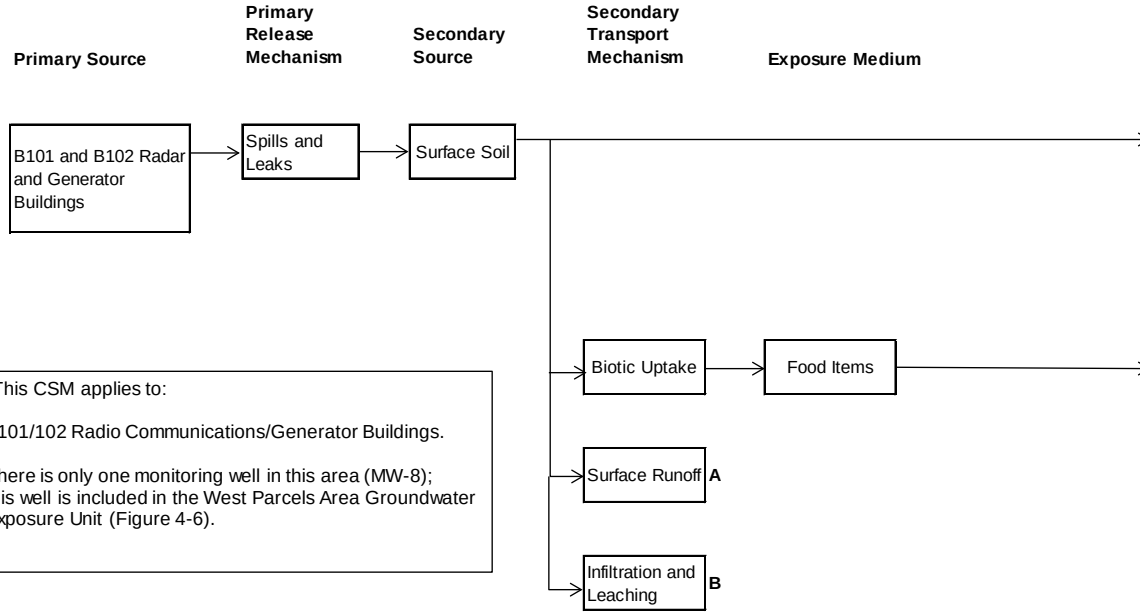
A Access and exposure to surface soil in the suspected burial pits considered unlikely given its depth (approximately 50 feet).

B VOCs were either not detected or were detected below screening levels in groundwater in the West Parcels Area

U.S. Army Corps of Engineers

Figure 5-1e. Conceptual Site Model for West Parcels Area

Former Naval Auxiliary Air Station Quillayute Quillayute, Washington



Pathway	Potential Receptors: Resident Child/Adult	Outdoor Worker	Excavation/ Construction Worker	Visitor/Recreationist Child/Adult
Ingestion	O	O	O	O
Inhalation of Particulates	O	O	O	O
Dermal Contact	O	O	O	O
Ingestion	--	--	--	--

*This CSM applies to:

B101/102 Radio Communications/Generator Buildings.

There is only one monitoring well in this area (MW-8); this well is included in the West Parcels Area Groundwater Exposure Unit (Figure 4-6).

O	Complete pathway for potential receptors
--	Incomplete pathway

A Surface runoff from this area likely to be minimal because of level topography.

B Chemicals detected in surface soil samples (PAHs) strongly sorbed to soil and unlikely to migrate vertically with infiltration.

U.S. Army Corps of Engineers

Figure 5-1f. Conceptual Site Model for East Parcels Area

Former Naval Auxiliary Air Station Quillayute Quillayute, Washington

TABLES

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Table 2-1. Monitoring wells at the formerQuillayute Naval Auxiliary Air Station

Well ID	Northing* (feet)	Easting* (feet)	Elevation (At Top of Casing)* (feet)	Total Depth from Top of Casing (feet)
MW-1	362309.62	727030.51	181.66	132.75
MW-2	362103.33	726662.45	182.80	130.00
MW-3	362021.64	726903.90	180.14	127.50
MW-6	365047.63	725654.97	181.54	99.75
MW-7	365451.13	727183.83	190.12	95.00
MW-8	366622.47	728248.25	195.58	83.16
MW-9	362716.52	724723.98	192.06	125.10
MW-10	366307.98	726669.03	189.20	95.30
MW-11	362418.28	726840.87	184.04	144.10
MW-12	361776.53	726865.45	186.56	17.00
MW-13	362625.11	727223.23	181.29	142.90
MW-14	362076.44	725781.12	179.37	131.00
MW-15	361917.63	725957.09	178.40	125.00
MW-16	361864.57	725593.22	178.52	110.00
MW-17	361997.35	726471.42	182.80	119.50

* Coordinates are referenced to the Washington State Plane, North Zone, NAD 83/91 and elevations to NAVD88 per Clallam County Geometric Framework, Volume 38, Page 84, Records of C.C., WA.
Field work for this project was performed on 11/09/04, 7/9/06, and 4/07/09.

Table 3-1. Federal and State Listed animal species for Clallum County, Washington

Species		Animal Type	State Listing[1]	Federal Listing[2]	Habitat[3]	Food	Comments
Common Name	Scientific Name						
Bald eagle	*Haliaeetus leucocephalus*	Bird	SS	FCo	Cliff, Forest - Conifer, Forest - Hardwood, Forest - Mixed, Woodland - Conifer, Woodland - Hardwood, Woodland - Mixed--Breeding habitat most commonly includes areas close to (within 4 km) coastal areas, bays, rivers, lakes, or other bodies of water that reflect the general availability of primary food sources including fish, waterfowl, and seabirds.	Carnivore, Piscivore	Habitat exists.
Black rockfish	*Sebastes melanops*	Fish	SC	--	Marine	--	No habitat exists within Study Area.
Black-backed woodpecker	*Picoides arcticus*	Bird	SC	none	Associated with boreal and montane coniferous forests, especially in areas with standing dead trees such as burns, bogs, and windfalls; less frequently in mixed forest and rarely in winter in deciduous woodland (AOU 1983). Distribution is closely associated with closed boreal forests and montane coniferous forests. The northern limits appear to coincide with the limit of continuous pine forest (Bock and Bock 1974). Extremely restricted in its use of habitat types and is strongly associated with recently burned forests (Raphael and White 1984, Hutto 1995b). Found in pine (PINUS spp.) including jack pine (P. BANKSIANA), white pine (P. STROBUS), and lodgepole pine (PINUS CONTORTA); spruce (PICEA spp.) such as black spruce (P. MARIANA) and white spruce (P. GLAUCA); fir (ABIES spp.) such as boreal balsam fir (A. BALSAMEA), and red fir (A. MAGNIFICA), Douglas-fir (PSEUDOTSUGA MENZIESII) and tamarack (LARIX spp.; Bock and Bock 1974, Goggans 1989, Villard and Beninger 1993, Villard 1994, Darveau et al. 1995).	Invertivore	No habitat exists within Study Area.
Blue whale	*Baleonoptera musculus*	Mammal	SE	--	Marine	Invertivore	No habitat exists within Study Area.
Bocaccio rockfish	*Sebastes paucispinis*	Fish	SC	--	Marine	Piscivore, Invertivore	No habitat exists within Study Area.
Brandt's cormorant	*Phalacrocorax penicillatus*	Bird	SC	--	Mainly inshore coastal zone, especially in areas having kelp beds; also around some offshore islands; less commonly, inshore on brackish bays; in winter, mostly around sheltered inlets and other quiet waters (Palmer 1962, AOU 1983, Johnsgard 1993). Typically nests on flat or gently sloping surfaces on tops of rocky islands along coast, favoring protected leeward sides of islands; frequently nests with other sea birds; may sometimes use wider ledges of mainland cliffs. Nest is built on ground by both sexes, may be re-used in subsequent year.	Invertivore, Piscivore	No habitat exists within Study Area. This species is associated with marine and coastal habitat.

Table 3-1. Federal and State Listed animal species for Clallum County, Washington

Species		Animal Type	State Listing[1]	Federal Listing[2]	Habitat[3]	Food	Comments
Common Name	**Scientific Name**						
Brown pelican	*Pelecanus occidentalis*	Bird	SE	FCo	Brown pelicans nest in colonies on offshore islands that are free of mammalian predators and human disturbance, are of sufficient elevation to prevent flooding of nests, and are associated with an adequate and consistent food supply. Brown pelicans roost communally, generally in areas that are near adequate food supplies, have some type of physical barrier to predation and disturbance, and provide some protection from environmental stresses such as wind and high surf. The brown pelican uses breakwaters, jetties, sand spits and offshore sand bars extensively as daily loafing and nocturnal roost areas. Brown pelican numbers in a given area may vary greatly with the season. The brown pelican is rarely found away from salt water and does not normally venture more than 20 miles out to sea.	Piscivore	No habitat exists within Study Area. This species is associated with marine and coastal habitat.
Brown rockfish	*Sebastes auriculatus*	Fish	SC	--	Marine	Piscivore, Invertivore	No habitat exists within Study Area.
Bull trout	*Salvelinus confluentus*	Fish	SC	FT	Freshwater	Carnivore, Invertivore, Piscivore	No habitat exists within Study Area.
Burrowing owl	*Athene cunicularia*	Bird	SC	FCo	Desert, Grassland/herbaceous, Savanna -Habitat includes open grasslands, especially prairie, plains, and savanna, sometimes other open areas such as vacant lots near human habitation or airports. This owl spends much time on the ground or on low perches such as fence posts or dirt mounds. Nests are in abandoned burrows, such as those dug by prairie dogs, ground squirrels, foxes, woodchucks, or (in Florida) gopher tortoises, and including badger excavations (see especially Green and Anthony 1989).	Carnivore, Invertivore-large insects and rodents	No habitat exists within Study Area.
California mountain kingsnake	*Lampropeltis zonata*	Reptile	SC	none	The species occurs in moist microhabitats in Oregon White Oak-Ponderosa Pine forest where individuals are usually found under woody debris and rocks.	--	No habitat exists within Study Area.
Canary rockfish	*Sebastes pinniger*	Fish	SC	--	Marine	--	No habitat exists within Study Area.

Table 3-1. Federal and State Listed animal species for Clallum County, Washington

Species		Animal Type	State Listing[1]	Federal Listing[2]	Habitat[3]	Food	Comments
Common Name	**Scientific Name**						
Cascades frog	*Rana cascadae*	Amphibian	--	FCo	Cascades frogs inhabit wet mountain meadows, sphagnum bogs, ponds, lakes, and streams, in open or patchy coniferous forests. Generally they are closely associated with water, but they sometimes move from one drainage to another by crossing over high mountain ridges. These frogs hibernate in mud at the bottom of ponds and in spring-water saturated ground up to at least 75 meters from a pond (Briggs 1987). Breeding sites are quiet ponds, where eggs are laid in open shallow water or among submerged vegetation.	Invertivore	No habitat exists within Study Area.
Cassin's auklet	*Ptychoramphus aleuticus*	Bird	SC	FCo	Nonbreeding: mostly pelagic, less frequently along rocky seacoasts (AOU 1983). Nests on offshore islands, mostly in areas with low vegetation (also under trees in some areas (e.g., southeastern Alaska, Washington), on both flat and sloping terrain, sometimes several hundred m from coast (Johnsgard 1987). Nests in burrow dug in ground or under rock; sometimes among driftwood or debris; usually uses same site in successive years	Invertivore	No habitat exists within Study Area. This species is associated with marine and coastal habitat.
China rockfish	*Sebastes nebulosus*	Fish	SC	--	Marine	--	No habitat exists within Study Area.
Chinook salmon (Lower Columbia)	*Oncorhynchus tshawytscha*	Fish	SC	--	Freshwater	--	No habitat exists within Study Area.
Chinook salmon (Puget Sound)	*Oncorhynchus tshawytscha*	Fish	SC	--	Freshwater	--	No habitat exists within Study Area.
Chinook salmon (Snake R. Fall)	*Oncorhynchus tshawytscha*	Fish	SC	--	Freshwater	Invertivore, Piscivore	No habitat exists within Study Area.
Chinook salmon (Snake R. Sp/Su)	*Oncorhynchus tshawytscha*	Fish	SC	--	Freshwater	--	No habitat exists within Study Area.
Chinook salmon (Upper Columbia Sp)	*Oncorhynchus tshawytscha*	Fish	SC	--	Freshwater	--	No habitat exists within Study Area.
Chinquapin hairstreak	*Habrodais grunus herri*	Butterfly or Moth	SC	none	--	--	--
Chum salmon (Hood Canal Su)	*Oncorhynchus keta*	Fish	SC	--	Freshwater	--	No habitat exists within Study Area.
Chum salmon (Lower Columbia)	*Oncorhynchus keta*	Fish	SC	--	Freshwater	--	No habitat exists within Study Area.
Coho salmon (Lower Columbia/SW WA)	*Oncorhynchus kisutch*	Fish	--	--	Freshwater	Invertivore, Piscivore	No habitat exists within Study Area.
Columbia clubtail (dragonfly)	*Gomphus lynnae*	Other Insect	SC	FCo	Found in sandy to rocky, slow-flowing rivers; eggs broadcast in water, larvae burrow in mud, adults forage among shrubs.	--	

Table 3-1. Federal and State Listed animal species for Clallum County, Washington

Species		Animal Type	State Listing[1]	Federal Listing[2]	Habitat[3]	Food	Comments
Common Name	**Scientific Name**						
Copper rockfish	*Sebastes caurinus*	Fish	SC	--	Marine	--	No habitat exists within Study Area.
Dolly Varden	*Salvelinus malma*	Fish	--	FPT	Marine	Piscivore, Invertivore	No habitat exists within Study Area.
Eulachon	*Thaleichthys pacificus*	Fish	SC	--	Freshwater	Invertivore	No habitat exists within Study Area.
Fisher	*Martes pennanti*	Mammal	SE	FC	Fishers inhabit upland and lowland forests, including coniferous, mixed, and deciduous forests. They occur primarily in dense coniferous or mixed forests, including early successional forest with dense overhead cover. Fishers commonly use hardwood stands in summer but prefer coniferous or mixed forests in winter. They generally avoid areas with little forest cover or significant human disturbance and conversely prefer large areas of contiguous interior forest. Forest type is probably not as important to fishers as the vegetative and structural aspects that lead to abundant prey populations and reduced fisher vulnerability to predation, and that they may select forests that have low and closed canopies. Several studies have shown that fishers are associated with riparian areas, which are in some cases protected from logging and generally more productive, thus having the dense canopy closure, large trees and general structural complexity associated with fisher habitat. Riparian areas may be important to fishers because they provide important rest site elements, such as broken tops, snags, and coarse woody debris. Fishers are regarded as habitat specialists in the western United States, occurring only at mid- to lower elevation in mature conifer and mixed conifer/hardwood forests characterized by dense canopies and abundant large trees, snags, and logs.	Carnivore	Most likey no habitat within study area since they generally avoid areas with little forest cover or significant human disturbance and prefer large areas of contiguous interior forest. Furthermore, they are associated with riparian areas. It is very unlikey this species inhabits the SA.
Giant Columbia River limpet	*Fisherola nuttalli*	Mollusk	SC	none			No habitat within SA
Golden eagle	*Aquila chrysaetos*	Bird	SC	--	Alpine, cliff, desert, grassland/herbaceous, savanna, tundra, woodland-conifer, hardwood, mixed--Generally open country, in prairies, arctic and alpine tundra, open wooded country, and barren areas, especially in hilly or mountainous regions. Nests on rock ledge of cliff or in large tree (e.g., oak or eucalytus in California, white pine in eastern North America).	Carnivore	No breeding habitat within SA. This species is associated with rock cliffs or ledges for nesting and breeding. However, it is possible this species would forage within the SA.
Gray whale	*Eschrichtius robustus*	Mammal	SS	--	Marine	Invertivore	No habitat exists within Study Area.

Table 3-1. Federal and State Listed animal species for Clallum County, Washington

Species		Animal Type	State Listing[1]	Federal Listing[2]	Habitat[3]	Food	Comments
Common Name	**Scientific Name**						
Greater Sage-grouse	*Centrocercus urophasianus*	Bird	ST	FC	Desert, grassland/herbaceous, savanna, shrubland/chaparral, riparian--Habitat includes foothills, plains, and mountain slopes where sagebrush is present (AOU 1983), often with a mixture of sagebrush, meadows, and aspen, in close proximity. This species uses a wide variety of sagebrush mosaic habitats, including (1) tall sagebrush types such as big sagebrush (*Artemisia tridentata*), three-tip sagebrush (*A. tripartita*), and silver sagebrush (*A. cana*); (2) low sagebrush types, such as low sagebrush (*A. arbuscula*) and black sagebrush (*A. nova*); (3) mixes of low and tall sagebrush with abundant forbs; (4) riparian and wet meadows; (5) steppe dominated by native forbs and bunchgrasses; (6) scrub-willow (*Salix* spp.); and (7) sagebrush/woodland mixes with juniper (*Juniperus* spp.), ponderosa pine (*Pinus ponderosa*), or quaking aspen (*Populus tremuloides* ; Schroeder et al. 1999).	granivore, herbivore, invertivore	No habitat exists within Study Area.
Green sea turtle	*Chelonia mydas*	Reptile	ST	--	Feeding occurs in shallow, low-energy waters with abundant submerged vegetation, and also in convergence zones in the open ocean (NMFS and USFWS 2007). Migrations may traverse open seas. Adults are tropical in distribution, whereas juveniles range into temperate waters (e.g., see Morreale and Standora, no date). Hatchlings often float in masses of marine macroalgae (e.g., Sargassum) in convergence zones. Coral reefs and rocky outcrops near feeding pastures often are used as resting areas. Inactive individuals may rest on the bottom in winter in the northern Gulf of California. Basking on beaches occurs in some areas (e.g., Hawaii). Nesting occurs on beaches, usually on islands but also on the mainland.	Marine	No habitat exists within Study Area.
Green sturgeon	*Acipenser medirostris*	Fish	--	--	Freshwater	Invertivore, Piscivore	No habitat exists within Study Area.
Greenstriped rockfish	*Sebastes elongatus*	Fish	SC	--	Marine	--	No habitat exists within Study Area.
Humpback whale	*Megaptera novaeangliae*	Mammal	SE	--	Marine	Invertivore, Piscivore, Plankivore	No habitat exists within Study Area.
Johnson's hairstreak	*Mitoura johnsoni*	Butterfly or Moth	SC	--	Occurs mostly in old-growth coniferous forests with red firs, western hemlocks, or gray pines on which its parasitic host grows (Opler, 1962; Shields, 1965). Opler (1999) account is similar.	Nectarivore	No habitat exists within Study Area. This species is associated with old growth coniferous forests. Unlikely this species inhabits the SA.

Table 3-1. Federal and State Listed animal species for Clallum County, Washington

Species		Animal Type	State Listing[1]	Federal Listing[2]	Habitat[3]	Food	Comments
Common Name	**Scientific Name**						
Keen's long-eared bat (formerly Keen's myotis)	*Myotis keenii*	Mammal	SC	--	The distributional range suggests an association with coastal forest habitat (van Zyll de Jong 1985; Nagorsen and Brigham, unpubl. manuscript). Apparently this bat is associated with mature forests (Balcombe, 1988 COSEWIC report), but it is not restricted to old growth (COSEWIC 2003). Across the range it has been found roosting in southwest-facing rock crevices, among geothermally heated rocks, in tree cavities, in bark crevices, and in buildings (D. Burles, pers. comm.; Firman et al. 1993; Nagorsen and Brigham 1993; Parker and Cook 1996; Mather et al. 2000). Tree cavities and loose bark are important natural roost sites and may be limiting in some parts of the range (British Columbia Ministry of Water, Land and Air Protection 2004).	Invertivore	Most likely not within SA since it is associated with mature forests.
Killer whale	*Orcinus orca*	Mammal	SE	--	Marine	Carnivore, Piscivore	No habitat exists within Study Area.
Leatherback sea turtle	*Dermochelys coriacea*	Reptile	SE	--	Marine; open ocean, often near edge of continental shelf; also seas, gulfs, bays, and estuaries. Mainly pelagic, seldom approaching land except for nesting (Eckert 1992).	Marine	No habitat exists within Study Area.
Loggerhead sea turtle	*Caretta caretta*	Reptile	ST	FE	Open sea to more than 500 miles from shore, mostly over continental shelf, and in bays, estuaries, lagoons, creeks, and mouths of rivers; mainly warm temperate and subtropical regions not far from shorelines. Nesting occurs usually on open sandy beaches above high-tide mark, seaward of well-developed dunes.		No habitat exists within Study Area.
Long-eared myotis	*Myotis evotis*	Mammal	--	FCo	Mostly forested areas, especially those with broken rock outcrops; also shrubland, over meadows near tall timber, along wooded streams, over reservoirs. Often roosts in buildings, also in hollow trees, mines, caves, fissures, etc.	Invertivore	Habitat exists.
Long-legged myotis	*Myotis volans*	Mammal	--	FCo	Primarily in montane coniferous forests, in the south most often at 2000-3000 m; also riparian and desert (Baja California) habitats. May change habitats seasonally. Uses caves and mines as hibernacula, but winter habits are poorly known. Roosts in abandoned buildings, rock crevices, under bark, etc. In summer, apparently does not use caves as daytime roost site. In some areas hollow trees are the most common nursery sites, but buildings and rock crevices are also used. See Vonhof and Barclay (1996) for information on characteristics of roost trees in British Columbia.	Invertivore	Habitat exists.

Table 3-1. Federal and State Listed animal species for Clallum County, Washington

Species		Animal Type	State Listing[1]	Federal Listing[2]	Habitat[3]	Food	Comments
Common Name	**Scientific Name**						
Marbled murrelet	*Brachyramphus marmoratus*	Bird	ST	FT	Marbled murrelets spend the majority of their lives on the ocean, but come inland to nest. They generally nest in old-growth forests, characterized by large trees, multiple canopy layers, and moderate to high canopy closure. Nests have been found inland from the coast up to a distance of 50 miles in Washington State.	Invertivore, Piscivore	No habitat within the SA. This species is associated with marine and old growth forests habitats.
Mazama (Western) pocket gopher	*Thomomys mazama*	Mammal	ST	FC	Associated with glacial outwash prairies in western Washington. Pocket gopher distribution is highly patchy, partly due to the patchy distribution of prairies, but also due to the soil rockiness within the prairie expanses.	Herbivore	No habitat exists within Study Area. This species is associated with prairie habitat. It is unlikely this species inhabits the SA.
Northern abalone	*Haliotis kamtschatkana*	Mollusk	SC	--	Habitat is predominantly kelp beds along outer well-exposed coasts; typically low intertidal to 30 feet depth, but ranges to 100 m depth (NOAA, 2004; Abalone Recovery Team, 2004). It occurs in a wide range of habitats from fairly sheltered bays to exposed coastlines but the populations with the highest densities are found in areas with the highest wave exposure (Lessard and Campbell, 2007).	Herbivore	No habitat exists within Study Area. This species is associated with coastal waters.
Northern goshawk	*Accipiter gentilis*	Bird	SC	FCo	Nests are generally constructed in the largest trees of dense, old or mature stands with high canopy closure (60-95 percent) and sparse groundcover, near the bottom of moderate slopes, and near water or dry openings(Bull and Hohmann 1994, Daw and DeStefano 2001, Hargis et al. 1994, Reynolds et al 1982, Siders and Kennedy 1994, Squires and Ruggiero 1996, Younk and Bechard 1994). Forages in both heavily forested and relatively open habitats.	Carnivore	No breeding habitat within SA. This species is associated with old growth forests for nesting and breeding. However, it is possible this species would forage within the SA.
Northern Sea otter	*Enhydra lutris kenyoni*	Mammal	SE	FCo	Coastal waters usually within 2 km of shore, especially shallows with kelp beds and abundant shellfish. In rough weather, takes refuge among kelp, or in coves and inlets. Often comes ashore in Alaska, rarely does so in California.	Invertivore	No habitat exists within Study Area. This species is associated with coastal waters.
Northern Spotted Owl	*Strix occidentalis*	Bird	SE	FT	Dense forest and deep wooded canyons; generally in mature stands or old growth (e.g., Bias and Gutiérrez. 1992); requires cool summer roosts. Nests on broken tree top, cliff ledge, in natural tree cavity, or in tree on stick platform, often the abandoned nest of hawk or mammal; sometimes in cave.	Carnivore	No habitat exists within Study Area. This species is associated with old growth forest habitat.

Table 3-1. Federal and State Listed animal species for Clallum County, Washington

Species		Animal Type	State Listing[1]	Federal Listing[2]	Habitat[3]	Food	Comments
Common Name	**Scientific Name**						
Olive-sided flycatcher	*Contopus cooperi*	Bird	--	FCo	Olive-sided flycatchers breed in various forest and woodland habitats: taiga, subalpine coniferous forest, mixed coniferous-deciduous forest, burned-over forest, spruce or tamarack bogs and other forested wetlands, and along the forested edges of lakes, ponds, and streams Most nesting sites contain dead standing trees, which are used as singing and feeding perches. Nests are placed most often in conifers, on horizontal limbs 2-15 meters from the ground. During the northern winter, this species occurs in a variety of forest, woodland, and open situations with scattered trees, especially where tall dead snags are present.	Invertivore	Habitat exists.
Olympia oyster	*Ostrea lurida*	Mollusk	SC	--	The conchaphila form is usually attached to living mollusks or the carapace of large crustaceans and is usually solitary while the lurida form is attached to dead shells or rocks and may form extensive reefs	Herbivore	No habitat exists within Study Area. This species is associated with coastal waters.
Olympic marmot	*Marmota olympus*	Mammal	SC	--	Typical habitat encompasses subalpine and alpine meadows and talus slopes near timberline; many colonies are located on south-facing slopes, where food availability is probably greater because of earlier snowmelt (Barash 1973). Young are born in underground burrows.	Herbivore	No habitat within the SA. Unlikely this species is located within SA since it is associated with subalpine and alpine meadows and talus slopes near timberline.
Olympic mudminnow	*Novumbra hubbsi*	Fish	SS	--	Freshwater	Invertivore	No habitat exists within Study Area.
Olympic torrent salamander	*Rhyacotriton olympicus*	Amphibian	--	FCo	Coastal coniferous forests in small, cold mountain streams and spring seepages. Larvae often occur under stones in shaded streams. Adults also inhabit these streams or streamsides in saturated moss-covered talus, or under rocks in splash zone. Primarily in older forest sites; required microclimatic and microhabitat conditions generally exist only in older forests (Welsh 1990).	Invertivore	No habitat exists within SA. Species associated with conferous streams and seeps.
Oregon silverspot butterfly	*Speyeria zerene hippolyta*	Butterfly or Moth	SE	FT	--	--	No habitat exists within Study Area.
Oregon vesper sparrow	*Pooecetes gramineus affinis*	Bird	SC	FCo	Grassland	Invertivore, Herbivore	No habitat exists within Study Area. Most open areas within SA are mowed grass.
Pacific cod (S&C Puget Sound)	*Gadus macrocephalus*	Fish	SC	--	Marine	--	No habitat exists within Study Area.
Pacific hake (Pacific-Georgia Basin DPS	*Merluccius productus*	Fish	SC	--	Marine	--	No habitat exists within Study Area.

Table 3-1. Federal and State Listed animal species for Clallum County, Washington

Species		Animal Type	State Listing[1]	Federal Listing[2]	Habitat[3]	Food	Comments
Common Name	**Scientific Name**						
Pacific harbor porpoise	*Phocoena phocoena*	Mammal	SC	--	Coastal waters and adjacent offshore shallows; also inhabits inshore areas such as bays, channels, and rivers. Mothers and young tend to move into sheltered coves and similar sites soon after parturition.	Invertivore, Piscivore	No habitat exists within Study Area. This species is associated with coastal waters.
Pacific herring	*Clupea pallasi*	Fish	SC	--	Marine	--	No habitat exists within Study Area.
Pacific lamprey	*Lampetra tridentata*	Fish	--	FCo	Freshwater	--	
Pacific pond turtle (Western pond turtle)	*Actinemys marmorata*	Reptile	SE		Habitat includes permanent and intermittent waters of rivers, creeks, small lakes and ponds, marshes, irrigation ditches, and reservoirs. Sometimes this turtle is found in brackish water. It often basks on logs, vegetation mats, or rocks. In a northern California stream, deep large pools with logs, branches, or boulders were favored sites (Bury 1972). When disturbed, baskers seek cover underwater.	Carnivore, Invertivore, Piscivore	No habitat exists within Study Area. Utilizes ponds or lakes. Several small wetlands and man made pond located in the southern portion of Industrial Area West. However, these areas are quite small and do not contain any basking habitat. It is unlikely this species inhabits the SA
Pacific Townsend's big-eared bat	*Corynorhinus townsendii townsendii*	Mammal	SC	FCo	Maternity and hibernation colonies typically are in caves and mine tunnels. Prefers relatively cold places for hibernation, often near entrances and in well-ventilated areas. Throughout much of the known range, commonly occurs in mesic habitats characterized by coniferous and deciduous forests (Kunz and Martin 1982), but occupies a broad range of habitats (e.g., see Handley 1959). On West Coast found regularly in forested regions and buildings, and in areas with a mosaic of woodland, grassland, and/or shrubland.	Insectivore	Habitat exists.
Peregrine falcon	*Falco peregrinus*	Bird	SS	FCo	Various open situations from tundra, moorlands, steppe, and seacoasts, especially where there are suitable nesting cliffs, to mountains, open forested regions, and human population centers (AOU 1983). When not breeding, occurs in areas where prey concentrate, including farmlands, marshes, lakeshores, river mouths, tidal flats, dunes and beaches, broad river valleys, cities, and airports.	Carnivore	Habitat exists.
Pileated woodpecker	*Dryocopus pileatus*	Bird	SC	--	Dense deciduous (favored in southeast), coniferous (favored in north, northwest and west), or mixed forest, open woodland, second growth, and (locally) parks and wooded residential areas of towns. Prefers woods with a tall closed canopy and a high basal area. Most often in areas of extensive forest or minimal isolation from extensive forest.	Invertivore	Habitat exists.

Table 3-1. Federal and State Listed animal species for Clallum County, Washington

Species		Animal Type	State Listing[1]	Federal Listing[2]	Habitat[3]	Food	Comments
Common Name	**Scientific Name**						
Puget blue	*Plebejus icarioides blackmorei*	Butterfly or Moth	SC	--	Subalpine and alpine habitat.	Nectarivore	No habitat within the SA. Unlikely this species is located within SA since it is associated with subalpine and alpine meadows habitat.
Purple martin	*Progne subis*	Bird	SC	--	A wide variety of open and partly open situations, frequently near water or around towns. In west and formerly in east nests in tree cavities, abandoned woodpecker holes (including those in saguaro cacti), crevices in rocks; in east and midwest now nests in bird-houses and gourds put up by humans.	Invertivore	Habitat exists.
Pygmy whitefish	*Prosopium coulteri*	Fish	SS	--	Freshwater	Invertivore, Piscivore	No habitat exists within Study Area.
Queen Charlotte's Copper (formerly Makah copper)	*Lycaena mariposa charlottensis*	Butterfly or Moth	SC	FCo	Coastal areas.	Nectarivore	No habitat exists within Study Area.
Quillback rockfish	*Sebastes maliger*	Fish	SC	--	Marine	--	No habitat exists within Study Area.
Redstripe rockfish	*Sebastes proriger*	Fish	SC	--	Marine	--	No habitat exists within Study Area.
River lamprey	*Lampetra ayresi*	Fish	SC	FCo	Freshwater	Herbivore, Invertivore, Piscivore	No habitat exists within Study Area.
Sage sparrow	*Amphispiza belli*	Bird	SC	none	Strongly associated with sagebrush for breeding. Also found in salt-bush brushland, shadscale, antelope brush, rabbitbrush, black greasewood (Colorado), mesquite, and chaparral (California; AOU 1998; Green and Smith 1981; Martin and Carlson 1998; Paige and Ritter 1998; Reynolds 1981). Prefers semi-open habitats, shrubs 1-2 meters tall (Martin and Carlson 1998). Habitat structure (vertical structure, shrub density, and habitat patchiness) is important to habitat selection (Martin and Carlson 1998). Positively correlated with big sagebrush (ARTEMISIA TRIDENTATA), shrub cover, bare ground, above-average shrub height, and horizontal patchiness; negatively correlated with grass cover (Rotenberry and Wiens 1980; Wiens and Rotenberry 1981; Larson and Bock 1984).	granivore, invertivore	No habitat exists within Study Area.

Table 3-1. Federal and State Listed animal species for Clallum County, Washington

Species		Animal Type	State Listing[1]	Federal Listing[2]	Habitat[3]	Food	Comments
Common Name	**Scientific Name**						
Sage thrasher	*Oreoscoptes montanus*	Bird	SC	none	Sagebrush plains, primarily in arid or semi-arid situations, rarely around towns (AOU 1998). Usually breeds between 1300 and 2000 meters above sea level (Reynolds and Rich 1978). In eastern Washington, showed strongest correlation to amount of sagebrush cover of all shrub-steppe birds; most abundant where sagebrush percent cover was 11% which is similar to estimated historic sagebrush cover (Dobler 1992, Dobler et al. 1996). In northern Great Basin, breeds and forages in tall sagebrush/bunchgrass, juniper/sagebrush/bunchgrass, mountain mahogany/shrub, and aspen/sagebrush/bunchgrass communities (Maser et al. 1984).	frugivore, invertivore	No habitat exists within Study Area.
Sagebrush lizard	*Sceloporus graciosus*	Reptile	SC	FCo	In Washington, this gregarious lizard is primarily associated with sand dunes and other sandy habitats that support shrubs and have large areas of bare ground. Sagebrush Lizards bask in the morning and late afternoon. Typically, they can be seen on the ground at the edge of shrubs or other vegetation that provide cover from predators. When ground temperatures become hot, Sagebrush Lizards move into the low branches of shrubs or under vegetation. At night, on rainy days and on cool cloudy days they move underground or shelter under debris.		
Sandhill crane	*Grus canadensis*	Bird	SE	none	Breeding habitat includes open grasslands, marshes, marshy edges of lakes and ponds, and river banks (Terres 1980). Nests are on the ground or in shallow water on open tundra, large marshes, bogs, fens, or wet forest meadows. Individuals exhibit high fidelity to breeding territories (see Littlefield 1995). During the nonbreeding season, sandhill cranes roost at night in shallow water along river channels, on alluvial islands of braided rivers, or in natural basin wetlands.	Carnivore, frugivore, granivore, herbivore, invertivore	
Sand-verbena moth	*Copablepharon fuscum*	Butterfly or Moth	SC	--	Beaches, dunes, and sand spits with dense vigorous patches of sand verbena (*Abronia latifolia*), but not sandy meadows or nearly bare sand with sparse or non-flowering sand verbena plants only.	Nectarivore	No habitat exists within Study Area. This species is associated with beaches and dunes. Very unlikely this species inhabits the SA.

Table 3-1. Federal and State Listed animal species for Clallum County, Washington

Species		Animal Type	State Listing[1]	Federal Listing[2]	Habitat[3]	Food	Comments
Common Name	**Scientific Name**						
Short-tailed albatross	*Diomedea albatrus*	Bird	SC	FE	This is a pelagic bird that often occurs in regions of high marine productivity. It nests on the ground on small oceanic islands; on volcanic ash slopes with sparse vegetation, formerly on level open areas adjacent to tall clumps of the grass *Miscanthus sinensis* (i.e., on Torishima, where also present was the composite *Chrysanthemum pacificum* and the nettle *Boehmeria biloba* , which stabilized the soil).	Invertivore, Piscivore	No habitat exists within Study Area. Species associated with marine activity.
Snowy plover	*Charadrius nivosus*	Bird	SE	FT	Beaches, dry mud or salt flats, sandy shores of rivers, lakes, and ponds.	invertivore	No habitat exists within Study Area.
Sockeye salmon (Ozette Lake)	*Oncorhynchus nerka*	Fish	SC	--	Freshwater	--	No habitat exists within Study Area.
Sperm whale	*Physeter macrocephalus*	Mammal	SE	--	Marine	Invertivore	No habitat exists within Study Area.
Steller sea lion	*Eumetopias jubatus*	Mammal	ST	--	Marine	Invertivore, Piscivore	No habitat exists within Study Area.
Tailed frog	*Ascaphus truei*	Amphibian		FCo	Clear, cold swift-moving mountain streams with coarse substrates. Primarily in older forest sites; required microclimatic and microhabitat conditions are more common in older forests (Welsh 1990).	Invertivore, herbivore	No habitat exists within SA. Species associated with mountain streams.
Taylor's checkerspot	*Euphydryas editha taylori*	Butterfly or Moth	SE	FC	Dry prairies or prairie-like native grassland in Puget Sound, Willamette portions of range, maritime meadows within Garry oak ecosystems in Canada	Nectarivore	No habitat exists within Study Area. This species is associated with prairie habitat. It is unlikely this species inhabits the SA.
Tiger rockfish	*Sebastes nigrocinctus*	Fish	SC	--	Marine	--	No habitat exists within Study Area.
Tufted puffin	*Fratercula cirrhata*	Bird	SC	FCo	Primarily pelagic. Can be found well out to sea all year; summer observations probably immature nonbreeders (Johnsgard 1987). Immatures more likely than adults to winter in bays (Johnsgard 1987). Probably the most pelagic of alcids. Nests on offshore islands or along the coast. Nests on slopes in ground burrows, sometimes under boulders and piles of rocks, occasionally under dense vegetation (AOU 1983); also recorded nesting in sandy estuarine islands along north-central Alaska Peninsula (Spendelow and Patton 1988). May nest in association with murres, cormorants, auklets, gulls. See Spendelow and Patton (1988) for further details on nesting habitat.	Invertivore, Piscivore	No habitat exists within Study Area. Species located out at sea or along coast.

Table 3-1. Federal and State Listed animal species for Clallum County, Washington

Species		Animal Type	State Listing[1]	Federal Listing[2]	Habitat[3]	Food	Comments
Common Name	**Scientific Name**						
Valley silverspot	*Speyeria zerene bremnerii*	Butterfly or Moth	SC	FCo	Prairies with nearby forest openings.	Nectarivore	No habitat exists within Study Area. This species is associated with prairie habitat. It is unlikely this species inhabits the SA.
Van Dyke's salamander	*Plethodon vandykei*	Amphibian	SC	FCo	Van Dyke's Salamander is primarily associated with streams and seeps (Leonard et al. 1993, Wilson et al. 1995), but also occurs in upland forest (Slater 1933), talus (especially well-shaded, north-facing slopes) (Herrington 1988), lake shores (C. Crisafulli, personal communication) and cave entrances (Aubry et al. 1987). It can be found under bark, in and under logs, and in leaf litter in wet weather. The species is often most abundant in old forest stands that have complex stand structure and moderate to high levels of woody debris and colluvial rock present (Hallock and McAllister 2002).	Invertivore, Herbivore	Very unlikely habitat exists within SA. This species is most often associated with old forest habitat, therefore, it is very unlikely this species inhabitats the SA.
Vaux's swift	*Chaetura vauxi*	Bird	SC	--	In North America, prefers late seral stages of coniferous and mixed deciduous/coniferous forests; more abundant in old-growth forests than in younger stands.	Invertivore	No habitat exists within the SA. The species associated with late seral stages or old growth forest habitat. SA contains young forest.
Walleye pollock (So. Puget Sound)	*Theragra chalcogramma*	Fish	SC	--	Marine	--	No habitat exists within Study Area.
Western grebe	*Aechmophorus occidentalis*	Bird	SC	--	Marshes, lakes, and bays; in migration and winter also sheltered seacoasts, less frequently along rivers (Subtropical and Temperate zones) (AOU 1983). Nests on large inland bodies of water. Breeding ponds/lakes in North Dakota usually have 20 ha or more of open water. Nests usually in or very close to water deep enough to allow bird to swim submerged. Nests typically is anchored to, or build up over, living vegetation (Ehrlich et al. 1992).	Invertivore, Piscivore	Most likely not within SA since it is associated with marshes, lakes and bays deep enough allow bird to swim submerged.
Western toad	*Anaxyrus boreas*	Amphibian	SC	FCo	Western toads occur in a wide variety of habitats ranging from desert springs to mountain wetlands. They range into various upland habitats around ponds, lakes, reservoirs, and slow-moving rivers and streams; sometimes they move up to a few kilometers through uplands. For shelter, they dig their own burrow in loose soil or use those of small mammals or seclude themselves under logs or rocks. Egg laying sites include shallow areas of ponds, lakes, or reservoirs, or pools of slow-moving streams.	Invertivore, Herbivore	Habitat exists.

Table 3-1. Federal and State Listed animal species for Clallum County, Washington

Species		Animal Type	State Listing[1]	Federal Listing[2]	Habitat[3]	Food	Comments
Common Name	**Scientific Name**						
Widow rockfish	*Sebastes entomelas*	Fish	SC	--	Marine	--	No habitat exists within Study Area.
Yellow-billed cuckoo	*Coccyzus americanus*	Bird	SC	--	Open woodland (especially where undergrowth is thick), parks, deciduous riparian woodland; in the West, nests in tall cottonwood and willow riparian woodland. Nests in deciduous woodlands, moist thickets, orchards, overgrown pastures; in tree, shrub, or vine, an average of 1-3 meters above ground. NONBREEDING: forest, woodland, and scrub.	Invertivore	Habitat exists.
Yelloweye rockfish	*Sebastes ruberrimus*	Fish	SC	--	Marine	--	No habitat exists within Study Area.
Yellowtail rockfish	*Sebastes flavidus*	Fish	SC	--	Marine	--	No habitat exists within Study Area.

Description of Codes

[1]**State Status -** Washington Department of Fish and Wildlife 2012 Statewide List and Distribution by County. Viewed March 2012. http://wdfw.wa.gov/conservation/phs/list/

SE=State Endangered, ST=State Threatened, SC=State Candidate, SS=State Sensitive

[2]**Federal Status -**Listed and Proposed Endangered and Threatened Species and Critical Habitat; Candidate Species' and Species of Concern in Clallum County

FE=Federally Endangered, FT=Federally Threatened, FCo=Federal Species of Concern, FC=Federal Candidate, FPT=Federal Proposed Threatened

[3]NatureServe Explorer (NatureServe) 2011. Online Data Search. Viewed April 2012. Accessed online at: http://www.natureserve.org/explorer/servlet/NatureServe?init=Species

Table 3-2. Animal species observed during the ecological reconaisasnce

Terrestrial Habitat Type	Species		Animal Type	Observation Type
	Common Name	Scientific Name		
Urban	American Robin	*Turdus migratorius*	Avian	sight, call
	Common Raven	*Corvus corax*	Avian	sight, call
	Coyote	*Canis latrans*	Mammal	sight, call
	Elk	*Cervus canadensis*	Mammal	call
Forest	Black-capped Chickadee	*Poecile atricapillus*	Avian	sight
	Oregon Junco	*Junco hymalis*	Avian	call
	Winter Wren	*Troglodytes troglodytes*	Avian	sight, call
	Western gray squirrel	*Sciurus griseus*	Mammal	paw print
Scrub-shrub	Song Sparrow	*Melospiza melodia*	Avian	sight

Table 3-3. Plant species observed within the western portion of the Industrial Complex Area during the ecological reconnaissance

Terrestrial Habitat Type	Species	
	Common Name	**Scientific Name**
Urban	Red alder	*Alnus rubra*
	Orchard grass	*Dactylus glomerata*
	Wild carrot	*Daucus carota*
	Spreading shield fern	*Dryopteris expansa*
	Quack grass	*Elytrigia repens*
	Giant horsetail	*Equisetum telmateia*
	Tall fescue	*Festuca arundinacea*
	Atlantic ivy	*Hedera helix ssp. hibernica*
	Common St. John'swort	*Hypericum perfoliatum*
	English ivy	*Ilex aquifolium*
	Timothy	*Phleum pratense*
	Sitka spruce	*Picea sitchensis*
	Lodgepole pine	*Pinus contorta*
	Western white pine	*Pinus monticola*
	English plantain	*Plantago lanceolata*
	Annual bluegrass	*Poa annua*
	Canada bluegrass	*Poa compressa*
	Kentucky bluegrass	*Poa pratensis*
	Douglas-fir	*Pseudotsuga mentziesii*
	Cut-leaf blackberry	*Rubus laciniatus*
	Common dandelion	*Taraxacum officinale*
	Western red-cedar	*Thuja plicata*
	White clover	*Trifolium repens*
	Western hemlock	*Tsuga heterophylla*
	Lawn speedwell	*Veronica filiformis*
Forested	Silver fir	*Abies amabilis*
	Bigleaf maple	*Acer macrophyllum*
	Red alder	*Alnus rubra*
	Sweet vernal grass	*Anthoxanthum odoratum*
	Deer fern	*Blechnum spicant*
	Salal	*Gaultheria shallon*
	Indian plum	*Oemleria cerasiformis*
	Oregon wood sorrel	*Oxalis oregona*
	Sitka spruce	*Picea sitchensis*
	Licorice fern	*Polypodium glycyrrhiza*
	Sword fern	*Polystichum munitum*
	Red current	*Ribes sanguineum*
	Salmonberry	*Rubus spectabilis*
	Western hemlock	*Tsuga heterophylla*
	Evergreen huckleberry	*Vaccinium ovatum*
	Red huckleberry	*Vaccinium parvifolium*
	Redwoods violet	*Viola sempervirens*
Old Field	Bigleaf maple	*Acer macrophyllum*
	Red alder	*Alnus rubra*
	Scotch broom	*Cytisus scoparius*
	Sword fern	*Polystichum munitum*
	Bracken fern	*Pteridium aquilinum var. pubescens*
	Nootka rose	*Rosa nootkana*
	Himalayan blackberry	*Rubus armeniacus*
	Menzies' spiraea	*Spiraea douglasii var. menziesii*

Table 3-3. Plant species observed within the western portion of the Industrial Complex Area during the ecological reconnaissance

Terrestrial Habitat Type	Species	
	Common Name	**Scientific Name**
Scrub-shrub	Red alder	*Alnus rubra*
	Deer fern	*Blechnum spicant*
	Woodland strawberry	*Fragaria vesca var. crinita*
	Salal	*Gaultheria shallon*
	Apple	*Malus*
	Sword fern	*Polystichum munitum*
	Salmonberry	*Rubus spectabilis*
	Red huckleberry	*Vaccinium parvifolium*
	Redwoods violet	*Viola sempervirens*
Wetland	Slough sedge	*Carex obnupta*
	Common rush	*Juncus effusus*
	Skunk cabbage	*Lysichiton americanus*
	Sitka spruce	*Picea sitchensis*
	Black cottonwood	*Populus balsamifera ssp. trichocarpa*

Table 4-1. Summary of types of soil samples and analyses performed on soil samples from each area of potential concern, as well as chemicals of potential concern identified by risk screening

Area of Potential Concern	Volatile Organic Compounds (VOCs)	Semi-volatile Organic Compounds (SVOCs)	Polycyclic Aromatic Hydrocarbons (PAHs)	Polychlorinated Biphenyls (PCBs)	RCRA Metals	Silver	Chemicals of Potential Concern*
B4 Public Works Shop	--	3 to 6 or 6 to 9 inches bgs	3 to 6 or 6 to 9 inches bgs	--	--	3 to 6 or 6 to 9 inches bgs	Pentachlorophenol, BaP-Eq
B5 Transportation Maintenance	--	3 to 6 or 6 to 9 inches bgs	3 to 6 or 6 to 9 inches bgs	--	--	3 to 6 or 6 to 9 inches bgs	Naphthalene, Pentachlorphenol, BaP-Eq
B6 Fire Station	Subsurface (>25 feet bgs)	--	--	--	--	--	None
B7 Transformer Vault	--	--	3 to 6 or 6 to 9 inches bgs	3 to 6 or 6 to 9 inches bgs	--	--	BaP-Eq
B9 Blacksmith	--	3 to 6 or 6 to 9 inches bgs	3 to 6 or 6 to 9 inches bgs	--	--	3 to 6 or 6 to 9 inches bgs	BaP-Eq
B10 Gunnery Training	--	3 to 6 or 6 to 9 inches bgs	3 to 6 or 6 to 9 inches bgs	--	--	3 to 6 or 6 to 9 inches bgs	BaP-Eq
B11 Radio and Radar Building	--	--	3 to 6 or 6 to 9 inches bgs	3 to 6 or 6 to 9 inches bgs	--	--	BaP-Eq
B12 Class "C" Overhaul Shop	Subsurface (>25 feet bgs)	3 to 6 or 6 to 9 inches bgs	3 to 6 or 6 to 9 inches bgs	--	--	Near-surface	BaP-Eq
B17 Wash rack and shelter	--	3 to 6 or 6 to 9 inches bgs	3 to 6 or 6 to 9 inches bgs	--	--	Near-surface	Pentachlorophenol, BaP-Eq
B18 and B19 Paint Shops	Subsurface (>25 feet bgs)	3 to 6 or 6 to 9 inches bgs	3 to 6 or 6 to 9 inches bgs	--	--	Near-surface	None
B20 Hangar	Subsurface (>25 feet bgs)	3 to 6 or 6 to 9 inches bgs	3 to 6 or 6 to 9 inches bgs	--	--	Near-surface	Pentachlorophenol, BaP-Eq
B29 Photograph Laboratory	Subsurface (>25 feet bgs)	3 to 6 or 6 to 9 inches bgs	3 to 6 or 6 to 9 inches bgs	--	--	Near-surface	None
B40 Barracks (borehole for MW-15)	Subsurface (>25 feet bgs)	Subsurface (>25 feet bgs)	--	--	Subsurface (>25 feet bgs)	--	None
B41 Boiler and Generator (borehole for MW-14)	Subsurface (>25 feet bgs)	Subsurface (>25 feet bgs)	3 to 6 or 6 to 9 inches bgs	3 to 6 or 6 to 9 inches bgs	Subsurface (>25 feet bgs)	--	BaP-Eq
B44 Laundry	Subsurface (>25 feet bgs)	--	--	--	--	--	None
B49 Auxiliary Generator Building	--	--	3 to 6 or 6 to 9 inches bgs	3 to 6 or 6 to 9 inches bgs	--	--	BaP-Eq
B65 Auxiliary Generator Building	--	--	3 to 6 or 6 to 9 inches bgs	3 to 6 or 6 to 9 inches bgs	--	--	None
B101 and B102 Radio and Generator Building	--	--	3 to 6 or 6 to 9 inches bgs	3 to 6 or 6 to 9 inches bgs	--	--	BaP-Eq
B119 and B119A Paint Shops	Subsurface (>25 feet bgs)	3 to 6 or 6 to 9 inches bgs	3 to 6 or 6 to 9 inches bgs	--	--	3 to 6 or 6 to 9 inches bgs	None
E120 (Fire Station)	Subsurface (>25 feet bgs)	Subsurface (>25 feet bgs)	--	--	Subsurface (>25 feet bgs)	--	None
LD Alleged Liquid Disposal Area	Subsurface (>25 feet bgs)	Subsurface (>25 feet bgs)	Subsurface (>25 feet bgs)	--	--	Subsurface (>25 feet bgs)	None
Near NI Well	Subsurface (>25 feet bgs)	--	--	--	--	--	None
TL Suspected Tetraethyl Lead Area	Subsurface (>25 feet bgs)	Subsurface (>25 feet bgs)	Subsurface (>25 feet bgs)	--	--	--	None

Soil samples were generally collected from 3-6 inches below ground surface (bgs) or 6-9 inches at a few locations where elevated PAH was measured in samples from 3-6 inches bgs.

Subsurface soil samples were mostly collected from boreholes drilled to 25 feet maximum depth. Subsurface soil samples from monitoring well boreholes were drilled to depths of ~110 feet bgs.

*BaP-Eq - Benzo(a)pyrene-Equivalent, Sum of (concentration times the toxicity equivalency factor) for benzo(a)pyrene, benz(a)anthracene, benz(b)fluoranthene, benzo(k)fluoranthene, chrysene, dibenz(a,h)anthracene, and indeno(1,2,3-cd)pyrene.

Table 4-2. Methods for soil analyses

Analyte Group	Method Number	Analysis Method
Volatile Organic Compounds	SW846-8260B	Volatile Organic Compounds by Gas Chromatograph/Mass Spectrometry (extraction by 5035A)
Volatile Organic Compounds - Vinyl Chloride	SW846-8260B-SIM	Volatile Organic Compounds by Gas Chromatograph/Mass Spectrometry - Selective Ion Monitoring
Semivolatile Organic Compounds	SW-8270C/D	Semivolatile Organic Compounds by Gas Chromatography/Mass Spectrometry
Polynuclear Aromatic Hydrocarbons	SW-8270C/D-SIM	Semivolatile Organic Compounds by Gas Chromatography/Mass Spectrometry - Selective Ion Monitoring
Total Organic Carbon	ASTM D4129-82	Organic Carbon, Total (Combustion or Oxidation)
Metals	SW846-6020A	Inductively Coupled Plasma - Mass Spectrometry
	SW846-7471A	Mercury in Solid or Semisolid Waste (Manual Cold-Vapor Technique)

Table 4-3. Summary of groundwater analyses and chemicals of potential concern identified by risk screening

Well ID	Volatile Organic Compounds (VOCs)	Semi-volatile Organic Compounds (SVOCs)	Polycyclic Aromatic Hydrocarbons (PAHs)	Total Organic Carbon (TOC)	Silver	Other Metals	Chemicals of Potential Concern
Airport Well	28-Mar-09	28-Mar-09	28-Mar-09	28-Mar-09	03-Apr-09		--
B6	03-Apr-09	03-Apr-09	03-Apr-09	03-Apr-09	30-Mar-09		--
B14	28-Mar-09	28-Mar-09	28-Mar-09	28-Mar-09	28-Mar-09	28-Mar-09	--
B21	03-Apr-09	03-Apr-09	03-Apr-09	03-Apr-09	03-Apr-09	03-Apr-09	bis(2-ethylhexyl)phthalate
	23-Nov-09	23-Nov-09	23-Nov-09	23-Nov-09	23-Nov-09	23-Nov-09	--
B24	28-Mar-09	28-Mar-09	28-Mar-09	28-Mar-09	28-Mar-09	28-Mar-09	--
B26	03-Apr-09	03-Apr-09	03-Apr-09	03-Apr-09	03-Apr-09		--
MW-1	31-Mar-09	31-Mar-09	31-Mar-09	31-Mar-09	31-Mar-09		Carbon tetrachloride
MW-2	02-Apr-09	02-Apr-09	02-Apr-09	02-Apr-09	31-Mar-09		Carbon tetrachloride
MW-3	01-Apr-09	01-Apr-09	01-Apr-09	01-Apr-09	31-Mar-09		Carbon tetrachloride
MW-6	03-Apr-09	02-Apr-09	02-Apr-09	02-Apr-09	30-Mar-09		--
MW-7	02-Apr-09	02-Apr-09	02-Apr-09	02-Apr-09	30-Mar-09	02-Apr-09	--
MW-8	01-Apr-09	01-Apr-09	01-Apr-09	01-Apr-09	01-Apr-09		--
MW-9	03-Apr-09	03-Apr-09	03-Apr-09	03-Apr-09	03-Apr-09		--
MW-10	30-Mar-09	30-Mar-09	30-Mar-09	30-Mar-09	30-Mar-09	30-Mar-09	--
MW-11	29-Mar-09	29-Mar-09	29-Mar-09	29-Mar-09	03-Apr-09		--
MW-12	31-Mar-09	31-Mar-09	31-Mar-09	31-Mar-09	31-Mar-09	31-Mar-09	--
MW-13	02-Apr-09	02-Apr-09	02-Apr-09	02-Apr-09	03-Apr-09		--
MW-14	15-Dec-10	15-Dec-10			15-Dec-10	15-Dec-10	--
		13-Dec-11	13-Dec-11				--
MW-15	18-Dec-10	17-Dec-10			18-Dec-10	18-Dec-10	--
		15-Dec-11	15-Dec-11				--
MW-16	17-Dec-10	18-Dec-10			17-Dec-10	17-Dec-10	Carbon tetrachloride
		13-Dec-11	13-Dec-11				--
MW-17	06-Jan-11	06-Jan-11			06-Jan-11	06-Jan-11	Carbon tetrachloride
		14-Dec-11	14-Dec-11				--
NI Well	31-Mar-09	31-Mar-09	31-Mar-09		31-Mar-09		--
	18-Dec-10						--
NNW	14-Dec-11	14-Dec-11	14-Dec-11	14-Dec-11	14-Dec-11	14-Dec-11	--
Pond south of NI	14-Nov-09						--
P-12	28-Mar-09	28-Mar-09	28-Mar-09		28-Mar-09		--
P-13	28-Mar-09	28-Mar-09	28-Mar-09		28-Mar-09	28-Mar-09	--
P-17/P-18	03-Apr-09	03-Apr-09	03-Apr-09		03-Apr-09		--

Table 4-4. Methods for groundwater analyses

Analyte Group	Method Number	Analysis Method
Volatile organic compounds	SW846-8260B	Volatile Organic Compounds by Gas Chromatograph/Mass Spectrometry (extraction by 5035A)
Volatile organic compounds - Vinyl Chloride	SW846-8260B-SIM	Volatile Organic Compounds by Gas Chromatograph/Mass Spectrometry - Selective Ion Monitoring
Semi-volatile organic compounds	SW-8270C/D	Semivolatile Organic Compounds by Gas Chromatography/Mass Spectrometry
Polynuclear aromatic hydrocarbons	SW-8270C/D-SIM	Semivolatile Organic Compounds by Gas Chromatography/Mass Spectrometry - Selective Ion Monitoring
Total organic carbon	415.1	Organic Carbon, Total (Combustion or Oxidation)
Metals	200.8	Determination of Trace Elements in Waters and Wastes by Inductively Coupled Plasma - Mass Spectrometry
	245.1	Mercury in Water by Manual Cold Vapor Atomic Absorption
	SW846-6010B	Inductively Coupled Plasma - Atomic Emission Spectrometry
	SW846-6020A	Inductively Coupled Plasma - Mass Spectrometry
	SW846-7470A	Mercury in Liquid Waste (Manual Cold-Vapor Technique)

Table 4-5a. Soil screening levels for volatile organic compounds

Analyte	CAS #	MTCA Method A [a] (µg/kg)	Risk-based Screening Level			Minimum of Risk-based Screening Level (µg/kg)	Basis for Min. Risk-based Screening Level
			MTCA Method B Carcinogenic (µg/kg) [a]	MTCA Method B Non-Carcinogenic [a] (µg/kg)	USEPA Residential Soil RSL [a] (µg/kg)		
1,1,1,2-Tetrachloroethane	630-20-6	Researched-No Data	38,000	2,400,000	1,900	1,900	c
1,1,1-Trichloroethane (TCA)	71-55-6	2,000	Not Researched	160,000,000	8,700,000	8,700,000	n
1,1,2,2-Tetrachloroethane	79-34-5	Researched-No Data	5,000	1,600,000	560	560	c
1,1,2-Trichloroethane	79-00-5	Researched-No Data	18,000	320,000	1,100	1,100	c
1,1-Dichloroethane	75-34-3	Researched-No Data	Not Researched	16,000,000	3,300	3,300	c
1,1-Dichloroethene	75-35-4	Researched-No Data	Researched-No Data	4,000,000	240,000	240,000	n
1,1-Dichloropropene	563-58-6	Not available	Not available	Not available	Not listed in RSL	Not available	
1,2,3-Trichlorobenzene	87-61-6	Not available	Not available	Not available	49,000	49,000	n
1,2,3-Trichloropropane	96-18-4	Researched-No Data	33	320,000	5	5	c
1,2,4-Trichlorobenzene	120-82-1	Researched-No Data	35,000	800,000	22,000	22,000	c
1,2,4-Trimethylbenzene	95-63-6	Not Researched	Not Researched	Researched-No Data	62,000	62,000	n
1,2-Dibromo-3-chloropropane	96-12-8	Researched-No Data	1,300	16,000	5	5	c
1,2-Dichlorobenzene	95-50-1	Researched-No Data	Not Researched	7,200,000	1,900,000	1,900,000	n
1,2-Dichloroethane (EDC)	107-06-2	Researched-No Data	11,000	1,600,000	430	430	c
1,2-Dichloropropane	78-87-5	Researched-No Data	Researched-No Data	Not Researched	940	940	c
1,3,5-Trimethylbenzene	108-67-8	Not Researched	Not Researched	800,000	780,000	780,000	n
1,3-Dichlorobenzene	541-73-1	Not Researched	Not Researched	Not Researched	Not listed in RSL	Not available	
1,3-Dichloropropane	142-28-9	Not available	Not available	Not available	1,600,000	1,600,000	n
1,4-Dichlorobenzene	106-46-7	Researched-No Data	Researched-No Data	Not Researched	2,400	2,400	c
1,4-Dioxane	123-91-1	Researched-No Data	10,000	2,400,000	4,900	4,900	c
2,2-Dichloropropane	594-20-7	Not available	Not available	Not available	Not listed in RSL	Not available	
2-Butanone (MEK)	78-93-3	Researched-No Data	Not Researched	48,000,000	28,000,000	28,000,000	n
2-Chlorotoluene	95-49-8	Researched-No Data	Not Researched	1,600,000	1,600,000	1,600,000	n
4-Chlorotoluene	106-43-4	Not available	Not available	Not available	1,600,000	1,600,000	n
4-Isopropyltoluene	99-87-6	Not available	Not available	Not available	Not listed in RSL	Not available	
4-Methyl-2-pentanone (MIBK)	108-10-1	Researched-No Data	Not Researched	6,400,000	5,300,000	5,300,000	n
Acetone	67-64-1	Researched-No Data	Not Researched	72,000,000	61,000,000	61,000,000	n
Acrylonitrile	107-13-1	Researched-No Data	1,900	Researched-No Data	240	240	c
Benzene	71-43-2	30	18,000	320,000	1,100	1,100	c
Bromobenzene	108-86-1	Not available	Not available	Not available	300,000	300,000	n
Bromochloromethane	74-97-5	Not available	Not available	Not available	160,000	160,000	n
Bromodichloromethane	75-27-4	Researched-No Data	16,000	1,600,000	270	270	c
Bromoform	75-25-2	Researched-No Data	130,000	1,600,000	62,000	62,000	c
Bromomethane	74-83-9	Researched-No Data	Not Researched	110,000	7,300	7,300	n
Carbon Disulfide	75-15-0	Researched-No Data	Not Researched	8,000,000	820,000	820,000	n
Carbon Tetrachloride	56-23-5	Researched-No Data	14,000	320,000	610	610	c
Chlorobenzene	108-90-7	Researched-No Data	Not Researched	1,600,000	290,000	290,000	n
Chloroethane	75-00-3	Researched-No Data	Researched-No Data	Researched-No Data	15,000,000	15,000,000	n
Chloroform	67-66-3	Researched-No Data	Researched-No Data	800,000	290	290	c
Chloromethane	74-87-3	Researched-No Data	Researched-No Data	Not Researched	120,000	120,000	n
cis-1,2-Dichloroethene	156-59-2	Researched-No Data	Not Researched	160,000	160,000	160,000	n
Dibromochloromethane	124-48-1	Researched-No Data	12,000	1,600,000	680	680	c
Dibromomethane	74-95-3	Researched-No Data	Not Researched	800,000	25,000	25,000	n
Ethylbenzene	100-41-4	6,000	Not Researched	8,000,000	5,400	5,400	c
Hexachlorobutadiene	87-68-3	Researched-No Data	13,000	80,000	6,200	6,200	c
Isopropylbenzene	98-82-8	Researched-No Data	Not Researched	8,000,000	2,100,000	2,100,000	n
m,p-Xylenes	1330-20-7	9,000	Not Researched	16,000,000	630,000	630,000	n
Methyl tert-Butyl Ether	1634-04-4	100	Researched-No Data	Researched-No Data	43,000	43,000	c
Methylene Chloride	75-09-2	20	130,000	4,800,000	56,000	56,000	c
Naphthalene	91-20-3	5,000	Not Researched	1,600,000	3,600	3,600	c
n-Butylbenzene	104-51-8	Not Researched	Not Researched	Not Researched	3,900,000	3,900,000	n
n-Propylbenzene	103-65-1	Not Researched	Not Researched	8,000,000	3,400,000	3,400,000	n
o-Xylene	95-47-6	Researched-No Data	Not Researched	16,000,000	690,000	690,000	n
sec-Butylbenzene	135-98-8	Not Researched	Not Researched	Not Researched	7,800,000	7,800,000	n

Table 4-5a. Soil screening levels for volatile organic compounds

Analyte	CAS #	MTCA Method A [a] (µg/kg)	Risk-based Screening Level			Minimum of Risk-based Screening Level (µg/kg)	Basis for Min. Risk-based Screening Level
			MTCA Method B Carcinogenic (µg/kg) [a]	MTCA Method B Non-Carcinogenic [a] (µg/kg)	USEPA Residential Soil RSL [a] (µg/kg)		
Styrene	100-42-5	Researched-No Data	Researched-No Data	16,000,000	6,300,000	6,300,000	n
tert-Butylbenzene	98-06-6	Not Researched	Not Researched	Not Researched	7,800,000	7,800,000	n
Tetrachloroethene (PCE)	127-18-4	50	Not available	800,000	22,000	22,000	c
Toluene	108-88-3	7,000	Not Researched	6,400,000	5,000,000	5,000,000	n
trans-1,2-Dichloroethene	156-60-5	Researched-No Data	Not Researched	1,600,000	150,000	150,000	n
trans-1,3-Dichloropropene	10061-02-6	Not available	Not available	Not available	Not listed in RSL	Not available	
trans-1,4-Dichloro-2-butene	110-57-6	Not available	Not available	Not available	7	7	c
Trichloroethene (TCE)	79-01-6	30	Not available	Not available	910	910	c
Trichlorofluoromethane	75-69-4	Researched-No Data	Not Researched	24,000,000	790,000	790,000	n
Vinyl Chloride	75-01-4	Researched-No Data	Not available	240,000	60	60	c

[a] Model Toxics Control Act (MTCA) Method A and Method B criteria downloaded July 2012 from Cleanup Levels and Risk Calculation (CLARC) database maintained by the Washington Department of Ecology. USEPA Regional Screening Levels (RSL) used are from May 2013.

c=cancer, n=non-cancer

Table 4-5b. Soil screening criteria for semi-volatile organic compounds (including polycyclic aromatic hydrocarbons)

Analyte	CAS #	MTCA Method A [a] (µg/kg)	Risk-based Screening Levels			Minimum of Risk-based Screening Level (µg/kg)	Basis for Risk-Based Screening Level
			MTCA Method B Carcinogenic (µg/kg) [a]	MTCA Method B Non-Carcinogenic [a] (µ/kg)	USEPA Residential Soil RSL [a] (µg/kg)		
1,2,4-Trichlorobenzene	120-82-1	Researched-No Data	35,000	800,000	22,000	22,000	c
1-Methylnaphthalene	90-12-0	Not Researched	35,000	Not Researched	16,000	16,000	c
2,4,5-Trichlorophenol	95-95-4	Researched-No Data	Not Researched	8,000,000	6,100,000	6,100,000	n
2,4,6-Trichlorophenol	88-06-2	Researched-No Data	91,000	80,000	44,000	44,000	c
2,4-Dichlorophenol	120-83-2	Researched-No Data	Not Researched	240,000	180,000	180,000	n
2,4-Dimethylphenol	105-67-9	Researched-No Data	Not Researched	1,600,000	1,200,000	1,200,000	n
2,4-Dinitrophenol	51-28-5	Researched-No Data	Not Researched	160,000	120,000	120,000	n
2-Chloronaphthalene	91-58-7	Researched-No Data	Not Researched	6,400,000	6,300,000	6,300,000	n
2-Chlorophenol	95-57-8	Researched-No Data	Not Researched	400,000	390,000	390,000	n
2-Methyl-4,6-dinitrophenol	534-52-1	Not available	Not available	Not available	4,900	4,900	n
2-Methylphenol	95-48-7	Researched-No Data	Not Researched	4,000,000	3,100,000	3,100,000	n
2-Nitroaniline	88-74-4	Researched-No Data	Not Researched	800,000	610,000	610,000	n
2-Nitrophenol	88-75-5	Not available	Not available	Not available	Not listed in RSL	Not available	
3,3'-Dichlorobenzidine	91-94-1	Researched-No Data	2,200	Not Researched	1,100	1,100	c
3,3-Dichlorobenzidine	91-94-1	Researched-No Data	2,200	Not Researched	1,100	1,100	c
3-Nitroaniline	99-09-2	Not available	Not available	Not available	Not listed in RSL	Not available	
4-Bromophenyl Phenyl Ether	101-55-3	Not available	Not available	Not available	Not listed in RSL	Not available	
4-Chloro-3-methylphenol	59-50-7	Not available	Not available	Not available	6,100,000	6,100,000	n
4-Chloroaniline	106-47-8	Researched-No Data	5,000	320,000	2,400	2,400	c
4-Chlorophenyl Phenyl Ether	7005-72-3	Not available	Not available	Not available	Not listed in RSL	Not available	
4-Methylphenol	106-44-5	Researched-No Data	Not Researched	400,000	6,100,000	400,000	n
4-Nitroaniline	100-01-6	Not available	Not available	Not available	24,000	24,000	c
4-Nitrophenol	100-02-7	Not available	Not available	Not available	Not listed in RSL	Not available	
Acenaphthene	83-32-9	Researched-No Data	Not Researched	4,800,000	3,400,000	3,400,000	n
Acenaphthylene	208-96-8	Not Researched	Not Researched	Not Researched	Not listed in RSL	Not available	
Aniline	62-53-3	Researched-No Data	180,000	560,000	85,000	85,000	c
Anthracene	120-12-7	Researched-No Data	Not Researched	24,000,000	17,000,000	17,000,000	n
Benz(a)anthracene	56-55-3	Researched-No Data	1,400	Not Researched	150	150	c
Benzo(a)pyrene	50-32-8	100	140	Not Researched	15	15	c
Benzo(b)fluoranthene	205-99-2	Researched-No Data	1,400	Not Researched	150	150	c
Benzo(g,h,i)perylene	191-24-2	Not Researched	Not Researched	Not Researched	Not listed in RSL	Not available	
Benzo(k)fluoranthene	207-08-9	Researched-No Data	14,000	Not Researched	1,500	1,500	c
Benzoic Acid	65-85-0	Researched-No Data	Not Researched	320,000,000	240,000,000	240,000,000	n
Benzyl Alcohol	100-51-6	Researched-No Data	Not Researched	8,000,000	6,100,000	6,100,000	n
Bis(2-chloroethoxy)methane	111-91-1	Not available	Not available	Not available	180,000	180,000	n
Bis(2-chloroethyl) Ether	111-44-4	Researched-No Data	910	Not Researched	210	210	c
Bis(2-ethylhexyl) Phthalate	117-81-7	Researched-No Data	71,000	1,600,000	35,000	35,000	c
Butyl Benzyl Phthalate	85-68-7	Researched-No Data	530,000	16,000,000	260,000	260,000	c
Chrysene	218-01-9	Researched-No Data	140,000	Not Researched	15,000	15,000	c
Dibenz(a,h)anthracene	53-70-3	Researched-No Data	140	Not Researched	15	15	c
Diethyl Phthalate	84-66-2	Researched-No Data	Not Researched	64,000,000	49,000,000	49,000,000	n
Dimethyl Phthalate	131-11-3	Researched-No Data	Not Researched	Researched-No Data	Not listed in RSL	Not available	

Table 4-5b. Soil screening criteria for semi-volatile organic compounds (including polycyclic aromatic hydrocarbons)

Analyte	CAS #	MTCA Method A [a] (µg/kg)	Risk-based Screening Levels			Minimum of Risk-based Screening Level (µg/kg)	Basis for Risk-Based Screening Level
			MTCA Method B Carcinogenic (µg/kg) [a]	MTCA Method B Non-Carcinogenic [a] (µ/kg)	USEPA Residential Soil RSL [a] (µg/kg)		
Di-n-butyl Phthalate	84-74-2	Researched-No Data	Not Researched	8,000,000	6,100,000	6,100,000	n
Di-n-octyl Phthalate	117-84-0	Researched-No Data	Not Researched	Researched-No Data	610,000	610,000	n
Fluoranthene	206-44-0	Researched-No Data	Not Researched	3,200,000	2,300,000	2,300,000	n
Fluorene	86-73-7	Researched-No Data	Not Researched	3,200,000	2,300,000	2,300,000	n
Hexachlorobenzene	118-74-1	Researched-No Data	630	64,000	300	300	c
Hexachlorocyclopentadiene	77-47-4	Researched-No Data	Not Researched	480,000	370,000	370,000	n
Hexachloroethane	67-72-1	Researched-No Data	71,000	80,000	12,000	12,000	c
Indeno(1,2,3-cd)pyrene	193-39-5	Researched-No Data	1,400	Not Researched	150	150	c
Isophorone	78-59-1	Researched-No Data	1,100,000	16,000,000	510,000	510,000	c
Naphthalene	91-20-3	5,000	Not Researched	1,600,000	3,600	3,600	c
N-Nitrosodimethylamine	62-75-9	Researched-No Data	20	640	2	2	c
N-Nitrosodi-n-propylamine	621-64-7	Researched-No Data	140	Not Researched	69	69	c
N-Nitrosodiphenylamine	86-30-6	Researched-No Data	200,000	Not Researched	99,000	99,000	c
Pentachlorophenol	87-86-5	Researched-No Data	2,500	400,000	890	890	c
Phenol	108-95-2	Researched-No Data	Not Researched	24,000,000	18,000,000	18,000,000	n
Pyrene	129-00-0	Researched-No Data	Not Researched	2,400,000	1,700,000	1,700,000	n
Pyridine	110-86-1	Researched-No Data	Not Researched	80,000	78,000	78,000	n

[a] Model Toxics Control Act (MTCA) Method A and Method B criteria downloaded July 2012 from Cleanup Levels and Risk Calculation (CLARC) database maintained by the Washington Department of Ecology. USEPA Regional Screening Levels (RSL) used are from May 2013.
c=cancer, n=non-cancer

Table 4-5c. Soil screening levels for polychlorinated biphenyls

Analyte	CAS #	MTCA Method A (mg/kg)	Risk-based Screening Levels				Minimum of Risk-based Screening Level (µg/kg)	Basis for Risk-Based Screening Level
			MTCA Method B Carcinogenic (µg/kg) [a]	MTCA Method B Non-Carcinogenic [a] (µg/kg)	USEPA RSL (mg/kg)	USEPA Residential Soil RSL [a] (µg/kg)		
Aroclor 1016	12674-11-2	Researched-No Data	14,000	5,600	3.9	3,900	3,900	n
Aroclor 1221	11104-28-2	Not available	Not available	Not available	0.14	140	140	c
Aroclor 1232	11141-16-5	Not available	Not available	Not available	0.14	140	140	c
Aroclor 1242	53469-21-9	Not available	Not available	Not available	0.22	220	220	c
Aroclor 1248	12672-29-6	Not available	Not available	Not available	0.22	220	220	c
Aroclor 1254	11097-69-1	Researched-No Data	500	1,600	0.22	220	220	c
Aroclor 1260	11096-82-5	Not Researched	500	Not Researched	0.22	220	220	c
Aroclor 1262 [b]	1336-36-3	1	500	Not Researched	0.22	220	220	c
Aroclor 1268 [b]	1336-36-3	1	500	Not Researched	0.22	220	220	c
Total PCBs [c]	N/A	1	500	Not Researched	N/A	N/A	500	c

[a] Model Toxics Control Act (MTCA) Method A and Method B criteria downloaded July 2012 from Cleanup Levels and Risk Calculation (CLARC) database maintained by the Washington Department of Ecology. USEPA Regional Screening Levels (RSL) used are from May 2013.

[b] CAS Number for EPA RSL for high-risk PCBs used

[c] PCB mixture evaluated in accordance with MRCA Cleanup Regulation (WAC 173-340-708(8)).

c=cancer, n=non-cancer

Table 4-5d. Soil screening levels for metals

Analyte	CAS #	MTCA Method A [a] (µg/kg)	Risk Based Screening Levels			Minimum of Risk-based Screening Level (mg/kg)	Basis for Min. Risk-Based Screening Level	Puget Sound 90th Percentile (San Juan 1994)
			MTCA Method B Carcinogenic [a] (µg/kg)	MTCA Method B Non-Carcinogenic [a] (mg/kg)	USEPA RSL Residential Soil [a] (mg/kg)			
Arsenic	7440-38-2	20,000	670	24,000	610	610.00	c	7000
Cadmium	7440-43-9	Researched-No Data	Not Researched	80,000	70,000	70,000	n	1000
Chromium [b]	16065-83-1	2,000,000	Not Researched	120,000,000	120,000,000	120,000,000	n	42000
Iron	7439-89-6	Researched-No Data	Not Researched	56,000,000	55,000,000	55,000,000	n	42,100,000
Manganese	7439-96-5	Researched-No Data	Not Researched	11,000,000	--	11,000,000	n	1,100,000
Mercury	7439-97-6	2,000	Not Researched	Researched-No Data	10,000	10,000	n	70
Silver	7440-22-4	Researched-No Data	Not Researched	400,000	390,000	390,000	n	NA

[a] Model Toxics Control Act (MTCA) Method A and Method B criteria downloaded July 2012 from Cleanup Levels and Risk Calculation (CLARC) database maintained by the Washington Department of Ecology. USEPA Regional Screening Levels (RSL) used are from May 2013.

[b] Assume Chromium III, because no source of Chromium VI has been identified based on historical land use (Shannon and Wilson 2012)

c=cancer, n=non-cancer

Table 4-6a. Groundwater screening levels for volatile organic compounds

Analyte	CAS #	MTCA Method A[a] µg/L	Risk-Based Screening Levels			Minimum of Risk-based Screening Levels (µg/L)	Basis of Min. Risk-based Screening Level	Maximum Contaminant Level (µg/L)
			MTCA Method B Carcinogenic[a] (µg/L)	MTCA Method B Non-Carcinogenic[a] (µg/L)	USEPA Tapwater RSL[a] (µg/L)			
1,1,1,2-Tetrachloroethane	630-20-6	Researched-No Data	1.7	240	0.5	0.5	c	--
1,1,1-Trichloroethane (TCA)	71-55-6	200	Not Researched	16,000	7,500	7,500	n	200
1,1,2,2-Tetrachloroethane	79-34-5	Researched-No Data	0.22	160	0.066	0.066	c	--
1,1,2-Trichloroethane	79-00-5	Researched-No Data	0.77	32	0.24	0.24	c	5
1,1-Dichloroethane	75-34-3	Researched-No Data	Not Researched	1600	2.4	2.4	c	--
1,1-Dichloroethene	75-35-4	Researched-No Data	Researched-No Data	400	260	260	n	7
1,1-Dichloropropene	563-58-6	Not in CLARC	Not in CLARC	Not in CLARC	Not in RSL table	Not in Tables	--	Not in RSL table
1,2,3-Trichlorobenzene	87-61-6	Not in CLARC	Not in CLARC	Not in CLARC	5.2	5.2	n	--
1,2,3-Trichloropropane	96-18-4	Researched-No Data	0.0015	32	0.00065	0.00065	c	--
1,2,4-Trichlorobenzene	120-82-1	Researched-No Data	1.5	80	0.99	0.99	c	70
1,2,4-Trimethylbenzene	95-63-6	Not Researched	Not Researched	Researched-No Data	15	15	n	--
1,2-Dibromo-3-chloropropane	96-12-8	Researched-No Data	0.055	1.6	0.00032	0.00032	c	0.2
1,2-Dichlorobenzene	95-50-1	Researched-No Data	Not Researched	720	280	280	n	600
1,2-Dichloroethane (EDC)	107-06-2	5	0.48	160	0.15	0.15	c	5
1,2-Dichloropropane	78-87-5	Researched-No Data	Researched-No Data	Not Researched	0.38	0.38	c	5
1,3,5-Trimethylbenzene	108-67-8	Not Researched	Not Researched	80	87	80	n	--
1,3-Dichlorobenzene	541-73-1	Not Researched	Not Researched	Not Researched	Not in RSL table	Not in Tables	--	Not in RSL table
1,3-Dichloropropane	142-28-9	Not in CLARC	Not in CLARC	Not in CLARC	290	290	n	--
1,4-Dichlorobenzene	106-46-7	Researched-No Data	Researched-No Data	Not Researched	0.42	0.42	c	75
1,4-Dioxane	123-91-1	Researched-No Data	0.44	240	0.67	0.44	c	--
2,2-Dichloropropane	594-20-7	Not in CLARC	Not in CLARC	Not in CLARC	Not in RSL table	Not in Tables	--	Not in RSL table
2-Butanone (MEK)	78-93-3	Researched-No Data	Not Researched	4,800	4,900	4,800	n	--
2-Chlorotoluene	95-49-8	Researched-No Data	Not Researched	160	180	160	n	--
4-Chlorotoluene	106-43-4	Not in CLARC	Not in CLARC	Not in CLARC	190	190	n	--
4-Isopropyltoluene	99-87-6	Not in CLARC	Not in CLARC	Not in CLARC	Not in RSL table	Not in Tables	--	Not in RSL table
4-Methyl-2-pentanone (MIBK)	108-10-1	Researched-No Data	Not Researched	640	1,000	640	n	--
Acetone	67-64-1	Researched-No Data	Not Researched	7,200	12,000	7,200	n	--
Acrylonitrile	107-13-1	Researched-No Data	0.081	Researched-No Data	0.045	0.045	c	--
Benzene	71-43-2	5	0.8	32	0.39	0.39	c	5
Bromobenzene	108-86-1	Not in CLARC	Not in CLARC	Not in CLARC	54	54	n	--
Bromochloromethane	74-97-5	Not in CLARC	Not in CLARC	Not in CLARC	83	83	n	--
Bromodichloromethane	75-27-4	Researched-No Data	0.71	160	0.12	0.12	c	--
Bromoform	75-25-2	Researched-No Data	5.5	160	7.9	5.5	c	--
Bromomethane	74-83-9	Researched-No Data	Not Researched	11	7	7	n	--
Carbon Disulfide	75-15-0	Researched-No Data	Not Researched	800	720	720	n	--
Carbon Tetrachloride	56-23-5	Researched-No Data	0.63	32	0.39	0.39	c	5
Chlorobenzene	108-90-7	Researched-No Data	Not Researched	160	72	72	n	100
Chloroethane	75-00-3	Researched-No Data	Researched-No Data	Researched-No Data	21,000	21,000	n	--
Chloroform	67-66-3	Researched-No Data	Researched-No Data	80	0.19	0.19	c	--
Chloromethane	74-87-3	Researched-No Data	Researched-No Data	Not Researched	190	190	n	--
cis-1,2-Dichloroethene	156-59-2	Researched-No Data	Not Researched	16	28	16	n	70
Dibromochloromethane	124-48-1	Researched-No Data	0.52	160	0.15	0.15	c	--
Dibromomethane	74-95-3	Researched-No Data	Not Researched	80	7.9	7.9	n	--
Ethylbenzene	100-41-4	700	Not Researched	800	1.3	1.3	c	700
Hexachlorobutadiene	87-68-3	Researched-No Data	0.56	8	0.26	0.26	c	--
Isopropylbenzene	98-82-8	Researched-No Data	Not Researched	800	390	390	n	--

Table 4-6a. Groundwater screening levels for volatile organic compounds

Analyte	CAS #	MTCA Method A[a] µg/L	Risk-Based Screening Levels			Minimum of Risk-based Screening Levels (µg/L)	Basis of Min. Risk-based Screening Level	Maximum Contaminant Level (µg/L)
			MTCA Method B Carcinogenic[a] (µg/L)	MTCA Method B Non-Carcinogenic[a] (µg/L)	USEPA Tapwater RSL[a] (µg/L)			
m,p-Xylenes	1330-20-7	1,000	Not Researched	1,600	190	190	n	10,000
Methyl tert-Butyl Ether	1634-04-4	20	Researched-No Data	Researched-No Data	12	12	c	--
Methylene Chloride	75-09-2	5	5.8	480	9.9	5.8	c	5
Naphthalene	91-20-3	160	Not Researched	160	0.14	0.14	c	--
n-Butylbenzene	104-51-8	Not Researched	Not Researched	Not Researched	780	780	n	--
n-Propylbenzene	103-65-1	Not Researched	Not Researched	800	530	530	n	--
o-Xylene	95-47-6	Researched-No Data	Not Researched	1,600	190	190	n	--
sec-Butylbenzene	135-98-8	Not Researched	Not Researched	Not Researched	1600	1600	n	--
Styrene	100-42-5	Researched-No Data	Researched-No Data	1,600	1,100	1,100	n	100
tert-Butylbenzene	98-06-6	Not Researched	Not Researched	Not Researched	510	510	n	--
Tetrachloroethene (PCE)	127-18-4	5	Not available	80	9.7	9.7	c	5
Toluene	108-88-3	1,000	Not Researched	640	860	640	n	1000
trans-1,2-Dichloroethene	156-60-5	Researched-No Data	Not Researched	160	86	86	n	100
trans-1,3-Dichloropropene	10061-02-6	Not in CLARC	Not in CLARC	Not in CLARC	Not in RSL table	Not in Tables	--	Not in RSL table
trans-1,4-Dichloro-2-butene	110-57-6	Not in CLARC	Not in CLARC	Not in CLARC	0.0012	0.0012	c	--
Trichloroethene (TCE)	79-01-6	5	Not available	see additional information	0.44	0.44	c	5
Trichlorofluoromethane	75-69-4	Researched-No Data	Not Researched	2400	1,100	1100	n	--
Vinyl Chloride	75-01-4	0.2	Not available	24	0.015	0.015	c	2

[a] Model Toxics Control Act (MTCA) Method A and Method B criteria downloaded July 2012 from Cleanup Levels and Risk Calculation (CLARC) database maintained by the Washington Department of Ecology. USEPA Regional Screening Levels (RSL) used are from April 2012.

c=cancer; n=noncancer

Table 4-6b. Groundwater screening levels for semi-volatile organic compounds

Analyte	CAS #	MTCA Method A[a] µg/L	Risk-based Screening Levels			Minimum of Risk-based Screening Levels (µg/L)	Basis of Min. Risk-based Screening Level	Maximum Contaminant Level (µg/L)
			MTCA Method B Carcinogenic[a] (µg/L)	MTCA Method B Non-Carcinogenic[a] (µg/L)	USEPA Tapwater RSL[a] (µg/L)			
1,2,4-Trichlorobenzene	120-82-1	Researched-No Data	1.5	80	0.99	0.99	c	70
1-Methylnaphthalene	90-12-0	Not Researched	1.5	Not Researched	0.97	0.97	c	--
2,4,5-Trichlorophenol	95-95-4	Researched-No Data	Not Researched	800	890	800	n	--
2,4,6-Trichlorophenol	88-06-2	Researched-No Data	4	8	3.5	3.5	c	--
2,4-Dichlorophenol	120-83-2	Researched-No Data	Not Researched	24	35	24	n	--
2,4-Dimethylphenol	105-67-9	Researched-No Data	Not Researched	160	270	160	n	--
2,4-Dinitrophenol	51-28-5	Researched-No Data	Not Researched	32	30	30	n	--
2-Chloronaphthalene	91-58-7	Researched-No Data	Not Researched	640	550	550	n	--
2-Chlorophenol	95-57-8	Researched-No Data	Not Researched	40	71	40	n	--
2-Methyl-4,6-dinitrophenol	534-52-1	Not in CLARC	Not in CLARC	Not in CLARC	1.2	1.2	n	--
2-Methylphenol	95-48-7	Researched-No Data	Not Researched	400	720	400	n	--
2-Nitroaniline	88-74-4	Researched-No Data	Not Researched	160	150	150	n	--
2-Nitrophenol	88-75-5	Not in CLARC	Not in CLARC	Not in CLARC	Not in RSL table	Not in Tables	--	Not in RSL table
3,3'-Dichlorobenzidine	91-94-1	Researched-No Data	0.19	Not Researched	0.11	0.11	c	--
3,3-Dichlorobenzidine	91-94-1	Researched-No Data	0.19	Not Researched	0.11	0.11	c	--
3-Nitroaniline	99-09-2	Not in CLARC	Not in CLARC	Not in CLARC	Not in RSL table	Not in Tables	--	Not in RSL table
4-Bromophenyl Phenyl Ether	101-55-3	Not in CLARC	Not in CLARC	Not in CLARC	Not in RSL table	Not in Tables	--	Not in RSL table
4-Chloro-3-methylphenol	59-50-7	Not in CLARC	Not in CLARC	Not in CLARC	1,100	1,100	n	--
4-Chloroaniline	106-47-8	Researched-No Data	0.22	32	0.32	0.22	c	--
4-Chlorophenyl Phenyl Ether	7005-72-3	Not in CLARC	Not in CLARC	Not in CLARC	Not in RSL table	Not in Tables	--	Not in RSL table
4-Methylphenol	106-44-5	Researched-No Data	Not Researched	40	1,400	40	n	--
4-Nitroaniline	100-01-6	Not in CLARC	Not in CLARC	Not in CLARC	3.3	3.3	c	--
4-Nitrophenol	100-02-7	Not in CLARC	Not in CLARC	Not in CLARC	Not in RSL table	Not in Tables	--	Not in RSL table
Aniline	62-53-3	Researched-No Data	7.7	56	12	7.7	c	--
Benzoic Acid	65-85-0	Researched-No Data	Not Researched	64,000	58,000	58,000	n	--
Benzyl Alcohol	100-51-6	Researched-No Data	Not Researched	800	1,500	800	n	--
Bis(2-chloroethoxy)methane	111-91-1	Not in CLARC	Not in CLARC	Not in CLARC	46	46	n	--
Bis(2-chloroethyl) Ether	111-44-4	Researched-No Data	0.04	Not Researched	0.012	0.012	c	--
Bis(2-ethylhexyl) Phthalate	117-81-7	Researched-No Data	6.3	320	4.8	4.8	c	6.0
Butyl Benzyl Phthalate	85-68-7	Researched-No Data	46	3,200	14	14	c	--
Diethyl Phthalate	84-66-2	Researched-No Data	Not Researched	13,000	11,000	11,000	n	--
Dimethyl Phthalate	131-11-3	Researched-No Data	Not Researched	Researched-No Data	Not in RSL table	Not in Tables	--	Not in RSL table
Di-n-butyl Phthalate	84-74-2	Researched-No Data	Not Researched	1600	670	670	n	--
Di-n-octyl Phthalate	117-84-0	Researched-No Data	Not Researched	Researched-No Data	160	160	n	--
Hexachlorobenzene	118-74-1	Researched-No Data	0.055	13	0.042	0.042	c	1.0
Hexachlorocyclopentadiene	77-47-4	Researched-No Data	Not Researched	48	22	22	n	50
Hexachloroethane	67-72-1	Researched-No Data	3.1	8	0.79	0.79	c	--
Isophorone	78-59-1	Researched-No Data	46	1,600	67	46	c	--
Naphthalene	91-20-3	160	Not Researched	160	0.14	0.14	c	--
N-Nitrosodimethylamine	62-75-9	Researched-No Data	0.00086	0.064	0.00042	0.00042	c	--
N-Nitrosodi-n-propylamine	621-64-7	Researched-No Data	Researched-No Data	Researched-No Data	0.0093	0.0093	c	--
N-Nitrosodiphenylamine	86-30-6	Researched-No Data	Researched-No Data	Researched-No Data	10	10	c	--
Pentachlorophenol	87-86-5	Researched-No Data	0.22	80	0.035	0.035	c	1.0
Phenol	108-95-2	Researched-No Data	Not Researched	2,400	4,500	2,400	n	--
Pyridine	110-86-1	Researched-No Data	Not Researched	8	15	8	n	--

[a] Model Toxics Control Act (MTCA) Method A and Method B criteria downloaded July 2012 from Cleanup Levels and Risk Calculation (CLARC) database maintained by the Washington Department of Ecology. USEPA Regional Screening Levels (RSL) used are from May 2013.

c=cancer; n=noncancer

Table 4-6c. Groundwater screening levels for polynuclear aromatic hydrocarbons

Analyte	CAS No.	MTCA Method A[a] µg/L	Risk-Based Screening Levels			Minimum of Risk-based Screening Levels	Basis of Min. Risk-based Screening Level	Maximum Contaminant Level (µg/L)
			MTCA Method B Carcinogenic[a] (µg/L)	MTCA Method B Non-Carcinogenic[a] (µg/L)	USEPA Tapwater RSL[a] (µg/L)			
Acenaphthene	83-32-9	Researched-No Data	Not Researched	960	400	400	n	--
Acenaphthylene	208-96-8	Not Researched	Not Researched	Not Researched	Not in RSL table	Not in Tables	--	Not in RSL table
Anthracene	120-12-7	Researched-No Data	Not Researched	4800	1300	1300	n	--
Benz(a)anthracene	56-55-3	Researched-No Data	0.12	Not Researched	0.029	0.029	c	--
Benzo(a)pyrene	50-32-8	0.1	0.012	Not Researched	0.0029	0.0029	c	0.2
Benzo(b)fluoranthene	205-99-2	Researched-No Data	0.12	Not Researched	0.029	0.029	c	--
Benzo(g,h,i)perylene	191-24-2	Not Researched	Not Researched	Not Researched	Not in RSL table	Not in Tables	--	Not in RSL table
Benzo(k)fluoranthene	207-08-9	Researched-No Data	1.2	Not Researched	0.29	0.29	c	--
Chrysene	218-01-9	Researched-No Data	12	Not Researched	2.9	2.9	c	--
Dibenz(a,h)anthracene	53-70-3	Researched-No Data	0.012	Not Researched	0.0029	0.0029	c	--
Fluoranthene	206-44-0	Researched-No Data	Not Researched	640	630	630	n	--
Fluorene	86-73-7	Researched-No Data	Not Researched	640	220	220	n	--
Indeno(1,2,3-cd)pyrene	193-39-5	Researched-No Data	0.12	Not Researched	0.029	0.029	c	--
Pyrene	129-00-0	Researched-No Data	Not Researched	480	87	87	n	--

[a] Model Toxics Control Act (MTCA) Method A and Method B criteria downloaded July 2012 from Cleanup Levels and Risk Calculation (CLARC) database maintained by the Washington Department of Ecology. USEPA Regional Screening Levels (RSL) used are from May 2013.
c=cancer; n=noncancer

Table 4-6d. Groundwater screening levels for metals

Analyte	CAS No.	MTCA Method A[a] µg/L	Risk-Based Screening Levels			Minimum of Risk-based Screening Levels (µg/L)	Basis of Min. Risk-based Screening Level	Maximum Contaminant Level (µg/L)
			MTCA Method B Carcinogenic[a] (µg/L)	MTCA Method B Non-Carcinogenic[a] (µg/L)	USEPA Tapwater RSL[a] (µg/L)			
Arsenic	7440-38-2	5	0.058	4.8	0.045	0.045	c	10
Barium	7440-39-3	Researched-No Data	Not Researched	3,200	2,900	2,900	n	2,000
Cadmium	7440-43-9	5	Not Researched	16	6.9	6.9	n	5
Chromium	7440-47-3	50	Not Researched	Not Researched	--	Not in Tables	--	100
Copper	7440-50-8	Researched-No Data	Not Researched	640	620	620	n	1,300
Iron	7439-89-6	Researched-No Data	Not Researched	11,000	11,000	11,000	n	--
Manganese	7439-96-5	Researched-No Data	Not Researched	2,200	320	320	n	--
Mercury	7439-97-6	2	Not Researched	Researched-No Data	0.63	0.63	n	2
Selenium	7782-49-2	Researched-No Data	Not Researched	80	78	78	n	50
Silver	7440-22-4	Researched-No Data	Not Researched	80	71	71	n	--

[a] Model Toxics Control Act (MTCA) Method A and Method B criteria downloaded July 2012 from Cleanup Levels and Risk Calculation (CLARC) database maintained by the Washington Department of Ecology. USEPA Regional Screening Levels (RSL) used are from May 2013.

c=cancer; n=noncancer

Table 4-7. Residential air screening levels for volatile organic compounds

Analyte	CAS #	Risk-based Screening Levels			Min. Risk-Based Screening Level ($\mu g/m^3$)	Basis of Risk-Based Screening Level
		Method B (Carcinogen)[a] ($\mu g/m^3$)	Method B (Non-Carcinogen) [a] ($\mu g/m^3$)	USEPA Resident Air RSL [a] ($\mu g/m^3$)		
1,1,1-Trichloroethane	71-55-6	Not Researched	2,300	5,200	2,300	n
1,1,2,2-Tetrachloroethane	79-34-5	Researched-No Data	Not Researched	0.042	0.042	c
1,1,2-Trichloroethane	79-00-5	0.16	Not Researched	0.15	0.15	c
1,1-Dichloroethane	75-34-3	Not Researched	Researched-No Data	1.5	1.5	c
1,1-Dichloroethene	75-35-4	Researched-No Data	91	210	91	n
1,2,4-Trichlorobenzene	120-82-1	Not Researched	0.91	2.1	0.91	n
1,2,4-Trimethylbenzene	95-63-6	Not Researched	3.2	7.3	3.2	n
1,2-Dibromoethane (EDB)	106-93-4	0.0042	4.1	0.0041	0.0041	c
1,2-Dichlorobenzene	95-50-1	Not Researched	91	210	91	n
1,2-Dichloroethane	107-06-2	0.096	Researched-No Data	0.094	0.094	c
1,2-Dichloropropane	78-87-5	Not Researched	1.8	0.24	0.24	c
1,3,5-Trimethylbenzene	108-67-8	Not Researched	Researched-No Data	--	--	--
1,3-Butadiene	106-99-0	0.083	0.91	0.081	0.081	c
1,3-Dichlorobenzene	541-73-1	Not Researched	Not Researched	Not in RSL	--	--
1,4-Dichlorobenzene	106-46-7	Not Researched	370	0.22	0.22	c
1,4-Dioxane	123-91-1	Not Researched	Not Researched	0.32	0.32	c
2,2,4-Trimethylpentane	540-84-1	Not in MTCA	Not in MTCA	Not in RSL	--	--
2-Butanone (Methyl Ethyl Ketone)	78-93-3	Not Researched	2,300	5,200	2,300	n
2-Hexanone	591-78-6	Not in MTCA	Not in MTCA	31	31	n
2-Propanol	67-63-0	Not in MTCA	Not in MTCA	7,300	7,300	n
3-Chloropropene	107-05-1	Not Researched	0.46	0.41	0.41	c
4-Ethyltoluene	622-96-8	Not in MTCA	Not in MTCA	Not in RSL	--	--
4-Methyl-2-pentanone	108-10-1	Not Researched	1,400	3,100	1,400	n
Acetone	67-64-1	Not Researched	Not Researched	32,000	32,000	n
alpha-Chlorotoluene	100-44-7	Researched-No Data	0.46	0.05	0.05	c
Benzene	71-43-2	0.32	14	0.31	0.31	c
Bromodichloromethane	75-27-4	Not Researched	Not Researched	0.066	0.066	c
Bromoform	75-25-2	2.3	Not Researched	2.2	2.2	c
Bromomethane	74-83-9	Not Researched	2.3	5.2	2.3	n
Carbon Disulfide	75-15-0	Not Researched	320	730	320	n
Carbon Tetrachloride	56-23-5	0.42	46	0.41	0.41	c
Chlorobenzene	108-90-7	Not Researched	23	52	23	n
Chloroethane	75-00-3	Researched-No Data	4,600	10,000	4,600	n
Chloroform	67-66-3	0.11	Not Researched	0.11	0.11	c
Chloromethane	74-87-3	Researched-No Data	41	94	41	n
cis-1,2-Dichloroethene	156-59-2	Not Researched	Researched-No Data	--	--	--
cis-1,3-Dichloropropene	10061-01-5	Not in MTCA	Not in MTCA	Not in RSL	--	--
Cumene	98-82-8	Not Researched	180	420	180	n
Cyclohexane	110-82-7	Not Researched	2,700	6,300	2,700	n
Dibromochloromethane	124-48-1	Not Researched	Not Researched	0.09	0.09	c
Ethanol	64-17-5	Not in MTCA	Not in MTCA	Not in RSL	--	--
Ethylbenzene	100-41-4	Not Researched	460	0.97	0.97	c
Freon 11	75-69-4	Not Researched	320	730	320	n
Freon 113	76-13-1	Not Researched	14,000	31,000	14,000	n
Freon 114	76-14-2	Not in MTCA	Not in MTCA	Not in RSL	--	--
Freon 12	75-71-8	Not Researched	91	100	91	n
Heptane	142-82-5	Not Researched	Not Researched	Not in RSL	--	--
Hexachlorobutadiene	87-68-3	0.11	Not Researched	0.11	0.11	c
Hexane	110-54-3	Not Researched	320	730	320	n
m,p-Xylene	1330-20-7	Not Researched	46	100	46	n
Methyl tert-butyl ether	1634-04-4	Researched-No Data	1400	9.4	9.4	c
Methylene Chloride	75-09-2	5.3	Researched-No Data	96	5.3	c
o-Xylene	95-47-6	Not Researched	Researched-No Data	100	100	n
Propylbenzene	103-65-1	Not Researched	460	1,000	460	n
Styrene	100-42-5	Researched-No Data	460	1,000	460	n
Tetrachloroethene	127-18-4	see additional information	see additional information	9.4	9.4	c
Tetrahydrofuran	109-99-9	Not in MTCA	Not in MTCA	2,100	2,100	n
Toluene	108-88-3	Not Researched	2,300	5,200	2,300	n
trans-1,2-Dichloroethene	156-60-5	Not Researched	27	63	27	n
trans-1,3-Dichloropropene	10061-02-6	Not in MTCA	Not in MTCA	Not in RSL	--	--
Trichloroethene	79-01-6	see additional information	see additional information	0.43	0.43	c
Vinyl Chloride	75-01-4	see additional information	46	0.16	0.16	c

[a] Model Toxics Control Act (MTCA) Method A and Method B criteria downloaded July 2012 from Cleanup Levels and Risk Calculation (CLARC) database maintained by the Washington Department of Ecology. USEPA Regional Screening Levels (RSL) used are from May 2013

c=cancer, n=noncancer

Table 4-8a. Site-wide screening of volatile organic compounds in soil

		Screening Levels			Analytical Limits				Data Summary					
Analyte	CAS #	MTCA Method A[a] (µg/kg)	Min. of Risk-based Criteria (µg/kg)	Basis for Min. Risk criterion	Min. Detection Limit (µg/kg)	Max. Detection Limit (µg/kg)	Min. Practical Quantitation Limit (µg/kg)	Max. Practical Quantitation Limit (µg/kg)	Number of valid reported results	Number of rejected results	Number of detections	Max. detected concentration (µg/kg)	COPC	Rationale
1,1,1,2-Tetrachloroethane	630-20-6	Researched-No Data	1,900	c	0.11	0.51	2.6	11	211	0	0	--	No	Not detected, SL > DL and PQL
1,1,1-Trichloroethane (TCA)	71-55-6	2000	8,700,000	n	0.11	0.71	2.6	11	211	0	0	--	No	Not detected, SL > DL and PQL
1,1,2,2-Tetrachloroethane	79-34-5	Researched-No Data	560	c	0.13	0.73	2.6	11	211	0	0	--	No	Not detected, SL > DL and PQL
1,1,2-Trichloroethane	79-00-5	Researched-No Data	1,100	c	0.15	0.47	2.6	11	211	0	0	--	No	Not detected, SL > DL and PQL
1,1-Dichloroethane	75-34-3	Researched-No Data	3,300	c	0.12	0.41	2.6	11	211	0	0	--	No	Not detected, SL > DL and PQL
1,1-Dichloroethene	75-35-4	Researched-No Data	240,000	n	0.23	0.47	2.6	11	211	0	0	--	No	Not detected, SL > DL and PQL
1,1-Dichloropropene	563-58-6	Not available	Not available	--	0.13	0.55	2.6	11	211	0	0	--	No	Not detected, SL > DL and PQL
1,2,3-Trichlorobenzene	87-61-6	Not available	49,000	n	0.19	0.43	11.0	41	211	0	3	0.51 J	No	Max. detected concentration < SL
1,2,3-Trichloropropane	96-18-4	Researched-No Data	5	c	0.36	0.77	2.6	11	211	0	0	--	No	Not detected, SL > DL and PQL
1,2,4-Trichlorobenzene	120-82-1	Researched-No Data	22,000	c	0.13	0.47	11.0	41	211	0	2	0.48 J	No	Max. detected concentration < SL
1,2,4-Trimethylbenzene	95-63-6	Not Researched	62,000	n	0.05	0.57	11.0	41	211	0	2	0.64 J	No	Max. detected concentration < SL
1,2-Dibromo-3-chloropropane	96-12-8	Researched-No Data	5.4	c	0.40	1.40	11.0	41	211	0	0	--	No	Not detected, SL > DL
1,2-Dichlorobenzene	95-50-1	Researched-No Data	1,900,000	n	0.077	0.45	2.6	11	210	1	0	--	No	Not detected, SL > DL and PQL
1,2-Dichloroethane (EDC)	107-06-2	Researched-No Data	430	c	0.06	0.24	2.6	11	211	0	12	0.23 J	No	Max. detected concentration < SL
1,2-Dichloropropane	78-87-5	Researched-No Data	940	c	0.13	0.45	2.6	11	211	0	0	--	No	Not detected, SL > DL and PQL
1,3,5-Trimethylbenzene	108-67-8	Not Researched	780,000	n	0.092	0.73	11.0	41	211	0	0	--	No	Not detected, SL > DL and PQL
1,3-Dichlorobenzene	541-73-1	Not Researched	Not available	--	0.09	0.49	2.6	11	211	0	0	--	No	Not detected
1,3-Dichloropropane	142-28-9	Not available	1,600,000	n	0.12	0.41	2.6	11	211	0	0	--	No	Not detected, SL > DL and PQL
1,4-Dichlorobenzene	106-46-7	Researched-No Data	2,400	c	0.09	0.51	2.6	11	211	0	3	1.1 J	No	Max. detected concentration < SL
1,4-Dioxane	123-91-1	Researched-No Data	4,900	c	13	29	130.0	540	171	40	0	--	No	Not detected, SL > DL and PQL
2,2-Dichloropropane	594-20-7	Not available	Not available		0.10	0.73	2.6	11	211	0	0	--	No	Not detected
2-Butanone (MEK)	78-93-3	Researched-No Data	28,000,000	n	0.90	2	11.0	41	198	13	47	9.2 J	No	Max. detected concentration < SL
2-Chlorotoluene	95-49-8	Researched-No Data	1,600,000	n	0.12	0.59	11.0	41	211	0	0	--	No	Not detected, SL > DL and PQL
4-Chlorotoluene	106-43-4	Not available	1,600,000	n	0.088	0.53	11.0	41	211	0	0	--	No	Not detected, SL > DL and PQL
4-Isopropyltoluene	99-87-6	Not available	Not available	--	0.06	0.57	11.0	41	211	0	11	2.4 J	No	No SL
4-Methyl-2-pentanone (MIBK)	108-10-1	Researched-No Data	5,300,000	n	0.74	2.4	11.0	41	211	0	6	7.1 J	No	Max. detected concentration < SL
Acetone	67-64-1	Researched-No Data	61,000,000	n	1.70	6.2	11.0	41	211	0	11	470 J	No	Max. detected concentration < SL
Acrylonitrile	107-13-1	Researched-No Data	240	c	0.43	2.5	11.0	41	211	0	0	--	No	Not detected, SL > DL and PQL
Benzene	71-43-2	30	1,100	c	0.05	0.45	2.6	11	211	0	78	2.8 J	No	Max. detected concentration < SL
Bromobenzene	108-86-1	Not available	300,000	n	0.088	0.45	2.6	11	211	0	0	--	No	Not detected, SL > DL and PQL
Bromochloromethane	74-97-5	Not available	160,000	n	0.14	0.32	2.6	11	211	0	0	--	No	Not detected, SL > DL and PQL
Bromodichloromethane	75-27-4	Researched-No Data	270	c	0.15	0.31	2.6	11	211	0	0	--	No	Not detected, SL > DL and PQL
Bromoform	75-25-2	Researched-No Data	62,000	c	0.14	0.61	2.6	11	211	0	0	--	No	Not detected, SL > DL and PQL
Bromomethane	74-83-9	Researched-No Data	7,300	n	0.20	1.30	2.6	11	211	0	2	0.5 J	No	Max. detected concentration < SL
Carbon Disulfide	75-15-0	Researched-No Data	820,000	n	0.092	0.53	2.6	11	211	0	10	2.6 J	No	Max. detected concentration < SL
Carbon Tetrachloride	56-23-5	Researched-No Data	610	c	0.09	0.73	0.5	11	211	0	23	38 J	No	Max. detected concentration < SL
Chlorobenzene	108-90-7	Researched-No Data	290,000	n	0.06	0.51	2.6	11	211	0	0	--	No	Not detected, SL > DL and PQL
Chloroethane	75-00-3	Researched-No Data	15,000,000	n	0.23	0.97	2.6	11	211	0	0	--	No	Not detected, SL > DL and PQL
Chloroform	67-66-3	Researched-No Data	290	c	0.11	0.45	2.6	11	211	0	18	1.3 J	No	Max. detected concentration < SL
Chloromethane	74-87-3	Researched-No Data	120,000	n	0.18	0.75	2.6	11	211	0	9	0.77 J	No	Max. detected concentration < SL
cis-1,2-Dichloroethene	156-59-2	Researched-No Data	160,000	n	0.12	0.47	2.6	11	211	0	0	--	No	Not detected, SL > DL and PQL
Dibromochloromethane	124-48-1	Researched-No Data	680	c	0.18	0.39	2.6	11	211	0	0	--	No	Not detected, SL > DL and PQL
Dibromomethane	74-95-3	Researched-No Data	25,000	n	0.24	0.57	2.6	11	211	0	0	--	No	Not detected, SL > DL and PQL
Ethylbenzene	100-41-4	6000	5,400	c	0.09	0.45	2.6	11	211	0	9	3.9 J	No	Max. detected concentration < SL
Hexachlorobutadiene	87-68-3	Researched-No Data	6,200	c	0.21	0.53	11.0	41	211	0	0	--	No	Not detected, SL > DL and PQL
Isopropylbenzene	98-82-8	Researched-No Data	2,100,000	n	0.081	0.27	11.0	41	211	0	2	0.14 J	No	Max. detected concentration < SL
m,p-Xylenes	1330-20-7	9000	630,000	n	0.10	0.75	2.6	11	211	0	32	1.4 J	No	Max. detected concentration < SL
Methyl tert-Butyl Ether	1634-04-4	100	43,000	c	0.12	0.37	2.6	11	211	0	62	3.1 J	No	Max. detected concentration < SL
Methylene Chloride	75-09-2	20	56,000	c	0.12	0.68	5.2	21	211	0	14	25 J	No	Max. detected concentration < SL*
Naphthalene	91-20-3	5000	3600	c	0.13	0.73	11.0	41	210	1	4	0.91 J	*See SVOC screening in Table 4-8b.*	
n-Butylbenzene	104-51-8	Not Researched	3,900,000	n	0.07	0.65	11.0	41	211	0	0	--	No	Not detected, SL > DL and PQL
n-Propylbenzene	103-65-1	Not Researched	3,400,000	n	0.13	0.73	11.0	41	211	0	0	--	No	Not detected, SL > DL and PQL
o-Xylene	95-47-6	Researched-No Data	690,000	n	0.081	0.27	2.6	11	211	0	28	0.51 J	No	Max. detected concentration < SL

Table 4-8a. Site-wide screening of volatile organic compounds in soil

		Screening Levels			Analytical Limits				Data Summary					
Analyte	**CAS #**	**MTCA Method A[a] (µg/kg)**	**Min. of Risk-based Criteria (µg/kg)**	**Basis for Min. Risk criterion**	**Min. Detection Limit (µg/kg)**	**Max. Detection Limit (µg/kg)**	**Min. Practical Quantitation Limit (µg/kg)**	**Max. Practical Quantitation Limit (µg/kg)**	**Number of valid reported results**	**Number of rejected results**	**Number of detections**	**Max. detected concentration (µg/kg)**	**COPC**	**Rationale**
sec-Butylbenzene	135-98-8	Not Researched	7,800,000	n	0.07	0.63	11.0	41	211	0	2	1.8 J	No	Max. detected concentration < SL
Styrene	100-42-5	Researched-No Data	6,300,000	n	0.13	0.27	2.6	11	211	0	0	--	No	Not detected, DL < SL
tert-Butylbenzene	98-06-6	Not Researched	7,800,000	n	0.14	0.67	11.0	41	211	0	0	--	No	Not detected, DL < SL
Tetrachloroethene (PCE)	127-18-4	50	22,000	c	0.16	0.53	2.6	11	211	0	17	200 J	No	Max. detected concentration < SL*
Toluene	108-88-3	7000	5,000,000	n	0.15	0.37	2.6	11	211	0	153	3.7 J	No	Max. detected concentration < SL
trans-1,2-Dichloroethene	156-60-5	Researched-No Data	150,000	n	0.12	0.71	2.6	11	211	0	0	--	No	Not detected, SL > DL and PQL
trans-1,3-Dichloropropene	10061-02-6	Not available	Not available	--	0.11	0.69	2.6	11	211	0	0	--	No	Not detected, no SL
trans-1,4-Dichloro-2-butene	110-57-6	Not available	6.9	c	0.27	0.57	11.0	41	211	0	0	--	No	Not detected, SL > DL
Trichloroethene (TCE)	79-01-6	30	910	c	0.15	0.55	2.6	11	211	0	0	--	No	Not detected, SL > DL and PQL
Trichlorofluoromethane	75-69-4	Researched-No Data	790,000	n	0.09	0.43	2.6	11	211	0	0	--	No	Not detected, SL > DL and PQL
Vinyl Chloride	75-01-4	Researched-No Data	60	c	0.044	0.49	2.6	11	211	0	0	--	No	Not detected, SL > DL and PQL

[a] Model Toxics Control Act (MTCA) Method A and Method B criteria downloaded July 2012 from Cleanup Levels and Risk Calculation (CLARC) database maintained by the Washington Department of Ecology.

c=cancer, COPC=chemical of potential concer, DL=detection limit, n=noncancer, PQL=practical quantitation limit, SL=screening limit, SVOC=semi-volatile organic compounds

J - estimated analytical results; D - result from diluted sample

*Maximum concentrations exceed the MTCA screening levels in duplicate field samples collected near B44; however these were outliers based on other soil samples collected from B44.

Table 4-8b. Site-wide screening of semi-volatile organic compounds in soil

		Screening Levels			Analytical Limits				Sample Data Summary						
Analyte	CAS #	MTCA Method A[a] (µg/kg)	Minimum of Risk-based Criteria (µg/kg)	Basis of Risk Criteria	Min. Detection Limit (µg/kg)	Max. Detection Limit (µg/kg)	Min. Practical Quantitation Limit (µg/kg)	Max. Practical Quantitation Limit (µg/kg)	Number of Rejected data	Number of reported values	Number of valid analysis	No. of detections	Maximum Detected (µg/kg)	COPC	Rationale
1,2,4-Trichlorobenzene	120-82-1	Researched-No Data	22,000	c	2.6	130	5.5	500	0	169	169	0	--	No	Not detected, SL > DL and PQL
1-Methylnaphthalene	90-12-0	Not Researched	16,000	c	2.2	110	5.5	500	0	169	169	23	180 JD	No	Max. detected concentration < SL
2,4,5-Trichlorophenol	95-95-4	Researched-No Data	6,100,000	n	1.5	75	5.5	500	11	169	158	0	--	No	Not detected, SL > DL and PQL
2,4,6-Trichlorophenol	88-06-2	Researched-No Data	44,000	c	1.4	70	5.5	500	11	169	158	0	--	No	Not detected, SL > DL and PQL
2,4-Dichlorophenol	120-83-2	Researched-No Data	180,000	n	1	50	5.5	500	11	169	158	0	--	No	Not detected, SL > DL and PQL
2,4-Dimethylphenol	105-67-9	Researched-No Data	1,200,000	n	5.5	280	28	2,500	32	169	137	0	--	No	Not detected, SL > DL and PQL
2,4-Dinitrophenol	51-28-5	Researched-No Data	120,000	n	17	850	110	10,000	11	169	158	0	--	No	Not detected, SL > DL and PQL
2-Chloronaphthalene	91-58-7	Researched-No Data	6,300,000	n	1.6	80	5.5	500	0	169	169	0	--	No	Not detected, SL > DL and PQL
2-Chlorophenol	95-57-8	Researched-No Data	390,000	n	2	100	5.5	500	11	169	158	0	--	No	Not detected, SL > DL and PQL
2-Methyl-4,6-dinitrophenol	534-52-1	Not available	4,900	n	1.4	70	55	5,000	11	169	158	0	--	No	Not detected, SL > DL and PQL
2-Methylphenol	95-48-7	Researched-No Data	3,100,000	n	1.5	75	5.5	500	11	169	158	0	--	No	Not detected, SL > DL and PQL
2-Nitroaniline	88-74-4	Researched-No Data	610,000	n	3.2	160	11	1,000	0	169	169	0	--	No	Not detected, SL > DL and PQL
2-Nitrophenol	88-75-5	Not available	Not available	--	1.5	75	5.5	500	11	169	158	0	--	No	Not detected, no SL
3,3-Dichlorobenzidine	91-94-1	Researched-No Data	1,100	c	3.7	190	55	5,000	0	169	169	1	12 J	No	Max. detected concentration < SL
3-Nitroaniline	99-09-2	Not available	Not available	--	2.5	130	11	1,000	0	169	169	0	--	No	Not detected, no SL
4-Bromophenyl Phenyl Ether	101-55-3	Not available	Not available	--	1.6	80	5.5	500	0	169	169	0	--	No	Not detected, no SL
4-Chloro-3-methylphenol	59-50-7	Not available	6,100,000	n	1.4	70	5.5	500	11	169	158	0	--	No	Not detected, SL > DL and PQL
4-Chloroaniline	106-47-8	Researched-No Data	2,400	c	1.9	95	5.5	500	0	169	169	0	--	No	Not detected, SL > DL and PQL
4-Chlorophenyl Phenyl Ether	7005-72-3	Not available	Not available	--	1.4	70	5.5	500	0	169	169	0	--	No	Not detected, no SL
4-Methylphenol	106-44-5	Researched-No Data	400,000	n	1.5	75	5.5	500	11	169	158	3	610 D	No	Max. detected concentration < SL
4-Nitroaniline	100-01-6	Not available	24,000	c	1.8	90	11	1,000	0	169	169	0	--	No	Not detected, SL > DL and PQL
4-Nitrophenol	100-02-7	Not available	Not available	--	18	900	55	5,000	12	169	157	0	--	No	Not detected, no SL
Acenaphthene	83-32-9	Researched-No Data	3,400,000	n	1.4	14	5.5	100	0	6	6	0	--	*See Table 4-8c for screening of PAH data*	
Acenaphthylene	208-96-8	Not Researched	Not available	--	1.2	12	5.5	100	0	6	6	0	--	*See Table 4-8c for screening of PAH data*	
Aniline	62-53-3	Researched-No Data	85,000	c	1.5	75	11	1,000	0	169	169	0	--	No	Not detected, SL > DL and PQL
Anthracene	120-12-7	Researched-No Data	17,000,000	n	1.6	16	5.5	100	0	6	6	0	--	*See Table 4-8c for screening of PAH data*	
Benz(a)anthracene	56-55-3	Researched-No Data	150	c	1.7	17	5.5	100	0	6	6	0	--	*See Table 4-8c for screening of PAH data*	
Benzo(a)pyrene	50-32-8	100	15	c	1.7	17	5.5	100	0	6	6	0	--	*See Table 4-8c for screening of PAH data*	
Benzo(b)fluoranthene	205-99-2	Researched-No Data	150	c	1.2	12	5.5	100	0	6	6	1	--	*See Table 4-8c for screening of PAH data*	
Benzo(g,h,i)perylene	191-24-2	Not Researched	Not available	--	1.5	15	5.5	100	0	6	6	1	--	*See Table 4-8c for screening of PAH data*	
Benzo(k)fluoranthene	207-08-9	Researched-No Data	1500	c	1.4	14	5.5	100	0	6	6	0	--	*See Table 4-8c for screening of PAH data*	
Benzoic Acid	65-85-0	Researched-No Data	240,000,000	n	96	4800	120	10,000	12	169	157	42	3400	No	Max. detected concentration < SL
Benzyl Alcohol	100-51-6	Researched-No Data	6,100,000	n	2.1	110	11	1,000	11	169	158	14	120	No	Max. detected concentration < SL
Bis(2-chloroethoxy)methane	111-91-1	Not available	180,000	n	1.5	75	5.5	500	0	169	169	1	230 JD	No	Max. detected concentration < SL
Bis(2-chloroethyl) Ether	111-44-4	Researched-No Data	210	c	1.9	310	5.5	500	0	169	169	1	24 JD	No	Max. detected concentration < SL
Bis(2-ethylhexyl) Phthalate	117-81-7	Researched-No Data	35,000	c	7	350	55	5,000	0	169	169	79	410	No	Max. detected concentration < SL
Butyl Benzyl Phthalate	85-68-7	Researched-No Data	260,000	c	3.2	160	5.5	500	0	169	169	6	91	No	Max. detected concentration < SL
Chrysene	218-01-9	Researched-No Data	15,000	c	1.5	15	5.5	100	0	6	6	1	2.4	*See Table 4-8c for screening of PAH data*	
Dibenz(a,h)anthracene	53-70-3	Researched-No Data	15	c	1.5	15	5.5	100	0	6	6	0	--	*See Table 4-8c for screening of PAH data*	
Diethyl Phthalate	84-66-2	Researched-No Data	49,000,000	n	1.3	65	5.5	500	0	169	169	29	660 D	No	Max. detected concentration < SL
Dimethyl Phthalate	131-11-3	Researched-No Data	Not available	--	1	50	5.5	500	0	169	169	89	1900 D	No	No SL
Di-n-butyl Phthalate	84-74-2	Researched-No Data	6,100,000	n	7.9	450	11	1,200	0	169	169	21	5600 D	No	Max. detected concentration < SL
Di-n-octyl Phthalate	117-84-0	Researched-No Data	610,000	n	1.7	85	5.5	500	0	169	169	0	--	No	Not detected, SL > DL and PQL
Fluoranthene	206-44-0	Researched-No Data	2,300,000	n	1.6	16	5.5	100	0	6	6	1	2.4	*See Table 4-8c for screening of PAH data*	
Fluorene	86-73-7	Researched-No Data	2,300,000	n	1.1	11	5.5	100	0	6	6	1	68	*See Table 4-8c for screening of PAH data*	
Hexachlorobenzene	118-74-1	Researched-No Data	300	c	1.2	60	5.5	500	0	169	169	0	--	No	Not detected, SL > detection and majority of practical quantitation limits
Hexachlorocyclopentadiene	77-47-4	Researched-No Data	370,000	n	29	1500	29	2,500	0	169	169	0	--	No	Not detected, SL > detection and practical quantitation limits
Hexachloroethane	67-72-1	Researched-No Data	12,000	c	3.1	160	5.5	500	0	169	169	0	--	No	Not detected, SL > detection and practical quantitation limits
Indeno(1,2,3-cd)pyrene	193-39-5	Researched-No Data	150	c	1.5	15	5.5	100	0	6	6	0	--	*See Table 4-8c for screening of PAH data*	
Isophorone	78-59-1	Researched-No Data	510,000	c	1	50	5.5	500	0	169	169	0	--	No	Not detected; detection limit < SL
Naphthalene	91-20-3	5000	3,600	c	2.3	120	5.5	500	1	169	168	44	4600	Yes	Max. concentration comparable to MTCA Method A SL and greater than risk-based SL
N-Nitrosodimethylamine	62-75-9	Researched-No Data	2.3	c	6.1	310	28	2,500	0	169	169	0	--	No	SL < DL but compound was unlikely to have been used at NAAS

Table 4-8b. Site-wide screening of semi-volatile organic compounds in soil

		Screening Levels			Analytical Limits				Sample Data Summary						
Analyte	**CAS #**	**MTCA Method A[a] (µg/kg)**	**Minimum of Risk-based Criteria (µg/kg)**	**Basis of Risk Criteria**	**Min. Detection Limit (µg/kg)**	**Max. Detection Limit (µg/kg)**	**Min. Practical Quantitation Limit (µg/kg)**	**Max. Practical Quantitation Limit (µg/kg)**	**Number of Rejected data**	**Number of reported values**	**Number of valid analysis**	**No. of detections**	**Maximum Detected (µg/kg)**	**COPC**	**Rationale**
N-Nitrosodi-n-propylamine	621-64-7	Researched-No Data	69	c	2.4	120	5.5	500	0	169	169	0	--	No	Not detected, SL > DL and PQL for most samples
N-Nitrosodiphenylamine	86-30-6	Researched-No Data	99,000	c	1.6	80	5.5	500	0	169	169	5	360 D	No	Max. detected concentration < SL
Pentachlorophenol	87-86-5	Researched-No Data	890	c	20	1000	55	5,000	12	169	157	14	1600 D	Yes	Max. detected concentration > SL
Phenol	108-95-2	Researched-No Data	18,000,000	n	2	100	17	1,500	11	169	158	34	660	No	Max. detected concentration < SL
Pyrene	129-00-0	Researched-No Data	1,700,000	n	1.5	15	5.5	100	0	6	6	2	34	*for screening of PAH data*	
Pyridine	110-86-1	Researched-No Data	78,000	n	50	2500	50	2,500	0	169	169	0	--	No	Not detected, SL > detection and practical quantitation limits

Chemical identified as COPC

[a] Model Toxics Control Act (MTCA) Method A and Method B criteria downloaded July 2012 from Cleanup Levels and Risk Calculation (CLARC) database maintained by the Washington Department of Ecology.

c=cancer, COPC=chemical of potential concer, DL=detection limit, n=noncancer, PQL=practical quantitation limit, SL=screening limit, SVOC=semi-volatile organic compounds

J - estimated analytical results; D - result from diluted sample

Table 4-8c. Site-wide screening of polynuclear aromatic hydrocarbons in soil

		Screening Levels			Analytical Limits				Sample Data Summary					
Analyte	**CAS No.**	**MTCA Method A[a] (µg/kg)**	**Min. of Risk-based Criteria (µg/kg)**	**Basis for Risk Criteria**	**Min. Detection Limit (µg/kg)**	**Max. Detection Limit (µg/kg)**	**Min. Practical Quantitation Limit (µg/kg)**	**Max. Practical Quantitation Limit (µg/kg)**	**Number of rejected data**	**Number of reported values**	**Number of valid results**	**Maximum Detected Concentration (µg/kg)**	**COPC**	**Rationale**
Acenaphthene	83-32-9	Researched-No Data	3,400,000	n	0.23	1.2	1.5	13	0	224	224	290	No	Max. detected concentration < SL
Acenaphthylene	208-96-8	Not Researched	NA		0.24	71	1.5	71	0	224	224	1300	No risk criteria	No SL
Anthracene	120-12-7	Researched-No Data	17,000,000	n	0.47	4.7	1.5	25	0	224	224	1700	No	Max. detected concentration < SL
Benz(a)anthracene	56-55-3	Researched-No Data	150	c	0.48	11	1.5	35	0	224	224	3600	Yes	Max. detected concentration > SL
Benzo(a)pyrene	50-32-8	100	15	c	0.14	1.4	1.5	35	0	224	224	3700	Yes	Max. detected concentration > SL
Benzo(b)fluoranthene	205-99-2	Researched-No Data	150	c	0.25	9.2	1.5	35	0	224	224	4100	Yes	Max. detected concentration > SL
Benzo(g,h,i)perylene	191-24-2	Not Researched	Not available	--	0.64	6.4	1.5	35	0	224	224	1600	No risk criteria	No SL
Benzo(k)fluoranthene	207-08-9	Researched-No Data	1,500	c	0.15	8.7	1.5	35	0	224	224	1800	Yes	Max. detected concentration > SL
Chrysene	218-01-9	Researched-No Data	15,000	c	0.25	2.5	1.5	35	0	224	224	4500	Yes	Max. detected concentration < SL but analyte is one of PAHs in MTCA Table 708-1
Dibenz(a,h)anthracene	53-70-3	Researched-No Data	15	c	0.28	2.8	1.5	35	0	224	224	580	Yes	Max. detected concentration > SL
Fluoranthene	206-44-0	Researched-No Data	2,300,000	n	0.61	13	1.5	50	0	224	224	11000	No	Max. detected concentration < SL
Fluorene	86-73-7	Researched-No Data	2,300,000	n	0.5	5	1.5	25	0	224	224	2100	No	Max. detected concentration < SL
Indeno(1,2,3-cd)pyrene	193-39-5	Researched-No Data	150	c	0.16	1.6	1.5	35	0	224	224	2200	Yes	Max. detected concentration > SL
Pyrene	129-00-0	Researched-No Data	1,700,000	n	0.37	3.7	1.5	35	0	224	224	8100	No	Max. detected concentration < SL

Chemical identified as a preliminary COPC.

[a] Model Toxics Control Act (MTCA) Method A and Method B criteria downloaded July 2012 from Cleanup Levels and Risk Calculation (CLARC) database maintained by the Washington Department of Ecology.

c=cancer, COPC=chemical of potential concer, DL=detection limit, n=noncancer, PQL=practical quantitation limit, SL=screening limit, SVOC=semi-volatile organic compounds

J - estimated analytical results; D - result from diluted sample

Table 4-8d. Site-wide screening of polychlorinated biphenyls in soil

		Screening Levels			Analytical Limits				Sample Data Summary					
Analyte	**CAS #**	**MTCA Method A[a] (µg/kg)**	**Min. of Risk-based Criteria**	**Basis for Risk-based criteria**	**Min. Detection Limit (µg/kg)**	**Max. Detection Limit (µg/kg)**	**Min. Practical Quantitation Limit (µg/kg)**	**Max. Practical Quantitation Limit (µg/kg)**	**Number of valid results**	**Number of rejected results**	**Number of detections**	**Max detected (µg/kg)**	**COPC**	**Rationale**
Aroclor 1016	12674-11-2	Researched-No Data	3900	n	2.1	11	5.7	50	41	0	0	--	No	Not detected, detection and quantitation limit < SL
Aroclor 1221	11104-28-2	Not available	140	c	2.1	11	12	100	41	0	0	--	No	Not detected, detection and quantitation limit < SL
Aroclor 1232	11141-16-5	Not available	140	c	2.1	11	5.7	50	41	0	0	--	No	Not detected, detection and quantitation limit < SL
Aroclor 1242	53469-21-9	Not available	220	c	2.1	11	5.7	50	41	0	0	--	No	Not detected, detection and quantitation limit < SL
Aroclor 1248	12672-29-6	Not available	220	c	2.1	11	5.7	50	41	0	0	--	No	Not detected, detection and quantitation limit < SL
Aroclor 1254	11097-69-1	Researched-No Data	220	c	2.1	22	5.7	50	41	0	2	11	No	Max. detected concentration < SL
Aroclor 1260	11096-82-5	Not Researched	220	c	2.1	50	5.7	50	41	0	2	14	No	Max. detected concentration < SL
Aroclor 1262 [b]	1336-36-3	1000	220	c	2.1	120	5.7	120	41	0	6	39	No	Max. detected concentration < SL
Aroclor 1268 [b]	1336-36-3	1000	220	c	2.1	50	5.7	50	41	0	10	45	No	Max. detected concentration < SL
Total PCBs [c]	N/A	1000	500	c	2.1	11	5.7	50	41	0	20	84	No	Max. detected concentration < SL

[a] Model Toxics Control Act (MTCA) Method A and Method B criteria downloaded July 2012 from Cleanup Levels and Risk Calculation (CLARC) database maintained by the Washington Department of Ecology.

[b] EPA RSL for high-risk PCBs used as SL

[c] PCB mixture evaluated in accordance with MTCA Cleanup Regulation (WAC 173-340-708(8)).

c=cancer, COPC=chemical of potential concer, DL=detection limit, n=noncancer, PQL=practical quantitation limit, SL=screening limit, SVOC=semi-volatile organic compounds

J - estimated analytical results; D - result from diluted sample

Table 4-8e. Site-wide screening of metals in soil

		Screening Levels				Analytical Limits				Sample Data Summary			
Analyte	**CAS #**	**MTCA Method A [a] (µg/kg)**	**Minimum of Risk-based Screening Criteria [b] (µg/kg)**	**Basis for Risk Criterion**	**Puget Sound Background (90th Percentile Values) (µg/kg)**	**Min. detection limit (µg/kg)**	**Max. detection limit (µg/kg)**	**Min. Practical Quantitation Limit (µg/kg)**	**Max. Practical Quantitation Limit (µg/kg)**	**Number of Valid Analyses**	**Maximum Detected Concentration (µg/kg)**	**COPC**	**Rationale**
Arsenic	7440-38-2	20000	610	c	7000	50	60	490	600	10	6050	No	Max. detected concentration < Puget Sound background
Cadmium	7440-43-9	2000	70000	n	1000	4	5	19	24	10	198	No	Max. detected concentration < SL and Puget Sound background
Chromium [c]	16065-83-1	2000000	120,000,000	n	42000	20	20	190	240	10	83400	No	Max. detected concentration < SL
Iron	7439-89-6	Researched-No Data	55,000,000	n	42,100,000	700	8600	3900	48800	10	58,800,000	No	Max. detected concentration comparable to SL
Manganese	7439-96-5	Researched-No Data	11,000,000	n	1,100,000	20	240	1930	24400	10	1610000	No	Max. detected concentration < SL
Mercury	7439-97-6	2000	10000	n	70	2	2	19	20	10	120	No	Max. detected concentration < SL
Silver	7440-22-4	Researched-No Data	390000	n	NA	5	26	18	26	144	21200	No	Max. detected concentration < SL

*Lead was not evaluated in this report because it is not actionable under FUDS.

[a] Model Toxics Control Act (MTCA) Method A criteria downloaded July 2012 from the Cleanup Levels and Risk Calculation (CLARC) maintained by Washington Department of Ecology.

[b] Screening Level (SL) is the lowest of the MTCA Method B carcinogenic and non-carcinogenic criteria (downloaded July 2012 from CLARA catabase) and USEPA Regional Screening Levels (May 2013)

[c] Assume Chromium III, because no source of Chromium VI has been identified based on historical land use (Shannon and Wilson 2012)

c=cancer, COPC=chemical of potential concer, DL=detection limit, n=noncancer, PQL=practical quantitation limit, SL=screening limit, SVOC=semi-volatile organic compounds

Table 4-9. Selected volatile organic compounds detected in subsurface soil

Area of Potential Concern	Borehole ID	Depth (feet bgs)	Sample ID	Collected Date	Carbon Tetrachloride 56-23-5 (µg/kg)	Q	VQ	Tetrachloroethene (PCE) 127-18-4 (µg/kg)	Q	VQ	Methylene Chloride 75-09-2 (µg/kg)	Q	VQ	Benzene 71-43-2 (µg/kg)	Q	VQ	Methyl tert-Butyl Ether 1634-04-4 (µg/kg)	Q	VQ	Toluene 108-88-3 (µg/kg)	Q	VQ
B12	B12:SB-1	25	B12:SB-1:25:211	2009/07/08	**0.83**	**J**		5.3	U		0.6	J	U	**0.24**	**J**		**0.27**	**J**		**0.53**	**J**	
	B12:SB-4	25	B12:SB-4:25:321	2009/11/10	**1**	**J**		5.1	U		11	U		**0.57**	**J**		5.1	U		1.2	J	U
	B12:SB-6	25	B12:SB-6:25:323	2009/11/10	**0.52**	**J**		4.6	U		9.2	U		**0.27**	**J**		4.6	U		0.33	J	U
	B12:SB-7	25	B12:SB-7:25:325	2009/11/10	**0.94**	**J**		4.6	U		0.31	J	U	**0.49**	**J**		4.6	U		0.95	J	U
	B12:SB-7	25	B12:SB-7:25:326	2009/11/10	**0.66**	**J**		4.6	U		0.28	J	U	0.22	J	U	4.6	U		0.28	J	U
B19	B19:SB-3	25	B19:SB-3:25:330	2009/11/10	**0.37**	**J**		5.1	U		0.3	J	U	5.1	U		5.1	U		**0.22**	**J**	
B20	B20:SB-1	25	B20:SB-1:25:205	2009/07/07	**0.83**	**J**		4.3	U		8.60	U		4.3	U		**0.31**	**J**		4.3	U	
	B20:SB-1	25	B20:SB-1:25:284	2009/11/08	**0.59**	**J**		4.5	U		0.42	J	U	**0.42**	**J**		0.31	J	U	**0.76**	**J**	
	B20:SB-3	25	B20:SB-3:25:280	2009/11/08	**1.2**	**J**		5.4	U		11	U		**0.56**	**J**		5.4	U		**1.2**	**J**	
	B20:SB-4	25	B20:SB-4:25:278	2009/11/08	**1.6**	**J**		5	U		**0.39**	**J**		5	U		**0.19**	**J**		5	U	
B41	B41:RS-1	22	B41:RS-1:22:427	2010/11/29	**0.8**	**J**		4	U		**4.2**	**J**		**1.4**	**J**		**0.24**	**J**		**2.2**	**J**	
B44	B44:SB-6	7.5	B44:SB-6:7.5:223	2009/11/05	**1.2**	**J**		**5**	**J**	**J**	0.2	J	U	7.4	U		7.4	U		7.4	U	
		25	B44:SB-6:25:224	2009/11/05	**36**	**J**	**J**	**200**	**J**	**J**	**22**	**J**	**J**	73	U	UJ	72	U	UJ	**13**	**J**	**J**
		25	B44:SB-6:25:225	2009/11/05	**36**	**J**	**J**	**190**	**J**	**J**	**25**	**J**	**J**	83	U	UJ	83	U	UJ	**23**	**J**	**J**
	B44:RS-3	12	B44:RS-3:12:433	2010/12/13	**0.88**	**J**	**J**	**1.4**	**J**	**J**	2.2	J	UJ	4.9	U		0.77	J	UJ	**0.67**	**J**	**J**
		18	B44:RS-3:18:434	2010/12/13	**2.2**		**J**	**1.1**	**J**	**J**	2.2	J	UJ	**0.34**	**J**	**J**	0.74	J	UJ	**0.78**	**J**	**J**
		25	B44:RS-3:25:435	2010/12/13	**1**	**J**	**J**	**4.9**	**J**	**J**	2.6	J	UJ	**0.33**	**J**	**J**	1	J	UJ	**1.1**	**J**	**J**
		70	B44:RS-3:70:436	2010/12/14	**0.64**	**J**	**J**	**10**		**J**	2.7	J	UJ	**2.8**	**J**	**J**	0.68	J	UJ	**3.7**	**J**	**J**

Detected concentrations are shown in bold font.

bgs=below ground surface, c=cancer, COPC=chemical of potential concer, DL=detection limit, n=noncancer, PQL=practical quantitation limit, Q: Laboratory Qualifier, SL=screening limit, SVOC=semi-volatile organic compounds, VQ: Validation Qualifier

D - result from diluted sample; J - estimated analytical results; U: Not detected, value shown is the Practical Quantitation Limit

Table 4-10. Naphthalene and pentachlorophenol in soil

Area of Potential Concern	Sample ID	Sampling Date	Naphthalene (µg/kg)	Q	VQ	Pentachlorophenol (µg/kg)	Q	VQ	Evaluation of COPCs status for naphthalene and pentachlorophenol
		Compound	Naphthalene			Pentachlorophenol			
		CAS #	91-20-3			87-86-5			
		MTCA Method A (µg/kg)	5,000			Researched-No data			
		Min. Risk-based Criterion (µg/kg)	3,600			890			
B4, Surface soil	B4:SS-1:79	2009/03/29	300	U		**1600**	**JD**	J	Naphthalene - No. All detections and practical quantitaion limits
	B4:SS-10:88	2009/03/29	250	U		2500	U		are less than the SL.
	B4:SS-11:89	2009/03/29	7.1	J		99	U		
	B4:SS-12:90	2009/03/29	260	U					
	B4:SS-13:91	2009/03/29	10	U		100	U		Pentachlorophenol - Yes. Max. detection exceeded SL.
	B4:SS-14:92	2009/03/29	3	J		30	J		
	B4:SS-15:93	2009/03/29	10	U		34	J		
	B4:SS-16:94	2009/03/29	500	U					
	B4:SS-2:80*	2009/03/29	250	U		**1000**	**JD**		
	B4:SS-3:81*	2009/03/29	250	U		**1200**	**JD**		
	B4:SS-4:82	2009/03/29	74	JD		**1400**	**JD**		
	B4:SS-5:83	2009/03/29	10	U		100	U		
	B4:SS-6:84	2009/03/29	9.9	U		99	U		
	B4:SS-7:85	2009/03/29	4.1	J		45	J		
	B4:SS-8:86	2009/03/29	4.1	J		100	U		
	B4:SS-9:87	2009/03/29	4.9	J		100	U		
B5, Surface soil	B5:SS-1:168	2009/04/02	250	U		2500	U		Naphthalene - Yes. Max. detected concentration > SL
	B5:SS-10:177	2009/04/02	320	JD		5000	U		
	B5:SS-11:178	2009/04/02	500	U		5000	U		Pentachlorophenol - Yes, not detected but PQL > SL
	B5:SS-12:179	2009/04/02	460	U		4600	U		
	B5:SS-2:169	2009/04/02	250	U		2500	U		
	B5:SS-3:170	2009/04/02	80	JD					
	B5:SS-4:171	2009/04/02	1200	D		3500	U		
	B5:SS-5:172	2009/04/02	**4600**	**D**		5000	U		
	B5:SS-6:173	2009/04/02	140	JD		5000	U		
	B5:SS-7:174	2009/04/02	360	JD		5000	U		
	B5:SS-8:175	2009/04/02	450	JD		5000	U		
	B5:SS-9:176	2009/04/02	1300	D		5000	U		
B9, Surface soil	B9:SS-1:95	2009/03/29	15	JD		570	U		Naphthalene - No. All detections and practical quantitaion limits
	B9:SS-2:96	2009/03/29	31	JD		310	JD		are less than the SL.
	B9:SS-3:97	2009/03/29	2.9	J		100	U		
	B9:SS-4:98	2009/03/29	2.8	J		100	U	UJ	Pentachlorophenol - No. Pentachlorophenol was
	B9:SS-5-99	2009/03/29	3.2	J	J	99	U	UJ	either not detected (PQL < SL) or detected below the SL.
	B9:SS-5-99-DUP	2009/03/29	17	J		400	U		
	B9:SS-6:100	2009/03/29	250	U					
	B9:SS-7:101	2009/03/29	22	JD		490	U		
	B9:SS-8:102	2009/03/29	9.6	U	UJ	96	U	UJ	
	B9:SS-8:102-DUP	2009/03/29	39	U		390	U		
	B9:SS-9:103	2009/03/29	4.4	J		120	U		
B10, Surface soil	B10:SS-1:114	2009/03/30	10	U		100	U		Naphthalene - No. All detections and practical quantitation limits
	B10:SS-10:123	2009/03/30	100	U		*1000*	*U*		are less than the SL.
	B10:SS-11:124	2009/03/30	5	J		100	U		
	B10:SS-12:125	2009/03/30	3	J		100	U		Pentachlorophenol - No. In a majority of the samples,
	B10:SS-13:126*	2009/03/30	2.5	J		51	J		pentachlorophenol was either not (PQL < SL) or detected below the SL.
	B10:SS-14:127*	2009/03/30	3.5	J		52	J		
	B10:SS-2:115	2009/03/30	10	U		40	J		
	B10:SS-3:116	2009/03/30	10	U		100	U		
	B10:SS-4:117	2009/03/30	110	U		*1100*	*U*		
	B10:SS-5:118	2009/03/30	2.4	J		50	J		
	B10:SS-6:119	2009/03/30	250	U		2500	U		
	B10:SS-7:120	2009/03/30	100	U		*1000*	*U*		
	B10:SS-8:121	2009/03/30	2.7	J		99	U		
	B10:SS-9:122	2009/03/30	100	U		*1000*	*U*		
B12, Surface soil	B12:SS-1:60	2009/03/28	7	U		70	U	UJ	Naphthalene - No. All detections and practical quantitaion limits
	B12:SS-10:69	2009/03/28	7.7	U		77	U	UJ	are less than the SL.
	B12:SS-11:70	2009/03/28	7.2	U		72	U		Pentachlorophenol - No. Pentachlorophenol was
	B12:SS-12:71	2009/03/29	12			51	J		either not detected (PQL < SL) or detected below the SL.
	B12:SS-2:61	2009/03/28	7.5	U					
	B12:SS-3:62	2009/03/28	7.9	U		230			
	B12:SS-4:63	2009/03/28	7.4	U		74	U		
	B12:SS-5:64	2009/03/28	3.9	J		85	U		
	B12:SS-6:65	2009/03/28	7.7	U					
	B12:SS-7:66	2009/03/28	8.1	U		81	U		
	B12:SS-8:67	2009/03/28	8.8	U		88	U		
	B12:SS-9:68	2009/03/28	7.6	U		76	U		
B17, Surface soil	B17:SS-1:181	2009/04/03	420	U		*4200*	*U*		Naphthalene - No. All detections and practical quantitaion limits
	B17:SS-10:190	2009/04/03	740	D		*2300*	*U*		are less than the SL.
	B17:SS-2:182	2009/04/03	330	U					
	B17:SS-3:183	2009/04/03	440	U		*4400*	*U*		Pentachlorophenol - Yes not detected but PQL > SL
	B17:SS-4:184	2009/04/03	460	U					in majority of samples
	B17:SS-5:185	2009/04/03	19			84	U	UJ	
	B17:SS-6:186	2009/04/03	410	U					
	B17:SS-7:187	2009/04/03	500	U					
	B17:SS-8:188	2009/04/03	290	U		*2900*	*U*		
	B17:SS-9:189	2009/04/03	2.6	J		58	U		
B18 and B19	B18:SS-1:75*	2009/03/29	9.9	U		99	U		Naphthalene - No. Not detected, PQL < SL
Surface soil	B18:SS-2:76*	2009/03/29	9.9	U		99	U		
	B18:SS-3:77	2009/03/29	10	U		100	U		Pentachlorophenol - No. Not detected, PQL < SL.
	B18:SS-4:78	2009/03/29	9.8	U		98	U		
	B19:SS-1:72	2009/03/29	7.7	U		77	U		Naphthalene - No. Not detected, PQL < SL
	B19:SS-2:73	2009/03/29	10	U		100	U		
	B19:SS-3:74	2009/03/29	10	U		100	U		Pentachlorophenol - No. Not detected, PQL < SL.
B20, Surface soil	B20:SS-1:129	2009/03/30	250	U		*2500*	*U*		Naphthalene - No. Not detected, PQL < SL
	B20:SS-2:130	2009/03/30	250	U					
	B20:SS-3:131	2009/03/30	250	U		*2500*	*U*		Pentachlorophenol - Yes, not detected but PQL > SL
	B20:SS-4:132	2009/03/30	500	U					

Table 4-10. Naphthalene and pentachlorophenol in soil

Area of Potential Concern	Sample ID	Sampling Date	Naphthalene (µg/kg)	Q	VQ	Pentachlorophenol (µg/kg)	Q	VQ	Evaluation of COPCs status for naphthalene and pentachlorophenol
		Compound	Naphthalene			Pentachlorophenol			
		CAS #	91-20-3			87-86-5			
		MTCA Method A (µg/kg)	5,000			Researched-No data			
		Min. Risk-based Criterion (µg/kg)	3,600			890			
B29, Surface soil	B29:SS-1:191	2009/04/03	8	U		80	U		Naphthalene - No. All detections and practical quantitaion limits
	B29:SS-10:200	2009/04/03	9.2	U		92	U		are less than the SL.
	B29:SS-2:192	2009/04/03	3.7	J		80	U		
	B29:SS-3:193	2009/04/03	2.9	J		81	U		Pentachlorophenol - No. Not detected, PQL < SL.
	B29:SS-4:194	2009/04/03	7.7	U		77	U		
	B29:SS-5:195	2009/04/03	7.2	U		72	U		
	B29:SS-6:196	2009/04/03	8.1	U		81	U	UJ	
	B29:SS-7:197	2009/04/03	6.6	U		66	U		
	B29:SS-8:198	2009/04/03	6.7	U		67	U		
	B29:SS-9:199	2009/04/03	9.3	U		93	U		
B40, Subsurface soil	B40:RS-2:107:431	2010/12/07	10	U		100	U		Naphthalene - No. Not detected, PQL < SL
9,17,107 ft bgs	B40:RS-2:17:430	2010/12/03	5.5	U		55	U		Pentachlorophenol - No. Not detected, PQL < SL.
	B40:RS-2:9:429	2010/12/03	6.1	U		61	U		
B41, Subsurface soil	B41:RS-1:10:426	2010/11/29	10	U	UJ	100	U	UJ	Naphthalene - No. Not detected, PQL < SL
10,22,109 ft bgs	B41:RS-1:109:428	2010/12/01	10	U		100	U		Pentachlorophenol - No. Not detected, PQL < SL.
	B41:RS-1:22:427	2010/11/29	100	U	UJ	1000	U	UJ	
B119 and B119A	B119:SS-1:109	2009/03/29	9.8	U		98	U		Naphthalene - No. All detections and practical quantitaion limits
Surface Soil	B119:SS-2:110	2009/03/29	2.8	J		99	U		are less than the SL.
	B119:SS-3:111	2009/03/29	4.1	J		100	U		Pentachlorophenol -No. Not detected, PQL < SL.
	B119:SS-4:112	2009/03/29	22			100	U		
	B119A:SS-1:104	2009/03/29	4.9	J		90	U		
	B119A:SS-2:105	2009/03/29	5.9	J		130	U	UJ	
	B119A:SS-3:106	2009/03/29	9.6			91	U		
	B119A:SS-4:107*	2009/03/29	7	J		100	U		
	B119A:SS-5:108*	2009/03/29	6.8	J		120	U		
E120, Subsurface	E120:RS-4:100:442	2010/12/17	6.2	U		62	U		Naphthalene - No. Not detected, PQL < SL
Soil	E120:RS-4:18:440	2010/12/15	3.4	J		69	U		Pentachlorophenol - No. Not detected, PQL < SL.
8, 18, 100 ft bgs	E120:RS-4:18:441	2010/12/15	5.6	U		56	U		
	E120:RS-4:8:439	2010/12/15	5.6	U		56	U		
Suspected Liquid	LD:SB-1:10:359	2009/11/11	9.7	U	UJ	97	U		Naphthalene - No. Not detected, PQL < SL
Disposal Area	LD:SB-1:15:360	2009/11/11	9.8	U	UJ	98	U		Pentachlorophenol - No. Not detected, PQL < SL.
Subsurface soil	LD:SB-1:20:361	2009/11/11	9.7	U	UJ	97	U		
5,10,15,20,25 ft bgs	LD:SB-1:25:362	2009/11/11	9.8	U	UJ	98	U		
	LD:SB-1:5:357	2009/11/11	9.8	U	UJ	98	U		
	LD:SB-1:5:358	2009/11/11	10	U	UJ	100	U		
	LD:SB-2:10:364	2009/11/11	9.9	U	UJ	99	U		
	LD:SB-2:15:365	2009/11/11	9.8	U	UJ	98	U		
	LD:SB-2:20:366	2009/11/11	10	U	UJ	100	U		
	LD:SB-2:25:367	2009/11/11	9.9	U		99	U		
	LD:SB-2:5:363	2009/11/11	9.8	U		98	U		
	LD:SB-3:10:370	2009/11/11	9.8	U		98	U		
	LD:SB-3:15:371	2009/11/11	10	U		100	U		
	LD:SB-3:20:372	2009/11/11	9.8	U		98	U		
	LD:SB-3:25:373	2009/11/11	10	U		100	U		
	LD:SB-3:5:368	2009/11/11	13	U	UJ	130	U		
	LD:SB-3:5:369	2009/11/11	9.7	U		97	U		
	LD:SB-4:10:375	2009/11/11	10	U		100	U		
	LD:SB-4:15:376	2009/11/11	9.8	U		98	U		
	LD:SB-4:20:377	2009/11/11	9.9	U		99	U		
	LD:SB-4:25:378	2009/11/11	9.9	U		99	U		
	LD:SB-4:5:374	2009/11/11	9.9	U		99	U		
	LD:SB-5:10:380	2009/11/11	10	U		100	U		
	LD:SB-5:15:381	2009/11/11	10	U		100	U		
	LD:SB-5:20:382	2009/11/11	10	U		100	U		
	LD:SB-5:25:383	2009/11/11	9.9	U		99	U		
	LD:SB-5:5:379	2009/11/11	9.8	U		98	U		
	LD:SB-6:10:385	2009/11/11	10	U		100	U		
	LD:SB-6:15:386	2009/11/11	9.9	U		99	U		
	LD:SB-6:20:387	2009/11/11	9.9	U		99	U		
	LD:SB-6:25:388	2009/11/11	10	U		100	U		
	LD:SB-6:5:384	2009/11/11	10	U	UJ	100	U		
Suspected Tetraethyl	TL:SB-1:10:336	2009/11/11	10	U		100	U		Naphthalene - No. Not detected, PQL < SL
Lead Disposal Area	TL:SB-1:10:337	2009/11/11	10	U		100	U		Pentachlorophenol - No. Not detected, PQL < SL.
(Sludge Disposal Area)	TL:SB-1:15:338	2009/11/11	9.9	U		99	U		
5,10,15,20,25 ft bgs	TL:SB-1:20:339	2009/11/11	9.9	U		99	U		
	TL:SB-1:25:340	2009/11/11	10	U		100	U		
	TL:SB-1:5:335	2009/11/11	10	U		100	U		
	TL:SB-2:10:342	2009/11/11	10	U		100	U		
	TL:SB-2:15:343	2009/11/11	10	U		100	U		
	TL:SB-2:20:344	2009/11/11	10	U		100	U		
	TL:SB-2:25:345	2009/11/11	10	U		100	U		
	TL:SB-2:5:341	2009/11/11	10	U		100	U		
	TL:SB-3:10:348	2009/11/11	9.9	U		99	U		
	TL:SB-3:15:349	2009/11/11	9.9	U		99	U		
	TL:SB-3:20:350	2009/11/11	10	U	UJ	100	U		
	TL:SB-3:25:351	2009/11/11	9.8	U	UJ	98	U		
	TL:SB-3:5:346	2009/11/11	10	U	U	100	U		
	TL:SB-3:5:347	2009/11/11	10	U		100	U		
	TL:SB-4:10:353	2009/11/11	10	U		100	U		
	TL:SB-4:15:354	2009/11/11	9.7	U	UJ	97	U		
	TL:SB-4:20:355	2009/11/11	10	U	UJ	100	U		
	TL:SB-4:25:356	2009/11/11	10	U	UJ	100	U		
	TL:SB-4:5:352	2009/11/11				110	U		

*Field Duplicates

Value Samples with concentrations > SL

Value Nondetect samples where quantitation limit > SL

Q=Laboratory Qualifiers, VQ=Validation Qualifiers, U=not detected; J=estimated; D=Diluted

bgs=below ground surface, COPC=chemical of potential concern, DL=detection limit, ft=foot/feet, PQL=practical quantitation limit, SL=screening level, µg/kg=micrograms per kilogram

Table 4-11. Toxicity equivalency factors for carcinogenic polynuclear aromatic hydrocarbons from USEPA (1993a) and MTCA (WDEC 2007)

Analyte	CAS #	Toxicity Equivalency Factor (unitless) USEPA (1993)
Benzo(a)pyrene	50-32-08	1
Benzo(a)anthracene	56-55-3	0.1
Benzo(b)fluoranthene	205-99-2	0.1
Benzo(k)fluoranthene	207-08-9	0.01
Chrysene	218-01-9	0.001
Dibenz(a,h)anthracene	53-70-3	1
Indeno(1,2,3-cd)pyrene	193-39-5	0.1

Table 4-12. Toxicity equivalent concentrations of benzo(a)pyrene in soil

			BaP-Eq calculated using USEPA TEF and Kaplan Meier [a]	
		MTCA Method A (µg/kg)	100	
		Min. of Risk-based Criteria (µg/kg)	15	
Building/Soil Type	**Sample ID**	**Sampling Date**	(µg/kg)	**COPC status and rationale (using BaP-Eq based USEPA TEF)**
B4, Surface soil	B4:SS-1:79	3/29/2009	**137.9**	Yes. BaP-Eq > SL
	B4:SS-10:88	3/29/2009	**89.0**	
	B4:SS-11:89	3/29/2009	4.6	
	B4:SS-12:90	3/29/2009	**132.5**	
	B4:SS-12B:602	11/14/2009	**27.8**	
	B4:SS-13:91	3/29/2009	7.7	
	B4:SS-14:92	3/29/2009	9.9	
	B4:SS-15:93	3/29/2009	9.2	
	B4:SS-16:94	3/29/2009	**151.0**	
	B4:SS-16B:601	11/14/2009	**80.0**	
	B4:SS-17:603	11/14/2009	9.5	
	B4:SS-18:604	11/14/2009	**51.0**	
	B4:SS-19:605	11/14/2009	9.0	
	B4:SS-1B:600	11/14/2009	**38.7**	
	B4:SS-2:80*	3/29/2009	**81.8**	
	B4:SS-3:81*	3/29/2009	**111.0**	
	B4:SS-4:82	3/29/2009	**114.4**	
	B4:SS-5:83	3/29/2009	13.7	
	B4:SS-6:84	3/29/2009	4.1	
	B4:SS-7:85	3/29/2009	**35.3**	
	B4:SS-8:86	3/29/2009	**22.8**	
	B4:SS-9:87	3/29/2009	**22.7**	
B5, Surface soil	B5:SS-1:168	4/2/2009	**52.9**	Yes. BaP-Eq > SL
	B5:SS-10:177 (asph)	4/2/2009	**757.0**	
	B5:SS-10B:675	11/13/2009	**17.9**	
	B5:SS-11:178	4/2/2009	**247.9**	
	B5:SS-12:179 (asph)	4/2/2009	**83.3**	
	B5:SS-12B:676*	11/13/2009	6.7	
	B5:SS-12B:677*	11/13/2009	14.7	
	B5:SS-13:678	11/13/2009	**93.7**	
	B5:SS-14:679	11/13/2009	**135.3**	
	B5:SS-2:169	4/2/2009	**208.2**	
	B5:SS-3:170 (asph)	4/2/2009	**1800.8**	
	B5:SS-4:171 (asph)	4/2/2009	**2075.4**	
	B5:SS-5:172 (asph)	4/2/2009	**5292.5**	
	B5:SS-5B:670	11/13/2009	**80.9**	
	B5:SS-6:173 (asph)	4/2/2009	**545.9**	
	B5:SS-6B:671	11/13/2009	7.3	
	B5:SS-7:174 (asph)	4/2/2009	**757.2**	
	B5:SS-7B:672	11/13/2009	**38.7**	
	B5:SS-8:175 (asph)	4/2/2009	**1183.0**	
	B5:SS-8B:673	11/13/2009	**58.7**	
	B5:SS-9:176 (asph)	4/2/2009	**1104.5**	
	B5:SS-9B:674	11/13/2009	**48.2**	

Table 4-12. Toxicity equivalent concentrations of benzo(a)pyrene in soil

			BaP-Eq calculated using USEPA TEF and Kaplan Meier [a]	
		MTCA Method A (µg/kg)	100	
		Min. of Risk-based Criteria (µg/kg)	15	
Building/Soil Type	**Sample ID**	**Sampling Date**	(µg/kg)	**COPC status and rationale (using BaP-Eq based USEPA TEF)**
B7, Surface soil	B7:SS-1:56	3/28/2009	**16.4**	Yes. BaP-Eq > SL
	B7:SS-2:57	3/28/2009	14.3	
	B7:SS-3:58	3/28/2009	3.9	
	B7:SS-4:59	3/28/2009	9.9	
B9, Surface soil	B9:SS-1:95	3/29/2009	**23.6**	Yes. BaP-Eq > SL
	B9:SS-2:96	3/29/2009	13.2	
	B9:SS-3:97	3/29/2009	10.2	
	B9:SS-4:98	3/29/2009	4.5	
	B9:SS-5-99	3/29/2009	**54.4**	
	B9:SS-6:100	3/29/2009	**69.1**	
	B9:SS-7:101	3/29/2009	9.7	
	B9:SS-8:102	3/29/2009	3.8	
	B9:SS-9:103	3/29/2009	**17.9**	
B10, Surface Soil	B10:SS-1:114	3/30/2009	**154.81**	Yes, BaP-Eq > SL
	B10:SS-10:123	3/30/2009	7.6	at multiple locations
	B10:SS-11:124	3/30/2009	**30.1**	
	B10:SS-12:125	3/30/2009	**24.8**	
	B10:SS-13:126*	3/30/2009	**30.5**	
	B10:SS-14:127*	3/30/2009	**33.5**	
	B10:SS-2:115	3/30/2009	**32.8**	
	B10:SS-3:116	3/30/2009	3.8	
	B10:SS-4:117	3/30/2009	6.1	
	B10:SS-5:118	3/30/2009	1.9	
	B10:SS-6:119	3/30/2009	**52.0**	
	B10:SS-7:120	3/30/2009	**17.8**	
	B10:SS-8:121	3/30/2009	5.0	
	B10:SS-9:122	3/30/2009	4.3	
B11, Surface soil	B11:SS-1:51*	3/28/2009	14.7	Yes, BaP-Eq > SL
	B11:SS-2:52*	3/28/2009	8.5	at multiple locations
	B11:SS-3:53	3/28/2009	**95.3**	
	B11:SS-4:54	3/28/2009	**18.5**	
	B11:SS-5:55	3/28/2009	**27.9**	
B12, Surface soil	B12:SS-1:60	3/28/2009	2.9	Yes. BaP-Eq> SL
	B12:SS-10:69	3/28/2009	5.1	
	B12:SS-11:70	3/28/2009	2.6	
	B12:SS-12:71	3/29/2009	**48.0**	
	B12:SS-2:61	3/28/2009	3.3	
	B12:SS-3:62	3/28/2009	3.7	
	B12:SS-4:63	3/28/2009	7.2	
	B12:SS-5:64	3/28/2009	**15.7**	
	B12:SS-6:65	3/28/2009	1.8	
	B12:SS-7:66	3/28/2009	3.7	
	B12:SS-8:67	3/28/2009	4.7	
	B12:SS-9:68	3/28/2009	2.8	

Table 4-12. Toxicity equivalent concentrations of benzo(a)pyrene in soil

			BaP-Eq calculated using USEPA TEF and Kaplan Meier [a]	
		MTCA Method A (µg/kg)	100	
		Min. of Risk-based Criteria (µg/kg)	15	
Building/Soil Type	**Sample ID**	**Sampling Date**	(µg/kg)	**COPC status and rationale (using BaP-Eq based USEPA TEF)**
B17, Surface soil	B17:SS-1:181	4/3/2009	**23.7**	Yes. BaP-Eq > SL
	B17:SS-10:190 (asph)	4/3/2009	**1406.4**	
	B17:SS-10B:680	11/13/2009	**23.0**	
	B17:SS-11:682	11/13/2009	3.2	
	B17:SS-12:683	11/13/2009	10.1	
	B17:SS-13:684	11/13/2009	4.9	
	B17:SS-14:685*	11/13/2009	5.4	
	B17:SS-14:686*	11/13/2009	5.1	
	B17:SS-2:182	4/3/2009	**41.3**	
	B17:SS-3:183 (asph)	4/3/2009	**248.6**	
	B17:SS-3B:681	11/13/2009	**27.3**	
	B17:SS-4:184	4/3/2009	**98.2**	
	B17:SS-5:185	4/3/2009	**37.5**	
	B17:SS-6:186	4/3/2009	**18.9**	
	B17:SS-7:187	4/3/2009	**83.1**	
	B17:SS-8:188	4/3/2009	**36.3**	
	B17:SS-9:189	4/3/2009	5.1	
B18 and B19 Surface soil	B18:SS-1:75*	3/29/2009	3.2	No. No SL exceedances.
	B18:SS-2:76*	3/29/2009	4.1	
	B18:SS-3:77	3/29/2009	3.8	
	B18:SS-4:78	3/29/2009	4.1	
	B19:SS-1:72	3/29/2009	4.0	
	B19:SS-2:73	3/29/2009	3.5	
	B19:SS-3:74	3/29/2009	4.2	
B20, Surface soil	B20:SS-1:129	3/30/2009	**49.6**	Yes. BaP-Eq > SL
	B20:SS-2:130	3/30/2009	**63.8**	
	B20:SS-3:131	3/30/2009	**73.4**	
	B20:SS-4:132	3/30/2009	**106.3**	
B29, Surface soil	B29:SS-1:191	4/3/2009	2.4	No. BaP-Eq-EPA > SL at at isolated location. Next highest value is an order of magnitude lower.
	B29:SS-10:200	4/3/2009	3.1	
	B29:SS-11:689	11/13/2009	11.2	
	B29:SS-2:192	4/3/2009	2.9	
	B29:SS-3:193	4/3/2009	3.2	
	B29:SS-4:194	4/3/2009	6.3	
	B29:SS-5:195	4/3/2009	**147.2**	
	B29:SS-5B:687	11/13/2009	4.0	
	B29:SS-5B:688	11/13/2009	6.1	
	B29:SS-6:196	4/3/2009	3.0	
	B29:SS-7:197	4/3/2009	2.6	
	B29:SS-8:198	4/3/2009	3.5	
	B29:SS-9:199	4/3/2009	3.9	

Table 4-12. Toxicity equivalent concentrations of benzo(a)pyrene in soil

			BaP-Eq calculated using USEPA TEF and Kaplan Meier [a]	
		MTCA Method A (µg/kg)	100	
		Min. of Risk-based Criteria (µg/kg)	15	
Building/Soil Type	**Sample ID**	**Sampling Date**	(µg/kg)	**COPC status and rationale (using BaP-Eq based USEPA TEF)**
B41, Surface Soil	B41:SS-1:134	3/31/2009	**27.2**	Yes. BaP-Eq-EPA > SL
	B41:SS-10:143	3/31/2009	7.5	
	B41:SS-11:144	3/31/2009	10.3	
	B41:SS-12:145	3/31/2009	11.8	
	B41:SS-13:146	3/31/2009	**61.6**	
	B41:SS-14:147*	3/31/2009	**24.1**	
	B41:SS-15:148*	3/31/2009	11.9	
	B41:SS-2:135	3/31/2009	6.2	
	B41:SS-3:136	3/31/2009	**100.3**	
	B41:SS-4:137	3/31/2009	**142.8**	
	B41:SS-5:138	3/31/2009	**36.6**	
	B41:SS-6:139	3/31/2009	**74.0**	
	B41:SS-7:140	3/31/2009	9.3	
	B41:SS-8:141	3/31/2009	**16.9**	
	B41:SS-9:142	3/31/2009	**38.0**	
B49, Surface soil	B49:SS-1:150	3/31/2009	**45.0**	Yes. BaP-Eq > SL
	B49:SS-2:151	3/31/2009	**24.0**	
	B49:SS-3:152	3/31/2009	7.7	
	B49:SS-4:153	3/31/2009	6.9	
B65, Surface soil	B65:SS-1:154	3/31/2009	7.2	No. No SL exceedances.
	B65:SS-2:155	3/31/2009	7.2	
	B65:SS-3:156	3/31/2009	5.6	
	B65:SS-4:157	3/31/2009	6.5	
B101 and B102 Surface Soil	B101:SS-1:158*	4/1/2009	11.7	Yes, BaP-Eq > SL at multiple locations
	B101:SS-2:159*	4/1/2009	9.3	
	B101:SS-3:160	4/1/2009	**32.6**	
	B101:SS-4:161	4/1/2009	**84.3**	
	B101:SS-5:162	4/1/2009	14.9	
	B102:SS-1:163	4/1/2009	1.0	
	B102:SS-2:164	4/1/2009	8.4	
	B102:SS-3:165	4/1/2009	**15.2**	
	B102:SS-4:166	4/1/2009	8.4	
B119 and B119A Surface soil	B119:SS-1:109	3/29/2009	3.4	No. BaP-Eq > SL at at isolated location. Next highest value is an order of magnitude lower.
	B119:SS-2:110	3/29/2009	3.2	
	B119:SS-3:111	3/29/2009	2.9	
	B119:SS-4:112	3/29/2009	**88.8**	
	B119A:SS-1:104	3/29/2009	4.2	
	B119A:SS-2:105	3/29/2009	3.6	
	B119A:SS-3:106	3/29/2009	7.7	
	B119A:SS-4:107*	3/29/2009	5.1	
	B119A:SS-5:108*	3/29/2009	4.6	

Table 4-12. Toxicity equivalent concentrations of benzo(a)pyrene in soil

			BaP-Eq calculated using USEPA TEF and Kaplan Meier [a]	
		MTCA Method A (µg/kg)	100	
		Min. of Risk-based Criteria (µg/kg)	15	
Building/Soil Type	**Sample ID**	**Sampling Date**	(µg/kg)	**COPC status and rationale (using BaP-Eq based USEPA TEF)**
Suspected Liquid Disposal Area Subsurface soil 5,10,15,20,25 ft bgs	LD:SB-1:10:359	11/11/2009	Not calculated [b]	No. PAHs were not detected in majority of samples.
	LD:SB-1:15:360	11/11/2009		
	LD:SB-1:20:361	11/11/2009		
	LD:SB-1:25:362	11/11/2009		
	LD:SB-1:5:357	11/11/2009		
	LD:SB-1:5:358	11/11/2009		
	LD:SB-2:10:364	11/11/2009		
	LD:SB-2:15:365	11/11/2009		
	LD:SB-2:20:366	11/11/2009		
	LD:SB-2:25:367	11/11/2009		
	LD:SB-2:5:363	11/11/2009		
	LD:SB-3:10:370	11/11/2009		
	LD:SB-3:15:371	11/11/2009		
	LD:SB-3:20:372	11/11/2009		
	LD:SB-3:25:373	11/11/2009		
	LD:SB-3:5:368	11/11/2009		
	LD:SB-3:5:369	11/11/2009		
	LD:SB-4:10:375	11/11/2009		
	LD:SB-4:15:376	11/11/2009		
	LD:SB-4:20:377	11/11/2009		
	LD:SB-4:25:378	11/11/2009		
	LD:SB-4:5:374	11/11/2009		
	LD:SB-5:10:380	11/11/2009		
	LD:SB-5:15:381	11/11/2009		
	LD:SB-5:20:382	11/11/2009		
	LD:SB-5:25:383	11/11/2009		
	LD:SB-5:5:379	11/11/2009		
	LD:SB-6:10:385	11/11/2009		
	LD:SB-6:15:386	11/11/2009		
	LD:SB-6:20:387	11/11/2009		
	LD:SB-6:25:388	11/11/2009		
	LD:SB-6:5:384	11/11/2009		

Table 4-12. Toxicity equivalent concentrations of benzo(a)pyrene in soil

			BaP-Eq calculated using USEPA TEF and Kaplan Meier [a]	
		MTCA Method A (µg/kg)	100	
		Min. of Risk-based Criteria (µg/kg)	15	
Building/Soil Type	**Sample ID**	**Sampling Date**	(µg/kg)	**COPC status and rationale (using BaP-Eq based USEPA TEF)**
Suspected Tetraethyl Lead Disposal Area (Sludge Disposal Area) 5,10,15,20,25 ft bgs	TL:SB-1:10:336	11/11/2009	Not calculated [b]	No. PAHs were not detected in majority of samples.
	TL:SB-1:10:337	11/11/2009		
	TL:SB-1:15:338	11/11/2009		
	TL:SB-1:20:339	11/11/2009		
	TL:SB-1:25:340	11/11/2009		
	TL:SB-1:5:335	11/11/2009		
	TL:SB-2:10:342	11/11/2009		
	TL:SB-2:15:343	11/11/2009		
	TL:SB-2:20:344	11/11/2009		
	TL:SB-2:25:345	11/11/2009		
	TL:SB-2:5:341	11/11/2009		
	TL:SB-3:10:348	11/11/2009		
	TL:SB-3:15:349	11/11/2009		
	TL:SB-3:20:350	11/11/2009		
	TL:SB-3:25:351	11/11/2009		
	TL:SB-3:5:346	11/11/2009		
	TL:SB-3:5:347	11/11/2009		
	TL:SB-4:10:353	11/11/2009		
	TL:SB-4:15:354	11/11/2009		
	TL:SB-4:20:355	11/11/2009		
	TL:SB-4:25:356	11/11/2009		
	TL:SB-4:5:352	11/11/2009		

*Field duplicates

(asph) - Sample results impacted by deteriorated asphalt

Value	BaP-Eq calculated using MTCA TEF exceeded MTCA Method A criteria (100 µg/kg)
Value	BaP-Eq calculated using USEPA TEF exceeded the risk-based screening level (15 µg/kg)

BaP-Eq=toxicity equivalent concentration of benzo(a)pyrene, bgs=below ground surface, ft=foot/feet, MTCA=Model Toxics Control Act, PAHs=polynuclear aromatic hydrocarbons, SL=screening level, TEF=toxicity equivalent factor, USEPA=U.S. Environmental Protection Agency

[a] Sum of (concentration times the TEF) for the following PAHs: benzo(a)pyrene, benz(a)anthracene, benz(b)fluoranthene, benzo(k)fluoranthene, chrysene, dibenz(a,h)anthracene, and indeno(1,2,3-cd)pyrene. The reported value for U-qualified data,

[b] BaP-Eq was not calculated because a majority of the PAHs were not detected in the soil samples.

Table 4-13. Benzo(a)pyrene in co-located soil samples from 3 to 6 inches and 6 to 9 inches bgs

		Near-surface soil (3-6 inches bgs)			Near-surface soil (6-9 inches bgs)		
		Benzo(a)pyrene 50-32-8			Benzo(a)pyrene 50-32-8		
Area of Potential Concern	**Sample Location ID**	**Sample ID**	**(µg/kg)**	**Q**	**Sample ID**	**(µg/kg)**	**Q**
B4	B4:SS-1	B4:SS-1:79	71	D	B4:SS-1B:600	3	U
	B4:SS-12	B4:SS-12:90	71	D	B4:SS-12B:602	12	
	B4:SS-16	B4:SS-16:94	93	D	B4:SS-16B:601	44	
B5	B5:SS-10	B5:SS-10:177	530	D	B5:SS-10B:675	11	
	B5:SS-12	B5:SS-12:179	35	D	B5:SS-12B:677	7.1	
	B5:SS-5	B5:SS-5:172	3700	D	B5:SS-5B:670	35	
	B5:SS-6	B5:SS-6:173	360	D	B5:SS-6B:671	3.9	
	B5:SS-7	B5:SS-7:174	530	D	B5:SS-7B:672	25	
	B5:SS-8	B5:SS-8:175	840	D	B5:SS-8B:673	35	
	B5:SS-9	B5:SS-9:176	770	D	B5:SS-9B:674	25	
B29	B29:SS-5	B29:SS-5:195	110		B29:SS-5B:687	1.6	J

bgs=below ground surface, D: Diluted sample, J: estimated, Q: Laboratory qualifier, U: Not detected

Table 4-14a. Site-wide summary of volatile organic compounds in groundwater

Analyte	CAS #	Screening Levels				Analytical Limits		Wells where Detected	Max. Detected Concentration (µg/L)	COPC and Rationale
		MTCA Method A (µg/L)	Min of Risk-based Screening Levels (µg/L)	Basis of Risk-Based Screening Level	Maximum Contaminant Level (µg/L)	Detection Limit (µg/L)	Practical Quantitation Limit (µg/L)			
1,1,1,2-Tetrachloroethane	630-20-6	Researched-No Data	0.5	c	--	0.11	0.5	0	--	No Not detected
1,1,1-Trichloroethane (TCA)	71-55-6	200	7,500	n	200	0.08	0.5	0	--	No Not detected
1,1,2,2-Tetrachloroethane	79-34-5	Researched-No Data	0.066	c	--	0.16	0.5	0	--	No Not detected
1,1,2-Trichloroethane	79-00-5	Researched-No Data	0.24	c	5	0.14	0.5	0	--	No Not detected
1,1-Dichloroethane	75-34-3	Researched-No Data	2.4	c	--	0.08	0.5	0	--	No Not detected
1,1-Dichloroethene	75-35-4	Researched-No Data	260	n	7	0.10	0.5	0	--	No Not detected
1,1-Dichloropropene	563-58-6	Not in CLARC	Not available	--	--	0.09	0.5	0	--	No Not detected
1,2,3-Trichlorobenzene	87-61-6	Not in CLARC	5.2	n	--	0.11	2	0	--	No Not detected
1,2,3-Trichloropropane	96-18-4	Researched-No Data	0.00065	c	--	0.20	0.5	0	--	No Not detected
1,2,4-Trichlorobenzene	120-82-1	Researched-No Data	0.99	c	70	0.13	2	0	--	No Not detected
1,2,4-Trimethylbenzene	95-63-6	Not Researched	15	n	--	0.07	2	0	--	No Not detected
1,2-Dibromo-3-chloropropane	96-12-8	Researched-No Data	0.00032	c	0.2	0.22	2	0	--	No Not detected
1,2-Dichlorobenzene	95-50-1	Researched-No Data	280	n	600	0.12	0.5	0	--	No Not detected
1,2-Dichloroethane (EDC)	107-06-2	5	0.15	c	5	0.08	0.5	0	--	No Not detected
1,2-Dichloropropane	78-87-5	Researched-No Data	0.38	c	5	0.09	0.5	0	--	No Not detected
1,3,5-Trimethylbenzene	108-67-8	Not Researched	80	n	--	0.09	2	0	--	No Not detected
1,3-Dichlorobenzene	541-73-1	Not Researched	Not available	--	--	0.10	0.5	0	--	No Not detected
1,3-Dichloropropane	142-28-9	Not in CLARC	290	n	--	0.14	0.5	0	--	No Not detected
1,4-Dichlorobenzene	106-46-7	Researched-No Data	0.42	c	75	0.12	0.5	0	--	No Not detected
1,4-Dioxane	123-91-1	Researched-No Data	0.44	c	--	13.00	100	0	--	No Not detected
2,2-Dichloropropane	594-20-7	Not in CLARC	Not available	--	--	0.06	0.5	0	--	No Not detected
2-Butanone (MEK)	78-93-3	Researched-No Data	4,800	n	--	3.80	20	0	--	No Not detected
2-Chlorotoluene	95-49-8	Researched-No Data	160	n	--	0.10	2	0	--	No Not detected
4-Chlorotoluene	106-43-4	Not in CLARC	190	n	--	0.13	2	0	--	No Not detected
4-Isopropyltoluene	99-87-6	Not in CLARC	Not available	--	--	0.05	2	0	--	No Not detected
4-Methyl-2-pentanone (MIBK)	108-10-1	Researched-No Data	640	n	--	3.00	20	0	--	No Not detected
Acetone	67-64-1	Researched-No Data	7,200	n	--	3.30	20	MW-1, MW-2, MW-3, MW-14, MW-11	7.3 (MW-2)	No Max. < SL
Acrylonitrile	107-13-1	Researched-No Data	0.045	c	--	0.31	50	0	--	No Not detected
Benzene	71-43-2	5	0.39	c	5	0.05	0.5	0	--	No Not detected
Bromobenzene	108-86-1	Not in CLARC	54	n	--	0.12	2	0	--	No Not detected
Bromochloromethane	74-97-5	Not in CLARC	83	n	--	0.16	0.5	0	--	No Not detected
Bromodichloromethane	75-27-4	Researched-No Data	0.12	c	80	0.09	0.5	0	--	No Not detected
Bromoform	75-25-2	Researched-No Data	5.5	c	80	0.16	0.5	0	--	No Not detected
Bromomethane	74-83-9	Researched-No Data	7	n	--	0.09	0.5	0	--	No Not detected
Carbon Disulfide	75-15-0	Researched-No Data	720	n	--	0.10	0.5	P-17	0.07 (P-17)	No Max. < SL
Carbon Tetrachloride	56-23-5	Researched-No Data	0.39	c	5	0.10	0.5	NNW, NI, MW-3, MW-2, MW-17, MW-16, MW-12, MW-1	6.8 (NI)	Yes Max. > SL
Chlorobenzene	108-90-7	Researched-No Data	72	n	100	0.11	0.5	0	--	No Not detected
Chloroethane	75-00-3	Researched-No Data	21,000	n	--	0.16	0.5	0	--	No Not detected
Chloroform	67-66-3	Researched-No Data	0.19	c	80	0.07	0.5	MW-9, MW-3, NI	0.1 (MW-3)	No Max. < SL
Chloromethane	74-87-3	Researched-No Data	190	n	--	0.07	0.5	MW-6, MW-2, MW-3, MW-14, MW-16, MW-17, B-21	0.66 (MW-14)	No Max. < SL
cis-1,2-Dichloroethene	156-59-2	Researched-No Data	16	n	70	0.07	0.5	0	--	No Not detected
Dibromochloromethane	124-48-1	Researched-No Data	0.15	c	80	0.14	0.5	0	--	No Not detected
Dibromomethane	74-95-3	Researched-No Data	7.9	n	--	0.15	0.5	0	--	No Not detected
Ethylbenzene	100-41-4	700	1.3	c	700	0.05	0.5	0	--	No Not detected
Hexachlorobutadiene	87-68-3	Researched-No Data	0.26	c	--	0.19	2	0	--	No Not detected
Isopropylbenzene	98-82-8	Researched-No Data	390	n	--	0.09	2	0	--	No Not detected
m,p-Xylenes	1330-20-7	1000	190	n	10,000	0.09	0.5	0	--	No Not detected

Table 4-14a. Site-wide summary of volatile organic compounds in groundwater

Analyte	CAS #	Screening Levels				Analytical Limits		Wells where Detected	Max. Detected Concentration (µg/L)	COPC and Rationale
		MTCA Method A (µg/L)	Min of Risk-based Screening Levels (µg/L)	Basis of Risk-Based Screening Level	Maximum Contaminant Level (µg/L)	Detection Limit (µg/L)	Practical Quantitation Limit (µg/L)			
Methyl tert-Butyl Ether	1634-04-4	20	12	c	--	0.11	0.5	0	--	No Not detected
Methylene Chloride	75-09-2	5	5.8	c	5	0.23	2	0	--	No Not detected
Naphthalene	91-20-3	160	0.14	c	--	0.10	2	0	--	No Not detected
n-Butylbenzene	104-51-8	Not Researched	780	n	--	0.42	2	0	--	No Not detected
n-Propylbenzene	103-65-1	Not Researched	530	n	--	0.53	2	0	--	No Not detected
o-Xylene	95-47-6	Researched-No Data	190	n	--	0.07	0.5	0	--	No Not detected
sec-Butylbenzene	135-98-8	Not Researched	Not in Tables	--	--	0.06	2	0	--	No Not detected
Styrene	100-42-5	Researched-No Data	1,100	n	100	0.12	0.5	0	--	No Not detected
tert-Butylbenzene	98-06-6	Not Researched	Not in Tables	--	--	0.05	2	0	--	No Not detected
Tetrachloroethene (PCE)	127-18-4	5	9.7	c	5	0.10	0.5	MW-16	0.21 (MW-16)	No Max. < SL
Toluene	108-88-3	1000	640	n	1000	0.05	0.5	B-21, MW-15, MW-16	0.16 (MW-15)	No Max. < SL
trans-1,2-Dichloroethene	156-60-5	Researched-No Data	86	n	100	0.09	0.5	0	--	No Not detected
trans-1,3-Dichloropropene	10061-02-6	Not in CLARC	Not in Tables	--	--	0.07	0.5	0	--	No Not detected
trans-1,4-Dichloro-2-butene	110-57-6	Not in CLARC	0.0012	c	--	0.35	10	0	--	No Not detected
Trichloroethene (TCE)	79-01-6	5	0.44	c	5	0.10	0.5	B-21, MW-3	0.29 (MW-3)	No Max. < SL
Trichlorofluoromethane	75-69-4	Researched-No Data	1,100	n	--	0.12	0.5	0	--	No Not detected
Vinyl Chloride	75-01-4	0.2	0.015	c	2	0.01	0.02	NI	0.28 (NI*)	No *See note

Maximum detection exceeded screening level

c=cancer, CLARC=Cleanup Levels and Risk Calculations, n=noncancer, SL=screening level

*Vinyl chloride was detected in a tap water sample from the NI well that was collected after a carbon filtration system. Since a sample collected before the filter did not contain vinyl chloride, the detection of 0.28 ug/L was deemed to be introduced by the filtration system or the sampling and analysis process (Shannon and Wilson 2012).

Table 4-14b. Site-wide summary of semi-volatile organic compounds in groundwater

Analyte	CAS #	Screening Levels				Analytical Limits		Wells where Detected	Max. Detected Concentration (µg/L)	COPC and Rationale
		MTCA Method A (µg/L)	Minimum of Risk-based Screening Level (µg/L)	Basis of Risk-based Screening Level	Maximum Contaminant Level (µg/L)	Analytical Detection Limit (µg/L)	Practical Quantitation Limit (µg/L)			
1,2,4-Trichlorobenzene	120-82-1	Researched-No Data	0.99	c	70	0.02	0.21	0	--	No Not detected
1-Methylnaphthalene	90-12-0	Not Researched	0.97	c	--	0.21	0.21	0	--	No Not detected
2,4,5-Trichlorophenol	95-95-4	Researched-No Data	800	n	--	0.03	0.53	0	--	No Not detected
2,4,6-Trichlorophenol	88-06-2	Researched-No Data	3.5	c	--	0.06	0.53	0	--	No Not detected
2,4-Dichlorophenol	120-83-2	Researched-No Data	24	n	--	0.05	0.53	0	--	No Not detected
2,4-Dimethylphenol	105-67-9	Researched-No Data	160	n	--	2.30	6.00	0	--	No Not detected
2,4-Dinitrophenol	51-28-5	Researched-No Data	30	n	--	0.18	4.20	0	--	No Not detected
2-Chloronaphthalene	91-58-7	Researched-No Data	550	n	--	0.04	0.21	0	--	No Not detected
2-Chlorophenol	95-57-8	Researched-No Data	40	n	--	0.06	0.53	0	--	No Not detected
2-Methyl-4,6-dinitrophenol	534-52-1	Not in CLARC	1.2	n	--	0.03	2.10	0	--	No Not detected
2-Methylphenol	95-48-7	Researched-No Data	400	n	--	0.12	0.53	0	--	No Not detected
2-Nitroaniline	88-74-4	Researched-No Data	150	n	--	0.03	0.21	0	--	No Not detected
2-Nitrophenol	88-75-5	Not in CLARC	Not available	--	--	0.07	0.53	0	--	No Not detected
3,3'-Dichlorobenzidine	91-94-1	Researched-No Data	0.11	c	--	0.43	4.00	0	--	No Not detected
3,3-Dichlorobenzidine	91-94-1	Researched-No Data	0.11	c	--	0.45	2.10	0	--	No Not detected
3-Nitroaniline	99-09-2	Not in CLARC	Not available	--	--	0.03	1.10	0	--	No Not detected
4-Bromophenyl Phenyl Ether	101-55-3	Not in CLARC	Not available	n	--	0.03	0.21	0	--	No Not detected
4-Chloro-3-methylphenol	59-50-7	Not in CLARC	1,100	n	--	0.04	0.53	0	--	No Not detected
4-Chloroaniline	106-47-8	Researched-No Data	0.22	c	--	0.03	0.21	0	--	No Not detected
4-Chlorophenyl Phenyl Ether	7005-72-3	Not in CLARC	Not available	--	--	0.03	0.21	0	--	No Not detected
4-Methylphenol	106-44-5	Researched-No Data	40	n	--	0.13	0.53	0	--	No Not detected
4-Nitroaniline	100-01-6	Not in CLARC	3.3	c	--	0.02	1.10	0	--	No Not detected
4-Nitrophenol	100-02-7	Not in CLARC	Not available	--	--	0.30	2.10	0	--	No Not detected
Aniline	62-53-3	Researched-No Data	7.7	c	--	0.05	1.10	0	--	No Not detected
Benzoic Acid	65-85-0	Researched-No Data	58,000	n	--	1.20	6.00	MW-9, MW-13	1.8J	No Max. < SL
Benzyl Alcohol	100-51-6	Researched-No Data	800	n	--	0.08	0.53	P-17	0.23J	No Max. < SL
Bis(2-chloroethoxy)methane	111-91-1	Not in CLARC	47	n	--	0.03	0.21	0	--	No Not detected
Bis(2-chloroethyl) Ether	111-44-4	Researched-No Data	0.012	c	--	0.04	0.21	0	--	No Not detected
Bis(2-ethylhexyl) Phthalate	117-81-7	Researched-No Data	4.8	c	6	0.14	9.90	Airport, B-14, B-21, MW-10, MW-7, MW-8, MW-9, MW-11, MW-13, MW-14, MW-15, MW-16, MW-17, MW-2, MW-3, NNW, P-12A, P-13, P-17, B-24	24D (B-21)	Yes Max. > SL and MCL
Butyl Benzyl Phthalate	85-68-7	Researched-No Data	14	c	--	0.02	0.21	B-21, MW-9, MW-14, MW-15, MW-16, MW-17, NNW, B-6, P-17	7.2 (P-17)	No Max. < SL
Diethyl Phthalate	84-66-2	Researched-No Data	11,000	n	--	0.01	0.21	Airport, B-21, MW-7, MW-8, MW-9, MW-13,MW-15, MW-16, MW-2, MW-3, B-26, B-6,P-17, MW-6	0.96 (MW-16)	No Max. < SL
Dimethyl Phthalate	131-11-3	Researched-No Data	Not available	--	--	0.02	0.21	P-17	0.16 (P-17)	No No SL; Only detected in one well
Di-n-butyl Phthalate	84-74-2	Researched-No Data	670	n	--	0.02	0.21	0	--	No
Di-n-octyl Phthalate	117-84-0	Researched-No Data	Not available	--	--	0.02	0.21	0	--	No
Hexachlorobenzene	118-74-1	Researched-No Data	0.042	c	1	0.02	0.21	0	--	No
Hexachlorocyclopentadiene	77-47-4	Researched-No Data	22	n	50	0.20	1.20	0	--	No
Hexachloroethane	67-72-1	Researched-No Data	0.79	c	--	0.03	0.30	0	--	No
Isophorone	78-59-1	Researched-No Data	46	c	--	0.02	0.21	0	--	No
Naphthalene	91-20-3	160	0.14	c	--	0.02	0.21	MW-7, MW-10, MW-16, MW-17	0.05 (MW-16)	No Max. < SL
N-Nitrosodimethylamine	62-75-9	Researched-No Data	0.00042	c	--	0.44	2.10	0	--	No
N-Nitrosodi-n-propylamine	621-64-7	Researched-No Data	0.0093	c	--	0.04	0.21	0	--	No
N-Nitrosodiphenylamine	86-30-6	Researched-No Data	10	c	--	0.05	0.21	0	--	No
Pentachlorophenol	87-86-5	Researched-No Data	0.17	c	1	0.36	1.10	0	--	No
Phenol	108-95-2	Researched-No Data	2,400	n	--	0.07	0.53	MW-15, MW-16	0.092 (MW-16)	No Max. < SL
Pyridine	110-86-1	Researched-No Data	8	n	--	1.50	5.30	0	--	No

Maximum detection exceeded screening level

c=cancer, CLARC=Cleanup Levels and Risk Calculations, MCL=Maximum Contaminant Level, n=noncancer, SL=screening level

Table 4-14c. Site-wide summary of polynuclear aromatic hydrocarbons in groundwater

Analyte	CAS #	MTCA Method A (µg/L)	Screening Level			Analytical Limit		Wells where Detected	Max. Detected Concentration (µg/L)	COPC and Rationale
			Minimum Risk-based Screening Level (µg/L)	Basis of Risk-based Screening Level	Maximum Contaminant Level (µg/L)	Detection Limit (µg/L)	Practical Quantitation Limit (µg/L)			
Acenaphthene	83-32-9	Researched-No Data	400	n	--	0.0049	0.023	B-21	0.025 (B-21)	No Max < SL
Acenaphthylene	208-96-8	Not Researched	Not available	--	--	0.0038	0.023	B-6	0.0048J (B-6)	No Only detected in one well. No SL.
Anthracene	120-12-7	Researched-No Data	1,300	n	--	0.004	0.023	B-21	0.0091J (B-21)	No Max < SL
Benz(a)anthracene	56-55-3	Researched-No Data	0.029	c	--	0.0029	0.023	B-21	0.007 (B-21)	No Max < SL
Benzo(a)pyrene	50-32-8	0.1	0.0029	c	0.2	0.0048	0.023	--	--	No Not detected
Benzo(b)fluoranthene	205-99-2	Researched-No Data	0.029	c	--	0.0026	0.023	B-6	0.0026J (B-6)	No Max < SL
Benzo(g,h,i)perylene	191-24-2	Not Researched	Not available	--	--	0.0033	0.023	--	--	No Not detected
Benzo(k)fluoranthene	207-08-9	Researched-No Data	0.29	c	--	0.0028	0.023	--	--	No Not detected
Chrysene	218-01-9	Researched-No Data	2.9	c	--	0.0038	0.023	--	--	No Not detected
Dibenz(a,h)anthracene	53-70-3	Researched-No Data	0.0029	c	--	0.0028	0.023	--	--	No Not detected
Fluoranthene	206-44-0	Researched-No Data	630	n	--	0.0049	0.023	B-6, B-21	0.028 (B-21)	No Max < SL
Fluorene	86-73-7	Researched-No Data	220	n	--	0.0043	0.023	B-21, MW-14, MW-17	0.036 (B-21)	No Max < SL
Indeno(1,2,3-cd)pyrene	193-39-5	Researched-No Data	0.029	c	--	0.0029	0.023	MW-11	0.0032J (MW-11)	No Max < SL
Pyrene	129-00-0	Researched-No Data	87	n	--	0.0039	0.023	B-21, MW-10, B-6, MW-6	0.016J (B-21)	No Max < SL

c=cancer, n=noncancer, SL=screening level

Table 4-14d. Site-wide summary of metals in groundwater

Analyte	CAS #	Screening Levels				Analytical Limits		Wells where Detected	Maximum Detected Concentration [a] (µg/L)	COPC and Rationale
		MTCA Method A Cleanup Level (µg/L)	Min of Risk-based Screening Levels (µg/L)	Basis of Risk-based Criteria	Maximum Contaminant Level (µg/L)	Analytical Detection Limit (µg/L)	Practical Quantitation Limit (µg/L)			
Arsenic	7440-38-2	5	0.045	c	10	0.20	0.5	B-21, MW-10, MW-14, MW-15, MW-16, MW-17	4.6 (MW-10) [a] 1.79 (MW-15)	No Max. < MTCA Method A [b]
Barium	7440-39-3	Researched-No Data	2,900	n	2,000	0.02	0.05	B-14, B-21, MW-10	216 (MW-10) [a] 23.1 (MW-15)	No Max. < SL
Cadmium	7440-43-9	5	16	--		0.005	0.02	B-21, MW-10, MW-7, MW-12, MW-14, MW-15, MW-16, MW-17, NNW	0.375 (MW-10) [a] 0.047 (MW-10)	No Max. < SL
Chromium	7440-47-3	50	Not in Tables	--	100	0.05	0.20	B-14, B-21, MW-10, MW- 7, MW-12, MW-14, MW-15, MW-16, MW-17, P-13, B-24	21.1 (MW-10) [a] 2.8 (MW-16)	No Max. < MTCA Method A
Copper	7440-50-8	Researched-No Data	620	n	1,300	0.02	0.10	B-21	20 (B-21)	No Max < Risk-screening criteria
Iron	7439-89-6	Researched-No Data	11,000	n	--	3	20	B-21, MW-10, MW-7, MW-14, MW-15, MW-16, MW-17, NNW, B-24	40800 (MW-10) [a] 3680 (NNW)	No Excluding MW-10 sample with high turbidity, next highest value < SL
Manganese	7439-96-5	Researched-No Data	2,200	--	--	0.20	5	B-14, B-21, MW-10, MW-7, MW-12, MW-15 ,MW-16, MW-17, NNW, P-13, B-24	1610 (MW-10) [a] 527 (MW-10)	No Max. < SL
Mercury	7439-97-6	2	0.63	n	2	0.05	0.20	MW-10	0.13B (MW-10)	No Max. < SL
Selenium	7782-49-2	Researched-No Data	78	n	50	0.40	1	B-14, B-21, MW-10, MW-12, MW-15, MW-16, B-24	1.5B (MW-10)	No Max. < SL
Silver	7440-22-4	Researched-No Data	71	n	--	0.009	0.02	Airport, B-21, MW-10, MW-7, MW-9, MW-8, MW-11, MW-12, MW-16, MW-3	0.317 (MW-10) [a] 0.033 (B-21)	No Max. < SL

c=cancer, COPC=chemical of potential concern, MTCA=Model Toxics Control Act, n=noncancer, SL=screening level

[a] Elevated metals in this sample from MW-10 (AO:MW-10:13) was very likely from suspended solids based on the sample's high turbidity (3926 NTU). Next highest metal concentration also listed.

[b] Method A cleanup level for arsenic in ground water is based on background concentrations for the state of Washington.

Table 4-15. Carbon tetrachloride concentrations measured in groundwater

(a) Monitoring and water supply wells in West Parcels Area Groundwater Exposure Unit

		Chemical of Potential Concern	**Carbon Tetrachloride**		
		CAS #	**56-23-5**		
		MTCA Method A (µg/L)	Researched-No Data		
		Min. risk-based screening level (µg/L)	0.39		
		Maximum Contaminant Level (µg/L)	5		
Well ID	**Sample ID**	**Sampling Date**	**(µg/L)**	**Q**	**VQ**
MW-6	NAASQ-MW06	2006/08/11	0.2	U	
	NAASQ-MW06(FD)	2006/08/11	0.2	U	
	WP:MW-6:30	2009/04/03	0.5	U	
MW-7	NAASQ-MW07	2006/08/10	0.2	U	
	AO:MW-7:24	2009/04/02	0.5	U	
MW-8	NAASQ-MW08	2006/08/09	0.2	U	
	EP:MW-8:21	2009/04/01	0.5	U	
MW-10	NAASQ-MW10	2006/08/10	0.2	U	
	AO:MW-10:13	2009/03/30	0.5	U	
B-6	OW:B-6:33	2009/04/03	0.5	U	
B-14	NAASQ-10	2006/08/08	0.2	U	
	AO:B-14:01	2009/03/28	0.5	U	
B-21	NAASQ-11	2006/08/07	0.2	U	
	AO:B-21:31	2009/04/03	0.5	U	
	AO:B21:900	2009/11/23	0.5	U	
B-24	WP:B-24:11	2009/03/30	0.5	U	
B-26	OW:B-26:35	2009/04/03	0.5	U	
		Number of samples	17		
		Number of detections	0		
		Average of detected concentrations (µg/L)	--		
		Median of detected concentrations (µg/L)	--		
		Standard of detected concentrations (µg/L)	--		

(b) Monitoring and water supply wells in Industrial Complex-Quillayute Airport Groundwater Exposure Unit

		Chemical of Potential Concern	**Carbon Tetrachloride**		
		CAS #	**56-23-5**		
		MTCA Method A (µg/L)	Researched-No Data		
		Min. risk-based screening level (µg/L)	0.39		
		Maximum Contaminant Level (µg/L)	5		
Well ID	**Sample ID**	**Sampling Date**	**(µg/L)**	**Q**	**VQ**
MW-9	NAASQ-MW09	2006/08/09	0.2	U	
	AO:MW-9:29	2009/04/03	0.5	U	
MW-11	NAASQ-MW11	2006/08/15	0.2	U	
	IC:MW-11:05	2009/03/29	0.5	U	
MW-13	NAASQ-MW13	2006/08/16	0.2	U	
	NAASQ-MW13 (FD)	2006/08/16	0.2	U	
	IC:MW-13:27	2009/04/02	0.5	U	
AIRPORT	NAASQ-01	2006/08/07	0.2	U	
	AO:AIRPORT:09	2009/03/28	0.5	U	
		Number of samples	9		
		Number of detections	0		
		Average of detected concentrations (µg/L)	--		
		Median of detected concentrations (µg/L)	--		
		Standard of detected concentrations (µg/L)	--		

(c) Monitoring and water supply wells - Industrial Complex Area-B44 Groundwater Exposure Unit

		Chemical of Potential Concern	**Carbon Tetrachloride**		
		CAS #	**56-23-5**		
		MTCA Method A (µg/L)	Researched-No Data		
		Min. risk-based screening level (µg/L)	0.39		
		Maximum Contaminant Level (µg/L)	5		
Well ID	**Sample ID**	**Sampling Date**	**(µg/L)**	**Q**	**VQ**
MW-14	IC:MW-14:50	2010/12/15	0.5	U	UJ
MW-15	IC:MW-15:54	2010/12/17	0.5	U	UJ
MW-16	IC:MW-16:55	2010/12/18	0.59		
	IC:MW-16:56	2010/12/18	0.62		
P-12A	NAASQ-07	2006/08/07	0.2	U	
	IC:P-12A:03	2009/03/28	0.5	U	
P-13	NAASQ-08	2006/08/07	0.2	U	
	IC:P-13:02	2009/03/28	0.5	U	
P-17	OW:P-17/18:34	2009/04/03	0.5	U	
		Number of samples	9		
		Number of detections	2		
		Average of detected concentrations (µg/L)	0.6		
		Median of detected concentrations (µg/L)	--		
		Standard of detected concentrations (µg/L)	--		

(d) Monitoring and water supply wells - Industrial Complex Area-NI Well Groundwater Exposure Unit

		Chemical of Potential Concern	**Carbon Tetrachloride**		
		CAS #	**56-23-5**		
		MTCA Method A (µg/L)	Researched-No Data		
		Min. risk-based screening level (µg/L)	0.39		
		Maximum Contaminant Level (µg/L)	5		
Well ID	**Sample ID**	**Sampling Date**	**(µg/L)**	**Q**	**VQ**
MW-1	NAASQ-MW01	2006/08/09	1	U	
	IC:MW-1:23	2009/04/02	1.6		
	IC:MW-1:52	2010/12/16	0.84		J
MW-2	NAASQ-MW02	2006/15/2006	1.2		
	IC:MW-2:26	2009/04/02	2		
	IC:MW-2:57	2010/12/18	1.7		
MW-3	NAASQ-MW03	2006/08/14	3.6		
	IC:MW-3:20	2009/04/01	4.7		J
	IC:MW-3:53	2010/12/16	2.8		J
MW-12	NAASQ-MW12	2006/08/15	0.2	U	
	IC:MW-12:14	2009/03/31	0.14	J	J
MW-17	IC:MW-17:62	2011/01/06	0.4	J	
NI	NAASQ-02	2006/08/08	3.4		
	NAASQ-02A*	2006/08/08	0.2	U	
	IC:DOD-NI:16	2009/03/31	6.7		J
	IC:DOD-NI:17	2009/03/31	6.8		J
	IC:DOD-NI:18	2009/03/31	0.5	U	
	IC:NI:58	2010/12/18	3.4		
NNW	IC:NNW:72	2011/12/14	0.12	J	
Pond [a]	Q4:POND:507	2009/11/14	0.5	U	
		Number of samples	20		
		Number of detections	13		
		Average of detected concentrations (µg/L)	3.0		
		Median of detected concentrations (µg/L)	2.8		
		Standard of detected concentrations (µg/L)	2.1		

Concentration higher than risk-based screening level

FD=Field Duplicate, J=Estimate (measured value is below the PQL but above the detection limit), MTCA=Model Toxics Control Act, Q=Lab Qualifier, U - Not detected (value shown is the Practical Quantitation Limit), VQ=Validation Qualifier

*Filtered sample

[a] Pond located near MW-12 (see Figure3-5b)

Table 4-16. Bis(2-ethylhexyl)phthalate concentrations measured in groundwater

(a) Monitoring and water supply wells in West Parcels Area Groundwater Exposure Unit

		Chemical of Potential Concern	Bis(2-ethylhexyl)Phthalate		
		CAS #	117-81-7		
		MTCA Method A (µg/L)	Researched-No Data		
		Min. risk-based screening level (µg/L)	4.8		
		Maximum Contaminant Level (µg/L)	6		
Well ID	**Sample ID**	**Sampling Date**	**(ug/L)**	**Q**	**VQ**
MW-6	NAASQ-MW06	2006/08/11	1	U	
	WP:MW-6:30	2009/04/03	1.1	U	
MW-7	NAASQ-MW07	2006/08/10	1	U	
	AO:MW-7:24	2009/04/02	0.28	J	
MW-8	NAASQ-MW08	2006/08/09	36		
	EP:MW-8:21	2009/04/01	0.51	J	
MW-10	NAASQ-MW10	2006/08/10	1.2		
	AO:MW-10:13	2009/03/30	0.25	J	
B-6	OW:B-6:33	2009/04/03	0.99	U	
B-14	NAASQ-10	2006/08/08	1	U	
	AO:B-14:01	2009/03/28	0.21	J	
B-21	NAASQ-11	2006/08/07	1	U	
	AO:B-21:31	2009/04/03	24	D	
	AO:B21:900	2009/11/23	0.48	J	J
B-24	WP:B-24:11	2009/03/30	0.2	J	
B-26	OW:B-26:35	2009/04/03	0.98	U	
		Number of samples	16		
		Number of detections	9		
		Average of detected concentrations (µg/L)	7.0		
		Median of detected concentrations (µg/L)	0.48		
		Standard of detected concentrations (µg/L)	13.4		

(b) Monitoring and water supply wells in Industrial Complex-Quillayute Airport Groundwater Exposure Unit

		Chemical of Potential Concern	Bis(2-ethylhexyl)Phthalate		
		CAS #	117-81-7		
		MTCA Method A (µg/L)	Researched-No Data		
		Min. risk-based screening level (µg/L)	4.8		
		Maximum Contaminant Level (µg/L)	6		
Well ID	**Sample ID**	**Sampling Date**	**(ug/L)**	**Q**	**VQ**
MW-9	NAASQ-MW09	2006/08/09	1	U	
	AO:MW-9:29	2009/04/03	0.23	J	
MW-11	NAASQ-MW11	2006/08/15	1	U	
	IC:MW-11:05	2009/03/29	1.8		
MW-13	NAASQ-MW13	2006/08/16	1	U	
	IC:MW-13:27	2009/04/02	0.6	J	
AIRPORT	NAASQ-01	2006/08/07	1	U	
	AO:AIRPORT:09	2009/03/28	0.37	J	
		Number of samples	8		
		Number of detections	4		
		Average of detected concentrations (µg/L)	0.75		
		Median of detected concentrations (µg/L)	0.49		
		Standard of detected concentrations (µg/L)	0.72		

(c) Monitoring and water supply wells - Industrial Complex Area-B44 Groundwater Exposure Unit

		Chemical of Potential Concern	Bis(2-ethylhexyl)Phthalate		
		CAS #	117-81-7		
		MTCA Method A (µg/L)	Researched-No Data		
		Min. risk-based screening level (µg/L)	4.8		
		Maximum Contaminant Level (µg/L)	6		
Well ID	**Sample ID**	**Sampling Date**	**(ug/L)**	**Q**	**VQ**
MW-14	IC:MW-14:50	2010/12/15	0.86	J	
	IC:MW-14:71	2011/12/13	0.34	JD	U
MW-15	IC:MW-15:54	2010/12/17	0.16	J	
	IC:MW-15: 76	2011/12/15	0.27	J	U
MW-16	IC:MW-16:55	2010/12/18	0.29	J	
	IC:MW-16:56	2010/12/18	0.29	J	
	IC:MW-16:70	2011/12/13	0.2	J	U
P-12A	NAASQ-07	2006/08/07	1	U	
	IC:P-12A:03	2009/03/28	0.38	J	
P-13	NAASQ-08	2006/08/07	1	U	
	IC:P-13:02	2009/03/28	0.17	J	
P-17/18	OW:P-17/18:34	2009/04/03	0.27	J	
		Number of samples	12		
		Number of detections	7		
		Average of detected concentrations (µg/L)	0.35		
		Median of detected concentrations (µg/L)	0.29		
		Standard of detected concentrations (µg/L)	0.24		

(d) Monitoring and water supply wells - Industrial Complex Area-NI Well Groundwater Exposure Unit

		Chemical of Potential Concern	Bis(2-ethylhexyl)Phthalate		
		CAS #	117-81-7		
		MTCA Method A (µg/L)	Researched-No Data		
		Min. risk-based screening level (µg/L)	4.8		
		Maximum Contaminant Level (µg/L)	6		
Well ID	**Sample ID**	**Sampling Date**	**(ug/L)**	**Q**	**VQ**
MW-1	NAASQ-MW01	2006/08/09	1	U	
	IC:MW-1:23	2009/04/02	1.1	U	
MW-2	NAASQ-MW02	2006/08/15	1	U	
	IC:MW-2:26	2009/04/02	0.14	J	
MW-3	NAASQ-MW03	2006/08/14	1	U	
	IC:MW-3:20	2009/04/01	0.18	J	
MW-12	NAASQ-MW12	2006/08/15	1	U	
	IC:MW-12:14	2009/03/31	1.1	U	
MW-17	IC:MW-17: 74	2011/12/14	0.84	J	U
	IC:MW-17:62	2011/01/06	0.27	J	U
NNW	IC:NNW:72	2011/12/14	0.23	J	U
NI	NAASQ-02	2006/08/08	1	U	
	NAASQ-02*	2006/08/08	1	U	
	IC:DOD-NI:16	2009/03/31	0.97	U	
	IC:DOD-NI:17	2009/03/31	0.97	U	
		Number of samples	15		
		Number of detections	2		
		Average of detected concentrations (µg/L)	0.16		
		Median of detected concentrations (µg/L)	--		
		Standard of detected concentrations (µg/L)	--		

Concentration higher than risk-based screening level

FD=Field Duplicate, J=Estimate (measured value is below the PQL but above the detection limit), MTCA=Model Toxics Control Act, Q=Lab Qualifier, U - Not

*Filtered sample

Table 4-17. Summary of volatile organic compounds in soil gas and crawl space air samples

Analyte	CAS #	Screening Levels: Min. Risk-based Screening Criterion for Indoor Air (µg/m^3)	Screening Levels: Basis for Risk-based Screening Level	Analytical Limits: Min Detection Limit (µg/m^3)	Analytical Limits: Max Detection Limit (µg/m^3)	Analytical Limits: Min. Practical Quantitation Limit (µg/m^3)	Analytical Limits: Max. Practical Quantitation Limit (µg/m^3)	Max. Detected in Soil Gas or Crawl Space Air (µg/m^3)	COPC and Rationale
1,1,1-Trichloroethane	71-55-6	2300	n	0.010	0.110	0.11	1.90	0.042 J	No Not detected, SL > detection limit
1,1,2,2-Tetrachloroethane	79-34-5	0.042	c	0.015	0.140	0.14	2.40	0.42 J	Yes Detected in soil gas > SL for indoor air
1,1,2-Trichloroethane	79-00-5	0.15	c	0.016	0.110	0.11	1.90	Not detected	No
1,1-Dichloroethane	75-34-3	1.5	c	0.012	0.081	0.08	1.40	Not detected	No
1,1-Dichloroethene	75-35-4	91	n	0.008	0.040	0.04	0.69	Not detected	No
1,2-Dichloroethane	107-06-2	0.094	c	0.016	0.081	0.08	1.40	0.16	Yes Detected in soil gas > SL for indoor air
Benzene	71-43-2	0.31	c	0.010	0.160	0.16	2.80	12	Yes Detected in soil gas > SL for indoor air
Carbon Tetrachloride	56-23-5	0.41	c	0.012	0.120	0.12	2.20	1900	Yes Detected in soil gas > SL for indoor air
cis-1,2-Dichloroethene	156-59-2	--	--	0.012	0.079	0.08	1.40	Not detected	No Not detected, no SL
Ethylbenzene	100-41-4	0.97	c	0.020	0.087	0.09	1.50	0.86	No Max. detection in soil gas < indoor air SL
m,p-Xylene	1330-20-7	46	n	0.013	0.170	0.17	3.00	4.3	No Max. detection in soil gas < indoor air SL
Methyl tert-butyl ether	1634-04-4	9.4	c	0.009	0.360	0.36	6.30	Not detected	--
Methylene Chloride	75-09-2	5.3	c	0.100	0.690	0.69	12.00	Not detected	--
o-Xylene	95-47-6	100	n	0.009	0.087	0.09	1.50	1.4	No Max. detection in soil gas < indoor air SL
Tetrachloroethene	127-18-4	9.4	c	0.012	0.140	0.14	2.40	1800	Yes Detected in soil gas > SL for indoor air
Toluene	108-88-3	2300	n	0.009	0.075	0.08	1.30	4	No Max. detection in soil gas < indoor air SL
trans-1,2-Dichloroethene	156-60-5	27	n	0.011	0.400	0.40	6.90	Not detected	No Not detected, SL > detection limit
Trichloroethene	79-01-6	0.43	c	0.020	0.110	0.11	1.90	5.7	Yes Detected in soil gas > SL for indoor air
Vinyl Chloride	75-01-4	0.16	c	0.005	0.026	0.03	0.44	0.046	No Max. detection in soil gas < indoor air SL

Concentration higher than risk-based screening level

c=cancer,COPC=chemical of potential concern, J=Estimate (measured value is below the PQL but above the detection limit), n=non-cancer,SL=Screening Level

Table 4-18. Site-wide summary of volatile organic compounds results for vapor intrusion samples

			1,1,2,2-Tetrachloroethane			1,2-Dichloroethane			Benzene			Carbon Tetrachloride			Tetrachloroethene			Trichloroethene		
		CAS #	**79-34-5**			**107-06-2**			**71-43-2**			**56-23-5**			**127-18-4**			**79-01-6**		
		Indoor Air Screening Level (µg/m^3)	0.042			0.094			0.31			0.41			9.4			0.43		
		Crawl Space Screening Level* (µg/m3)	0.05			0.1			0.3			0.5			10			0.5		
		Soil gas Screening Level **(µg/m^3)	1.4			3.1			10.3			13.7			313.3			14.3		
Air Sample Location/Type	**Sample ID**	**CollectedDate**	**(µg/m^3)**	**Q**	**VQ**	**(µg/m^3)**	**Q**	**VQ**	**(µg/m^3)**	**Q**	**VQ**	**(µg/m^3)**	**Q**	**VQ**	**(µg/m^3)**	**Q**	**VQ**	**(µg/m^3)**	**Q**	**VQ**
AMBIENT AIR SAMPLES																				
B-44, Ambient Air	B44:AM:420	2010/11/12	5	U		3	U		2.3	U		4.6	U		5	U		3.9	U	
B-44, Ambient Air	B44:AMI:489	2011/12/14	0.14	U		0.14			0.42			0.4			0.026	J		0.11	U	
CRAWL SPACE AIR SAMPLES* **																				
B-44, Crawl Space	B44:UT-1:487	2011/12/14	0.035	J	U	0.12			0.37			0.48			0.061	J		0.11	U	
B-44, Crawl Space	B44:UT-1:488	2011/12/14	0.14	U		0.13			0.34			0.45			0.06	J		0.11	U	
SOIL GAS SAMPLES																				
B-44, Soil gas	B44:SV-1:6:422	2010/11/12	0.99	U		0.58	U		1.2	U		380			770			0.77	U	
B-44, Soil gas	B44:SV-2:6:423	2010/11/13	0.2	U		0.12	U		0.48			18			7.2			0.16	U	
B-44, Soil gas	B44:SV-1:13:418	2010/11/12	2.4	U		1.4	U		2.8	U		1700			1800			2.7		
B-44, Soil gas	B44:SV-1:13:419	2010/11/12	2.4	U		1.4	U		2.8	U		1400			1400			2.4		
B-44, Soil gas	B44:SV-2:13:424	2010/11/13	1.3	U		0.75	U		12			730			13			1	U	
B-44, Soil gas	B44:SV-1:18:421	2010/11/12	2.4	U		1.4	U		2.8	U		1900			1300			5.7		
B-44, Soil gas	B44:SV-2:18:425	2010/11/13	2	U		1.2	U		2.9			1200			120			1.6	U	
Near NI well, Soil gas	NI:SV-1:6:490	2011/12/15	0.14	U		0.087	J		0.74			1.2			0.18	J		0.031	J	
Near NI well owner residence,	NR:SV-1:6:490	2011/12/15	0.42			0.16			2.2			0.19			0.037	J		0.022	J	

Exceeded appropriate screening level

U=Not detected, J=Estimated concentration below practical quantitation limit, Q=Laboratory Qualifier, SL=screening level, VQ=Validation Qualifier

*Calculated by dividing the Indoor Air SL by 0.9, the 95% attenuation factor from crawl space-to-indoor air from the vapor intrusion database compiled by USEPA (2012b)

**Calculated by dividing the Indoor Air SL by 0.03, the 95% attenuation factor for sub-slab soil gas-to-indoor air from the vapor intrusion database compiled by USEPA (2012b)

***Crawl space is open to the atmosphere.

Table 5-1a. Exposure parameters for residential receptors exposed to soil at the former NAAS Quillayute

Parameter	Units	Reasonable Maximum Exposure Scenario		Central Tendency Exposure Scenario		Source
		Resident Adult	Resident Child	Resident Adult	Resident Child	
Incidental Ingestion of Soil						
Soil Ingestion Rate (IRs)	(mg/day)	100	200	50	100	CTE: Table 5-1 of USEPA (2011a); RME: USEPA (1991a)
Exposure Frequency (EF)	(days/year)	350	350	350	350	USEPA (1991a)
Exposure Duration (ED) [a]	(years)	30	6	30	6	USEPA (2002b)
Body Weight (BW)	(kg)	70	15	70	15	USEPA (1991a)
Carcinogen Averaging Time (AT)	(days)	25,550	25,550	25,550	25,550	Lifetime of 70 years, USEPA (1991a)
Non-carcinogen Averaging Time (AT)	(days)	10,950	2,190	10,950	2,190	Same as Exposure Duration
Fraction ingested (FI)	(-)	1	1	1	1	
Dermal Contact with Soil						
Adherence Factor (AF)	(mg/cm^2)	0.07	0.2	0.07	0.2	USEPA (2002b)
Skin Area (SA)	(cm^2)	5,700	2,800	5,700	2,800	USEPA (2002b)
Event Frequency (EV)	(events/day)	1	1	1	1	Reasonable estimate
Exposure Frequency (EF)	(days/year)	350	350	350	350	USEPA (1991a)
Exposure Duration (ED)	(years)	30	6	30	6	USEPA (1991a)
Body weight (BW)	(kg)	70	15	70	15	USEPA (1991a)
Carcinogen Averaging Time (AT)	(days)	25,550	25,550	25,550	25,550	Lifetime of 70 years, USEPA (1991a)
Non-carcinogen Averaging Time (AT)	(days)	10,950	2,190	10,950	2,190	Same as Exposure Duration
Inhalation of Dust						
Particulate Emission factor (PEF)	(m^3/kg)	$1.36x10^9$	$1.36x10^9$	$1.36x10^9$	$1.36x10^9$	USEPA (2002b)
Exposure Frequency (EF)	(days/year)	350	350	350	350	USEPA (1991a)
Exposure Duration (ED)	(years)	30	6	30	6	USEPA (1991a)
Exposure Time (ET)	(hrs/day)	24	24	24	24	Reasonable estimate
Carcinogen averaging time (AT)	(days)	25,550	25,550	25,550	25,550	Lifetime of 70 years, USEPA (1991a)
Non-carcinogen averaging time (AT)	(days)	10,950	2,190	10,950	2,190	Same as Exposure Duration

[a] Exposure Duration for adult of 30 years consists of 6 years as child and 24 years as adult.

Parameters that vary between CTE and RME scenarios

CTE=Central Tendency Exposure, RME=Reasonable Maximum Exposure, USEPA=U.S. Environmental Protection Agency

Table 5-1b. Exposure parameters for visitors and recreationists receptors exposed to soil at the former NAAS Quillayute

Parameter	Units	Visitor/Recreationist Adult	Visitor/Recreationist Child	Source
Incidental Ingestion of Soil				
Soil Ingestion Rate (IRs)	(mg/day)	50	100	Assume half of residential receptor
Exposure Frequency (EF)	(days/year)	75	75	Reasonable estimate
Exposure Duration (ED) [a]	(years)	30	6	USEPA (2002b)
Body Weight (BW)	(kg)	70	15	USEPA (2002b)
Carcinogen Averaging Time (AT)	(days)	25,550	25,550	Lifetime of 70 years, USEPA (2002b)
Non-carcinogen Averaging Time (AT)	(days)	10,950	2,190	Same as Exposure Duration
Fraction ingested (FI)	(-)	1	1	
Dermal Contact with Soil				
Adherence Factor (AF)	(mg/cm^2)	0.07	0.2	USEPA (2002b)
Skin Area (SA)	(cm^2)	5,700	2,800	USEPA (2002b)
Event Frequency (EV)	(events/day)	1	1	Reasonable estimate
Exposure Frequency (EF)	(days/year)	75	75	Reasonable estimate
Exposure Duration (ED)	(years)	30	6	USEPA (2002b)
Body weight (BW)	(kg)	70	15	USEPA (2002b)
Carcinogen Averaging Time (AT)	(days)	25,550	25,550	Lifetime of 70 years, USEPA (2002b)
Non-carcinogen Averaging Time (AT)	(days)	10,950	2,190	Same as Exposure Duration
Inhalation of Dust				
Particulate Emission factor (PEF)	(m^3/kg)	$1.36x10^9$	$1.36x10^9$	USEPA (2002b)
Exposure Frequency (EF)	(days/year)	75	75	Reasonable estimate
Exposure Duration (ED)	(years)	30	6	USEPA (2002b)
Exposure Time (ET)	(hrs/day)	4	4	Reasonable estimate
Carcinogen averaging time (AT)	(days)	25,550	25,550	Lifetime of 70 years, USEPA (2002b)
Non-carcinogen averaging time (AT)	(days)	10,950	2,190	Same as Exposure Duration

[a] Exposure Duration for adult of 30 years consists of 6 years as child and 24 years as adult.

USEPA=U.S. Environmental Protection Agency

Table 5-1c. Exposure parameters for indoor and outdoor worker receptor exposed to soil at the former NAAS Quillayute

Parameter	Units	Indoor Worker	Outdoor Worker	Source
Incidental Ingestion of Soil				
Soil Ingestion Rate (IRs)	(mg/day)	50	100	USEPA (2002b)
Exposure Frequency (EF)	(days/year)	250	225	USEPA (2002b)
Exposure Duration (ED)	(years)	25	25	USEPA (2002b)
Body Weight (BW)	(kg)	70	70	USEPA (2002b)
Carcinogen Averaging Time (AT)	(days)	25,550	25,550	Lifetime of 70 years, USEPA (2002b)
Non-carcinogen Averaging Time (AT)	(days)	9,125	9,125	Same as Exposure Duration
Fraction ingested (FI)	(-)	1	1	
Dermal Contact with Soil				
Adherence Factor (AF)	(mg/cm^2)	--	0.2	USEPA (2002b)
Skin Area (SA)	(cm^2)	--	3,300	USEPA (2002b)
Event Frequency (EV)	(events/day)	--	1	Reasonable Estimate
Exposure Frequency (EF)	(days/year)	--	225	USEPA (2002b)
Exposure Duration (ED)	(years)	--	25	USEPA (2002b)
Body weight (BW)	(kg)	--	70	USEPA (2002b)
Carcinogen Averaging Time (AT)	(days)	--	25,550	Lifetime of 70 years, USEPA 2002b, Exhibit 1-2
Non-carcinogen Averaging Time (AT)	(days)	--	9,125	Same as Exposure Duration
Inhalation of Dust				
Particulate Emission factor (PEF)	(m^3/kg)	--	$1.36x10^9$	USEPA (2002b)
Exposure Frequency (EF)	(days/year)	--	225	USEPA (2002b)
Exposure Duration (ED)	(years)	--	25	USEPA (2002b)
Exposure Time (ET)	(hrs/day)	--	8	Reasonable Estimate
Carcinogen averaging time (AT)	(days)	--	25,550	Lifetime of 70 years, USEPA (2002b)
Non-carcinogen averaging time (AT)	(days)	--	9,125	Same as Exposure Duration

USEPA=U.S. Environmental Protection Agency

Table 5-1d. Exposure parameters for excavation/construction worker receptor exposed to soil at the former NAAS Quillayute

Parameter	Units	Excavation/Construction Worker	Source
Incidental Ingestion of Soil			
Soil Ingestion Rate (IRs)	(mg/day)	330	USEPA (2002)
Exposure Frequency (EF)	(days/year)	120	Corresponds to 24 weeks, 5 days a week
Exposure Duration (ED)	(years)	1	Reasonable estimate
Body Weight (BW)	(kg)	70	USEPA (2002)
Carcinogen Averaging Time (AT)	(days)	25,550	Lifetime of 70 years, USEPA (2002)
Non-carcinogen Averaging Time (AT)	(days)	365	Same as Exposure Duration
Fraction ingested (FI)	(-)	1	
Dermal Contact with Soil			
Adherence Factor (AF)	(mg/cm^2)	0.3	USEPA (2002)
Skin Area (SA)	(cm^2)	3,300	USEPA (2002)
Event Frequency (EV)	(events/day)	1	Reasonable estimate
Exposure Frequency (EF)	(days/year)	120	Corresponds to 24 weeks, 5 days a week
Exposure Duration (ED)	(years)	1	Reasonable estimate
Body weight (BW)	(kg)	70	USEPA (2002)
Carcinogen Averaging Time (AT)	(days)	25,550	Lifetime of 70 years, USEPA (2002)
Non-carcinogen Averaging Time (AT)	(days)	365	Same as Exposure Duration
Inhalation of Dust			
Particulate Emission factor (PEF)	(m^3/kg)	$1x10^6$	Cal-DTSC (2011) [a]
Exposure Frequency (EF)	(days/year)	120	Corresponds to 24 weeks, 5 days a week
Exposure Duration (ED)	(years)	1	Reasonable estimate
Exposure Time (ET)	(hrs/day)	8	Typical workday duration
Carcinogen averaging time (AT)	(days)	25,550	Lifetime of 70 years, USEPA (2002)
Non-carcinogen averaging time (AT)	(days)	1	Same as Exposure Duration

Cal-DTSC=California Department of Toxic Substances Control, USEPA=U.S. Environmental Protection Agency

[a] This PEF value corresponds to a respirable dust concentration of 1 mg/m^3. This is based on a maximum concentration of dust in air recommended by the American Conference of Government Industrial Hygienists, and that assumption that 10% of the mass of particles are in the respirable PM10 range. (Cal-DTSC 2011).

Table 5-2a. Exposure parameters for residential receptors exposed to groundwater as tap water at the former NAAS Quillayute

Parameter	Units	Reasonable Maximum Exposure		Central Tendency Exposure		Source
		Resident Adult	Resident Child	Resident Adult	Resident Child	
Ingestion of groundwater as tap water						
Drinking water ingestion rate (IRw)	(L/day)	2	1	1.04	0.327	CTE: Table 3-1 of USEPA (2011a) [a]; RME: USEPA (1989)
Exposure frequency (EF)	(days/year)	350	350	350	350	USEPA (1991a)
Exposure duration (ED)	(years)	30	6	30	6	USEPA (1991a)
Body weight (BW)	(kg)	70	15	70	15	USEPA (1991a)
Carcinogenic Averaging Time (AT)	(days)	25550	25550	25550	25550	Lifetime of 70 years, USEPA (1991a)
Non-carcinogen Averaging Time (AT)	(days)	10950	2190	10950	2190	Same as Exposure Duration
Dermal contact with groundwater as tap water while showering						
Event frequency (EV)	(event/day)	1	1	1	1	Reasonable estimate
Event duration (t_event)	(hr)	0.58	1	0.58	1	USEPA (2004)
Exposure frequency (EF)	(days/year)	350	350	350	350	USEPA (1991a)
Exposure duration (ED)	(years)	30	6	30	6	USEPA (1991a)
Apparent thickness of skin stratum corneum (lsc)	(cm)	0.001	0.001	0.001	0.001	USEPA (2004)
Surface Area of Skin exposed (SA)	(cm^2)	18000	6600	18000	6600	USEPA (2002b)
Body weight (BW)	(kg)	70	15	70	15	USEPA (2002b)
Carcinogen Averaging Time (AT)	(days)	25550	25550	25550	25550	Lifetime of 70 years, USEPA (2002b)
Non-carcinogen Averaging time (AT)	(days)	10950	2190	10950	2190	USEPA (2002)
Inhalation of volatiles from groundwater as tap water						
Andelman Volatilization Factor	(L/m^3)	0.5	0.5	0.5	0.5	USEPA (1991b)
Exposure Frequency (EF)	(days/year)	350	350	350	350	USEPA (1991a)
Exposure Duration (ED)	(years)	30	6	12	6	USEPA (1991a)
Exposure Time (ET)	(hrs/day)	24	24	24	24	Reasonable estimate
Carcinogen averaging time (AT)	(days)	25550	25550	25550	25550	Lifetime of 70 years, USEPA (2002b)
Non-carcinogen averaging time (AT)	(days)	10950	2190	4380	2190	Same as Exposure Duration

CTE=Central Tendency Exposure, RME=Reasonable Maximum Exposure, USEPA=U.S. Environmental Protection Agency

Highlighted cells show parameters that are different between the CTE and RME scenarios.

[a] CTE drinking water ingestion rates for resident adult (1.043 L/day) and child (0.327 L/day) correspond to the recommended values for mean drinking water ingestion rates in Table 3-1 of USEPA (2011) for age groups >21 years and 3 to <6 years, respectively.

Table 5-2b. Exposure parameters for visitors and recreationists exposed to groundwater as tap water at the former NAAS Quillayute

Parameter	Units	Visitor/Recreationist Adult	Visitor/Recreationist Child	Source
Ingestion of Groundwater as Tap water				
Drinking water ingestion rate (IRw)	(L/day)	1	0.5	Reasonable estimate
Exposure frequency (EF)	(days/year)	75	75	Reasonable estimate
Exposure duration (ED) [a]	(years)	30	6	USEPA (1991a)
Body weight (BW)	(kg)	70	15	USEPA (1991a)
Carcinogenic Averaging Time (AT)	(days)	25,550	25,550	Lifetime of 70 years, USEPA (1991a)
Non-carcinogen Averaging Time (AT)	(days)	10,950	2,190	Same as Exposure Duration

USEPA=U.S. Environmental Protection Agency

[a] ED for the visitor/recreationist adult assumed to be the same as exposure duration for adult residents. The ED for the adult visitor/recreationist is assumed to consist of 6 years as a child, and the remaining years as an adult.

Table 5-2c. Exposure parameters for indoor and outdoor worker receptors exposed to groundwater as tap water at the former NAAS Quillayute

Parameter	Units	Indoor Worker	Outdoor Worker	Source
Ingestion of groundwater as tap water				
Drinking water ingestion rate (IRw)	(L/day)	1	1	USEPA (1991a)
Exposure frequency (EF)	(days/year)	225	225	USEPA (2002b)
Exposure duration (ED)	(years)	25	25	USEPA (1991a)
Body weight (BW)	(kg)	70	70	USEPA (1991a)
Carcinogenic Averaging Time (AT)	(days)	25550	25,550	Lifetime of 70 years, USEPA (1991a)
Non-carcinogen Averaging Time (AT)	(days)	9125	9,125	Same as Exposure Duration
Dermal contact with groundwater as tap water while showering				
Event frequency (EV)	(event/day)	--	1	Reasonable estimate
Event duration (t_event)	(hr)	--	0.58	USEPA (2004)
Exposure frequency (EF)	(days/year)	--	225	USEPA (2002b)
Exposure duration (ED)	(years)	--	25	USEPA (1991a)
Apparent thickness of skin stratum corneum (lsc)	(cm^2)	--	0.001	USEPA (2004)
Surface Area of Skin exposed (SA)	(cm^2)	--	18,000	USEPA (2004)
Body weight (BW)	(kg)	--	70	USEPA (1991a)
Carcinogen Averaging Time (AT)	(days)	--	25,550	Lifetime of 70 years, USEPA (1991a)
Non-carcinogen Averaging time (AT)	(days)	--	9,125	Same as Exposure Duration

USEPA=U.S. Environmental Protection Agency

Table 5-2d. Exposure parameters for excavation/construction worker receptors exposed to groundwater as tap water at the former NAAS Quillayute

Parameter	Units	Excavation/Construction Worker	Source
Ingestion of groundwater as tap water			
Drinking water ingestion rate (IRw)	(L/day)	1	USEPA (1991a)
Exposure frequency (EF)	(days/year)	120	Correspond to 4 and 24 weeks, 5 days a week
Exposure duration (ED)	(year)	1	Reasonable estimate
Body weight (BW)	(kg)	70	USEPA (1991a)
Carcinogenic Averaging Time (AT)	(days)	25,550	Lifetime of 70 years, USEPA (1991a)
Non-carcinogen Averaging Time (AT)	(days)	365	Same as Exposure Duration
Dermal contact with groundwater as tap water while showering			
Event frequency (EV)	(event/day)	1	Reasonable estimate
Event duration (t_event)	(hr)	0.58	USEPA (2004)
Exposure frequency (EF)	(days/year)	120	Correspond to 4 and 24 weeks, 5 days a week
Exposure duration (ED)	(years)	1	Reasonable estimate
Apparent thickness of skin stratum corneum (lsc)	(cm^2)	0.001	USEPA (2004)
Surface Area of Skin exposed (SA)	(cm^2)	18,000	USEPA (2004)
Body weight (BW)	(kg)	70	USEPA (1991a)
Carcinogen Averaging Time (AT)	(days)	25,550	Lifetime of 70 years, USEPA (1991a)
Non-carcinogen Averaging time (AT)	(days)	365	Same as Exposure Duration

USEPA=U.S. Environmental Protection Agency

Table 5-3. Exposure parameters for residential receptors exposed to indoor air potentially impacted by vapor intrusion at the former NAAS Quillayute B44 slab

Parameter	Units	Reasonable Maximum Exposure Scenario		Central Tendency Exposure Scenario		Source
		Resident Adult	Resident Child	Resident Adult	Resident Child	
Inhalation of Volatiles in Indoor Air						
Exposure Time (ET)	(hrs/day)	24	24	20	18.5	CTE: USEPA (2011a)[a]; RME: Whole day exposure
Exposure frequency (EF)	(days/year)	350	350	350	350	USEPA (1991a)
Exposure duration (ED) [a]	(years)	30	6	30	6	USEPA (1991a)
Carcinogenic Averaging Time (AT)	(days)	25550	25550	25550	25550	Lifetime of 70 years, USEPA (1991a)
Non-carcinogen Averaging Time (AT)	(days)	10950	2190	10950	2190	Same as Exposure Duration

CTE=Central Tendency Exposure, RME=Reasonable Maximum Exposure, USEPA=U.S. Environmental Protection Agency

Highlighted cells show parameters that are different between the CTE and RME scenarios.

[a] The child and adult CTE Exposure Times are based on the mean time indoors at residence recommended by USEPA (2011a) (Table 16-1) for age groups birth to < 1 year and >65 years. USEPA (2011) provided recommended values for activity patterns by age groups, and the birth to < 1 year and > 65 years were the age groups with the longest exposure times for the child/<6 years and adult age ranges, respectively.

Table 5-4. Statistical summary data and exposure point concentrations for chemicals of potential concern in surface soil

Area of Potential Concern	COPC in Surface Soil	Number of Observations[a]	Outlier Concentration[b] (µg/kg)	Minimum Concentration (µg/kg)	Maximum Concentration (µg/kg)	Mean Concentration (µg/kg)	Median Concentration (µg/kg)	Standard Deviation (µg/kg)	EPC (µg/kg)[c]	Distribution, Basis for EPC
B4 Public Works Shop	Benzo(a)pyrene-Equivalent	18	None	4.1	151	52.0	22.8	54.0	86.3	Gamma, Approximate Gamma 95% UCL
	Pentachlorophenol	14	None	30	1,600	--	572.5	--	572.5	Median of detected concentrations
B5 Transportation Maintenance	Benzo(a)pyrene-Equivalent	12	None	7.3	248	83.7	55.79	76.9	144.6	Gamma, Approximate Gamma 95% UCL
	Pentachlorophenol	11	None	2,500U	5,000U	--	--	--	2,500	1/2 of maximum practical quantitation limit reported for non-detects
	Naphthalene	11	4700	80	1,300	550	360	495.5	659.6	Nonparametric, Kaplan Meir (t) UCL
B9 Blacksmith	Benzo(a)pyrene-Equivalent	9	None	3.8	69.1	22.9	13.3	23.2	45.1	Gamma, Approximate Gamma 95% UCL
B10 Gunnery Training	Benzo(a)pyrene-Equivalent	12	154.8	1.9	52	18.31	12.7	16.2	26.7	Normal, Student's-t 95% UCL
B11 and B7 Radio and Radar Building/Transformer Vault	Benzo(a)pyrene-Equivalent	7	95.3	3.9	27.94	15.1	14.7	7.4	20.6	Normal, Student's-t 95% UCL
B12 Class "C" Overhaul Shop	Benzo(a)pyrene-Equivalent	11	47.99	1.8	15.7	4.8	3.7	3.9	7.1	Gamma, Approximate Gamma 95% UCL
B17 Wash rack and shelter	Benzo(a)pyrene-Equivalent	14	None	3.2	98.2	29.9	23.4	29.0	49.7	Gamma, Approximate Gamma 95% UCL
	Pentachlorophenol [d]	6	None	58U	4,200U	--	--	--	2,100	1/2 of maximum practical quantitation limit reported for non-detects
B20 Hangar	Benzo(a)pyrene-Equivalent	4	None	49.56	106.3	73.27	68.6	24.1	106.3	Maximum, Limited data set
	Pentachlorophenol [d]	2	None	2,500U	2,500U	--	--	--	1,250	1/2 of maximum practical quantitation limit reported for non-detects
B41 Boiler and Generator	Benzo(a)pyrene-Equivalent	14	None	6.2	142.8	40.48	25.64	40.8	66.6	Gamma, Approximate Gamma 95% UCL
B49 Auxiliary Generator Building	Benzo(a)pyrene-Equivalent	4	None	6.9	45.0	20.9	15.9	17.9	45	Maximum, Limited data set
B101 and B102 Radio and Generator Building	Benzo(a)pyrene-Equivalent	8	None	1.0	84.3	22.07	13.3	26.7	52.4	Gamma, Approximate Gamma 95% UCL

[a] Number of observations is equal to the number of data points in the data set after asphalt-impacted results (at B5 and B17) and outliers were removed.

[b] Outlier status evaluated using ProUCL 4.1; outliers only removed if determined to be outliers at 1% significance level.

[c] 95% UCL calculated using RI data and ProUCL 4.1 (full data sets without non-detects)

[d] U - non-detect, reported value is the practical quantitation limit

COPC=chemical of potential concern, EPC=exposure point concentration, UCL=Upper Confidence Limit

Table 5-5. Statistical summary data and exposure point concentrations for chemicals of potential concern in groundwater

Groundwater Exposure Unit	COPC	Number of samples	Number of Detections	Maximum Detected Concentration (µg/L)	Average Concentration (µg/L)	Median Concentration (µg/L)	Standard Deviation (µg/L)	EPC (µg/L)	Basis for EPC
West Parcels Area	Bis(2-ethylhexyl)phthalate	16	9	36	7.0	0.5	13.4	0.5	Median of detections
Vicinity of Former B-44	Carbon tetrachloride	9	2	0.62	0.6	--	--	0.6	Average of detections
Vicinity of NI Well	Carbon tetrachloride	20	13	6.8	3.0	2.8	2.1	2.8	Median of detections

COPC=chemical of potential concern, EPC=exposure point concentration

Table 5-6. Statistical summary data for crawl space samples and exposure point concentrations for indoor air at the former B44 slab

Location Air Sample Type	COPC	Number of samples	Number of Detections	Minimum Concentration (µg/m^3)	Maximum Concentration (µg/m^3)	Average Detected Concentration (µg/m^3)	Median Detected Concentration (µg/m^3)	Standard Deviation (µ/m^3)	Indoor Air EPC (µg/m^3)	Basis for EPC
Ambient air [a]	1,2-Dichloroethane	2	1	ND (3U)	0.14	0.14	--	--	0.126	0.9*Detetected concentration in ambient air 12/14/2011
Sampling dates:	Benzene	2	1	ND (2.3U)	0.42	0.42	--	--	0.378	0.9*Detetected concentration in ambient air 12/14/2011
November 2010	Carbon Tetrachloride	2	1	ND (4.6U)	0.4	0.4	--	--	0.36	0.9*Detetected concentration in ambient air 12/14/2011
December 2011	Tetrachloroethene	2	1	ND (3.9U)	0.026	0.026	--	--	0.0234	0.9*Detetected concentration in ambient air 12/14/2011
Crawl Space [b]	1,2-Dichloroethane	2	2	0.12	0.13	0.13	--	--	0.12	0.9*Average of detections in crawl space samples [c]
Sampling date:	Benzene	2	2	0.34	0.37	0.36	--	--	0.32	0.9*Average of detections in crawl space samples [c]
December 2011	Carbon Tetrachloride	2	2	0.45	0.48	0.47	--	--	0.42	0.9*Average of detections in crawl space samples [c]
	Tetrachloroethene	2	2	0.06	0.061	0.06	--	--	0.05	0.9*Average of detections in crawl space samples [c]
Soil gas [6 ft bgs]	1,2-Dichloroethane	2	0	ND (0.2U)	ND (0.99U)	--	--	--	--	--
	Benzene	2	1	ND (1.2U)	0.48	0.48	--	--	0.1	0.3*Average of detections in soil gas from 6 ft bgs [d]
Sampling date:	Carbon Tetrachloride	2	2	18	380	199	--	256	59.7	0.3*Average of detections in soil gas from 6 ft bgs [d]
November 2010	Tetrachloroethene	2	2	7.2	770	389	--	539	116.7	0.3*Average of detections in soil gas from 6 ft bgs [d]
Soil gas [6-18 ft bgs]	1,2-Dichloroethane	7	0	ND (0.12U)	ND (1.4U)	--	--	--	--	--
	Benzene	7	3	ND (1.2U)	12	5.13	2.9	6.1	1.5	0.3*Average of detections in soil gas from 6-18 ft bgs [d]
Sampling date:	Carbon Tetrachloride	7	7	18	1900	1046	1200	696	313.8	0.3*Average of detections in soil gas from 6-18 ft bgs [d]
November 2010	Tetrachloroethene	7	7	7.2	1800	773	770.0	743	231.9	0.3*Average of detections in soil gas from 6-18 ft bgs [d]

[a] Summary of ambient air results for samples collected on 2010/11/12 and 2011/12/14.
[b] Crawl Space is open to the atmosphere.
[c] Vapor attenuation factor set to 0.9, corresponding to 95th percentile of crawl space-to-indoor air attenuation factors in database compiled by USEPA (2012b)
[d] Vapor attenuation factor set to 0.3, corresponding to 95th percentile of exterior soil gas-to-indoor air attenuation factors in database compiled by USEPA (2012b)
COPC=chemical of potential concern, EPC=exposure point concentration, bgs=below ground surface

Table 5-7. Carcinogenic toxicity values for chemicals of potential concern at the former NAAS Quillayute

COPC	CAS #	USEPA Carcinogenicity Assessment	IARC Carcinogenicity Assessment	Oral Slope Factor (mg/kg-day)$^{-1}$	Source	Inhalation Unit Risk (mg/m^3)$^{-1}$	Source	ABS_{GI} [a]	Dermal Slope Factor [b] (mg/kg-day)$^{-1}$
Benzene	71-43-2	A known carcinogen	1 Carcinogenic to humans	Not required [c]	--	0.0078	IRIS	Not required [c]	Not required [c]
Benzo(a)pyrene	50-32-8	B2 probable human carcinogen/	2B limited evidence in humans and less than sufficient evidence in animals	7.3	IRIS	1.1	Cal EPA	1	7.3
1,2-Dichloroethane	107-06-2	B2 probable human carcinogen/	2B limited evidence in humans and less than sufficient evidence in animals	Not required [c]	--	0.026	IRIS	Not required [c]	Not required [c]
Pentachlorophenol	87-86-5	B2 probable human carcinogen	2B limited evidence in humans and less than sufficient evidence in animals	0.4	IRIS	0.0051	Cal EPA	1	0.4
Naphthalene	91-20-3	None	2B limited evidence in humans and less than sufficient evidence in animals	None	None	0.034	Cal EPA	1	None
Carbon Tetrachloride	56-23-5	B2 probable human carcinogen	2B limited evidence in humans and less than sufficient evidence in animals	0.07	IRIS	0.0066	IRIS	1	0.07
Tetrachloroethene	127-18-4	None	2A limited Evidence in humans and sufficient evidence in animals.	2.1E-03	IRIS	2.6E-04	IRIS	1	2.1E-03
Bis(2-ethylhexyl)phthalate	117-81-7	B2 probable human carcinogen	2B limited evidence in humans and less than sufficient evidence in animals	0.014	IRIS	0.0024	Cal EPA	1	0.014

[a] ABS_{GI} = Fraction of contaminant absorbed in gastrointestinal tract (unitless), assumed to be 1 for organics, USEPA 2004 (RAGS Part E)

[b] Dermal Slope Factor = Oral Slope Factor / ABS_{GI}

[c] Benzene and 1,2-dichloroethane are only COPCs for indoor air.

Cal EPA=California EPA, COPC=chemical of potential concern, IRIS=Integrated Risk Information System, IARC=International Agency for Research on Cancer, USEPA=U.S. Environmental Protection Agency

Table 5-8. Non-carcinogenic toxicity values for chemicals of potential concern at the former NAAS Quillayute

COPC	CAS #	Oral Reference Dose (mg/kg-day)	Source	Reference Concentration (mg/m^3)	Source	ABS_{GI}[a]	Dermal Reference Dose [b] (mg/kg-day)
Benzene	71-43-2	Not required [c]	--	3E-02	IRIS	Not required [c]	Not required [c]
Benzo(a)pyrene	50-32-8	None	None	None	None	1	None
1,2-Dichloroethane	107-06-2	Not required [c]	--	None	None	Not required [c]	Not required [c]
Pentachlorophenol	87-86-5	0.005	IRIS	None	None	1	0.005
Naphthalene	91-20-3	0.02	IRIS	0.003	IRIS	1	0.02
Carbon Tetrachloride	56-23-5	0.004	IRIS	0.1	IRIS	1	0.004
Tetrachloroethene	127-18-4	0.006	IRIS	0.04	IRIS	1	0.006
Bis(2-ethylhexyl)phthalate	117-81-7	0.02	IRIS	None	None	1	0.02

[a] Fraction of contaminant absorbed in gastrointestinal tract (unitless), assumed to be 1 for organics, USEPA 2004 (RAGS Part E)

[b] Dermal Reference Dose = Oral Reference Dose x ABS_{GI}

[c] Benzene and 1,2-dichloroethane are only COPCs for indoor air.

COPC=chemical of potential concern, IRIS: Integrated Risk Information System (values shown are from August 2012), USEPA=U.S. Environmental Protection Agency

Table 5-9. Incremental lifetime carcinogenic risks for site receptors from exposure to chemicals of potential concern in soil under a Reasonable Maximum Exposure Scenario

			Incremental Lifetime Carcinogenic Risk						
Area of Potential Concern	**COPC**	**EPC (µg/kg)**	**Indoor Worker**	**Outdoor Worker**	**Excavation/ Construction Worker**	**Visitor / Recreationist Child**	**Visitor / Recreationist Adult**	**Resident Child**	**Resident Adult**
B4, Public Works Shop	Benzo(a)pyrene-Equivalent	86.3	1.1.E-07	3.7.E-07	1.9.E-08	6.8.E-07	8.0.E-07	5.0.E-06	5.8.E-06
	Pentachlorophenol	572.5	4.0.E-08	1.9.E-07	8.8.E-09	6.4.E-08	3.2.E-07	4.2.E-07	6.4.E-07
	TOTAL ILCR		**1.5.E-07**	**5.6.E-07**	**2.8.E-08**	**7.5.E-07**	**1.1.E-06**	**5.4.E-06**	**6.5.E-06**
B5, Transportation Maintenance	Benzo(a)pyrene-Equivalent	144.6	1.8.E-07	6.2.E-07	3.2.E-08	1.1.E-06	1.3.E-06	8.4.E-06	9.8.E-06
	Pentachlorophenol	2500	1.7.E-07	5.8.E-07	3.1.E-08	2.0.E-07	8.1.E-07	1.5.E-06	2.2.E-06
	Naphthalene	659.6	--	1.5.E-08	3.6.E-10	6.1.E-10	3.0.E-09	1.7.E-08	8.5.E-08
	TOTAL ILCR		**3.6.E-07**	**1.2.E-06**	**6.4.E-08**	**1.3.E-06**	**2.2.E-06**	**9.9.E-06**	**1.2.E-05**
B9, Blacksmith	Benzo(a)pyrene-Equivalent	45.1	5.8.E-08	1.9.E-07	1.0.E-08	3.6.E-07	4.2.E-07	2.6.E-06	3.1.E-06
	TOTAL ILCR		**5.8.E-08**	**1.9.E-07**	**1.0.E-08**	**3.6.E-07**	**4.2.E-07**	**2.6.E-06**	**3.1.E-06**
B10, Gunnery Training	Benzo(a)pyrene-Equivalent	26.7	3.4.E-08	1.1.E-07	6.0.E-09	2.1.E-07	2.5.E-07	1.6.E-06	1.8.E-06
	TOTAL ILCR		**3.4.E-08**	**1.1.E-07**	**6.0.E-09**	**2.1.E-07**	**2.5.E-07**	**1.6.E-06**	**1.8.E-06**
B11 and B7, Radio and Radar Building/Transformer Vault	Benzo(a)pyrene-Equivalent	20.6	8.8.E-08	8.8.E-08	4.6.E-09	1.6.E-07	1.9.E-07	1.2.E-06	1.4.E-06
	TOTAL ILCR		**8.8.E-08**	**8.8.E-08**	**4.6.E-09**	**1.6.E-07**	**1.9.E-07**	**1.2.E-06**	**1.4.E-06**
B12, Class "C" Overhaul Shop	Benzo(a)pyrene-Equivalent	7.1	9.1.E-09	3.0.E-08	1.6.E-09	5.6.E-08	6.6.E-08	4.1.E-07	4.8.E-07
	TOTAL ILCR		**9.1.E-09**	**3.0.E-08**	**1.6.E-09**	**5.6.E-08**	**6.6.E-08**	**4.1.E-07**	**4.8.E-07**
B17, Wash rack and shelter	Benzo(a)pyrene-Equivalent	49.7	6.3.E-08	2.1.E-07	1.1.E-08	3.9.E-07	4.6.E-07	2.9.E-06	3.4.E-06
	Pentachlorophenol	2100	1.5.E-07	7.0.E-07	3.3.E-08	2.4.E-07	3.6.E-07	1.6.E-06	2.4.E-06
	TOTAL ILCR		**2.1.E-07**	**9.1.E-07**	**4.4.E-08**	**6.3.E-07**	**8.2.E-07**	**4.5.E-06**	**5.7.E-06**
B20, Hangar	Benzo(a)pyrene-Equivalent	106.3	1.4.E-07	4.5.E-07	2.4.E-08	8.4.E-07	9.9.E-07	6.2.E-06	7.2.E-06
	Pentachlorophenol	1250	8.7.E-08	4.2.E-07	1.9.E-08	1.4.E-07	7.0.E-07	9.3.E-07	1.4.E-06
	TOTAL ILCR		**2.2.E-07**	**8.7.E-07**	**4.3.E-08**	**9.8.E-07**	**1.7.E-06**	**7.1.E-06**	**8.6.E-06**
B41, Boiler and Generator	Benzo(a)pyrene-Equivalent	66.6	8.5.E-08	2.8.E-07	1.5.E-08	5.3.E-07	6.2.E-07	3.9.E-06	4.5.E-06
	TOTAL ILCR		**8.5.E-08**	**2.8.E-07**	**1.5.E-08**	**5.3.E-07**	**6.2.E-07**	**3.9.E-06**	**4.5.E-06**
B49, Auxiliary Generator Building	Benzo(a)pyrene-Equivalent	45	5.7.E-08	1.9.E-07	1.0.E-08	3.6.E-07	4.2.E-07	2.6.E-06	3.0.E-06
	TOTAL ILCR		**5.7.E-08**	**1.9.E-07**	**1.0.E-08**	**3.6.E-07**	**4.2.E-07**	**2.6.E-06**	**3.0.E-06**
B101 and B102, Radio and Generator Building	Benzo(a)pyrene-Equivalent	52.4	6.7.E-08	2.2.E-07	1.2.E-08	4.1.E-07	4.9.E-07	3.0.E-06	3.5.E-06
	TOTAL ILCR		**6.7.E-08**	**2.2.E-07**	**1.2.E-08**	**4.1.E-07**	**4.9.E-07**	**3.0.E-06**	**3.5.E-06**

Exceeds 10^{-6}, the lower limit of the NCP target risk range of 10^{-6} to 10^{-4}.

COPC=chemical of potential concern, EPC=exposure point concentrations, ILCR=incremental lifetime cancer risk, MTCA=Model Toxics Control Act, NCP=National Oil and Hazardous Substances Pollution Contingency Plan

Table 5-10. Incremental carcinogenic lifetime risks for site receptors from exposure to chemicals of potential concern in soil under a Central Tendency Exposure scenario

Area of Potential Concern	COPC	EPC (µg/kg)	ILCR Resident Child	ILCR Resident Adult
B4, Public Works Shop	Benzo(a)pyrene-Equivalent	######	3.2E-06	3.7E-06
	Pentachlorophenol	######	3.0E-07	4.6E-07
	TOTAL ILCR		**3.5E-06**	**4.2E-06**
B5, Transportation Maintenance	Benzo(a)pyrene-Equivalent	######	5.3E-06	6.3E-06
	Pentachlorophenol	######	9.5E-07	1.4E-06
	Naphthalene	######	1.7E-08	8.5E-08
	TOTAL ILCR		**6.3E-06**	**7.8E-06**
B9, Blacksmith	Benzo(a)pyrene-Equivalent	######	1.2E-06	1.4E-06
	TOTAL ILCR		**1.2E-06**	**1.4E-06**
B10, Gunnery Training	Benzo(a)pyrene-Equivalent	######	9.8E-07	1.2E-06
	TOTAL ILCR		**9.8E-07**	**1.2E-06**
B11 and B7, Radio and Radar Building/Transformer Vault	Benzo(a)pyrene-Equivalent	######	3.6E-07	8.9E-07
	TOTAL ILCR		**3.6E-07**	**8.9E-07**
B12, Class "C" Overhaul Shop	Benzo(a)pyrene-Equivalent	######	2.6E-07	3.1E-07
	TOTAL ILCR		**2.6E-07**	**3.1E-07**
B17, Wash rack and shelter	Benzo(a)pyrene-Equivalent	######	1.3E-06	1.5E-06
	Pentachlorophenol	######	8.7E-07	1.4E-06
	TOTAL ILCR		**2.2E-06**	**2.9E-06**
B20, Hangar	Benzo(a)pyrene-Equivalent	######	2.8E-06	3.3E-06
	Pentachlorophenol	######	5.2E-07	8.1E-07
	TOTAL ILCR		**3.3E-06**	**4.1E-06**
B41, Boiler and Generator	Benzo(a)pyrene-Equivalent	######	1.7E-06	2.1E-06
	TOTAL ILCR		**1.7E-06**	**2.1E-06**
B49, Auxiliary Generator Building	Benzo(a)pyrene-Equivalent	######	1.2E-06	1.4E-06
	TOTAL ILCR		**1.2E-06**	**1.4E-06**
B101 and B102, Radio and Generator Building	Benzo(a)pyrene-Equivalent	######	1.4E-06	1.6E-06
	TOTAL ILCR		**1.4E-06**	**1.6E-06**

Exceeds 10^{-6}, the lower limit of the NCP target risk range of 10^{-6} to 10^{-4}.

Exceeds 10^{-5}, target MTCA risk

COPC=chemical of potential concern, EPC=exposure point concentrations, ILCR=incremental lifetime cancer risk, MTCA=Model Toxics Control Act, NCP=National Oil and Hazardous Substances Pollution Contingency Plan

Table 5-11. Hazard indices for site receptors from exposure to chemicals of potential concern in soil under a Reasonable Maximum Exposure scenario

Area of Potential Concern	COPC	EPC (µg/kg)	Hazard Index					
			Resident Adult	Resident Child	Visitor / Recreationist Adult	Visitor / Recreationist Child	Outdoor Worker	Excavation/ Construction Worker
B4, Public Works Shop	Benzo(a)pyrene-Equivalent[1]	86.3	--	--	--	--	--	--
	Pentachlorophenol	572.5	0.0007	0.002	0.0001	0.0004	0.0003	0.0003
B5, Transportation Maintenance	Benzo(a)pyrene-Equivalent[1]	144.6	--	--	--	--	--	--
	Pentachlorophenol	2,500	0.003	0.006	0.0004	0.0007	0.0008	0.001
	Naphthalene	659.6	0.002	0.002	0.00009	0.0001	0.0005	0.09
B9, Blacksmith	Benzo(a)pyrene-Equivalent[1]	45.1	--	--	--	--	--	--
B10, Gunnery Training	Benzo(a)pyrene-Equivalent[1]	26.7	--	--	--	--	--	--
B11 and B7, Radio and Radar	Benzo(a)pyrene-Equivalent[1]	20.6	--	--	--	--	--	--
B12, Class "C" Overhaul Shop	Benzo(a)pyrene-Equivalent[1]	7.1	--	--	--	--	--	--
B17, Wash rack and shelter	Benzo(a)pyrene-Equivalent[1]	49.7	--	--	--	--	--	--
	Pentachlorophenol	2,100	0.003	0.009	0.0004	0.001	0.001	0.001
B20, Hangar	Benzo(a)pyrene-Equivalent[1]	106.3	--	--	--	--	--	--
	Pentachlorophenol	1,250	0.002	0.005	0.0003	0.0008	0.0006	0.0007
B41, Boiler and Generator	Benzo(a)pyrene-Equivalent[1]	66.6	--	--	--	--	--	--
B49, Auxiliary Generator	Benzo(a)pyrene-Equivalent[1]	45	--	--	--	--	--	--
B101 and B102, Radio and	Benzo(a)pyrene-Equivalent[1]	52.4	--	--	--	--	--	--

[1] No non-cancer toxicity values available

COPC=chemical of potential concern, EPC=exposure point concentration

Table 5-12. Hazard indices for residential site receptors from exposure to chemicals of potential concern in soil under a Central Tendency Exposure scenario

Area of Potential Concern	COPC	EPC (µg/kg)	Hazard Index	
			Resident Adult	Resident Child
B4 Public Works Shop	Benzo(a)pyrene-Equivalent[1]	86.3	--	--
	Pentachlorophenol	572.5	0.0006	0.002
B5 Transportation Maintenance	Benzo(a)pyrene-Equivalent[1]	144.6	--	--
	Pentachlorophenol	2,500	0.002	0.003
	Naphthalene	659.6	0.002	0.002
B9 Blacksmith	Benzo(a)pyrene-Equivalent[1]	45.1	--	--
B10 Gunnery Training	Benzo(a)pyrene-Equivalent[1]	26.7	--	--
B11 and B7 Radio and Radar Building/Transformer Vault	Benzo(a)pyrene-Equivalent[1]	20.6	--	--
B12 Class "C" Overhaul Shop	Benzo(a)pyrene-Equivalent[1]	7.1	--	--
B17 Wash rack and shelter	Benzo(a)pyrene-Equivalent[1]	49.7	--	--
	Pentachlorophenol	2,100	0.002	0.005
B20 Hangar	Benzo(a)pyrene-Equivalent[1]	106.3	--	--
	Pentachlorophenol	1,250	0.001	0.003
B41 Boiler and Generator	Benzo(a)pyrene-Equivalent[1]	66.6	--	--
B49 Auxiliary Generator Building	Benzo(a)pyrene-Equivalent[1]	45	--	--
B101 and B102 Radio and Generator Building	Benzo(a)pyrene-Equivalent[1]	52.4	--	--

[1] No non-cancer toxicity values available

COPC=chemical of potential concern, EPC=exposure point concentration

Table 5-13. Incremental lifetime carcinogenic risks for site receptors from exposure to chemicals of potential concern in groundwater assuming a Reasonable Maximum Exposure scenario

			ILCR					
Groundwater Exposure Unit	**COPC**	**EPC (µg/L)**	**Resident Adult**	**Resident Child**	**Visitor / Recreationist Adult**	**Visitor / Recreationist Child**	**Outdoor Worker**	**Construction Worker**
West Parcels Area	Bis(2-ethylhexyl)phthalate	0.50	3.0E-07	1.0E-07	--	--	1.0E-07	--
		TOTAL ILCR	**3.0E-07**	**1.0E-07**	**--**	**--**	**1.0E-07**	**--**
Industrial Complex -B-44	Carbon tetrachloride	0.6	1.5E-06	4.4E-07	6.7E-08	2.5E-08	2.3E-07	4.4E-09
		TOTAL ILCR	**1.5E-06**	**4.4E-07**	**6.7E-08**	**2.5E-08**	**2.3E-07**	**4.4E-09**
Industrial Complex - NI well	Carbon tetrachloride	2.8	7.2E-06	2.0E-06	3.1E-07	1.2E-07	1.1E-06	2.0E-08
		TOTAL ILCR	**7.2E-06**	**2.0E-06**	**3.1E-07**	**1.2E-07**	**1.1E-06**	**2.0E-08**

Exceeds 10^{-6}, the lower limit of the NCP target risk range (10^{-6} to 10^{-4}).

COPC=chemical of potential concern, EPC=exposure point concentrations, ILCR=incremental lifetime cancer risk, MTCA=Model Toxics Control Act, NCP=National Oil and Hazardous Substances Pollution Contingency Plan

Table 5-14. Incremental lifetime carcinogenic risks for residential receptors from exposure to chemicals of potential concern in groundwater assuming a Central Tendency Exposure scenario

Groundwater Exposure Unit	COPC	EPC (µg/L)	ILCR Resident Adult	ILCR Resident Child
West Parcels Area	Bis(2-ethylhexyl)phthalate	0.5	2.1E-07	6.9E-08
		TOTAL ILCR	**2.1E-07**	**6.9E-08**
Vicinity of Former B-44	Carbon tetrachloride	0.6	1.2E-06	2.8E-07
		TOTAL ILCR	**1.2E-06**	**2.8E-07**
Vicinity of NI Well	Carbon tetrachloride	2.8	5.5E-06	1.3E-06
		TOTAL ILCR	**5.5E-06**	**1.3E-06**

Exceeds 10^{-6}, the lower limit of the NCP target risk range (10^{-6} to 10^{-4}).

COPC=chemical of potential concern, EPC=exposure point concentrations, ILCR=incremental

Table 5-15. Hazard indices for site receptors from exposure to chemicals of potential concern in groundwater assuming a Reasonable Maximum Exposure scenario

			HI					
Groundwater Exposure Unit	**COPC**	**EPC (µg/L)**	**Resident Adult**	**Resident Child**	**Visitor / Recreationist Adult**	**Visitor / Recreationist Child**	**Outdoor Worker**	**Excavation/ Construction Worker**
West Parcels Area	Bis(2-ethylhexyl)phthalate	0.5	0.002	0.004	--	--		--
		TOTAL HI	**0.002**	**0.004**	--	--		--
Vicinity of Former B-44	Carbon tetrachloride	0.6	0.01	0.02	0.0006	0.001	0.002	0.0004
		TOTAL HI	**0.01**	**0.02**	**0.0006**	**0.001**	**0.002**	**0.0004**
Vicinity of NI Well	Carbon tetrachloride	2.8	0.04	0.07	0.003	0.005	0.011	0.002
		TOTAL HI	**0.04**	**0.07**	**0.003**	**0.005**	**0.011**	**0.002**

COPC=chemical of potential concern, EPC=exposure point concentration, HI=Hazard Index

Table 5-16. Hazard indices for residential receptors from exposure to chemicals of potential concern in groundwater

Groundwater Exposure Unit	COPC	EPC (µg/L)	HI Resident Adult	HI Resident Child
West Parcels Area	Bis(2-ethylhexyl)phthalate	0.5	0.002	0.003
		TOTAL HI	**0.002**	**0.003**
Vicinity of Former B-44	Carbon tetrachloride	0.6	0.007	0.009
		TOTAL HI	**0.007**	**0.01**
Vicinity of NI Well	Carbon tetrachloride	2.8	0.03	0.04
		TOTAL HI	**0.03**	**0.04**

COPC=chemical of potential concern, EPC=exposure point concentration, HI=Hazard Index

Table 5-17. Incremental lifetime cancer risk for site receptors at former B44 slab from exposure to indoor air under a Reasonable Maximum Exposure scenario

Location	COPC	Basis for Indoor Air EPC	EPC (µg/m^3)	ILCR	
				Resident Adult	Resident Child
Former B-44	1,2-Dichloroethane	0.9*Average of detections in crawl space samples	0.12	1.3E-06	2.6E-07
	Benzene		0.32	1.0E-06	2.1E-07
	Carbon tetrachloride		0.42	1.1E-06	2.3E-07
	Tetrachloroethene		0.05	5.3E-09	1.1E-09
			TOTAL ILCR	**3.5E-06**	**6.9E-07**
Former B-44	1,2-Dichloroethane	0.9*Detetected concentration in ambient air 12/14/2011	0.13	1.3E-06	2.7E-07
	Benzene		0.38	1.2E-06	2.4E-07
	Carbon tetrachloride		0.36	9.8E-07	2.0E-07
	Tetrachloroethene		0.02	2.5E-09	5.0E-10
			TOTAL ILCR	**3.5E-06**	**7.1E-07**
Former B-44	1,2-Dichloroethane	0.3*Average of detections in soil gas from 6 feet below ground surface *Considered less reliable than estimate from data closer to receptor, i.e., from crawl space(DoD 2009)*	--	--	--
	Benzene		0.14	3.2E-07	6.4E-08
	Carbon tetrachloride		59.7	1.6E-04	3.2E-05
	Tetrachloroethene		116.7	1.2E-05	2.5E-06
			TOTAL ILCR	**1.7E-04**	**3.5E-05**
Former B-44	1,2-Dichloroethane	0.3*Average of detections in soil gas from 6 to 18 feet below ground surface *Considered less reliable than estimate from data closer to receptor, i.e., from crawl space (DoD 2009)*	--	--	--
	Benzene		1.54	4.8E-06	9.6E-07
	Carbon tetrachloride		313.8	8.5E-04	1.7E-04
	Tetrachloroethene		231.9	2.5E-05	5.0E-06
			TOTAL ILCR	**8.8E-04**	**1.8E-04**

Exceeds lower limit of NCP target risk range (10^{-6})

COPC=chemical of potential concern, EPC=exposure point concentrations, ILCR=incremental lifetime cancer risk, MTCA=Model Toxics Control Act, NCP=National Oil and Hazardous Substances Pollution Contingency Plan, bgs=below ground surface

Table 5-18. Incremental lifetime cancer risks for site receptors at former B44 slab from exposure to indoor air under a Central Tendency Exposure scenario.

Location	Chemical of Potential Concern	Basis for Indoor Air EPC	EPC (ug/m^3)	ILCR	
				Resident Adult	Resident Child
Former B-44	1,2-Dichloroethane	0.9*Average of detections in crawl space samples	0.12	1.1E-06	2.0E-07
	Benzene		0.32	8.4E-07	1.6E-07
	Carbon tetrachloride		0.42	9.4E-07	1.8E-07
	Tetrachloroethene		0.05	4.4E-09	8.2E-10
			TOTAL ILCR	**2.8E-06**	**5.3E-07**
Former B-44	1,2-Dichloroethane	0.9*Detetected concentration in ambient air 12/14/2011	0.13	1.1E-06	2.1E-07
	Benzene		0.38	9.9E-07	1.9E-07
	Carbon tetrachloride		0.36	8.0E-07	1.5E-07
	Tetrachloroethene		0.02	2.1E-09	3.9E-10
			TOTAL ILCR	**2.9E-06**	**5.5E-07**
Former B-44	1,2-Dichloroethane	0.3*Average of detections in soil gas from 6 ft bgs *Considered less reliable than estimate from data closer to receptor, i.e., from crawl space(DoD 2009)*	--	--	--
	Benzene		0.14	2.6E-07	4.9E-08
	Carbon tetrachloride		59.7	1.3E-04	2.5E-05
	Tetrachloroethene		116.7	1.0E-05	1.9E-06
			TOTAL ILCR	**1.4E-04**	**2.7E-05**
Former B-44	1,2-Dichloroethane	0.3*Average of detections in soil gas from 6-18 ft bgs *Considered less reliable than estimate from data closer to receptor, i.e., from crawl space (DoD 2009)*	--	--	--
	Benzene		1.54	3.9E-06	7.4E-07
	Carbon tetrachloride		313.80	7.0E-04	1.3E-04
	Tetrachloroethene		231.90	2.0E-05	3.8E-06
			TOTAL ILCR	**7.2E-04**	**1.4E-04**

Exceeds lower limit of NCP target risk range (10^{-6})

COPC=chemical of potential concern, EPC=exposure point concentrations, ILCR=incremental lifetime cancer risk, MTCA=Model Toxics Control Act, NCP=National Oil and Hazardous Substances Pollution Contingency Plan, bgs=below ground surface

Table 5-19. Hazard indices for site receptors at the former B44 slab from exposure to indoor air under a Reasonable Maximum Exposure scenario

Location	COPC	Basis for Indoor Air EPC	EPC ($\mu g/m^3$)	HI Resident Adult	HI Resident Child
Former B-44	1,2-Dichloroethane	0.9*Average of detections in crawl space samples	0.12	--	--
	Benzene		0.32	0.010	0.010
	Carbon tetrachloride		0.42	0.004	0.004
	Tetrachloroethene		0.05	0.001	0.001
			TOTAL HI	0.02	0.02
Former B-44	1,2-Dichloroethane	0.9*Detetected concentration in ambient air 12/14/2011	0.13	--	--
	Benzene		0.38	0.012	0.012
	Carbon tetrachloride		0.36	0.003	0.003
	Tetrachloroethene		0.02	0.001	0.001
			TOTAL HI	0.02	0.02
Former B-44	1,2-Dichloroethane	0.3*Average of detections in soil gas from 6 feet below ground surface *Considered less reliable than estimate from data closer to receptor, i.e., from crawl space(DoD 2009)*	--	--	--
	Benzene		0.14	0.003	0.003
	Carbon tetrachloride		59.70	0.6	0.6
	Tetrachloroethene		116.70	2.8	2.8
			TOTAL HI	**3.37**	**3.37**
Former B-44	1,2-Dichloroethane	0.3*Average of detections in soil gas from 6 to 18 feet below ground surface *Considered less reliable than estimate from data closer to receptor, i.e., from crawl space (DoD 2009)*	--	--	--
	Benzene		1.54	0.05	0.05
	Carbon tetrachloride		313.80	3.0	3.0
	Tetrachloroethene		231.90	5.6	5.6
			TOTAL HI	**8.62**	**8.62**

COPC=chemical of potential concern, EPC=exposure point concentration, HI=Hazard Index

Table 5-20. Hazard indices for site receptors at the former B44 slab from exposure to indoor air under a Central Tendency Exposure scenario

Location	COPC	Basis for Indoor Air EPC	EPC ($\mu g/m^3$)	HI	
				Resident Adult	Resident Child
Former B-44	1,2-Dichloroethane	0.9*Average of detections in crawl space samples	0.12	--	--
	Benzene		0.32	0.009	0.008
	Carbon tetrachloride		0.42	0.003	0.003
	Tetrachloroethene		0.05	0.001	0.001
			TOTAL HI	0.01	0.01
Former B-44	1,2-Dichloroethane	0.9*Detetected concentration in ambient air 12/14/2011	0.13	--	--
	Benzene		0.38	0.010	0.009
	Carbon tetrachloride		0.36	0.003	0.003
	Tetrachloroethene		0.02	0.000	0.000
			TOTAL HI	0.01	0.01
Former B-44	1,2-Dichloroethane	0.3*Average of detections in soil gas from 6 feet below ground surface *Considered less reliable than estimate from data closer to receptor, i.e., from crawl space(DoD 2009)*	--	--	--
	Benzene		0.14	0.003	0.002
	Carbon tetrachloride		59.70	0.5	0.4
	Tetrachloroethene		116.70	**2.3**	**2.2**
			TOTAL HI	**2.81**	**2.60**
Former B-44	1,2-Dichloroethane	0.3*Average of detections in soil gas from 6 to 18 feet below ground surface *Considered less reliable than estimate from data closer to receptor, i.e., from crawl space (DoD 2009)*	--	--	--
	Benzene		1.54	0.04	0.04
	Carbon tetrachloride		313.80	2.5	2.3
	Tetrachloroethene		231.90	4.6	4.3
			TOTAL HI	**7.18**	**6.64**

COPC=chemical of potential concern, EPC=exposure point concentration, HI=Hazard Index

Table 6-1. Screening of chemicals of potential ecological concern in soils

Hazardous Substance	Type	Max Concentration (mg/kg)	Exceeds MTCA 749-3[1] Screening Levels	Reasonable Maximum Exposure (95% UCL) (mg/kg)	MTCA 749-2[2] Screening Ecotoxicity Value (mg/kg)		MTCA 749-3[1] Screening Ecotoxicity Value (mg/kg)			Wildlife Exposure Calculations (MTCA 749-4[3] and 749-5[4] Screening Ecotoxicity Values) (mg/kg)			Eco-SSLs[5] (mg/kg)			
					Unrestricted Use	Industrial or Commercial Use	Plants	Soil Biota	Wildlife	Mammalian Predator: Shrew	Avian Predator: Robin	Mammalian Herbivore: Vole	Plants	Soil Invertebrates	Avian	Mammal
Silver	Metal	21.2	No*	--	--	--	2	--	--	--	--	--	560	--	4.2	14
Hexachlorobenzene	Pesticide	0.5	No	--	31	31	--	--	17	--	17	--	--	--	--	--
Pentachlorophenol	Pesticide	1.6	No	--	11	11	3	6	4.5	4.5	--	188	--	--	--	--
1,2,3-Trichlorobenzene	Other Chlorinated Organics	0.038	No	--	--	--	--	20	--	--	--	--	--	--	--	--
1,2,4-Trichlorobenzene	Other Chlorinated Organics	0.5	No	--	--	--	--	20	--	--	--	--	--	--	--	--
1,2-Dichloropropane	Other Chlorinated Organics	0.0093	No	--	--	--	--	700	--	--	--	--	--	--	--	--
1,4-Dichlorobenzene	Other Chlorinated Organics	0.0093	No	--	--	--	--	20	--	--	--	--	--	--	--	--
2,4,5-Trichlorophenol	Other Chlorinated Organics	0.5	No	--	--	--	4	9	--	--	--	--	--	--	--	--
2,4,6-Trichlorophenol	Other Chlorinated Organics	0.5	No	--	--	--	--	10	--	--	--	--	--	--	--	--
Chlorobenzene	Other Chlorinated Organics	0.0093	No	--	--	--	--	40	--	--	--	--	--	--	--	--
Hexachlorocyclopentadiene	Other Chlorinated Organics	2.5	No	--	--	--	10	--	--	--	--	--	--	--	--	--
PCB mixtures (total)	Other Chlorinated Organics	0.2848	No	--	2	2	40	--	0.65	--	--	--	--	--	--	--
2,4-Dinitrophenol	Other Non-Chlorinated Organics	10	No	--	--	--	20	--	--	--	--	--	--	--	--	--
4-Nitrophenol	Other Non-Chlorinated Organics	5	No	--	--	--	--	7	--	--	--	--	--	--	--	--
Acenaphthene	Other Non-Chlorinated Organics	0.0076	No	--	--	--	20	--	--	--	--	--	--	--	--	--
Benzo(a)pyrene	Other Non-Chlorinated Organics	0.11	No	--	30	300	--	--	12	12	--	80	--	--	--	--
Diethylphthalate	Other Non-Chlorinated Organics	0.66	No	--	--	--	100	--	--	--	--	--	--	--	--	--
Dimethylphthalate	Other Non-Chlorinated Organics	1.9	No	--	--	--		200	--	--	--	--	--	--	--	--
Di-n-butyl phthalate	Other Non-Chlorinated Organics	5.6	No	--	200	--	200	--	--	--	--	--	--	--	--	--
Fluorene	Other Non-Chlorinated Organics	0.014	No	--	--	--	--	30	--	--	--	--	--	--	--	--
N-nitrosodiphenylamine	Other Non-Chlorinated Organics	0.5	No	--	--	--	--	20	--	--	--	--	--	--	--	--
Phenol	Other Non-Chlorinated Organics	1.5	No	--	--	--	70	30	--	--	--	--	--	--	--	--
Styrene	Other Non-Chlorinated Organics	0.0093	No	--	--	--	300	--	--	--	--	--	--	--	--	--
Toluene	Other Non-Chlorinated Organics	0.0093	No	--	--	--	200	--	--	--	--	--	--	--	--	--

[1]Table 749-3 Ecological Indicator Soil Concentrations (mg/kg) for Protection of Terrestrial Plants and Animals (WAC 173-340-900).

[2]Table 749-2 Priority Contaminants of Ecological Concern for Sites that Qualify for the Simplified Terrestrial Ecological Evaluation Procedure (WAC 173-340-900).

[3]Table 749-4 Wildlife Exposure Model for Site-Specific Evaluations (WAC 173-340-900).

[4]Table 749-5 Default Values for Selected Hazardous Substances for use with the Wildlife Exposure Model in Table 749-4 (WAC 173-340-900).

[5]Ecological Soil Screening Levels (USEPA 2005) (USEPA 2006).

*The single silver dection was eliminated from the data set during outlier analysis.

MTCA=Model Toxics Control Act, PCB= polychlorinated biphenyl, UCL=Upper Confidence Limit, USEPA=U.S. Environmental Protection Agency, WAC=Washington Administrative Code

Table 7-1. Preliminary Remediation Goals for chemicals of potential concern

Analyte	Medium	Preliminary Remediation Goals for Residential and Industrial Land Use			
		Residential	**Source**	**Industrial**	**Source**
Benzo(a)pyrene and other carcinogenic PAHs	Soil	100 µg/kg	MTCA Method A, Residential	2000 µg/kg	MTCA Method A, Industrial
Pentachlorophenol	Soil	2500 µg/kg	MTCA Method B, Carcinogen Direct Contact (ingestion only)	330000 µg/kg	MTCA Method C, Carcinogen Direct Contact (ingestion only)
Carbon Tetrachloride	Groundwater	5 µg/L	Federal and State MCL	5 µg/L	Federal and State MCL

MCL= maximum contaminant level, MTCA=Model Toxics Control Act, PAHs: Polynuclear aromatic hydrocarbons, µg/kg: micrograms per kilogram, µg/L: micrograms per liter

APPENDICES

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APPENDIX A

PHOTOGRAPHS FROM ECOLOGICAL RECONNAISSANCE, MARCH 19-20, 2012

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Base map: ESRI Bing Maps Aerials

0 250 500 1,000 1,500 2,000 Feet

U.S. Army Corps of Engineers	**Industrial Complex Area-West**	**Former Naval Auxillary Air Station Quillayute Quillayute, Washington**

Photo 1. Former Building B5 – Transportation Building. View of foundation and surrounding urban and forested habitat.

Photo 2. Former Building B10 – Gunnery Training. View of foundation and surrounding urban habitat.

Photo 3. Building B12 – Class "C" Overhaul Shop. View of building and surrounding urban habitat.

Photo 4. Former Building B17 – Wash Rack & Shelter. View of approximate location and surrounding old field and forest habitat.

Photo 5. Former B18/19 – Paint Shops. View of building (may not be original to NAAS) and surrounding urban habitat.

Photo 6. Building B20 – Hangar. View of building and surrounding urban habitat.

Photo 7. Former Building B29 – Photo Laboratory. View of foundation (not visible) and dense scrub-shrub habitat.

Photo 1. Location of former Building B4 – Public Works Shop. Former foundation and surrounding forested habitat.

Photo 2. Location of former Building B9 – Blacksmith Shop, remaining fire pit and surrounding forested habitat.

Photo 3. Approximate location of former Buildings B119 and B119A – Paint Shops. Located in forested habitat.

Photo 1. Former Building B41 – Boiler and Generator Building. Located in forested habitat next to and south of Quillayute Road.

Photo 1. Urban habitat – mowed grass within the Quillayute Airport near Building B53.

Photo 2. Urban habitat – mowed grass within Quillayute Airport near Building B53.

Photo 3. Portion of a linear ditch in between Buildings B53 and B14.

Photo 4. Linear roadside ditch along road near Building B14.

Photo 5. Patch of *Rubus* located along the south side of Building B12.

Photo 6. Patch of Eurasian meadow located along the south side of Building B12 and west of Building B18/19.

Photo 7. Facing northeast, corner of former Building B10 and fence surrounding airport property.

Photo 8. Facing northwest, corner of Building B20 and fence surrounding airport property.

Photo 9. Roadside ditch, continuing from inside airport property, near Building B5 along Quillayute Road.

Photo 10. Roadside ditch along Quillayute Road.

Photo 11. Roadside ditch along the north side of Quillayute Road.

Photo 12. Roadside ditch along the south side of Quillayute Road.

Photo 13. Roadside ditch along the south side of Quillayute Road.

Photo 14. Facing south, view of residential property containing water supply well NI from Quillayute Road.

Photo 15. Facing south, view of man-made ponds and wetland fringe located south of residential property containing water well NI and Quillayute Road.

Photo 16. Man-made ponds and wetland fringe.

Photo 17. Wetland seep connected to man-made ponds and wetland fringe.

Photo 18. Mowed urban habitat surrounding man-made ponds and wetland fringe.

Photo 19. Gravel access road to man-made pond area located on residential property containing water supply well NI. Surrounded by scrub-shrub habitat along both sides of the road.

Photo 20. Mixed coniferous / deciduous forest located behind former Buildings B4 and B9.

Photo 21. Deciduous forest located near Building B3.

Photo 22. Coniferous forest located near Building B3.

Photo 23. Old field habitat located near Buildings B29 and B1.

Photo 24. Scrub-shrub habitat.

Photo 25. Culverted Linear ditch located near Building B40.

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APPENDIX B

DATA FROM REMEDIAL INVESTIGATION (SHANNON AND WILSON 2012)

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APPENDIX C

BASELINE RISK ASSESSMENT EQUATIONS FOR ESTIMATING EXPOSURE

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APPENDIX C - BASELINE RISK ASSESSMENT EQUATIONS FOR ESTIMATING EXPOSURE

C.1 Exposure Parameters and Exposure Calculation Results

Standard intake equations from USEPA guidance (USEPA 1989, USEPA 2004) for ingestion, dermal contact, and inhalation of chemicals (shown below) will be used along with the exposure parameters (i.e. ingestion rate, dermal absorption factors) shown in Tables C-1a through C-1d for soils, C-2a through C-2d for groundwater, and C-3 for indoor air.

C.1.1 Ingestion of Groundwater

Intakes for ingestion for groundwater chemicals of potential concern (COPCs) will be estimated using equation (C-1):

$$Chemical_Intake\left(\frac{mg}{kg-day}\right)=\frac{C_w \times IR_w \times EF \times ED}{BW \times AT} \qquad \text{(C-1)}$$

Where:

C_w	=	chemical concentration in water milligrams (mg) per liter (L)
IR_w	=	ingestion rate of water (L per day)
EF	=	exposure frequency (days/year)
ED	=	exposure duration (years)
BW	=	body weight in kilograms (kg)
AT	=	averaging (days) for carcinogens or non-carcinogens

C.1.2 Dermal contact with Groundwater

The dermal absorbed doses (DADs) from organic chemicals in groundwater will be calculated using equation (C-2) as follows (USEPA 2004):

$$DAD\left(\frac{mg}{kg-day}\right)=\frac{DA_{event} \times EV \times EF \times ED \times SA}{BW \times AT} \qquad \text{(C-2)}$$

Where:

DAD	=	dermal absorbed dose (mg/kg-day)
DA_{event}	=	absorbed dose per event in water [mg per square centimer(cm^2)-event]
EV	=	event frequency (1 event/day)
EF	=	exposure frequency (days/year)
ED	=	exposure duration (years)
SA	=	surface area of skin exposed (cm^2)
BW	=	body weight (kg)
AT	=	averaging time (days) for carcinogens or non-carcinogens

For organics, DA_{event} is calculated as follows:

(1) If $t_{event} \leq t^*$ then:

$$DA_{event}\left(\frac{mg}{cm^2 - event}\right) = 2 \times FA \times K_p \times C_w \times CF \times \left(6\tau_{event} \times \frac{t_{event}}{\pi}\right)^{1/2} \quad \text{(C-3)}$$

(2) If $t_{event} > t^*$ then:

$$DA_{event}\left(\frac{mg}{cm^2 - event}\right) = FA \times K_p \times C_w \times CF \times \left[\frac{t_{event}}{(1+B)} + 2\tau_{event}\left(\frac{1+3B+3B^2}{\{1+B\}^2}\right)\right] \quad \text{(C-4)}$$

Where:

DA_{event}	=	absorbed dose per event in water (mg/cm^2-event)
FA	=	fraction absorbed in water (chemical-specific, dimensionless)
K_p	=	permeability constant in water [chemical-specific, cm per hour (hr)]
C_w	=	concentration of chemical in water (mg/L)
CF	=	conversion factor (10^{-3} L/cm^3)
τ_{event}	=	lag time per event (chemical-specific, hr/event)
t_{event}	=	duration of event (hr/event; same value as exposure time)
B	=	chemical-specific constant reflecting the partitioning properties (dimensionless)
t*	=	chemical-specific time to reach steady-state (hr)

Values and equations for FA, K_p, t*, and B are from USEPA (2004). If a K_p value is not available for an organic COPC, it is calculated using the following empirical predictive equation (USEPA 2004):

$$\log(K_p) = -2.80 + 0.66\log(K_{ow}) - 0.0056W_M \quad \text{(C-5)}$$

Where:

K_{ow}	=	octanol/water coefficient (chemical-specific)
M_W	=	molecular weight (grams/mole)

For inorganics, DA_{event} was calculated as follows:

$$DA_{event}\left(\frac{mg}{kg - event}\right) = K_p \times C_w \times CF \times t_{event} \quad \text{(C-6)}$$

Where K_p, C_w, CF, and t_{event} are defined as shown above. Note that chemical-specific values for K_p are available from Risk Assessment Guidance for Superfund (RAGS) Part E (USEPA 2004) for selected inorganics. If no K_p value was provided, then a default value of 0.001 cm per hr is used for this class of chemicals (USEPA 2004).

C.1.3 Ingestion of Soil

Intakes for incidental ingestion of soil will be estimated by using equation (C-7):

$$Chemical_Intake\left(\frac{mg}{kg - day}\right) = \frac{C_S \times IR_S \times EF \times ED \times FI}{BW \times AT} \quad \text{(C-7)}$$

Where:

C_s = chemical concentration in soil (mg/kg)
IR_s = ingestion rate (kg/day)
EF = exposure frequency (days/year)
ED = exposure duration (years)
FI = fraction ingested (assumed value of 1, unitless)
BW = body weight (kg)
AT = averaging time (days) for carcinogens or non-carcinogens

C.1.4 Dermal Contact with Soil

The DAD from chemicals in soil will be calculated using equation (B-8) from USEPA 2004.

$$Chemical_DAD\left(\frac{mg}{kg-day}\right)=\frac{DA_{event}\times EV\times EF\times ED\times SA}{BW\times AT} \quad \text{(C-8)}$$

Where:

DAD = dermal absorbed dose (mg/kg-day)
DA_{event} = absorbed dose per event in soil (mg/cm^2-event)
EV = event frequency (1 event/day)
EF = exposure frequency (days/year)
ED = exposure duration (years)
SA = surface area of skin exposed (cm^2)
BW = body weight (kg)
AT = averaging time (days) for carcinogens or non-carcinogens

DA_{event} (mg/cm^2-event) is calculated as follows for soil COPCs:

$$DA_{event}\left(\frac{mg}{cm^2-event}\right)=C_s\times CF\times AF\times ABS \quad \text{(C-9)}$$

Where:

C_s = chemical concentration in soil (mg/kg)
CF = conversion factor (10^{-6} kg/mg)
AF = soil-to-skin adherence factor (mg/cm^2-event)
ABS = chemical-specific dermal absorption factor (unitless; USEPA 2004)

Note that only certain chemicals have a value for the dermal absorption factor (USEPA 2004). Therefore, the dermal contact with soil pathway is quantified only for these specific COPCs with a value for the dermal absorption factor.

C.1.5 Inhalation of Soil Intake

Intakes for inhalation of soil will be calculated using equation (C-10) USEPA 2009a):

$$EC\left(\frac{mg}{m^3}\right)=\left(\frac{C_a\times EF\times ED\times ET}{AT}\right) \quad \text{(C-10)}$$

Where:

EC = exposure concentration (mg/m^3)

C_a = chemical concentration in soil (mg/kg)
ET = exposure time (hrs/day)
EF = exposure frequency (days/year)
ED = exposure duration (years)
AT = averaging time (hours) for carcinogens or non-carcinogens

C_a is estimated using equation (C-11) USEPA 2002.

$$C_a\left(\frac{mg}{m^3}\right) = C_s\left(\frac{1}{PEF}\right) \quad \text{(C-11)}$$

Where:
C_s = chemical concentration in soil (mg/kg)
PEF = particulate emission factor (m^3/kg)

The particulate emission factor value used for all receptors with the exception of the construction worker (1.36×10^9 m^3/kg) is the default value in USEPA (2002). The particulate emission factor for the construction worker was set to $1x10^6$ which was recommended by Cal-DTSC 2011 to account for higher soil disturbance and dust generation during excavation work.

C.1.6 Inhalation of Volatiles in Air

Intakes for inhalation of volatile compounds in air will be calculated using equation (C-13):

$$EC\left(\frac{mg}{m^3}\right) = \frac{C_a \times EF \times ED \times ET}{AT} \quad \text{(C-13)}$$

Where:
EC = exposure concentration (mg/m^3)
C_s = chemical concentration in air (mg/m^3)
ET = exposure time (hrs/day)
EF = exposure frequency (days/year)
ED = exposure duration (years)
AT = averaging time (hours) for carcinogens or non-carcinogens

C.2 TOXICITY ASSESSMENT

The toxicity assessment will evaluate the potential for COPCs to cause adverse health effects in exposed individuals. If possible, it will estimate the relationship between intake or dose of a COPC and the likelihood or severity of adverse health effects as a result of exposure. Toxic effects have been evaluated extensively by USEPA, as presented in USEPA's *Human Health Toxicity Values in Superfund Risk Assessments* (USEPA 2003), which provides for selection of toxicity values from the following three-tiered hierarchy:

1. Tier 1 – USEPA's Integrated Risk Information System (USEPA 2009b);

2. Tier 2 – USEPA Provisional Peer Reviewed Toxicity Values;

3. Tier 3 – Other toxicity values from additional USEPA and non-USEPA sources, including California Environmental Protection Agency, Agency for Toxic Substances and

Disease Registry minimum risk levels, and USEPA's Health Effects Assessment Summary Tables (USEPA 1997).

C.3. RISK CHARACTERIZATION

The purpose of the risk characterization is to integrate the information obtained through the exposure and toxicity assessments to estimate potential risks and hazards. Potential carcinogenic effects are characterized by using projected intakes and chemical-specific, dose-response data [i.e., cancer slope factors (CSFs)] to estimate the probability that an individual will develop cancer over a lifetime. Potential non-carcinogenic effects will be characterized by comparing projected intakes of contaminants to toxicity values [i.e., reference dose (RfDs)]. The numerical risk and hazard estimates presented in the Human Health Baseline Risk Assessment must be interpreted in the context of the uncertainties and assumptions associated with the risk assessment process and with the data upon which the risk estimates are based.

C.3.1 Risk Characterization for Carcinogens

For carcinogens, risk is expressed as the probability that an individual will develop cancer over a lifetime as a result of exposure to the carcinogen. Cancer risk from exposure to contamination is expressed as the incremental lifetime cancer risk (ILCR), or the increased chance of cancer above the normal background rate of cancer. In the U.S., the background chance of contracting cancer will be a little more than three in 10, or 3×10^{-1}. The calculated ILCRs will be compared to the target goal of $1\text{x}10^{-6}$, the lowest of the range specified in the National Oil and Hazardous Substances Pollution Contingency Plan of 1×10^{-4} to 1×10^{-6}, or 1-in-10,000 to 1-in-1,000,000 exposed persons developing an excess cancer.

The ILCR for each medium/carcinogenic COPC will be calculated using one of the equations below (USEPA 1989, USEPA 2009a):

$$ILCR = I_C \times CSF \qquad \text{(C-14)}$$

$$ILCR = IUR \times EC \qquad \text{(C-15)}$$

Where:

I_C	=	chronic daily intake or DAD for carcinogenic effects calculated in the exposure assessment averaged over the receptor's lifetime (mg/kg-d)
EC	=	Exposure concentration (mg/m^3)
IUR	=	Inhalalation unit risk $(mg/m^3)^{-1}$
CSF	=	cancer slope factor $(mg/kg\text{-}day)^{-1}$

For a given exposure pathway from each investigation area, the total risk to a receptor exposed to several carcinogenic COPCs is the sum of the ILCRs for each carcinogen, as shown in equation C-16 below:

$$ILCR_{total} = \Sigma ILCR_i \qquad \text{(C-16)}$$

Where:

$ILCR_{total}$= total probability of cancer incidence associated with all carcinogenic COPCs
$ILCR_i$ = ILCR for the ith COPC

In addition to summing risks across all carcinogenic COPCs, risks will be summed across all exposure pathways for a given environmental medium (e.g., ingestion, inhalation, and dermal contact with soil). Per USEPA (1989) guidance, there will be two steps required to determine whether risks or hazard indexes (HIs) for two or more pathways should be combined for a single exposed individual or group of individuals. The first will be to identify reasonable exposure pathway combinations. The second will be to examine whether it will be likely that the same individuals would consistently face the Reasonable Maximum Exposure (RME) by more than one pathway. It is reasonable to assume that the same individual may be exposed to a given exposure medium at the RME level by multiple pathways. It should be noted that that ILCR is an upper bound estimate of the cancer risk that may occur as a result of the exposure; the "true" cancer risk, especially for chemicals where the slope factor is based on animal data, is likely to be less and may even be zero.

C.3.2 Risk Characterization for Non-Carcinogens

In addition to developing cancer from exposure to contaminants, an individual may experience other toxic effects. The term "toxic effects" is used here to describe a wide variety of systemic effects ranging from minor irritations, such as eye irritation and headaches, to more substantial effects, such as kidney or liver disease and neurological damage. The risks associated with toxic (i.e., non-carcinogenic) chemicals will be evaluated by comparing an estimated exposure (i.e., intake or dose) from site media to an acceptable exposure expressed as a reference dose (RfD). The RfD is the threshold level below which no toxic effects is expected to occur in a population, including sensitive subpopulations. The ratio of intake over the RfD is the hazard quotient (HQ) (USEPA 1989) and will be calculated as:

$$HQ = \frac{I_{NC}}{RfD} \qquad \text{(C-17)}$$

Where

I = daily intake or DAD for non-carcinogenic effects of a COPC averaged over the exposure duration (mg/kg-day)
RfD = reference dose (mg/kg-day)

The HQs for each COPC/investigation area will be summed to obtain an HI for an investigation area, as shown below:

$$HI = \Sigma HQ_i \qquad \text{(C-18)}$$

Where
HI = hazard index for all toxic effects
HQ_i = hazard quotient for the ith COPC

An HI greater than one has been defined as the level of concern for potential adverse non-carcinogenic health effects (USEPA 1989). This approach differs from the probabilistic approach used to evaluate carcinogens. An HQ of 0.01 does not imply a 1-in-100 chance of an adverse

effect, but indicates only that the estimated intake will be 100 times less than the threshold level at which adverse health effects may occur. In addition to summing hazards across all COPCs, hazards will be summed across all exposure pathways for a given environmental medium.

Note that HIs are determined by assuming dose additivity for those constituents acting by the same mechanism and inducing the same effects (USEPA 1989). Initially, all of the COPCs are assumed to have the same mechanism of toxicity. If the HI (across all COPCs) is below 1, then all target organ-specific HIs will also be below 1. If the HI exceeds 1, then HIs are calculated for each target organ. This approach provides a more accurate estimation of the potential systemic toxicity associated with exposure to the constituent mixture.

C.3.3 Identification of Contaminants of Concern

Carcinogenic contaminants of concern are defined for each media as those contaminants that have a total ILCR greater than 1×10^{-6} for a receptor in this BLRA. Non-carcinogenic COCs are defined for each media as those contaminants that produce an HI greater than 1 for a receptor in this BLRA.

C-4 REFERENCES

Cal-DTSC (California Department of Toxic Substances Control) 2011. Human Health Risk Assessment (HHRA) Note Number 1, Recommended DTSC Default Exposure Factors for Use in Risk Assessment at California Hazardous Waste Sites and Permitted Facilities

USEPA (U.S. Environmental Protection Agency) 1989. Risk Assessment Guidance for Superfund, Vol. 1: Human Health Evaluation Manual (Part A), USEPA/540/1-89/002, Washington, D.C.

USEPA (U.S. Environmental Protection Agency) 1997. Health Effects Assessment Summary Tables (HEAST), Office of Solid Waste and Emergency Response, Washington, D.C.

USEPA (U.S. Environmental Protection Agency) 2002. Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites, OSWER 9355.4-24. Office of Solid Waste and Emergency Response.

USEPA (U.S. Environmental Protection Agency) 2003. Human Health Toxicity Values in Superfund Risk Assessments.

USEPA (U.S. Environmental Protection Agency) 2004. Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment) Final, OSWER 9285.7-02EP.

USEPA (U.S. Environmental Protection Agency) 2009a. Risk Assessment Guidance for Superfund, Volume I: Human Health Evaluation Manual (Part F, Supplemental Guidance for Inhalation Risk Assessment, Final), USEPA-540-R-070-002, OSWER 9285.7-82. Washington, D.C

USEPA (U.S. Environmental Protection Agency) 2009b. Integrated Risk Information System (IRIS) Database, Office of Research and Development, Washington, D.C. Available online: http://cfpub.USEPA.gov/ncea/iris/index.cfm

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APPENDIX C TABLES

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Table C-1a. Exposure parameters for residential receptors exposed to soil at the former NAAS Quillayute

Parameter	Units	Reasonable Maximum Exposure Scenario		Central Tendency Exposure Scenario		Source
		Resident Adult	Resident Child	Resident Adult	Resident Child	
Incidental Ingestion of Soil						
Soil Ingestion Rate (IRs)	(mg/day)	100	200	50	100	CTE: Table 5-1 of USEPA (2011a); RME: USEPA (1991a)
Exposure Frequency (EF)	(days/year)	350	350	350	350	USEPA (1991a)
Exposure Duration (ED) [a]	(years)	30	6	30	6	USEPA (2002b)
Body Weight (BW)	(kg)	70	15	70	15	USEPA (1991a)
Carcinogen Averaging Time (AT)	(days)	25,550	25,550	25,550	25,550	Lifetime of 70 years, USEPA (1991a)
Non-carcinogen Averaging Time (AT)	(days)	10,950	2,190	10,950	2,190	Same as Exposure Duration
Fraction ingested (FI)	(-)	1	1	1	1	
Dermal Contact with Soil						
Adherence Factor (AF)	(mg/cm^2)	0.07	0.2	0.07	0.2	USEPA (2002b)
Skin Area (SA)	(cm^2)	5,700	2,800	5,700	2,800	USEPA (2002b)
Event Frequency (EV)	(events/day)	1	1	1	1	Reasonable estimate
Exposure Frequency (EF)	(days/year)	350	350	350	350	USEPA (1991a)
Exposure Duration (ED)	(years)	30	6	30	6	USEPA (1991a)
Body weight (BW)	(kg)	70	15	70	15	USEPA (1991a)
Carcinogen Averaging Time (AT)	(days)	25,550	25,550	25,550	25,550	Lifetime of 70 years, USEPA (1991a)
Non-carcinogen Averaging Time (AT)	(days)	10,950	2,190	10,950	2,190	Same as Exposure Duration
Inhalation of Dust						
Particulate Emission factor (PEF)	(m^3/kg)	$1.36x10^9$	$1.36x10^9$	$1.36x10^9$	$1.36x10^9$	USEPA (2002b)
Exposure Frequency (EF)	(days/year)	350	350	350	350	USEPA (1991a)
Exposure Duration (ED)	(years)	30	6	30	6	USEPA (1991a)
Exposure Time (ET)	(hrs/day)	24	24	24	24	Reasonable estimate
Carcinogen averaging time (AT)	(days)	25,550	25,550	25,550	25,550	Lifetime of 70 years, USEPA (1991a)
Non-carcinogen averaging time (AT)	(days)	10,950	2,190	10,950	2,190	Same as Exposure Duration

[a] Exposure Duration for adult of 30 years consists of 6 years as child and 24 years as adult.

Parameters that vary between CTE and RME scenarios

CTE=Central Tendency Exposure, RME=Reasonable Maximum Exposure, USEPA=U.S. Environmental Protection Agency

Table C-1b. Exposure parameters for visitors and recreationists receptors exposed to soil at the former NAAS Quillayute

Parameter	Units	Visitor/Recreationist Adult	Visitor/Recreationist Child	Source
Incidental Ingestion of Soil				
Soil Ingestion Rate (IRs)	(mg/day)	50	100	Assume half of residential receptor
Exposure Frequency (EF)	(days/year)	75	75	Reasonable estimate
Exposure Duration (ED) [a]	(years)	30	6	USEPA (2002b)
Body Weight (BW)	(kg)	70	15	USEPA (2002b)
Carcinogen Averaging Time (AT)	(days)	25,550	25,550	Lifetime of 70 years, USEPA (2002b)
Non-carcinogen Averaging Time (AT)	(days)	10,950	2,190	Same as Exposure Duration
Fraction ingested (FI)	(-)	1	1	
Dermal Contact with Soil				
Adherence Factor (AF)	(mg/cm^2)	0.07	0.2	USEPA (2002b)
Skin Area (SA)	(cm^2)	5,700	2,800	USEPA (2002b)
Event Frequency (EV)	(events/day)	1	1	Reasonable estimate
Exposure Frequency (EF)	(days/year)	75	75	Reasonable estimate
Exposure Duration (ED)	(years)	30	6	USEPA (2002b)
Body weight (BW)	(kg)	70	15	USEPA (2002b)
Carcinogen Averaging Time (AT)	(days)	25,550	25,550	Lifetime of 70 years, USEPA (2002b)
Non-carcinogen Averaging Time (AT)	(days)	10,950	2,190	Same as Exposure Duration
Inhalation of Dust				
Particulate Emission factor (PEF)	(m^3/kg)	$1.36x10^9$	$1.36x10^9$	USEPA (2002b)
Exposure Frequency (EF)	(days/year)	75	75	Reasonable estimate
Exposure Duration (ED)	(years)	30	6	USEPA (2002b)
Exposure Time (ET)	(hrs/day)	4	4	Reasonable estimate
Carcinogen averaging time (AT)	(days)	25,550	25,550	Lifetime of 70 years, USEPA (2002b)
Non-carcinogen averaging time (AT)	(days)	10,950	2,190	Same as Exposure Duration

[a] Exposure Duration for adult of 30 years consists of 6 years as child and 24 years as adult.

USEPA=U.S. Environmental Protection Agency

Table C-1c. Exposure parameters for outdoor worker receptor exposed to soil at the former NAAS Quillayute

Parameter	Units	Outdoor Worker	Source
Incidental Ingestion of Soil			
Soil Ingestion Rate (IRs)	(mg/day)	100	USEPA (2002b)
Exposure Frequency (EF)	(days/year)	225	USEPA (2002b)
Exposure Duration (ED)	(years)	25	USEPA (2002b)
Body Weight (BW)	(kg)	70	USEPA (2002b)
Carcinogen Averaging Time (AT)	(days)	25,550	Lifetime of 70 years, USEPA (2002b)
Non-carcinogen Averaging Time (AT)	(days)	9,125	Same as Exposure Duration
Fraction ingested (FI)	(-)	1	
Dermal Contact with Soil			
Adherence Factor (AF)	(mg/cm^2)	0.2	USEPA (2002b)
Skin Area (SA)	(cm^2)	3,300	USEPA (2002b)
Event Frequency (EV)	(events/day)	1	Reasonable Estimate
Exposure Frequency (EF)	(days/year)	225	USEPA (2002b)
Exposure Duration (ED)	(years)	25	USEPA (2002b)
Body weight (BW)	(kg)	70	USEPA (2002b)
Carcinogen Averaging Time (AT)	(days)	25,550	Lifetime of 70 years, USEPA 2002b, Exhibit 1-2
Non-carcinogen Averaging Time (AT)	(days)	9,125	Same as Exposure Duration
Inhalation of Dust			
Particulate Emission factor (PEF)	(m^3/kg)	$1.36x10^9$	USEPA (2002b)
Exposure Frequency (EF)	(days/year)	225	USEPA (2002b)
Exposure Duration (ED)	(years)	25	USEPA (2002b)
Exposure Time (ET)	(hrs/day)	8	Reasonable Estimate
Carcinogen averaging time (AT)	(days)	25,550	Lifetime of 70 years, USEPA (2002b)
Non-carcinogen averaging time (AT)	(days)	9,125	Same as Exposure Duration

USEPA=U.S. Environmental Protection Agency

Table C-1d. Exposure parameters for excavation/construction worker receptor exposed to soil at the former NAAS Quillayute

Parameter	Units	Excavation/Construction Worker	Source
Incidental Ingestion of Soil			
Soil Ingestion Rate (IRs)	(mg/day)	330	USEPA (2002)
Exposure Frequency (EF)	(days/year)	120	Corresponds to 24 weeks, 5 days a week
Exposure Duration (ED)	(years)	1	Reasonable estimate
Body Weight (BW)	(kg)	70	USEPA (2002)
Carcinogen Averaging Time (AT)	(days)	25,550	Lifetime of 70 years, USEPA (2002)
Non-carcinogen Averaging Time (AT)	(days)	365	Same as Exposure Duration
Fraction ingested (FI)	(-)	1	
Dermal Contact with Soil			
Adherence Factor (AF)	(mg/cm^2)	0.3	USEPA (2002)
Skin Area (SA)	(cm^2)	3,300	USEPA (2002)
Event Frequency (EV)	(events/day)	1	Reasonable estimate
Exposure Frequency (EF)	(days/year)	120	Corresponds to 24 weeks, 5 days a week
Exposure Duration (ED)	(years)	1	Reasonable estimate
Body weight (BW)	(kg)	70	USEPA (2002)
Carcinogen Averaging Time (AT)	(days)	25,550	Lifetime of 70 years, USEPA (2002)
Non-carcinogen Averaging Time (AT)	(days)	365	Same as Exposure Duration
Inhalation of Dust			
Particulate Emission factor (PEF)	(m^3/kg)	$1x10^6$	Cal-DTSC (2011) [a]
Exposure Frequency (EF)	(days/year)	120	Corresponds to 24 weeks, 5 days a week
Exposure Duration (ED)	(years)	1	Reasonable estimate
Exposure Time (ET)	(hrs/day)	8	Typical workday duration
Carcinogen averaging time (AT)	(days)	25,550	Lifetime of 70 years, USEPA (2002)
Non-carcinogen averaging time (AT)	(days)	1	Same as Exposure Duration

Cal-DTSC=California Department of Toxic Substances Control, USEPA=U.S. Environmental Protection Agency

[a] This PEF value corresponds to a respirable dust concentration of 1 mg/m^3. This is based on a maximum concentration of dust in air recommended by the American Conference of Government Industrial Hygienists, and that assumption that 10% of the mass of particles are in the respirable PM10 range. (Cal-DTSC 2011).

Table C-2a. Exposure parameters for residential receptors exposed to groundwater as tap water at the former NAAS Quillayute

Parameter	Units	Reasonable Maximum Exposure Resident Adult	Reasonable Maximum Exposure Resident Child	Central Tendency Exposure Resident Adult	Central Tendency Exposure Resident Child	Source
Ingestion of groundwater as tap water						
Drinking water ingestion rate (IRw)	(L/day)	2	1	1.04	0.327	CTE: Table 3-1 of USEPA (2011a) [a]; RME: USEPA (1989)
Exposure frequency (EF)	(days/year)	350	350	350	350	USEPA (1991a)
Exposure duration (ED)	(years)	30	6	30	6	USEPA (1991a)
Body weight (BW)	(kg)	70	15	70	15	USEPA (1991a)
Carcinogenic Averaging Time (AT)	(days)	25550	25550	25550	25550	Lifetime of 70 years, USEPA (1991a)
Non-carcinogen Averaging Time (AT)	(days)	10950	2190	10950	2190	Same as Exposure Duration
Dermal contact with groundwater as tap water while showering						
Event frequency (EV)	(event/day)	1	1	1	1	Reasonable estimate
Event duration (t_event)	(hr)	0.58	1	0.58	1	USEPA (2004)
Exposure frequency (EF)	(days/year)	350	350	350	350	USEPA (1991a)
Exposure duration (ED)	(years)	30	6	30	6	USEPA (1991a)
Apparent thickness of skin stratum corneum (lsc)	(cm)	0.001	0.001	0.001	0.001	USEPA (2004)
Surface Area of Skin exposed (SA)	(cm^2)	18000	6600	18000	6600	USEPA (2002b)
Body weight (BW)	(kg)	70	15	70	15	USEPA (2002b)
Carcinogen Averaging Time (AT)	(days)	25550	25550	25550	25550	Lifetime of 70 years, USEPA (2002b)
Non-carcinogen Averaging time (AT)	(days)	10950	2190	10950	2190	USEPA (2002)
Inhalation of volatiles from groundwater as tap water						
Andelman Volatilization Factor	(L/m^3)	0.5	0.5	0.5	0.5	USEPA (1991b)
Exposure Frequency (EF)	(days/year)	350	350	350	350	USEPA (1991a)
Exposure Duration (ED)	(years)	30	6	12	6	USEPA (1991a)
Exposure Time (ET)	(hrs/day)	24	24	24	24	Reasonable estimate
Carcinogen averaging time (AT)	(days)	25550	25550	25550	25550	Lifetime of 70 years, USEPA (2002b)
Non-carcinogen averaging time (AT)	(days)	10950	2190	4380	2190	Same as Exposure Duration

CTE=Central Tendency Exposure, RME=Reasonable Maximum Exposure, USEPA=U.S. Environmental Protection Agency

Highlighted cells show parameters that are different between the CTE and RME scenarios.

[a] CTE drinking water ingestion rates for resident adult (1.043 L/day) and child (0.327 L/day) correspond to the recommended values for mean drinking water ingestion rates in Table 3-1 of USEPA (2011) for age groups >21 years and 3 to <6 years, respectively.

Table C-2b. Exposure parameters for visitors and recreationists exposed to groundwater as tap water at the former NAAS Quillayute

Parameter	Units	Visitor/Recreationist Adult	Visitor/Recreationist Child	Source
Ingestion of Groundwater as Tap water				
Drinking water ingestion rate (IRw)	(L/day)	1	0.5	Reasonable estimate
Exposure frequency (EF)	(days/year)	75	75	Reasonable estimate
Exposure duration (ED) [a]	(years)	30	6	USEPA (1991a)
Body weight (BW)	(kg)	70	15	USEPA (1991a)
Carcinogenic Averaging Time (AT)	(days)	25,550	25,550	Lifetime of 70 years, USEPA (1991a)
Non-carcinogen Averaging Time (AT)	(days)	10,950	2,190	Same as Exposure Duration

USEPA=U.S. Environmental Protection Agency

[a] ED for the visitor/recreationist adult assumed to be the same as exposure duration for adult residents. The ED for the adult visitor/recreationist is assumed to consist of 6 years as a child, and the remaining years as an adult.

Table C-2c. Exposure parameters for outdoor worker receptor exposed to groundwater as tap water at the former NAAS Quillayute

Parameter	Units	Outdoor Worker	Source
Ingestion of groundwater as tap water			
Drinking water ingestion rate (IRw)	(L/day)	1	USEPA (1991a)
Exposure frequency (EF)	(days/year)	225	USEPA (2002b)
Exposure duration (ED)	(years)	25	USEPA (1991a)
Body weight (BW)	(kg)	70	USEPA (1991a)
Carcinogenic Averaging Time (AT)	(days)	25,550	Lifetime of 70 years, USEPA (1991a)
Non-carcinogen Averaging Time (AT)	(days)	9,125	Same as Exposure Duration
Dermal contact with groundwater as tap water while showering			
Event frequency (EV)	(event/day)	1	Reasonable estimate
Event duration (t_event)	(hr)	0.58	USEPA (2004)
Exposure frequency (EF)	(days/year)	225	USEPA (2002b)
Exposure duration (ED)	(years)	25	USEPA (1991a)
Apparent thickness of skin stratum corneum (lsc)	(cm^2)	0.001	USEPA (2004)
Surface Area of Skin exposed (SA)	(cm^2)	18,000	USEPA (2004)
Body weight (BW)	(kg)	70	USEPA (1991a)
Carcinogen Averaging Time (AT)	(days)	25,550	Lifetime of 70 years, USEPA (1991a)
Non-carcinogen Averaging time (AT)	(days)	9,125	Same as Exposure Duration

Table C-2d. Exposure parameters for excavation/construction worker receptors exposed to groundwater as tap water at the former NAAS Quillayute

Parameter	Units	Excavation/Construction Worker	Source
Ingestion of groundwater as tap water			
Drinking water ingestion rate (IRw)	(L/day)	1	USEPA (1991a)
Exposure frequency (EF)	(days/year)	120	Correspond to 4 and 24 weeks, 5 days a week
Exposure duration (ED)	(year)	1	Reasonable estimate
Body weight (BW)	(kg)	70	USEPA (1991a)
Carcinogenic Averaging Time (AT)	(days)	25,550	Lifetime of 70 years, USEPA (1991a)
Non-carcinogen Averaging Time (AT)	(days)	365	Same as Exposure Duration
Dermal contact with groundwater as tap water while showering			
Event frequency (EV)	(event/day)	1	Reasonable estimate
Event duration (t_event)	(hr)	0.58	USEPA (2004)
Exposure frequency (EF)	(days/year)	120	Correspond to 4 and 24 weeks, 5 days a week
Exposure duration (ED)	(years)	1	Reasonable estimate
Apparent thickness of skin stratum corneum (lsc)	(cm^2)	0.001	USEPA (2004)
Surface Area of Skin exposed (SA)	(cm^2)	18,000	USEPA (2004)
Body weight (BW)	(kg)	70	USEPA (1991a)
Carcinogen Averaging Time (AT)	(days)	25,550	Lifetime of 70 years, USEPA (1991a)
Non-carcinogen Averaging time (AT)	(days)	365	Same as Exposure Duration

USEPA=U.S. Environmental Protection Agency

Table C-3. Exposure parameters for residential receptors exposed to indoor air potentially impacted by vapor intrusion at the former NAAS Quillayute B44 slab

Parameter	Units	Reasonable Maximum Exposure Scenario		Central Tendency Exposure Scenario		Source
		Resident Adult	Resident Child	Resident Adult	Resident Child	
Inhalation of Volatiles in Indoor Air						
Exposure Time (ET)	(hrs/day)	24	24	20	18.5	CTE: USEPA (2011a)[a]; RME: Whole day exposure
Exposure frequency (EF)	(days/year)	350	350	350	350	USEPA (1991a)
Exposure duration (ED) [a]	(years)	30	6	30	6	USEPA (1991a)
Carcinogenic Averaging Time (AT)	(days)	25550	25550	25550	25550	Lifetime of 70 years, USEPA (1991a)
Non-carcinogen Averaging Time (AT)	(days)	10950	2190	10950	2190	Same as Exposure Duration

CTE=Central Tendency Exposure, RME=Reasonable Maximum Exposure, USEPA=U.S. Environmental Protection Agency

Highlighted cells show parameters that are different between the CTE and RME scenarios.

[a] The child and adult CTE Exposure Times are based on the mean time indoors at residence recommended by USEPA (2011a) (Table 16-1) for age groups birth to < 1 year and >65 years. USEPA (2011) provided recommended values for activity patterns by age groups, and the birth to < 1 year and > 65 years were the age groups with the longest exposure times for the child/<6 years and adult age ranges, respectively.

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APPENDIX D

PROUCL 4.1.01 RESULTS AND KAPLAN MEIER CALCULATIONS FOR BENZO(A)PYRENE EQUIVALENT CONCENTRATIONS

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Summary Statistics for Raw Full Data Sets

Variable	NumObs	Minimum	Maximum	Mean	Median	Variance	SD	MAD/0.675	Skewness	Kurtosis
BaPEq (b10)	12	1.941	52	18.31	12.73	260.9	16.15	14.64	0.803	-0.27
BaPEq (b101_b102)	8	1.046	84.29	22.07	13.32	715.2	26.74	7.363	2.249	5.344
BaPEq (b11_b7)	7	3.939	27.94	15.1	14.69	55.15	7.426	5.681	0.359	1.291
BaPEq (b119_b119a)	7	2.873	7.668	4.294	3.555	2.781	1.668	1.008	1.697	2.843
BaPEq (b12)	11	1.777	15.67	4.848	3.683	15.03	3.877	1.498	2.55	7.112
BaPEq (b17)	14	3.192	98.23	29.85	23.39	838.5	28.96	23.72	1.474	1.686
BaPEq (b18_b19)	6	3.197	4.248	3.812	3.933	0.167	0.408	0.363	-0.697	-1.068
BaPEq (b20)	4	49.56	106.3	73.27	68.6	581.5	24.11	17.65	1.044	1.472
BaPEq (b29)	10	2.372	11.18	4.207	3.158	7.216	2.686	0.68	2.377	5.78
BaPEq (b4)	18	4.088	151	51.96	22.75	2917	54.01	24.64	0.8	-1.125
BaPEq (b41)	14	6.249	142.8	40.48	25.64	1662	40.76	23.49	1.53	1.887
BaPEq (b49)	4	6.861	44.98	20.9	15.88	320.2	17.89	12.74	1.04	-0.321
BaPEq (b5)	12	7.31	247.9	83.7	55.79	5911	76.88	56.2	1.261	0.732
BaPEq (b65)	4	5.556	7.184	6.589	6.808	0.587	0.766	0.537	-1.055	-0.249
BaPEq (b9)	9	3.764	69.14	22.94	13.25	536.2	23.16	12.98	1.437	0.881

Percentiles for Raw Full Data Sets

Variable	NumObs	5%ile	10%ile	20%ile	25%ile(Q1)	50%ile(Q2)	75%ile(Q3)	80%ile	90%ile	95%ile
BaPEq (b10)	12	2.951	3.827	4.431	4.852	12.73	30.79	32.24	33.39	41.8
BaPEq (b101_b102)	8	3.604	6.162	8.356	8.356	13.32	19.57	25.67	48.13	66.21
BaPEq (b11_b7)	7	5.722	7.506	10.77	12.1	14.69	17.46	18.1	22.29	25.12
BaPEq (b119_b119a)	7	2.981	3.088	3.255	3.292	3.555	4.688	4.96	6.152	6.91
BaPEq (b12)	11	2.194	2.61	2.757	2.814	3.683	4.904	5.115	7.155	11.41
BaPEq (b17)	14	4.332	4.985	5.103	6.376	23.39	37.19	39.01	70.58	88.42
BaPEq (b18_b19)	6	3.262	3.327	3.457	3.549	3.933	4.09	4.107	4.178	4.213
BaPEq (b20)	4	51.7	53.84	58.12	60.26	68.6	81.61	86.55	96.44	101.4
BaPEq (b29)	10	2.47	2.568	2.842	2.932	3.158	3.788	4.365	6.787	8.985
BaPEq (b4)	18	4.522	6.74	9.089	9.292	22.75	105.5	113	134.1	139.8
BaPEq (b41)	14	7.049	8.023	9.905	10.69	25.64	55.68	66.56	92.43	115.2
BaPEq (b49)	4	6.989	7.118	7.375	7.503	15.88	29.28	32.42	38.7	41.84
BaPEq (b5)	12	11.37	15.02	22.08	33.48	55.79	104.1	127	200.9	226.1
BaPEq (b65)	4	5.692	5.827	6.098	6.234	6.808	7.163	7.168	7.176	7.18
BaPEq (b9)	9	4.056	4.349	7.613	9.691	13.25	23.63	35.94	57.35	63.25

	M
1	
2	
3	
4	
5	**CV**
6	0.882
7	1.212
8	0.492
9	0.388
10	0.8
11	0.97
12	0.107
13	0.329
14	0.639
15	1.04
16	1.007
17	0.856
18	0.919
19	0.116
20	1.009
21	
22	
23	
24	**99%ile**
25	49.96
26	80.67
27	27.38
28	7.517
29	14.82
30	96.27
31	4.241
32	105.3
33	10.74
34	148.7
35	137.3
36	44.35
37	243.5
38	7.183
39	67.96

	A	B	C	D	E	F	G	H	I	J	K	L
1					**Outlier Tests for Selected Variables**							
2				**User Selected Options**								
3				From File	C:\Users\Libby West\Documents\Geo\Quillayute\Risk Calcs July 2013\ProUCL July 2013\BaPEqNoDupsNoAsphaltSamps-Oct201							
4				Full Precision	OFF							
5				Test for Suspected Outliers with Dixon test	1							
6				Test for Suspected Outliers with Rosner test	1							
7												
8												
9				**Dixon's Outlier Test for BaPEq (b10)**								
10												
11	Number of data = 13											
12	10% critical value: 0.467											
13	5% critical value: 0.521											
14	1% critical value: 0.615											
15												
16	**1. Data Value 154.81 is a Potential Outlier (Upper Tail)?**											
17												
18	Test Statistic: 0.804											
19												
20	For 10% significance level, 154.81 is an outlier.											
21	For 5% significance level, 154.81 is an outlier.											
22	For 1% significance level, 154.81 is an outlier.											
23												
24	**2. Data Value 1.9411 is a Potential Outlier (Lower Tail)?**											
25												
26	Test Statistic: 0.047											
27												
28	For 10% significance level, 1.9411 is not an outlier.											
29	For 5% significance level, 1.9411 is not an outlier.											
30	For 1% significance level, 1.9411 is not an outlier.											
31												
32												
33				**Dixon's Outlier Test for BaPEq (b101_b102)**								
34												
35	Number of data = 8											
36	10% critical value: 0.479											
37	5% critical value: 0.554											
38	1% critical value: 0.683											
39												
40	**1. Data Value 84.2893333333333 is a Potential Outlier (Upper Tail)?**											
41												
42	Test Statistic: 0.680											
43												
44	For 10% significance level, 84.2893333333333 is an outlier.											
45	For 5% significance level, 84.2893333333333 is an outlier.											
46	For 1% significance level, 84.2893333333333 is not an outlier.											
47												
48	**2. Data Value 1.04626666666667 is a Potential Outlier (Lower Tail)?**											
49												
50	Test Statistic: 0.231											
51												
52	For 10% significance level, 1.04626666666667 is not an outlier.											
53	For 5% significance level, 1.04626666666667 is not an outlier.											
54	For 1% significance level, 1.04626666666667 is not an outlier.											
55												
56												
57				**Dixon's Outlier Test for BaPEq (b11_b7)**								
58												
59	Number of data = 8											

	A	B	C	D	E	F	G	H	I	J	K	L
60	10% critical value: 0.479											
61	5% critical value: 0.554											
62	1% critical value: 0.683											
63												
64	**1. Data Value 95.297 is a Potential Outlier (Upper Tail)?**											
65												
66	Test Statistic: 0.789											
67												
68	For 10% significance level, 95.297 is an outlier.											
69	For 5% significance level, 95.297 is an outlier.											
70	For 1% significance level, 95.297 is an outlier.											
71												
72	**2. Data Value 3.93896985313415 is a Potential Outlier (Lower Tail)?**											
73												
74	Test Statistic: 0.248											
75												
76	For 10% significance level, 3.93896985313415 is not an outlier.											
77	For 5% significance level, 3.93896985313415 is not an outlier.											
78	For 1% significance level, 3.93896985313415 is not an outlier.											
79												
80												
81	**Dixon's Outlier Test for BaPEq (b119_b119a)**											
82												
83	Number of data = 8											
84	10% critical value: 0.479											
85	5% critical value: 0.554											
86	1% critical value: 0.683											
87												
88	**1. Data Value 88.836 is a Potential Outlier (Upper Tail)?**											
89												
90	Test Statistic: 0.948											
91												
92	For 10% significance level, 88.836 is an outlier.											
93	For 5% significance level, 88.836 is an outlier.											
94	For 1% significance level, 88.836 is an outlier.											
95												
96	**2. Data Value 2.8734 is a Potential Outlier (Lower Tail)?**											
97												
98	Test Statistic: 0.075											
99												
100	For 10% significance level, 2.8734 is not an outlier.											
101	For 5% significance level, 2.8734 is not an outlier.											
102	For 1% significance level, 2.8734 is not an outlier.											
103												
104												
105	**Dixon's Outlier Test for BaPEq (b12)**											
106												
107	Number of data = 12											
108	10% critical value: 0.49											
109	5% critical value: 0.546											
110	1% critical value: 0.642											
111												
112	**1. Data Value 47.991 is a Potential Outlier (Upper Tail)?**											
113												
114	Test Statistic: 0.900											
115												
116	For 10% significance level, 47.991 is an outlier.											
117	For 5% significance level, 47.991 is an outlier.											
118	For 1% significance level, 47.991 is an outlier.											

	A	B	C	D	E	F	G	H	I	J	K	L
119												
120	**2. Data Value 1.7768 is a Potential Outlier (Lower Tail)?**											
121												
122	Test Statistic: 0.071											
123												
124	For 10% significance level, 1.7768 is not an outlier.											
125	For 5% significance level, 1.7768 is not an outlier.											
126	For 1% significance level, 1.7768 is not an outlier.											
127												
128												
129					**Dixon's Outlier Test for BaPEq (b17)**							
130												
131	Number of data = 14											
132	10% critical value: 0.492											
133	5% critical value: 0.546											
134	1% critical value: 0.641											
135												
136	**1. Data Value 98.23 is a Potential Outlier (Upper Tail)?**											
137												
138	Test Statistic: 0.611											
139												
140	For 10% significance level, 98.23 is an outlier.											
141	For 5% significance level, 98.23 is an outlier.											
142	For 1% significance level, 98.23 is not an outlier.											
143												
144	**2. Data Value 3.1918 is a Potential Outlier (Lower Tail)?**											
145												
146	Test Statistic: 0.049											
147												
148	For 10% significance level, 3.1918 is not an outlier.											
149	For 5% significance level, 3.1918 is not an outlier.											
150	For 1% significance level, 3.1918 is not an outlier.											
151												
152												
153					**Dixon's Outlier Test for BaPEq (b18_b19)**							
154												
155	Number of data = 6											
156	10% critical value: 0.482											
157	5% critical value: 0.56											
158	1% critical value: 0.698											
159												
160	**1. Data Value 4.248188 is a Potential Outlier (Upper Tail)?**											
161												
162	Test Statistic: 0.134											
163												
164	For 10% significance level, 4.248188 is not an outlier.											
165	For 5% significance level, 4.248188 is not an outlier.											
166	For 1% significance level, 4.248188 is not an outlier.											
167												
168	**2. Data Value 3.19741 is a Potential Outlier (Lower Tail)?**											
169												
170	Test Statistic: 0.247											
171												
172	For 10% significance level, 3.19741 is not an outlier.											
173	For 5% significance level, 3.19741 is not an outlier.											
174	For 1% significance level, 3.19741 is not an outlier.											
175												
176												
177					**Dixon's Outlier Test for BaPEq (b20)**							

	A	B	C	D	E	F	G	H	I	J	K	L
178												
179	Number of data = 4											
180	10% critical value: 0.679											
181	5% critical value: 0.765											
182	1% critical value: 0.889											
183												
184	**1. Data Value 106.33 is a Potential Outlier (Upper Tail)?**											
185												
186	Test Statistic: 0.581											
187												
188	For 10% significance level, 106.33 is not an outlier.											
189	For 5% significance level, 106.33 is not an outlier.											
190	For 1% significance level, 106.33 is not an outlier.											
191												
192	**2. Data Value 49.5553333333333 is a Potential Outlier (Lower Tail)?**											
193												
194	Test Statistic: 0.251											
195												
196	For 10% significance level, 49.5553333333333 is not an outlier.											
197	For 5% significance level, 49.5553333333333 is not an outlier.											
198	For 1% significance level, 49.5553333333333 is not an outlier.											
199												
200												
201					**Dixon's Outlier Test for BaPEq (b29)**							
202												
203	Number of data = 11											
204	10% critical value: 0.517											
205	5% critical value: 0.576											
206	1% critical value: 0.679											
207												
208	**1. Data Value 147.23 is a Potential Outlier (Upper Tail)?**											
209												
210	Test Statistic: 0.974											
211												
212	For 10% significance level, 147.23 is an outlier.											
213	For 5% significance level, 147.23 is an outlier.											
214	For 1% significance level, 147.23 is an outlier.											
215												
216	**2. Data Value 2.3719 is a Potential Outlier (Lower Tail)?**											
217												
218	Test Statistic: 0.061											
219												
220	For 10% significance level, 2.3719 is not an outlier.											
221	For 5% significance level, 2.3719 is not an outlier.											
222	For 1% significance level, 2.3719 is not an outlier.											
223												
224												
225					**Dixon's Outlier Test for BaPEq (b4)**							
226												
227	Number of data = 18											
228	10% critical value: 0.424											
229	5% critical value: 0.475											
230	1% critical value: 0.561											
231												
232	**1. Data Value 150.955 is a Potential Outlier (Upper Tail)?**											
233												
234	Test Statistic: 0.129											
235												
236	For 10% significance level, 150.955 is not an outlier.											

	A	B	C	D	E	F	G	H	I	J	K	L
237	For 5% significance level, 150.955 is not an outlier.											
238	For 1% significance level, 150.955 is not an outlier.											
239												
240	**2. Data Value 4.0876 is a Potential Outlier (Lower Tail)?**											
241												
242	Test Statistic: 0.028											
243												
244	For 10% significance level, 4.0876 is not an outlier.											
245	For 5% significance level, 4.0876 is not an outlier.											
246	For 1% significance level, 4.0876 is not an outlier.											
247												
248												
249					**Dixon's Outlier Test for BaPEq (b41)**							
250												
251	Number of data = 14											
252	10% critical value: 0.492											
253	5% critical value: 0.546											
254	1% critical value: 0.641											
255												
256	**1. Data Value 142.78 is a Potential Outlier (Upper Tail)?**											
257												
258	Test Statistic: 0.515											
259												
260	For 10% significance level, 142.78 is an outlier.											
261	For 5% significance level, 142.78 is not an outlier.											
262	For 1% significance level, 142.78 is not an outlier.											
263												
264	**2. Data Value 6.249 is a Potential Outlier (Lower Tail)?**											
265												
266	Test Statistic: 0.045											
267												
268	For 10% significance level, 6.249 is not an outlier.											
269	For 5% significance level, 6.249 is not an outlier.											
270	For 1% significance level, 6.249 is not an outlier.											
271												
272												
273					**Dixon's Outlier Test for BaPEq (b49)**							
274												
275	Number of data = 4											
276	10% critical value: 0.679											
277	5% critical value: 0.765											
278	1% critical value: 0.889											
279												
280	**1. Data Value 44.978 is a Potential Outlier (Upper Tail)?**											
281												
282	Test Statistic: 0.549											
283												
284	For 10% significance level, 44.978 is not an outlier.											
285	For 5% significance level, 44.978 is not an outlier.											
286	For 1% significance level, 44.978 is not an outlier.											
287												
288	**2. Data Value 6.8605 is a Potential Outlier (Lower Tail)?**											
289												
290	Test Statistic: 0.022											
291												
292	For 10% significance level, 6.8605 is not an outlier.											
293	For 5% significance level, 6.8605 is not an outlier.											
294	For 1% significance level, 6.8605 is not an outlier.											
295												

	A	B	C	D	E	F	G	H	I	J	K	L
296												
297					**Dixon's Outlier Test for BaPEq (b5)**							
298												
299	Number of data = 12											
300	10% critical value: 0.49											
301	5% critical value: 0.546											
302	1% critical value: 0.642											
303												
304	**1. Data Value 247.9 is a Potential Outlier (Upper Tail)?**											
305												
306	Test Statistic: 0.483											
307												
308	For 10% significance level, 247.9 is not an outlier.											
309	For 5% significance level, 247.9 is not an outlier.											
310	For 1% significance level, 247.9 is not an outlier.											
311												
312	**2. Data Value 7.3096 is a Potential Outlier (Lower Tail)?**											
313												
314	Test Statistic: 0.053											
315												
316	For 10% significance level, 7.3096 is not an outlier.											
317	For 5% significance level, 7.3096 is not an outlier.											
318	For 1% significance level, 7.3096 is not an outlier.											
319												
320												
321					**Dixon's Outlier Test for BaPEq (b65)**							
322												
323	Number of data = 4											
324	10% critical value: 0.679											
325	5% critical value: 0.765											
326	1% critical value: 0.889											
327												
328	**1. Data Value 7.18433333333333 is a Potential Outlier (Upper Tail)?**											
329												
330	Test Statistic: 0.017											
331												
332	For 10% significance level, 7.18433333333333 is not an outlier.											
333	For 5% significance level, 7.18433333333333 is not an outlier.											
334	For 1% significance level, 7.18433333333333 is not an outlier.											
335												
336	**2. Data Value 5.556 is a Potential Outlier (Lower Tail)?**											
337												
338	Test Statistic: 0.555											
339												
340	For 10% significance level, 5.556 is not an outlier.											
341	For 5% significance level, 5.556 is not an outlier.											
342	For 1% significance level, 5.556 is not an outlier.											
343												
344												
345					**Dixon's Outlier Test for BaPEq (b9)**							
346												
347	Number of data = 9											
348	10% critical value: 0.441											
349	5% critical value: 0.512											
350	1% critical value: 0.635											
351												
352	**1. Data Value 69.139 is a Potential Outlier (Upper Tail)?**											
353												
354	Test Statistic: 0.228											

	A	B	C	D	E	F	G	H	I	J	K	L
355												
356	For 10% significance level, 69.139 is not an outlier.											
357	For 5% significance level, 69.139 is not an outlier.											
358	For 1% significance level, 69.139 is not an outlier.											
359												
360	**2. Data Value 3.7637 is a Potential Outlier (Lower Tail)?**											
361												
362	Test Statistic: 0.014											
363												
364	For 10% significance level, 3.7637 is not an outlier.											
365	For 5% significance level, 3.7637 is not an outlier.											
366	For 1% significance level, 3.7637 is not an outlier.											
367												

	A	B	C	D	E	F	G	H	I	J	K	L
1				General UCL Statistics for Full Data Sets								
2		User Selected Options										
3			From File	C:\Users\Libby West\Documents\Geo\Quillayute\Risk Calcs July 2013\ProUCL July 2013\BaPEqNoDupsNoBSa								
4			Full Precision	OFF								
5			Confidence Coefficient	95%								
6			Number of Bootstrap Operations	2000								
7												
8												
9	BaPEq (b10)											
10												
11					General Statistics							
12					Number of Valid Observations	12				Number of Distinct Observations	12	
13												
14				Raw Statistics						Log-transformed Statistics		
15					Minimum	1.941				Minimum of Log Data	0.663	
16					Maximum	52				Maximum of Log Data	3.951	
17					Mean	18.31				Mean of log Data	2.446	
18					Geometric Mean	11.55				SD of log Data	1.081	
19					Median	12.73						
20					SD	16.15						
21					Std. Error of Mean	4.663						
22					Coefficient of Variation	0.882						
23					Skewness	0.803						
24												
25					Relevant UCL Statistics							
26				Normal Distribution Test						Lognormal Distribution Test		
27					Shapiro Wilk Test Statistic	0.87				Shapiro Wilk Test Statistic	0.921	
28					Shapiro Wilk Critical Value	0.859				Shapiro Wilk Critical Value	0.859	
29				Data appear Normal at 5% Significance Level						Data appear Lognormal at 5% Significance Level		
30												
31				Assuming Normal Distribution						Assuming Lognormal Distribution		
32					95% Student's-t UCL	26.69				95% H-UCL	56.21	
33				95% UCLs (Adjusted for Skewness)						95% Chebyshev (MVUE) UCL	47.62	
34					95% Adjusted-CLT UCL (Chen-1995)	27.14				97.5% Chebyshev (MVUE) UCL	59.85	
35					95% Modified-t UCL (Johnson-1978)	26.87				99% Chebyshev (MVUE) UCL	83.9	
36												
37				Gamma Distribution Test						Data Distribution		
38					k star (bias corrected)	0.973				Data appear Normal at 5% Significance Level		
39					Theta Star	18.82						
40					MLE of Mean	18.31						
41					MLE of Standard Deviation	18.57						
42					nu star	23.35						
43					Approximate Chi Square Value (.05)	13.36				Nonparametric Statistics		
44					Adjusted Level of Significance	0.029				95% CLT UCL	25.98	
45					Adjusted Chi Square Value	12.22				95% Jackknife UCL	26.69	
46										95% Standard Bootstrap UCL	25.52	
47					Anderson-Darling Test Statistic	0.52				95% Bootstrap-t UCL	28.39	
48					Anderson-Darling 5% Critical Value	0.752				95% Hall's Bootstrap UCL	26.81	
49					Kolmogorov-Smirnov Test Statistic	0.2				95% Percentile Bootstrap UCL	25.7	
50					Kolmogorov-Smirnov 5% Critical Value	0.251				95% BCA Bootstrap UCL	26.73	
51				Data appear Gamma Distributed at 5% Significance Level						95% Chebyshev(Mean, Sd) UCL	38.64	
52										97.5% Chebyshev(Mean, Sd) UCL	47.44	

	A	B	C	D	E	F	G	H	I	J	K	L
53	**Assuming Gamma Distribution**						99% Chebyshev(Mean, Sd) UCL					64.71
54	95% Approximate Gamma UCL (Use when n >= 40)					32.02						
55	95% Adjusted Gamma UCL (Use when n < 40)					35.01						
56												
57	**Potential UCL to Use**						Use 95% Student's-t UCL					26.69
58												
59	**Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.**											
60	**These recommendations are based upon the results of the simulation studies summarized in Singh, Singh, and Iaci (2002)**											
61	**and Singh and Singh (2003). For additional insight, the user may want to consult a statistician.**											
62												
63												
64	**BaPEq (b101_b102)**											
65												
66	**General Statistics**											
67	Number of Valid Observations					8	Number of Distinct Observations					8
68												
69	**Raw Statistics**						**Log-transformed Statistics**					
70	Minimum					1.046	Minimum of Log Data					0.0452
71	Maximum					84.29	Maximum of Log Data					4.434
72	Mean					22.07	Mean of log Data					2.512
73	Geometric Mean					12.33	SD of log Data					1.26
74	Median					13.32						
75	SD					26.74						
76	Std. Error of Mean					9.455						
77	Coefficient of Variation					1.212						
78	Skewness					2.249						
79												
80												
81	**Warning: There are only 8 Values in this data**											
82	**Note: It should be noted that even though bootstrap methods may be performed on this data set,**											
83	**the resulting calculations may not be reliable enough to draw conclusions**											
84												
85	**The literature suggests to use bootstrap methods on data sets having more than 10-15 observations.**											
86												
87	**Relevant UCL Statistics**											
88	**Normal Distribution Test**						**Lognormal Distribution Test**					
89	Shapiro Wilk Test Statistic					0.706	Shapiro Wilk Test Statistic					0.925
90	Shapiro Wilk Critical Value					0.818	Shapiro Wilk Critical Value					0.818
91	**Data not Normal at 5% Significance Level**						**Data appear Lognormal at 5% Significance Level**					
92												
93	**Assuming Normal Distribution**						**Assuming Lognormal Distribution**					
94	95% Student's-t UCL					39.98	95% H-UCL					191.7
95	**95% UCLs (Adjusted for Skewness)**						95% Chebyshev (MVUE) UCL					70.19
96	95% Adjusted-CLT UCL (Chen-1995)					45.65	97.5% Chebyshev (MVUE) UCL					90.36
97	95% Modified-t UCL (Johnson-1978)					41.23	99% Chebyshev (MVUE) UCL					130
98												
99	**Gamma Distribution Test**						**Data Distribution**					
100	k star (bias corrected)					0.704	**Data appear Gamma Distributed at 5% Significance Level**					
101	Theta Star					31.36						
102	MLE of Mean					22.07						
103	MLE of Standard Deviation					26.31						
104	nu star					11.26						

	A–E	F	G–L	
105	Approximate Chi Square Value (.05)	4.744	**Nonparametric Statistics**	
106	Adjusted Level of Significance	0.0195	95% CLT UCL	37.62
107	Adjusted Chi Square Value	3.732	95% Jackknife UCL	39.98
108			95% Standard Bootstrap UCL	37
109	Anderson-Darling Test Statistic	0.408	95% Bootstrap-t UCL	88.04
110	Anderson-Darling 5% Critical Value	0.736	95% Hall's Bootstrap UCL	127.9
111	Kolmogorov-Smirnov Test Statistic	0.251	95% Percentile Bootstrap UCL	37.63
112	Kolmogorov-Smirnov 5% Critical Value	0.302	95% BCA Bootstrap UCL	45.35
113	**Data appear Gamma Distributed at 5% Significance Level**		95% Chebyshev(Mean, Sd) UCL	63.28
114			97.5% Chebyshev(Mean, Sd) UCL	81.12
115	**Assuming Gamma Distribution**		99% Chebyshev(Mean, Sd) UCL	116.1
116	95% Approximate Gamma UCL (Use when n >= 40)	52.38		
117	95% Adjusted Gamma UCL (Use when n < 40)	66.58		
118				
119	**Potential UCL to Use**		Use 95% Approximate Gamma UCL	52.38
120				
121	**Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.**			
122	**These recommendations are based upon the results of the simulation studies summarized in Singh, Singh, and Iaci (2002)**			
123	**and Singh and Singh (2003). For additional insight, the user may want to consult a statistician.**			
124				
125				
126	**BaPEq (b11_b7)**			
127				
128	**General Statistics**			
129	Number of Valid Observations	7	Number of Distinct Observations	7
130				
131	**Raw Statistics**		**Log-transformed Statistics**	
132	Minimum	3.939	Minimum of Log Data	1.371
133	Maximum	27.94	Maximum of Log Data	3.33
134	Mean	15.1	Mean of log Data	2.579
135	Geometric Mean	13.19	SD of log Data	0.618
136	Median	14.69		
137	SD	7.426		
138	Std. Error of Mean	2.807		
139	Coefficient of Variation	0.492		
140	Skewness	0.359		
141				
142				
143	**Warning: A sample size of 'n' = 7 may not adequate enough to compute meaningful and reliable test statistics and estimates!**			
144				
145	**It is suggested to collect at least 8 to 10 observations using these statistical methods!**			
146	**If possible compute and collect Data Quality Objectives (DQO) based sample size and analytical results.**			
147				
148				
149	**Warning: There are only 7 Values in this data**			
150	**Note: It should be noted that even though bootstrap methods may be performed on this data set,**			
151	**the resulting calculations may not be reliable enough to draw conclusions**			
152				
153	**The literature suggests to use bootstrap methods on data sets having more than 10-15 observations.**			
154				
155	**Relevant UCL Statistics**			
156	**Normal Distribution Test**		**Lognormal Distribution Test**	

	A	B	C	D	E	F	G	H	I	J	K	L
157					Shapiro Wilk Test Statistic	0.965				Shapiro Wilk Test Statistic		0.894
158					Shapiro Wilk Critical Value	0.803				Shapiro Wilk Critical Value		0.803
159				**Data appear Normal at 5% Significance Level**					**Data appear Lognormal at 5% Significance Level**			
160												
161				**Assuming Normal Distribution**					**Assuming Lognormal Distribution**			
162					95% Student's-t UCL	20.55					95% H-UCL	31.62
163				**95% UCLs (Adjusted for Skewness)**							95% Chebyshev (MVUE) UCL	31.33
164					95% Adjusted-CLT UCL (Chen-1995)	20.12					97.5% Chebyshev (MVUE) UCL	38.19
165					95% Modified-t UCL (Johnson-1978)	20.62					99% Chebyshev (MVUE) UCL	51.66
166												
167				**Gamma Distribution Test**					**Data Distribution**			
168					k star (bias corrected)	2.301			**Data appear Normal at 5% Significance Level**			
169					Theta Star	6.562						
170					MLE of Mean	15.1						
171					MLE of Standard Deviation	9.953						
172					nu star	32.21						
173					Approximate Chi Square Value (.05)	20.24			**Nonparametric Statistics**			
174					Adjusted Level of Significance	0.0158					95% CLT UCL	19.71
175					Adjusted Chi Square Value	17.44					95% Jackknife UCL	20.55
176											95% Standard Bootstrap UCL	19.27
177					Anderson-Darling Test Statistic	0.331					95% Bootstrap-t UCL	20.78
178					Anderson-Darling 5% Critical Value	0.71					95% Hall's Bootstrap UCL	22.07
179					Kolmogorov-Smirnov Test Statistic	0.241					95% Percentile Bootstrap UCL	19.43
180					Kolmogorov-Smirnov 5% Critical Value	0.313					95% BCA Bootstrap UCL	19.63
181				**Data appear Gamma Distributed at 5% Significance Level**							95% Chebyshev(Mean, Sd) UCL	27.33
182											97.5% Chebyshev(Mean, Sd) UCL	32.63
183				**Assuming Gamma Distribution**							99% Chebyshev(Mean, Sd) UCL	43.03
184					95% Approximate Gamma UCL (Use when n >= 40)	24.03						
185					95% Adjusted Gamma UCL (Use when n < 40)	27.89						
186												
187				**Potential UCL to Use**							Use 95% Student's-t UCL	20.55
188												
189	**Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.**											
190	**These recommendations are based upon the results of the simulation studies summarized in Singh, Singh, and Iaci (2002)**											
191	**and Singh and Singh (2003). For additional insight, the user may want to consult a statistician.**											
192												
193												
194	**BaPEq (b119_b119a)**											
195												
196				**General Statistics**								
197					Number of Valid Observations	7					Number of Distinct Observations	7
198												
199				**Raw Statistics**					**Log-transformed Statistics**			
200					Minimum	2.873					Minimum of Log Data	1.055
201					Maximum	7.668					Maximum of Log Data	2.037
202					Mean	4.294					Mean of log Data	1.403
203					Geometric Mean	4.069					SD of log Data	0.339
204					Median	3.555						
205					SD	1.668						
206					Std. Error of Mean	0.63						
207					Coefficient of Variation	0.388						
208					Skewness	1.697						

	A	B	C	D	E	F	G	H	I	J	K	L
209												
210												
211	Warning: A sample size of 'n' = 7 may not adequate enough to compute meaningful and reliable test statistics and estimates!											
212												
213	It is suggested to collect at least 8 to 10 observations using these statistical methods!											
214	If possible compute and collect Data Quality Objectives (DQO) based sample size and analytical results.											
215												
216												
217	Warning: There are only 7 Values in this data											
218	Note: It should be noted that even though bootstrap methods may be performed on this data set,											
219	the resulting calculations may not be reliable enough to draw conclusions											
220												
221	The literature suggests to use bootstrap methods on data sets having more than 10-15 observations.											
222												
223	Relevant UCL Statistics											
224	Normal Distribution Test						Lognormal Distribution Test					
225					Shapiro Wilk Test Statistic	0.816				Shapiro Wilk Test Statistic		0.897
226					Shapiro Wilk Critical Value	0.803				Shapiro Wilk Critical Value		0.803
227	Data appear Normal at 5% Significance Level						Data appear Lognormal at 5% Significance Level					
228												
229	Assuming Normal Distribution						Assuming Lognormal Distribution					
230					95% Student's-t UCL	5.518				95% H-UCL		5.889
231	95% UCLs (Adjusted for Skewness)									95% Chebyshev (MVUE) UCL		6.662
232					95% Adjusted-CLT UCL (Chen-1995)	5.762				97.5% Chebyshev (MVUE) UCL		7.696
233					95% Modified-t UCL (Johnson-1978)	5.586				99% Chebyshev (MVUE) UCL		9.728
234												
235	Gamma Distribution Test						Data Distribution					
236					k star (bias corrected)	5.507	Data appear Normal at 5% Significance Level					
237					Theta Star	0.78						
238					MLE of Mean	4.294						
239					MLE of Standard Deviation	1.83						
240					nu star	77.09						
241					Approximate Chi Square Value (.05)	57.87	Nonparametric Statistics					
242					Adjusted Level of Significance	0.0158				95% CLT UCL		5.33
243					Adjusted Chi Square Value	52.87				95% Jackknife UCL		5.518
244										95% Standard Bootstrap UCL		5.24
245					Anderson-Darling Test Statistic	0.478				95% Bootstrap-t UCL		7.568
246					Anderson-Darling 5% Critical Value	0.709				95% Hall's Bootstrap UCL		9.985
247					Kolmogorov-Smirnov Test Statistic	0.246				95% Percentile Bootstrap UCL		5.348
248					Kolmogorov-Smirnov 5% Critical Value	0.312				95% BCA Bootstrap UCL		5.627
249	Data appear Gamma Distributed at 5% Significance Level									95% Chebyshev(Mean, Sd) UCL		7.041
250										97.5% Chebyshev(Mean, Sd) UCL		8.23
251	Assuming Gamma Distribution									99% Chebyshev(Mean, Sd) UCL		10.57
252					95% Approximate Gamma UCL (Use when n >= 40)	5.72						
253					95% Adjusted Gamma UCL (Use when n < 40)	6.261						
254												
255	Potential UCL to Use									Use 95% Student's-t UCL		5.518
256												
257	Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.											
258	These recommendations are based upon the results of the simulation studies summarized in Singh, Singh, and Iaci (2002)											
259	and Singh and Singh (2003). For additional insight, the user may want to consult a statistician.											
260												

	A	B	C	D	E	F	G	H	I	J	K	L
261												
262	BaPEq (b12)											
263												
264					General Statistics							
265					Number of Valid Observations	11				Number of Distinct Observations		11
266												
267				Raw Statistics						Log-transformed Statistics		
268					Minimum	1.777				Minimum of Log Data		0.575
269					Maximum	15.67				Maximum of Log Data		2.752
270					Mean	4.848				Mean of log Data		1.392
271					Geometric Mean	4.021				SD of log Data		0.585
272					Median	3.683						
273					SD	3.877						
274					Std. Error of Mean	1.169						
275					Coefficient of Variation	0.8						
276					Skewness	2.55						
277												
278					Relevant UCL Statistics							
279				Normal Distribution Test						Lognormal Distribution Test		
280					Shapiro Wilk Test Statistic	0.68				Shapiro Wilk Test Statistic		0.915
281					Shapiro Wilk Critical Value	0.85				Shapiro Wilk Critical Value		0.85
282				Data not Normal at 5% Significance Level						Data appear Lognormal at 5% Significance Level		
283												
284				Assuming Normal Distribution						Assuming Lognormal Distribution		
285					95% Student's-t UCL	6.966				95% H-UCL		7.295
286				95% UCLs (Adjusted for Skewness)						95% Chebyshev (MVUE) UCL		8.396
287					95% Adjusted-CLT UCL (Chen-1995)	7.731				97.5% Chebyshev (MVUE) UCL		10
288					95% Modified-t UCL (Johnson-1978)	7.116				99% Chebyshev (MVUE) UCL		13.15
289												
290				Gamma Distribution Test						Data Distribution		
291					k star (bias corrected)	2.118				Data appear Gamma Distributed at 5% Significance Level		
292					Theta Star	2.289						
293					MLE of Mean	4.848						
294					MLE of Standard Deviation	3.331						
295					nu star	46.6						
296					Approximate Chi Square Value (.05)	31.93				Nonparametric Statistics		
297					Adjusted Level of Significance	0.0278				95% CLT UCL		6.77
298					Adjusted Chi Square Value	29.96				95% Jackknife UCL		6.966
299										95% Standard Bootstrap UCL		6.721
300					Anderson-Darling Test Statistic	0.714				95% Bootstrap-t UCL		10.97
301					Anderson-Darling 5% Critical Value	0.734				95% Hall's Bootstrap UCL		15.04
302					Kolmogorov-Smirnov Test Statistic	0.23				95% Percentile Bootstrap UCL		6.861
303					Kolmogorov-Smirnov 5% Critical Value	0.257				95% BCA Bootstrap UCL		8.018
304				Data appear Gamma Distributed at 5% Significance Level						95% Chebyshev(Mean, Sd) UCL		9.943
305										97.5% Chebyshev(Mean, Sd) UCL		12.15
306				Assuming Gamma Distribution						99% Chebyshev(Mean, Sd) UCL		16.48
307					95% Approximate Gamma UCL (Use when n >= 40)	7.074						
308					95% Adjusted Gamma UCL (Use when n < 40)	7.539						
309												
310				Potential UCL to Use						Use 95% Approximate Gamma UCL		7.074
311												
312	Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.											

These recommendations are based upon the results of the simulation studies summarized in Singh, Singh, and Iaci (2002) and Singh and Singh (2003). For additional insight, the user may want to consult a statistician.

BaPEq (b17)

General Statistics

Number of Valid Observations	14	Number of Distinct Observations	14

Raw Statistics		Log-transformed Statistics	
Minimum	3.192	Minimum of Log Data	1.161
Maximum	98.23	Maximum of Log Data	4.587
Mean	29.85	Mean of log Data	2.916
Geometric Mean	18.47	SD of log Data	1.089
Median	23.39		
SD	28.96		
Std. Error of Mean	7.739		
Coefficient of Variation	0.97		
Skewness	1.474		

Relevant UCL Statistics

Normal Distribution Test		Lognormal Distribution Test	
Shapiro Wilk Test Statistic	0.819	Shapiro Wilk Test Statistic	0.934
Shapiro Wilk Critical Value	0.874	Shapiro Wilk Critical Value	0.874
Data not Normal at 5% Significance Level		Data appear Lognormal at 5% Significance Level	
Assuming Normal Distribution		**Assuming Lognormal Distribution**	
95% Student's-t UCL	43.56	95% H-UCL	81.27
95% UCLs (Adjusted for Skewness)		95% Chebyshev (MVUE) UCL	75.15
95% Adjusted-CLT UCL (Chen-1995)	45.84	97.5% Chebyshev (MVUE) UCL	94.06
95% Modified-t UCL (Johnson-1978)	44.07	99% Chebyshev (MVUE) UCL	131.2

Gamma Distribution Test		Data Distribution
k star (bias corrected)	0.975	Data appear Gamma Distributed at 5% Significance Level
Theta Star	30.61	
MLE of Mean	29.85	
MLE of Standard Deviation	30.23	
nu star	27.31	
Approximate Chi Square Value (.05)	16.39	**Nonparametric Statistics**
Adjusted Level of Significance	0.0312	95% CLT UCL 42.58
Adjusted Chi Square Value	15.28	95% Jackknife UCL 43.56
		95% Standard Bootstrap UCL 42.03
Anderson-Darling Test Statistic	0.362	95% Bootstrap-t UCL 52.56
Anderson-Darling 5% Critical Value	0.757	95% Hall's Bootstrap UCL 109.3
Kolmogorov-Smirnov Test Statistic	0.161	95% Percentile Bootstrap UCL 43.52
Kolmogorov-Smirnov 5% Critical Value	0.234	95% BCA Bootstrap UCL 46.71
Data appear Gamma Distributed at 5% Significance Level		95% Chebyshev(Mean, Sd) UCL 63.59
		97.5% Chebyshev(Mean, Sd) UCL 78.18
Assuming Gamma Distribution		99% Chebyshev(Mean, Sd) UCL 106.9
95% Approximate Gamma UCL (Use when n >= 40)	49.74	
95% Adjusted Gamma UCL (Use when n < 40)	53.36	

	A	B	C	D	E	F	G	H	I	J	K	L
365	**Potential UCL to Use**						Use 95% Approximate Gamma UCL					49.74
366												
367	**Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.**											
368	**These recommendations are based upon the results of the simulation studies summarized in Singh, Singh, and Iaci (2002)**											
369	**and Singh and Singh (2003). For additional insight, the user may want to consult a statistician.**											
370												
371												
372	**BaPEq (b18_b19)**											
373												
374	**General Statistics**											
375	Number of Valid Observations					6	Number of Distinct Observations					6
376												
377	**Raw Statistics**						**Log-transformed Statistics**					
378	Minimum					3.197	Minimum of Log Data					1.162
379	Maximum					4.248	Maximum of Log Data					1.446
380	Mean					3.812	Mean of log Data					1.333
381	Geometric Mean					3.794	SD of log Data					0.11
382	Median					3.933						
383	SD					0.408						
384	Std. Error of Mean					0.167						
385	Coefficient of Variation					0.107						
386	Skewness					-0.697						
387												
388												
389	**Warning: A sample size of 'n' = 6 may not adequate enough to compute meaningful and reliable test statistics and estimates!**											
390												
391	**It is suggested to collect at least 8 to 10 observations using these statistical methods!**											
392	**If possible compute and collect Data Quality Objectives (DQO) based sample size and analytical results.**											
393												
394												
395	**Warning: There are only 6 Values in this data**											
396	**Note: It should be noted that even though bootstrap methods may be performed on this data set,**											
397	**the resulting calculations may not be reliable enough to draw conclusions**											
398												
399	**The literature suggests to use bootstrap methods on data sets having more than 10-15 observations.**											
400												
401	**Relevant UCL Statistics**											
402	**Normal Distribution Test**						**Lognormal Distribution Test**					
403	Shapiro Wilk Test Statistic					0.923	Shapiro Wilk Test Statistic					0.912
404	Shapiro Wilk Critical Value					0.788	Shapiro Wilk Critical Value					0.788
405	**Data appear Normal at 5% Significance Level**						**Data appear Lognormal at 5% Significance Level**					
406												
407	**Assuming Normal Distribution**						**Assuming Lognormal Distribution**					
408	95% Student's-t UCL					4.148	95% H-UCL					4.203
409	**95% UCLs (Adjusted for Skewness)**						95% Chebyshev (MVUE) UCL					4.562
410	95% Adjusted-CLT UCL (Chen-1995)					4.036	97.5% Chebyshev (MVUE) UCL					4.886
411	95% Modified-t UCL (Johnson-1978)					4.14	99% Chebyshev (MVUE) UCL					5.523
412												
413	**Gamma Distribution Test**						**Data Distribution**					
414	k star (bias corrected)					50.43	**Data appear Normal at 5% Significance Level**					
415	Theta Star					0.0756						
416	MLE of Mean					3.812						

	A	B	C	D	E	F	G	H	I	J	K	L
417					MLE of Standard Deviation	0.537						
418					nu star	605.1						
419					Approximate Chi Square Value (.05)	549.1	**Nonparametric Statistics**					
420					Adjusted Level of Significance	0.0122					95% CLT UCL	4.087
421					Adjusted Chi Square Value	529.6					95% Jackknife UCL	4.148
422											95% Standard Bootstrap UCL	4.06
423					Anderson-Darling Test Statistic	0.352					95% Bootstrap-t UCL	4.087
424					Anderson-Darling 5% Critical Value	0.696					95% Hall's Bootstrap UCL	3.997
425					Kolmogorov-Smirnov Test Statistic	0.231					95% Percentile Bootstrap UCL	4.058
426					Kolmogorov-Smirnov 5% Critical Value	0.332					95% BCA Bootstrap UCL	4.026
427	**Data appear Gamma Distributed at 5% Significance Level**										95% Chebyshev(Mean, Sd) UCL	4.539
428											97.5% Chebyshev(Mean, Sd) UCL	4.853
429				**Assuming Gamma Distribution**							99% Chebyshev(Mean, Sd) UCL	5.47
430					95% Approximate Gamma UCL (Use when n >= 40)	4.202						
431					95% Adjusted Gamma UCL (Use when n < 40)	4.356						
432												
433				**Potential UCL to Use**							Use 95% Student's-t UCL	4.148
434												
435	**Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.**											
436	**These recommendations are based upon the results of the simulation studies summarized in Singh, Singh, and Iaci (2002)**											
437	**and Singh and Singh (2003). For additional insight, the user may want to consult a statistician.**											
438												
439	**Note: For highly negative-skewed data, confidence limits**											
440	**(e.g., Chen, Johnson, Lognormal, and Gamma) may not be**											
441	**reliable. Chen's and Johnson's methods provide**											
442	**adjustments for positvely skewed data sets.**											
443												
444												
445	**BaPEq (b20)**											
446												
447				**General Statistics**								
448					Number of Valid Observations	4					Number of Distinct Observations	4
449												
450												
451	**Warning: This data set only has 4 observations!**											
452	**Data set is too small to compute reliable and meaningful statistics and estimates!**											
453	**The data set for variable BaPEq (b20) was not processed!**											
454												
455	**It is suggested to collect at least 8 to 10 observations before using these statistical methods!**											
456	**If possible, compute and collect Data Quality Objectives (DQO) based sample size and analytical results.**											
457												
458												
459												
460	**BaPEq (b29)**											
461												
462				**General Statistics**								
463					Number of Valid Observations	10					Number of Distinct Observations	10
464												
465				**Raw Statistics**			**Log-transformed Statistics**					
466					Minimum	2.372					Minimum of Log Data	0.864
467					Maximum	11.18					Maximum of Log Data	2.414
468					Mean	4.207					Mean of log Data	1.315

	A	B	C	D	E	F	G	H	I	J	K	L
469					Geometric Mean	3.725					SD of log Data	0.47
470					Median	3.158						
471					SD	2.686						
472					Std. Error of Mean	0.849						
473					Coefficient of Variation	0.639						
474					Skewness	2.377						
475												
476					**Relevant UCL Statistics**							
477			**Normal Distribution Test**						**Lognormal Distribution Test**			
478					Shapiro Wilk Test Statistic	0.66					Shapiro Wilk Test Statistic	0.803
479					Shapiro Wilk Critical Value	0.842					Shapiro Wilk Critical Value	0.842
480			**Data not Normal at 5% Significance Level**						**Data not Lognormal at 5% Significance Level**			
481												
482			**Assuming Normal Distribution**						**Assuming Lognormal Distribution**			
483					95% Student's-t UCL	5.764					95% H-UCL	5.851
484			**95% UCLs (Adjusted for Skewness)**								95% Chebyshev (MVUE) UCL	6.815
485					95% Adjusted-CLT UCL (Chen-1995)	6.286					97.5% Chebyshev (MVUE) UCL	7.986
486					95% Modified-t UCL (Johnson-1978)	5.87					99% Chebyshev (MVUE) UCL	10.28
487												
488			**Gamma Distribution Test**						**Data Distribution**			
489					k star (bias corrected)	3.056			**Data do not follow a Discernable Distribution (0.05)**			
490					Theta Star	1.377						
491					MLE of Mean	4.207						
492					MLE of Standard Deviation	2.406						
493					nu star	61.12						
494					Approximate Chi Square Value (.05)	44.14			**Nonparametric Statistics**			
495					Adjusted Level of Significance	0.0267					95% CLT UCL	5.604
496					Adjusted Chi Square Value	41.64					95% Jackknife UCL	5.764
497											95% Standard Bootstrap UCL	5.513
498					Anderson-Darling Test Statistic	1.112					95% Bootstrap-t UCL	11.07
499					Anderson-Darling 5% Critical Value	0.729					95% Hall's Bootstrap UCL	12.83
500					Kolmogorov-Smirnov Test Statistic	0.3					95% Percentile Bootstrap UCL	5.631
501					Kolmogorov-Smirnov 5% Critical Value	0.268					95% BCA Bootstrap UCL	6.42
502			**Data not Gamma Distributed at 5% Significance Level**								95% Chebyshev(Mean, Sd) UCL	7.91
503											97.5% Chebyshev(Mean, Sd) UCL	9.512
504			**Assuming Gamma Distribution**								99% Chebyshev(Mean, Sd) UCL	12.66
505					95% Approximate Gamma UCL (Use when n >= 40)	5.825						
506					95% Adjusted Gamma UCL (Use when n < 40)	6.174						
507												
508			**Potential UCL to Use**								Use 95% Student's-t UCL	5.764
509											or 95% Modified-t UCL	5.87
510												
511			**Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.**									
512			**These recommendations are based upon the results of the simulation studies summarized in Singh, Singh, and Iaci (2002)**									
513			**and Singh and Singh (2003). For additional insight, the user may want to consult a statistician.**									
514												
515												
516	**BaPEq (b4)**											
517												
518					**General Statistics**							
519					Number of Valid Observations	18					Number of Distinct Observations	18
520												

	A	B	C	D	E	F	G	H	I	J	K	L
521	**Raw Statistics**						**Log-transformed Statistics**					
522					Minimum	4.088				Minimum of Log Data		1.408
523					Maximum	151				Maximum of Log Data		5.017
524					Mean	51.96				Mean of log Data		3.282
525					Geometric Mean	26.62				SD of log Data		1.269
526					Median	22.75						
527					SD	54.01						
528					Std. Error of Mean	12.73						
529					Coefficient of Variation	1.04						
530					Skewness	0.8						
531												
532	**Relevant UCL Statistics**											
533	**Normal Distribution Test**						**Lognormal Distribution Test**					
534					Shapiro Wilk Test Statistic	0.795				Shapiro Wilk Test Statistic		0.898
535					Shapiro Wilk Critical Value	0.897				Shapiro Wilk Critical Value		0.897
536	**Data not Normal at 5% Significance Level**						**Data appear Lognormal at 5% Significance Level**					
537												
538	**Assuming Normal Distribution**						**Assuming Lognormal Distribution**					
539					95% Student's-t UCL	74.11				95% H-UCL		152.3
540	**95% UCLs (Adjusted for Skewness)**									95% Chebyshev (MVUE) UCL		138.4
541					95% Adjusted-CLT UCL (Chen-1995)	75.46				97.5% Chebyshev (MVUE) UCL		174.3
542					95% Modified-t UCL (Johnson-1978)	74.51				99% Chebyshev (MVUE) UCL		244.8
543												
544	**Gamma Distribution Test**						**Data Distribution**					
545					k star (bias corrected)	0.768	**Data Follow Appr. Gamma Distribution at 5% Significance Level**					
546					Theta Star	67.66						
547					MLE of Mean	51.96						
548					MLE of Standard Deviation	59.29						
549					nu star	27.65						
550					Approximate Chi Square Value (.05)	16.65	**Nonparametric Statistics**					
551					Adjusted Level of Significance	0.0357				95% CLT UCL		72.9
552					Adjusted Chi Square Value	15.84				95% Jackknife UCL		74.11
553										95% Standard Bootstrap UCL		71.98
554					Anderson-Darling Test Statistic	0.921				95% Bootstrap-t UCL		77.28
555					Anderson-Darling 5% Critical Value	0.772				95% Hall's Bootstrap UCL		71.93
556					Kolmogorov-Smirnov Test Statistic	0.186				95% Percentile Bootstrap UCL		71.88
557					Kolmogorov-Smirnov 5% Critical Value	0.21				95% BCA Bootstrap UCL		74.67
558	**Data follow Appr. Gamma Distribution at 5% Significance Level**									95% Chebyshev(Mean, Sd) UCL		107.5
559										97.5% Chebyshev(Mean, Sd) UCL		131.5
560	**Assuming Gamma Distribution**									99% Chebyshev(Mean, Sd) UCL		178.6
561					95% Approximate Gamma UCL (Use when n >= 40)	86.26						
562					95% Adjusted Gamma UCL (Use when n < 40)	90.71						
563												
564	**Potential UCL to Use**									Use 95% Approximate Gamma UCL		86.26
565												
566	**Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.**											
567	**These recommendations are based upon the results of the simulation studies summarized in Singh, Singh, and Iaci (2002)**											
568	**and Singh and Singh (2003). For additional insight, the user may want to consult a statistician.**											
569												
570												
571	**BaPEq (b41)**											
572												

	A	B	C	D	E	F	G	H	I	J	K	L
573	**General Statistics**											
574	Number of Valid Observations					14	Number of Distinct Observations					14
575												
576	**Raw Statistics**						**Log-transformed Statistics**					
577	Minimum					6.249	Minimum of Log Data					1.832
578	Maximum					142.8	Maximum of Log Data					4.961
579	Mean					40.48	Mean of log Data					3.245
580	Geometric Mean					25.65	SD of log Data					1.005
581	Median					25.64						
582	SD					40.76						
583	Std. Error of Mean					10.89						
584	Coefficient of Variation					1.007						
585	Skewness					1.53						
586												
587	**Relevant UCL Statistics**											
588	**Normal Distribution Test**						**Lognormal Distribution Test**					
589	Shapiro Wilk Test Statistic					0.812	Shapiro Wilk Test Statistic					0.955
590	Shapiro Wilk Critical Value					0.874	Shapiro Wilk Critical Value					0.874
591	**Data not Normal at 5% Significance Level**						**Data appear Lognormal at 5% Significance Level**					
592												
593	**Assuming Normal Distribution**						**Assuming Lognormal Distribution**					
594	95% Student's-t UCL					59.77	95% H-UCL					92.78
595	**95% UCLs (Adjusted for Skewness)**						95% Chebyshev (MVUE) UCL					91.88
596	95% Adjusted-CLT UCL (Chen-1995)					63.16	97.5% Chebyshev (MVUE) UCL					114.1
597	95% Modified-t UCL (Johnson-1978)					60.52	99% Chebyshev (MVUE) UCL					157.9
598												
599	**Gamma Distribution Test**						**Data Distribution**					
600	k star (bias corrected)					1.019	**Data appear Gamma Distributed at 5% Significance Level**					
601	Theta Star					39.73						
602	MLE of Mean					40.48						
603	MLE of Standard Deviation					40.1						
604	nu star					28.53						
605	Approximate Chi Square Value (.05)					17.34	**Nonparametric Statistics**					
606	Adjusted Level of Significance					0.0312	95% CLT UCL					58.4
607	Adjusted Chi Square Value					16.19	95% Jackknife UCL					59.77
608							95% Standard Bootstrap UCL					58.2
609	Anderson-Darling Test Statistic					0.378	95% Bootstrap-t UCL					73.04
610	Anderson-Darling 5% Critical Value					0.756	95% Hall's Bootstrap UCL					71.45
611	Kolmogorov-Smirnov Test Statistic					0.149	95% Percentile Bootstrap UCL					57.88
612	Kolmogorov-Smirnov 5% Critical Value					0.234	95% BCA Bootstrap UCL					61.98
613	**Data appear Gamma Distributed at 5% Significance Level**						95% Chebyshev(Mean, Sd) UCL					87.97
614							97.5% Chebyshev(Mean, Sd) UCL					108.5
615	**Assuming Gamma Distribution**						99% Chebyshev(Mean, Sd) UCL					148.9
616	95% Approximate Gamma UCL (Use when n >= 40)					66.6						
617	95% Adjusted Gamma UCL (Use when n < 40)					71.33						
618												
619	**Potential UCL to Use**						Use 95% Approximate Gamma UCL					66.6
620												
621	**Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.**											
622	**These recommendations are based upon the results of the simulation studies summarized in Singh, Singh, and Iaci (2002)**											
623	**and Singh and Singh (2003). For additional insight, the user may want to consult a statistician.**											
624												

	A	B	C	D	E	F	G	H	I	J	K	L
625												
626	BaPEq (b49)											
627												
628						General Statistics						
629					Number of Valid Observations	4				Number of Distinct Observations		4
630												
631												
632						Warning: This data set only has 4 observations!						
633						Data set is too small to compute reliable and meaningful statistics and estimates!						
634						The data set for variable BaPEq (b49) was not processed!						
635												
636						It is suggested to collect at least 8 to 10 observations before using these statistical methods!						
637						If possible, compute and collect Data Quality Objectives (DQO) based sample size and analytical results.						
638												
639												
640												
641	BaPEq (b5)											
642												
643						General Statistics						
644					Number of Valid Observations	12				Number of Distinct Observations		12
645												
646					Raw Statistics					Log-transformed Statistics		
647					Minimum	7.31				Minimum of Log Data		1.989
648					Maximum	247.9				Maximum of Log Data		5.513
649					Mean	83.7				Mean of log Data		3.986
650					Geometric Mean	53.81				SD of log Data		1.066
651					Median	55.79						
652					SD	76.88						
653					Std. Error of Mean	22.19						
654					Coefficient of Variation	0.919						
655					Skewness	1.261						
656												
657						Relevant UCL Statistics						
658					Normal Distribution Test					Lognormal Distribution Test		
659					Shapiro Wilk Test Statistic	0.853				Shapiro Wilk Test Statistic		0.967
660					Shapiro Wilk Critical Value	0.859				Shapiro Wilk Critical Value		0.859
661					Data not Normal at 5% Significance Level					Data appear Lognormal at 5% Significance Level		
662												
663					Assuming Normal Distribution					Assuming Lognormal Distribution		
664					95% Student's-t UCL	123.6				95% H-UCL		251.9
665					95% UCLs (Adjusted for Skewness)					95% Chebyshev (MVUE) UCL		216.9
666					95% Adjusted-CLT UCL (Chen-1995)	128.8				97.5% Chebyshev (MVUE) UCL		272.3
667					95% Modified-t UCL (Johnson-1978)	124.9				99% Chebyshev (MVUE) UCL		381.2
668												
669					Gamma Distribution Test					Data Distribution		
670					k star (bias corrected)	1.01				Data appear Gamma Distributed at 5% Significance Level		
671					Theta Star	82.86						
672					MLE of Mean	83.7						
673					MLE of Standard Deviation	83.28						
674					nu star	24.24						
675					Approximate Chi Square Value (.05)	14.03				Nonparametric Statistics		
676					Adjusted Level of Significance	0.029				95% CLT UCL		120.2

	A	B	C	D	E	F	G	H	I	J	K	L
677					Adjusted Chi Square Value	12.86					95% Jackknife UCL	123.6
678											95% Standard Bootstrap UCL	118.6
679					Anderson-Darling Test Statistic	0.182					95% Bootstrap-t UCL	147.3
680					Anderson-Darling 5% Critical Value	0.751					95% Hall's Bootstrap UCL	162.3
681					Kolmogorov-Smirnov Test Statistic	0.112					95% Percentile Bootstrap UCL	121.4
682					Kolmogorov-Smirnov 5% Critical Value	0.251					95% BCA Bootstrap UCL	124.8
683					**Data appear Gamma Distributed at 5% Significance Level**						95% Chebyshev(Mean, Sd) UCL	180.4
684											97.5% Chebyshev(Mean, Sd) UCL	222.3
685					**Assuming Gamma Distribution**						99% Chebyshev(Mean, Sd) UCL	304.5
686					95% Approximate Gamma UCL (Use when n >= 40)	144.6						
687					95% Adjusted Gamma UCL (Use when n < 40)	157.8						
688												
689					**Potential UCL to Use**						Use 95% Approximate Gamma UCL	144.6
690												
691	**Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.**											
692	**These recommendations are based upon the results of the simulation studies summarized in Singh, Singh, and Iaci (2002)**											
693	**and Singh and Singh (2003). For additional insight, the user may want to consult a statistician.**											
694												
695												
696	**BaPEq (b65)**											
697												
698					**General Statistics**							
699					Number of Valid Observations	4					Number of Distinct Observations	4
700												
701												
702	**Warning: This data set only has 4 observations!**											
703	**Data set is too small to compute reliable and meaningful statistics and estimates!**											
704	**The data set for variable BaPEq (b65) was not processed!**											
705												
706	**It is suggested to collect at least 8 to 10 observations before using these statistical methods!**											
707	**If possible, compute and collect Data Quality Objectives (DQO) based sample size and analytical results.**											
708												
709												
710												
711	**BaPEq (b9)**											
712												
713					**General Statistics**							
714					Number of Valid Observations	9					Number of Distinct Observations	9
715												
716					**Raw Statistics**						**Log-transformed Statistics**	
717					Minimum	3.764					Minimum of Log Data	1.325
718					Maximum	69.14					Maximum of Log Data	4.236
719					Mean	22.94					Mean of log Data	2.698
720					Geometric Mean	14.86					SD of log Data	0.997
721					Median	13.25						
722					SD	23.16						
723					Std. Error of Mean	7.719						
724					Coefficient of Variation	1.009						
725					Skewness	1.437						
726												
727												
728	**Warning: There are only 9 Values in this data**											

	A	B	C	D	E	F	G	H	I	J	K	L
729	Note: It should be noted that even though bootstrap methods may be performed on this data set,											
730	the resulting calculations may not be reliable enough to draw conclusions											
731												
732	The literature suggests to use bootstrap methods on data sets having more than 10-15 observations.											
733												
734	Relevant UCL Statistics											
735	Normal Distribution Test						Lognormal Distribution Test					
736					Shapiro Wilk Test Statistic	0.789				Shapiro Wilk Test Statistic		0.953
737					Shapiro Wilk Critical Value	0.829				Shapiro Wilk Critical Value		0.829
738	Data not Normal at 5% Significance Level						Data appear Lognormal at 5% Significance Level					
739												
740	Assuming Normal Distribution						Assuming Lognormal Distribution					
741					95% Student's-t UCL	37.29				95% H-UCL		76.27
742	95% UCLs (Adjusted for Skewness)									95% Chebyshev (MVUE) UCL		56.75
743					95% Adjusted-CLT UCL (Chen-1995)	39.59				97.5% Chebyshev (MVUE) UCL		71.48
744					95% Modified-t UCL (Johnson-1978)	37.91				99% Chebyshev (MVUE) UCL		100.4
745												
746	Gamma Distribution Test						Data Distribution					
747					k star (bias corrected)	0.935	Data appear Gamma Distributed at 5% Significance Level					
748					Theta Star	24.52						
749					MLE of Mean	22.94						
750					MLE of Standard Deviation	23.72						
751					nu star	16.84						
752					Approximate Chi Square Value (.05)	8.557	Nonparametric Statistics					
753					Adjusted Level of Significance	0.0231				95% CLT UCL		35.64
754					Adjusted Chi Square Value	7.346				95% Jackknife UCL		37.29
755										95% Standard Bootstrap UCL		34.76
756					Anderson-Darling Test Statistic	0.373				95% Bootstrap-t UCL		65.6
757					Anderson-Darling 5% Critical Value	0.738				95% Hall's Bootstrap UCL		114.5
758					Kolmogorov-Smirnov Test Statistic	0.16				95% Percentile Bootstrap UCL		35.81
759					Kolmogorov-Smirnov 5% Critical Value	0.285				95% BCA Bootstrap UCL		38.54
760	Data appear Gamma Distributed at 5% Significance Level									95% Chebyshev(Mean, Sd) UCL		56.59
761										97.5% Chebyshev(Mean, Sd) UCL		71.14
762	Assuming Gamma Distribution									99% Chebyshev(Mean, Sd) UCL		99.74
763					95% Approximate Gamma UCL (Use when n >= 40)	45.14						
764					95% Adjusted Gamma UCL (Use when n < 40)	52.58						
765												
766	Potential UCL to Use									Use 95% Approximate Gamma UCL		45.14
767												
768	Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.											
769	These recommendations are based upon the results of the simulation studies summarized in Singh, Singh, and Iaci (2002)											
770	and Singh and Singh (2003). For additional insight, the user may want to consult a statistician.											
771												

APPENDIX E

HUMAN HEALTH CALCULATIONS

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APPENDIX F

TOXICOLOGICAL PROFILES FOR CHEMICALS OF POTENTIAL CONCERN

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APPENDIX G

GEOGRAPHIC INFORMATION SYSTEMS DATA

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