Final
Fort Morrow Phase II
Remedial Investigation Report
Port Heiden, Alaska

Prepared for:
U.S. Army Corps of Engineers, Alaska District

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Final
Fort Morrow Phase II
Remedial Investigation Report
Port Heiden, Alaska

November 2016

Contract No. W911KB-11-D-0006, Delivery Order No. 0007

Prepared for:
U.S. Army Corps of Engineers, Alaska District
Joint Base Elmendorf - Richardson, Alaska 99506

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EXECUTIVE SUMMARY

North Wind, Inc. conducted remedial investigation activities at the Former Fort Morrow Army Post, located at Port Heiden, Alaska under Contract No. W911KB-11-D-0006, Delivery Order # 0007 for the United States Army Corps of Engineers, Alaska District. Under the Formerly Used Defense Sites Program, the Former Fort Morrow is eligible for environmental restoration funding. A remedial investigation is required under the Comprehensive Environmental Response, Compensation, and Liability Act prior to performing extensive remediation activities.

Closure of the Fort in 1945 resulted in the documented abandonment of thousands of drums of aviation fuel, petroleum, oil, lubricants, and other maintenance fluids. The Former Fort Morrow was divided into 13 Areas of Concern (AOCs), A through M, based on military activities that occurred within each area. Remedial investigation activities were divided into two phases, with Phase I investigations addressing AOCs C through L and Phase II investigations addressing AOCs B and M. AOC A is currently in operation under the jurisdiction of the Alaska Department of Transportation and Public Facilities and is not part of the remedial investigation scope. The results of Phase I investigations were reported in 2013. This report provides the methods, results, and conclusions of Phase II investigation activities conducted during 2014 and 2015.

A total of 195 features were screened for petroleum, oil, and lubricant (POL) contamination between AOC B (21 features), AOC M (171 features), AOC E (one feature), and AOC F (two features). Features in AOCs E and F were screened to supplement information gathered during Phase I investigations. In all, 1,979 primary characterization screening probes were drilled. Screening detections correlating to potential exceedances of POL were observed in 124 probes at 39 features: four in AOC B, one in AOC E, one in AOC F, and 33 in AOC M. Soil sampling confirmed exceedances of POL at 10 of the 39 features:

- B-DA-003,
- B-DA-004,
- B-DA-005,
- F-BU-001,
- M-DA-023,
- M-PR-001,
- M-PR-005,
- M-SH-002,
- M-TF-001, and
- M-UN-002.

Exceedances of project action levels (PALs) for POL were for diesel range organics (DRO) exclusively, with results ranging from 350 milligrams per kilogram (mg/kg) in feature M-PR-005 to 25,000 mg/kg in feature B-DA-004 (PAL for DRO is 250 mg/kg).

A total of 287 characterization confirmation soil samples were collected at 166 features designated for sampling. In addition to the 10 features mentioned above, an exceedance of DRO was confirmed at feature M-ST-006, for a total of 11 features with confirmed soil DRO contamination.

Fourteen monitoring wells were sampled from AOCs B, C, J, and M. Exceedances of DRO were found in AOC B wells B-MW-001, B-MW-002, and B-MW-003 associated with features B-DA-003 and B-DA-004; and in AOC C well C-MW-001 associated with feature C-LT-002. Monitoring well J-MW-003 was sampled for lead only: none was detected. DRO exceedances in groundwater ranged from 2,300 micrograms per liter (µg/L) in B-MW-002 to 28,000 µg/L in C-MW-001. One exceedance of residual range organics was confirmed in well B-MW-001 at 2,800 µg/L.

Nine mounded material, shop, and debris type features in AOCs B and M were screened for soil lead contamination to a depth of 2 feet. A total of 156 screening measurements plus duplicates were taken using X-ray fluorescence. Only three measurements were greater than 100 parts per million (25% of the PAL of 400 ppm). Confirmation sampling of the six highest measurements resulted in only one exceedance of lead at feature M-SH-001 of 780 mg/kg.

Eight power house, radar building, and transformer features in AOC M were sampled for polychlorinated biphenyls (PCBs) in surface soils using nine-point composite sampling techniques. A total of 27 samples were submitted for analyses. No exceedances for PCBs were noted.

Subsurface metal investigations were performed at 24 feature sites or locations in AOCs B, C, E, F, and M. Significant buried metal was detected via geophysical surveys in five features: E-DS-001, F-BU-001, M-GS-043, M-SH-001, and M-SH-002. Test pit investigations were performed in E-DS-001, C-BD-001, M-BP-001, and M-SH-001. Significant buried debris in three test pits in C-DB-001 appeared to be municipal in origin. Buried debris from three test pits in E-DS-001, though consistent with typical construction-type debris, could be of post-war military origin. No buried metal debris was discovered in M-BP-001 or M-SH-001. Analytical results from test pits showed no exceedances for POL.

Incidental soil removal actions were performed at four locations where POL or lead contamination had been identified during Phase I investigations. Approximately 199 cubic yards (CY) of POL contaminated soil and 3 CY of lead contaminated soil, equaling 150 tons total, were removed. Site features J-SP-003 and F-OT-001 require no further action. Analytical results indicate that some contaminated soil remains at features J-SP-002 and J-WH-002.

The volume of POL contaminated soil encountered during Phase II investigations based on geographic information system modeling is approximately 4,996 CY. Breakdown by AOC includes:

- AOC B – 3,231 CY,
- AOC F – 64 CY, and
- AOC M – 1,701 CY.

Contamination in M-PR-005, detected at a depth of 25 feet below ground surface, was associated with an organic rich layer. No POL exceedances were confirmed in any of the other features at depths greater than 12 feet below ground surface.

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FIGURES

TABLES

APPENDICES

ACRONYMS AND ABBREVIATIONS

AAC	Alaska Administrative Code
ADEC	Alaska Department of Environmental Conservation
AGC	Army Geospatial Center
amsl	above mean sea level
AOC	Area of Concern
AST	aboveground storage tank
ASTM	American Society of Testing and Materials
ATV	all-terrain vehicle
bgs	below ground surface
BTEX	benzene, toluene, ethylbenzene, and xylenes
BTOC	below top of casing
°C	degrees Celsius
CAA	Civil Aeronautics Authority
CDQR	Chemical Data Quality Report
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
COPC	contaminant of potential concern
CSM	conceptual site model
CY	cubic yards
DERP	Defense Environmental Restoration Program
DoD	Department of Defense
DOT	Department of Transportation
DOT/PF	Department of Transportation and Public Facilities
DRO	diesel range organics
EDB	ethylene dibromide

EM	electromagnetic
EPA	U.S. Environmental Protection Agency
°F	degrees Fahrenheit
FD	field duplicate
GIS	geographic information system
GPS	global positioning system
GRO	gasoline range organics
HTRW	hazardous, toxic, and radiological waste
ID	identification
IDW	investigation derived waste
LCS	laboratory control sample
LCSD	laboratory control sample duplicate
LIF	laser induced fluorescence
MCL	maximum contaminant level
mg/kg	milligrams per kilogram
MMRP	Military Munitions Response Program
MS	matrix spike
MSD	matrix spike duplicate
NAPL	non-aqueous phase liquid
North Wind	North Wind, Inc.
PAH	polycyclic aromatic hydrocarbon
PAL	project action level
PARCCS	precision, accuracy, representativeness, comparability, completeness and sensitivity
PCB	polychlorinated biphenyl
PID	photoionization detector
POL	petroleum, oil, and lubricant

ppm	parts per million
PVC	polyvinyl chloride
QC	quality control
QSM	Quality Systems Manual
RCRA	Resource Conservation and Recovery Act
RI	remedial investigation
RPD	relative percent difference
RRO	residual range organics
RRS	Radio Relay Station
SOP	Standard Operating Procedure
SVOC	semivolatile organic compound
TAL	Test America Laboratories
TCLP	toxicity characteristic leaching procedure
TOC	top of casing
TSCA	Toxic Substances Control Act
UFP-QAPP	Uniform Federal Policy for Quality Assurance Project Plans
µg/L	micrograms per liter
USACE	United States Army Corps of Engineers
USAF	United States Air Force
UST	underground storage tank
UTL	upper tolerance level
UVOST	Ultra Violet Optical Screening Tool
VOC	volatile organic compound
WACS	White Alice Communication System
WWII	World War II
XRF	x-ray fluorescence

Data Qualifiers

B	Potential blank contaminant less than 10 times the blank level
J	Estimated detected result
MH	Potential matrix interference, potential high bias
ML	Potential matrix interference, potential low bias
MN	Potential matrix interference, bias unknown
ND	Not detected result
QH	Quality control failure other than matrix interference, potential high bias
QL	Quality control failure other than matrix interference, potential low bias
QN	Quality control failure other than matrix interference, bias unknown
R	Rejected result

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1. INTRODUCTION

The United States Army Corps of Engineers (USACE) executes the Formerly Used Defense Sites Program on behalf of the U.S. Army. The former Fort Morrow was evaluated against program criteria and found eligible for environmental restoration funding and cleanup to be conducted in accordance with the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). As such, an RI of the former Fort Morrow site is required in accordance with 40 Code of Federal Regulations (CFR) 300, Subpart E, "Hazardous Substance Response."

The Fort Morrow site was occupied by the U.S. Army between 1942 and 1945 to support efforts associated with WWII in the Aleutian Islands. Supplies used as part of this effort included thousands of drums of aviation fuel; petroleum, oil, and lubricants (POL); and other maintenance fluids. The amount of these materials released to the environment is not accurately known. Previous limited investigations have indicated that contaminated soils are present and may exceed 18 Alaska Administrative Code (AAC) 75 Method 2 cleanup levels.

North Wind, Inc. (North Wind) has been tasked with conducting Phase II of this remedial investigation (RI) for Areas of Concern (AOCs) B and M of the former World War II (WWII)-era Fort Morrow Army Post under Contract No. W911KB-11-D-0006, Delivery Order # 0007. The investigation was conducted in accordance with the *Final Port Heiden/Fort Morrow Remedial Investigation Phase II Uniform Federal Policy for Quality Assurance Project Plans* (UFP-QAPP; North Wind, 2014), hereinafter referred to as the Work Plan. This RI report presents the results of the investigation and an evaluation of the nature and extent of identified areas of contamination.

1.1 Purpose

The purpose of this investigation was to collect data of sufficient quality to answer the following questions:

- What areas have been impacted by Army operations?
- Does environmental contamination at specific features of the former Fort Morrow exceed the project action levels (PALs) established by 18 AAC 75, *Oil and Other Hazardous Substances Pollution Control*, Method 2 tables?
- What is the nature, areal extent, and maximum concentration levels of contamination at any areas or site features that exceed the applicable PALs?
- Does the contamination that may exceed PALs pose unacceptable risks to receptors identified in the Conceptual Site Model (CSM)?

1.2 Objectives

The objectives for this investigation were as follows:

1. Assess the presence or absence of contaminated surface and subsurface soils, surface water (if present), and groundwater;

2. Where present, assess the nature and extent of contamination;

3. Collect sufficient data to develop an ecological and human health CSM to evaluate potential exposure pathways and assess risk; and

4. Gather sufficient data to ultimately determine the possible cleanup alternative actions for each of the AOCs and associated features.

1.3 Scope

Characterization activities for Phase II were primarily limited to the screening and sampling of site features in AOCs B and M. However, some additional screening and sampling, buried metal investigations, and POL-contaminated soil removal activities were performed in AOCs C, F, J, and K as follow-up to Phase I investigation activities.

1.4 Key Personnel

Key personnel involved in the project and field execution are included in Table 1-1.

Table 1-1. Key Personnel.

Name	Title	Organizational Affiliation	Responsibilities
Meseret Ghebresllassie	Project Manager	USACE	Oversees project and responds to the Alaska Department of Environmental Conservation (ADEC) Technical Lead.
Lisa Geist	Environmental Engineering Supervisor	USACE	Contracting Officer's Representative.
Craig Scola	Project Engineer	USACE	Lead engineer.
Sean Benjamin	Project Chemist	USACE	Chemistry oversight.
Neil Folcik	Ultra Violet Optical Screening Tool (UVOST) Support Team Lead	USACE	Leads USACE UVOST activities.
Louis Howard	Project Manager	ADEC	Regulatory oversight.
Gerda Kosbruk	Administrator	Village of Port Heiden	Impacted local entity.

Table 1-1. Key Personnel (continued).

Name	Title	Organizational Affiliation	Responsibilities
Kim Kearney	Project Manager (2014) Alternate Project Manager (2015)	North Wind	Manages project – coordinates between lead agency and subcontractors.
Erik Whitmore	Project Manager (2015)	North Wind	Manages project – coordinates between lead agency and subcontractors.
Kishor Gala	Senior Chemist/ Data Validation (2014 and 2015)	North Wind	Conducts oversight of laboratory, performs data validation, and is responsible for ensuring project data quality objectives are met.
Michal Pelka	Field Manager / Site Health and Safety Officer (2014 and 2015)	North Wind	Supervises field sampling and coordinates all field activities. Certified UVOST operator.
Sue Johnson	Data Manager / Assistant Field Manager (2014 and 2015)	North Wind	Performs reviews of field data collection, provides backup support to Field Manager.
Kari Holder	UVOST Operator (2014)	North Wind	Management and maintenance of collected field screening data. Also assisted with screening data and sample collection activities.
Chris Horrell	UVOST Operator (2015)	North Wind	Management and maintenance of collected field screening data. Also assisted with screening data and sample collection activities.

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2. BACKGROUND

2.1 Location

The former Fort Morrow is located in and around the present village of Port Heiden, Lake and Peninsula Borough County, Alaska. Port Heiden is located on the western coast of the Alaska Peninsula near the Bering Sea and North Pacific Ocean (see Figure 2-1).

2.2 Description

Approximately 8,000 acres of the Fort Morrow site were occupied by the U.S. Army between 1942 and 1945 to support the war effort in the Aleutian Islands. Logistical supplies for the support of the Aleutian campaign, as well as for the support of the nearly 5,000 airmen and soldiers stationed at Fort Morrow, were shipped to the area and then were stored onsite. Thousands of drums of aviation fuel, POL, and other maintenance fluids were stored at Fort Morrow in large drum caches. The amount of these materials released to the environment is not accurately known. Previous limited investigations have indicated that contaminated soils are present at the former Fort Morrow site, which prompted further investigation. The contaminants of potential concern (COPCs) identified include POL, solvents, and polychlorinated biphenyl (PCB) compounds above regulatory action levels.

2.3 History

In 1942, the War Department acquired 1,023,927.22 acres for Fort Morrow in support of operations against the Japanese in the Aleutian Islands during WWII. Construction began in July 1942 and included cantonment buildings, a hospital, and docking facilities. In October 1942, 10,350 acres of land were reserved for use by the Civil Aeronautics Authority (CAA) in maintenance of Air Navigation Facilities. Fort Morrow was placed in caretaker status on February 1, 1944, and following the end of WWII, the site was abandoned in October 1945. The CAA/Federal Aviation Administration administered the property from 1948 to the 1960s. In the 1950s, the Air Force acquired 172.04 acres within the former Fort Morrow and constructed the White Alice Communication System (WACS). In 1966, the State of Alaska Department of Transportation and Public Facilities (DOT/PF) took over ownership of the airport. The Air Force operated the WACS until 1969 when it was converted to the Radio Relay Site, which became obsolete in the 1970s and was abandoned in November 1978.

During its brief existence, Fort Morrow was staffed by a combination of U.S. Army Air Corps and U.S. Army units. The Air Corp units were located near the airfield, with the Army units providing general defense and logistics support. The type of military unit and operation in any given area would ultimately determine the types of materials present and potentially the types of releases associated with each of the occupied areas.

2.4 Regulatory Setting

2.4.1 Regulatory Requirements

This investigation is being conducted in accordance with CERCLA, as amended by the Superfund Amendments and Reauthorization Act of 1986 (PL 99-499), and to the maximum extent practicable, the National Oil and Hazardous Substances Pollution Contingency Plan (40 CFR 300). POL-contaminated sites fall under the CERCLA petroleum exclusion and are therefore being addressed under the authority of the Defense Environmental Restoration Program (DERP) (10 USC § 2701 et seq.).

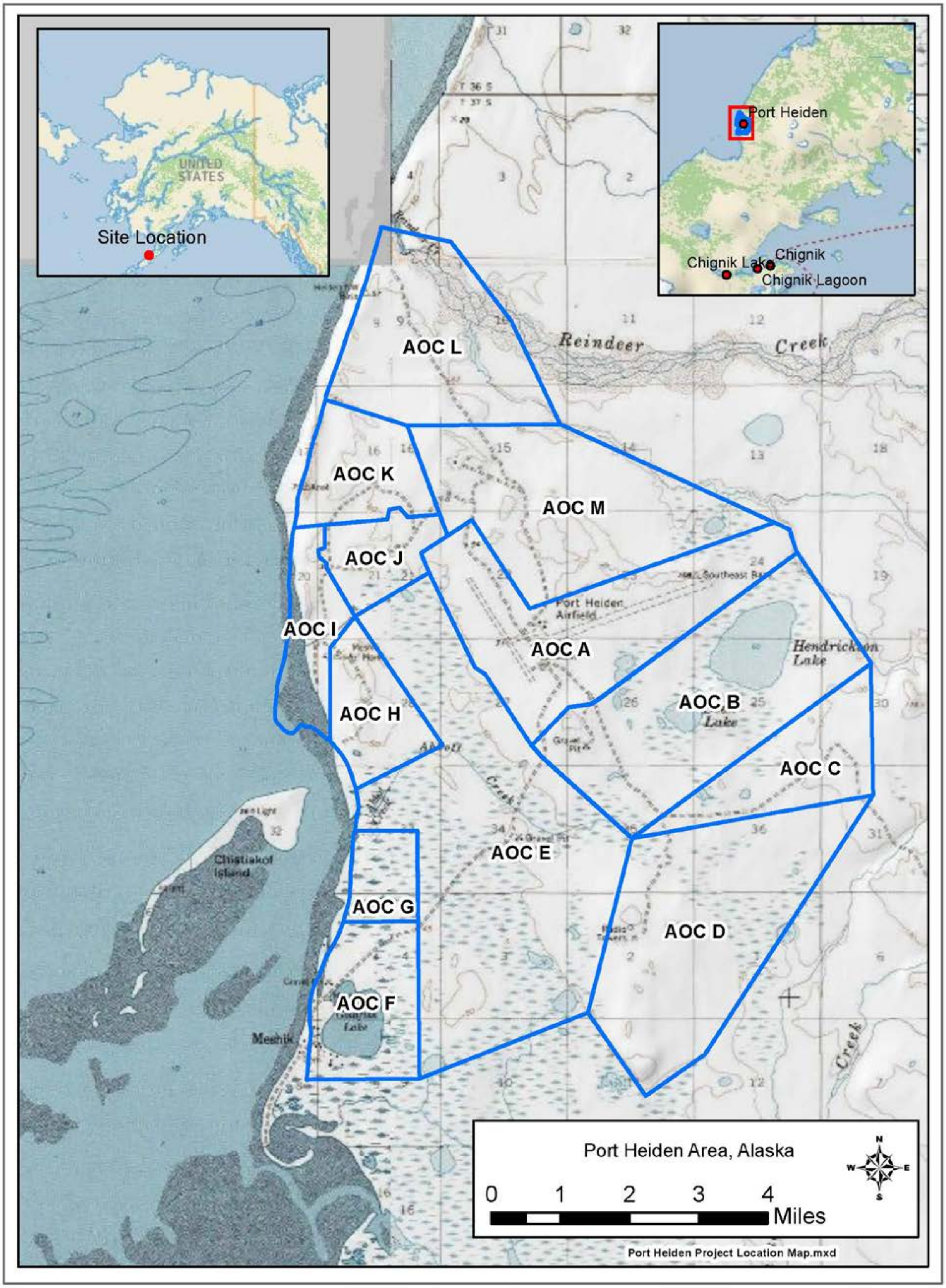


Figure 2-1. Former Fort Morrow/Port Heiden Location and Vicinity Map.

The DERP provides authority to clean up petroleum contamination when it may pose an imminent and substantial endangerment to public health, welfare, or the environment. For this effort, the USACE follows the ADEC Site Cleanup Rules (18 AAC 75, Article 3, “Oil and Other Hazardous Substances Pollution Control”) that are risk-based and indicative of when imminent and substantial endangerment to the public health or welfare or the environment has been mitigated. The former Fort Morrow is identified in the ADEC Contaminated Sites Database as Hazard ID 73.

Releases of fuels or other hazardous substances, their characterization, and remediation are regulated based on the point or depth of release, as well as the media in which the contaminants are released or found. Surface releases are regulated under 18 AAC 75 Sub-Section 3 (ADEC, 2012); 18 AAC 78, *Underground Storage Tanks*, may also be applicable, as it is possible that underground storage tanks (USTs) exist or existed at the former Fort Morrow area or that drums containing hazardous materials may have been buried. In situations where groundwater is closely connected hydrologically to nearby surface water, ADEC Water Quality Standards under 18 AAC 70 are applicable, as specified in 18 AAC 75.345. These water quality standards are dependent on the type of water (i.e., fresh or marine) and the use classification of the water body (i.e., water supply; water recreation; growth and propagation of fish, shellfish, other aquatic life, and wildlife; and harvesting for consumption of raw mollusks or other raw aquatic life).

During development of the Work Plan for Phase II investigation activities, PALs for all COPCs were either adopted from ADEC Method 2 cleanup levels or from the Environmental Protection Agency (EPA) regional screening levels (as available November 2013). The list of established PALs for all environmental media is provided in Worksheet #15 of the Work Plan (North Wind, 2014). Approved analytical methods are provided in Worksheet #12 of the Work Plan.

2.4.2 Receptors

The future land use of the former Fort Morrow facility is considered to be unrestricted residential use. Local residents are known to be subsistence harvesters (e.g., berries and vegetation) and subsistence consumers (e.g., fish, fowl, eggs, mammals, and clams).

It is possible that occupied buildings on the site, or which may be constructed on the site in the future, are in an area that could be affected by contaminant vapors. Receptors are those within 30 horizontal or vertical feet of petroleum contaminated soil or groundwater or within 100 feet of non-petroleum contaminated soil or groundwater.

2.5 Initial Site Evaluation

The initial site feature identification was conducted by the Army Geospatial Center (AGC) and the USACE from a variety of historical sources. Aerial photography from several date ranges (including as early as 1943) was used to assist in the identification of specific areas utilized for military operations. As-built drawings from the 1986 and 1989 removal of military debris from the former Fort Morrow provided extensive data on the location and former use of hundreds of buildings and site features. Historical photographs and miscellaneous maps located in the National Archives in College Park, Maryland were used to determine the historical use of individual features and to pictorially validate locations of suspected possible storage and release sites. The *Narrative Report of Alaska Construction 1941-1944* (Bush, 1944), a compilation of war-time construction activities, was also used extensively. A geodatabase of the data was created by the USACE to identify and track the individual site features.

The USACE used meetings with project stakeholders to facilitate the planning of the RI. Systematic planning is considered the first leg of the EPA Triad Approach and sets the goals of the remainder of the Triad (EPA, 2005). The three main elements associated with the Triad Approach include:

1. Systematic planning,
2. Dynamic work strategy, and
3. Real time measurement systems.

For the sake of manageability, the site was divided into 13 AOCs – A through M (see Figure 2-1). While each of these AOCs is based on a specific geographical area, attempts were made to group site features that were associated with a specific company, battalion, or special general type of land usage (e.g., hospital, warehouse, fueling area, airfield operations).

The Triad Team met to discuss and plan the RI on nine occasions. The Triad planning group included members of the impacted local community (Port Heiden), USACE representatives, ADEC, and the RI contractor (North Wind). Individuals from several other entities attended some of the planning meetings. The Triad Team used the list of site features and previous preliminary sampling to identify the list of COPCs and to plan the RI. Decisions regarding implementation of the RI were made by mutual agreement of all involved stakeholders.

A total of 1,269 individual site features located in the 13 AOCs were identified by the Triad Team for potential investigation. A total of 161 of these site features were found to be ineligible for hazardous, toxic, and radiological waste (HTRW) program funding (e.g., ammunition storage sites, munition dump sites, defensive position ranges, and gun emplacements to be addressed as part of the USACE Military Munitions Response Program [MMRP] at a later date). Additionally, 15 site features associated with Air Force operations subsequent to the closure of Fort Morrow were also excluded. The remaining number of site features to be evaluated under this investigation was 1,093.

Site features were divided into two categories depending on the probability for release of significant contamination to the environment. Site features with the greatest potential of significant releases were identified for screening and sampling at 100% of their occurrence within any given AOC. Site features with lower probability of significant releases were identified for screening at a lesser frequency of 25% of their total occurrence within any AOC, and sampling at a frequency of 10% of those that were screened. Additionally, the amount of screening data to obtain at each feature type was determined. Smaller features and those with the highest probability of contamination were assigned 20-foot grid spacing, while larger features and those with less probability of contamination were assigned 35-foot grid spacing, with some exceptions. Table 2-1 lists the 32 types of identified site features found at Fort Morrow, their sample identification (ID) code, associated screening frequency, and grid spacing requirements.

Table 2-1. Site Feature Types, Sample ID Codes, and Screening Frequency.

Site Feature Type	Sample ID Code	Screening Frequency (%)	Grid (see note)	Site Feature Type	Sample ID Code	Screening Frequency (%)	Grid (see note)
Administration	AD	25	20-ft	Power House	PR	100	20-ft
Antennae	AT	100	20-ft	Pump House	PH	100	20-ft
Building Unknown	BU	25	20-ft	Quarters or Barracks	QT	25	2 points (see note)
Buried Drums	BD	100	20-ft	Radar Building	RD	100	20-ft
Burn Pit	BP	100	20-ft	Radio Station	RS	100	20-ft
Debris	DB	100	20-ft	Recreation	RC	25	20-ft

Table 2-1. Site Feature Types, Sample ID Codes, and Screening Frequency (continued).

Site Feature Type	Sample ID Code	Screening Frequency (%)	Grid (see note)	Site Feature Type	Sample ID Code	Screening Frequency (%)	Grid (see note)
Drum Area, Former	DA	100	20-ft	Shop	SH	100	20-ft
Dump Site	DS	100	20-ft	Showers	SW	25	20-ft
Fuel Storage	FS	100	35-ft	Spill	SP	100	20-ft
Ground Scars	GS	25	35-ft	Storage	ST	100	20-ft
Latrine	LT	100	20-ft	Tank	TK	100	20-ft
Loose Storage	LS	100	20-ft	Transformer	TF	100	20-ft
Mess Halls	MH	100	See note	Trench	TR	100	35-ft
Mounded Material	MM	100	20-ft (see note)	Warehouse	WH	100	20-ft
Other	OT	100	20-ft	Well	WL	100	20-ft
Pit	PT	100	20-ft	X-Ray Building	XR	100	20-ft

Note: Grid spacing may be increased from 20 to 35-feet for large feature areas (over 1,600 square feet). The minimum number of screening points per feature is four points, with the exception of mess halls and quarters. Quarters or barracks shall be screened at each end of Quonset offset 5-feet from center. Rectangular mess halls shall be screened around the perimeter; "T" shaped mess halls shall have two screening points outside of "T."

2.6 Previous Investigations and Remedial Actions

Several previous investigations and remedial actions have been completed in the former Fort Morrow area pertinent to the scope of this investigation. Table 2-2 provides a list of previous investigation documents, and Appendix A provides a detailed summary of each.

Table 2-2. Previous Investigations at Fort Morrow.

FRMD NUMBER	Document	Year Published
No FRMD number	SGS North America Inc. *Level II Laboratory Data Package*, ND	No Date
F10AK002704_01.04_0500_p	*Port Heiden Site Photos for Areas 3, 5,6, 7, 8, 10, and 13*	No Date
F10AK002700_01.06_0001_p	USACE, Alaska District. *Debris Removal and Cleanup Study Aleutian Islands and Lower Alaska Peninsula Alaska*, Oct. 1976	1976
No FRMD number	USACE. *Environmental Assessment Department of Defense Environmental Restoration Account Port Heiden, Alaska*, Apr. 1987	1987
F10AK0027--_01.09_0504_a	USACE, *Summary of THM (Toxic/Hazardous Material) at DERA 3500: Port Heiden/Port Moller*, Geotechnical Branch, Jan. 1987	1987
F10AK002803_01.09_0500_a	USACE, Alaska District. *Engineering Report for the Defense Environmental Restoration Program, Sampling Results and Cleanup Design for Port Heiden and Port Moller*, Dec. 1987	1987
F10AK002703_01.14_0502_a	USACE, AK District. *Safety Plan for Hazardous Waste Site Investigation at Port Heiden, Alaska*. Engineers, Materials and Instrumentation Section, June 1988	1988

Table 2-2. Previous Investigations at Fort Morrow (continued).

FRMD NUMBER	Document	Year Published
F10AK0027-_01.13_0502_a	Brooks, Eddie. *Trip Report - Recon Trip to Port Heiden and Port Moller*, June 88	1988
F10AK002703_01.14_0500_a	USACE. *Sampling Plan for Port Heiden.* Materials and Instrumentation Section, June 1988	1988
F10AK002702_01.04_0500_p	USACE. *Port Heiden and Port Moller Defense Environmental Restoration Program Debris Cleanup and Site Restoration*, 1989	1989
F10AK0027--_01.09_0501_a	Clark, Robert J. *Water Sample Test Results*, March 1989	1989
F10AK0027--_03.11_0500_a	USACE, AK District. *Final Risk Analysis Defense Environmental Remediation Program Port Heiden, Alaska,* June 1991	1991
No FRMD number	CH2MHill. *Preliminary Assessment Port Heiden*. Prepared for USAF 11th CEOS, Jan. 1994	1994
F10AK002702_07.16_0500_p	USACE, *Debris Cleanup and Site Restoration Defense Environmental Restoration Program Port Heiden, Alaska Landfill Closure Report Solid Waste Disposal Permit Numbers 8721-BA012 and 8721-BA013*, Feb. 1996	1996
F10AK0027--_01.09_0500_a	USAF, 611th CES. *Final Preliminary Assessment/Site Inspection Port Heiden Radio Relay Station Port Heiden, Alaska*, March 1996	1996
F10AK002703_01.05_0500_p	Keres Consulting. *Limited Drinking Water Quality Assessment of Domestic Wells in the Native Village of Port Heiden, Alaska*, Oct. 2003	2003
No FRMD number	Anderson, Scott. *Surface water sample data provided by village*, Nov. 2003	2003
No FRMD number	USAF, 611th CES. *Final Remedial Investigation/Feasibility Study Port Heiden Radio Relay Station Port Heiden, Alaska, Volume I*, April 2006	2006
F10AK200702_07.08_0500_p	Jacobs Engineering. *2007 Port Heiden Drum Disposal Area Remedial Action Port Heiden Drum Area, Port Heiden, Alaska*, Final, April 2008	2008
No FRMD number	Keres Consulting. *Draft Step I Site Assessment Report Native Village of Port Heiden, Alaska. Port Heiden Radio Relay Station*, March 2008	2008
No FRMD number	Keres Consulting. *Draft Step I Site Assessment Report Native Village of Port Heiden, Alaska. Fort Morrow A, Fort Morrow B, Fort Morrow C*, Sep. 2008	2008
No FRMD number	USAF. *Summary of PCB spills*, July 2010	2010
No FRMD number	USACE, Alaska District. *Port Heiden/Fort Morrow, Alaska Examination of Historical Aerial Photography Final Report*, Sep. 2010	2010
No FRMD number	Sundance Consulting. *Draft Step III Site Assessment Report Native Village of Port Heiden, Alaska. Fort Morrow*, March 2011	2011
F10AK002704_03.10_0500 200-1e	North Wind Inc. *Final Remedial Investigation Report Fort Morrow Remedial Investigation Port Heiden, Alaska*, Nov. 2013	2013

2.7 Conceptual Site Model Development

2.7.1 AOC B

The CSM scoping and graphic forms for AOC B (see Appendix B) are updated based on 2014 and 2015 screening and sampling results. The CSM graphic form is included as Figure 2-2, while the potential release mechanisms and potential exposure pathways are illustrated in Figure 2-3.

Potential sources of contamination in AOC B included USTs, aboveground storage tanks (ASTs), fuel dispensers, drums, vehicles, landfills, and latrine plumbing. The potential release mechanisms at AOC B included spills, leaks, and direct discharge. The potentially impacted media in AOC B included surface soil, subsurface soil, air, groundwater, and biota.

Direct contact by incidental soil ingestion is a complete pathway at AOC B because contaminants are present in the soil between 0 and 15 feet below ground surface (bgs). Dermal absorption of contaminants is a complete exposure pathway because contaminants that can permeate the skin were detected in the soil between 0 and 15 feet bgs. Ingestion of groundwater is a complete exposure pathway because contaminants were detected in the groundwater. Ingestion of surface water is an incomplete exposure pathway. Surface water was not sampled because it was determined that there were no bodies of water that met the approved Work Plan definition of a "significant body of more than 100 square feet located within 50 feet downgradient of contaminated groundwater" (North Wind, 2014).

Contamination is present where it can potentially be taken up by biota and is in an area that is, or could be, used for hunting and harvesting; therefore, ingestion of wild foods is a complete exposure pathway. Inhalation of outdoor air is a complete exposure pathway because volatile and petroleum compounds are present in the surface soil. Inhalation of indoor air, or vapor intrusion, is a complete pathway for future receptors in AOC B because petroleum and volatile contaminants were detected within 30 feet of a potential future building site.

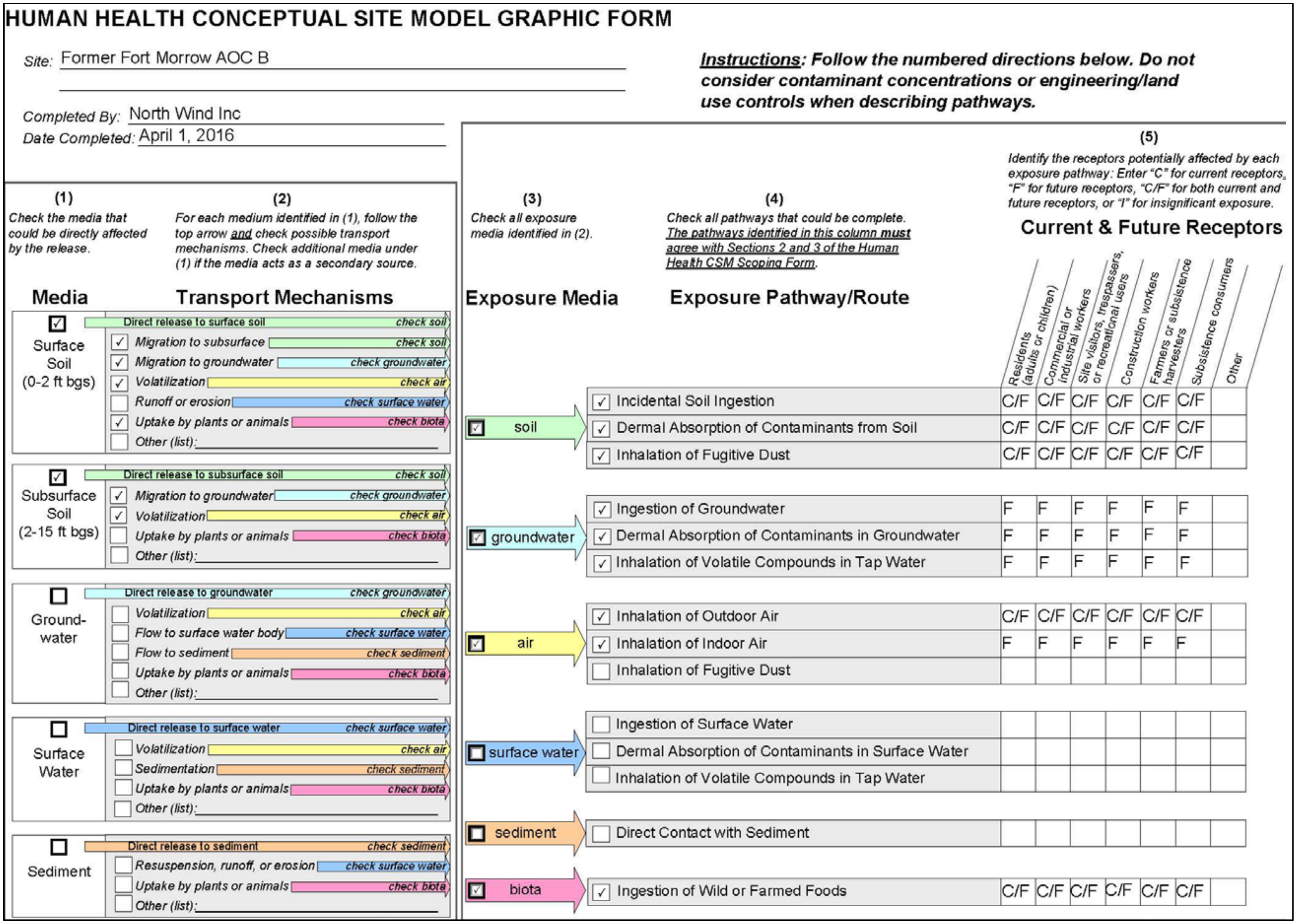
2.7.2 AOC M

The CSM forms for AOC M have been updated based on the 2014 and 2015 screening and sampling results. The potential release mechanisms and potential exposure pathways are illustrated in Figure 2-3, and the CSM graphic form is included as Figure 2-4.

Potential sources of contamination in AOC M included USTs, ASTs, fuel dispensers, drums, and vehicles. The potential release mechanisms at AOC M included spills, leaks, and direct discharge. The potentially impacted media in AOC M include surface and subsurface soil, air, groundwater, and biota.

Direct contact by incidental soil ingestion is a complete pathway at AOC M because contaminants are present in the soil between 0 and 15 feet bgs. Dermal absorption of contaminants is a complete exposure pathway because contaminants that can permeate the skin were detected in the soil between 0 and 15 feet bgs. Ingestion of groundwater is a complete exposure pathway because detected contaminants in the soil could migrate to groundwater in the future. Ingestion of surface water is an incomplete exposure pathway. Surface water was not sampled because it was determined that there were no bodies of water that met the approved Work Plan definition of a "significant body of more than 100 square feet located within 50 feet downgradient of contaminated groundwater" (North Wind, 2014).

Contamination is present where it can potentially be taken up by biota, and is in an area that is, or could be, used for hunting and harvesting; therefore, ingestion of wild foods is a complete exposure pathway. Inhalation of outdoor air is a complete exposure pathway because volatile and petroleum compounds are present in the soil between 0 and 15 feet bgs. Inhalation of indoor air, or vapor intrusion, is a complete pathway in AOC M. Although it is unlikely that this area will be used for building in the future, petroleum and volatile contaminants may be present within 30 feet of a future building site, thus potentially impacting future receptors.



HUMAN HEALTH CONCEPTUAL SITE MODEL GRAPHIC FORM

Site: Former Fort Morrow AOC B

Completed By: North Wind Inc

Date Completed: April 1, 2016

***Instructions**: Follow the numbered directions below. Do not consider contaminant concentrations or engineering/land use controls when describing pathways.*

(1) *Check the media that could be directly affected by the release.*

(2) *For each medium identified in (1), follow the top arrow and check possible transport mechanisms. Check additional media under (1) if the media acts as a secondary source.*

(3) *Check all exposure media identified in (2).*

(4) *Check all pathways that could be complete. The pathways identified in this column must agree with Sections 2 and 3 of the Human Health CSM Scoping Form.*

(5) *Identify the receptors potentially affected by each exposure pathway: Enter "C" for current receptors, "F" for future receptors, "C/F" for both current and future receptors, or "I" for insignificant exposure.*

Media / Transport Mechanisms

Media	Transport Mechanisms	
☑ Surface Soil (0-2 ft bgs)	Direct release to surface soil	check soil
	✓ Migration to subsurface	check soil
	✓ Migration to groundwater	check groundwater
	✓ Volatilization	check air
	☐ Runoff or erosion	check surface water
	✓ Uptake by plants or animals	check biota
	☐ Other (list):	
☑ Subsurface Soil (2-15 ft bgs)	Direct release to subsurface soil	check soil
	✓ Migration to groundwater	check groundwater
	✓ Volatilization	check air
	☐ Uptake by plants or animals	check biota
	☐ Other (list):	
☐ Ground-water	Direct release to groundwater	check groundwater
	☐ Volatilization	check air
	☐ Flow to surface water body	check surface water
	☐ Flow to sediment	check sediment
	☐ Uptake by plants or animals	check biota
	☐ Other (list):	
☐ Surface Water	Direct release to surface water	check surface water
	☐ Volatilization	check air
	☐ Sedimentation	check sediment
	☐ Uptake by plants or animals	check biota
	☐ Other (list):	
☐ Sediment	Direct release to sediment	check sediment
	☐ Resuspension, runoff, or erosion	check surface water
	☐ Uptake by plants or animals	check biota
	☐ Other (list):	

Exposure Media / Exposure Pathway/Route / Current & Future Receptors

Exposure Media	Exposure Pathway/Route	Residents (adults or children)	Commercial or industrial workers	Site visitors, trespassers, or recreational users	Construction workers	Farmers or subsistence harvesters	Subsistence consumers	Other
☑ soil	✓ Incidental Soil Ingestion	C/F	C/F	C/F	C/F	C/F	C/F	
	✓ Dermal Absorption of Contaminants from Soil	C/F	C/F	C/F	C/F	C/F	C/F	
	✓ Inhalation of Fugitive Dust	C/F	C/F	C/F	C/F	C/F	C/F	
☑ groundwater	✓ Ingestion of Groundwater	F	F	F	F	F	F	
	✓ Dermal Absorption of Contaminants in Groundwater	F	F	F	F	F	F	
	✓ Inhalation of Volatile Compounds in Tap Water	F	F	F	F	F	F	
☑ air	✓ Inhalation of Outdoor Air	C/F	C/F	C/F	C/F	C/F	C/F	
	✓ Inhalation of Indoor Air	F	F	F	F	F	F	
	☐ Inhalation of Fugitive Dust							
☐ surface water	☐ Ingestion of Surface Water							
	☐ Dermal Absorption of Contaminants in Surface Water							
	☐ Inhalation of Volatile Compounds in Tap Water							
☐ sediment	☐ Direct Contact with Sediment							
☑ biota	✓ Ingestion of Wild or Farmed Foods	C/F	C/F	C/F	C/F	C/F	C/F	

Figure 2-2. CSM Graphic Form for AOC B.

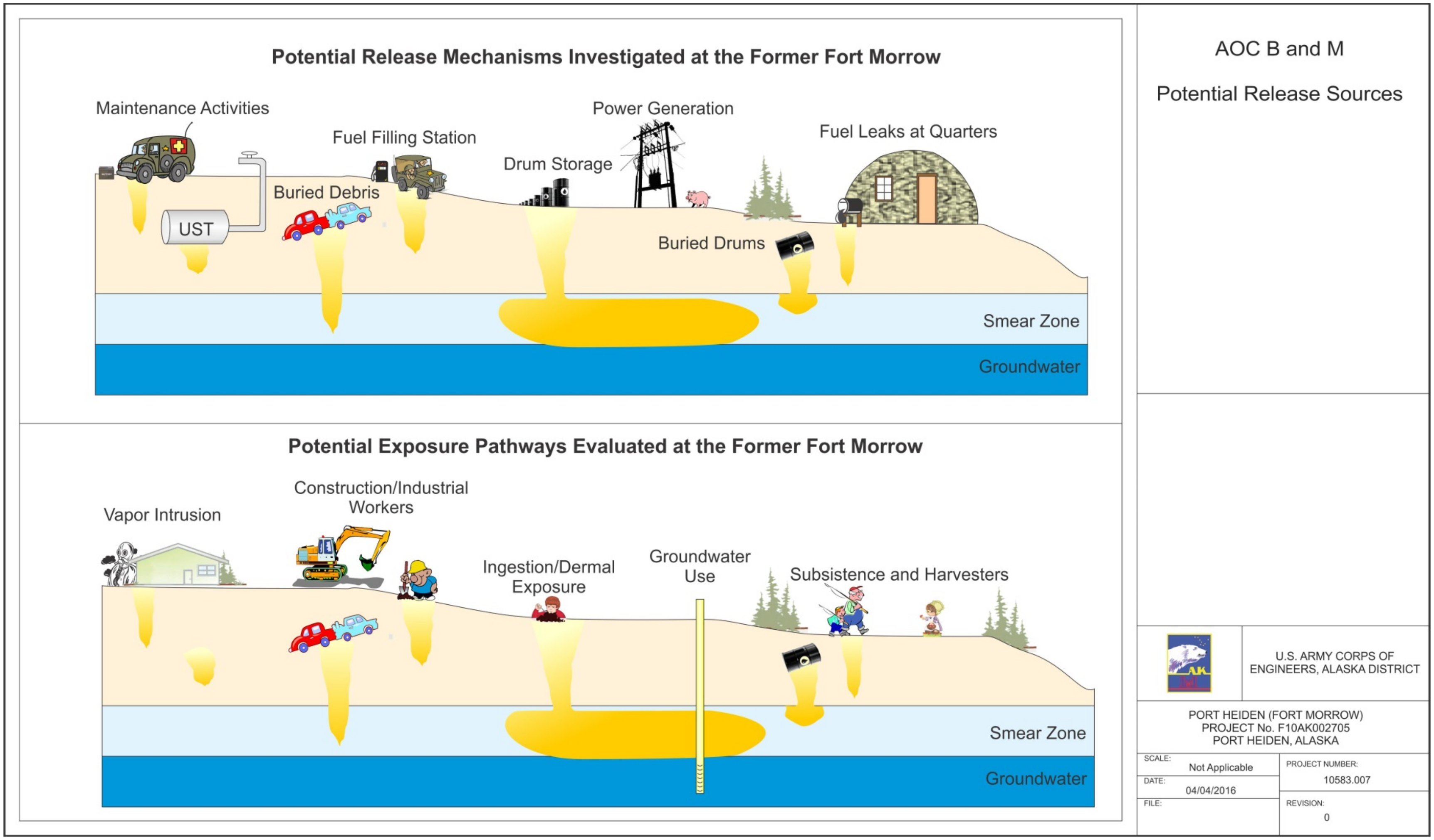
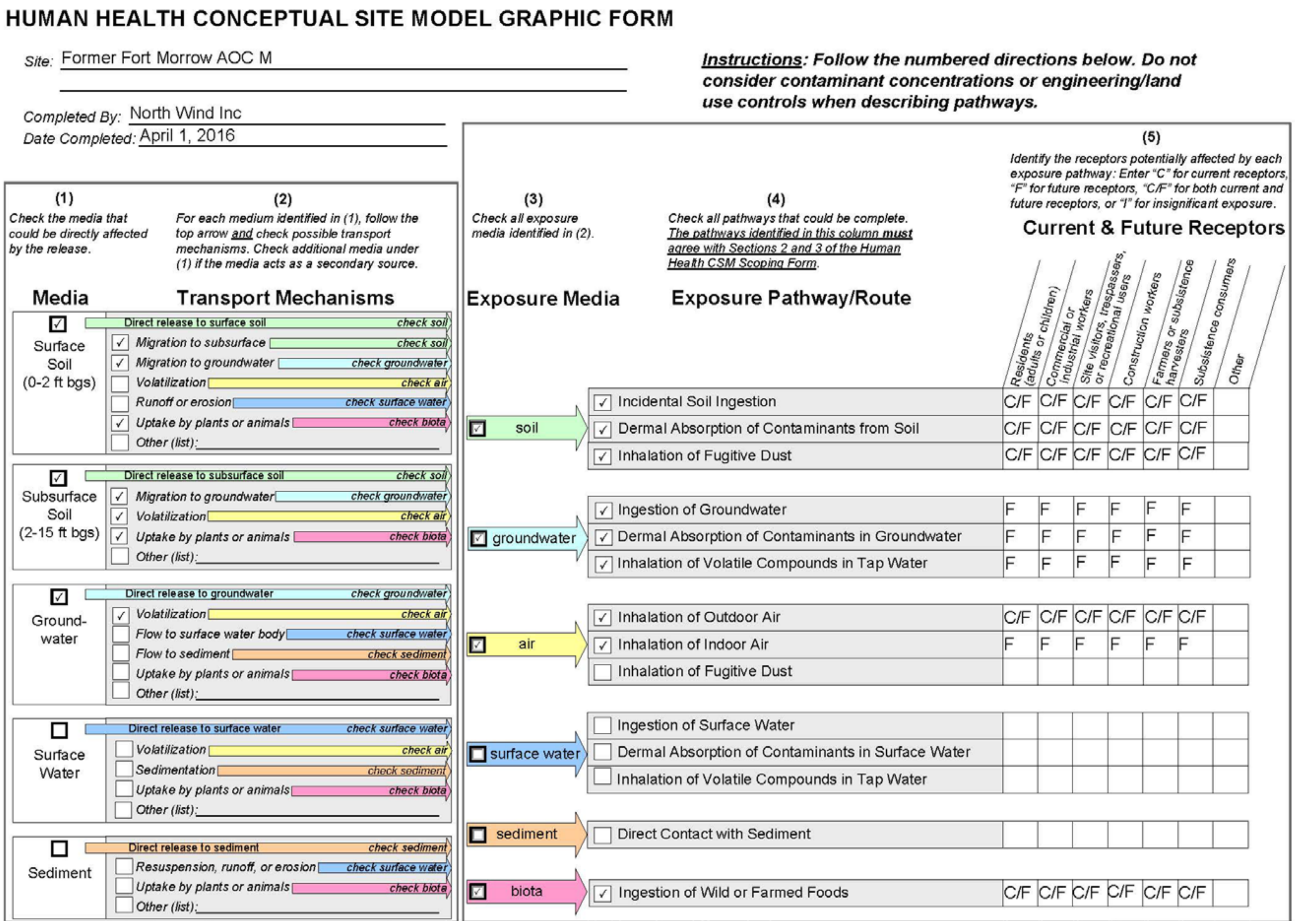


Figure 2-3. Potential Release Mechanisms and Exposure Sources at AOCs B and M.



HUMAN HEALTH CONCEPTUAL SITE MODEL GRAPHIC FORM

Site: Former Fort Morrow AOC M

Completed By: North Wind Inc
Date Completed: April 1, 2016

***Instructions*: Follow the numbered directions below. Do not consider contaminant concentrations or engineering/land use controls when describing pathways.**

(1) *Check the media that could be directly affected by the release.*

(2) *For each medium identified in (1), follow the top arrow and check possible transport mechanisms. Check additional media under (1) if the media acts as a secondary source.*

(3) *Check all exposure media identified in (2).*

(4) *Check all pathways that could be complete. The pathways identified in this column must agree with Sections 2 and 3 of the Human Health CSM Scoping Form.*

(5) *Identify the receptors potentially affected by each exposure pathway: Enter "C" for current receptors, "F" for future receptors, "C/F" for both current and future receptors, or "I" for insignificant exposure.*

Media	Transport Mechanisms
☑ Surface Soil (0-2 ft bgs)	Direct release to surface soil – check soil
	✓ Migration to subsurface – check soil
	✓ Migration to groundwater – check groundwater
	☐ Volatilization – check air
	☐ Runoff or erosion – check surface water
	✓ Uptake by plants or animals – check biota
	☐ Other (list):
☑ Subsurface Soil (2-15 ft bgs)	Direct release to subsurface soil – check soil
	✓ Migration to groundwater – check groundwater
	✓ Volatilization – check air
	✓ Uptake by plants or animals – check biota
	☐ Other (list):
☑ Groundwater	Direct release to groundwater – check groundwater
	✓ Volatilization – check air
	☐ Flow to surface water body – check surface water
	☐ Flow to sediment – check sediment
	☐ Uptake by plants or animals – check biota
	☐ Other (list):
☐ Surface Water	Direct release to surface water – check surface water
	☐ Volatilization – check air
	☐ Sedimentation – check sediment
	☐ Uptake by plants or animals – check biota
	☐ Other (list):
☐ Sediment	Direct release to sediment – check sediment
	☐ Resuspension, runoff, or erosion – check surface water
	☐ Uptake by plants or animals – check biota
	☐ Other (list):

Current & Future Receptors

Exposure Media	Exposure Pathway/Route	Residents (adults or children)	Commercial or industrial workers	Site visitors, trespassers, or recreational users	Construction workers	Farmers or subsistence harvesters	Subsistence consumers	Other
☑ soil	✓ Incidental Soil Ingestion	C/F	C/F	C/F	C/F	C/F	C/F	
	✓ Dermal Absorption of Contaminants from Soil	C/F	C/F	C/F	C/F	C/F	C/F	
	✓ Inhalation of Fugitive Dust	C/F	C/F	C/F	C/F	C/F	C/F	
☑ groundwater	✓ Ingestion of Groundwater	F	F	F	F	F	F	
	✓ Dermal Absorption of Contaminants in Groundwater	F	F	F	F	F	F	
	✓ Inhalation of Volatile Compounds in Tap Water	F	F	F	F	F	F	
☑ air	✓ Inhalation of Outdoor Air	C/F	C/F	C/F	C/F	C/F	C/F	
	✓ Inhalation of Indoor Air	F	F	F	F	F	F	
	☐ Inhalation of Fugitive Dust							
☐ surface water	☐ Ingestion of Surface Water							
	☐ Dermal Absorption of Contaminants in Surface Water							
	☐ Inhalation of Volatile Compounds in Tap Water							
☐ sediment	☐ Direct Contact with Sediment							
☑ biota	✓ Ingestion of Wild or Farmed Foods	C/F	C/F	C/F	C/F	C/F	C/F	

Figure 2-4. CSM Graphic Form for AOC M.

3. PHYSICAL CHARACTERISTICS OF STUDY AREA

Geologic and climatological parameters have a dramatic effect on the fate and transport, as well as the duration, of any possible contaminants at the former Fort Morrow site. The following sections discuss the physical characteristics of the study area.

3.1 Climatological Conditions

Port Heiden has a maritime climate (Hartman and Johnson, 1984). Climatic conditions are affected by the Bering Sea and the North Pacific Ocean and are characterized by small temperature variations, high humidity, heavy precipitation, and frequent cloudy periods. Cyclonic storms with high winds, fog, and poor visibility occur frequently (Hartman and Johnson, 1984). Mountainous terrain of the Aleutian Range is approximately 10 kilometers east of Port Heiden and provides protection from approaching southeasterly winds and precipitation. The mean annual temperature for the periods 1952 and 1987 for Port Heiden is 36.14 degrees Fahrenheit (°F). Mean monthly temperatures range from an August mean maximum of 57.92°F to a February mean minimum of 15.98°F (Leslie, 1989; Table 1). Mean annual precipitation is approximately 15.55 inches, and mean annual snowfall is approximately 51.57 inches. The mean monthly and annual temperature, precipitation, and snowfall for Port Heiden, Alaska (USGS, 1995) are summarized in Table 3-1.

Table 3-1. Temperature and Precipitation at Port Heiden, Alaska.

Annual Temperature and Precipitation for Port Heiden, Alaska													
	Jan.	**Feb.**	**Mar.**	**Apr.**	**May**	**Jun.**	**Jul.**	**Aug.**	**Sep.**	**Oct.**	**Nov.**	**Dec.**	**Annual**
Temperature (°F)													
Mean maximum[1]	28.5	28.4	32.3	37.4	46.5	52.8	57.2	57.9	53.4	43.1	35.9	30.2	42.0
Mean minimum[2]	16.1	15.9	19.4	25.5	34.1	40.8	46.0	47.6	42.2	32.3	24.9	19.0	30.3
Mean	22.2	22.2	25.7	31.2	40.4	46.9	51.6	52.8	47.8	37.7	30.5	24.6	36.1
Precipitation (inches of moisture)													
	0.70	0.51	0.82	0.66	0.78	1.10	1.65	2.20	2.08	2.40	1.45	1.14	15.49
Snowfall (inches)													
	11.61	7.91	6.29	6.41	1.81	0.11	0	0	0	2.51	5.31	9.68	51.64

[1] Record maximum, 87.08°F, July 1971.
[2] Record minimum, -25.96°F, March 1971.
Table modified from Leslie (1989).

3.2 Vegetation

Vegetation in the Port Heiden area consists of tundra, shrub tundra, and beach vegetation (Viereck and Little, 1972; NPS, 1987). Wet-tundra vegetation grows in lowlands on poorly drained organic-rich soils and is dominated by water-tolerant plants such as sphagnum. Moist-tundra vegetation grows on terraces, subalpine slopes, and coastal lowlands and consists of heaths, shrubs, and grasses. Alpine tundra vegetation is found on exposed slopes in upland areas and on the summits of ridges and knolls and consists of scattered heaths, lichens, and mosses. Shrub tundra is found on moderately well-drained lowlands and slopes below approximately 300 meters in elevation and consists of alder, willow, and grasses. Beach vegetation is found on well-drained coastal sand dunes and consists principally of ryegrass.

3.3 Geology, Soils, and Topography

Detterman et al. (1981a, b) have mapped the geology of the former Fort Morrow area. Major geologic units observed near the site of the former Fort Morrow include till and volcanic, estuarine, alluvial, outwash, swamp, and marine terrace deposits. The volcanic deposits in the Fort Morrow area consist of pumice, ash, debris-flow deposits, and ash-flow tuff of Holocene and Pleistocene age (Detterman et al., 198la).

The ash-flow tuff deposits were emplaced during the most recent caldera-forming eruption of Aniakchak Crater approximately 3,400 years ago. The volcanic tuff is unsorted, poorly stratified, and primarily composed of pumice in a matrix of fine to coarse ash and lithic fragments (Detterman et al., 1981b). The ash-fall tuff is moderately well sorted, well stratified, and consists of fine- to medium-grained dacitic ash. Near the Port Heiden airfield, volcanic deposits are exposed on either side of the runway, around the radio beacon, on slopes adjacent to Reindeer Creek and Aniakchak Crater, and along the eastern shoreline of Hendrickson Lake. The depth to volcanic tuff deposits in other areas of the former Fort Morrow is not known specifically but is likely between 75 and 150 feet bgs.

Debris-flow, pumice, and ash deposits were found near the ground surface in much of the investigation area. Typically, these units non-conformably overlay a paleosol developed on earlier geologic deposits. The thickness of this most recent deposit stratigraphic sequence was found to vary from 2 to 20 feet (where present).

Estuarine deposits found along the Bering Sea coast consist of dark-brown to black organic silt and clay. Swamp deposits are adjacent to the estuarine deposits south-southwest of the Port Heiden Airfield. These deposits form by the accumulation of sedge and sphagnum peat. A large alluvial fan, consisting mostly of well-sorted pumice, extends northwestward from the base of Aniakchak Crater toward the coast. These deposits extend to approximately 6.2 miles east of the airfield. Alluvial deposits also are adjacent to Reindeer Creek near the northern edge of the former Fort Morrow. Outwash deposits found northwest of the airfield consist of moderately well-sorted and stratified sand, silt, and gravel that form a flat to gently sloping plain. Marine terrace deposits south of the airfield are typically about 40 feet above mean high tide. These deposits consist of stratified and well-sorted sand and gravel that form level plains truncated by steep wave-cut scarps (USGS, 1995).

The soils in the Fort Morrow area are generally poorly developed due to the geologically frequent deposition of volcanic ash (Rieger et al., 1979; Howard Grey and Associates, Inc., 1982). Where soils are well developed, they are dark brown to reddish brown and typically have buried surface horizons because of repeated deposition of volcanic ash. The soil particles are mostly sand or gravel size (Howard Grey and Associates, Inc., 1982). The Port Heiden area is generally free of permafrost (USGS, 1995).

Buried surface horizons, or paleosols, were present in some UVOST boreholes. The paleosols were also very evident in the wave cut beach scarps along the Bearing Sea coast. UVOST boings showed elevated laser induced fluorescence (LIF) of 2 to 3 feet thick when penetrating the paleosols. Paleosols identified in sample boreholes were typically composed of fine-grained sand and silt with abundant organic material.

3.4 Hydrology and Groundwater Use

The principal groundwater aquifers near Port Heiden consist of (1) unconsolidated sand and gravel, (2) volcanic tuff (mostly pumice), and (3) bedrock. Silt- and clay-rich till layers locally act as confining beds (USGS, 1995). At the former Fort Morrow site, groundwater is present at relatively shallow depths ranging from 4 feet to approximately 60 feet. The deepest depths to groundwater are in AOC M near the Radio Relay Station (RRS) and shallower depths are observed to the southeast and southwest areas of the former Fort Morrow site. Known depths to groundwater in AOC B east of the gravel pit are 15 to 20 feet.

Most domestic drinking water wells in the area are completed to depths well below the local piezometric surface. The hydraulic head or elevation of groundwater in wells constructed well below the groundwater surface is nearly identical to wells constructed spanning the piezometric surface. This indicates that the aquifer is, in general, a continuous unconfined system. It was noted during Phase I investigations that the surface elevation of local open water bodies closely matched the elevation of groundwater in wells located nearby. Figure 3-1 shows general groundwater flow directions in and around the Former Fort Morrow area based on previous investigations and augmented with information obtained during Phase I and II investigation activities.

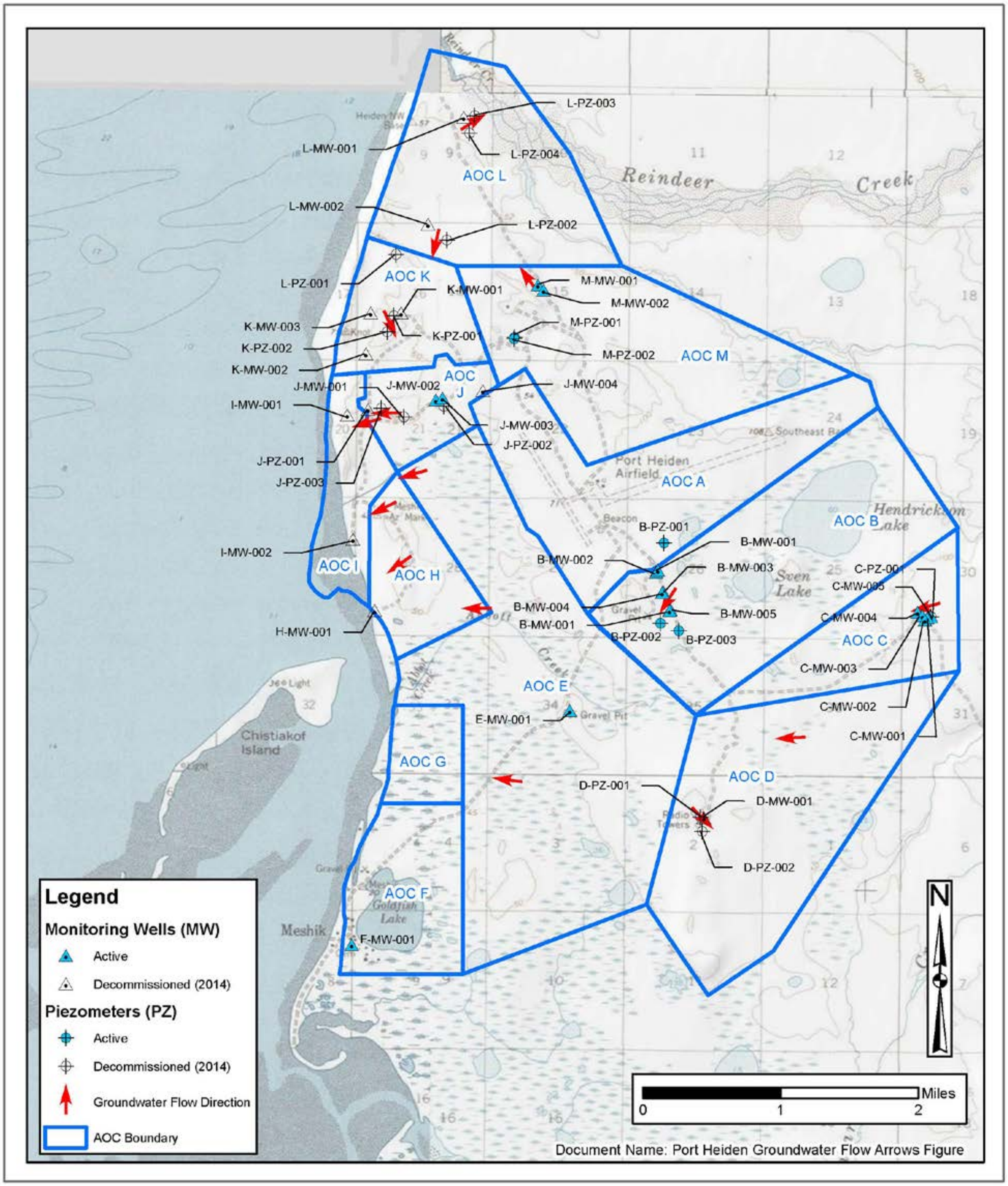


Figure 3-1. Generalized Groundwater Flow Directions at Former Fort Morrow.

4. FIELD ACTIVITIES AND METHODS

4.1 Mobilization/Demobilization

Phase II investigation activities were conducted during the 2014 and 2015 field seasons. Mobilization in 2014 took place June 18 to 21 and demobilization took place October 7 and 8. Equipment was transported by Lynden Air Cargo L-100-30 aircraft while project personnel were transported by Security Aviation. Mobilization in 2015 took place May 20 through 24. Demobilization of the majority of project equipment took place September 28, with final demobilization of remaining equipment and personnel October 3 through 6. On November 16, crew members mobilized via Lake Clark Air to collect several hand auger boreholes for emulation and samples to fill identified data gaps. Demobilization occurred on November 18, also via Lake Clark Air.

4.2 Initial Site Feature Surveys

Initial site feature surveys were completed in 2014. Field crews located 395 site features in AOCs B and M using aerial field maps and global positioning system (GPS) units pre-loaded with feature location data. GPS feature locations were verified on the ground against evidence of past disturbance (e.g., ground scars, stunted vegetation, mounded soil banks, and remnant construction debris) and feature boundaries were adjusted as necessary. Features were then staked with a wooden lath marked with the feature ID and photographed (see Appendix C).

Field forms documenting location, feature type, description, and vehicle accessibility were completed (see Appendix D). The presence of construction debris, metal debris, or obvious signs of contaminated soils or visual clues to contamination (i.e., distressed or discolored vegetation) was also documented. Figure 4-1 shows photo documentation and field marking of site feature M-QT-020, typical of site feature documentation.

Figure 4-1. Field Marking of Feature M-QT-020, Typical Field Identification of Site Features.

4.3 Field Screening

This section discusses screening methods for POL and lead. Geophysical surveys are discussed in Section 4.6, Subsurface Metal Investigations.

4.3.1 Screening for Petroleum, Oils, and Lubricants

A total of 192 features were screened for POL contamination between AOC B (21 features) and AOC M (171 features). Two additional features in AOC F and one in AOC E were screened to supplement information gathered during Phase I investigations. In all, 1,979 primary characterization screening probes were drilled. Logs for all probes are provided in Appendix E, ordered by AOC, then probe number. Maps depicting screening locations for each feature are provided in Appendix F.

The UVOST® system was employed for delineating subsurface POL contamination. The UVOST system, in simplistic terms, consists of a laser unit, an oscilloscope, a threaded probe that holds the laser delivery system and attaches to a drill rod, and a fiber optic cable connecting the probe to the laser and oscilloscope. Ultraviolet light generated by the laser is emitted into the soil surrounding the probe, inducing a fluorescence response of any polycyclic aromatic hydrocarbon (PAH) components that may be present. As the probe is advanced through the soil column, a graphic interpretation is generated by the OST® software and viewed by the operator. The operator can view immediately any changes in fluorescence response potentially indicative of POL contamination above soil background and make real-time field decisions regarding site characterization activities (i.e., target probe depths and number of boreholes necessary to delineate potential POL contamination).

Four drill rigs were used with the UVOST system during Phase II investigations. In 2014, a Bobcat-mounted Power Probe® model 9630 VTR-M and a track-mounted GeoProbe® 7822DT were used. In 2015, a track-mounted AMS® 9500 and a track-mounted GeoProbe® 6620 were used. In all cases, rig masts had some adjustment for degree of plumb to accommodate for uneven terrain, though the PowerProbe 9630 VTR-M was most limited.

Prior to field UVOST screening, each feature was marked with pin flags on a pre-determined grid pattern and grid size. The grid size for each feature type was designated as part of the systematic planning process, as discussed in Section 2.5. Field maps with a “best-fit” grid pattern were provided to field crews for “flagging” or “staking out” features. Field crews adjusted the screening grid as necessary to fit actual field conditions.

Operation of the UVOST system was performed by Dakota Technologies™-certified operators and in accordance with the UVOST user manual for safety, general operations, and maintenance, as incorporated into project-specific Standard Operating Procedure (SOP)-15, *Ultra Violet Optical Screening Tool (UVOST) Screening*. Operators followed proceduralized steps for daily pre-operational checks, collecting appropriate calibration data before and after each logging event, field documentation requirements, and daily data backup requirements.

Feature screening methodology was as follows: UVOST probes were advanced to the vertical extent of contamination, to 2 feet below the groundwater interface at non-detect probe locations, or to refusal. Field screening continued until the entire area was screened on the designated grid system and the minimum required points were completed. If no contamination was detected, the crew advanced to the next site feature. If screening indicated the presence of contamination potentially above regulatory levels, additional screening points or “step outs” were performed in all eight cardinal and ordinal directions (e.g., N, NE, E, SE) until no further indication of contamination was detected. No area greater than 1,225 square feet was left unscreened to preclude missing potential contamination.

An attempt to determine depth to groundwater was made at each feature. The first probe in each feature was advanced to the expected depth of groundwater (based on previous investigations or knowledge of groundwater occurrence in surrounding features). The presence of water in probe holes was determined using a water level meter (e.g., Solinst® or similar). If no water or potential contamination was encountered on the first probe, subsequent probes were advanced to 20 feet with additional attempts to reach groundwater every fifth probe, or at a rate of 20% total probe count. However, if potential contamination was detected, screening advanced to the vertical extent and subsequent probes were advanced to that depth.

An ex-situ field correlation study to establish the degree to which the UVOST field response was indicative of potential POL at regulatory limits was performed in 2014 and repeated in 2015, as the 2014 results were inconclusive. Based on the 2015 results, and limited to the soil types encountered, a correlation value of 1.6% of the reference emitter, or x-axis on the UVOST log, correlated to the PAL of 250 milligrams per kilogram (mg/kg) of diesel range organics (DRO), the primary contaminant encountered during this investigation. Operators performing UVOST screening utilized this correlation value, as well as their own discretion, to determine when additional “step outs” to delineate contamination potentially above regulatory limits were needed. Ex-situ correlation documentation is provided in Appendix G and further discussed in Section 4.3.3.

Upon completion of daily screening activities at each feature, UVOST boreholes were verified to be plugged with 3/8-inch diameter bentonite chips from borehole depth to ground surface. Where possible, damage to vegetation during screening operations was minimized, or repaired to the extent possible. Each borehole was marked with a pin flag documenting the borehole ID and then surveyed to sub-meter accuracy using a GeoXH 6000 GPS unit or similar.

At features that were inaccessible to drill rigs, AMS hand augers with 2-inch diameter buckets were used to obtain soil columns at each screening point. Once again, an attempt was made to determine depth to groundwater, which was occasionally successful when water was within the 16- to 20-foot depth. Hand auger borings were advanced to no less than 8 feet, unless met with refusal after at least three attempts. Soil columns were collected in 1-foot intervals, placed in sample coolers, and transported to the field office where they were subsequently screened in the UVOST system’s “Emulation mode” function.

4.3.2 X-Ray Fluorescence Screening for Lead

Nine features between AOC B and AOC M were screened using X-ray fluorescence (XRF) soil screening methods, as prescribed for detecting the presence of lead contamination associated with additives in gasoline or the storage of lead acid batteries. As there were no significant detections of gasoline range organics (GRO) during UVOST operations, XRF soil screening was limited to features where lead storage or disposal may have occurred (e.g., mounded material, shops, and debris features).

Personnel using the Niton® or Delta® XRF analyzers followed EPA Method 6200, *Field Portable X-Ray Fluorescence Spectrometry for the Determination of Elemental Concentrations in Soil and Sediment* (EPA, 2007). Project procedure SOP-22, *X-ray Fluorescence (XRF) Screening*, provided steps for safety, sample preparation, calibration, operation, and quality data collection.

Sample analyses were batched by feature, with beginning energy calibration, precision, and accuracy documented prior to performing actual soils analyses. A silicon dioxide blank was analyzed between batches to determine that the XRF unit had not been contaminated. A registered soils standard, SRM 2711a, was measured twice at the beginning of each batch (to establish beginning precision and accuracy), during batch analyses, and again at the end of each batch to ensure precision was maintained within a 20% difference between first and last measurements. Duplicate samples were analyzed every 20 samples or at least one per batch.

Site feature screening for lead was performed using the same grid pattern as UVOST screening for POL, with samples taken at ground surface, 1-foot, and 2-foot depth intervals. Roughly 100 grams of soil was collected from the bottom of each depth interval using a spade for surface samples and the hand auger for samples at depth. Ground surface samples were taken just under the vegetative cover at the soil interface. Effort was taken to remove large debris and organic matter from each soil sample. Each sample was then homogenized and placed into an individually marked XRF sample bag for subsequent analyses. Sample locations were marked with a pin flag documenting the borehole ID and then surveyed to sub-meter accuracy using a GeoXH 6000 GPS unit or similar.

In addition to site feature screening, the XRF analyzer was used to guide a 3-cubic yard (CY) excavation of lead contaminated soil in feature J-WH-002. Soils were measured *in-situ* on an established grid pattern sufficient to determine the lateral extent of contaminated surface soil, and then again after excavation of roughly 1-foot of soil. Several confirmation samples, based on the highest XRF readings, were submitted for laboratory analyses to verify that lead contamination had effectively been removed, and no further excavation was required.

4.3.3 Screening Method Constraints

Site Conditions

The primary field screening methodology of using the UVOST system with a direct-push drill rig was not always employable. Site topography, recessed features, or excessive tussocks and vegetation hampered drill rig and vehicle access. In these cases, boreholes were hand-augered and samples collected for UVOST emulation. Hand-auger boreholes were rarely able to be advanced greater than 16 feet bgs due to refusal or borehole collapse.

Impenetrable soils were encountered in several areas within AOC M. The effectiveness of UVOST screening in these areas was greatly reduced and coupled with increased equipment damage. Shallow refusal depths in these areas compromised the ability to acquire good characterization data through the soil column to the groundwater interface.

UVOST System Response and Correlation Constraints

Typical types of POL (i.e., gasoline, diesel fuel, jet fuel, and hydraulic fluids) can be detected based on the LIF response of their specific types and ratios of PAH constituents. The fluorescence signal is typically observed to scale approximately proportionally with the concentration of non-aqueous phase liquid (NAPL) in the subsurface.

An ex-situ correlation study was conducted to establish the degree of UVOST response to known contaminant concentrations in site-specific soils. Soil samples were collected in an area known to contain DRO contamination. These samples, representative of a range of concentrations, were individually analyzed for UVOST LIF response (i.e., homogenized and placed directly on the UVOST probe sapphire window), then placed in corresponding sample containers for laboratory analyses. This correlation method excludes variability (i.e., from soil heterogeneity or preferential contaminant pathways) that is inherent in field sample collection methodology. The resulting correlation between the ex-situ LIF response and corresponding DRO concentration is provided in Figure 4-2. Supporting documentation is provided in Appendix G.

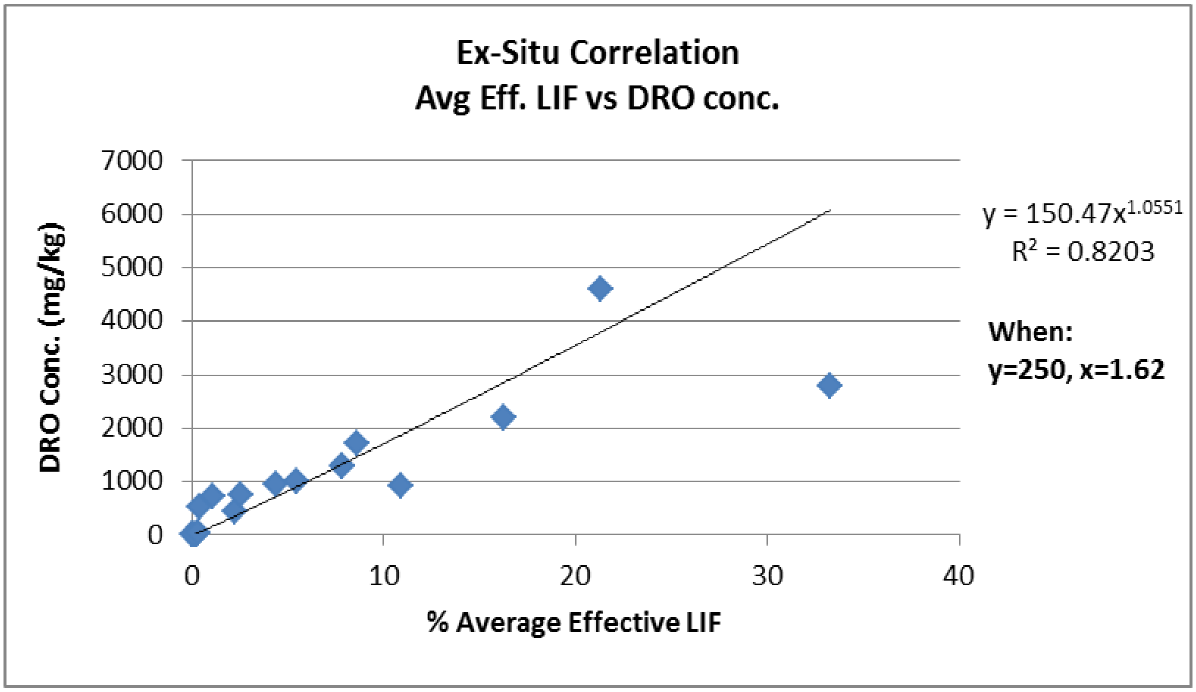


Figure 4-2. Ex-Situ Correlation of LIF compared to DRO Concentrations.

Another method for establishing the correlation between soil contamination and the degree of UVOST response is to perform an in-situ correlation analysis. Average effective LIF values are obtained from UVOST logs representing the location and depth of samples collected for confirmation analyses. Analytical results are plotted against LIF values to provide a correlation that incorporates site investigation variability.

Figure 4-3 presents a comparison of DRO analytical results against the average effective LIF of the depth interval sampled. The data plot within four distinct quadrants, defined by the PAL of 250 mg/kg on the x-axis and the effective LIF correlation value of 1.6% on the y-axis as follows:

- True positives – values plotted in the upper right quadrant show elevated LIF responses and also exceed the PAL. True positives account for 9.7% of the data.
- True negatives – values plotted within the lower left quadrant show LIF responses below 1.6% and do not exceed the PAL. True negatives account for 84.0% of the data.
- False positives – values in the upper left quadrant exhibit high LIF but do not exceed the PAL. False positives account for 1.6% of the data. Potential causes of false positives are discussed below.
- False negatives – values in the lower right quadrant have LIF responses below 1.6% but exceed the PAL. False negatives account for 4.7 % of the data. Potential causes of false negatives are discussed below.

This in-situ evaluation method typically provides a more concrete determination of the actual LIF correlation achieved for the site-specific conditions encountered. For this data set, an assigned LIF value of 0.7% excludes 12 of 15 false negatives, correlating more strongly to an actual LIF value representative of site conditions and variability. For data evaluation purposes, the in-situ correlation value of 0.7% was applied for determining nature and extent of contamination instead of the field acquired ex-situ value of 1.6%.

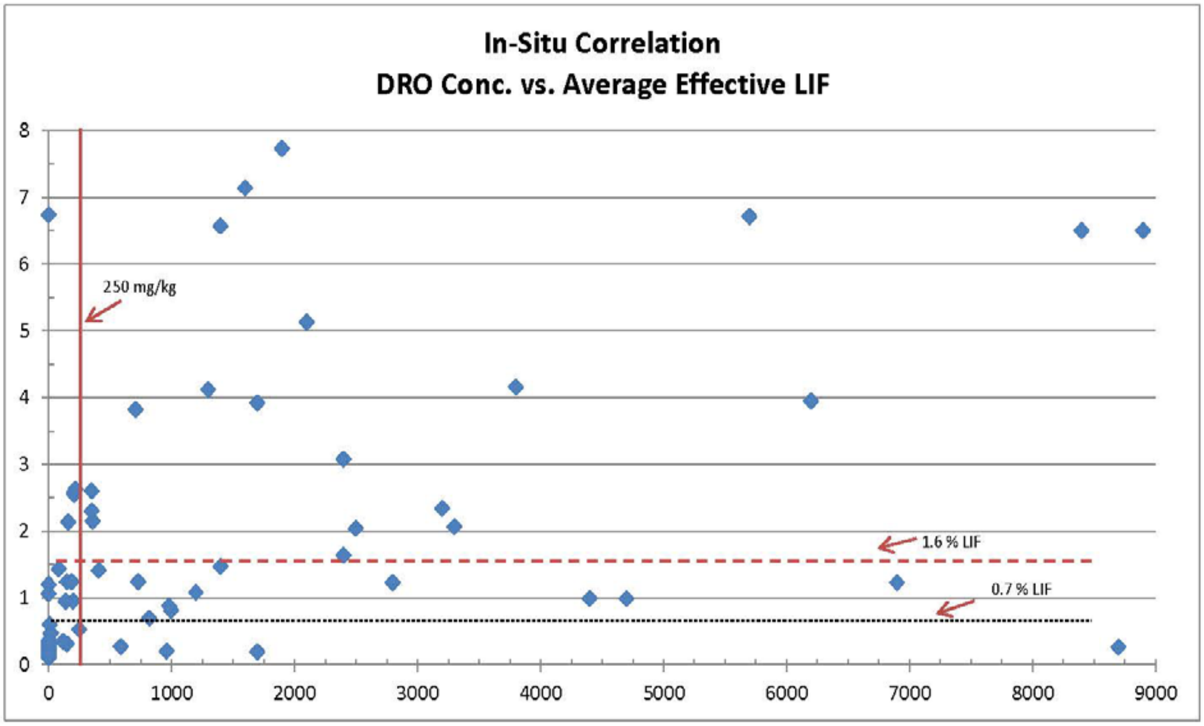


Figure 4-3. In-Situ Correlation of DRO Concentrations Compared to LIF.

When applying a 0.7% correlation LIF value, true positives represent 13.5% of the total data set, while false negatives represent less than 1%. The four remaining false negatives are discussed as follows:

- UVOST log 15FMMSH002UV018 exhibited high soil background and a noisy instrument background. Though intervals with potential fuel signature were easily discernable for confirmation sampling, the average LIF of the sample interval (1.02%) was not largely different from the soil background (0.76%), thus providing an average effective LIF value (0.26%) less than the what would be expected to correlate with the DRO analytical result of 8700 mg/kg detected in sample 15FMMSH002DT001.

- UVOST log 14FMBDA003UV076 also exhibited a noisy instrument background. Additionally, the sample borehole, located 2 feet away, may have encountered soil with higher DRO concentration than soil penetrated by the UVOST probe. The analytical result of 1700 mg/kg DRO for sample 14FMBDA003DT004 does not correlate well with an average effective LIF of 0.19% observed in the UVOST log. Heterogeneity is the likely factor affecting correlation at this location.

- UVOST log 14FMBDA003UV041, with an average effective LIF value of 0.27%, most likely did not penetrate soils of the same DRO concentration as sample borehole 14FMBDA002DT011 (DRO result of 590 mg/kg). Site heterogeneity within feature B-DA-003 is the most likely factor.

- UVOST log 14FMMST006UV003, with an average effective LIF value of 0.19%, also most likely did not penetrate soils of the same DRO concentration as sample borehole 14FMMST006DT001 (DRO result of 960 mg/kg [QL qualified]).

Several factors affect the strength of the correlation between LIF response and resulting analytical soil concentrations. These factors fall into three categories:

1. Equipment or technology constraints,
2. Variability in analytical methodology, and
3. Heterogeneity in site conditions.

Equipment and technology constraints are well documented by Dakota Technologies (www.dakotatechnologies.com). LIF technology is limited to the detection of PAHs only in the NAPL phase. It will not detect PAHs in dissolved or vapor phase. The fluorescence response of PAHs in the subsurface is limited to soils in contact with the probe window, and the intensity of the response is variable with soil density. Similar PAH concentrations in sand and silt will provide different intensities of responses, with sand providing the higher intensity. The fluorescence response of naturally occurring mineral soils, organic materials, or buried debris can return odd or potential fuel-like waveforms, which may result in false positive determinations.

Variability in sample collection, preparation, and analytical methods is documented through the analysis of field duplicate samples and laboratory quality control samples. Analytical results for 48 duplicate field sample pairs collected in 2014 and 2015 varied by 0% to 59% with an average variation of 17%.

Heterogeneity in site conditions includes both variations in soil types as well as heterogeneity in distribution of contamination. The heterogeneity of the subsurface was tested by installing multiple duplicate UVOST probes located approximately 1-foot apart. The average LIF values in these “butterfly” probes were compared foot by foot to determine a relative percent difference (RPD) within the subsurface. The resulting average RPD of subsurface LIF values was 28%. Examples of soil and contaminant distribution heterogeneity in Drum Areas B-DA-003 and B-DA-005 are provided in Figure 4-4.

4.4 Piezometers and Monitoring Wells

Monitoring wells were installed where contamination was known or suspected to exist below the water table or within 5 feet above it based on UVOST screening and confirmation sampling. Project quality objectives required the placement of one monitoring well within the known highest contamination point and, if sample results indicated contamination of the groundwater, one downgradient monitoring well to determine extent of contamination.

Piezometers were installed to provide depth-to-water and flow direction information in and near areas of contamination. This information was necessary for determining appropriate placement of downgradient wells.

4.4.1 Installation of Piezometers

A total of five piezometers were installed in 2014 and 2015. Three piezometers were installed in AOC B near features B-DA-003, B-DA-004, and B-DA-005; and two were installed in AOC M near feature M-PR-005. Piezometers were installed in accordance with ADEC monitoring well guidance (ADEC, 2013) and American Society for Testing and Materials (ASTM) D6725, *Standard Practice for Direct Push Installation of Prepacked Screen Monitoring Wells in Unconsolidated Aquifers* (ASTM, 2010). Completed piezometers were surveyed by PDC, Inc. Engineers to within 0.01 foot vertical and 1 foot horizontal with tieback to existing monuments.

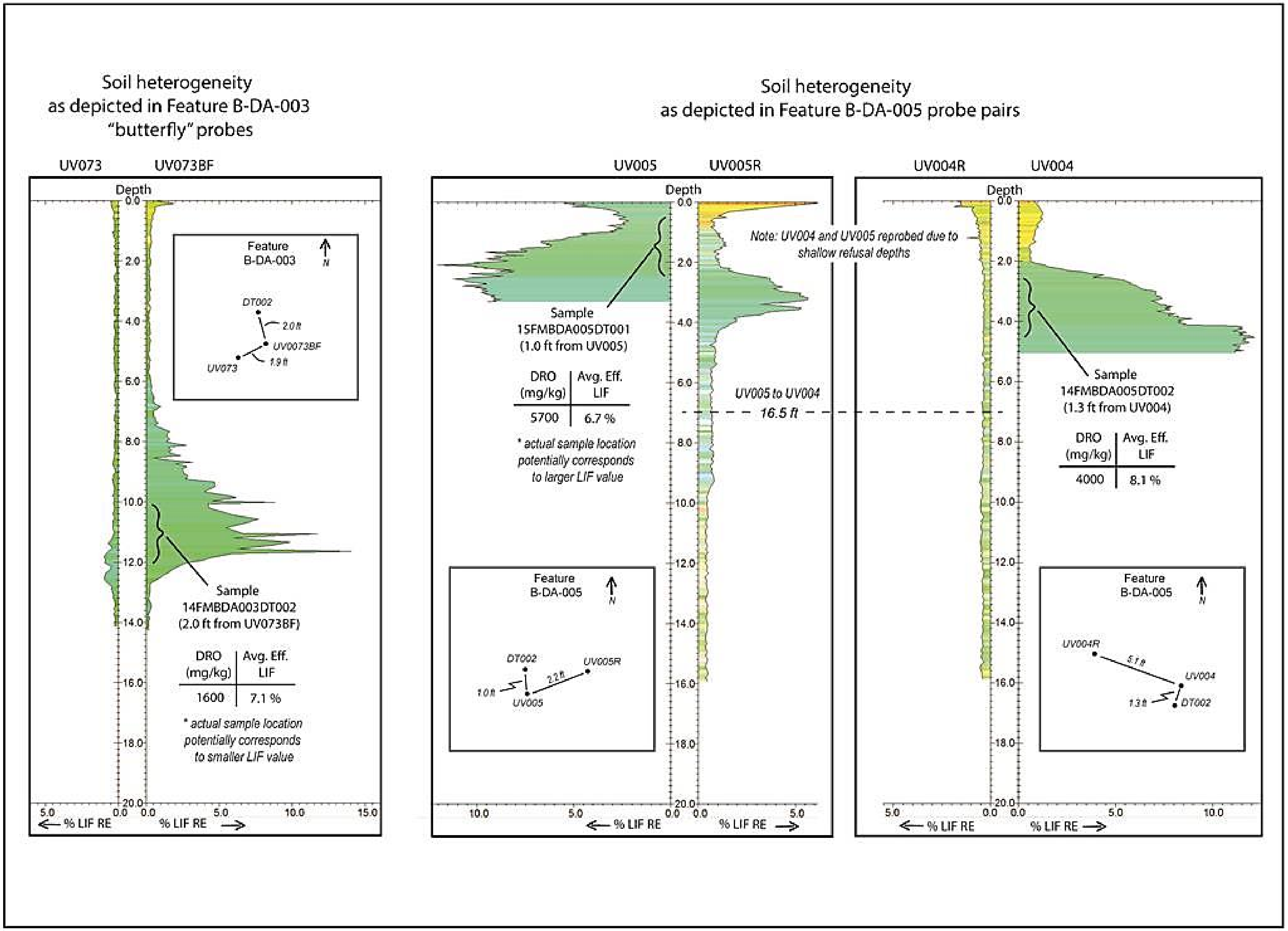


Figure 4-4. Heterogeneity in subsurface contaminant distribution in AOC B Drum Areas.

Piezometers installed in 2014 were constructed of 2-inch schedule 40 polyvinyl chloride (PVC) threaded well casings with slotted screens. Two piezometers were installed using direct push drilling methods. One piezometer was installed using a hand-auger. In all cases, piezometer strings consisted of a bottom cap, a length of screen sufficient to extend above the expected piezometric surface, and blank casing to extend above ground surface. Screened intervals were backfilled with 20-40 Colorado silica sand to 2 feet above the top of the screen. The borehole was backfilled with 3/8-inch bentonite chips to 1 to 2 feet bgs and hydrated to seal the annular space. Native soil was added from the top of the bentonite seal to ground surface.

Piezometers installed in 2015 were constructed of 3/4-inch schedule 40 PVC threaded casings with ¾-inch pre-pack screens. Both piezometers were installed using direct push drilling methods. Drill casing 2-3/8 inches in diameter was advanced to depth with an expendable drive point. The piezometer string consisting of a bottom cap, length of prepack screen sufficient to extend above the expected piezometric surface, and blank casing to extend above ground was placed inside the drill casing. Foam bridges were used to form a seal above the pre-packed screened interval. Drill casing was extracted and the remaining borehole filled with 3/8-inch bentonite chips to just below ground surface and hydrated to seal the annular space. Native soil was placed above the bentonite seal to ground surface.

All three piezometers in AOC B encountered groundwater and provided good information regarding depth to water and gradient. A piezometric surface map was developed to assist with placement of monitoring wells within features B-DA-003, B-DA-004, and B-DA-005 (see Figure 4-5).

Only one of the two piezometers installed in AOC M feature M-PR-005 encountered groundwater. The other piezometer (installed 48 feet north) was expected to encounter water between 15 and 20 feet bgs, the depth range at which boring collapse during UVOST screening in the area was common and thought to be caused by the presence of saturated soils. However, groundwater was not encountered, suggesting that no piezometric surface of any lateral extent existed at the depths that contamination was detected during screening and sampling. No further groundwater investigations were conducted in feature M-PR-005 or surrounding features.

Completion diagrams for piezometers are provided in Appendix H. Surveyor's reports are provided in Appendix I. Completion details are provided in Table 4-1.

4.4.2 Installation of Monitoring Wells

Nine monitoring wells were installed between 2014 and 2015. Six monitoring wells were installed in AOC B within features B-DA-003, B-DA-004, and B-DA-005; two monitoring wells were installed in AOC M in features M-TF-001 and M-SH-002; and one monitoring well was installed in AOC C in feature C-PR-001 as a replacement of piezometer C-PZ-001. Monitoring wells were installed in accordance with ADEC monitoring well guidance (ADEC, 2013), and ASTM D6725, *Standard Practice for Direct Push Installation of Prepacked Screen Monitoring Wells in Unconsolidated Aquifers* (ASTM, 2010). Completed monitoring wells were surveyed by PDC, Inc. Engineers to within 0.01 foot vertical and 1 foot horizontal with tieback to existing monuments.

Monitoring wells were constructed of 2-inch schedule 40 PVC threaded well casings and 2-inch pre-pack screens. All wells were installed using direct push drilling methods. Drill casing 3-1/2 inches in diameter was advanced to depth with an expendable drive point. The well string consisting of a bottom cap, a length of screen sufficient to extend above the expected piezometric surface, and blank casing to extend above ground surface was placed inside the drill casing. Foam bridges were used to form a seal above the pre-packed screened interval. Drill casing was extracted and the remaining borehole filled with 3/8-inch bentonite chips and hydrated to roughly 1-1/2 feet bgs. All monitoring wells installed in 2014 were completed with a steel protective casing set in a 2-foot × 2-foot concrete pad installed flush with the ground surface.

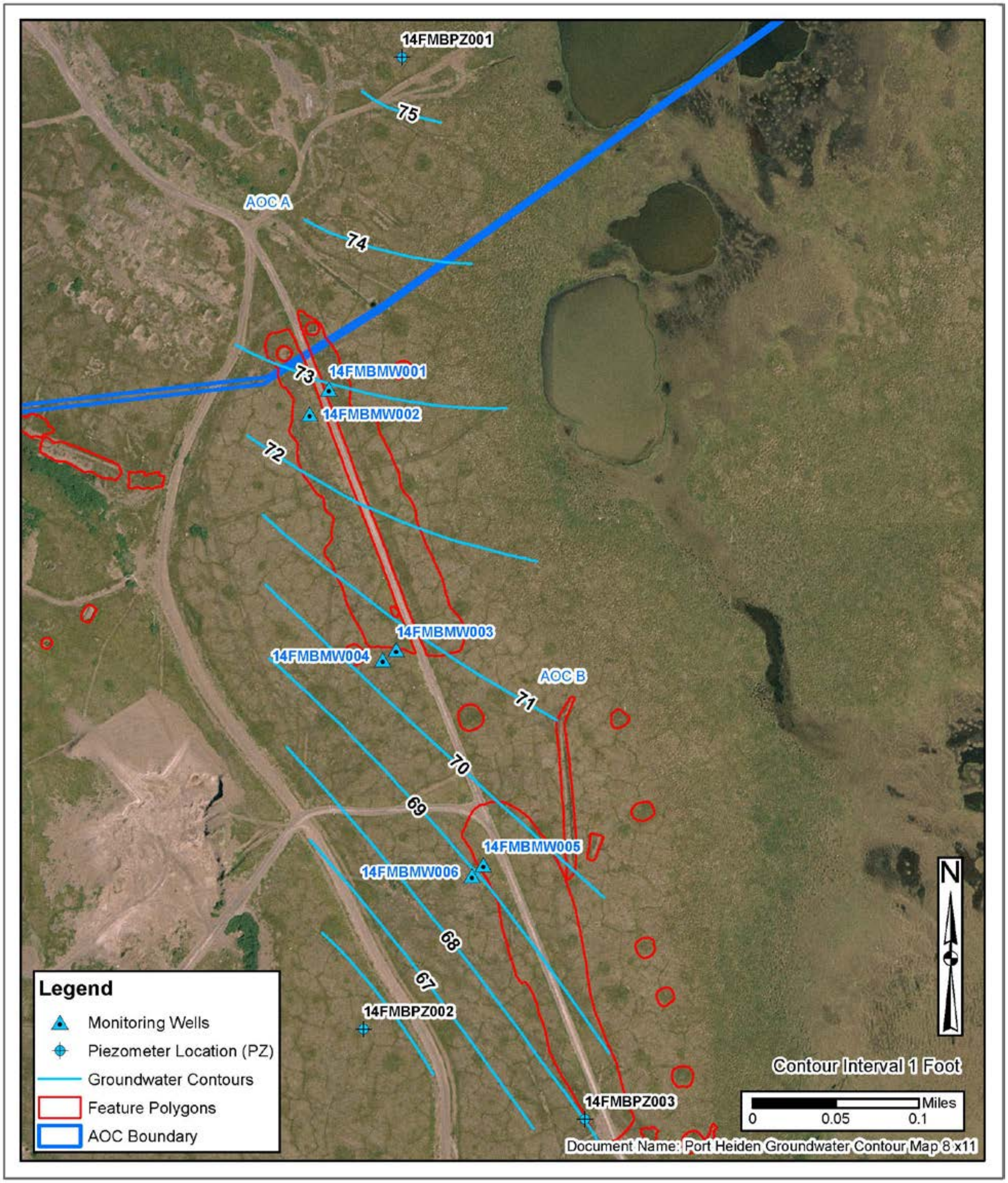


Figure 4-5. Groundwater Contour Elevations at Features B-DA-003, B-DA-004, and B-DA-005.

Table 4-1. Piezometer and Well Completion Details.

ID	Depth Drilled	TOC Elev.* (ft amsl)	Stick up (ft above ground surface)	Completion	Ground Elev. (ft amsl)	Water BTOC** (ft)	Water (ft bgs)	Water Elev. (amsl)
B-PZ-001	10.0	84.75	3.1	2-inch PVC stickup	81.65	9.35	6.25	75.40
B-PZ-002	21.0	85.78	2.45	2-inch PVC stickup	83.33	20.53	18.08	65.25
B-PZ-003	14.0	78.57	2.5	2-inch PVC stickup	76.07	10.50	8.00	68.07
B-MW-001	15.75	79.75	0	Concrete pad	79.75	6.10	6.10	73.65
B-MW-002	12.62	80.85	0	Concrete pad	80.85	8.11	8.11	72.74
B-MW-003	13.63	83.69	0	Concrete pad	83.69	12.51	12.51	71.18
B-MW-004	18.20	83.6	0	Concrete pad	83.6	12.60	12.60	71.00
B-MW-005	12.93	81.09	0	Concrete pad	81.09	11.20	11.20	69.89
B-MW-006	12.25	81.65	0	Concrete pad	81.65	12.01	12.01	69.64
C-MW-005	20.33	133.65	0	Concrete pad	133.65	15.45	15.45	118.2
M-PZ-001	24.00	86.16	3.1	3/4-inch PVC stickup	83.06	No GW	N/A	N/A
M-PZ-002	31.80	85.15	3.2	3/4-inch PVC stickup	81.95	19.15	15.95	66.00
M-MW-001	22.0	53.17	4.0	4-inch steel casing	49.17	16.05	12.05	37.12
M-MW-002	20.0	50.23	4.0	4-inch steel casing	46.23	12.3	8.30	37.93

*From PDC Inc. Engineers Survey Reports.
**Piezometer measurements from time of installation; Well measurements from time of sampling.

amsl = above mean sea level
BTOC = below top of casing
TOC = top of casing

Monitoring wells were developed but no sooner than 24 hours after installation to allow annular materials to seal. Well development activities were performed in accordance with project SOP-12, *Installation and Development of Groundwater Monitoring Wells and Points* (North Wind, 2014). Development was accomplished using a combination of surging and pumping. Wells were surged using a 2-inch stainless steel surge block followed by pumping with a 2-inch diameter submersible pump, or in some cases, a bailer. Development continued with alternating surging and pumping until water clarity stabilized. Care was taken to develop the full length of screened zones. Development water was containerized for sampling and disposal.

Wells were sampled but no sooner than 48 hours after development. Purging and sampling methods are provided in Section 4.5.3, Groundwater Sampling.

Completion diagrams for monitoring wells are provided in Appendix H. Surveyor's reports are provided in Appendix I. Completion details are provided in Table 4-1.

4.4.3 Decommissioned Wells and Piezometers

Eleven monitoring wells and 12 piezometers previously installed in and around the Former Fort Morrow area were determined by USACE and ADEC to be of no further use and were decommissioned in 2014. Monitoring wells and piezometers were decommissioned and abandoned in accordance with project

SOP-10, *Well and Boring Decommissioning and Abandonment* (North Wind, 2014) and the specifications outlined in the ADEC *Monitoring Well Guidance* (ADEC, 2013).

Casings were filled with 3/8-inch bentonite chips to just below ground surface. Blank casing was removed to the maximum depth possible, allowing the bentonite within to fill the empty borehole from the bottom up. Screened intervals were left in place. If blank casing above the screens could not be removed, it was cut off 2 feet below grade and plugged with bentonite. Native soil was used to backfill to ground surface above the bentonite plug.

Figure 3-1 shows the location of all monitoring wells and piezometers, and includes their status as active or decommissioned as of 2014. Table 4-2 lists wells and piezometers decommissioned during 2014.

Table 4-2. Monitoring Wells and Piezometers Decommissioned in 2014.

Well	Date Drilled	Date Decommissioned	Nearest Feature	Depth Drilled (ft)	Screen Length (ft)	Casing Diameter (in.)
C-PZ-001	7/9/2012	2014	C-PR-001	14	5	1
D-MW-001	9/30/2012	8/26/2014	D-TF-001	28	5	2
D-PZ-001	9/30/2012	8/26/2014	D-UN-001	30	5	1
D-PZ-002	9/30/2012	8/26/2014	D-DS-001	48	5	0.75
H-MW-001	9/27/2012	8/26/2014	H-FS-022	16	5	2
I-MW-001	9/18/2012	8/25/2014	I-QT-001	19	5	2
I-MW-002	9/27/2012	8/25/2014	I-GS-002	18	5	2
J-MW-001	9/18/2012	8/24/2014	J-QT-001	17	5	2
J-MW-004	10/10/2012	2014	J-SP-003	19	5	2
J-PZ-001	9/15/2012	8/26/2014	J-ST-002	19	5	0.75
J-PZ-002	9/15/2012	8/26/2014	J-WH-005	20	5	0.75
J-PZ-003	10/4/2012	8/25/2014	J-DA-003	14	5	0.75
K-MW-001	9/5/2012	8/25/2014	K-ST-001	29	5	2
K-MW-002	9/18/2012	8/24/2014	K-SP-001	22	5	2
K-MW-003	9/20/2012	8/25/2014	K-GS-001	16.7	5	2
K-PZ-001	9/3/2012	8/25/2014	K-MH-001	29	5	1
K-PZ-002	9/14/2012	8/24/2014	K-SW-001	23	5	0.75
L-MW-001	9/20/2012	2014	L-GS-014	19.8	5	2
L-MW-002	9/26/2012	8/26/2014	L-GS-004	35	5	1
L-PZ-001	9/26/2012	8/29/2014	K-GS-004	35	5	0.75
L-PZ-002	9/26/2012	8/26/2014	L-BU-007	35	5	0.75
L-PZ-003	9/20/2012	2014	L-GS-013	19	5	0.75
L-PZ-004	9/20/2012	2014	L-BU-021	19	5	0.75

4.5 Sample Collection

4.5.1 Sampling Methodology

During the initial site evaluation of the former Fort Morrow, over 1,000 features were identified to be of potential environmental concern. COPCs were identified based on feature types and historical use documentation. Project quality objectives were developed to address what environmental data were needed and where, how much, and what the PALs would be to fully address the purpose and goals of the RI.

The resulting sampling methodology included a list of analytes to be collected at each feature type, the percent of features to be sampled, the sampling frequency, the analytical methods to be used, and field and analytical laboratory quality assurance and quality control (QC) requirements. The field sample collection methodology was as follows:

- Site features with the greatest potential of significant releases were sampled at 100% of their total occurrence, while site features with lower probability of significant releases were sampled at 10% of only the number of features screened for POL (see Table 4-3).

- At features requiring sampling, a minimum of one full-suite sample was collected with additional POL-only samples collected at a frequency of 10% of total screening locations. For features with greater than 100 screening locations, additional full-suite samples were collected at a frequency of 1% of total screening locations.

- Sample locations and depths were chosen to target screening locations that indicated the presence, or potential presence, of POL. Boreholes for sample collection were located immediately adjacent to target screening locations so that analytical samples were representative of the screening zone targeted.

- For features where no potential POL was indicated during screening, samples were taken either at the surface, at a change in soil lithology, or within the zone of seasonal groundwater flux in accordance with ADEC sampling guidance (ADEC, 2010).

- Some features were identified for PCB surface sampling in addition to full suite analyses (see Table 4-3).

- Groundwater samples were collected at features where soil contamination extends to within 5 feet of the piezometric surface.

- Surface water and sediment samples were not collected as the criterion for sampling was not met (i.e., soil contamination exceeding cleanup levels discovered within 50 feet of a surface water body).

4.5.2 Soil Sampling

Soil sampling was conducted in accordance with the ADEC "Draft Field Sampling Guidance" (ADEC, 2010) and as incorporated into project procedure SOP-16, *Soil Sampling*. Samples collected were discrete samples in every case except where compositing prior to analysis was required by federal regulations (e.g., Toxic Substances Control Act [TSCA] for PCBs or Resource Conservation and Recovery Act [RCRA] waste disposal characterization).

Table 4-3. Screening and Sampling Frequency and Analytical Methods by Feature Type.

Screening and Sampling Frequency / Analytical Methods by Feature Type													
			Analytes										
Feature Description	**Screening Percent**	**Sampling Percent**	**GRO AK-101**	**DRO AK-102**	**RRO AK-103**	**BTEX[1] 8021**	**VOC 8260C**	**SVOC 8270D**	**Metals 6020, 7471**	**PCB**	**PCB (9-pt grid)**	**Pesticide**	**Dioxin[2]**
Administration (AD)	25%	10%	X	X	X	X	X	X	X				
Antennae (AT)	100%	100%							X	X	X		
Building Unknown (BU)	25%	10%	X	X	X	X	X	X	X	X		X	
Buried Drums (BD)	100%	100%	X	X	X	X	X	X	X	X		X	
Burn Pit (BP)	100%	100%	X	X	X	X	X	X	X	X		X	X
Debris (DB)	100%	100%	X	X	X	X	X	X	X	X		X	
Drum Area, Former (DA)	100%	100%	X	X	X	X	X	X	X	X		X	
Dump Site (DS)	100%	100%	X	X	X	X	X	X	X	X		X	
Fuel Storage (FS)	100%	100%	X	X	X	X	X	X	X	X		X	
Ground Scars (GS)	25%	10%	X	X	X	X	X	X	X	X		X	
Latrine (LT)	100%	100%	X	X	X	X	X	X	X	X			
Loose Storage (LS)	100%	100%	X	X	X	X	X	X	X	X		X	
Mess Halls (MH)	100%	100%	X	X	X	X	X	X	X	X			
Mounded Materia (MM)l	100%	100%	X	X	X	X	X	X	X	X		X	
Other (OT)	100%	100%	X	X	X	X	X	X	X	X		X	
Pit (PT)	100%	100%	X	X	X	X	X	X	X	X		X	
Power House (PR)	100%	100%	X	X	X	X	X	X	X	X	X		
Pump House (PH)	100%	100%	X	X	X	X	X	X	X	X			

Table 4-3. Screening and Sampling Frequency and Analytical Methods by Feature Type (continued).

			Analytes										
Feature Description	**Screening Percent**	**Sampling Percent**	**GRO AK-101**	**DRO AK-102**	**RRO AK-103**	**BTEX[1] 8021**	**VOC 8260C**	**SVOC 8270D**	**Metals 6020, 7471**	**PCB**	**PCB (9-pt grid)**	**Pesticide**	**Dioxin[2]**
Quarters or Barracks (QT)	25%	10%	X	X	X	X	X	X	X				
Radar Building (RD)	100%	100%	X	X	X	X	X	X	X	X	X		
Radio Station (RS)	100%	100%	X	X	X	X	X	X	X	X	X		
Recreation (RC)	25%	10%	X	X	X	X	X	X	X				
Shop (SH)	100%	100%	X	X	X	X	X	X	X	X			
Showers (SW)	25%	10%	X	X	X	X	X	X	X				
Spill (SP)	100%	100%	X	X	X	X	X	X	X	X			
Storage (ST)	100%	100%	X	X	X	X	X	X	X	X		X	
Tank (TK)	100%	100%	X	X	X	X	X	X	X	X		X	
Transformer (TF)	100%	100%		X	X	X			X	X	X		
Trench (TR)	100%	100%	X	X	X	X	X	X	X			X	
Warehouse (WH)	100%	100%	X	X	X	X	X	X	X			X	
Well (WL)	100%	100%	X	X	X	X	X	X	X				
X-Ray Building (XR)	100%	100%	X	X	X	X	X	X	X				

[1] Additional GRO, DRO, and BTEX sampling required at features that have more than 10 screening locations.
[2] Dioxin sampling required at features where pentachlorophenol is detected above the Method 2, Under 40-inch Zone, migration to groundwater cleanup level of 0.047 mg/kg.

BTEX = benzene, toluene, ethylbenzene, and xylenes
RRO = residual range organics
SVOC = semivolatile organic compound
VOC = volatile organic compound

Sampling was performed by ADEC qualified samplers. Sample collection methods included the use of shovels and stainless steel trowels, hand augers, or continuous core direct-push drilling methods. Soil samples were collected as part of feature characterization activities, at excavations to confirm adequate removal of contaminated soils, at test pits prior to backfilling, for confirmation of XRF screening analyses, for a background metals study, and for waste characterization. Regardless of purpose, project SOPs for sample collection, integrity, handling, and preservation; equipment selection; decontamination; and field documentation provided consistency with Work Plan sampling requirements (North Wind, 2014).

The following subsections provide more detail regarding field sample collection activities for features screened for POL and for the composite PCB sampling approach. Analytical data are provided in Appendix J.

POL Sampling at Features

A total of 287 characterization confirmation soil samples were collected at 166 features designated for sampling. Soil samples were collected adjacent to UVOST probe locations identified for sampling. Sampling personnel either hand-augered to depth or employed continuous core drilling methods. Hand auger application was typically limited to shallower sample depths and areas inaccessible to the drill rig.

Sample locations were cleared of vegetation and surface debris to the mineral surface. An AMS hand auger with a stainless steel 2-inch bucket was used to bring soil to the surface in 6- to 8-inch lifts. Soils were placed on plastic sheeting next to the borehole for logging. Once the target sampling interval was reached, soils were captured in a plastic bag for homogenization. Pre-tared sample jars for GRO, BTEX, and VOC analyses were filled from the bottom of the auger bucket immediately upon its withdrawal from the borehole to minimize volatilization. Methanol preservative was added and the jars were capped. The remainder of soil from the sampling interval was homogenized and placed in sample jars for non-volatile analyses, as required (e.g., DRO, RRO, SVOCs, metals, PCBs, and pesticides).

Sampling with the drill rig consisted of using a lexan liner inserted within the direct push extension of the drill rig. The probe drive string and lexan sampler were advanced through the soil to obtain a continuous soil core in 4-foot sections until the sample depth was reached. Each tube was removed when filled and placed on the sampling table where it was opened and logged. Once the tube containing the targeted sample interval was delivered to the table, it was immediately opened and sample jars for volatile compounds were filled, preserved, and capped. Care was taken to collect some soil from the entire interval for analyses. The remaining soil was homogenized and placed in sample jars for non-volatile analyses, as required.

Samples were placed in plastic bags to protect labels from dirt or excessive moisture and then placed in field coolers with gel ice packs for preservation and protected from breakage. Samples were transferred to the sample refrigerator at the field office, typically within 3 to 4 hours of field sample times.

Soil boring geology was logged according to “Alaska Field Guide for Soil Classification” (ADOT, 2005) by the Alaska Department of Transportation and Public Facilities and SOP-17, *Soil Logging*. Sampling and logging activities were performed by an ADEC qualified sampler. Sampling details, including sample ID, date, time, requested analyses, preservatives, locations, and depth, were recorded in a field sampling logbook (see Appendix D). Soil boring logs are included in Appendix K.

All soil boring locations were backfilled with 3/8-inch bentonite chips and hydrated in accordance with the ADEC *Monitoring Well Guidance* (ADEC, 2013). Sample locations were marked with a pin flag, labeled with the sample ID, and then surveyed to sub-meter accuracy with a GeoXH 6000 GPS unit or similar. Decontamination rinse water and remaining soils from sampling intervals were containerized and placed (or transferred) into designated waste containers for management per SOP-21, *Investigation Derived Waste* (North Wind, 2014).

PCB Composite Sampling

Five feature types were identified during initial site evaluation for PCB composite sampling to address the increased likelihood of PCB contamination in surface soils. A total of 27 composite samples were collected from eight features and submitted for laboratory analyses.

A 10-foot grid was mapped out over the feature boundaries, incorporating any surrounding areas covered by the grid pattern. Soil sample material from adjacent nine-point grids was composited. The surface grids were extended to cover the entire feature and surrounding area to be evaluated with a total number of grid sample points divisible by nine. Grid sizes were decreased to 5 feet in areas of known PCB contamination.

A clean, non-plated stainless steel shovel was used to remove the top 6 inches of soil. Sample material was collected from approximately 6 inches below the soil surface. One dedicated steel sampling spoon was used to scoop roughly 25 grams of soil from each of the nine locations within the grid. These nine scoops were then homogenized and placed into an 8-ounce sample container. Sample jars were then labeled, placed in plastic bags, and placed in field coolers for protection from damage while in the field. Samples were transferred to the sample refrigerator at the field office, typically within 3 to 4 hours of field sample times.

4.5.3 Groundwater Sampling

Groundwater sampling was conducted in accordance with the ADEC “Draft Field Sampling Guidance” (ADEC, 2010) and as incorporated into project procedures SOP-06, *Groundwater Level Measurements;* SOP-07, *Field Water Quality Measurements*; and SOP-08, *Groundwater Sampling* (North Wind, 2014).

Samples were collected from 14 monitoring wells: B-MW-001 through B-MW-006, C-MW-001 through C-MW-005, J-MW-003, and M-MW-001 and M-MW-002. A minimum of three well volumes were purged from each well prior to sampling using a low-flow submersible or peristaltic pump. Purge water was captured and managed as investigation derived waste (IDW), as was water used to decontaminate all equipment between samples. Field parameters for temperature, pH, conductivity, oxidation-reduction potential, dissolved oxygen, and turbidity were measured with a YSI® multimeter during and after purging.

Samples were collected after purging activities were completed and field parameters had stabilized. Appropriate sample containers and preservatives were provided by the analytical laboratory. Sample containers were filled in a manner to minimize turbulence and agitation. For volatile analyses, sample containers were filled with a positive meniscus prior to being capped to minimize air bubbles. Containers were labeled with unique sample ID numbers, requested analyses, and sample dates and times, and were placed in field sample coolers with sufficient gel ice packs to cool samples to 4±2 degrees Celsius (°C). Samples were transferred to the temperature controlled sample refrigerator upon returning to the field office. Samples were packaged and shipped within 2 days of collection to meet the 7-day hold time.

4.5.4 Sample Handling, Packaging, and Shipping

Samples were identified with unique ID numbers that included the AOC, feature name, media matrix, and a three-digit unique sample number from that specific site and matrix. Duplicate samples were identified uniquely from primary samples. Possession and control of samples was maintained and appropriate sample information was recorded in the field sampling logbook as well as on electronic chain-of-custody forms in accordance with project SOP-13, *Sample Handling*, and project SOP-14, *Packaging and Shipping Environmental Samples*. Samples were kept in a dedicated sample refrigerator in a locked office building with limited access.

Samples were packaged the morning of the shipment day. Samples were bubble wrapped, placed inside sealable plastic bags, and packaged in such a way as to minimize movement during transport, thereby reducing the risk of a sample jar breaking on the way to the laboratory. The sample coolers were packed with gel ice to ensure proper temperatures were maintained during shipment. Signed and dated chain-of-custody seals were affixed to the sealed coolers. Chain-of-custody forms were sent in each cooler and also emailed to the analytical laboratory, Test America Laboratories (TAL) in Denver, Colorado.

Samples were shipped from the site approximately within 1 week of collection by chartered aircraft to Anchorage, Alaska. They were then shipped from Anchorage to TAL in Denver by GoldStreak Package Express. The sealed coolers were then picked up by a courier and delivered to TAL Denver.

4.6 Subsurface Metal Investigations

Subsurface metal investigations were prescribed as part of Phase II investigation activities for mounded features or where buried debris was suspected. The methodology included performing initial geophysical surveys of feature types meeting criteria for potential or known buried metal debris, and then excavating small test pits in areas indicated by geophysical surveys where further investigation was necessary to meet project objectives.

4.6.1 Geophysical Surveys

Geophysical surveys were performed in 2014 by Sage Earth Science at 24 locations. Surveys were conducted from June 25 to July 14 and September 24 to September 30. The locations surveyed were either specific features, as prescribed in the Work Plan (North Wind, 2014), locations where buried debris was observed or suspected during field activities, or locations identified during a USACE-requested site evaluation conducted with local residents.

Dump site and debris type features were surveyed as part of Work Plan requirements as features that “could potentially contain buried waste.” These included B-DS-001 through B-DS-003; M-DS-001 through M-DS-005; M-DB-001; and M-BP-001 (included within M-DS-005). Additionally, a survey was performed to delineate a pipeline at C-LT-002 that was identified during 2012 Phase I investigation activities.

Features and locations where buried debris was observed or suspected during the course of field activities were also surveyed. These included M-DA-023; M-GS-043; the area around M-FS-016 where most of the Fuel Station features in AOC M are located; M-FS-018 and M-FS-019; M-PR-005 (including pump house M-PH-002); M-SH-001 and M-SH-002; and two “unknown” areas, M-UN-003 and M-UN-006.

Four locations identified as requiring further delineation, or identified by local residents as areas where WWII era debris, munitions, vehicles and equipment had been previously stockpiled or discarded, were also surveyed. These included a slightly mounded area between features B-DS-001 and B-DS-003, the area between E-DS-001 and “Jack’s Store,” the area between F-BU-001 and the beach cliff, and the area near M-QT-095.

Area surveys were performed using a Geonics electromagnetic (EM) 61-MK2 high-resolution, time-domain metal detector capable of detecting both ferrous and non-ferrous metallic objects, and potentially up to 9-feet deep. The EM61 was attached to wheels and pulled across the ground along an established grid. EM data were acquired continuously at 10 readings per second.

Delineation of the pipeline at feature C-LT-002 was accomplished using a Geonics EM31-MK2, an EM transmitter with a matched receiver antenna mounted on a 10-foot boom that is carried by the operator with the help of a shoulder holster. Peak responses were produced when the boom was centered over the pipe, thereby allowing the pipe’s location to be pinpointed and flagged or staked along its length.

Maps for each location surveyed are provided in Appendix L. Additional information regarding EM data processing and visual display are included in the Surveyor's reports, also provided in Appendix L. A discussion of survey results is provided in Section 6.4, Subsurface Metal Investigation Results.

4.6.2 Test Pit Investigations

Nine test pit investigations were conducted between 2014 and 2015 out of the 18 recommended. Test pits were not conducted at F-DS-001 or F-BU-001 due to the eroding beach cliff causing safety concerns and equipment access issues. Test pits at M-GS-043, M-PR-005, and M-SH-002 were not conducted due to POL contamination detected during perimeter feature UVOST screening.

Test pit investigations were conducted in C-DB-001 (three test pits), E-DS-001 (three test pits), M-BP-001 (one test pit), and M-SH-001 (two test pits). In each case, test pit locations were chosen to investigate concentrations of buried metal debris with the exception of the test pit in M-BP-001, which was chosen to verify the nature of a suspect circular feature. Figures showing test pit locations with respect to geophysical survey results are provided in Appendix L as Maps SM-5, SM-7, SM-13, and SM-20. Results of test pit investigations are discussed in Section 6.4.

Test pit investigations were performed per SOP-19, *Test Pit Excavations* (North Wind, 2014). Prior to excavation, perimeters of subject areas were screened for POL contamination using the UVOST system. If POL was detected and confirmed via sampling, test pit investigations were cancelled so as not to increase the potential for a release to the environment during excavation. In two instances due to oversight, test pits areas at E-DS-001 and C-DB-001 were not screened for POL prior to investigation; however, no POL was detected during investigations.

Test pits were excavated using locally available excavation equipment and operators. Target pit size was roughly 8-feet × 8-feet × 4-feet deep. An excavation backhoe bucket with no teeth was used to reduce the potential for puncturing any in-tact buried drums or containers that might have been encountered. Plastic sheeting was placed on the ground near the test pit area. Soil was removed from the test pit in roughly 6- to 8-inch lifts, placed on the sheeting, and monitored with a photoionization detector (PID). The contents of the test pits were documented.

Analytical samples were collected from the bottom of each test pit via soil from the excavator bucket. Soil stockpiles were also sampled to confirm cleanup levels were met for use as backfill. Analytical results are provided in Appendix J.

4.7 Incidental Soil Removal Actions

Four areas of soil contamination identified during the Phase I RI in 2012 were excavated in 2014. Approximately 199 CY of POL contaminated soil and 3 CY of lead contaminated soil totaling 150 tons were removed from these areas and disposed of by ELM Solutions at Columbia Ridge Landfill in Arlington, Oregon.

Excavations were completed in features F-OT-001, J-SP-002, J-SP-003, and J-WH-002 using locally available equipment and operators. Work was conducted in accordance with project SOP-26, *Excavation of Contaminated Soil*, and within the safety mitigations outlined in the Accident Prevention Plan/Site Safety and Health Plan. Perimeters of excavation areas were surrounded with high-visibility snow fencing to preclude personnel from entering the excavation areas unintentionally.

Excavations of POL contaminated soil were guided by the use of the 2020 ComboPRO™ PID. Soils were removed using an excavator bucket where PID readings indicated the presence of hydrocarbons. Soils were removed in shallow lifts and placed in 1-CY or 5-CY super sacks. PID readings were repeated and additional soils were excavated until all contamination was removed. Confirmation samples for laboratory analyses were collected from all four sides and the bottom of excavations in accordance with ADEC field sampling guidance (ADEC, 2010). If analytical results indicated no additional contamination, excavations were backfilled using material from the local borrow pit, snow fencing was removed, and the as-left condition photographed.

In two cases (J-WH-002 and part of J-SP-002), analytical results indicated that contaminated soils had not completely been removed. Due to time constraints associated with the arrival of the waste transportation barge, it was not possible to continue the excavations. With USACE concurrence, 6-mil plastic sheeting was used to line the portions of excavations requiring additional soil removal, and the excavations were backfilled.

Excavation of lead contaminated soil was performed by hand with a shovel. The extent of lead contamination was determined using a hand-held Niton® XRF analyzer. Confirmation samples for laboratory analyses were collected. When analytical results indicated no additional contamination, the area was backfilled with clean material, and the as-left condition was photographed.

Further discussion and analytical results are provided in Section 6.5. Figures illustrating locations and details of excavations are provided in Appendix F as Maps F-1 and J-1. Completed waste manifests and certificates of disposal are provided in Appendix M.

4.8 Placement of Signs at Landfill B

Three signs provided by USACE were placed around Landfill B, a permitted landfill that was created and used for disposal of structural and metal debris, contaminated soils, and asbestos containing materials during the Port Heiden Debris Disposal and Site Restoration Project (USACE, 1996). The landfill was closed in 1991.

Signs were erected in three locations around Landfill B as a reminder of its existence, and in accordance with HTRW program long-term management goals for protection of the public. Since 1991, native vegetation has been re-established and evidence of the landfill boundary is diminishing. A nearby borrow pit established by the Department of Transportation (DOT) has been steadily expanding toward the landfill.

Signs were placed where they are visible from existing non-maintained access roads to the landfill and the DOT borrow pit. Installation was designed to withstand winds up to 100 miles per hour. Four-foot sections of 10-gauge galvanized steel tubing (2-3/16 inches square) were set in high-strength concrete to roughly 3-1/2 feet deep to form a “sleeve” for 10-foot lengths of perforated 10-gauge tubing (2-1/2 inches square). Concrete was allowed 7 (or more) days to cure. Perforated tubing was installed to the bottom of the sleeves and bolted, leaving roughly 6 feet above ground. Signs were drilled and bolted to the perforated tubing in four places (see Figure 4-6).

Figure 4-6. Installation of Signs for Landfill B Disposal Site.

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5. WORK PLAN DEVIATIONS

5.1 Features Screened and Sampled

Prior to beginning Phase II investigation activities, a list of features to be screened and sampled was established, which included 100% of features posing a higher risk of contributing contamination to the environment and 25% of features having a lower risk of doing so. The list of lower risk features was established by assigning a number at random to each feature within a feature type (i.e., ground scars, quarters, etc.) and then choosing the features in order of random number.

The Work Plan methodology provided for substituting lower risk features that were not able to be screened with alternate features in order of the next highest random number (North Wind, 2014). This methodology assured that a list of features were ultimately screened and sampled regardless of size, ease of access, or proximity to areas being actively screened.

Additionally, the Work Plan methodology provided for the addition of suspect feature areas discovered during site evaluation. These suspect feature areas were identified as "Unknown" features, documented on evaluation forms, and added to the list of features to be screened and sampled at a frequency of 100%.

Though technically not a deviation from the Work Plan, the list of features ultimately screened and sampled differs from the original designated list. Table 5-1 provides the complete list of features screened during Phase II investigations, including features previously screened where additional information was required, and features chosen as alternates and the rationale for doing so.

5.2 Deviations

Deviations to the Work Plan include those locations where the established screening and sampling methodology was not fully applied, or where additional data collection was performed though not prescribed. The following discussion addresses specific locations where data collection methods deviated from the Work Plan. Table 5-1 provides the list of features screened with deviations and rationale documented.

- Feature M-RD-001: UVOST in-situ screening at M-RD-001 was not able to be performed due to the impenetrable rocky nature of the soil (see Figure 5-1). Attempts to hand auger for ex-situ emulation analyses were met with refusal at ground surface. Concurrence was received from USACE for an alternate sampling scheme in lieu of UVOST screening. Five samples below 0.5 foot bgs were taken and submitted for laboratory analyses. Samples were taken from approximately the four corners of the feature and one in the middle.

- Features M-DA-009 and M-MH-003: These two features are located adjacent to each other in an area roughly 2 acres in size. One, or both, of the features are partially recessed with roughly 10-foot elevation between the top of the bermed areas to the bottom of the feature, and greatly overgrown with alders on the surface and within the recessed area (see Figure 5-2). Subsequent to a site visit, concurrence was received from USACE to collect hand auger boreholes for emulation within the recessed area between both features, as close to the established grid spacing requirements as possible. Ten hand auger boreholes were collected for ex-situ UVOST emulation, and one analytical sample was collected.

- Feature M-UN-004: This feature was not screened or sampled due to its proximity to significant buried metal in adjacent feature M-GS-043. Per the Work Plan, a perimeter screening pattern was established around M-GS-043 to encompass the extent of buried metal. Feature M-UN-004 is located within that perimeter and therefore was not screened due to the potential of penetrating the buried metal debris.

- Geophysical surveys at various locations: Geophysical surveys were prescribed at locations that "could potentially contain buried waste" and specifically limited to debris, dump site, and mounded material feature types in the Work Plan. However, geophysical surveys were conducted at multiple features other than those types specified, including F-BU-001, M-GS-043, M-SH-001 and -002, M-UN-003 and -006, M-DA-023, M-FS-018 and -019 and near M-FS-016, and an area near M-QT-095.

  The rationale for these investigations was previously discussed in Section 4.6, Subsurface Metal Investigations. Where applicable to specific features screened during Phase II, deviations and their rationale are captured in Table 5-1.

- Modified screening approach after August 20, 2015: The screening approach outlined in the Work Plan was to advance UVOST probes through the vertical extent of contamination, to 2 feet below the groundwater interface at non-detect probe locations, or to refusal. Concurrence was received from USACE regarding a modified screening approach in AOC M for features where depth to groundwater could not be established and where no contamination was detected. The modified approach was as follows: an attempt was made to reach groundwater at each feature, with 20% of probes extending to groundwater at features with greater than 10 probes. Otherwise, UVOST probes were terminated at the 20-foot depth in features where no contamination was identified.

Table 5-1. List of Features Screened and Sampled with Deviations Documented.

No.	Feature Screened	Deviation	Nature of Deviation	Rationale
AOC B				
1	B-BU-004	YES	Alt. to B-BU-002	No drill rig access due to marshy area with excessive vegetation.
2	B-DA-001	---	---	---
3	B-DA-002	---	---	---
4	B-DA-003	---	---	---
5	B-DA-004	---	---	---
6	B-DA-005	---	---	---
7	B-DS-001	---	---	---
8	B-DS-002	---	---	---
9	B-DS-003	---	---	---
10	B-GS-002	---	---	---
11	B-GS-003	YES	Alt. to B-GS-001	No drill rig access due to excessive vegetation.
12	B-GS-004	---	---	---
13	B-GS-008	---	---	---
14	B-GS-011	---	---	---
15	B-MM-001	---	---	---
16	B-MM-002	---	---	---
17	B-OT-001	---	---	---
18	B-QT-001	---	---	---
19	B-SP-001	---	---	---
20	B-SP-002	---	---	---
21	B-ST-001	---	---	---
AOC C				
1	C-GS-004	YES[1]	Additional data	Sample UV probe with potential POL signature
2	C-LT-002	YES[1]	Additional data	Resample monitoring well C-MW-001 for POL

Table 5-1. List of Features Screened and Sampled with Deviations Documented (continued).

No.	Feature Screened	Deviation	Nature of Deviation	Rationale
AOC E				
1	E-DS-001	YES[1]	Additional data	Perimeter screening and sampling
AOC F				
1	F-BU-001	YES[1]	Additional data	Additional screening and sampling
2	F-OT-001	YES[1]	Additional data	Additional screening and sampling
AOC K				
1	K-ST-001	YES[1]	Additional data	Additional sample
AOC M				
1	M-AD-001	---	---	---
2	M-AD-004	---	---	---
3	M-AD-008	---	---	---
4	M-BP-001	---	---	---
5	M-BU-002	---	---	---
6	M-BU-004	---	---	---
7	M-BU-009	---	---	---
8	M-BU-018	---	---	---
9	M-BU-024	---	---	---
10	M-DA-001	---	---	---
11	M-DA-002	---	---	---
12	M-DA-003	---	---	---
13	M-DA-004	---	---	---
14	M-DA-005	---	---	---
15	M-DA-006	---	---	---
16	M-DA-007	---	---	---
17	M-DA-008	---	---	---
18	M-DA-009	YES	Screening locations and pattern	Concurrence from USACE provided for multiple hand-auger probes within interior of recessed, overly vegetated adjacent features M-DA-009 and M-MH-003.
19	M-DA-010	---	---	---
20	M-DA-011	---	---	---
21	M-DA-012	---	---	---
22	M-DA-013	---	---	---
23	M-DA-014	---	---	---
24	M-DA-015	---	---	---
25	M-DA-016	---	---	---
26	M-DA-017	---	---	---
27	M-DA-018	---	---	---
28	M-DA-019	---	---	---
29	M-DA-020	---	---	---
30	M-DA-021	---	---	---
31	M-DA-022	---	---	---

Table 5-1. List of Features Screened and Sampled with Deviations Documented (continued).

No.	Feature Screened	Deviation	Nature of Deviation	Rationale
32	M-DA-023	YES	Geophysical Survey	Survey conducted due to surface metal debris observed in the immediate area.
33	M-DA-024	---	---	---
34	M-DA-025	---	---	---
35	M-DA-026	---	---	---
36	M-DA-027	---	---	---
37	M-DB-001	---	---	---
38	M-DS-001	---	---	---
39	M-DS-002	---	---	---
40	M-DS-003	---	---	---
41	M-DS-004	---	---	---
42	M-DS-005	---	---	---
43	M-FS-001	---	---	---
44	M-FS-002	---	---	---
45	M-FS-003	---	---	---
46	M-FS-004	---	---	---
47	M-FS-005	---	---	---
48	M-FS-006	---	---	---
49	M-FS-007	---	---	---
50	M-FS-008	---	---	---
51	M-FS-009	---	---	---
52	M-FS-010	YES	Geophysical Survey	Feature partially surveyed as part of surrounding area where buried debris suspected due to large presence of surface metal debris.
53	M-FS-011	---	---	---
54	M-FS-012	---	---	---
55	M-FS-013	---	---	---
56	M-FS-014	---	---	---
57	M-FS-015	---	---	---
58	M-FS-016	YES	Geophysical Survey	Feature partially surveyed as part of surrounding area where buried debris suspected due to large presence of surface metal debris.
59	M-FS-017	---	---	---
60	M-FS-018	YES	Geophysical Survey	Survey conducted due to suspected buried metal in Fuel Storage feature types within AOC M.
61	M-FS-019	YES	Geophysical Survey	Survey conducted due to suspected buried metal in Fuel Storage feature types within AOC M.
62	M-GS-001	YES	Alt. to M-GS-046	Impenetrable surface soil (cobbles, boulders).
63	M-GS-002	YES	Alt. to M-GS-021	Large tussocks precluded drill rig use.
64	M-GS-004	YES	Alt. to M-GS-013	Large tussocks precluded drill rig use.
65	M-GS-007	---	---	---
66	M-GS-017	YES	Alt. to M-GS-011	Large tussocks precluded drill rig use.
67	M-GS-033	YES	Alt. to M-GS-040	Large tussocks precluded drill rig use.

Table 5-1. List of Features Screened and Sampled with Deviations Documented (continued).

No.	Feature Screened	Deviation	Nature of Deviation	Rationale
68	M-GS-034	---	---	---
69	M-GS-035	---	---	---
70	M-GS-036	---	---	---
71	M-GS-037	---	---	---
72	M-GS-041	YES	Alt. to M-GS-039	Large tussocks precluded drill rig use.
73	M-GS-043	YES	Geophysical Survey	Survey conducted due to evidence of buried metal structure between features M-GS-043 and M-MH-002.
74	M-LT-001	---	---	---
75	M-LT-002	---	---	---
76	M-LT-003	---	---	---
77	M-LT-004	---	---	---
78	M-LT-005	---	---	---
79	M-LT-006	---	---	---
80	M-LT-007	---	---	---
81	M-LT-008	---	---	---
82	M-LT-009	---	---	---
83	M-LT-010	---	---	---
84	M-MH-001	---	---	---
85	M-MH-002	---	---	---
86	M-MH-003	YES	Screening locations and pattern	Concurrence from USACE provided for multiple hand-auger probes within interior of recessed, overly vegetated adjacent features M-DA-009 and M-MH-003.
87	M-MH-004	---	---	---
88	M-MH-005	---	---	---
89	M-MH-006	---	---	---
90	M-MM-001	---	---	---
91	M-MM-002	---	---	---
92	M-MM-003	---	---	---
93	M-MM-004	---	---	---
94	M-PH-001	---	---	---
95	M-PH-002	---	---	---
96	M-PH-003	---	---	---
97	M-PH-004	---	---	---
98	M-PH-005	---	---	---
99	M-PH-006	---	---	---
100	M-PR-001	---	---	---
101	M-PR-002	---	---	---
102	M-PR-003	---	---	---
103	M-PR-004	---	---	---
104	M-PR-005	YES	Geophysical Survey	Evidence of metal piping prompted geophysical survey for potential buried tank or other debris.

Table 5-1. List of Features Screened and Sampled with Deviations Documented (continued).

No.	Feature Screened	Deviation	Nature of Deviation	Rationale
105	M-PR-006	---	---	---
106	M-QT-011	---	---	---
107	M-QT-025	---	---	---
108	M-QT-030	YES	Sampling alternate to M-QT-064	Originally designated for screening only, but sampled as next highest random feature in place of M-QT-064 (inaccessible).
109	M-QT-033	---	---	---
110	M-QT-036	---	---	---
111	M-QT-039	---	---	---
112	M-QT-044	---	---	---
113	M-QT-047	---	---	---
114	M-QT-053	---	---	---
115	M-QT-054	---	---	---
116	M-QT-062	---	---	---
117	M-QT-067	---	---	---
118	M-QT-068	---	---	---
119	M-QT-069	---	---	---
120	M-QT-072	---	---	---
121	M-QT-081	---	---	---
122	M-QT-085	---	---	---
123	M-QT-088	---	---	---
124	M-QT-092	---	---	---
125	M-QT-097	YES	Screening alternate to M-QT-064	M-QT-064 inaccessible to drill rig.
126	M-QT-101	---	---	---
127	M-QT-122	---	---	---
128	M-QT-123	---	---	---
129	M-QT-124	---	---	---
130	M-QT-127	---	---	---
131	M-QT-132	---	---	---
132	M-QT-136	---	---	---
133	M-QT-139	---	---	---
134	M-QT-143	---	---	---
135	M-QT-145	---	---	---
136	M-QT-147	---	---	---
137	M-RC-004	YES	Screening alternate to M-RC-007	Feature M-RC-007 inaccessible to the drill rig.
138	M-RC-008	YES	Sampling alternate to M-RC-007	Originally designated for screening, but sampled as next highest random feature in place of M-RC-007 (inaccessible).
139	M-RD-001	YES	No. of screening locations	Concurrence from USACE to sample four corners and center of feature in place of screening due to impenetrable surface soils.

Table 5-1. List of Features Screened and Sampled with Deviations Documented (continued).

No.	Feature Screened	Deviation	Nature of Deviation	Rationale
140	M-SH-001	YES	Geophysical Survey	Survey conducted due to evidence of partially exposed buried drums and pipes in area.
141	M-SH-002	YES	Geophysical Survey	Survey conducted due to buried metal debris observed in other Shop feature in AOC M.
142	M-ST-001	---	---	---
143	M-ST-002	---	---	---
144	M-ST-003	---	---	---
145	M-ST-004	---	---	---
146	M-ST-005	---	---	---
147	M-ST-006	---	---	---
148	M-ST-007	---	---	---
149	M-ST-008	---	---	---
150	M-SW-002	---	---	---
151	M-SW-003	---	---	---
152	M-TF-001	---	---	---
153	M-TR-001	---	---	---
154	M-TR-002	---	---	---
155	M-UN-002	---	---	---
156	M-UN-003	YES	Geophysical Survey	Survey conducted due to unknown nature of feature, presence of metal debris, and similarity to debris or mounded material sites.
157	M-UN-004	YES	No. of screening locations	Feature located within perimeter screening conducted at feature GS-041; no specific screening locations associated with M-UN-004.
158	M-UN-005	YES	No. of screening locations	West portion of feature not screened due to proximity to buried metal in Feature GS-041.
159	M-UN-006	YES	Geophysical Survey	Survey conducted due to unknown nature of feature, and similarity to dump site feature types.
160	M-UN-007	---	---	---
161	M-UN-008	---	---	---
162	M-UN-009	---	---	---
163	M-WH-001	---	---	---
164	M-WH-002	YES	No. of screening locations	Presence of partially exposed drums and buried metal debris in northwest corner of feature.
165	M-WH-003	---	---	---
166	M-WH-004	---	---	---
167	M-WH-005	---	---	---
168	M-WH-006	---	---	---
169	M-WH-007	---	---	---
170	M-WH-008	---	---	---
171	M-WH-009	---	---	---

[1] Data collection in AOCs other than B and M were to address data gaps from Phase I investigation or to fulfill contract scope of work.

Figure 5-1. Impenetrable Soil at Feature M-RD-001.

Figure 5-2. Overgrowth of Vegetation at Features M-DA-009 and M-MH-003.

6. INVESTIGATION RESULTS

6.1 Background Metals Study

Fourteen soil borings were drilled throughout the Former Fort Morrow in areas with no known evidence of past or present anthropogenic activity. Twenty-seven soil samples were collected from different soil types encountered and submitted for laboratory analyses for metals in order to evaluate naturally occurring background metal concentrations and determining whether site sample concentrations fall within the range of background concentrations. Map S-2 in Appendix F shows locations for borings where background metal samples were collected.

Analyses of the 27 background metal samples showed few exceedances of PALs with the exception of arsenic, cobalt, iron, manganese, and molybdenum (see Appendix J). The upper tolerance level (UTL) at 95% confidence was established for comparison to background metal UTLs developed in the 2006 study conducted by the USAF (USAF, 2006). Table 6-1 compares the UTLs resulting from this study with those from the USAF study and with PALs. The number of exceedances of project-wide soils analyses is evaluated against the PAL and the 2015 UTLs.

Table 6-1. Comparison of Background Metals UTLs, PALs, and Number of Exceedances.

Metal	2006 UTL (USAF)[1] (mg/kg)	2015 UTL[2] (mg/kg)	PAL (mg/kg)	2015 UTL Exceedances	PAL Exceedances
Antimony	0.12	2.2	3.6	0	0
Arsenic	7.05	6.2	3.9	8	45
Barium	3,662	170	1,100	19	0
Beryllium	0.43	0.67	42	0	0
Cadmium	0.38	0.094	5	79	0
Chromium	25.18	19	25	2	1
Cobalt	28.68	12	0.021	7	232
Copper	57.26	27	460	7	0
Iron	54,670	41,000	27	0	232
Lead	22.46	5.4	400	25	1
Manganese	6,309	620	2.1	21	232
Mercury	0.09	0.058	1.4	8	0
Molybdenum	0.94	0.49	0.16	34	173
Nickel	26.49	15	86	4	0
Selenium	7.73	0.54	3.4	57	0
Silver	0.02	0.89	11.2	0	0
Thallium	7.12	0.13	1.9	21	0
Vanadium	151.81	74	710	14	0
Zinc	108.55	52	4,100	24	0

[1] 2006 UTL values are derived from subsurface soils.
[2] 2015 UTL values are derived from a combination of surface and subsurface soils.

The 2015 UTL values are greater than PALs for arsenic, cobalt, iron, manganese, and molybdenum, suggesting that project analytical results greater than UTLs for these analytes are potentially contributable to anthropogenic contamination sources.

6.2 Feature Screening and Sampling Results

Screening and sampling of features was performed in AOCs B, E, F, and M. Eleven features were identified where POL contamination was confirmed in surface or subsurface soils above PALs. One feature was identified where lead contamination was confirmed in surface soils above the PAL. Four areas were identified where contamination was confirmed in groundwater. Table 6-2 lists the contaminated site features identified during this investigation. Results of screening and sampling activities are discussed by AOC in the following sections. Further discussion of the nature and extent of contamination at features listed in Table 6-2 is provided in Section 7, Site Features of Concern.

Table 6-2. Features with POL and Lead Contamination.

Feature	POL Soil Contamination	Lead Soil Contamination	POL Groundwater Contamination
B-DA-003	YES	–	YES
B-DA-004	YES	–	YES
B-DA-005	YES	–	YES
C-LT-002	Yes (2012)	–	YES
F-BU-001	YES	–	–
M-DA-023	YES	–	–
M-PR-001	YES	–	–
M-PR-005	YES	–	–
M-SH-001	–	YES	–
M-SH-002	YES	–	–
M-ST-006	YES	–	–
M-TF-001	YES	–	–
M-UN-002	YES	–	–

6.2.1 AOC B

Twenty-one features were screened and sampled for POL contamination in AOC B, two features were screened for lead contamination, and three features were sampled for groundwater contamination. Compilations of screening and sampling activities conducted at each feature are provided in Appendix F, Maps B-1 through B-6. Analytical results are provided in Appendix J.

POL Screening and Sampling Results

In total, 527 UVOST screening locations (or probes) were drilled to provide characterization data necessary to meet project quality objectives, as well as the screening methodology outlined in the Work Plan (North Wind, 2014). Logs of UVOST probes are provided in Appendix E (ordered by AOC, then probe number).

The average depth screened in AOC B was 13.6 feet bgs, with a range of 1.43 to 32.1 feet bgs. Depths to groundwater ranged from 5.4 feet at feature B-OT-001 to 23.0 feet at feature B-ST-001. Summaries of screening and sampling information are provided in Tables 6-3 and 6-4.

Forty-two UVOST probes had detections (i.e., potential fuel signatures) above the in-situ correlation value of 0.7% effective LIF. Screening detections were located in features B-DA-003 (11 detections), B-DA-004 (21 detections), and B-DA-005 (9 detections) and B-GS-002 (1 detection).

A total of 68 confirmation soil samples were collected; 25 "full suite" samples (i.e., per the prescribed sample suite in the Work Plan [North Wind, 2014]) and 43 POL-only samples, as shown in Table 6-3. Thirty-one sample results exceeded PALs for POL. These were associated with UVOST detections in every case except two: UVOST probe 14FMBDA003UV041 had a DRO result of 590 mg/kg associated with an effective LIF value of 0.27%, below the correlation value of 0.7%. UVOST probe 14FMBDA004UV076 had a DRO result of 1,700 mg/kg associated with an effective LIF value of 0.19%. These false negative results are most likely due to soil heterogeneity as discussed in Section 4.3.3 or limited lateral extent of contamination.

Six groundwater samples were collected in areas of contamination, three of which had exceedances of PALs for POL. Section 6.3 provides further discussion of groundwater sampling results. Section 7 provides further discussion of site features of concern B-DA-003, B-DA-004, and B-DA-005.

Lead Screening and Sampling Results

Two mounded material features in AOC B were screened for potential lead contamination in surface soils. Ten locations were screened (six at B-MM-001 and four at B-MM-002) for a total of 30 screening results plus duplicates. No exceedances of the PAL for lead of 400 mg/kg were observed. No confirmation samples were submitted for laboratory analyses.

Only 13 of the 30 results were above the limit of detection of the portable XRF unit. Results ranged from 3.5 parts per million (ppm) to 6.1 ppm. Two detections were at the top of the mineral surface just underneath any vegetative cover, three detections were at 1.0 foot bgs, and eight detections were at 2.0 feet bgs.

Sample Results Other Than Lead and POL

In addition to POL and lead, soil analyses were performed for BTEX, VOCs, SVOCs, metals, pesticides, and PCBs, as specified in the Work Plan (North Wind, 2014) for each feature type. Table 6-4 provides a summary of sample analyses and exceedances by analyte for each feature. The PAL exceedances from Table 6-4 are discussed below.

<u>VOCs</u>

Four VOC exceedances are documented for AOC B. The PAL (0.016 mg/kg) for methylene chloride was exceeded three times. The PAL (20 mg/kg) for naphthalene was exceeded once.

Methylene chloride values ranged from 0.022 to 0.024 mg/kg. All three results were B-qualified for potential method blank or trip blank contamination. As methylene chloride is a common laboratory contaminant, these exceedances are not considered to represent actual soil contamination.

One exceedance for naphthalene is documented for feature B-DA-003 with a result of 44 mg/kg. It is associated with sample 14FMBDA003DT008, which also exceeded the PAL for DRO, and therefore may be attributable to soil contamination.

Table 6-3. AOC B Screening and Sampling Summary for POL in Soil.

Site Feature	No. UVOST Screening Locations	Max Depth Screened (ft)	No. Full Suite Samples	No. POL Samples	UVOST Screening Detections (qty)	POL Results Above PAL (qty)	Highest POL Result			Sample Depth (ft)	Depth to Water (ft)
							Analyte	Result (mg/kg)	Avg. Eff. POL %LIF at Sample Depth		
B-BU-004	4	3.9	2	0	No	No	DRO	31	NA	2.75-3.25	NM
B-DA-001	8	18.9	1	0	No	No	DRO	2.3	NA	0.5-1.0	14.2
B-DA-002	8	18.5	1	0	No	No	DRO	14	NA	0.5-1.0	11
B-DA-003	126	19.1	2	11	Yes (11)	Yes (10)	DRO	13000	3.770	2.0-3.0	8.2
B-DA-004	149	22.8	2	15	Yes (21)	Yes (15)	DRO	25000	7.680	1.0-2.0	8.5
B-DA-005	137	32.1	2	14	Yes (9)	Yes (6)	DRO	5700	7.088	0.5-2.5	7.8
B-DS-001	4	15.0	1	0	No	No	DRO	99 ML	0.280	0.5-1.5	8.1
B-DS-002	4	15.1	1	0	No	No	DRO	5.1	NA	5.0-8.0	11.4
B-DS-003	6	11.2	1	0	No	No	DRO	17 QN	NA	0.5-1.5	6.7
B-GS-002	5	13.9	1	0	Yes (1)	No	DRO	18	0.760	2.0-3.0	NM
B-GS-003	24	16.4	1	2	No	No	DRO	2.1	0.135	6.0-7.0	NM
B-GS-004	5	15.5	1	0	No	No	DRO	3.8	NA	2.0-3.0	8.3
B-GS-008	4	9.9	1	0	No	No	DRO	58	0.231	0.5-1.5	NM
B-GS-011	4	14.8	1	0	No	No	DRO	1.8	NA	8.0-9.0	8.3
B-MM-001	6	18.2	1	0	No	No	DRO	3.2	NA	1.0-2.0	14.7
B-MM-002	4	18.3	1	0	No	No	DRO	3.1	NA	13.5-15.5	15.4
B-OT-001	10	14.9	1	0	No	No	DRO	5.6	NA	1.0-2.0	5.4
B-QT-001	2	14.9	1	0	No	No	DRO	1.7	NA	0.5-1.5	5.9
B-SP-001	4	18.9	1	0	No	No	DRO	3.4	NA	0.5-2.0	7.8
B-SP-002	4	14.1	1	0	No	No	DRO	2.7	NA	0.5-2.0	10
B-ST-001	9	27.9	1	1	No	No	DRO	3.5	0.210	0.5-1.5	23
Total	**527**	**32.1 ft max**	**25**	**43**	**4 (42)**	**3 (31)**					

Avg. Eff. POL %LIF-Average effective % laser-induced fluorescence attributable to the presence of a potential fuel type waveform.
NA – Not Applicable

NM-Not measured (depth to water).

Data Qualifiers:
ML-Matrix spike recovery not compliant: biased low.
QN-Field duplicate precision not compliant.

Table 6-4. AOC B Soil Sample Results Summary for Analyses other than POL.

Site Feature	No. Full Suite Samples	No. XRF Measurements[a]	No. PCB 9-pt Grid Samples[b]	No. of Detects[c] Exceeding PALs (mg/kg)							Sample Depth (ft)	Depth to Water (ft)
				BTEX	VOC	SVOC	Metals	Pesticides	PCBs	Lead (XRF conf.)		
B-BU-004	2	0	0	0	1	0	6	0	0	NA	2.75-3.25	NM
B-DA-001	1	0	0	0	0	0	3	0	0	NA	0.5-1.0	14.2
B-DA-002	1	0	0	0	1	0	3	0	0	NA	0.5-1.0	11
B-DA-003	2	0	0	0	1	1	5	0	0	NA	2.0-3.0	8.2
B-DA-004	2	0	0	0	0	0	4	0	0	NA	1.0-2.0	8.5
B-DA-005	2	0	0	0	0	0	6	0	0	NA	0.5-2.5	7.8
B-DS-001	1	0	0	0	0	0	3	0	0	NA	0.5-1.5	8.1
B-DS-002	1	0	0	0	0	0	3	0	0	NA	5.0-8.0	11.4
B-DS-003	1	0	0	0	0	0	3	0	0	NA	0.5-1.5	6.7
B-GS-002	1	0	0	0	0	0	4	0	0	NA	2.0-3.0	NM
B-GS-003	1	0	0	0	0	0	3	0	0	NA	6.0-7.0	NM
B-GS-004	1	0	0	0	0	0	3	0	0	NA	2.0-3.0	8.3
B-GS-008	1	0	0	0	0	0	3	0	0	NA	0.5-1.5	NM
B-GS-011	1	0	0	0	0	0	2	0	0	NA	8.0-9.0	8.3
B-MM-001	1	18	0	0	1	0	3	0	0	NA	1.0-2.0	14.7
B-MM-002	1	12	0	0	0	0	2	0	0	NA	13.5-15.5	15.4
B-OT-001	1	0	0	0	0	0	3	0	0	NA	1.0-2.0	5.4
B-QT-001	1	0	0	0	0	0	2	-[d]	-	NA	0.5-1.5	5.9
B-SP-001	1	0	0	0	0	0	3	-	0	NA	0.5-2.0	7.8
B-SP-002	1	0	0	0	0	0	3	-	0	NA	0.5-2.0	10
B-ST-001	1	0	0	0	0	0	3	-	0	NA	0.5-1.5	23
Total	**25**	**30**	**0**	**0**	**4**	**1**	**70**	**0**	**0**	**0**		

[a] XRF measurements collected at 0.0 ft, 1.0 ft and 2.0 ft depths at each sample location.
[b] PCB 9-pt grid samples collected at 0.5 ft depth.
[c] PALs for some VOC and SVOC compounds are less than typical limits of detection; only detected exceedances are counted.
[d] Dashes indicate feature not sampled or specific analysis not requested per Work Plan.

NM-Not Measured (depth to water).
NA-Not Applicable (not analyzed).

SVOCs

One SVOC exceedance is documented for AOC B. Compound 2-methylnaphthalene was present above the PAL (6.1 mg/kg) at a value of 50 mg/kg. It is also associated with sample 14FMBDA003DT008, which exceeded the PAL for DRO, and therefore may likely be attributable to soil contamination.

Metals

Metal detections exceeded PALs 70 times. Exceedances were for arsenic (1 exceedance), iron (25 exceedances), manganese (25 exceedances), and molybdenum (19 exceedances). When compared to 2015 UTLs established from the background metals study conducted during this investigation (see Section 6.1), only one exceedance for manganese persists.

Manganese is present in sample 14FMBBU004DT001 at 660 mg/kg. This value exceeds the current PAL of 2.1 mg/kg and the 2015 UTL of 620 mg/kg. It does not exceed the 2006 UTL of 6,309 mg/kg established by the USAF. Sample 14FMBBU004DT001 was taken from a depth of 0.5 to 1.5 feet. This location was resampled in 2015 at a depth of 2.75 to 3.25 feet to correlate with an increased LIF response noted in the UVOST log. The resulting sample, 15FMBBU004DT002, showed no exceedances for metals or otherwise.

6.2.2 AOC C

No UVOST probes were drilled in AOC C during this investigation. One feature previously screened in 2012, C-GS-004, was sampled for additional information regarding potential soil POL contamination. Five groundwater wells associated with multiple features, including one well in feature C-LT-002 with known soil contamination from 2012 investigations, were sampled but no additional screening or soil sampling was conducted. Groundwater sampling results are discussed in Section 6.3; 2012 soil sampling results are not discussed in this report.

Three test pit investigations were conducted at C-BD-001 based on geophysical survey results from 2012. Section 6.3 includes the groundwater monitoring results, while the subsurface metal investigation and sampling results are provided in Section 6.4. Compilations of screening and sampling activities conducted at features in AOC are provided in Appendix F, Maps C-1 and C-2.

Analytical results for sample 14FMCGS004DT001 returned no PAL exceedances for the analytical suite except for metals, as shown in Tables 6-5 and 6-6. Exceedances were for iron (one exceedance at 7,600 mg/kg) and manganese (one exceedance at 160 mg/kg). Both exceedances were below the 2015 UTLs and are not discussed further. Analytical results are provided in Appendix J.

6.2.3 AOC E

One feature, E-DS-001, was screened and sampled, and the results are summarized in Tables 6-5 and 6-6. Three test pit investigations were conducted (see Section 6.4). A figure depicting screening and sampling activities conducted at E-DS-001 is included in Appendix F, Map E-1.

POL Screening and Sampling Results

Forty-five UVOST probes were drilled at E-DS-001. The average depth screened was 11.8 feet bgs, with a range of 7.6 to 27.9 feet bgs. Screening was performed around the perimeter of the feature based on geophysical survey data showing extensive buried metal debris within the perimeter. Depth to groundwater was not measured.

Two UVOST probe locations had detections above 0.7% effective LIF, potentially indicative of POL contamination. One location was sampled while the other one was not, as it was not identified as potential POL until post field season data review.

Five samples were collected, of which one was submitted for full suite analysis; the remaining four were submitted for POL analysis only. Results returned no exceedances of POL.

Sample Results Other Than Lead and POL

Analytical results for samples collected at E-DS-001 returned no PAL exceedances for the analytical suite except for metals, as shown in Table 6-6. Exceedances were for iron (one exceedance at 11,000 mg/kg), manganese (one exceedance at 270 mg/kg), and molybdenum (one exceedance at 0.17 mg/kg [J-qualified as estimated value]). All exceedances were from sample 15FMEDS001DT001 from UVOST probe location 15FMEDS001UV030. All metals exceedances were below the 2015 UTLs and are not discussed further. Analytical results are provided in Appendix J.

6.2.4 AOC F

Two features previously screened in 2012, F-BU-001 and F-OT-001, were screened and sampled for additional information regarding detected POL contamination. A soil removal action was performed in feature F-OT-001, the results of which are discussed in Section 6.5. Compilations of screening and sampling activities conducted at AOC F are provided in Appendix F, Map F-1. Analytical results are provided in Appendix J.

POL Screening and Sampling Results

A total of eight UVOST boreholes were hand-augered for UVOST emulation (four in each feature) for the purpose of delineating POL contamination confirmed with sample analyses. Summaries of screening and sampling information are provided in Tables 6-5 and 6-6.

Two UVOST probes had detections above 0.7% effective LIF; both were in F-BU-001. Additional probes to delineate UVOST detections were not feasible due to proximity to the eroding beach cliff.

Four confirmation samples were collected; one from F-BU-001 for POL and metals and three from F-OT-001 for POL only. Only one sample exceeded PALs for POL. Sample 14FMFBU001DT001, taken in UVOST probe 12FMFBU001UV007, had a DRO result of 3,000 mg/kg associated with an effective LIF value of 0.295%. This false negative result is most likely due to soil heterogeneity, or limited lateral extent of contamination.

Sample Results Other Than Lead and POL

Metal analyses for sample 14FMFBU001DT001 returned two PAL exceedances: iron (14,000 mg/kg) and manganese (280 mg/kg). Both exceedances were below the 2015 UTLs and are not discussed further. Analytical results are provided in Appendix J.

6.2.5 AOC K

No UVOST probes were drilled in AOC K during this investigation. One feature previously screened in 2012, K-ST-001, was sampled for additional information regarding potential POL soil contamination. A map showing previous screening and current sampling activities conducted in AOC K is provided in Appendix F, Map K-1.

Analytical results for sample 14FMKST001DT001 returned no PAL exceedances for the analytical suite except for metals, as shown in Tables 6-5 and 6-6. Exceedances were for iron (8,800 mg/kg), manganese (180 mg/kg) and molybdenum (0.17 mg/kg [J-qualified as estimated value]). Both exceedances were below the 2015 UTLs and are not discussed further. Analytical results are provided in Appendix J.

Table 6-5. AOCs C, E, F, and K Screening and Sampling Summary for POL in Soil.

Site Feature	No. UVOST Screening Locations	Max Depth Screened (ft)	No. Full Suite Samples	No. POL Samples	UVOST Screening Detections (qty)	POL Results Above PAL (qty)	Highest POL Result			Sample Depth (ft)	Depth to Water (ft)
							Analyte	Result (mg/kg)	Avg. Eff. POL %LIF at Sample Depth		
C-GS-004[a]	0	NA	1	0	NA	No	DRO	ND 2.7	4.547	4.5-5.5	NM
E-DS-001	45	27.9	1	4	Yes (2)	No	DRO	9.3	0.595	0.5-1.0	NM
F-BU-001[a]	4	13	0	1	Yes (2)	Yes (1)	DRO	3000	0.295	4.5-5.2	NM
F-OT-001[a]	4	6	0	3	No	No	DRO	3.3	0.041	4.0-4.5	NM
K-ST-001[a]	0	NA	1	0	NA	No	DRO	ND 2.2	1.692	0.5-2.5	NM
Total	**53**		**1**	**8**	**2 (4)**	**1 (1)**					

[a] Feature previously screened and sampled in 2012.
Avg. Eff. POL %LIF-Average effective % laser-induced fluorescence attributable to the presence of a potential fuel type waveform.
NA-Not Applicable.
NM-Not measured (depth to water).

Data Qualifiers:
ND-Not Detected.

Table 6-6. AOCs C, E, F, and K Soil Sample Results Summary for Analyses other than POL.

Site Feature	No. Full Suite Samples	No. XRF Measurements[a]	No. PCB 9-pt Grid Samples[b]	No. of Detects[c] Exceeding PALs (mg/kg)							Sample Depth (ft)	Depth to Water (ft)
				BTEX	VOC	SVOC	Metals	Pesticides	PCBs	Lead (XRF conf. samples)		
C-GS-004[c]	1	0	0	0	0	0	2	0	0	NA	4.5-5.5	NM
E-DS-001	1	0	0	0	0	0	3	0	0	NA	0.5-1.0	NM
F-BU-001[d]	0[e]	0	0	-[f]	-	-	2	-	-	NA	4.5-5.2	NM
F-OT-001[d]	0	0	0	-	-	-	-	-	-	NA	4.0-4.5	NM
K-ST-001[d]	1	0	0	0	0	0	3	0	0	NA	0.5-2.5	NM
Total	**3**	**0**	**0**	**0**	**0**	**0**	**10**	**0**	**0**	**0**		

[a] XRF measurements collected at 0.0 ft, 1.0 ft and 2.0 ft depths at each sample location.
[b] PCB 9-pt grid samples collected at 0.5 ft depth.
[c] PALs for some VOC and SVOC compounds are less than typical limits of detection; only detected exceedances are counted.
[d] Feature previously screened and sampled in 2012.
[e] F-BU-001 one analysis for POL and metals only.
[f] Dashes indicate feature not sampled or specific analysis not requested per Work Plan.

NM-Not Measured (depth to water).
NA-Not Applicable.

6.2.6 AOC M

A total of 171 features were screened and sampled for POL contamination in AOC M. Seven features were screened for lead contamination, eight features were sampled for PCB surface contamination, two features were sampled for groundwater contamination, and three test pit investigations were conducted. Compilations of screening and sampling activities conducted at each feature are provided in Appendix F, Maps M-1 through M-41. Analytical results are provided in Appendix J.

POL Screening and Sampling Results

In total, 1,399 UVOST probes were drilled to provide the characterization data necessary to meet project quality objectives, as well as the screening methodology outlined in the Work Plan (North Wind, 2014). Logs of UVOST probes are provided in Appendix E (ordered by AOC, then probe number).

The average depth screened in AOC M was 24.9 feet bgs, with a range of 1.0 to 60.0 feet bgs. Depths to groundwater ranged from 7.0 feet at feature M-GS-036 to 59.8 feet at feature M-AD-004, where measured. Summaries of screening and sampling information are provided in Tables 6-7 and 6-8.

Seventy-eight UVOST probes in 33 features had detections of potential POL above the correlation value of 0.7% effective LIF. Thirty-eight of these detections were sampled for confirmation, of which seven exceeded PALs for POL (specifically DRO). Two features with UVOST detections (M-PH-001 and M-WH-004) were not sampled at the location of the detection (i.e., the presence of a potential fuel-type waveform was determined after field work was complete). Features where UVOST detections were confirmed to exceed PALs for POL included M-DA-023, M-PR-001, M-PR-005, M-SH-002, M-TF-001, and M-UN-002. The number of UVOST detections and confirmation samples exceeding PALs for POL for each feature are summarized in Table 6-7.

A total of 210 confirmation soil samples were collected; 148 “full suite” samples (i.e., per the prescribed sample suite in the Work Plan [North Wind, 2014]) and 66 POL-only samples, as shown in Table 6-8. Nine sample results exceeded PALs for POL; these were associated with UVOST detections in every case except two. Sample 15FMMSH002DT001 was taken in feature M-SH-002 in UVOST probe 15FMMSH002UV018 associated with a potential fuel signature at 0.225% average effective LIF. Sample 15FMMST006DT001 was taken in feature M-ST-006 in UVOST probe 14FMMST006UV003, which showed no indication of POL. These false negative results are possibly due to the limited lateral extent of soil contamination (i.e., the sampling borehole encountered contamination while the screening borehole did not).

Two groundwater samples were collected in areas of contamination, neither of which had exceedances of PALs for POL. Section 6.3 provides further discussion of groundwater sampling results, while Section 7 provides further discussion of site features of concern M-DA-023, M-PR-001, M-PR-005, M-SH-002, M-ST-006, M-TF-001, and M-UN-002.

Lead Screening and Sampling Results

Seven features in AOC M were screened for potential lead contamination in surface soils: M-DB-001, M-MM-001, M-MM-002, M-MM-003, M-MM-004, M-SH-001, and M-SH-002. A total of 126 screening measurements (plus duplicates) were taken. One measurement of 626 ppm in M-SH-001 exceeded the correlating PAL value for lead of 400 ppm. This sample, and six others correlating to the highest XRF measurements, were submitted for confirmation laboratory analyses.

Table 6-7. AOC M Screening and Sampling Summary for POL in Soil.

Site Feature	No. UVOST Screening Locations	Max Depth Screened (ft)	No. Full Suite Samples	No. POL Samples	UVOST Screening Detections (qty)	POL Results Above PAL (qty)	Highest POL Result			Sample Depth (ft)	Depth to Water (ft)
							Analyte	Result (mg/kg)	Avg. Eff. POL %LIF at Sample Depth		
M-AD-001	4	26.3	0	0	No	No	- [e]	-	-	-	NM
M-AD-004	6	59.9	1	0	No	No	DRO	3.6	NA	22.0-23.0	59.85
M-AD-008	6	32.1	0	0	No	No	-	-	-	-	NM
M-BP-001	10	53.5	1	0	No	No	DRO	1.4	NA	27.0-30.0	23
M-BU-002	6	37.2	0	0	No	No	-	-	-	-	20.7
M-BU-004	4	26.9	0	0	No	No	-	-	-	-	NM
M-BU-009	4	31.3	1	0	No	No	DRO	6 B	NA	5.0-6.0	16.6
M-BU-018	6	20.1	1	0	No	No	DRO	2.5	No Data[f]	8.0-9.0	NM
M-BU-024	6	23.6	1	0	No	No	DRO	1.3 B	NA	5.0-6.0	NM
M-DA-001	4	14.9	1	0	No	No	DRO	19 ML	NA	0.5-1.5	NM
M-DA-002	6	36.6	1	0	No	No	DRO	6	NA	0.5-1.5	NM
M-DA-003	11	40.0	1	1	Yes (3)	No	DRO	ND 2.4	NA	0.5-1.5	NM
M-DA-004	4	34.4	1	0	No	No	DRO	8.7 B	NA	4.5-5.5	NM
M-DA-005	4	33.5	1	0	No	No	DRO	2.1	NA	0.5-1.5	NM
M-DA-006	31	42.1	2	2	Yes (7)	No	DRO	4.4	NA	7.0-8.0	NM
M-DA-007	7	28.0	1	0	No	No	DRO	11	NA	4.0-4.5	NM
M-DA-008	4	42.0	1	0	No	No	DRO	16	NA	0.5-1.5	36.0
M-DA-009	10	6.0	1	0	No	No	DRO	4.7	No Data[f]	2.0-3.0	NM
M-DA-010	4	10.9	1	0	No	No	DRO	ND 2.1	NA	0.5-1.5	NM
M-DA-011	12	48.8	1	1	No	No	DRO	ND 2.3	NA	8.5-9.5	17.4
M-DA-012	6	35.7	1	0	Yes (1)	No	DRO	14	0.325	0.5-1.5	27.5
M-DA-013	10	35.9	1	0	Yes (1)	No	DRO	2.6 B	0.26	17.0-18.0	23.5
M-DA-014	4	24.1	1	0	No	No	DRO	9.5	NA	0.5-1.5	21.4
M-DA-015	5	32.1	1	0	No	No	DRO	ND 2.3	NA	0.5-1.5	22.9
M-DA-016	4	25.1	1	0	No	No	DRO	3.4	NA	0.5-1.5	29.5
M-DA-017	4	24.1	1	0	No	No	DRO	2.1	NA	0.5-1.5	22.7
M-DA-018	4	26.0	1	0	No	No	DRO	2.9	NA	0.5-1.5	18.7
M-DA-019	4	24.1	1	0	No	No	DRO	6	NA	0.5-1.5	21.6

Table 6-7. AOC M Screening and Sampling Summary for POL in Soil (continued).

Site Feature	No. UVOST Screening Locations	Max Depth Screened (ft)	No. Full Suite Samples	No. POL Samples	UVOST Screening Detections (qty)	POL Results Above PAL (qty)	Highest POL Result			Sample Depth (ft)	Depth to Water (ft)
							Analyte	Result (mg/kg)	Avg. Eff. POL %LIF at Sample Depth		
M-DA-020	5	24.0	1	0	No	No	DRO	2.3	NA	0.5-1.5	18.0
M-DA-021	4	20.2	1	0	No	No	DRO	3.5	NA	9.0-10.0	17.4
M-DA-022	4	20.1	1	0	No	No	DRO	2.3	NA	0.5-1.5	17.0
M-DA-023	17	49.3	1	1	Yes (1)	Yes (1)	DRO	1900	7.73	4.0-5.0	21.2
M-DA-024	9	32.1	1	0	No	No	DRO	2.8	NA	0.5-1.5	29.1
M-DA-025	6	32.0	2	0	No	No	DRO	1.5	NA	3.0-5.0	31.0
M-DA-026	13	40.2	1	1	Yes (1)	No	DRO	14	0.455	9.0-11.0	29.9
M-DA-027	6	28.6	1	0	No	No	DRO	2.4	< 0	14.0-15.0	NM
M-DB-001	10	47.8	1	0	No	No	DRO	2.8	< 0	14.5-15.5	NM
M-DS-001	6	37.0	1	0	No	No	DRO	2.4	NA	21.0-23.0	NM
M-DS-002	4	30.8	1	0	No	No	DRO	5.5	NA	4.0-5.0	16.0
M-DS-003	4	27.2	1	0	No	No	DRO	4.6 MN	NA	10.0-11.0	NM
M-DS-004	6	24.6	1	0	No	No	DRO	2.5	NA	15.0-15.5	16.6
M-DS-005	86	52.2	1	8	Yes (1)	No	DRO	2.8	0.484	19.0-21.0	26.5
M-FS-001	16	31.5	2	1	Yes (1)	No	DRO	8.8	0.223	0.5-1.5	26.0
M-FS-002	5	32.2	1	0	No	No	DRO	2.3 B	0.163	13.5-14.5	NM
M-FS-003	6	36.1	1	0	No	No	DRO	19	NA	0.5-1.5	NM
M-FS-004	9	36.1	1	0	No	No	DRO	1.5	NA	0.5-1.5	33.0
M-FS-005	16	43.8	1	1	Yes (2)	No	DRO	2.6	<0	10.0-12.0	27.5
M-FS-006	5	40.2	1	0	No	No	DRO	2.5 B	NA	7.5-8.5	18.0
M-FS-007	6	40.4	1	0	No	No	DRO	1.3	0.035	5.5-6.0	36.0
M-FS-008	5	31.1	1	0	No	No	DRO	38	NA	0.5-1.5	29.3
M-FS-009	6	40.1	1	0	No	No	DRO	3	NA	6.0-9.0	38.0
M-FS-010	5	40.1	1	0	No	No	DRO	4.5	NA	0.5-1.5	32.3
M-FS-011	11	32.0	1	0	No	No	DRO	4	NA	17.0-18.0	23.6
M-FS-012	15	44.1	1	1	No	No	DRO	3.4	NA	23.0-24.0	25.0
M-FS-013	4	42.0	1	0	No	No	DRO	2.3	NA	14.0-15.0	NM
M-FS-014	4	42.0	1	0	Yes (1)	No	DRO	1.5 B	0.193	13.5-14.5	NM
M-FS-015	4	42.0	1	0	No	No	DRO	40	0.156	0.5-1.5	36.0
M-FS-016	5	41.3	1	0	Yes (1)	No	DRO	2.1	0.184	13.0-14.0	31.5
M-FS-017	9	48.0	2	0	Yes (1)	No	DRO	5.1	0.642	0.5-1.5	NM

Table 6-7. AOC M Screening and Sampling Summary for POL in Soil (continued).

Site Feature	No. UVOST Screening Locations	Max Depth Screened (ft)	No. Full Suite Samples	No. POL Samples	UVOST Screening Detections (qty)	POL Results Above PAL (qty)	Highest POL Result			Sample Depth (ft)	Depth to Water (ft)
							Analyte	Result (mg/kg)	Avg. Eff. POL %LIF at Sample Depth		
M-FS-018	4	34.1	1	0	No	No	DRO	2.2	NA	13.5-14.5	13.0
M-FS-019	8	35.6	1	0	No	No	DRO	1.7	0.237	10.0-11.0	9.5
M-GS-001	34	44.4	1	3	Yes (2)	No	DRO	2.4 QN	0.240	0.5-1.5	NM
M-GS-002	4	25.3	0	0	No	No	-	-	-	-	NM
M-GS-004	5	36.0	0	0	No	No	-	-	-	-	23.4
M-GS-007	5	39.6	0	0	No	No	-	-	-	-	29.9
M-GS-017	4	27.2	0	0	No	No	-	-	-	-	NM
M-GS-033	4	31.7	0	0	No	No	-	-	-	-	NM
M-GS-034	6	42.6	1	0	No	No	DRO	1.2 QN	NA	4.0-5.0	20.5
M-GS-035	6	22.0	1	0	No	No	DRO	1.3	NA	7.5-8.5	20.5
M-GS-036	4	20.10	1	0	No	No	DRO	77	NA	10.0-11.0	7.0
M-GS-037	5	23.7	0	0	No	No	-	-	-	-	NM
M-GS-041	12	47.7	1	0	No	No	DRO	3.7	0.14	11.5-12.5	20.0
M-GS-043	33	40.6	1	3	Yes (7)	No	DRO	210 QL	2.55	19.0-21.0	NM
M-LT-001	4	8.9	1	0	No	No	DRO	ND 2.3	NA	4.0-5.0	NM
M-LT-002	4	31.7	2	0	No	No	DRO	7.1 B	NA	5.0-6.0	NM
M-LT-003	4	27.1	1	0	No	No	DRO	7.2	NA	4.0-5.0	NM
M-LT-004	4	35.2	1	0	No	No	DRO	2.6	NA	4.0-6.0	NM
M-LT-005	4	32.7	1	0	No	No	DRO	4.8	NA	4.0-6.0	NM
M-LT-006	4	36.2	1	0	No	No	DRO	3.2	NA	9.0-10.0	NM
M-LT-007	9	40.4	1	0	Yes (1)	No	DRO	2.8 B	0.154	10.0-11.0	NM
M-LT-008	9	42.4	1	0	No	No	DRO	2.5 B	NA	5.5-7.0	NM
M-LT-009	10	38.7	1	0	No	No	DRO	2.8	NA	14.0-16.0	30.0
M-LT-010	4	41.2	1	0	No	No	DRO	1.7	NA	14.0-16.0	NM
M-MH-001	2	38.9	1	0	No	No	DRO	2.4	NA	8.0-10.0	NM
M-MH-002	15	36.1	1	1	Yes (1)	No	DRO	3.3	0.082	16.0-17.5	NM
M-MH-003	10[a]	6.0	0	0	No	No	DRO	4.7	No Data[f]	2.0-3.0	NM
M-MH-004	10	23.8	1	0	No	No	DRO	2.8	NA	7.0-8.5	14.0
M-MH-005	2	7.9	1	0	No	No	DRO	1.4	NA	3.0-5.0	NM
M-MH-006	23	37.2	1	2	No	No	DRO	3.6	0.106	12.0-13.0	NM
M-MM-001	4	11.9	1	0	No	No	DRO	5.5	NA	2.0-2.5	10.0

Table 6-7. AOC M Screening and Sampling Summary for POL in Soil (continued).

Site Feature	No. UVOST Screening Locations	Max Depth Screened (ft)	No. Full Suite Samples	No. POL Samples	UVOST Screening Detections (qty)	POL Results Above PAL (qty)	Highest POL Result			Sample Depth (ft)	Depth to Water (ft)
							Analyte	Result (mg/kg)	Avg. Eff. POL %LIF at Sample Depth		
M-MM-002	4	13.0	1	0	No	No	DRO	3.3	NA	7.0-9.0	11.0
M-MM-003	4	12.0	1	0	No	No	DRO	2.5	NA	7.5-8.5	NM
M-MM-004	4	7.9	1	0	No	No	DRO	2.2	NA	6.0-8.0	NM
M-PH-001	6	33.8	1	0	Yes (1)	No	DRO	2	0.360	10.0-12.0	21.2
M-PH-002	4[b]	35.5	1	0	No	No	DRO	1.9	0.527	15.0-16.0	NM
M-PH-003	4	59.5	1	0	No	No	DRO	1.4	0.28	12.0-14.0	NM
M-PH-004	4	23.7	1	0	No	No	DRO	3.9 B	NA	3.0-4.0	NM
M-PH-005	4	31.2	1	0	No	No	DRO	4.6	NA	5.0-6.0	NM
M-PH-006	4	28.2	1	0	No	No	DRO	2.1	0.008	16.0-17.0	NM
M-PR-001	10	23.9	1	0	Yes (1)	Yes (1)	DRO	6900	1.23	3.0-6.0	10.5
M-PR-002	6	29.7	1	0	No	No	DRO	2.8	NA	22.0-23.0	NM
M-PR-003	8	38.8	1	0	No	No	DRO	2.2 QL	NA	16.5-17.5	NM
M-PR-004	4	27.7	1	0	No	No	DRO	2.9	NA	8.0-9.0	NM
M-PR-005	47	35.5	1	4	Yes (20)	Yes (2)	DRO	350	2.630	15.5-17.0	NM
M-PR-006	9	25.5	1	0	No	No	DRO	1.8	0.26	11.0-12.0	NM
M-QT-011	2	51.2	0	0	No	No	-	-	-	-	21.0
M-QT-025	2	28.1	1	0	No	No	DRO	1.4	NA	7.0-8.0	NM
M-QT-030	2	15.9	1	0	No	No	DRO	2	NA	12.0-13.5	NM
M-QT-033	2	27.8	1	0	No	No	DRO	3.4 B	NA	10.0-11.0	13.4
M-QT-036	2	13.9	1	0	No	No	DRO	14	NA	2.0-3.0	NM
M-QT-039	10	39.9	1	0	Yes (1)	No	DRO	11	0.36	1.0-2.0	28.0
M-QT-044	2	52.2	1	0	No	No	DRO	1.5	NA	10.5-11.5	NM
M-QT-047	2	7.0	0	0	No	No	-	-	-	-	NM
M-QT-053	2	23.3	0	0	No	No	-	-	-	-	22.0
M-QT-054	2	20.5	1	0	No	No	DRO	4.8	NA	10.0-11.0	NM
M-QT-062	2	11.9	1	0	No	No	DRO	2.6	NA	9.0-10.0	NM
M-QT-067	2	33.1	1	0	No	No	DRO	1.6	NA	3.5-4.5	NM
M-QT-068	2	26.3	0	0	No	No	-	-	-	-	NM
M-QT-069	2	32.0	1	0	No	No	DRO	3	NA	7.0-8.0	NM
M-QT-072	2	26.1	1	0	No	No	DRO	1.4	NA	9.5-10.5	NM
M-QT-081	2	27.1	1	0	No	No	DRO	1.6	NA	8.5-9.5	NM

Table 6-7. AOC M Screening and Sampling Summary for POL in Soil (continued).

Site Feature	No. UVOST Screening Locations	Max Depth Screened (ft)	No. Full Suite Samples	No. POL Samples	UVOST Screening Detections (qty)	POL Results Above PAL (qty)	Highest POL Result			Sample Depth (ft)	Depth to Water (ft)
							Analyte	Result (mg/kg)	Avg. Eff. POL %LIF at Sample Depth		
M-QT-085	2	7.0	0	0	No	No	-	-	-	-	NM
M-QT-088	2	7.0	0	0	No	No	-	-	-	-	NM
M-QT-092	2	25.6	0	0	No	No	-	-	-	-	NM
M-QT-097	2	56.0	0	0	No	No	-	-	-	-	NM
M-QT-101	9	29.3	1	0	Yes (1)	No	DRO	ND 2.2	NA	4.0-5.0	19.0
M-QT-122	2	37.3	0	0	No	No	-	-	-	-	13.5
M-QT-123	2	49.2	0	0	No	No	DRO	-	-	-	NM
M-QT-124	2	20.7	1	0	No	No	DRO	1.4	NA	11.0-12.0	NM
M-QT-127	2	34.6	0	0	No	No	-	-	-	-	NM
M-QT-132	2	29.0	0	0	No	No	-	-	-	-	NM
M-QT-136	2	37.6	0	0	No	No	-	-	-	-	NM
M-QT-139	2	43.3	0	0	No	No	-	-	-	-	NM
M-QT-143	2	47.7	1	0	No	No	DRO	ND 2.4	NA	6.0-7.0	41.4
M-QT-145	2	53.6	1	0	No	No	DRO	2.3	NA	7.5-9.0	NM
M-QT-147	2	37.5	0	0	No	No	-	-	-	-	15.2
M-RC-004	4	30.0	0	0	No	No	-	-	-	-	NM
M-RC-008	8	31.1	1	0	No	No	DRO	2.5	0.23	11.0-12.0	NM
M-RD-001	0[c]	1.5	2	3	No	No	DRO	ND 2.3	NA	0.5-1.0	NM
M-SH-001	27	28.2	1	2	No	No	DRO	3.2 B	0.026	15.5-16.5	NM
M-SH-002	24	32.0	1	2	Yes (4)	Yes (2)	DRO	8700	0.26	3.0-5.0	8.5
M-ST-001	35	32.5	1	3	Yes (1)	No	DRO	84 QN	1.09	15.5-16.5	15.2
M-ST-002	4	31.6	1	0	No	No	DRO	1.7	NA	6.0-8.0	27.0
M-ST-003	4	6.9	1	0	No	No	DRO	1.6	NA	6.5-7.5	NM
M-ST-004	4	12.9	1	0	No	No	DRO	ND 2.4	NA	2.0-3.2	NM
M-ST-005	9	60.0	1	0	No	No	DRO	3.3	NA	22.0-26.0	NM
M-ST-006	11	30.4	1	5	No	Yes (1)	DRO	960 QL	0.740	4.0-6.0	NM
M-ST-007	6	54.0	1	0	No	No	DRO	3.1	NA	21.0-23.0	NM
M-ST-008	22	40.1	1	2	No	No	DRO	3.1	NA	4.0-4.5	17.2
M-SW-002	6	46.6	0	0	Yes (1)	No	-	-	-	-	NM
M-SW-003	4	21.5	1	0	No	No	DRO	2.2	NA	4.5-5.5	NM
M-TF-001	7	19.9	1	0	Yes (1)	Yes (1)	DRO	2400	1.64	8.0-10.0	12.0

Table 6-7. AOC M Screening and Sampling Summary for POL in Soil (continued).

Site Feature	No. UVOST Screening Locations	Max Depth Screened (ft)	No. Full Suite Samples	No. POL Samples	UVOST Screening Detections (qty)	POL Results Above PAL (qty)	Highest POL Result			Sample Depth (ft)	Depth to Water (ft)
							Analyte	Result (mg/kg)	Avg. Eff. POL %LIF at Sample Depth		
M-TR-001	21	39.7	1	2	No	No	DRO	3	NA	22.5-23.5	30.0
M-TR-002	23	40.0	1	2	Yes (5)	No	DRO	3.9	0.149	15.0-16.5	24.0
M-UN-002	12	30.5	1	1	Yes (2)	Yes (1)	DRO	6800	23.02	7.0-12.0	NM
M-UN-003	4	35.4	1	0	No	No	DRO	ND 2.3	NA	8.0-9.0	NM
M-UN-004	0[d]	NA	0	0	No	No	-	-	-	-	NM
M-UN-005	6	36.1	1	0	Yes (1)	No	DRO	2.8	0.218	20.5-21.5	NM
M-UN-006	6	38.4	1	0	No	No	DRO	2.3 B	0.16	18.5-19.5	NM
M-UN-007	4	23.7	1	0	No	No	DRO	1.5 B	NA	7.0-8.0	NM
M-UN-008	4	32.5	1	0	No	No	DRO	2.7 B	NA	4.0-5.0	NM
M-UN-009	18	34.1	1	1	Yes (1)	No	DRO	12 B	0.78	5.5-7.0	NM
M-WH-001	32	52.0	1	3	No	No	DRO	5.4	NA	0.5-1.5	NM
M-WH-002	17	39.8	1	1	No	No	DRO	2.7	NA	0.5-1.5	17.3
M-WH-003	19	39.9	1	1	Yes (1)	No	DRO	2.1	0.344	16.0-18.0	24.0
M-WH-004	29	42.9	1	2	Yes (2)	No	DRO	6	0.340	0.5-1.5	NM
M-WH-005	30	40.0	1	2	Yes (2)	No	DRO	3.5	0.403	8.0-9.0	NM
M-WH-006	23	40.1	1	2	Yes (1)	No	DRO	4.1	No Data[f]	14.0-15.0	22.9
M-WH-007	16	54.0	1	1	No	No	DRO	ND 2.3	NA	24.0-25.0	26.9
M-WH-008	12	50.6	1	1	No	No	DRO	7.1	NA	21.0-23.0	25.1
M-WH-009	6	52.5	1	0	No	No	DRO	3.6	NA	10.0-12.0	NM
Total	**1399**	**60 ft max**	**148**	**66**	**33 (78)**	**7 (9)**					

[a] M-MH-003 screened with M-DA-009.
[b] M-PH-002 located within M-PR-005, screened via M-PR-005.
[c] M-RD-001 sampled to 1.5 ft bgs in place of screening due to impenetrable soils.
[d] M-UN-004 not screened: located within buried metal exclusion area.
[e] Dashes indicate feature not sampled or specific analysis not requested per Work Plan.
[f] Sample zone below UVOST probe depth.
Avg. Eff. POL %LIF-Average effective % laser-induced fluorescence attributable to presence of potential fuel type waveform.
NA-Not Applicable.
NM-Not measured (depth to water).

Data Qualifiers:
B-Potential method blank contamination.
ND-Not Detected.
ML-Matrix spike recovery not compliant. Low bias.
MN- Matrix spike recovery not compliant. No bias.
QN-Field duplicate precision not compliant.
QL-Surrogate recovery not compliant. Low bias.

Table 6-8. AOC M Soil Sample Results Summary for Analyses other than POL.

Site Feature	No. Full Suite Samples	No. XRF Measure-ments[a]	No. PCB 9-pt Grid Samples[b]	No. of Detects[c] Exceeding PALs (mg/kg)								Sample Depth (ft)	Depth to Water (ft)
				BTEX	VOC	SVOC	Metals	Pesticides	PCBs	Dioxin/ Furans	Lead (XRF conf.)		
M-AD-001	0	0	0	-[d]	-	-	-	-	-	-	NA	-	NM
M-AD-004	1	0	0	0	0	1	3	-	-	-	NA	22.0-23.0	59.85
M-AD-008	0	0	0	-	-	-	-	-	-	-	NA	-	NM
M-BP-001	1	0	0	0	1	0	9	0	0	0	NA	27.0-30.0	23
M-BU-002	0	0	0	-	-	-	-	-	-	-	NA	-	20.7
M-BU-004	0	0	0	-	-	-	-	-	-	-	NA	-	NM
M-BU-009	1	0	0	0	1	0	4	0	0	-	NA	5.0-6.0	16.6
M-BU-018	1	0	0	0	0	0	3	0	0	-	NA	8.0-9.0	NM
M-BU-024	1	0	0	0	1	0	3	0	0	-	NA	5.0-6.0	NM
M-DA-001	1	0	0	0	0	0	3	0	0	-	NA	0.5-1.5	NM
M-DA-002	1	0	0	0	1	0	3	0	0	-	NA	0.5-1.5	NM
M-DA-003	1	0	0	0	1	0	2	0	0	-	NA	0.5-1.5	NM
M-DA-004	1	0	0	0	1	0	3	0	0	-	NA	4.5-5.5	NM
M-DA-005	1	0	0	0	1	0	3	0	0	-	NA	0.5-1.5	NM
M-DA-006	2	0	0	0	1	0	5	0	0	-	NA	7.0-8.0	NM
M-DA-007	1	0	0	0	1	0	3	0	0	-	NA	4.0-4.5	NM
M-DA-008	1	0	0	0	1	0	3	0	0	-	NA	0.5-1.5	36.0
M-DA-009	1	0	0	0	1	0	4	0	0	-	NA	2.0-3.0	NM
M-DA-010	1	0	0	0	0	0	4	0	0	-	NA	0.5-1.5	NM
M-DA-011	1	0	0	0	1	0	2	0	0	-	NA	8.5-9.5	17.4
M-DA-012	1	0	0	0	1	0	3	0	0	-	NA	0.5-1.5	27.5
M-DA-013	1	0	0	0	0	0	3	0	0	-	NA	17.0-18.0	23.5
M-DA-014	1	0	0	0	0	1	2	0	0	-	NA	0.5-1.5	21.4
M-DA-015	1	0	0	0	0	1	2	0	0	-	NA	0.5-1.5	22.9
M-DA-016	1	0	0	0	0	1	2	0	0	-	NA	0.5-1.5	29.5
M-DA-017	1	0	0	0	0	0	2	0	0	-	NA	0.5-1.5	22.7
M-DA-018	1	0	0	0	0	0	2	0	0	-	NA	0.5-1.5	18.7
M-DA-019	1	0	0	0	0	0	3	0	0	-	NA	0.5-1.5	21.6
M-DA-020	1	0	0	0	0	1	2	0	0	-	NA	0.5-1.5	18.0
M-DA-021	1	0	0	0	0	0	4	0	0	-	NA	9.0-10.0	17.4
M-DA-022	1	0	0	0	0	0	2	0	0	-	NA	0.5-1.5	17.0

Table 6-8. AOC M Soil Sample Results Summary for Analyses other than POL (continued).

Site Feature	No. Full Suite Samples	No. XRF Measure-ments[a]	No. PCB 9-pt Grid Samples[b]	No. of Detects[c] Exceeding PALs (mg/kg)								Sample Depth (ft)	Depth to Water (ft)
				BTEX	VOC	SVOC	Metals	Pesticides	PCBs	Dioxin/ Furans	Lead (XRF conf.)		
M-DA-023	1	0	0	0	1	1	3	0	0	-	NA	4.0-5.0	21.2
M-DA-024	1	0	0	0	0	0	2	0	0	-	NA	0.5-1.5	29.1
M-DA-025	2	0	0	0	1	1	4	0	0	-	NA	3.0-5.0	31.0
M-DA-026	1	0	0	0	1	0	4	0	0	-	NA	9.0-11.0	29.9
M-DA-027	1	0	0	0	0	0	3	0	0	-	NA	14.0-15.0	NM
M-DB-001	1	0	0	0	0	0	3	-	0	-	NA	14.5-15.5	NM
M-DS-001	1	0	0	0	1	0	3	0	0	-	NA	21.0-23.0	NM
M-DS-002	1	0	0	0	1	0	3	0	0	-	NA	4.0-5.0	16.0
M-DS-003	1	0	0	0	1	0	3	0	0	-	NA	10.0-11.0	NM
M-DS-004	1	0	0	0	1	0	3	0	0	-	NA	15.0-15.5	16.6
M-DS-005	1	0	0	0	1	0	3	0	0	-	NA	19.0-21.0	26.5
M-FS-001	2	0	0	0	1	0	6	0	0	-	NA	0.5-1.5	26.0
M-FS-002	1	0	0	0	1	0	3	0	0	-	NA	13.5-14.5	NM
M-FS-003	1	0	0	0	1	0	3	0	0	-	NA	0.5-1.5	NM
M-FS-004	1	0	0	0	0	1	2	0	0	-	NA	0.5-1.5	33.0
M-FS-005	1	0	0	0	1	0	4	0	0	-	NA	10.0-12.0	27.5
M-FS-006	1	0	0	0	1	0	3	0	0	-	NA	7.5-8.5	18.0
M-FS-007	1	0	0	0	2	0	3	0	0	-	NA	5.5-6.0	36.0
M-FS-008	1	0	0	0	0	0	3	0	0	-	NA	0.5-1.5	29.3
M-FS-009	1	0	0	0	1	0	3	0	0	-	NA	6.0-9.0	38.0
M-FS-010	1	0	0	0	1	0	3	0	0	-	NA	0.5-1.5	32.3
M-FS-011	1	0	0	0	1	0	4	0	0	-	NA	17.0-18.0	23.6
M-FS-012	1	0	0	0	1	0	2	0	0	-	NA	23.0-24.0	25.0
M-FS-013	1	0	0	0	1	0	3	0	0	-	NA	14.0-15.0	NM
M-FS-014	1	0	0	0	1	0	2	0	0	-	NA	13.5-14.5	NM
M-FS-015	1	0	0	0	1	0	3	0	0	-	NA	0.5-1.5	36.0
M-FS-016	1	0	0	0	1	0	3	0	0	-	NA	13.0-14.0	31.5
M-FS-017	2	0	0	0	1	0	6	0	0	-	NA	0.5-1.5	NM
M-FS-018	1	0	0	0	0	1	3	0	0	-	NA	13.5-14.5	13.0
M-FS-019	1	0	0	0	0	0	4	0	0	-	NA	10.0-11.0	9.5

Table 6-8. AOC M Soil Sample Results Summary for Analyses other than POL (continued).

Site Feature	No. Full Suite Samples	No. XRF Measure-ments[a]	No. PCB 9-pt Grid Samples[b]	No. of Detects[c] Exceeding PALs (mg/kg)								Sample Depth (ft)	Depth to Water (ft)
				BTEX	VOC	SVOC	Metals	Pesticides	PCBs	Dioxin/ Furans	Lead (XRF conf.)		
M-GS-001	1	0	0	0	1	0	3	0	0	-	NA	0.5-1.5	NM
M-GS-002	0	0	0	-	-	-	-	-	-	-	NA	-	NM
M-GS-004	0	0	0	-	-	-	-	-	-	-	NA	-	23.4
M-GS-007	0	0	0	-	-	-	-	-	-	-	NA	-	29.9
M-GS-017	0	0	0	-	-	-	-	-	-	-	NA	-	NM
M-GS-033	0	0	0	-	-	-	-	-	-	-	NA	-	NM
M-GS-034	1	0	0	0	1	0	3	0	0	-	NA	4.0-5.0	20.5
M-GS-035	1	0	0	0	0	1	3	0	0	-	NA	7.5-8.5	20.5
M-GS-036	1	0	0	0	0	0	3	0	0	-	NA	10.0-11.0	7.0
M-GS-037	0	0	0	0	0	0	3	0	0	-	NA	-	NM
M-GS-041	1	0	0	0	0	0	3	0	0	-	NA	11.5-12.5	20.0
M-GS-043	1	0	0	0	1	0	3	0	0	-	NA	19.0-21.0	NM
M-LT-001	1	0	0	0	0	0	2	0	-	-	NA	4.0-5.0	NM
M-LT-002	2	0	0	0	1	0	7	-	0	-	NA	5.0-6.0	NM
M-LT-003	1	0	0	0	1	0	3	-	0	-	NA	4.0-5.0	NM
M-LT-004	1	0	0	0	1	0	3	-	0	-	NA	4.0-6.0	NM
M-LT-005	1	0	0	0	1	0	3	-	0	-	NA	4.0-6.0	NM
M-LT-006	1	0	0	0	1	0	4	-	0	-	NA	9.0-10.0	NM
M-LT-007	1	0	0	0	1	0	3	-	0	-	NA	10.0-11.0	NM
M-LT-008	1	0	0	0	0	0	3	-	0	-	NA	5.5-7.0	NM
M-LT-009	1	0	0	0	0	0	3	-	0	-	NA	14.0-16.0	30.0
M-LT-010	1	0	0	0	0	1	3	-	0	-	NA	14.0-16.0	NM
M-MH-001	1	0	0	0	0	1	4	-	0	-	NA	8.0-10.0	NM
M-MH-002	1	0	0	0	0	0	2	-	0	-	NA	16.0-17.5	NM
M-MH-003	0[e]	0	0	-	-	-	-	-	-	-	NA	-	-
M-MH-004	1	0	0	0	1	0	4	-	0	-	NA	7.0-8.5	14.0
M-MH-005	1	0	0	0	1	0	3	-	0	-	NA	3.0-5.0	NM
M-MH-006	1	0	0	0	1	0	3	-	0	-	NA	12.0-13.0	NM
M-MM-001	1	12	0	0	0	0	4	0	0	-	NA	2.0-2.5	10.0
M-MM-002	1	12	0	0	1	0	4	0	0	-	NA	7.0-9.0	11.0

Table 6-8. AOC M Soil Sample Results Summary for Analyses other than POL (continued).

Site Feature	No. Full Suite Samples	No. XRF Measure-ments[a]	No. PCB 9-pt Grid Samples[b]	No. of Detects[c] Exceeding PALs (mg/kg)								Sample Depth (ft)	Depth to Water (ft)
				BTEX	VOC	SVOC	Metals	Pesticides	PCBs	Dioxin/ Furans	Lead (XRF conf.)		
M-MM-003	1	12	0	0	1	0	4	0	0	-	NA	7.5-8.5	NM
M-MM-004	1	12	0	0	1	0	4	0	0	-	NA	6.0-8.0	NM
M-PH-001	1	0	0	0	0	0	3	-	0	-	NA	10.0-12.0	21.2
M-PH-002	1	0	0	0	1	0	3	-	0	-	NA	15.0-16.0	NM
M-PH-003	1	0	0	0	0	0	4	-	0	-	NA	12.0-14.0	NM
M-PH-004	1	0	0	0	1	0	3	-	0	-	NA	3.0-4.0	NM
M-PH-005	1	0	0	0	1	0	3	-	0	-	NA	5.0-6.0	NM
M-PH-006	1	0	0	0	0	0	4	-	0	-	NA	16.0-17.0	NM
M-PR-001	1	0	2	0	1	0	3	0	0	-	NA	3.0-6.0	10.5
M-PR-002	1	0	2	0	1	0	3	-	0	-	NA	22.0-23.0	NM
M-PR-003	1	0	12	0	0	0	3	-	0	-	NA	16.5-17.5	NM
M-PR-004	1	0	1	0	1	0	3	0	0	-	NA	8.0-9.0	NM
M-PR-005	1	0	1	0	1	0	4	0	0	-	NA	15.5-17.0	NM
M-PR-006	1	0	1	0	1	0	4	-	0	-	NA	11.0-12.0	NM
M-QT-011	0	0	0	-	-	-	-	-	-	-	NA	-	21.0
M-QT-025	1	0	0	0	1	0	3	-	-	-	NA	7.0-8.0	NM
M-QT-030	1	0	0	0	0	1	3	-	-	-	NA	12.0-13.5	NM
M-QT-033	1	0	0	0	1	0	3	-	-	-	NA	10.0-11.0	13.4
M-QT-036	1	0	0	0	1	0	2	-	-	-	NA	2.0-3.0	NM
M-QT-039	1	0	0	0	1	0	3	-	-	-	NA	1.0-2.0	28.0
M-QT-044	1	0	0	0	0	0	4	-	-	-	NA	10.5-11.5	NM
M-QT-047	0	0	0	-	-	-	-	-	-	-	NA	-	NM
M-QT-053	0	0	0	-	-	-	-	-	-	-	NA	-	22.0
M-QT-054	1	0	0	0	0	0	2	-	-	-	NA	10.0-11.0	NM
M-QT-062	1	0	0	0	1	0	2	-	-	-	NA	9.0-10.0	NM
M-QT-067	1	0	0	0	1	0	3	-	-	-	NA	3.5-4.5	NM
M-QT-068	0	0	0	-	-	-	-	-	-	-	NA	-	NM
M-QT-069	1	0	0	0	1	0	2	-	-	-	NA	7.0-8.0	NM
M-QT-072	1	0	0	0	0	0	4	-	-	-	NA	9.5-10.5	NM
M-QT-081	1	0	0	0	0	0	3	-	-	-	NA	8.5-9.5	NM

Table 6-8. AOC M Soil Sample Results Summary for Analyses other than POL (continued).

Site Feature	No. Full Suite Samples	No. XRF Measure-ments[a]	No. PCB 9-pt Grid Samples[b]	No. of Detects[c] Exceeding PALs (mg/kg)								Sample Depth (ft)	Depth to Water (ft)
				BTEX	VOC	SVOC	Metals	Pesticides	PCBs	Dioxin/ Furans	Lead (XRF conf.)		
M-QT-085	0	0	0	-	-	-	-	-	-	-	NA	-	NM
M-QT-088	0	0	0	-	-	-	-	-	-	-	NA	-	NM
M-QT-092	0	0	0	-	-	-	-	-	-	-	NA	-	NM
M-QT-097	0	0	0	-	-	-	-	-	-	-	NA	-	NM
M-QT-101	1	0	0	0	0	0	4	-	-	-	NA	4.0-5.0	19.0
M-QT-122	0	0	0	-	-	-	-	-	-	-	NA	-	13.5
M-QT-123	0	0	0	-	-	-	-	-	-	-	NA	-	NM
M-QT-124	1	0	0	0	0	0	4	-	-	-	NA	11.0-12.0	NM
M-QT-127	0	0	0	-	-	-	-	-	-	-	NA	-	NM
M-QT-132	0	0	0	-	-	-	-	-	-	-	NA	-	NM
M-QT-136	0	0	0	-	-	-	-	-	-	-	NA	-	NM
M-QT-139	0	0	0	-	-	-	-	-	-	-	NA	-	NM
M-QT-143	1	0	0	0	0	0	-	-	-	-	NA	6.0-7.0	41.4
M-QT-145	1	0	0	0	1	0	3	-	-	-	NA	7.5-9.0	NM
M-QT-147	0	0	0	-	-	-	-	-	-	-	NA	-	15.2
M-RC-004	0	0	0	-	-	-	-	-	-	-	NA	-	NM
M-RC-008	1	0	0	0	0	0	3	-	0	-	NA	11.0-12.0	NM
M-RD-001	2	0	7	0	1	0	6	-	0	-	NA	0.5-1.0	NM
M-SH-001	1	24	0	0	1	0	4	-	0	-	1	15.5-16.5	NM
M-SH-002	1	24	0	0	0	1	3	-	0	-	0	3.0-5.0	8.5
M-ST-001	1	0	0	0	0	0	3	0	0	-	NA	15.5-16.5	15.2
M-ST-002	1	0	0	0	0	0	3	0	0	-	NA	6.0-8.0	27.0
M-ST-003	1	0	0	0	1	0	3	0	0	-	NA	6.5-7.5	NM
M-ST-004	1	0	0	0	0	0	2	0	0	-	NA	2.0-3.2	NM
M-ST-005	1	0	0	0	0	0	3	0	0	-	NA	22.0-26.0	NM
M-ST-006	1	0	0	0	1	0	3	0	0	-	NA	4.0-6.0	NM
M-ST-007	1	0	0	0	1	0	3	0	0	-	NA	21.0-23.0	NM
M-ST-008	1	0	0	0	1	0	3	0	0	-	NA	4.0-4.5	17.2
M-SW-002	0	0	0	-	-	-	-	-	-	-	NA	-	NM
M-SW-003	1	0	0	0	0	0	3	-	-	-	NA	4.5-5.5	NM

Table 6-8. AOC M Soil Sample Results Summary for Analyses other than POL (continued).

Site Feature	No. Full Suite Samples	No. XRF Measure-ments[a]	No. PCB 9-pt Grid Samples[b]	No. of Detects[c] Exceeding PALs (mg/kg) BTEX	VOC	SVOC	Metals	Pesticides	PCBs	Dioxin/ Furans	Lead (XRF conf.)	Sample Depth (ft)	Depth to Water (ft)
M-TF-001	1	0	1	0	0	0	2	-	0	-	NA	8.0-10.0	12.0
M-TR-001	1	0	0	0	0	0	2	0	-	-	NA	22.5-23.5	30.0
M-TR-002	1	0	0	0	0	0	4	0	-	-	NA	15.0-16.5	24.0
M-UN-002	1	0	0	0	1	0	5	0	0	-	NA	7.0-12.0	NM
M-UN-003	1	0	0	0	1	0	3	0	0	-	NA	8.0-9.0	NM
M-UN-004	0[f]	0	0	-	-	-	-	-	-	-	NA	-	NM
M-UN-005	1	0	0	0	1	0	4	0	0	-	NA	20.5-21.5	NM
M-UN-006	1	0	0	0	1	0	3	0	0	-	NA	18.5-19.5	NM
M-UN-007	1	0	0	0	1	0	2	0	0	-	NA	7.0-8.0	NM
M-UN-008	1	0	0	0	1	0	3	0	0	-	NA	4.0-5.0	NM
M-UN-009	1	0	0	1	1	0	4	0	0	-	NA	5.5-7.0	NM
M-WH-001	1	0	0	0	0	1	2	0	-	-	NA	0.5-1.5	NM
M-WH-002	1	0	0	0	0	1	3	0	-	-	NA	0.5-1.5	17.3
M-WH-003	1	0	0	0	0	0	4	0	-	-	NA	16.0-18.0	24.0
M-WH-004	1	0	0	0	0	1	3	0	-	-	NA	0.5-1.5	NM
M-WH-005	1	0	0	0	1	0	4	0	-	-	NA	8.0-9.0	NM
M-WH-006	1	0	0	0	0	0	3	0	-	-	NA	14.0-15.0	22.9
M-WH-007	1	0	0	0	1	0	4	0	-	-	NA	24.0-25.0	26.9
M-WH-008	1	0	0	0	1	0	4	0	-	-	NA	21.0-23.0	25.1
M-WH-009	1	0	0	0	1	0	3	-	0	-	NA	10.0-12.0	NM
Total	**148**	**126**	**27**	**1**	**85**	**17**	**452**	**0**	**0**	**0**	**1**		

[a] XRF measurements collected at 0.0 ft, 1.0 ft and 2.0 ft depths at each sample location.
[b] PCB 9-pt grid samples collected at 0.5 ft depth
[c] PALs for some VOC and SVOC compounds are less than typical limits of detection.
[d] Dashes indicate feature not sampled or specific analysis not requested per Work Plan.
[e] M-MH-003 screened and sampled with M-DA-009.
[f] M-UN-004 not screened: located within buried metal exclusion area
NM-Not Measured (depth to water)
NA-Not Applicable

Ninety-four of the 126 measurements were above the limit of detection of the portable XRF unit, with 11 measurements greater than 20 ppm, three greater than 100 ppm, and one greater than 400 ppm. Results ranged from 2.6 ppm to 626 ppm, with an average value of 22.7 ppm (or 12.8 ppm for values less than 100 ppm). Thirty-three detections were at ground surface ranging from 3.1 ppm to 626 ppm. Twenty-eight detections were at 1.0 foot bgs, ranging from 3.0 ppm to 67.9 ppm. Thirty-three detections were at 2.0 feet bgs, ranging from 2.9 ppm to 10.2 ppm. Of the 11 measurements greater than 20 ppm, 10 were at ground surface, and one was at 1.0 ft bgs.

One of the seven confirmation samples sent for laboratory analysis exceeded the PAL for lead of 400 mg/kg. The result for sample 15FMMSH001XR007, taken at ground surface in feature M-SH-001, was 780 mg/kg. Results for five other samples in that feature ranged from 32 mg/kg to 120 mg/kg, all at ground surface. Screening locations and analytical results are provided on respective feature maps in Appendix F (Maps M-8, M-22, and M-32). Note that the sample location for 15FMMSH001XR007 is outside the boundaries of the two test pit investigations that were later conducted in feature M-SH-001.

Nine-point PCB Sampling Results

Eight features were sampled using nine-point PCB surface soil composite sampling techniques: M-PR-001 through M-PR-006, M-RD-001, and M-TF-001. A total of 27 samples were submitted for analyses. No exceedances of the PAL (1 mg/kg) for PCBs were noted. Sampling locations and analytical results are provided on respective feature maps in Appendix F (Maps M-24, M-25, and M-31).

Sample Results Other Than Lead, POL, and Nine-point PCB

In addition to POL and lead, soil analyses were performed for BTEX, VOCs, SVOCs, metals, pesticides, and PCBs, as specified in the Work Plan (North Wind, 2014) for each feature type. Table 6-8 provides a summary of sample analyses and exceedances by analyte for each feature. The PAL exceedances from Table 6-8 are discussed below.

<u>BTEX</u>

The results of one benzene analysis exceeded the PAL of 0.025 mg/kg with a detection of 0.032 mg/kg in sample 15FMMUN009DT001 from feature M-UN-009. This result was biased high by the analytical laboratory, due to a non-compliant surrogate recovery, and likely is not representative of true soil contamination.

<u>VOCs</u>

The results of 84 methylene chloride analyses exceeded the PAL of 0.016 mg/kg with a range of 0.017 to 1.3 mg/kg. All values except six were qualified by the laboratory as being associated with potential method blank or trip blank contamination, or non-compliant matrix recovery. The six remaining values are less than the limit of detection and are therefore not considered to be representative of true soil contamination.

One result for tetrachloroethene exceeded the PAL of 0.024 mg/kg with a detection of 0.046 mg/kg in sample 15FMMFS007DT001 from feature M-FS-007. There are no other exceedances in this sample except for methylene chloride. Review of laboratory data (i.e., retention time, mass spectrum and calibration data) indicates that the detection of tetrachloroethene is accurate. This compound has historically been used as a degreasing and dry cleaning compound; however, specific history of its use at the former Fort Morrow is not readily documented. Of 243 analyses site-wide, tetrachloroethene was detected only twice, and the PAL exceeded only this once.

SVOCs

Analyses for SVOCs were exceeded 17 times in AOC M. The PAL for benzyl alcohol (0.037 mg/kg) was exceeded 15 times. The PAL for 2-methylnaphthalene (6.1 mg/kg) was exceeded twice, and the exceedances are associated with samples that also exceeded the PAL for DRO. The result for sample 15FMMDA023DT001 from feature M-DA-023 is 7 mg/kg. The result for sample 15FMMSH002DT001 from feature M-SH-002 is 16 mg/kg.

Metals

Excluding the lead exceedance from XRF confirmation previously discussed, metal detections exceeded PALs 452 times in AOC M. Exceedances were for arsenic (36 exceedances), iron (150 exceedances), manganese (150 exceedances), and molybdenum (116 exceedances). When compared to the 2015 UTLs established from the background metals study conducted during this investigation (see Section 6.1), 46 exceedances persist for arsenic (4 exceedances), manganese (18 exceedances), and molybdenum (24 exceedances).

Exceedances for arsenic (PAL = 3.6 mg/kg) ranged from 4 mg/kg to 15 mg/kg. Four exceedances of the 2015 UTL (6.2 mg/kg) ranged from 6.7 mg/kg to 15 mg/kg. None of the samples with UTL exceedances for arsenic had exceedances of other non-metal analyses representative of true soil contamination (i.e., not laboratory contaminants).

Exceedances for manganese (PAL = 2.1 mg/kg) ranged from 48 mg/kg to 2,000 mg/kg. Eighteen exceedances of the 2015 UTL (620 mg/kg) ranged from 630 mg/kg to 2,000 mg/kg. None of the samples with UTL exceedances for arsenic had exceedances of other non-metal analyses representative of true soil contamination.

Exceedances for molybdenum (PAL = 0.16 mg/kg) ranged from 0.17 mg/kg to 1.7 mg/kg. Twenty-four exceedances of the 2015 UTL (0.49 mg/kg) ranged from 0.5 mg/kg to 1.7 mg/kg. One sample, 15MMPR005DT001 from feature M-PR-005 with an exceedance of the 2015 UTL for manganese, also exceeded the PAL for DRO.

Metals exceedances are summarized by feature type in Table 6-9. For feature types with multiple features, the following deductions can be made regarding the number of exceedances in relation to the number of features sampled:

- Exceedances for arsenic do not appear to be associated with any specific feature type, except possibly mounded material features where all of the four features sampled exceeded the PAL and one of the four features exceeded the 2015 UTL.
- Arsenic PAL exceedances do not occur ubiquitously at all features, as do manganese and molybdenum PAL exceedances.
- Exceedances of manganese and molybdenum above the 2015 UTLs appear to occur in latrine, mounded material, and warehouse type features at a higher ratio of features sampled than in other features types (with multiple features).

Table 6-9. Summary of Metal Exceedances by Feature Type.

Feature Type[1] (No. sampled)	No. of Features per Type with Metals Exceedances		
	Arsenic UTL / PAL	Manganese UTL / PAL	Molybdenum UTL / PAL
AD (1)	0 / 0	0 / 1	0 / 1
BP (1)	0 / 1	1 / 1	0 / 1
BU (4)	0 / 1	0 / 3	0 / 3
DA (27)	0 / 4	3 / 27	3 / 16
DB (1)	0 / 0	0 / 1	0 / 1
DS (5)	0 / 0	0 / 5	0 / 5
FS (19)	1 / 3	1 / 19	3 / 16
GS (6)	0 / 0	0 / 6	2 / 5
LT (10)	0 / 2	3 / 10	3 / 9
MH (5)	1 / 1	0 / 5	1 / 4
MM (4)	1 / 4	2 / 4	3 / 4
PH (6)	0 / 2	0 / 6	0 / 6
PR (6)	0 / 3	1 / 6	1 / 5
QT (15)	0 / 4	2 / 15	2 / 11
RC (1)	0 / 0	0 / 1	0 / 1
RD (1)	0 / 1	0 / 1	0 / 0
SH (2)	0 / 0	0 / 2	0 / 2
ST (8)	0 / 0	1 / 8	1 / 7
SW (1)	0 / 0	0 / 1	0 / 1
TF (1)	0 / 0	0 / 1	0 / 0
TR (2)	0 / 1	1 / 2	0 / 1
UN (7)	0 / 2	0 / 7	1 / 6
WH (9)	1 / 5	3 / 9	4 / 7

[1] See Table 2-1 for full feature type identification.

6.3 Groundwater Sampling Results

Fourteen monitoring wells were sampled from three AOCs. Thirteen of the wells were sampled for full suite or POL analyses only. One well in AOC J was sampled for lead only. Four wells exceeded PALs for POL; three in AOC B and one in AOC C. All eight wells sampled for full suite analyses had exceedances for metals. Exceedances for POL were for DRO and RRO only; GRO was detected only four times at 1% or less than the PAL. Metal exceedances were for cobalt (total and dissolved), iron, and manganese (total and dissolved).

Well locations are depicted on Figure 3-1 and in Appendix F, Map S-3. Table 6-10 summarizes the groundwater sampling results. The PAL exceedances are discussed below.

Table 6-10. Groundwater Sampling Results Summary.

Monitoring Well ID	No. Samples	Sample Suite	POL Above PAL	Other Above PAL	No. of Detects[c] Exceeding PALs (mg/kg)										
					DRO	**RRO**	**GRO**	**BTEX**	**EDB**	**VOC**	**SVOC**	**Metals**	**Mercury**	**PCB**	**Pesticides**
B-MW-001	1	Full	YES	YES-metals	1	1	0	0	-[b]	0	0	4	0	0	0
B-MW-002	1	Full	YES	YES-metals	1	0	0	0	-	0	0	3	0	0	0
B-MW-003	1	Full	YES	YES-metals	1	0	0	0	-	0	0	3	0	0	0
B-MW-004	1	Full	No	YES-metals	0	0	0	0	-	0	0	2	0	0	0
B-MW-005	1	Full	No	YES-metals	0	0	0	0	-	0	0	3	0	0	0
B-MW-006	1	Full	No	YES-metals	0	0	0	0	-	0	0	2	0	0	0
C-MW-001	1	POL / EDB	YES	No	1	0	0	0	0	-	-	-	-	-	-
C-MW-002	1	POL / EDB	No	No	0	0	0	0	0	-	-	-	-	-	-
C-MW-003	1	POL / EDB	No	No	0	0	0	0	0	-	-	-	-	-	-
C-MW-004	1	POL / EDB	No	No	0	0	0	0	0	-	-	-	-	-	-
C-MW-005	1	POL / EDB	No	No	0	0	0	0	0	-	-	-	-	-	-
J-MW-003	1	Lead	NA	No	-	-	-	-	-	-	-	0	-	-	-
M-MW-001	1	Full	No	YES-metals	0	0	0	0	-	0	0	3	0	0	0
M-MW-002	1	Full	No	YES-metals	0	0	0	0	-	0	0	2	0	0	0
Total	**14**		**4**	**8**	**4**	**1**	**0**	**0**	**0**	**0**	**0**	**22**	**0**	**0**	**0**

[a] PALs for some VOC and SVOC compounds are less than typical limits of detection.
[b] Dashes indicate feature not sampled or specific analysis not requested per Work Plan.

EDB = ethylene dibromide

6.3.1 POL Sampling Results

Three monitoring wells with POL exceedances were intentionally placed where previous soil confirmation sampling indicated POL exceedances. These included B-MW-001, B-MW-003, and C-MW-001. One downgradient well, B-MW-002, also showed a POL exceedance. Figure 4-3 shows well locations and groundwater contour elevations at features B-DA-003, B-DA-004, and B-DA-005.

Monitoring well B-MW-001 results exceeded DRO at 21,000 micrograms per liter (µg/L) (PAL = 1,500 µg/L), and RRO at 2,800 µg/L (PAL = 1,100 µg/L). This well was located in feature B-DA-004 immediately adjacent to UVOST probe 14FMBDA004UV017, which showed significant LIF response (max LIF 25%) indicative of POL at the measured depth to water of 6.1 ft bgs. Associated soil sample 14FMBDA004DT002 results from an interval of 6.0 to 8.0 ft bgs showed a DRO exceedance of 5,200 mg/kg (PAL of 250 mg/kg), though only 210 mg/kg of RRO, which is significantly below the PAL of 10,000 mg/kg. (Note: B-MW-001 groundwater results were QL-qualified, i.e., noncompliant surrogate or laboratory control sample recovery, low bias.)

Monitoring well B-MW-002 results exceeded DRO at 2,300 µg/L. This well is located in feature B-DA-003 downgradient of B-MW-001. It is located downgradient of UVOST probe 14FMBDA003UV041, which showed aminor indication of POL at just 0.4% max LIF; however it showed a DRO exceedance of 590 mg/kg in associated soil sample 15FMBDA003DT011 taken from a sample interval of 6.0-8.0 ft bgs, just above the depth to water of 8.1 ft bgs.

Monitoring well B-MW-003 results exceeded DRO at 10,000 µg/L. This well was located in feature B-DA-003 immediately adjacent to UVOST probe 14FMBDA003UV073BF, which showed significant LIF response (max LIF 14%) indicative of POL within 5 feet of the estimated water table (12.5 ft bgs). Associated soil sample 14FMBDA003DT002 results showed a DRO exceedance of 1,600 mg/kg for the sample interval of 10.0-12.0 ft bgs.

Monitoring well C-MW-001 results exceeded DRO at 28,000 µg/L. This well was located in feature C-LT-002 immediately adjacent to UVOST probe 12FMCLT002UV001. This probe location showed multiple depths with potential POL, including below the estimated water table of 14.7 ft bgs. This well exceeded DRO in 2012 with a result of 3,500 µg /L. (Note: C-MW-001 groundwater results are QH-qualified, i.e., noncompliant surrogate or laboratory control sample recovery, high bias.)

Generally, analytical results in excess of 5000 µg/L DRO are considered to be in excess of the solubility limit for water (NIOSH, 2015).

6.3.2 Metals Sampling Results

Groundwater sampling results for metals exceedances are summarized Table 6-10. Cobalt was exceeded in every well except M-MW-002. Results ranged from 0.63 µg/L (J-qualified to indicate estimated value) to 5.6 µg/L. Iron was present in wells B-MW-001 at 13,000 µg/L and B-MW-003 at 17,000 µg/L. Manganese was exceeded in every well. Results ranged from 54 µg/L to 460 µg/L except for one value of 3,000 µg/L for B-MW-001 (3,100 µg/L for manganese [dissolved]).

6.4 Subsurface Metal Investigation Results

6.4.1 Geophysical Survey Results

Geophysical surveys performed in 2014 detected significant buried metal in five feature locations:

- One dump site (E-DS-001),
- One building unknown (F-BU-001),
- One ground scar (M-GS-043), and
- Two shops (M-SH-001 and M-SH-002).

One anomalous circular feature was identified (M-BP-001 within M-DS-005) and subsequently investigated with a test pit (see Section 6.4.2, Test Pit Investigations).

Eighteen other surveyed locations in AOC B and AOC M showed little to no significant metal debris, with that presently being primarily small scattered surface debris: Nine dump sites and debris features surveyed as designated in the Work Plan (North Wind, 2014); seven fuel storage sites, former drum areas, pump houses, and "unknown" features identified during field investigations suspected to contain buried metal debris; and two areas of concern identified by local stakeholders.

Two pipes located at C-LT-002 were traced. The suspect water pipe was determined to extend from site C-LT-002 in the general direction of pump house C-PH-001 for approximately 463 feet. The suspect fuel line extended only 2 feet.

Surveyor's reports are included in Appendix L along with figures showing geophysical survey results overlain with feature boundaries, UVOST screening locations, and test pit locations (where applicable). Table 6-11 summarizes the rationale and results of subsurface metal investigations, including locations where test pits were conducted.

Table 6-11. Summary of Subsurface Metal Investigation Results.

Survey Location	Rationale	Investigation Results
Area between B-DS-001 and B-DS-003	Stakeholder area of concern	No metal debris detected via EM61.
B-DS-001	Work Plan	No metal debris detected via EM61.
B-DS-002	Work Plan	No metal debris detected via EM61.
B-DS-003	Work Plan	No metal debris detected via EM61.
C-BD-001 (2012 survey)	2012 Work Plan	Significant buried metal detected via EM61. Three test pit investigations performed: Significant metal and plastic debris including an empty crushed fuel tank and an ATV. Debris not indicative of military origin.
C-LT-002	Pipe delineation	Pipe extends approximately 463 feet northwest toward pump house C-PH-001.
E-DS-001	Work Plan	Significant buried metal debris detected via EM61 around inside of feature perimeter. Three test pit investigations performed in north end of feature: Buried drums, various metal items representative of construction debris, and one rifle shell were documented. Debris potentially of military origin.
F-BU-001	Stakeholder area of concern/ USACE concurrence	Surface and buried debris present in the form of exposed and buried drums along with some scattered surface debris (two test pits proposed but not conducted due to proximity of eroding shoreline).
M-DA-023	Observed surface metal, buried debris suspected	Small metal item and some surface debris detected, not considered significant per surveyor's comments.

Table 6-11. Summary of Subsurface Metal Investigation Results (continued).

Survey Location	Rationale	Investigation Results
M-DB-001	Work Plan	No metal debris detected via EM61.
M-DS-001	Work Plan	No metal debris detected via EM61.
M-DS-002	Work Plan	Small metal debris detected via EM61, not considered significant per surveyors comments.
M-DS-003	Work Plan	Small metal debris detected via EM61.
M-DS-004	Work Plan	Small metal debris detected via EM61.
M-DS-005 & M-BP-001	Work Plan	Suspect circular feature detected via EM61 at M-BP-001. Test pit investigation performed: no buried metal or other buried man-made features (i.e., reinforced concrete slab) encountered.
Area near M-FS-016	Observed surface metal, buried debris suspected	Small scattered metal debris detected via EM61, mostly on the surface.
M-FS-018	Observed surface metal, buried debris suspected	No metal debris detected via EM61.
M-FS-019	Observed surface metal, buried debris suspected	Few small scattered metal debris via EM61, mostly on the surface and not considered significant per surveyors comments.
M-GS-043	Visible subsurface metal debris	Large area of buried debris detected via EM61. Area was further delineated using a Schonstedt magnetic locator to determine perimeter UVOST screening locations and appears to extend the full length of the feature (one test pit proposed to verify continuation of buried debris beyond extent of geophysical survey, but not performed due to detection of subsurface contamination during perimeter UVOST screening).
M-PR-005	Observed surface metal, buried debris suspected	Some buried metal debris detected via EM61 (two test pits proposed, one at each concentration of buried debris, but not performed due to detection of subsurface contamination during UVOST perimeter screening.)
Area near M-QT-095	Stakeholder area of concern	No significant metal debris detected via EM61.
M-SH-001	Suspect buried debris	Significant buried debris detected via EM61 throughout the feature. Area was further delineated using a Schonstedt magnetic locator to determine perimeter UVOST screening locations and appears to extend beyond the feature boundary in all directions. Two test pit investigations performed, one on each end of feature, however nothing more than small rusted metal fragments were encountered.
M-SH-002	Suspect buried debris	Significant buried debris detected via EM61 in center of feature with a linear suspect pipe leading to it. Survey partially detected similar feature at north extent of survey (two test pits proposed to verify presence of underground tank, but not performed due to detection of subsurface contamination during UVOST perimeter screening).
M-UN-003	Observed surface metal, unknown nature of feature	No significant metal debris detected via EM61. Some small items present in and around the feature area.
M-UN-006	Surface metal in vicinity, unknown nature of feature	No metal debris detected via EM61.

6.4.2 Test Pit Investigations

Nine test pit investigations were performed at four features: (1) buried drum feature C-BD-001, (2) dump site E-DS-001, (3) burn pit M-BP-001, and (4) shop M-SH-001. One full suite analytical soil sample was taken in each test pit. Samples were collected from areas of visible staining (when present), otherwise they were taken from the center bottom of the pit. Large metallic debris that was encountered was cleaned using a dry brush on site and then disposed of in the village landfill.

Figures showing test pit locations in relation to geophysical surveys are provided in Appendix L as Maps SM-5, SM-7, SM-13, and SM-20. Test pit locations are also depicted on the feature screening and sampling maps provided in Appendix F (Maps C-2, E-1, M-10, and M-32). Analytical results for test pit samples are provided in Appendix J. A summary of subsurface metal investigation results is provided in Table 6-11. A summary of analytical exceedances is provided in Table 6-12.

C-BD-001

Three test pit investigations were conducted at this site feature to an approximate depth of 4 feet bgs. Material found in these pits consisted of large plastic and foam fishing floats, home appliances, all-terrain vehicle (ATV) parts (including one full ATV), and one crushed drum. No apparent military related debris was encountered. As this area is known to be a historic dump site for the Native Village of Port Heiden, the findings are consistent with expectations. Analytical results showed no exceedances of PALs.

E-DS-001

Three test pit investigations were conducted at this site feature to an approximate depth of 5 feet bgs. Material found in these pits consisted of metal and glass jars, a remnant of one drum, one rifle shell, hand tools (i.e., saws), and other construction-type debris. As this area is known to be a historic dump site for the Native Village of Port Heiden, the findings are consistent with expectations; however, the possibility remains that some post-war debris encountered could be of military origin. One analytical result from Test Pit #3 showed one exceedance of PALs for metals arsenic and chromium.

M-BP-001

One test pit investigation was conducted at this feature to approximately 4 feet bgs within the suspect circular area. No buried metal or debris of any kind was encountered. Analytical results showed no exceedances of PALs.

M-SH-001

Two test pit investigations were conducted at this feature to approximately 4 feet bgs. No metal debris of any kind was encountered in either test pit, although surface metal debris was present in the vicinity. Investigators described a “tar-like” substance found at or near the surface in both test pits. Analytical results of samples taken from the center of the pits showed no exceedances of PALs.

6.5 Incidental Soil Removal Action Results

During 2014, four areas of soil contamination identified during the Phase I RI in 2012 were excavated. Approximately 199 CY of POL contaminated soil and 3 CY of lead contaminated soil, equaling 150 tons of POL and lead contaminated soil, were removed from these areas and disposed of by ELM solutions at Columbia Ridge Landfill in Arlington, Oregon. Waste manifests, profiles, and certificates of disposal are provided in Appendix M.

Two areas require further excavation: J-SP-002 and J-WH-002 (see Table 6-13). Two areas require no further action: J-SP-003 and F-OT-001 (see Table 6-13). Specific details on each of the removal actions are provided below.

Table 6-12. Summary of Test Pit Analyses.

Test Pit	No. Samples	Sample Suite	POL Above PAL	No. of Detects[a] Exceeding PALs (mg/kg)									
				DRO	RRO	GRO	BTEX	VOC	SVOC	Metals	PCB	Pesticides	Dioxin
C-BD-001-TP1	1	Full	No	0	0	0	0	1	0	3	0	0	-[b]
C-BD-001-TP2	1	Full	No	0	0	0	0	1	0	3	0	0	-
C-BD-001-TP3	1	Full	No	0	0	0	0	0	0	3	0	0	-
E-DS-001-TP1	1	Full	No	0	0	0	0	1	0	3	0	0	-
E-DS-001-TP2	1	Full	No	0	0	0	0	1	0	3	0	0	-
E-DS-001-TP3	1	Full	No	0	0	0	0	0	0	3	0	0	-
M-BP-001-TP1	1	Full	No	0	0	0	0	1	0	2	0	0	0
M-SH-001-TP1	1	Full	No	0	0	0	0	1	0	3	0	-	-
M-SH-001-TP2	1	Full	No	0	0	0	0	1	0	2	0	-	-
Total	**9**		**0**	**0**	**0**	**0**	**0**	**7**	**0**	**25**	**0**	**0**	**0**

[a] PALs for some VOC and SVOC compounds are less than typical limits of detection.
[b] Dashes indicate feature not sampled or specific analysis not requested per Work Plan.

Table 6-13. Summary of Soil Removal Action Analyses.

Excavation	No. Samples	Sample Suite	POL Above PAL	No. of Detects[a] Exceeding PALs (mg/kg)								
				DRO	RRO	GRO	BTEX	VOC	SVOC	Metals	PCB	Pesticides
F-OT-001-EX1	4	Full	No	0	0	0	0	1	0	8	0	0
J-SP-002-EX1 and EX2	11	POL	YES	1	0	0	0	-[b]	-	-	-	-
J-SP-003-EX1	5	Full	No	0	0	0	0	0	0	7	0	0
J-WH-002-EX1	9	Full	YES	2	1	0	0	-	0	-	0	0
	6	Lead	-	-	-	-	-	-	-	0	-	-
Total	**35**		**2**	**3**	**1**	**0**	**0**	**1**	**0**	**15**	**0**	**0**

[a] PALs for some VOC and SVOC compounds are less than typical limits of detection.
[b] Dashes indicate feature not sampled or specific analysis not requested per Work Plan.

6.5.1 AOC F – Other 001 (F-OT-001)

Fifteen CY of DRO-contaminated soil was excavated from site feature F-OT-001. Confirmation samples collected from the bottom and side walls of the excavation confirm no contaminated soil remains at this site feature. The excavation boundary, sample locations, and analytical results are depicted on Map F-1 in Appendix F.

6.5.2 AOC J – Spill 002 (J-SP-002)

Sixty-four CY of DRO-contaminated soil was excavated from site feature J-SP-002. The volume removed was higher than anticipated because of the heterogeneous nature of the POL contamination and the unconsolidated sandy soil resulted in some mixing of contaminated and uncontaminated soil. To limit the amount of excess soil removed, multiple sizes of excavator buckets were used to find one that limited excess soil mixing. Confirmation sampling resulted in one sample that exceeded PAL for DRO at 300 mg/kg (PAL of 250 mg/kg). It is estimated up to 10 additional CY of soil may need to be removed.

Before closing this excavation, a 6-mil polyethylene liner was placed over the area where contamination remains above PALs. The excavation boundary, including the lined area, was recorded with a GPS unit, and the excavation was backfilled with certified clean material from the village gravel pit. The excavation boundary, sample locations, analytical results, and polyethylene lined area are depicted on Map J-1 in Appendix F.

6.5.3 AOC J – Spill 003 (J-SP-003)

Fifty CY of DRO-contaminated soil was excavated from site feature J-SP-003. Confirmation samples collected from the bottom and side walls of the excavation confirm no contaminated soil remains at feature J-SP-003. The excavation boundary, sample locations, and analytical results are depicted on Map J-1 in Appendix F.

6.5.4 AOC J – Warehouse 002 (J-WH-002)

Seventy CY of DRO-contaminated soil was excavated from site feature J-WH-002. The volume removed was higher than anticipated because of the heterogeneous nature of the POL contamination and the unconsolidated sandy soil resulted in some mixing of contaminated and uncontaminated soil. This excavation was not able to be completed during the 2014 field season. Confirmation sampling resulted in one bottom sample exceeding PALs for DRO at 2,200 mg/kg and RRO at 12,000 mg/kg (PAL of 10,000 mg/kg) and one on the west side wall exceeding PAL for DRO at 710 mg/kg.

Before closing this excavation, a 6-mil polyethylene liner was placed over the area where contamination remains above PALs. The excavation boundary, including the lined area, was recorded with a GPS unit, and the excavation was backfilled with certified clean material from the village gravel pit. The excavation boundary, sample locations, analytical results, and polyethylene lined area are depicted on Map J-1 in Appendix F.

6.6 Chemical Data Quality Summary

The Phase II off-site analytical data were validated for data usability and limitations in accordance with the project UFP-QAPP (North Wind, 2014). Samples were collected in 2014 and 2015. One hundred percent of these data were validated. The data validation approach is consistent with the UFP-QAPP and the Department of Defense (DoD) Quality Systems Manual (QSM), Version 4.2 (DoD, 2010), DoD-QSM, Version 5 (DoD, July 2013), and the Technical Memorandum *Environmental Laboratory Data and Quality Assurance Requirements* (ADEC, 2009).

Problems with method and trip blank contamination, surrogate and matrix spike recoveries, holding time exceedances, outside the acceptance criteria, and field duplicate (FD) imprecision were observed. The types and magnitude of these problems are in line with the industry-wide experience in environmental analytical chemistry. As a result of these problems, data were qualified as estimated values and estimated detection limits. The direction of bias in the reported values was determined where possible. Only 45 records out of 51,000 measurements were rejected during data validation. The rest of the data are usable within the limits of the data qualifiers. A complete review of data quality is provided in the Chemical Data Quality Report (CDQR) in Appendix N. The following paragraphs provide a summary.

Of approximately 51,200 analytical measurements of the target chemicals in the parent and FD samples and the trip blanks, 4,900 records (approximately 10% of the total) were qualified for one or more QC nonconformance during data validation. Further discussion is provided in the CDQR in Appendix N. The overall data accuracy, precision and completeness goals were met for the sampling and analysis.

The cumulative effect of the project non-compliant QC on data usability is measured in terms of the precision, accuracy, representativeness, comparability, completeness and sensitivity (PARCCS). The details of the PARCCS evaluation are presented in the CDQR.

The data precision metrics are provided in Table 6-14. Precision is measured through a comparison of duplicate sample results and duplicate spike results (matrix spikes or blank or laboratory control spikes). Approximately 2% of the results were qualified for non-compliant laboratory control sample/laboratory control sample duplicate (LCS/LCSD), matrix spike/matrix spike duplicate (MS/MSD) and FD RPDs. This level of nonconformance occurrence is not uncommon in the environment analyses of solid samples. Overall, the precision of the project analytical data is deemed to be acceptable.

The accuracy metrics are presented in Table 6-15. Surrogate recoveries outside the acceptance windows were the most frequent QC issue with the analyses. The noncompliant surrogate recoveries are usually indicative of matrix effects that bias the results. Depending on whether the recoveries were higher or lower than the expected value, the results could be biased high (actual concentration may be lower than the reported concentration) or low (actual concentration may be higher than the reported concentration). The data qualifiers include the letters “H” or “L” to alert the data users of the potential bias in the results. Again, the level of noncompliant surrogate recoveries is not out of the ordinary for solid matrices. Occasional problems were also experienced with the MS/MSD recoveries, and LCS recoveries. Approximately 5.5% of the results were qualified for noncompliant accuracy criteria. Overall, the accuracy of the analytical data for the project is deemed acceptable.

Random laboratory blank contamination or trip blank contamination was observed that resulted in qualifying the sample data as potential laboratory contamination.

Table 6-16 presents the completeness statistics for the off-site analyses. A total of 45 results (37 pesticide results) were rejected due to severe MS/MSD or surrogate recovery problems. The rejected data comprise less than 0.1% of the total results. Practically all of the data are usable as reported and qualified.

As part of data review and validation, the ADEC Laboratory Data Review Checklists, Version 2.7, were completed for each individual laboratory data package and are provided as Supplemental information).

Table 6-14. Summary of Data Precision Measurements and Qualifications.

Media	Total Results	BTEX (8021B)	CN (9012B)	Dioxin/Furans (8290A)	DRO_RRO (AK102_103)	EDB (8011)	GRO (AK101)	HERB (8151A)	ICP-AES Metals (6010C)	ICP-MS Metals (6020A)	Mercury (7470A)	Mercury (7471B)	Moisture (D2216)	PCB (8082A)	Pest (8081B)	pH (9045D)	S (9034)	SVOC (8270D)	VOC (8260B)	Total
Soil	SA + FD + TB	2130	7	68	832	NA	450	14	635	4149	8	262	258	1617	3796	7	8	16076	18456	48773
Soil	FD/LD Qualified	10	0	8	12	NA	36	0	2	44	0	4	0	2	10	0	0	178	284	590
Soil	LCS/LCSD Qualified	0	0	0	0	NA	0	0	0	0	0	0	0	0	0	0	0	0	12	12
Soil	MS/MSD Qualified	24	0	0	5	NA	9	0	4	21	0	1	0	6	4	0	1	20	189	284
Water	SA + FD + TB	95	NA	NA	38	7	19	NA	23	395	23	NA	NA	70	154	NA	NA	759	845	2428
Water	FD/LD Qualified	4	NA	NA	2	0	0	NA	0	26	0	NA	NA	0	2	NA	NA	6	2	42
Water	LCS/LCSD Qualified	0	NA	NA	0	0	0	NA	0	0	0	NA	NA	0	0	NA	NA	0	0	0
Water	MS/MSD Qualified	0	NA	NA	1	0	0	NA	0	0	0	NA	NA	0	0	NA	NA	1	0	2

SA = Primary sample, FD = field duplicate, LD = lab duplicate, TB = trip blank
Note: Two results, the parent sample result and the field duplicate result, were qualified for every field duplicate RPD exceedance occurrence.
NA = QC measure not applicable or analysis not performed, RPD = relative percent difference, FD = field duplicate, MS/MSD = matrix spike/matrix spike duplicate, LSC/LCSD = laboratory control sample/laboratory control sample duplicate.

Table 6-15. Summary of Data Accuracy Measurements and Qualification.

Media	Total Results	BTEX (8021B)	CN (9012B)	Dioxin/Furans (8290A)	DRO_RRO (AK102_103)	EDB (8011)	GRO (AK101)	HERB (8151A)	ICP-AES Metals (6010C)	ICP-MS Metals (6020A)	Mercury (7470A)	Mercury (7471B)	Moisture (D2216)	PCB (8082A)	Pest (8081B)	pH (9045D)	S (9034)	SVOC (8270D)	VOC (8260B)	Total
Soil	SA + FD + TB	2130	7	68	832	NA	450	14	635	4149	8	262	258	1617	3796	7	8	16076	18456	48773
Soil	LCS/LCSD Qualified	0	0	0	0	NA	0	0	1	0	0	0	0	0	0	0	0	35	16	52
Soil	Surr. Qualified	116	0	0	41	NA	105	6	0	0	0	0	0	441	1635	0	0	0	9	2353
Soil	MS/MSD Qualified	26	0	0	5	NA	14	0	14	80	0	0	0	4	72	0	1	9	116	341
Water	SA + FD + TB	95	NA	NA	38	7	19	NA	23	395	23	NA	NA	70	154	NA	NA	759	845	2428
Water	LCS/LCSD Qualified	0	NA	NA	0	0	0	NA	0	0	0	NA	NA	0	0	NA	NA	0	0	0
Water	Surr. Qualified	0	NA	NA	6	0	0	NA	0	0	0	NA	NA	0	43	NA	NA	0	0	49
Water	MS/MSD Qualified	0	NA	NA	1	0	0	NA	0	2	0	NA	NA	0	0	NA	NA	0	0	3

SA = Primary sample, FD = field duplicate, TB = trip blank, NA = QC measure not applicable, or the analysis not performed.
NA = QC measure not applicable or analysis not performed, Surr. = Surrogate, MS = matrix spike, MSD = matrix spike duplicate, LCS = laboratory control sample, LCSD = laboratory control sample duplicate.

Table 6-16. Completeness Statistics for the Off-Site Analyses.

Media	Total Results	BTEX (8021B)	CN (9012B)	Dioxin/Furans (8290A)	DRO_RRO (AK102_103)	EDB (8011)	GRO (AK101)	HERB (8151A)	ICP-AES Metals (6010C)	ICP-MS Metals (6020A)	Mercury (7470A)	Mercury (7471B)	Moisture (D2216)	PCB (8082A)	Pest (8081B)	pH (9045D)	S (9034)	SVOC (8270D)	VOC (8260B)	Total
Soil	SA samples planned	82	20	1	337	0	301	20	282	282	20	282	335	335	157	20	20	215	220	2929
Soil	SA samples collected	333	7	3	371	0	354	7	241	246	8	233	225	202	156	7	8	204	204	2809
Soil	FD samples collected	42	0	1	45	0	44	0	29	30	0	29	24	29	23	0	0	29	29	354
Soil	SA + FD +TB results	2130	7	68	832	NA	451	14	636	4150	8	262	258	1617	3833	7	8	16077	18460	48818
Soil	SA + FD +TB results Qualified	172	7	24	113	NA	278	6	22	199	1	27	0	449	1673	0	1	959	817	4748
Soil	SA + FD +TB results rejected	0	0	0	0	NA	1	0	1	1	0	0	0	0	37	0	0	1	4	45
Soil	Usable Results	2130	7	68	832	NA	450	14	635	4149	8	262	258	1617	3796	7	8	16076	18456	48773
Soil	Completeness, %	100.0%	100.0%	100.0%	100.0%	NA	99.8%	100.0%	99.8%	100.0%	100.0%	100.0%	100.0%	100.0%	99.0%	100.0%	100.0%	100.0%	100.0%	99.9%
Water	SA samples planned	0	0	0	10	1	10	0	10	10	10	0	10	10	10	0	0	10	10	101
Water	SA samples collected	13	0	0	16	5	13	0	11	12	11	0	0	8	6	0	0	9	9	113
Water	FD samples collected	3	0	0	3	1	3	0	2	3	2	0	0	2	1	0	0	2	2	24
Water	SA + FD +TB results	95	NA	NA	38	7	19	NA	23	395	23	NA	NA	70	154	NA	NA	759	845	2428
Water	SA + FD +TB results Qualified	4	NA	NA	9	0	1	NA	0	38	0	NA	NA	0	44	NA	NA	7	3	106
Water	SA + FD +TB results rejected	0	NA	NA	0	0	0	NA	0	0	0	NA	NA	0	0	NA	NA	0	0	0
Water	Usable Results	95	NA	NA	38	7	19	NA	23	395	23	NA	NA	70	154	NA	NA	759	845	2428
Water	Completeness, %	100.0%	NA	NA	100.0%	100.0%	100.0%	NA	100.0%	100.0%	100.0%	NA	NA	100.0%	100.0%	NA	NA	100.0%	100.0%	100.0%

SA = Primary sample, FD = field duplicate, TB = trip blank, NA = QC measure not applicable, or the analysis not performed.
NA = QC measure not applicable or analysis not performed, Surr. = Surrogate, MS = matrix spike, MSD = matrix spike duplicate, LCS = laboratory control sample, LCSD = laboratory control sample duplicate.

7. SITE FEATURES OF CONCERN

7.1 AOC B Features of Concern

7.1.1 Drum Areas B-DA-003 and B-DA-004

Drum Areas B-DA-003 and B-DA-004 are located adjacent to each other. Two other features are contained within the boundary of B-DA-003: B-DS-001 and B-SP-002. One other feature, B-SP-001, is contained within the boundary of B-DA-004. The screening and sampling locations, and resulting POL detections, are included in Appendix F, Maps B-1, B-2 (a and b), and B-6.

Thirty-two screening locations, out of 275 total, had detections of POL greater than 0.7% effective LIF, corresponding to a potential exceedance of the PAL for DRO. The average probe depth was 13.9 feet bgs, with groundwater encountered between 8.2 to 14 feet bgs. The maximum depth probed was 22.8 feet, with POL detected to 14 feet bgs in at least one location (14FMBDA004UV013).

Twenty-five analytical samples, out of 30 total, confirmed exceedances of DRO in soils both above and below the groundwater surface. Results ranged from 590 mg/kg to 13,000 mg/kg for B-DA-003, and from 360 mg/kg to 25,000 mg/kg for B-DA-004. The maximum confirmed depth of soils exceeding the PAL for DRO is 12 feet bgs in six locations (14FMBDA003UV073BF, 14FMBDA3UV099, 15FMBDA003UV124, 14FMBDA004UV013, 14FMBDA004UV087, and 14FMBDA004UV089). Analytical results greater than 12,500 mg/kg DRO are considered by the State of Alaska to be indicative of an increased potential for migration or for risk to human health, safety, welfare, or the environment. Alaska regulations (18 AAC 75) require remediation of petroleum hydrocarbons in excess of the maximum allowable concentration unless it can be demonstrated that they will not migrate or pose a significant risk to human health or the environment.

Contamination was confirmed in groundwater in three monitoring wells: B-MW-001, its downgradient well B-MW-002 in the northern end of the features, and B-MW-003 at the southern end of B-DA-003. Groundwater contamination was not detected at downgradient well B-MW-004. B-MW-001 had exceedances for both DRO and RRO, though RRO was not exceeded in the associated soil sample for this location (14FMBDA004DT002 at probe location 14FMBDA004UV017).

Subsurface contamination areas in features B-DA-003 and B-DA-004 are illustrated with 12 transects to augment visualization of the horizontal and vertical extents of contamination (see Appendix O, Transects A through L). Additionally, areas of subsurface contamination were evaluated in 2-foot depth intervals based on UVOST detections. The average effective LIF values corresponding to intervals of potential or confirmed POL were modeled in ArcView Geographic Information System (GIS)® to determine the estimated volume of soil exceeding the PAL for DRO (see Appendix P, Map SC-1 (a through h).

Seven areas of soil contamination have been identified. The total volume of contaminated soil at these two site features, estimated to exceed the DRO PAL using effective LIF, is approximately 2914 CY and extends to a depth of 14 feet bgs and into groundwater.

7.1.2 Drum Area B-DA-005

Nine screening locations, out of 137 total, had detections of POL greater than 0.7% effective LIF, corresponding to a potential exceedance of the PAL for DRO. The average probe depth was 14.0 feet bgs, with groundwater encountered between 7.8 to 13 feet bgs. The maximum depth probed was 32.1 feet, with POL detected to 10 feet bgs in at least two locations (14FMBDA005UV063 and 14FMBDA005UV126). The screening and sampling locations, and resulting POL detections, are included in Appendix F, Map B-3 (a and b).

Six analytical samples, out of 16 total, confirmed exceedances of DRO in soils both above and within 5 feet of the groundwater surface. Results ranged from 710 mg/kg to 5,700 mg/kg. The maximum confirmed depth of soils exceeding the PAL for DRO is 10 feet bgs in one location (14FMBDA005UV126).

Groundwater monitored in well B-MW-005 and downgradient well B-MW-006 showed no exceedances for POL. Detections for DRO were 1,100 µg/L in B-MW-005 and 440 µg/L in B-MW-006.

Subsurface contamination areas in B-DA-005 are illustrated with four transects to augment visualization of horizontal and vertical extents of contamination (see Appendix O, Transects M through P). Additionally, areas of contamination were evaluated in 2-foot intervals based on UVOST detections. The average effective LIF values corresponding to intervals of potential or confirmed POL were modeled in ArcView GIS® to determine the estimated volume of soil exceeding the PAL for DRO (see Appendix P, Map SC-2 (a through f).

Two areas of soil contamination are identified. The total volume of contaminated soil estimated to exceed the DRO PAL using average effective LIF is approximately 317 CY and extends to a depth of 10 feet bgs. Contamination does not extend to the groundwater surface at this location, which is estimated at 12 feet bgs.

7.2 AOC C Features of Concern

Results from monitoring well C-MW-001 exceeded PAL for DRO at 28,000 µg/L. This well was located in feature C-LT-002 immediately adjacent to UVOST probe 12FMCLT002UV001. This probe location showed multiple depths with potential POL, including below the estimated water table. Downgradient well C-MW-002 showed no detection of DRO. Monitoring well C-MW-001 exceeded DRO in 2012 with a result of 3,500 µg/L, and continues to be of concern. Groundwater sampling locations and resulting POL detections are included in Appendix F, Map C-2.

7.3 AOC F Features of Concern

In 2012, eight UVOST probes were advanced at F-BU-001 resulting in one log with a waveform consistent with fuel contaminated soil (12FMFBU001UV007). The log in question was located on the western side of the building and was not bounded by a clean edge on the west and south sides. In the 2014 field season, 12FMFBU001UV007 was sampled and resulted in a DRO exceedance of 3,000 mg/kg. Four additional UVOST probes were advanced to the south and west of this probe location to delineate the contamination boundary. Two of these probes (14FMFBU001UV010 and 14FMFBU001UV011) indicated fuels signatures; however, they were located within approximately 10 feet of the encroaching sea cliff so no additional probes were advanced. See Map F-1 in Appendix F for 2012 screening, and 2014 screening and sampling locations.

The fuel contamination in question seems to be co-located with a drum storage area that is currently eroding from the sea cliff, as shown in the geophysical survey map (Appendix L, Map SM-8). Continued erosion observed in 2015 precluded additional characterization or test pit investigations.

The vertical and horizontal extent of soil contamination was modeled based on the available UVOST data. The estimated volume of contaminated soil identified in site feature F-BU-001 above the DRO PAL using effective LIF is approximately 64 CY and extends to a depth of 6 feet bgs (see Appendix P, Map SC-3).

7.4 AOC M Features of Concern

7.4.1 Drum Area M-DA-023

One screening location, 15FMMDA023UV009, detected POL at intervals of 4 to 6 feet bgs and 9 to 11 feet bgs. No other detections were noted within the feature. A total of 17 probes were drilled, with one attempt to groundwater to 49.4 feet bgs, and the remaining probes ranging from 14.0 to 23.9 feet bgs. Groundwater was detected at 21.2 feet. See Map M-7 in Appendix F for screening and sampling locations.

Analytical sample 15FMMDA023DT001 (associated with the UVOST detection) confirmed an exceedance of DRO in soil of 1,900 mg/kg at 4 to 6 feet bgs. Subsurface contamination is illustrated via cross section in Appendix O, Transect H. The total volume of contaminated soil estimated to exceed the DRO PAL using effective LIF is approximately 443 CY and extends to a depth of 10 feet bgs (see Appendix P, Map SC-4). Contamination does not extend to the groundwater at this location.

7.4.2 Power House M-PR-001

One screening location, 15FMMPR001UV001, had potential POL detections at 5 feet and 10 feet bgs. No other detections were noted in nine other probes at this location. Probe depths ranged from 15.6 to 23.9 feet bgs. Groundwater was detected between 9 and 13 feet. See Map M-24 in Appendix F for screening and sampling locations.

Soil contamination was confirmed at 4 to 6 feet bgs in probe 15FMMPR001UV001, with a DRO exceedance of 6,900 mg/kg. Subsurface contamination is illustrated via cross section in Appendix O, Transect A. The total volume of contaminated soil estimated to exceed the DRO PAL using effective LIF is approximately 49 CY and extends to a depth of 10 feet bgs (see Appendix P, Map SC-5 [a through c]), just above the estimated depth to groundwater of 10.5 feet at this location.

7.4.3 Power House M-PR-005 Area

The M-PR-005 screening area includes screening locations from features M-GS-043, M-MH-002, M-UN-005 and a sampling location from M-PH-002 (see Maps M-18 and M-25 in Appendix F). Twenty-nine screening locations, out of 80 total, had detections of potential POL greater than 0.7% effective LIF, corresponding to a potential exceedance of the PAL for DRO. The average probe depth was 27.6 feet bgs. The maximum depth probed was 59.5 feet. Attempts to determine the presence of groundwater in this area were impeded by borehole collapse.

Two analytical samples, out of 10 total, confirmed exceedances of DRO in soils at 350 mg/kg. The maximum confirmed depth of soil exceeding the PAL for DRO is 25 feet in sample 15FMMPR005DT001 (sample interval 23.5 to 25.0 ft bgs). Sample 15FMMPR005DT003 was taken at 15.5 to 17.0 ft bgs.

Only one of two piezometers installed in M-PR-005 encountered groundwater. The other piezometer (installed 48 feet to the north) was expected to encounter water between 15 and 20 feet bgs, the depth range at which boring collapse was thought to be caused by presence of saturated soils. However, groundwater was not encountered, suggesting that no piezometric surface of any lateral extent existed at the depths that contamination was detected during screening and sampling.

Subsurface contamination is illustrated via four cross sections in Appendix O (Transects D through G). Modeling of the average effective LIF value associated with UVOST POL detections at this feature resulted in approximately 2542 CY of contaminated soil. This estimate is biased high for two reasons. First, the average effective LIF values associated with sample intervals were high with respect to the slight exceedance of the PAL observed. Second, modeling incorporated UVOST locations where sampling indicated no PAL exceedances. Subtracting modeled soil volumes associated with probes with confirmed non-exceedances provides an estimated 847 CY of contaminated soil. Map SC-6 (a through d) in Appendix P provides the modeling results and backup calculations.

7.4.4 Shop M-SH-001

Lead contamination in soil above PAL (400 mg/kg) was confirmed in one sample location at M-SH-001. Twenty-four XRF screening locations resulted in measurements ranging from 3.9 to 626 ppm. Five confirmation samples were submitted for laboratory analyses, corresponding to five XRF measurements ranging from 59.7 to 626 ppm. Analytical analyses returned one result of 780 mg/kg with the remaining four ranging from 32 to 120 mg/kg.

Screening locations were roughly 20 feet apart. The extent of lead contamination exceeding the PAL is not sufficiently bounded. The feature screening and sampling maps for screening and sample confirmation locations and results are provided in Appendix F, Map M-32. Note that all XRF screening locations are outside the boundaries of the two test pit investigations that were conducted later.

7.4.5 Shop M-SH-002

Four screening locations, out of 24 total, had detections of POL greater than 0.7% effective LIF, corresponding to a potential exceedance of the PAL for DRO. The average probe depth was 15.0 feet bgs, not including one probe to 32.1 feet bgs. Groundwater was encountered between 9 and 11 feet. Contamination was detected to 8 feet bgs in UVOST probe 15FMMSH002UV014. See Map M-32 in Appendix F for screening and sampling locations.

Two analytical samples, out of three total, confirmed exceedances of DRO in soils both above and within 5 feet of the groundwater surface. Results for sample 15FMMSH002DT001 (taken at probe location 15FMMSH002UV018) exceeded the PAL for DRO, with a result of 8,700 mg/kg. Results for sample 15FMMSH002DT002 (taken at 15FMMSH002UV014) exceeded the PAL for DRO, with a result of 6,200 mg/kg. The unexpected exceedance at 15FMMSH002UV018 is associated with an effective LIF value of 0.260%, which is significantly below the correlation value of 0.7%.

The maximum confirmed depth of soils exceeding the PAL for DRO is 7.5 feet. Groundwater monitored in well M-MW-002, installed immediately adjacent to 15FMMSH002UV014, did not exceed PALs for POL.

Subsurface contamination is illustrated via cross section in Appendix O, Transect B. The contaminated soil volume was modeled using actual and calculated average effective LIF values. The volume of soil estimated to exceed the DRO PAL is approximately 95 CY. Modeling results and backup calculations are included in Appendix P, Map SC-5 (a through c).

7.4.6 Storage M-ST-006

Soil contamination was confirmed in feature M-ST-006 in sample 15FMMST006DT001 with a DRO exceedance of 960 mg/kg (QL qualified). Sample 15FMMST006DT001 was taken in feature M-ST-006 near UVOST probe 14FMMST006UV003, which showed no indication of POL. This false negative result is most likely due to limited lateral extent of soil contamination (i.e., the sampling borehole encountered contamination while the screening borehole did not). See Map M-34 in Appendix F for screening and sampling locations.

Maximum confirmed depth of soils exceeding the PAL for DRO is 6 feet. Groundwater was not encountered in this feature during screening. The contaminated soil volume was modeled using a calculated effective LIF of 5.7% for UVOST location 14FMMST006UV003 over the sample interval of 4 to 6 feet bgs. The volume of soil estimated to exceed the DRO PAL is approximately 67 CY (see Map SC-7 in Appendix P).

7.4.7 Transformer M-TF-001

Soil contamination was confirmed in this feature in UVOST probe 15FMMTF001UV003 with a DRO exceedance of 2,400 mg/kg over a sample interval of 8 to 11 feet bgs. No other detections were noted in six other probes at this location, which ranged from 19.6 to 19.9 feet bgs. Groundwater was measured at 12.1 feet bgs at monitoring well M-MW-001, which was installed immediately adjacent to probe 15FMMTF001UV003. See Map M-24 in Appendix F for screening and sampling locations.

Subsurface contamination is illustrated via cross section in Appendix O, Transect A. The total volume of contaminated soil estimated to exceed the DRO PAL using effective LIF is approximately 17 CY and extends to a depth of 11 feet bgs (see Appendix P, Map SC-5), just above the estimated depth to groundwater of 12 feet at this location. Modeling results and backup calculations are provided in Appendix P, Map SC-5 (a through c).

7.4.8 Unknown M-UN-002

Two screening locations, out of 12 total, had detections of POL greater than 0.7% effective LIF. The average probe depth was 15.7 feet bgs, not including one probe to 30.5 feet bgs. Groundwater was not encountered during screening. Contamination was detected in UVOST probe 15FMMUN002UV004 with sample 15FMMUN002DT002 exceeding the PAL for DRO with a result of 6,800 mg/kg across the sample interval of 7 to 12 feet bgs. See Map M-37 in Appendix F for screening and sampling locations.

Subsurface contamination is illustrated via cross section in Appendix O, Transect C. The total volume of contaminated soil estimated to exceed the DRO PAL using effective LIF is approximately 183 CY and extends to a depth of 12 feet bgs (see Appendix P, Map SC-8).

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8. WASTE MANAGEMENT

All IDW was containerized in approved DOT containers and tracked on an excel tracking sheet. IDW consisted of remaining soil from contaminated soil borings, decontamination water, and purge water from well development and sampling.

8.1 Solid IDW

Approximately 150 tons of excavated soil was placed in supersacks and profiled based on excavation confirmation sample results. All soil was profiled as non-hazardous, POL-containing soil (Profile Number 116093OR) and transported and disposed of by ELM Solutions Corp. at Columbia Ridge Landfill in Arlington, OR (Manifest Number 14FM-001).

Soil boring cuttings with field screening results that indicated likely contamination (i.e., UVOST LIF over 1% RE, elevated PID, or noticeable POL odor) were containerized as generated during field activities. Prior to disposal, representative samples were submitted for toxicity characteristic leaching procedure (TCLP) analysis, which returned no exceedances of maximum contaminant levels (MCLs). Roughly 4 tons of soil cuttings were consolidated into two 1-CY supersacks and one 30-gallon drum for disposal. Soil is profiled as non-regulated soil and debris (Profile Number OR330526) for disposal by ELM Solutions Corp at Columbia Ridge Landfill in Arlington, OR.

Completed waste profiles and returned, signed manifests to date are provided in Appendix M.

8.2 Liquid IDW

Liquid IDW generated during sampling activities was containerized in two 55-gallon polyethylene drums and one 15-gallon polyethylene drum. TCLP results indicated no exceedances of MCLs. Water is profiled as non-regulated water (Profile Number OR330527) for disposal by ELM Solutions Corp at Columbia Ridge Landfill in Arlington, OR.

Completed waste profiles and returned, signed manifests to date are provided in Appendix M.

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9. CONCLUSIONS AND RECOMMENDATIONS

9.1 Conclusions

During Phase II investigations, 195 features were screened and 166 features were sampled for potential POL contamination, nine features were screened for potential surface soil lead contamination, and eight features were sampled for potential PCB surface soil contamination. Full suite analyses at each of the features sampled for POL also included BTEX, VOCs, SVOCs, metals, and either PCBs or pesticides, or both depending on feature type. The following observations and conclusions are made regarding UVOST detections and analytical confirmations of soil contamination at site features:

- Exceedances of PALs for POL in surface and subsurface soils were for DRO exclusively. Exceedances were confirmed at 11 features, or 6.6% of those sampled. Exceedances were observed in former Drum Area, Building Unknown, Power House, Shop, Storage, Transformer, and “Unknown” feature types.

- Exceedances of the PAL for lead screening in surface soil were confirmed at one feature, or 11% of those screened. The exceedance occurred in a Shop feature type. The largest screening detections were in Shop features exclusively.

- Some VOC or SVOC contaminants exceeded PALs in many samples but are not considered to be contributable to environmental contamination; they are common laboratory contaminants. These contaminants include methylene chloride. Methylene chloride is a suspected laboratory contaminant not associated with activities at Fort Morrow.

- Many detections of arsenic and chromium above the PAL are likely naturally occurring and are not from anthropogenic sources with the exception of sample results from a test pit in E-DS-001. At this location, both arsenic and chromium levels are above the UTL set by the 2015 background study as well as the 2006 Air Force Metals Background Study at the Port Heiden Radio Relay Station (USAF, 2006) and the PALs.

- Contamination (for DRO) in M-PR-005 was detected at a depth of 25 feet bgs associated with an organic rich layer, and may be due to biogenic interference rather than actual POL contamination. No POL exceedances were confirmed in any of the other nine features at depths greater than 12 feet bgs. (Note: The potential contribution of biogenic interference has not been confirmed through ADEC-accepted methods by qualified personnel).

- No exceedances of PALs for POL were confirmed in Quarters features. Thirty-one features were screened with roughly half screened inside the discernable recessed area and half immediately outside the perimeter. Two potential POL detections were noted; one at M-QT-039 on the outside perimeter and one at M-QT-101 inside the recessed area.

- For metals analyses in AOC M, exceedances of the PAL for arsenic do not appear to be associated with any specific feature type, except possibly mounded material features where all four features sampled exceeded the PAL and one of the four features exceeded the 2015 UTL. Exceedances of manganese and molybdenum above 2015 UTLs appear to occur in latrine, mounded material, and warehouse type features at a higher ratio of features sampled than in other features types (with multiple features).

Fourteen monitoring wells were sampled from three AOCs. Thirteen wells from AOCs B and C were sampled for POL; one well from AOC J was sampled for lead only. The following observations and conclusions are made:

- Exceedances for POL in groundwater were confirmed in four monitoring wells. Three of the wells were installed in locations of known highest contamination. One downgradient well was impacted.

- Exceedance of POL in one downgradient well may be due to migration of the contaminant plume or the well's proximity to another source of contamination. No other downgradient wells were impacted.

- Eight wells analyzed for total and dissolved metals had exceedances for metals. Exceedances were for iron, manganese, dissolved manganese, or cobalt.

- No exceedances for lead were observed.

Groundwater occurrence in AOC M was not consistently documented at features with confirmed contamination in soils above PALs. Depth to the groundwater surface was not clearly defined at features M-ST-006, M-UN-002, and M-PR-005.

- Feature M-ST-006 had confirmed DRO contamination at 6 feet bgs. This feature is located on terrain above the elevation of the adjacent maintained road near feature M-ST-008 by approximately 10 feet. Depth to water was measured in M-ST-008 at 17 feet bgs, so it is unlikely that contamination at M-ST-006 is within 5 feet of the groundwater surface.

- Feature M-UN-002 had confirmed DRO contamination at 12 feet bgs. The elevation of this feature is approximately 30 feet higher than monitoring well M-MW-002 located in feature M-SH-002. It is unlikely that contamination at M-UN-002 is within 5 feet of the groundwater surface.

- Two piezometers installed at M-PR-005 did not provide consistent information regarding the occurrence of groundwater in and around this feature. Water was detected in one piezometer but not the other one just 50 feet away, suggesting possible isolated perched zones with no lateral continuity.

Subsurface metal investigations were conducted at 24 locations. These included geophysical surveys and test pit investigations. Observations and conclusions include:

- Significant buried metal was detected via geophysical surveys in five features: E-DS-001, F-BU-001, M-GS-043, M-SH-001, and M-SH-002.

- No significant buried metal was detected in or around Dump Site or Debris site feature surveys (i.e., those feature types prescribed by the Work Plan as being most likely of containing buried metal debris).

- Test pit investigations were performed in E-DS-001, C-BD-001, M-BP-001, and M-SH-001. Significant buried debris in three test pits in C-DB-001 appeared to be municipal in origin. Buried debris from three test pits in E-DS-001, though consistent with typical construction-type debris, could be of post-war military origin. No buried metal or debris was discovered in M-BP-001 within the suspect circular feature identified on the geophysical survey. No buried metal debris was noted at two test pits in M-SH-001, though the survey showed significant debris.

- Ground Scar feature M-GS-043 may be miscategorized. Test pit investigations to determine whether survey results identified an underground tank were not able to be performed due to UVOST screening detections of potential POL. Some buried metal debris might be consistent with the ground scar feature type; however, the presence of an underground tank would not be consistent.

The volume of contaminated soil encountered during Phase II investigations based on GIS modeling is approximately 4,996 CY. Breakdown by AOC includes 3,231 CY for AOC B, 64 CY for AOC F, and 1,701 CY for AOC M. Some observations and conclusions include:

- Contamination in M-PR-005 was detected at a depth of 25 feet bgs and accounts for approximately 846 CY of contaminated soil. Exceedances of DRO at this depth appear to be associated with an organic rich layer, and therefore may be due to biogenic interference rather than actual POL contamination. (Note: The potential contribution of biogenic interference has not been confirmed through ADEC-accepted methods by qualified personnel).

- Other than at M-PR-005, no POL exceedances were confirmed in any other feature at depths greater than 12 feet bgs. The deepest UVOST detections (unconfirmed by sampling), other than at M-PR-005, were to 16 feet bgs on only two occurrences.

- Volume estimates are based on the average effective LIF of UVOST probes except in four locations where sample results were used to estimate a correlating effective LIF value. These four locations are where sample results for DRO exceeded the PAL, but the UVOST probe sampled showed little or no potential POL. These include 14FMBDA003UV041, 14FMBDA003UV076BF, 15FMMSH002UV018, and 14FMMST006UV003.

9.2 Recommendations

A total of 166 features were sampled based on established methodology requiring UVOST detections to be sampled at the highest LIF representative of potential POL. In some instances, multiple detections occur within the same feature. Field decisions are made regarding sample locations in compliance with Work Plan requirements. However, occasionally post-field season reviews identify better or additional sampling opportunities. The following additional sampling opportunities are identified:

- K-ST-001: Possible contamination in probe 12FMKST001UV003 has not been adequately confirmed with sampling. The location of sample 14FMKST001DT001 was approximately 10 feet north of the probe.

- M-PH-001: At the time of field sampling, feature M-PH-001 was determined to be free of UVOST logs with any indication of POL. However, a subsequent review revealed that 15FMPH001UV005 contains a spike at 9 feet bgs that could potentially represent POL. An additional sample at this location would provide confirmation of POL.

- E-DS-001: A subsequent review of UVOST data has identified potential indications of POL in several boreholes above the applied in-situ correlation value of 0.7% effective LIF. Some indications are within the first foot of soil and at the time of sampling may have been determined to not be representative of WWII-era contamination. These include UVOST detections in 15FMEDS001UV008 and 15FMEDS001UV005BF. Deeper detections were noted at 15FMEDS001UV015 at 20 feet bgs and 15FMEDS001UV018 at 11 feet bgs.

- M-DA-020: Indications of potential POL exist in probe 14FMMDA020UV003 at 7 feet and 17 feet bgs. This probe was sampled at 0.5 to 1.5 feet bgs. An additional sample at 17 feet bgs would provide confirmation of POL at this depth.

- M-GS-001: Indications of potential POL exist in probe 15FMMGS001UV030 at 8 feet bgs at an effective LIF value of 1.4%. An additional sample at this location would provide confirmation of POL at this depth.

- M-WH-005: Indications of potential POL exist in probe 15FMMWH005UV005 at 24 feet at an effective LIF value of 0.9%. An additional sample at this location would provide confirmation of POL at this depth.

- Small Spikes: Three small spikes indicative of potential POL exist in M-DA-004 at probe 14FMMDA004UV004 at 4.6 feet bgs, at M-DA-012 at probe 14FMMDA012UV005 at 10 feet bgs, and at M-WH-004 at probe 14FMMWH004UV020 at 28 feet bgs. Small spikes such as these are difficult to sample because a narrow sample interval is difficult to target and sufficient material required for analyses is usually not captured. However, additional sampling attempts may be warranted.

Three monitoring wells in AOC B had exceedances for POL. Analyses for EDB were required where sample results showed the presence of POL. Results confirming POL were not received until after field investigations were complete. Analyses for EDB should be included in any additional sampling performed at wells B-MW-001, B-MW-002, or B-MW-003.

It is suspected that DRO exceedances associated with feature M-PR-005 may be biogenic in nature due to the high LIF responses noted in UVOST screening logs coupled with low concentrations of DRO in laboratory results. Biogenic interference has not been confirmed through ADEC-accepted methods by qualified personnel. Evaluation of sample chromatographs by an ADEC-qualified chemist should be performed, and if interference is confirmed, its contribution to original sample results should be determined before removal actions are considered. The estimated contaminated soil volume for M-PR-005 and surrounding features is approximately 847 CY. Remedial actions would not be required if the nature of DRO exceedances were determined contributable to naturally occurring organic material.

Contamination in the groundwater is known to exist in three features: B-DA-003, B-DA-004, and C-LT-002. The extent of contamination has not been fully delineated at this time. An exceedance in one downgradient well in B-DA-003 exists. Additional sampling performed in monitoring well C-MW-001 at C-LT-002 showed a 10-fold increase in concentration of DRO in groundwater from 2012 analytical results. Sampling of downgradient wells C-MW-002 and C-MW-003 showed no detections of DRO.

In two cases where incidental soil removal actions were performed (J-WH-002 and part of J-SP-002), analytical results indicated that contaminated soils had not completely been removed. Further evaluation should be performed to determine what future actions may be necessary at these two locations.

10. REFERENCES

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The following Standard Operating Procedures (SOPs), taken from the *Final Port Heiden/Fort Morrow Remedial Investigation, Phase II Port Heiden, Alaska, Uniform Federal Policy for Quality Assurance Project Plan (UFP-QAPP)* (North Wind, 2014), were used as reference material for this RI report:

- SOP-06, *Groundwater Level Measurements.*
- SOP-07, *Field Water Quality Measurements.*
- SOP-08, *Groundwater Sampling.*
- SOP-10, *Well and Boring Decommissioning and Abandonment.*
- SOP-12, *Installation and Development of Groundwater Monitoring Wells and Points.*
- SOP-15, *Ultra Violet Optical Screening Tool (UVOST) Screening*.
- SOP-16, *Soil Sampling.*
- SOP-17, *Soil Logging.*
- SOP-19, *Test Pit Excavations.*
- SOP-21, *Investigation Derived Waste.*
- SOP-22, *X-ray Fluorescence (XRF) Screening.*
- SOP-26, *Excavation of Contaminated Soil*.