Fort Vancouver National Historic Site

EAST AND SOUTH VANCOUVER BARRACKS: INVESTIGATION SUMMARY AND ENGINEERING EVALUATION/COST ANALYSIS

PUBLIC REVIEW DRAFT

Prepared for

National Park Service
Fort Vancouver National Historic Site
612 E. Reserve Street
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Acronyms

ALM	Adult Lead Model
ARAR	applicable or relevant and appropriate requirement
bgs	below ground surface
BMP	best management practices
bw	body weight
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
COC	chemical of concern
COPC	chemical of potential concern
cPAH	carcinogenic polycyclic aromatic hydrocarbon
DDD	dichlorodiphenyldichloroethane
DDE	dichlorodiphenyldichloroethylene
DDT	dichlorodiphenyltrichloroethane
DU	decision unit
dw	dry weight
EBS	environmental baseline survey
Ecology	Washington State Department of Ecology
EE/CA	engineering evaluation/cost analysis
EPA	US Environmental Protection Agency
ESL	environmental screening level
ESVB	East and South Vancouver Barracks
FOVA	Fort Vancouver National Historic Site
HBC	Hudson's Bay Company
HPAH	high-molecular-weight polycyclic aromatic hydrocarbon
IC	institutional control
IEUBK	Integrated Exposure Uptake Biokinetic
LBP	lead-based paint

LOAEL	lowest-observed-adverse-effect level
LPAH	low-molecular-weight polycyclic aromatic hydrocarbon
MEC	munitions and explosives of concern
MTCA	Model Toxics Control Act
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
NOEC	no-observed-effect concentration
NPS	National Park Service
NTCRA	non-time-critical removal action
O&M	operations & maintenance
OSHA	Occupational Safety and Health Administration
PA	preliminary assessment
PAH	polycyclic aromatic hydrocarbon
PCB	polychlorinated biphenyl
ppm	parts per million
PRG	preliminary remediation goal
QAPP	quality assurance project plan
QC	quality control
RAO	removal action objective
RCRA	Resource Conservation and Recovery Act
SMMS	synthetic metals mineralization system
SVOC	semivolatile organic compound
total DDx	sum of all six DDT isomers (2,4′-DDD, 4,4′-DDD, 2,4′-DDE, 4,4′-DDE, 2,4′-DDT and 4,4′-DDT)
TBC	to be considered
TCLP	toxicity characteristic leaching procedure
TEE	terrestrial ecological evaluation
TEQ	toxic equivalent
TPH-D	total petroleum hydrocarbons-diesel
TPH-O	total petroleum hydrocarbons-oil

TRV	toxicity reference value
USC	United States Code
UST	underground storage tank
WAC	Washington Administrative Code
Windward	Windward Environmental LLC
WISHA	Washington Industrial Safety and Health Act
XRF	X-ray fluorescence spectrometer

1 Introduction

This document presents the results of an engineering evaluation/cost analysis (EE/CA) performed to identify and select a removal action to be performed at the East and South Vancouver Barracks (ESVB), located within the boundaries of the Fort Vancouver National Historic Site (FOVA), Vancouver, Washington. The ESVB is on lands owned by the United States and managed by the National Park Service (NPS). In exercising its delegated response authority under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), 42 U.S.C. §§ 9601 *et seq.*, and the National Oil and Hazardous Substances Pollution Contingency Plan (NCP), 40 Code of Federal Regulations (CFR) Part 300, the NPS retained Windward Environmental LLC (Windward) to conduct an EE/CA. This EE/CA describes and provides supporting documentation for a non-time-critical removal action (NTCRA), hereafter referred to as the removal action, to be conducted at the FOVA ESVB. The EE/CA was conducted in compliance with CERCLA, the NCP, and US Environmental Protection Agency's (EPA's) *Guidance on Conducting Non-Time-Critical Removal Actions Under CERCLA* (1993).

This EE/CA report is a streamlined, focused document that provides site characterization data, assesses risks to human health, evaluates ecological exposures, evaluates various response alternatives, recommends a preferred response alternative, and provides a vehicle for public involvement. This EE/CA was conducted in accordance with the NPS-approved EE/CA work plan (Windward 2012a).

1.1 Site Location and Background

The ESVB is located adjacent to what was the original FOVA site in Clark County, Washington (Figure 1). The US Army relinquished the ESVB to the NPS, and it was incorporated into FOVA in May 2012. The ESVB area was first developed by the Hudson's Bay Company (HBC) as Fort Vancouver, which existed as a headquarters and supply depot for an extensive fur trading operation from 1829 to the 1860s. The US Army arrived in 1849, established the Vancouver Barracks adjacent to the HBC depot, and used the area for a variety of purposes, including training facilities, barracks, firing ranges, and administrative and logistical support. The National Historic Site was established by the US Congress to protect the location's rich cultural resources. These nationally significant cultural resources are listed on the National Register of Historic Places as the Vancouver National Historic Reserve National Historic District, and include historic structures, cultural landscapes, and some of the most significant and well-preserved historical archaeological sites in the Pacific Northwest. Additional detail regarding the history of Fort Vancouver is available at: http://www.nps.gov/fova/historyculture/historical-studies.htm.

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Figure 1. Fort Vancouver East and South Barracks

Prepared by craigh, 10/3/2013; W:\Projects\Fort Vancouver EECA (National Park Service)\Data\GIS\Maps and Analyses\EECA Work Plan\Fig 1 5297 Ft Vancouver E and S barracks.mxd

1.2 PREVIOUS ENVIRONMENTAL INVESTIGATIONS

Several environmental actions were conducted at the Vancouver Barracks, of which the ESVB site is a part, prior to its relinquishment by the US Army. A 1993 underground storage tank (UST) removal program intended to remove three documented USTs from the Vancouver Barracks revealed that two of the USTs had been previously removed; the third UST could not be located using the documentation available (Woodward-Clyde 1998).

In 1996, a preliminary assessment (PA) was conducted in response to a reported oil spill to evaluate general site risk to human health and the environment (USACE 1996). The PA concluded that neither the reported spill nor past or ongoing site activities represented a potential negative impact on human health or the environment, and no further action was recommended at that time. A follow-up site inspection was conducted in 1998, during which soil was analyzed from several locations at the site (Woodward-Clyde 1998). Although several chemicals were detected in site soils, none of the concentrations exceeded the Washington State Department of Ecology's (Ecology's) soil cleanup regulations (i.e., Method A) developed under the Model Toxics Control Act (MTCA) (Ecology 2007). Subsequent review by EPA determined that remediation was not considered necessary, and no further action was planned.

In 2002, the first of several assessments was conducted in support of the US Army's decision to close and relinquish the ESVB. The 2002 environmental baseline survey (EBS), prepared to document the environmental conditions at the Vancouver Barracks property (ENSR 2002), and identified the following:

- The status of 15 USTs removed during the 1990s
- Lead in the form of lead dust from the former indoor firing ranges in several buildings, and lead-based paint (LBP) throughout the site
- Post-abatement asbestos remaining in several buildings
- Fluorescent light ballasts possibly containing polychlorinated biphenyls (PCBs)

In 2005, an inventory of PCB-containing equipment was conducted (e^2M 2005). Lighting ballasts were confirmed to contain PCBs and their removal was recommended.

In 2006, a Phase I site assessment was conducted to describe the current and former uses of the Vancouver Barracks property, and to identify areas of potential environmental concern (CH2M HILL 2006). The 2006 Phase I site assessment identified:

- The storage of hazardous materials in several buildings at the site
- LBP used throughout the site and peeling from several buildings
- The use of several varieties of pesticides
- One potential location containing munitions and explosives of concern (MEC)

In 2007, separate investigations were conducted in regard to 1) potential petroleum contamination at a former wash rack sump and used oil sump, and 2) lead dust contamination at the former indoor firing ranges (Shaw Environmental 2007). The inspections conducted at the wash rack and used oil sumps did not reveal any compromised structures, and no further action was recommended at the time. The investigation of the former indoor firing ranges identified the presence of lead dust within the wood grain of the building structures. In 2007, it was noted that on a practical level, this lead dust could not be removed to meet target cleanup levels without the removal of significant building infrastructure (e.g., floorboards, trusses, etc.). However, the US Army subsequently hired Trihydro Corporation to conduct a cleanup effort of the lead dust in the attics of barracks buildings 987, 989, and 993. This work was completed in July 2012 (Cozby 2014).

A 2009 Phase I site assessment (Tetra Tech 2009) confirmed the environmental conditions cited in the 2006 Phase I site assessment (CH2M HILL 2006) (i.e., pesticides, LBP, lead dust at the former firing ranges, PCBs in lighting ballasts, and possible MEC). In addition, the 2009 study (Tetra Tech 2009) identified asbestos-containing tile in site soils, the historical use of wood preservatives in former railroads associated with the site, potentially stained soils associated with a pit identified in historical aerial photographs, and the documented presence of radon levels exceeding EPA-recommended action levels in three buildings.

In 2011, the *Level II Environmental Site Assessment Report* was prepared to investigate and document the environmental conditions at the site (Alisto 2011). Lead was detected in all but two soil samples analyzed; the highest concentrations of lead in soil were found in the vicinity of Buildings 991 and 993. Results ranged from 654 to 12,300 mg/kg, well above the corresponding environmental screening level (ESL) for unrestricted land use (250 mg/kg), which is based on Ecology's MTCA Method A soil cleanup level (2007). Other chemicals (i.e., organochlorine pesticides; gasoline-range, diesel-range, and residual-range petroleum hydrocarbons; toluene; semivolatile organic compounds [SVOCs]; and metals other than lead) were detected at concentrations either below their respective ESLs or within naturally occurring background levels (e.g., arsenic, total chromium, etc.), or were not detected above laboratory reporting limits (i.e., asbestos, benzene, and PCBs).

Based on the reported findings, the *Level II Environmental Site Assessment Report* (Alisto 2011) recommended further assessment of the spatial extent of lead in soil, particularly at the east barracks, where concentrations of lead in soil were well above the unrestricted land use ESL, and were high enough to pose a potential threat to human health and the environment.

1.3 HUDSON'S BAY COMPANY CEMETERY

The HBC cemetery (Figure 2) was purposefully excluded from those features within the ESVB considered in this EE/CA, due to considerations regarding the protection of human remains and sensitive cultural resources. Conditions within the cemetery area thus remain uncharacterized, and will not be subject to the conclusions and recommendations provided within this EE/CA. The methods utilized in the assessment, development, and implementation of this EE/CA may be considered models for an approach to the uncharacterized conditions within the cemetery, which features site conditions and buildings similar to those examined in adjacent investigation and assessment areas.

Figure 2. Decision units and soil sample locations

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2 Site Characterization

This section describes the characterization of soil conditions at the site, the streamlined human health and ecological risk evaluations, and the development of site-specific cleanup levels.

2.1 Source, Nature, and Extent of Contamination

This section presents the results of site characterization activities conducted as part of the EE/CA. All site activities and data analyses were conducted in accordance with the quality assurance project plan (QAPP) (Windward 2012b). In addition to the HBC cemetery, the western half of the south barracks area (i.e., Buildings 400, 401, 402, 404, and 405) (Figure 1) was also excluded from this EE/CA investigation. This area was sampled during the *Level II Environmental Site Assessment* investigation (Alisto 2011), and contaminant concentrations were well below screening levels. In addition, the buildings in this area were constructed in the 1980s, during which time LBP would not have been used. Consequently, there was no rationale for additional sampling in this area.

2.1.1 Soil

Soil sampling for characterization included the collection of surface soil samples from 0 to 6 in. below ground surface (bgs). The goal of the sampling design was to better delineate the spatial extent of contamination in soil; the design utilized a risk-based approach based on a composite soil sample compiled from soil collected from 30 separate locations within each of the 6 decision units (DUs). Each DU was established to encompass an area where a single removal action alternative could be taken, based on the results of the chemical analysis of the composite sample from that DU. DUs and specific sampling locations are shown in Figure 2 and Figures 3 through 8.

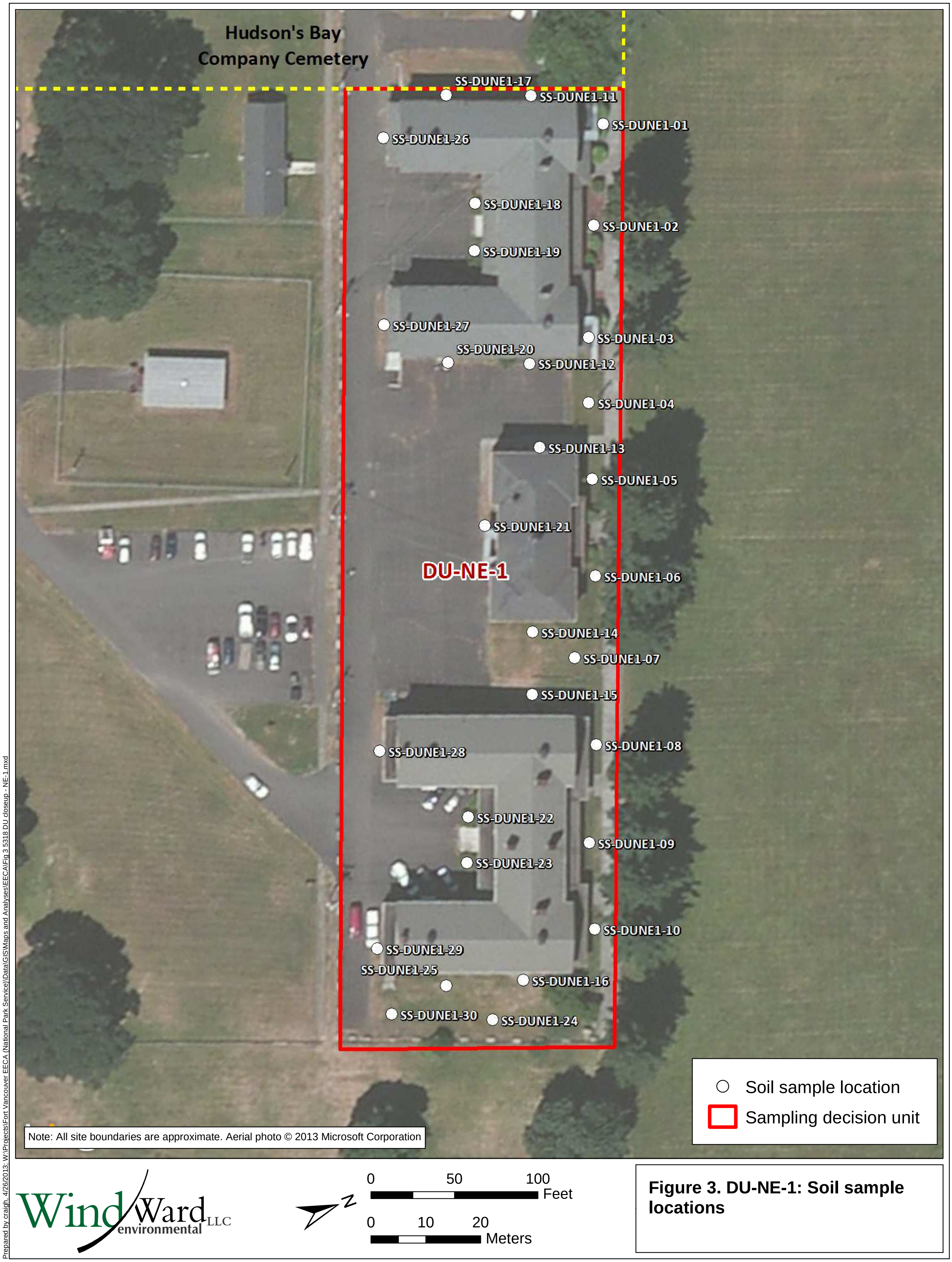

Figure 3. DU-NE-1: Soil sample locations

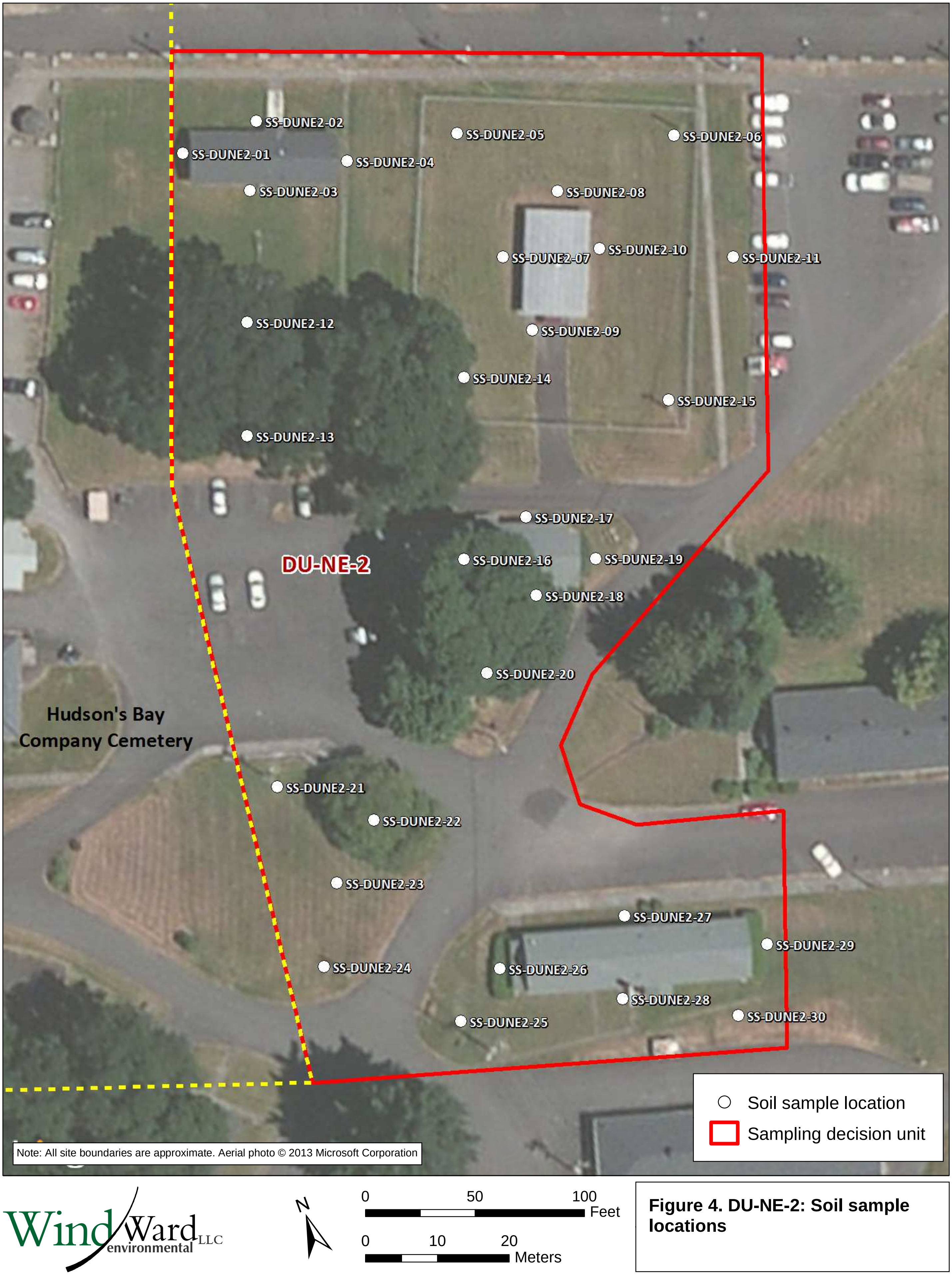

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Figure 4. DU-NE-2: Soil sample locations

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Figure 5. DU-NE-3: Soil sample locations

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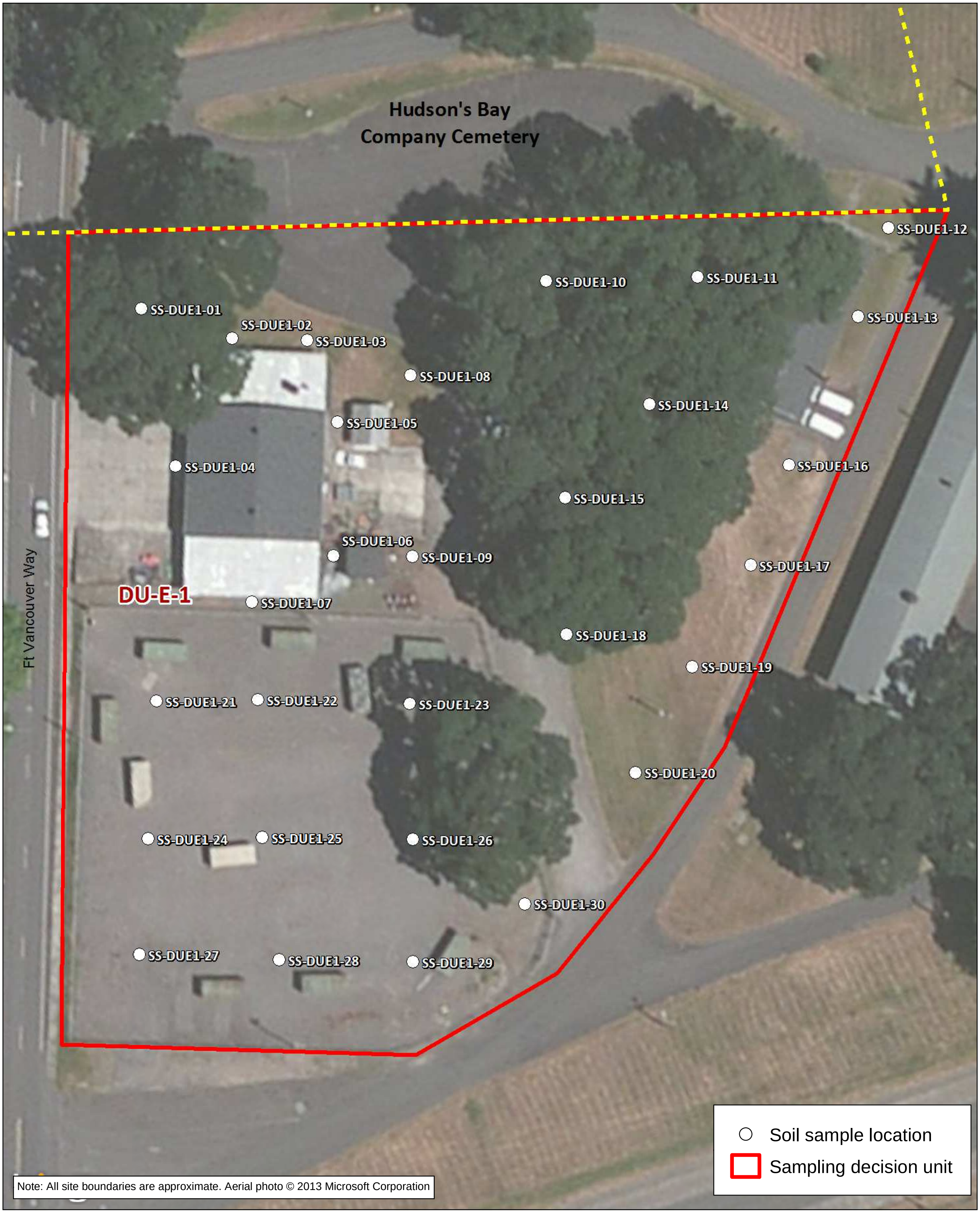

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N

0 50 100 Feet

0 10 20 Meters

Figure 6. DU-E-1: Soil sample locations

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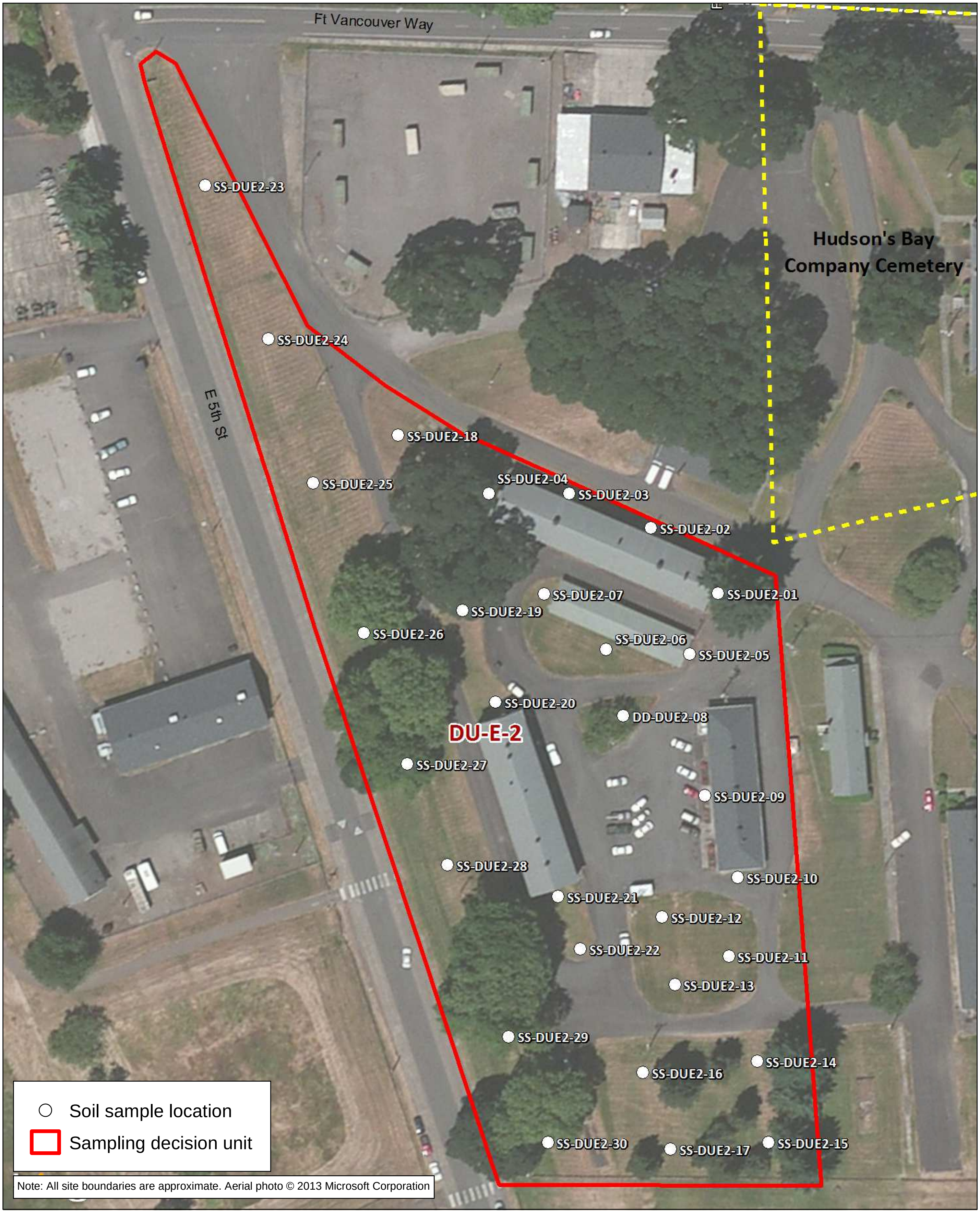

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0 50 100 Feet

0 10 20 Meters

Figure 7. DU-E-2: Soil sample locations

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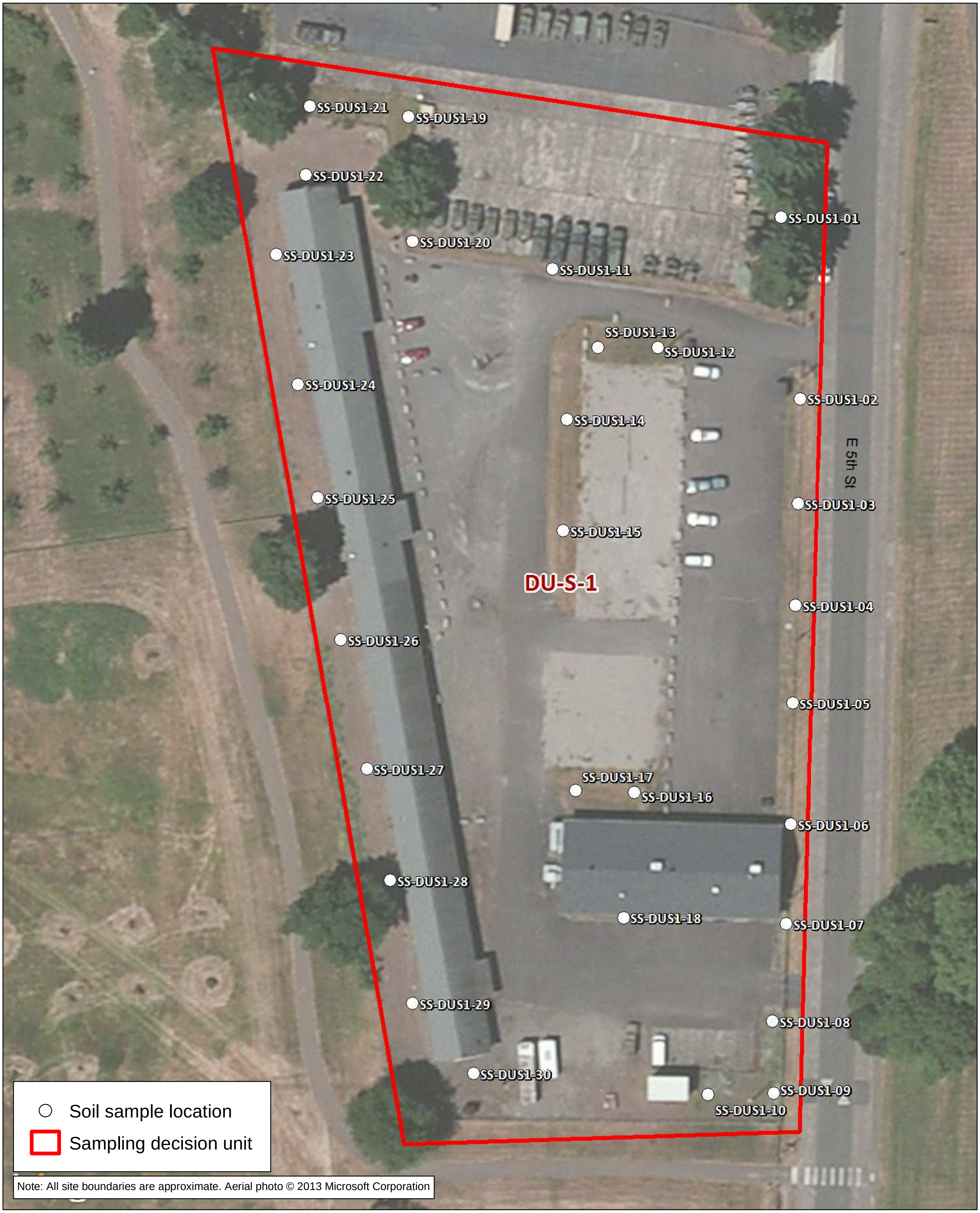

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N

0 50 100 Feet

0 10 20 Meters

Figure 8. DU-S-1: Soil sample locations

Based on previous characterization results, the composite soil samples for the DUs were submitted for laboratory analysis of the following constituents: lead, organochlorine pesticides, SVOCs, total petroleum hydrocarbons-diesel (TPH-D), total petroleum hydrocarbons-oil (TPH-O), and other metals (i.e., arsenic, cadmium, chromium, and mercury). Selected results for each of the DUs, including all detected concentrations of targeted analytes, are summarized in Table 2-1. Complete laboratory analytical reports are provided in Appendix A.

Table 2-1. Soil analytical summary

Chemical Name	Unit	SS-DU-E1	SS-DU-E1 Dup	SS-DU-E2	SS-DU-NE1	SS-DU-NE2	SS-DU-NE3	SS-DU-S1
Metals								
Arsenic[a]	mg/kg	*10 U*	*20 U*	*20 U*	*10 U*	*20 U*	*20 U*	*10 U*
Cadmium	mg/kg	1.5	1.8	1.7	2.1	1.4	1.4	1.5
Total chromium	mg/kg	21	21	18	20	22	20	16
Lead	mg/kg	157	156	266	1,890	410	258	152
Mercury	mg/kg	0.15 J	0.15	0.27 J	0.20 J	0.23 J	0.33 J	0.12 J
Pesticides								
4,4'-DDD	µg/kg	*19 U*	9.1 J	890	*18 U*	11 J	*17 U*	260
4,4'-DDE	µg/kg	12 J	11 J	720	16 J	*21 U*	6.5 J	110
4,4'-DDT	µg/kg	21	16 J	1,600	28	19 J	12 J	2,100
Total DDx	µg/kg	33 J	36 J	3,210	44 J	30 J	19 J	2,470
alpha-Chlordane	µg/kg	*9.5 U*	*7.8 U*	*11 U*	*9.2 U*	*10 U*	*8.5 U*	180 J
Petroleum								
TPH-D	mg/kg	82	95	81	92	140	73	100
TPH-O	mg/kg	410	380	350	380	470	300	450
SVOCs								
Benzo(a)pyrene	µg/kg	55	37 J	120	90	110	68	140
Total HPAHs	µg/kg	720 J	550 J	1,430	1,290	1,300	890 J	1,840
Total LPAHs	µg/kg	280 J	690 J	370 J	1,370	290 J	360	400
Total PAHs	µg/kg	1,000 J	1,240 J	1,810 J	2,650	1,590 J	1,250 J	2,250
cPAH TEQ[b]	µg/kg	82.0 J	61.0 J	180	142	170	100 J	210

Italic values indicate non-detects at laboratory detection levels.

[a] The detection limits presented in this table are equal to the laboratory reporting limits, which are significant to only one digit.

[b] The cPAH TEQ is a calculated sum of the concentrations of individual cPAHs scaled based on their toxicity relative to that of benzo(a)pyrene.

cPAH – carcinogenic polycyclic aromatic hydrocarbon
DDD – dichlorodiphenyldichloroethane
DDE – dichlorodiphenyldichloroethylene
DDT – dichlorodiphenyltrichloroethane
HPAH – high-molecular-weight polycyclic aromatic hydrocarbon
J – estimated concentration
LPAH – low-molecular-weight polycyclic aromatic hydrocarbon
PAH – polycyclic aromatic hydrocarbons
SVOC – semivolatile organic compound
total DDx – sum of all six DDT isomers (2,4′-DDD, 4,4′-DDD, 2,4′-DDE, 4,4′-DDE, 2,4′-DDT and 4,4′-DDT)
TEQ – toxic equivalent
TPH-D – total petroleum hydrocarbons-diesel
TPH-O – total petroleum hydrocarbons-oil
U – not detected at given concentration

2.1.2 Data validation

The laboratory analytical data reports were validated by a third party following the most recent EPA validation guidance (EPA 2008) and using the quality control (QC) summary forms provided by the laboratory. The results of the quality assurance review indicate that the analytical data are acceptable for use as qualified. A data validation report is provided in Appendix B.

2.2 SCREENING ASSESSMENT

This section presents the screening assessment for human health and ecological risks using default MTCA screening levels. Chemicals with detected concentrations greater than the applicable screening levels will be identified as chemicals of potential concern (COPCs), and will be evaluated further in the streamlined human health or ecological risk evaluations.

2.2.1 Human health

To determine COPCs for the protection of human health, detected concentrations in surface soil were compared with the MTCA Method A soil screening values for unrestricted land use (Table 2-2). These screening levels have been determined by Ecology to be protective of human health and are generally more protective than corresponding EPA screening values. Only those chemicals for which a MTCA Method A soil screening level is available are presented in this table. It should be noted that although benzo(a)pyrene is one of the chemicals included in the carcinogenic polycyclic aromatic hydrocarbon (cPAH) toxic equivalent (TEQ), the values for both of these chemicals are considered separately in this document for completeness.

Table 2-2. Human health screening assessment

Chemical Name	Soil Screening Level[a]	Unit	DU					
			DU-E-1[b]	DU-E-2	DU-NE-1	DU-NE-2	DU-NE-3	DU-S-1
Metals								
Arsenic[c]	20	mg/kg	*10 U/20 U*	*20 U*	*10 U*	*20 U*	*20 U*	*10 U*
Cadmium	2	mg/kg	1.5/1.8	1.7	**2.1**	1.4	1.4	1.5
Chromium (total)	2,000[d]	mg/kg	21/21	18	20	22	20	16
Lead	250	mg/kg	157/156	**266**	**1,890**	**410**	**258**	152
Mercury	2	mg/kg	0.15 J/0.15	0.27 J	0.20 J	0.23 J	0.33 J	0.12 J
Pesticides								
4,4'-DDT	3,000	µg/kg	21/16 J	1,600	28	19 J	12 J	2,100
Petroleum								
TPH-D	2,000	mg/kg	82/95	81	92	140	73	100
TPH-O	2,000	mg/kg	410/380	350	380	470	300	450
SVOCs								
Benzo(a)pyrene	100	µg/kg	55/37 J	**120**	90	**110**	68	**140**

Chemical Name	Soil Screening Level[a]	Unit	DU					
			DU-E-1[b]	DU-E-2	DU-NE-1	DU-NE-2	DU-NE-3	DU-S-1
cPAH TEQ	100[e]	µg/kg	82.0 J/61.0 J	**180**	**142**	**170**	100 J	**210**

Bold, highlighted values indicate detected concentrations greater than the applicable soil screening value.
Italic values indicate non-detects at laboratory detection levels.

a MTCA Method A soil screening value for unrestricted land use (WAC 173-340-900 Table 740-1).

b Values presented are for the original and duplicate sample from DU-E-1.

c Based on a review of the laboratory minimum detection limits, all of the non-detected arsenic results were below the screening level of 20 mg/kg.

d Soil screening level for chromium III. The rationale for the use of this screening level is presented in the text following this table.

e The soil screening value used for cPAHs is based upon value for benzo(a)pyrene.

cPAH – carcinogenic polycyclic aromatic hydrocarbon
DDT – dichlorodiphenyltrichloroethane
DU – decision unit
J – estimated concentration
MTCA – Model Toxics Control Act
SVOC – semivolatile organic compound
TEQ – toxic equivalent
TPH-D – total petroleum hydrocarbons-diesel
TPH-O – total petroleum hydrocarbons-oil
U – not detected at given concentration
WAC – Washington Administrative Code

As indicated in Table 2-2, the MTCA Method A screening level for chromium III (2,000 mg/kg) was used to evaluate total chromium concentrations (rather than the screening level for chromium VI [19 mg/kg]) based on the following considerations:

- There is no evidence to suggest that chromium VI is present at the site. Chromium III occurs naturally in the environment and is an essential nutrient, while chromium VI is produced as a result of industrial processes.
- A site-specific chromium speciation analysis was conducted for DU-NE-3. The results of this analysis found that chromium VI accounted for approximately 5% of the total chromium concentration.

Thus, there are no potential risks to human health based on exposure to chromium at the site. Additionally, the total chromium concentrations in soil at all of the DUs were less than the natural background concentration of 27 mg/kg for chromium that was established by Ecology for Clark County (Ecology 1994).

As shown in Table 2-2, the concentrations of arsenic, chromium, mercury, 4,4′-dichlorodiphenyltrichloroethane (DDT), TPH-D, and TPH-O were less than the respective screening levels for all DUs. Therefore, these chemicals were not considered further. Cadmium, lead, benzo(a)pyrene, and cPAH TEQ were detected at concentrations greater than the respective screening levels in at least one DU, and thus were identified as COPCs and retained for further evaluation.

2.2.2 Ecological

Before conducting a terrestrial ecological evaluation (TEE), it is necessary to determine whether a site needs an ecological evaluation and, if so, the degree of scrutiny required to ensure the protection of terrestrial ecological receptors at the site. The ESVB did not qualify for either exclusion from further evaluation[1], or from evaluation under a simplified TEE.[2] Thus, a TEE was conducted for the site according to procedures provided in MTCA (Ecology 2007).

To determine COPCs for the protection of ecological receptors, detected concentrations in surface soil were compared with MTCA ecological indicator soil concentrations for the protection of terrestrial plants and animals (Ecology 2007, Table 749-3). This comparison is presented in Table 2-3 for all detected chemicals for which ecological indicator soil screening levels are available.

Table 2-3. Ecological screening assessment

Chemical Name	Units	MTCA Ecological Indicator Soil Concentrations			DU					
		Plants	Soil Biota	Wildlife	DU-E-1[b]	DU-E-2	DU-NE-1	DU-NE-2	DU-NE-3	DU-S-1
Cadmium	mg/kg	4	20	14	1.5/1.8	1.7	2.1	1.4	1.4	1.5
Chromium (total)	mg/kg	42	42	67	21/21	18	20	22	20	16
Lead	mg/kg	50	500	180	**157/156**	**266**	**1,890**	**410**	**258**	**152**
Mercury (inorganic)	mg/kg	0.3	0.1	5.5	**0.15 J /0.15**	**0.27 J**	**0.20 J**	**0.23 J**	**0.33 J**	**0.12 J**
Total DDx	µg/kg	--	--	750	33 J/36 J	**3,210**	44 J	30 J	19 J	**2,470**
TPH-D	mg/kg	--	200	6,000	82/95	81	92	140	73	100
Benzo(a) pyrene	µg/kg	--	--	12,000	55/37 J	120	90	110	68	140

Bold highlighted values indicate soil concentrations greater than one or more of the MTCA ecological indicator soil concentrations.

[a] Values presented are for the original and duplicate sample from DU-E-1.

-- Indicates that no value has been established.

DDD – dichlorodiphenyldichloroethane

DDE – dichlorodiphenyldichloroethylene

DDT – dichlorodiphenyltrichloroethane

DU – decision unit

J – estimated concentration

MTCA – Model Toxics Control Act

total DDx – sum of all six DDT isomers (2,4′-DDD, 4,4′-DDD, 2,4′-DDE, 4,4′-DDE, 2,4′-DDT and 4,4′-DDT)

TPH-D – total petroleum hydrocarbons-diesel

The detected concentrations of cadmium, chromium, TPH-D, and benzo(a)pyrene were less than the respective TEE indicator values for listed terrestrial ecological receptors in

[1] The site did not qualify for exclusion for four reasons: 1) known site contaminants exist above the point of compliance, 2) contaminated soils are not, nor will be, covered with an impermeable surface, 3) contaminated soils - including those confirmed as contaminated with (DDT) comprise more than 0.25 ac of contiguous undeveloped land, and 4) contaminant concentrations are greater than natural background levels.

[2] The site did not qualify for a simplified TEE because it supports a population of Oregon white oak, a priority native species in the State of Washington (Larsen and Morgan 1998).

all DUs. Therefore, these chemicals were not considered further. Lead, mercury, and total (DDT) detected concentrations were greater than at least one detected concentration in the DUs, and thus were retained for further evaluation.

2.2.3 COPCs identified for further evaluation

Table 2-4 presents a summary of the results of the human health and ecological screening evaluations based on the MTCA Method A soil screening levels for unrestricted land use and the MTCA ecological indicator soil concentration, respectively. Only those chemicals for which the concentration in one or more DU was greater than the applicable screening level are shown in Table 2-4.

Table 2-4. Summary of screening assessment

Chemical	DUs with Soil Concentrations Greater than Default Screening Levels					
	DU-E-1	DU-E-2	DU-NE-1	DU-NE-2	DU-NE-3	DU-S-1
Human health						
Cadmium			X			
Lead		X	X	X	X	
benzo(a)pyrene		X		X		X
cPAH TEQ		X	X	X		X
Ecological						
Lead	X (plants)	X (plants, wildlife)	X (plants, soil biota, wildlife)	X (plants, wildlife)	X (plants, wildlife)	X (plants)
Mercury	X (soil biota)	X (soil biota)	X (soil biota)	X (soil biota)	X (plants, soil biota)	X (soil biota)
Total DDx		X (wildlife)				X (wildlife)

cPAH – carcinogenic polycyclic aromatic hydrocarbon
DDD – dichlorodiphenyldichloroethane
DDE – dichlorodiphenyldichloroethylene
DDT – dichlorodiphenyltrichloroethane
DU – decision unit
TEQ – toxic equivalent
total DDx – sum of all six DDT isomers (2,4′-DDD, 4,4′-DDD, 2,4′-DDE, 4,4′-DDE, 2,4′-DDT and 4,4′-DDT)

As shown, four chemicals (cadmium, lead, benzo(a)pyrene, and cPAH TEQ) were identified as COPCs for human health, and three chemicals (lead, mercury, and total DDx [the sum of all six DDT isomers (2,4′-DDD [dichlorodiphenyldichloroethane], 4,4′-DDD, 2,4′-DDE [dichlorodiphenyldichloroethylene]) 4,4′-DDE, 2,4′-DDT and 4,4′-DDT)]) were identified as COPCs for ecological receptors. These chemicals will be discussed further in the streamlined human health and ecological risk evaluations (Sections 2.3 and 2.4, respectively).

2.3 Streamlined Human Health Risk Evaluation

Based on the results of the human health screening assessment described in Section 2.2.1, lead, benzo(a)pyrene, cPAH TEQ, and cadmium were identified as COPCs, and will thus be evaluated further in this streamlined human health risk evaluation. This evaluation involved the calculation of site-specific cleanup levels, as provided for under MTCA and for which site-specific scenarios must be developed, or the consideration of additional information regarding potential risks associated with a given COPC (e.g., natural background considerations).

2.3.1 Site-specific exposure scenarios

A wide variety of human activities occur, or will occur, at ESVB, but the people participating in these activities can be grouped into two generic categories: site visitors and site workers. Health-protective exposure scenarios were developed for both of these categories.

2.3.1.1 Child site visitor

Site visitors can include both children and adults. Since, based on previous evaluations, lead is the primary COPC at ESVB and children are more vulnerable to the effects of lead than are adults, the site visitor scenario is based on children rather than adults. At present, site use of ESVB by children is likely to be rather infrequent, but increased usage is anticipated once planned development of the ESVB area occurs. Accordingly, a single scenario that is protective of both current and future child visitors was developed.

One key variable in the exposure scenario is exposure frequency to ESVB soils. The default MTCA exposure frequency, based on unrestricted or residential land use, is 365 days/year. Since residential site use is not anticipated at ESVB, this exposure frequency is overly protective. There are no available site-specific data on exposure frequency, particularly for future use, so an exposure frequency of once per week (i.e., 52 days per year) was selected based on best professional judgment. Given ESVB's non-residential characteristics and the types of activities contemplated in the master plan for the area (NPS 2011), this exposure frequency is expected to be protective of child and adult site visitors under all anticipated future uses.

Other exposure parameters for the child visitor scenario are assumed to be equal to the MTCA default values, as indicated in Table 2-5.

Table 2-5. Parameters for site-specific exposure scenarios

Parameter	Child Visitor		Adult Site Worker	
	Value	Source	Value	Source
Exposure frequency (days/yr)	52	best professional judgment (once per week)	104	best professional judgment (twice per week)
Exposure duration (yrs)	6	Ecology (2007)	20	Ecology (2007)
Body weight (kg)	16	Ecology (2007)	70	Ecology (2007)
Soil ingestion rate (mg/day)	200	Ecology (2007)	200	Ecology (2007)
Gastrointestinal absorption fraction (unitless)	1	Ecology (2007)	1	Ecology (2007)
Averaging time-cancer endpoint (days)	27,375	Ecology (2007)	27,375	Ecology (2007)

Ecology – Washington State Department of Ecology

2.3.1.2 Adult site worker

A variety of site workers are employed at ESVB, including archaeologists, maintenance workers, and groundskeepers. Additional types of site workers may be present at the site in the future, once planned developments occur. A single adult site worker scenario was established to be protective of both current and future adult site workers.

As with the child visitor scenario, the key variable reflecting site-specific conditions for the adult site worker scenario is exposure frequency. The exposure frequencies of current site workers were identified through an informal survey of FOVA staff; the results of this survey are summarized below.

For the maintenance crew, the primary activity requiring direct contact with soil is underground utility repair. This type of activity accounted for 190 man-hours in the 2012 fiscal year, and 196 man-hours so far in 2013; one additional week of direct soil contact is expected during the remainder of 2013. Based on these data, the current exposure frequency for the maintenance crew is no more than 30 days per year, assuming an 8-hour work day. Several members of the archaeological staff were exposed to ESVB soil for 8 weeks in the 2012 fiscal year, and are likely to be exposed for 10 weeks in 2013 and 4 to 6 weeks in 2014. Based on this information, the maximum exposure frequency for archaeological workers is 10 weeks per year, or 50 days per year.

To be protective of future site workers whose exposure frequency could be greater than that of current site workers, an exposure frequency of twice per week (i.e., 104 days per year) was selected to calculate site-specific cleanup levels for adult site workers. Other exposure parameters for the adult worker scenario are assumed to be equal to MTCA default values, as indicated in Table 2-5. Some site workers, particularly the maintenance workers and archaeologists identified above, are typically highly exposed to site soils because of the nature of their work. The calculation of site-specific cleanup levels based on potential limited residential use by adults (i.e., individuals who reside on the site for 3 months [approximately 90 days per year] or less during the year) is protective of future site workers. The soil ingestion rate given in Table 2-5 is expected to be protective of these workers, since it is a high-end value derived from studies of children playing in soil.

2.3.2 Chemical-specific evaluations

2.3.2.1 Lead

Health risks from lead exposure are typically evaluated with models approved for use by both EPA and Ecology. The Integrated Exposure Uptake Biokinetic (IEUBK) model (EPA 1994) was designed to evaluate the exposure of young children aged 0 to 6 years, which is considered to be the most sensitive age group. This model was used to calculate site-specific cleanup levels for lead for the child visitor scenario. The Adult Lead Model (ALM) (EPA 2003b) was designed to evaluate the exposure of adults, and to predict the transfer of lead from the blood of pregnant women to fetuses. The ALM was used to calculate site-specific cleanup levels for lead for the adult worker scenario. Lead has acute effects on both children and adults, but the developmental effects on young children that are the focus of the IEUBK model and the ALM occur at lower concentrations than do the acute effects. Accordingly, cleanup levels developed using these models are considered protective against acute effects.

As historically implemented, both the IEUBK model and the ALM utilize a target blood lead concentration of 10 µg/dl as a threshold below which development impacts are thought to be minimal. However, recent research suggests that adverse impacts could occur at blood lead concentrations lower than 10 µg/dl (Ecology 2010). Although MTCA rulemaking was suspended in 2011 because of budgetary considerations, Ecology's draft rule language indicated that a threshold of 5 µg/dl would be more health protective. Accordingly, 5 µg/dl was used as a target threshold for both the IEUBK model and the ALM.

Both the IEUBK model and the ALM assume continuous exposure in their default configurations. EPA has developed guidance to assess intermittent or variable exposure at sites where lead is a concern (EPA 2003a). The exposure frequencies developed for the site-specific exposure scenarios described above were used, in keeping with the method proposed in EPA guidance.

Child Visitor Scenario

Based on EPA's guidance for assessing intermittent or variable exposure to lead (EPA 2003a), the site-specific lead cleanup level for children was evaluated using the simple time-weighted approach presented in EPA's guidance document, reproduced here as Equation 1. The main premise of this approach is that because children are exposed to lead both at and outside of the site, both of these exposures should be considered when calculating a site-specific cleanup level.

$$\text{Weighted } PbC_{medium} = \sum_{i=1}^{n} C_i \times EF_i$$ **Equation 1**

where:

Weighted PbC_{medium}	=	Weighted lead concentration in medium (parts per million [ppm])
C_i	=	Media concentration at location *i* (ppm)
EF_i	=	Exposure frequency at location *i* (as unitless fraction)

To calculate a protective site-specific soil lead concentration, Equation 1 was used in conjunction with a target protective soil concentration derived from the IEUBK model (150 mg/kg) and a background concentration of 24 mg/kg. These values were derived as follows:

- **Target protective soil concentration** – The 150 mg/kg target was calculated using default values in the integrated exposure version of the IEUBK model (IEUBKwin32, version 1.1, build 11), which incorporates lead sources other than soil. A target blood lead concentration of 5 µg/dl and a probability of exceeding the target blood lead concentration of 5% were used in the IEUBK model. The target soil cleanup concentration of 150 mg/kg is at the approximate middle of those values considered by Ecology (2010) during recent deliberations associated with updating the MTCA rule.
- **Background concentration –** The background soil concentration for lead of 24 mg/kg is equal to the 90th percentile of soil lead concentrations from an Ecology (1994) study. This study evaluated background soil concentrations in Washington State, including in Clark County, where the ESVB site is located.

Equation 1 was rearranged to solve for a site-specific soil lead concentration that would yield a Weighted PbC_{medium} value of 150 mg/kg. This resulted in the calculation of a site-specific soil lead cleanup value for the child visitor scenario of 910 mg/kg.

Adult Worker Scenario

Site-specific cleanup levels for lead for the adult worker scenario were calculated using the ALM. The key calculations of the ALM are shown in Equations 2 and 3.

$$\text{Cleanuplevel} = \frac{PbB_{adult\_goal} - PbB_{baseline} \times AT}{BKSF \times SIR \times AF \times EF}$$ **Equation 2**

Where:

Cleanup level	=	soil lead cleanup level (mg/kg)
PbB_{adult_goal}	=	blood lead concentration in pregnant adult that is protective of fetus (µg/dl; calculated using Equation 3)
$PbB_{baseline}$	=	baseline blood lead concentration in pregnant adult, considering multiple sources [1.0 µg/dl, according to Ecology (2010)]
AT	=	averaging time (365 days/yr)

BKSF	=	biokinetic slope factor [0.4 µg/dl per µg/day lead uptake; default in ALM and also used in Ecology (2010)]
SIR	=	soil ingestion rate (200 mg/day, as given in Table 2-5)
AF	=	absorption fraction [0.12 (unitless); default in ALM and also used in Ecology (2010)]
EF	=	exposure frequency (104 days/yr, as given in Table 2-5)

$$PbB_{adult\_goal} = \frac{PbB_{fetal\_goal}}{GSD^{1.645} \times R_{fetal/maternal}} \qquad \textbf{Equation 3}$$

Where:

PbB_{fetal_goal}	=	protective blood lead concentration in fetus [(5 µg/dl, health-protective assumption per Ecology (2010)]
GSD	=	geometric standard deviation [1.8 (unitless); default in ALM and also used in Ecology (2010)]
$R_{fetal/maternal}$	=	fetal/maternal blood lead ratio [0.9 (unitless); default in ALM and also used in Ecology (2010)]

Using Equations 2 and 3, the site-specific lead cleanup level for the adult site worker scenario is 410 mg/kg.

Conclusions

The concentrations of lead in soil (Table 2-2) were compared to the calculated cleanup values (910 mg/kg for child visitors and 410 mg/kg for adult workers). The maximum lead concentration of 1,890 ppm at DU-NE-1 (as determined by analytical laboratory methods) exceeded the calculated site-specific cleanup values for both the child visitor and adult site worker scenarios. Thus, DU-NE-1 needs to be considered for the corrective action process for lead in soil.

The lead concentration at DU-NE-2 was equal to, but did not exceed the site-specific cleanup level for adult workers (410 mg/kg). Thus, this DU does not need to be considered for corrective action. Lead concentrations in the other DUs did not exceed these site-specific cleanup values.

2.3.2.2 cPAH TEQ and benzo(a)pyrene

Site-specific cleanup levels for cPAH TEQ and benzo(a)pyrene were calculated for both the child visitor and adult site worker scenarios according to MTCA Equation 740-5, which is reproduced here as Equation 4.

$$C_{soil} = \frac{Risk \times ABW \times AT}{EF \times ED\left[\left(\frac{SIR \times AB1 \times CPF_o}{10^6 mg/kg}\right) + \left(\frac{SA \times AF \times ABS \times CPF_d}{10^6 mg/kg}\right)\right]} \qquad \textbf{Equation 4}$$

Where:

C_{soil} = soil cleanup level (mg/kg)

Risk	=	acceptable cancer risk (1 in 1,000,000; unitless)
ABW	=	average body weight over the exposure duration (kg; see Table 2-5)
AT	=	averaging time (days/yr; see Table 2-5)
EF	=	exposure frequency (days/yr; see Table 2-5)
ED	=	exposure duration (years; see Table 2-5)
SIR	=	soil ingestion rate (mg/day; see Table 2-5)
AB1	=	gastrointestinal absorption fraction [1.0 (unitless)]
CPF_o	=	oral cancer potency factor (7.3 kg-day/mg)
CPF_d	=	dermal cancer potency factor (kg-day/mg, derived by CPF_o/GI)
GI	=	gastrointestinal absorption conversion factor [0.5 (unitless), per Ecology (2007)]
SA	=	dermal surface area [2,200 cm^2 for children, 2,500 cm^2 for adults, per Ecology (2007)]
AF	=	adherence factor [0.2 mg/cm^2-day, per Ecology (2007)]
ABS	=	dermal absorption fraction [0.1 (unitless), per Ecology (2007)]

Using Equation 4, the site-specific cPAH TEQ and benzo(a)pyrene soil cleanup levels are 670 and 420 µg/kg for the child visitor and adult site worker scenarios, respectively.

The cPAH TEQ and benzo(a)pyrene concentrations in soils (Table 2-2) were compared to the values calculated above. Concentrations of these two analytes were less than the calculated site-specific cleanup values in all of the DUs for both the child visitor and adult site worker scenarios. Thus, none of the DUs need be considered for the corrective action process based on cPAH TEQ or benzo(a)pyrene in soil.

2.3.2.3 Cadmium

The concentration of cadmium in DU-NE-1 (2.1 mg/kg) was just above the MTCA Method A soil screening levels for unrestricted land use (2 mg/kg), which is based on the protection of groundwater. This exceedance of the MTCA Method A screening level is located in the same DU as the highest lead concentration at the site. As discussed in Section 2.4.2.1, DU-NE-1 is already being considered for future corrective action based on the lead concentration. In addition, depth to groundwater at FOVA is more than 100 ft bgs (Tetra Tech 2009) therefore, it is unlikely that surface soil cadmium concentrations slightly above the MTCA Method A soil screening level would cause groundwater contamination.

Further, EPA's regional cadmium screening level for residential use is 70 mg/kg (EPA 2011). Cadmium concentrations in all DUs are well below this threshold, so adverse effects associated with the anticipated future use of the site (i.e., the adult and child scenarios described in Section 2.4.1) are not expected based on exposure to cadmium.

2.4 Streamlined Ecological Risk Evaluation

Based on the results of the ecological screening assessment described in Section 2.2, lead, mercury, and total DDx were identified as COPCs and will thus be evaluated further in this streamlined ecological risk evaluation. Section 2.4.1 presents the site-specific exposure pathways and ecological receptors, and Section 2.4.2 presents the site-specific TEE for the COPCs.

2.4.1 Site-specific exposure pathways and ecological receptors

Concentrations of COPCs were greater than their respective indicator values in shallow surface soils for the following terrestrial receptor guilds in at least one DU:

- Vascular plants
- Soil biota (earthworm)
- Wildlife:
  - Ground-feeding mammalian predators (shrew)
  - Ground-feeding mammalian herbivores (vole)
  - Ground-feeding avian predators (American robin)

These receptors could be exposed through either direct contact with soils or ingestion of contaminated prey. Therefore, risks to these guilds were further examined in the ecological evaluation.

2.4.2 Site-specific terrestrial ecological evaluation for COPCs

MTCA guidance and primary literature were reviewed for toxicity reference values (TRVs) for each of the receptor species guilds, and COPCs were identified for further evaluation. If more relevant TRVs were available in the primary literature, these alternative values were selected per MTCA guidance.

The selected TRVs were compared to soil exposure concentrations calculated according to the MTCA wildlife exposure model for site-specific evaluations (Ecology 2007, Tables 749-4 and 749-5).

2.4.2.1 Lead

Lead was identified as a COPC for further evaluation for plant, soil biota, and wildlife indicators.

For plants, a study of the effects of lead on the development of rye grass and fescue established a no-observed-effect concentration (NOEC) of 1,000 mg/kg, based on a reduction in clipping weight (Carlson and Rolfe 1979). This NOEC is greater than concentrations of lead in all DUs except DU-NE-1; therefore, the potential risk associated with the effects of lead on plants is considered to be low.

The primary literature did not provide alternative TRVs for soil biota that would have improved upon Ecology’s indicator concentrations for this receptor guild. Thus, Ecology’s recommended protective concentration of 500 mg/kg dry weight (dw) of lead in soil was accepted for soil biota.

The toxic effects of lead exposure on the offspring of rats, a common ground-feeding mammalian predator, included kidney damage and lower body weights (Azar et al. 1973). The study determined a lowest-observed-adverse-effect level (LOAEL) of 90 mg/kg body weight (bw)/day, which was substituted for the Ecology TRV; the result was a protective exposure concentration of 563 mg/kg dw of lead in soil for the mammalian predator. This value is greater than the detected lead concentrations at all DUs except DU-NE-1.

A concentration of lead in soil protective of the vole was calculated using Ecology's recommended TRV of 20 mg/kg bw/day. MTCA lists the vole's home range as 0.08 ac, so any individual's home range is assumed to lie entirely within a single DU. The resulting calculated protective concentration was 2,132 mg/kg dw, greater than the detected lead concentrations in all DUs.

The American robin generally migrates to wintering habitat in roughly mid-September, and returns in roughly mid-March (Sallabanks and James 1999). Based on these migratory habits, a practical annual site use of approximately 50% is assumed for the robin, which limits its time spent in northern breeding habitat to 6 months or fewer. Although MTCA lists the American robin's home range as 0.6 ac, ranges as large as 2.0 ac have been reported by other sources (Sallabanks and James 1999). Such larger home ranges are greater in size than most of the contiguous areas of undeveloped land within each of the DUs (which are broken up by roads, parking lots, and building complexes). As a result, any robins foraging within the DUs must include within their home ranges adjacent areas within a given DU, other DUs, or areas away from the site. The frequency of human activity at the site (including recreational foot traffic and vehicular road use) may further discourage robins from nesting and foraging in this area, and prompt them to seek out less active and more productive adjacent areas. Thus, 50% is a conservative estimate of site use by the American robin.

A study of the toxic effects of the ingestion of lead acetate on the reproduction of Japanese quail found a marked decrease in egg hatchability at a LOAEL of 20 mg/kg bw/day (Edens et al. 1976). When this LOAEL is interpreted using a site use factor of 50% (as described for the robin), the calculated protective concentration of lead in soil for the robin is 418 mg/kg dw, greater than the lead concentrations in all DUs except DU-NE-1.

Therefore, to be protective of the environment, lead remains a chemical of ecological concern in DU-NE-1. The recommended cleanup value for lead is 418 mg/kg, the lowest reviewed and calculated soil concentration.

2.4.2.2 Mercury

Mercury was identified as a COPC for further evaluation for plant and soil biota indicators.

In a review of plant toxicity studies, the Efroymson et al. (1997) plant benchmark compilation (upon which the MTCA ecological indicator concentrations for mercury in soil are based (Ecology 2007)) cited Kabata-Pendias and Pendias (1984) as reporting that unspecified toxic effects on plants grown in surface soil were observed at 0.3 mg/kg of mercury. However, a review of Efroymson et al. (1997) indicated that Kabata-Pendias and Pendias (1984) provided an overview of two papers: Shacklette et al. (1978) and Davis et al. (1978). Shacklette et al. (1978) reported observed mercury concentrations in plants, but no toxicity data. Davis et al. (1978) reported toxic effects (i.e., the reduction of plant yield of dry matter) on spring barley at 4 mg/L of mercury in solution, which resulted in a mercury in plant tissue concentration of 3 mg/kg dw. Based on the information provided in these papers, it is unclear how the 0.3 mg/kg of mercury in soil threshold cited in Efroymson et al. (1997) was derived. As a result, the estimated concentration of 0.33 mg/kg of mercury in soil at DU-NE-3 is considered to represent a low potential risk to the plant receptor guild.

For soil biota, a toxicity study was identified (Abbasi and Soni 1983) in which researchers assessed the effects of mercury on the survival and reproduction of earthworms. A LOAEL of 0.5 mg/kg dw was determined to cause a 65% reduction in earthworm survival and cocoon production; the number of juveniles produced by exposed earthworms was not affected. This LOAEL value is greater than detected concentrations of mercury in all DUs, so potential risk to the earthworm receptor guild is considered low in all DUs.

The conclusion of this evaluation of toxicological studies for these indicator guilds is that mercury should not be considered further as a chemical of ecological concern.

2.4.2.3 Total DDx

Total DDx was identified as a COPC for further evaluation for wildlife indicators. For ground-feeding mammals (the shrew and the vole), protective soil concentrations of total DDx were calculated using Ecology's recommended TRVs:[3] 3.7 mg/kg dw for the shrew and 734 mg/kg dw for the vole, both of which were greater than the detected total DDx concentrations in all DUs. The potential risk to these two receptor guilds is therefore considered to be low. As noted in the discussion for lead, the vole's home range (0.08 ac) is assumed to lie entirely within any single given DU. The MTCA-listed home range for the shrew is 0.1 ac, and thus is also assumed to lie entirely within any given single DU.

Toxicity studies pertaining to the effects of forms of DDT, DDD, and DDE on ground-feeding avian predators (i.e., American robin) were evaluated to select an appropriate TRV. A study of Japanese quail exposed to dietary technical-grade DDT (a common grade of insecticide composed of a combination of ingredients, including DDT, DDD, and DDE) resulted in reduced fertility, egg hatchability, and adult survival over four generations of exposure at a LOAEL of 3.0 mg/kg bw/day (Shellenberger 1978). When this LOAEL is substituted for the Ecology TRV, the result is a protective exposure

[3] Ecology's recommended TRVs are 8.79 mg/kg bw/day for the shrew and 6.72 mg/kg bw/day for the vole.

concentration of 2.6 mg/kg dw in soil. This value is greater than the detected concentration of total DDx in DU-S-1, but less than the detected concentration of total DDx in DU-E-2. However, as noted in the discussion of exposure to lead, actual site use by the robin is estimated to be only 50% due to migratory habits, home range, and human site activity. When interpreted for a site use of 50%, the calculated protective soil concentration for total DDx for the robin is 5.2 mg/kg dw, a value greater than the total DDx concentration detected in DU-E-2. Therefore, the potential risk to the avian predator receptor guild is considered to be low.

The conclusion of this evaluation of toxicological studies for these indicator guilds is that total DDT should not be considered further as a chemical of ecological concern.

2.5 SUMMARY OF STREAMLINED HUMAN HEALTH AND ECOLOGICAL RISK EVALUATIONS AND SOIL PRELIMINARY REMEDIATION GOALS

Based on the conclusions of the streamlined human health and ecological risk evaluations, lead was identified as the only chemical of concern (COC) at ESVB (Table 2-6). Lead exceeded the site-specific cleanup levels in DU-NE-1 only. Therefore, DU-NE-1 is the only DU for which removal action objectives and alternatives need to be developed.

Table 2-6. Summary of human health and ecological risk evaluations

Parameter	Summary of Human Health Risk Evaluation	Summary of Ecological Risk Evaluation	DUs that Exceed Site-specific Cleanup Levels
Cadmium	Unacceptable risks to human health are not expected. The cadmium concentration (2.1 mg/kg) slightly exceeded the MTCA Method A soil screening level (2 mg/kg), which is based on protection of groundwater, at only one DU. EPA regional soil screening levels for residential use are much higher than all cadmium concentrations at the site.	not of concern for ecological health[a]	none
Lead	Site-specific cleanup levels were calculated for adult site workers (410 mg/kg) and child visitors (910 mg/kg). The lead concentration at DU-NE-1 was greater than both of these values; no other DUs had concentrations that exceeded these levels.[b]	Site-specific cleanup level was calculated for American robin (418 mg/kg). The lead concentration in DU-NE-1 was greater than this value.	DU-NE-1 (based on both human health and ecological risks)
Mercury	not of concern for human health[c]	determined not to be of ecological concern after TEE	none
Total DDx	not of concern for human health[c]	determined not to be of ecological concern after TEE	none
Benzo(a) pyrene and cPAH TEQ	Site-specific cleanup levels were calculated for adult site workers (420 µg/kg) and child visitors (670 µg/kg). cPAH TEQs and benzo(a)pyrene concentrations were below these values for all DUs.	not of concern for ecological health[a]	none

[a] Soil concentrations for all DUs were below MTCA ecological indicator soil concentrations (see Table 2-3).

[b] The soil concentration in DU-NE-2 was equal to, but did not exceed the lowest applicable site-specific cleanup level for lead (410 mg/kg).

[c] Soil concentrations in all DUs were below the MTCA Method A screening levels (see Table 2-2).

cPAH – carcinogenic polycyclic aromatic hydrocarbon
DU – decision unit
EPA – US Environmental Protection Agency
MTCA – model toxics control act
TEE – terrestrial ecological evaluation
TEQ – toxic equivalent

The preliminary remediation goals (PRGs) for lead in soil at ESVB are based on the site-specific cleanup levels derived in the human health and ecological risk evaluations: 410 mg/kg lead for the adult site worker exposure scenario, 910 mg/kg lead for the child visitor exposure scenario, and 418 mg/kg lead for the American robin as the ecological receptor.

Further evaluation of human health screening levels relative to options for future use of the ESVB property was performed at the request of NPS and summarized in a memorandum (Appendix C). The memorandum includes a calculation of the maximum acceptable exposures (in days per year) for adults and children at each of the DUs within ESVB relative to lead, cPAH, TEQ, benzo(a)pyrene, and cadmium.

3 Identification of Removal Action Objectives

This section describes the objectives of the removal action. Removal actions can include a variety of activities undertaken to prevent, minimize, or mitigate damage to the environment or human health (USDOE 1994). For example, removal actions could include the use of surface water drainage controls, warning signs and fences, contaminated soil capping, or excavation of contaminated soils.

3.1 Statutory Limits on Removal Actions

Authority for responding to releases or threats of releases from an impacted site is addressed in Section 104(a) of CERCLA, 42 United States Code (USC) § 9604(a). Section 300.415 of the NCP specifically address NTCRAs.

3.2 Scope of the Removal for the Site

The scope of removal for ESVB is to comply with site-specific cleanup levels, attain conditions protective of human health and the environment, and maintain the effectiveness of the action over time through the use of institutional controls, if needed. The scope will be limited to directly dealing with the potential impacts of lead in soil from historical site activity at DU-NE-1.

3.3 Potential Schedules for the Removal at the Site

The schedule for removal activities will be determined by NPS and will be designed within a time frame that will ensure adequate protection of public and site worker health. Ideally, the timing of removal activities will be coordinated with the abatement of LBP remaining on buildings within DU-NE-1, thereby controlling potential sources of lead to soil before soil removal actions are implemented. This would provide the greatest opportunity for the long-term effectiveness of the removal action.

3.4 Potential Removal/Remedial Actions

Potential removal activities at the site will consist of tasks intended to reduce lead to concentrations protective of human health and the environment. Removal activities may include, but will not be limited to:

- No action
- Institutional controls
- Excavation and disposal of contaminated soils
- Capping of contaminated soils
- Treatment of contaminated soils
- Site restoration

Potential removal activities are detailed further in Sections 4, 5, and 6.

3.5 REMOVAL ACTION OBJECTIVES

Removal action objectives (RAOs) were developed based on the nature and extent of contamination described in Sections 2.1 and 2.2, as well as site-specific cleanup levels established by the streamlined human health and ecological risk evaluations (Sections 2.4 and 2.5, respectively). These analyses indicate that there is a single contaminant within ESVB for which RAOs must be established: lead in soil. The RAOs are 1) to minimize the potential for lead to impact human health, and 2) to protect the environment from exposure to lead.

3.6 APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS

This section presents a summary of applicable or relevant and appropriate requirements (ARARs) for the site. Consistent with CERCLA Section 121(d) and in compliance with NCP Section 300.415(j), CERCLA removal actions must, to the extent practicable considering the exigencies of the situation, attain ARARs under federal environmental or state environmental or facility siting laws at the completion or during the implementation of the removal action, or both depending on the nature of the requirements. In determining whether compliance with ARARs is practicable, the urgency of the situation, and the scope of the removal action to be conducted may be considered (40 CFR § 300.415(j)). Only those state standards and requirements that are promulgated, identified in a timely manner, and are more stringent than federal requirements may be applicable or relevant and appropriate (40 CFR § 300.400(g)(4)). In addition to ARARs, NCP Section 300.415(j) also provides that other federal and state advisories, criteria, or guidance may, as appropriate, be considered in formulating the removal action. Although not legally binding, these materials are "to be considered" (TBC). In response to a request by NPS, the Washington State provided a list of identified State ARARs (Appendix D) that may apply to potential response actions. These ARARs have been used to develop the ARARs set forth in this section of the EE/CA.

3.6.1 Definitions of "applicable" and "relevant and appropriate"

3.6.1.1 Applicable

Applicable requirements are those cleanup standards, standards of control, and other substantive requirements, criteria, or limitations promulgated under federal environmental, state environmental, or facility siting laws that specifically address a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance found at a CERCLA site (40 CFR § 300.5). In other words, applicable requirements are laws and regulations that would be enforceable at a particular site, even if there was no CERCLA response action taking place. Only those state standards identified by the state in a timely manner and more stringent than federal requirements may be deemed applicable.

3.6.1.2 Relevant and appropriate

Relevant and appropriate requirements are those cleanup standards, standards of control, and other substantive requirements, criteria, or limitations promulgated under federal environmental, state environmental, or facility siting laws that, while not "applicable" to a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance at a CERCLA site, address problems or situations sufficiently similar to those encountered at a CERCLA site that their use is well suited to that particular site (40 CFR § 300.5). Only those state standards identified in a timely manner and more stringent than federal requirements may be relevant and appropriate.

3.6.2 Chemical-, location-, and action-specific requirements

ARARs are divided into chemical-, location-, and action-specific requirements.

Chemical-specific ARARs are typically health- or risk-based numerical values or methodologies which, when applied to site-specific conditions, result in the establishment of numerical values. These values establish the acceptable amount or concentration of a contaminant that may be found in or discharged to the ambient environment. In the case of the FOVA ESVB, COCs are limited to lead in soil.

Location-specific ARARs relate to the geographic or physical location of the site, rather than the nature of the contaminants. These ARARs place restrictions on specific practices, such as the concentration of hazardous substances or the conduct of cleanup activities, due to the location of these practices within their environment.

Action-specific ARARs typically are technology- or activity-based requirements for actions taken with respect to hazardous substances. A particular response activity will trigger an action-specific ARAR. Unlike contaminant- or location-specific ARARs, action-specific ARARs do not determine the removal action alternative to be employed, but rather how the selected remedy must be achieved.

The removal action alternatives presented in this EE/CA were selected based on a combination of chemical-, location-, and action-specific ARARs.

3.7 SUMMARY OF POTENTIAL ARARS

Pursuant to its delegated CERCLA lead agency authority, NPS has identified ARARs and TBCs for the ESVB EE/CA. The results of the ARARs analysis are summarized in Tables 3-1, 3-2, and 3-3. Information provided by the State of Washington (Appendix D) was also considered in identifying potential ARARs.

Table 3-1. Chemical-specific potential ARARs

Standard, Requirement Criteria, or Limitation	Citation	Description	Applicable or Relevant and Appropriate?
Federal			
National Primary Drinking Water Standards, MCLs	Safe Drinking Water Act 42 USC §§ 300f et seq., 40 CFR Part 141	human health-based drinking water standards, MCLs for public water systems	Neither applicable nor relevant and appropriate; site groundwater and surface water are not currently used as drinking water and are not potential drinking water sources.
National Secondary Drinking Water Standards, Secondary MCLs	Safe Drinking Water Act, 42 USC §§ 300f *et seq.*, 40 CFR Part 143	establishes aesthetic drinking water standards (secondary MCLs) for public water systems	TBC if groundwater or surface water at Site were current or potential drinking water sources. Not TBC because Site groundwater and surface water are not currently used as drinking water and are not potential drinking water sources.
Toxic Substances Control Act, Residential Lead-Based Paint Hazard Reduction Act of 1992 (Federal rule for identifying dangerous levels of lead in soils)	40 USC §§ 745 *et seq.*	establishes a hazard standard for lead in soils	Applicable for the assessment and remediation of lead if a child-occupied facility is in one of the buildings at the Site.
Risk Assessment: Technical Guidance Manual (RSLs for Chemical Contaminants at Superfund Sites)	EPA/903/R-93-001	establishes chemical-specific concentrations for contaminants in air, drinking water, and soil that may warrant further investigation or site cleanup	TBC
Ecological Soil Screening Levels for Lead	OSWER Directive 9285.7-70	establishes concentrations of contaminants in soil that are protective of ecological receptors that commonly come into contact with and/or consume biota that live in or on soil	TBC
State			
MTCA (Washington State Cleanup Levels for Soils)	WAC §§ 173-340-740 and 173-340-745	establishes cleanup standards for unrestricted and industrial land uses	applicable
Washington Water Quality Standards for Surface water	Chapter 173-201A WAC	implements a system to impose effluent limitations on, or otherwise prevent, discharges of pollutants into any waters of the state from any point source	Surface water is not a medium present at the site; not applicable.

Standard, Requirement Criteria, or Limitation	Citation	Description	Applicable or Relevant and Appropriate?
Sediment Management Standards	Chapter 173-204 WAC	establishes sediment cleanup study plan requirements and sediment standards	Sediment is not a medium present at the site; not applicable.
Military Munitions – Dangerous Waste Regulations	Chapter 173-303 WAC	state-specific military munitions regulations under state's hazardous waste program regulations	Munitions are not a source or contaminant of concern at the site; not applicable.

CFR – Code of Federal Regulations
EPA – US Environmental Protection Agency
MCL – Maximum Contaminant Level
MTCA – Model Toxics Control Act
OSWER – Office of Solid Waste and Emergency Response
RCL – Regional Screening Level
TBC – to be considered
USC – United States Code
WAC – Washington Administrative Code

Table 3-2. Location-specific potential ARARs

Standard, Requirement Criteria, or Limitation	Citation	Description	Applicable or Relevant and Appropriate?
Federal			
NPS Organic Act	16 USC § 1	The Organic Act directs the NPS "to promote and regulate the use of . . . national parks . . . by such means and measures as conform to the fundamental purpose of the said parks . . . which purpose is to conserve the scenery and the natural and historic objects and the wild life therein and to provide for the enjoyment of the same in such manner and by such means as will leave them unimpaired for the enjoyment of future generations." Section 1a-1 further provides that "the protection, management, and administration of these areas shall be conducted in light of the high public value and integrity of the National Park System and shall not be exercised in derogation of the values and purposes for which these various areas have been established . . . ."	applicable
FOVA enabling legislation	62 Stat. 352 (1948) and 16 USC § 450ff-3	FOVA was established to preserve the historical features of the area for the benefit of the people of the United States.	applicable

Standard, Requirement Criteria, or Limitation	Citation	Description	Applicable or Relevant and Appropriate?
Solid Waste Disposal Sites in Units of the NPS	16 USC § 460*l*-22(c), 36 CFR Part 6	Applicable, *inter alia*, to the creation of any new solid waste disposal units within the boundary of a unit of the NPS, the regulations prohibit the operation of any solid waste disposal site, except as specifically provided for by the regulations. Prohibits the disposal within a NPS unit of solid waste containing specified materials including hazardous waste, PCBs, other CERCLA hazardous substances, or petroleum.	Applicable to the disposal of solid waste within park boundaries; none of the removal action alternatives contemplate such action at the Site.
National Park Resource Protection, Public Use and Recreation	36 CFR Part 2	This regulation prescribes and regulates various activities in National Parks. For example, Section 2.1 (a) prohibits "(1) Possessing, destroying, injuring, defacing, removing, digging, or disturbing from its natural state: (i) . . . wildlife or fish . . . . (ii) Plants or the parts or products thereof . . . . (2) Introducing . . . plants . . . into a park area ecosystem. (3) Tossing, throwing or rolling rocks or other items inside caves or caverns, into valleys, canyons, or caverns, down hillsides or mountainsides, or into thermal features." Section 2.2 (a)(2) prohibits "feeding, touching, teasing, frightening or intentional disturbing of wildlife nesting, breeding or other activities." Section 2.14 (a) prohibits "(1) Disposing of refuse in other than refuse receptacles. . . . (6) Polluting or contaminating park area waters or water courses."	relevant and appropriate to NPS activities
National Park Area Nuisance	36 CFR § 5.13	This regulation prohibits the creation or maintenance of a nuisance within a park area.	relevant and appropriate to NPS activities
Floodplain Management Order	Executive Order No. 11988	This regulation requires consideration of impacts on areas within the 100-year floodplain in order to reduce flood loss risks; minimize flood impacts on human health, safety, and welfare; and preserve and/or restore floodplain values.	Based on review of FEMA Flood Rate Insurance Maps, the ESVB is outside of the 100-year floodplain; not applicable.
Protection of Wetlands Order and Section 404 of the CWA	Executive Order No. 11990 and 33 USC § 1344(b)(1), 40 CFR Parts 230 and 231	This regulation requires consideration of impacts on wetlands in order to minimize their destruction, loss, or degradation, and to preserve/enhance wetland values; also prohibits the discharge of dredged or fill material into waters of the United States.	Not an ARAR; wetlands are not present on the site.

Standard, Requirement Criteria, or Limitation	Citation	Description	Applicable or Relevant and Appropriate?
National Historic Preservation Act	16 USC §§ 470 *et seq.*, 36 CFR Part 800	This regulation requires federal agencies to consider the effect of any federally assisted undertaking on any district, site building, structure, or object that is included in, or eligible for, the Register of Historic Places, and to minimize or mitigate reasonably unavoidable effects. Native American cultural and historical resources must be evaluated, and effects avoided, minimized, or mitigated.	applicable if a federal undertaking (i.e., cleanup) could adversely affect historic properties that are included in or eligible for inclusion in the National Register of Historic Places.
Historic Sites, Buildings, and Antiquities Act	16 USC §§ 461 *et seq*.	This regulation requires federal agencies to consider the existence and location of historic or prehistoric sites, buildings, objects, and properties of national historical or archaeological significance when evaluating response action alternatives.	applicable to Site response activities involving soil disturbance that could impact areas of historical or archaeological significance
Archaeological and Historic Preservation Act	16 USC §§ 469 *et seq*.	This regulation establishes requirements for evaluation and preservation of historical and archaeological data, including Native American cultural and historic data, which may be destroyed through alteration of terrain as a result of federal construction projects, *inter alia*. If eligible scientific, pre-historical, or archaeological data are discovered during site activities, such data must be preserved in accordance with these requirements.	applicable to Site response activities that could result in the discovery of archeological or historical resources
Archaeological Resources Protection Act	16 USC §§ 470aa-ii *et seq*., 43 CFR §§ 7.1 *et seq*.	This regulation provides for the protection of archeological resources located on public and tribal lands, and establishes criteria that must be met for the land manager's approval of any excavation or removal of archaeological resources if a proposed activity involves soil disturbances.	applicable to Site response activities involving soil disturbance

Standard, Requirement Criteria, or Limitation	Citation	Description	Applicable or Relevant and Appropriate?
NAGPRA	25 USC § 3001; 25 USC § 3002(d); 43 CFR §§ 10.1 – 10.17	This regulation provides for the disposition of Native American remains and objects inadvertently discovered on federal or tribal lands after November 1990. If the response activities result in the discovery of Native American human remains or related objects, the activity must stop while the head of the federal land management agency (in this case, NPS) and appropriate Native American tribes are notified of the discovery. After the discovery, the response activity must cease and a reasonable effort must be made to protect the Native American human remains or related objects. The response activity may later resume (43 CFR Section 10.4).	applicable if discovery of Native American remains and objects occurs during response action activities
Fish and Wildlife Coordination Act	16 USC §§ 661 *et seq*.	This regulation requires consideration of impacts on wildlife resources resulting from the modification of waterways.	Applicable to the diversion or other modification of waterways; none such modification is contemplated by any of the removal action alternatives.
Migratory Bird Treaty Act	16 USC§§ 703 *et seq*.	This regulation establishes a federal responsibility for the protection of the international migratory bird resource and requires continued consultation by NPS with USFWS during removal action design and construction to ensure that the cleanup of the site does not unnecessarily impact migratory birds.	Applicable; migratory birds have been identified in the vicinity of the Site. However, no threatened or endangered species or critical habitat areas have been identified at FOVA.
Responsibilities of Federal Agencies to Protect Migratory Birds	Executive Order 13186, 66 Fed. Reg. 3853 (Jan. 17, 2001)	This Order directs executive departments and agencies to take certain actions to further implement the Migratory Bird Treaty Act, including supporting the conservation intent of the migratory bird conventions by integrating bird conservation principles, measures, and practices into agency activities, and by avoiding or minimizing, to the extent practicable, adverse impacts on migratory bird resources when conducting agency actions.	Applicable; migratory birds have been identified in the vicinity of the Site.

Standard, Requirement Criteria, or Limitation	Citation	Description	Applicable or Relevant and Appropriate?
ESA	16 USC §§ 1531 – 1544, 50 CFR Part 402	Any federal activity or federally authorized activity may not jeopardize the continued existence of any threatened or endangered species known to live or to have lived in the affected environment or destroy or adversely modify a critical habitat. This ARAR requires NPS to ensure that the selected remedy is sufficiently protective of the environment containing the threatened or endangered species, with an emphasis on reducing the risks from the contaminants of concern to the listed species described in the ecological risk assessment to an acceptable level, with consideration given to the special status of the listed or threatened species. It also requires NPS to ensure that the selected remedy is implemented in a manner such that effects on any existing threatened or endangered species are avoided or mitigated.	Not applicable; no federally listed threatened or endangered species have been identified at or in the vicinity of the Site.
FOVA General Management Plan 2003	Final General Management Plan	FOVA was established to preserve historical features of the area for the benefit and inspiration of the people.	TBC
Plan for ESVB	Master Plan and Environmental Assessment and Finding of Significant Impact	This document establishes a plan for the ESVB.	TBC
Plan for Cultural Landscape	Vancouver National Historic Reserve Cultural Landscape Report, October 2005	This document provides a detailed analysis of the landscape characteristics that contribute to historic significance of the Historic Reserve and sets forth treatment recommendations for the preservation of the Historic Reserve's cultural landscape.	TBC
Cooperative Management Plan	Vancouver National Historic Reserve Cooperative Management Plan, 2000	This document provides for the cooperative administration of the Vancouver National Historic Reserve.	TBC
State			
Shoreline Management Act and Regulations	Chapter 173-27 WAC and Chapter 90.58 RCW	This regulation regulates activities conducted on most shorelines of the state, including marine waters, streams and rivers, lakes and reservoirs, associated wetlands, and portions of the flood plains.	Project is not within a shoreline area; not applicable.

Standard, Requirement Criteria, or Limitation	Citation	Description	Applicable or Relevant and Appropriate?
Hydraulics Project Approval Regulations	Chapter 220-110 WAC	This regulation regulates any work within designated shoreline that changes the natural flow or bed of the water body and therefore has the potential to affect fish habitat.	Project is not within a regulated waterway; not applicable.
Archaeological and Historical Preservation Act	Chapter 27.34 RCW	This regulation provides for the protection and preservation of sites and buildings listed on state or federal historic registries.	Regulation is addressed through federal regulation; not an ARAR.
Archaeological and Cultural Resources Act	Chapter 27.53 RCW	This regulation provides for the preservation of cultural or archaeological data which might be destroyed or lost as the result of site activities.	Regulation is addressed through federal regulation; not an ARAR.

ARAR – applicable or relevant and appropriate requirement
CERCLA – Comprehensive Environmental Response, Compensation, and Liability Act
CFR – Code of Federal Regulations
CWA – Clean Water Act
ESA – Endangered Species Act
ESVB – East and South Vancouver Barracks
FEMA – Federal Emergency Management Agency
FOVA – Fort Vancouver National Historic Site
PCB – polychlorinated biphenyl
NAGPRA – Native American Graves Protection and Repatriation Act
NPS – National Park Service
RCW – Revised Code of Washington
TBC – to be considered
USC – United States Code
USFWS – US Fish and Wildlife Service
WAC – Washington Administrative Code

Table 3-3. Action-specific potential ARARs

Standard, Requirement Criteria, or Limitation	Citation	Description	Applicable or Relevant and Appropriate?
Federal			
Clean Air Act, NAAQS	42 USC §§ 7409-7410; 40 CFR Part 50	NAAQS regulate ambient air quality to protect public health and welfare.	Relevant and appropriate; may be applicable if activities generating dust are required, or if a MPE system is used.
Federal Water Pollution Control Act (CWA)	33 USC §§ 1251 *et seq.*	This regulation establishes requirements for hazardous substance discharges to nation's waters.	neither applicable nor relevant

Standard, Requirement Criteria, or Limitation	Citation	Description	Applicable or Relevant and Appropriate?
RCRA Subtitle C Requirements	42 USC §§ 6921 *et seq.*; 40 CFR Part 260 *et seq.;* 49 CFR Part 171 *et seq.*	This act regulates the generation, transportation, treatment, storage, and disposal of hazardous wastes. Because all wastes currently located at the Site were deposited before November 19, 1980, RCRA Subtitle C requirements will apply only to hazardous wastes generated, transported, or disposed of on-site as part of the Site removal action activities. Consolidation of wastes within a RCRA "Area of Contamination" does not constitute disposal. Off-site transportation and disposal are subject to applicable RCRA and Hazardous Materials Transportation Act requirements.	Certain provisions may be relevant and appropriate if Subtitle C wastes are generated, disposed of, or transported off-site.
RCRA Subtitle D Requirements	42 USC §§ 6941 *et seq.*; 40 CFR Part 239 *et seq.*	This regulation provides minimum technical criteria for state and local governments for the management and disposal of household, industrial, and commercial non-hazardous solid wastes.	Relevant and appropriate; non-hazardous soil and other wastes may be managed at an off-site solid waste facility.
DOT HMRs	49 CFR Parts 171-180	This regulation specifies DOT-related requirements for shipping of hazardous materials. Note: hazardous waste transporters are also regulated under RCRA (see above).	Certain provisions may be relevant and appropriate if hazardous waste are transported or shipped off-site.
OSHA	29 USC §§ 651	This regulation specifies measures applicable to cleanup sites to ensure that site workers are protected from hazards such as exposure to toxic chemicals, excessive noise levels, mechanical dangers, heat or cold stress, or unsanitary conditions	applicable to soil cleanup actions
State			
SEPA	Chapter 43.21C RCW and Chapter 197-11 WAC	Cleanup actions under MTCA rules must comply with the provisions SEPA regulations.	addressed through NEPA; not applicable
Washington State Industrial Safety and Health Act	Chapter 296-62 WAC	This regulation provides standards for workers and the workplace to ensure worker and workplace safety.	addressed through OSHA regulations; not applicable
Washington State Hazardous Waste Management Act and State Dangerous Waste Regulations	Chapter 70.105 RCW *et seq.* and WAC §§ 173-303-010 *et seq.*	This regulation establishes a comprehensive statewide framework for the planning, regulation, control, and management of hazardous waste. Regulations are applicable to the identification and disposal of wastes that are moved outside the area of contamination and are designated as federally hazardous or dangerous under state regulations.	Discrete requirements are relevant and appropriate and some may be applicable, especially for waste transported off-site for disposal in Washington State.

Standard, Requirement Criteria, or Limitation	Citation	Description	Applicable or Relevant and Appropriate?
Washington Solid Waste Management Act Regulations	Chapter 173-350 WAC	These regulations are applicable to the management and disposal of waste materials that are not Washington State-designated dangerous waste or federally designated non-hazardous. They provide minimal functional standards for solid waste handling.	Discrete requirements are relevant and appropriate and some may be applicable.
Washington Clean Air Act and Regulations	Chapter 70.94 RCW and Chapter 173-400-040	This regulation establishes standards and rules generally applicable to the control and/or prevention of the emission of air contaminants.	Discrete requirements are relevant and appropriate and some may be applicable.
State Water Pollution Control Act	Chapter 90.48 RCW	This regulation establishes requirements for hazardous substance discharges to state waters.	neither applicable nor relevant

CFR – Code of Federal Regulations
CWA – Clean Water Act
DOT – Department of Transportation
HMR – Hazardous Materials Regulation
MPE – multi-phase extraction
MTCA – Model Toxics Control Act
NAAQS – National Primary and Secondary Ambient Air Quality Standards
NEPA – National Environmental Policy Act
OSHA – Occupational Safety and Health Act
RCRA – Resource Conservation and Recovery Act
RCW – Revised Code of Washington
SEPA – State Environmental Policy Act
USC – United States Code

4 Identification of Applicable Removal Action Alternatives

Remedial action technologies will address visitor (including child and adult) and site worker (i.e., adult) exposure to lead in soils, as well as the environmental impacts of lead in soils at DU-NE-1, by reducing the likelihood of exposure. The purpose of this section is to identify and screen technologies to be considered for the remediation of lead in site soils. Retained technologies are used for the further development and evaluation of removal action alternatives in Section 5.

4.1 Institutional Controls

Control measures that are social in nature can be as effective as remedial technologies in preventing human exposure to metals. Therefore, institutional controls (ICs), such as site worker health education and access restrictions, are included in this section along with technologies. ICs may be developed to reduce or prevent exposure to contamination in soil, or to protect the remedy where contaminants are left in place and documented as part of an ICs implementation plan.

4.1.1 Site worker health education

Site worker health education involves distributing information about lead exposure to those working in areas affected by lead in soils. Education can alert workers to issues such as exposure routes, sources of lead, people at risk, and preventative measures. As an example of this type of control, NPS has developed a health and safety protocol to minimize exposure to lead-contaminated soil during archaeological investigations at ESVB (Windward 2012c).

Educating site workers can be used as a supplemental action to reduce exposure and decrease risk. Education is appropriate because the primary exposure route, ingestion, is controllable. Specific education activities that may prove effective in reducing exposures include holding meetings, training, and providing literature. Education, especially if it is the primary means of reaching remediation goals, must be an ongoing process.

Typically, health education is not a stand-alone remedy, but is used as a supplemental action in conjunction with an engineered action. Health education activities would be useful in addressing initial site risks as the remedy is being implemented; then, as contamination cleanup is completed, these activities could be phased out.

4.1.2 Access restrictions

Access restrictions, in the form of either physical barriers or legal stipulations, can help prevent physical contact with contaminated soils. General activities associated with these restrictions are:

- Physical access restrictions – Physical access restrictions may include fencing, no trespassing signs, or security guards.

- Legal access restrictions – Legal access restrictions may include deed notices, zoning, and building restrictions. For facilities owned or controlled by federal entities such as NPS, and where deed notices are not feasible, the restrictions are commonly listed in the facility's master plan documents. Legal restrictions are typically used to deal with contamination left on-site that is addressed through the use of controls at the completion of the remedial action. These controls may include restrictions such as zoning or permit requirements for future construction to ensure that contaminated soil is managed properly. The effectiveness of legal access restrictions is limited by the ability to enforce the specific control.
- Site use – Limiting site use includes maintaining the site as part of a park facility in order to ensure that current exposure assumptions remain correct. Any further development of the site would require additional evaluation of site conditions and intended use.

4.2 Soil Excavation and Disposal

4.2.1 Excavation

Excavation prevents human contact with soils by physically removing soils for disposal. Contaminated site soils can be either totally or partially removed. Soil excavation may be difficult and costly, particularly where site surfaces include trees, shrubs, walkways, subsurface utilities, and access roads. In addition, given the significant cultural resources present at the FOVA site, excavation presents additional challenges and potential costs. Extensive excavation in sensitive areas could pose a significant risk to irreplaceable artifacts or site conditions that must be preserved for future generations. At the same time, limited or "focused" soil removal can be an effective means of selectively removing shallow contamination and/or installing a soil cover (e.g., a cap), without unacceptably modifying the ground surface elevation or putting at risk cultural resources.

4.2.2 Disposal

Disposal options must be considered as a means of managing soils generated during excavation. The lead-contaminated soils removed from DU-NE-1 would require disposal at an appropriate facility. Several options exist for the disposal of lead-contaminated soil from the site, and are discussed in the following subsections.

4.2.2.1 Off-site disposal

Removed soils will be disposed of off-site at an appropriate disposal facility. The downsides to using an off-site disposal facility are possible regulatory constraints and cost. Off-site disposal will incur added transportation expenses and disposal fees at the assigned landfill.

Archived soil samples collected from DU-NE-1 and DU-NE-2 as part of this EE/CA were submitted for lead toxicity characteristic leaching procedure (TCLP) analysis for general information purposes related to soil disposal. The samples from these DUs were selected for TCLP analysis because they had the highest soil lead concentrations of all the DU samples. The results for both samples (1.4 mg/L for DU-NE-1 and 0.1 U [not detected at given concentration] mg/L for DU-NE-2) were well below the TCLP lead limit of 5 mg/L. Additional TCLP testing of removed soils may be required by the disposal facility. If any of the excavated and stockpiled soils fail this test, they will require either disposal as a hazardous material, or pretreatment (e.g., stabilization to reduce lead leachability) prior to disposal.

4.2.2.2 Pre-disposal soil stabilization

Technologies are available to chemically stabilize leachable and oxidized heavy metals, such as lead, rendering them relatively inert to environmental influences. Stabilization of soil with lead concentrations in the general range of those observed at FOVA greatly improves the likelihood that the soil will pass the TCLP test limit and allow for disposal of the material as a non-state-designated dangerous waste and non-hazardous waste. The cost savings of stabilization compared to those of managing soil as a dangerous or hazardous waste are significant. As described in Section 4.2.2.1, TCLP tests of archived soil samples from DU-NE-1 and DU-NE-2 indicated leachable lead concentrations well below the concentration that would categorize the soil as hazardous (5.0 mg/L). Therefore, pre-disposal soil stabilization is not anticipated to be necessary, but would be an option to avoid or reduce hazardous waste disposal requirements. Stabilization technologies are discussed further in Section 4.4.

4.3 SOIL CAPPING TECHNOLOGIES

Capping prevents direct human contact with lead contamination in soil. Technologies used for capping include:

- Soil
- Pavement
- Geosynthetic barriers
- Vegetation

The majority of DU-NE-1 is already effectively capped due to the presence of buildings and paved areas (Figure 3). Additional capping technologies may be used alone or in combination with other methodologies (e.g., selective soil excavation) to prevent human and/or ecological-related exposure to lead in soil. Each of the capping technologies is described in the following subsections.

4.3.1 Soil

Soil caps are generally constructed using either simple topsoil covers or low-permeability clay layers to prevent human contact with and transport off-site of soils.

Simple topsoil caps can be used to cover contaminated soil directly with a protective layer, preventing human contact with the underlying contaminated soils. Other materials, such as crushed rock, pavement, or other physical barriers, can also be used as soil caps, and are allowed under MTCA (an ARAR) as a means to prevent certain potential ecological-related exposures. The advantage of capping is that deeper, less-contaminated soils remain in place, thereby reducing excavation-related issues and costs associated with transport and disposal. The use of a cap significantly reduces the potential to disturb buried cultural resources, and at the same time protects human and ecological receptors from contact with contaminated soils.

Based on the ecological risk evaluation (Section 2.5), the American robin is the only ecological receptor at risk from site soil lead concentrations. Soil capping using a variety of materials would be expected to prevent direct contact between the American robin and underlying soils. One drawback of in-place capping is that it would raise the landscaping level 6 to 12 in., which could create problems regarding correct contouring to existing driveways, walkways, and below-grade access to buildings. However, these problems can be off-set and the desired finished grade achieved by selective soil removal and/or grading prior to cap placement.

Low-permeability clays used as capping materials have the drawback of poor drainage, potentially affecting building foundations, walkways, and access roads. Low-permeability caps are typically employed where water infiltration needs to be limited to address leaching and protect underlying groundwater. At this site, the predominant contaminant is lead which has a low partitioning coefficient and therefore does not readily leach into percolating groundwater. The depth to groundwater in the site vicinity is greater than 100 ft (Tetra Tech 2009), and therefore it is highly unlikely that soluble lead from shallow soil contamination would be transported to the water table.

4.3.2 Pavement

Asphalt and concrete pavements and foundations, if properly maintained and constructed, are recognized as effective barriers to direct exposure of human and ecological receptors to underlying soil. Pavements at the FOVA site, including sidewalks and parking lots, are maintained in good condition and can continue to be relied upon as an effective cap for low-level contaminated soil. Pavements are checked periodically as part of the facility’s maintenance program to determine if repair or patching is needed.

4.3.3 Geosynthetic barriers

Geosynthetic barriers can be constructed of geotextile fabrics and/or geomembrane sheeting. Geotextile fabrics are woven from synthetic material and made to withstand both chemical degradation and biodegradation. The fabric is laid over untreated or undisturbed soils, effectively separating them from clean fill material with a physical and visual barrier. Geomembranes can be used instead of or in conjunction with geotextile fabrics, and provide physical barriers to vapor or liquid migration. The advantage of these barriers is that a site worker digging in a remediated area with contamination at depth would be made aware of the contamination by the presence of the barrier. Geosynthetic barriers also inhibit the migration of earthworms and other small soil biota beyond the barrier depth, thus reducing their contact with the contaminated soils beneath the barrier and protecting ecological receptors, like the American robin, from ingesting contaminated prey.

4.3.4 Vegetation

Vegetative covers such as sod can prevent human contact with contaminated soils by creating a physical barrier. Roots from cover plants hold the soil in place, preventing erosion and off-site transport by surface runoff or wind. Vegetative covers alone may be appropriate for soils with low concentrations of metals, but may also be used in conjunction with clean fill or geotextile fabrics. The advantage of a vegetative cover is that grass grows well at the site and, with proper maintenance, can be an effective barrier. Routine maintenance (i.e., mowing, watering, and fertilizing) is necessary to maintain the vegetative cover. An additional disadvantage of a grass-only cover is that the protective layer is relatively thin, and without proper maintenance, the grass can die and potentially re-expose contaminated soil.

4.4 Soil Treatment

The soil treatment technologies most relevant to the removal action alternatives for ESVB are those that chemically stabilize leachable or oxidizable heavy metals, such as lead, rendering them relatively inert to environmental influences. Two types of *in situ* soil stabilization will be discussed: pozzolanic stabilization and phosphate stabilization.

4.4.1 *In situ* Stabilization

In situ stabilization refers to the treatment of soils with chemical agents to either fix metals in place or form complexes that make metals less toxic. Two methods of *in situ* stabilization appropriate for lead contamination are pozzolanic stabilization and phosphate stabilization. These treatment technologies are both used routinely, and are described in the following subsections.

4.4.1.2 Pozzolanic stabilization

Pozzolanic stabilization is the addition of a solidifying agent, such as Portland cement or fly ash, to soils to form a monolith, similar to concrete. The pozzolan is injected into the soil in the form of a slurry mixture, then mixed with an auger. The resulting monolith lessens the leachability and mobility of metals in soils by reducing soil particle surface area, and inhibits human and environmental contact by encapsulating soils. The advantage of pozzolanic stabilization is that treatment materials are inexpensive and readily available. The limitations of in-place pozzolanic stabilization include impermeable surfaces and increased material volume, which, at ESVB, would change the elevation of yards.

4.4.1.3 Phosphate stabilization

Phosphate addition is a chemical stabilization procedure by which phosphate salts or other phosphate-bearing materials, in either solid or liquid form, are added to and mixed with soils. Phosphate ions combine with lead to form the less soluble lead phosphate complexes. The formation of lead phosphates, such as pyromorphite, occurs naturally in the presence of sufficient concentrations of phosphate and lead. Lead phosphates are highly stable lead minerals that have been demonstrated to be less bioavailable due to their low solubility. Although the metals are not removed from the site, they become less bioavailable to humans and the environment, since lead that occurs in soil as lead phosphate is less likely to be absorbed when ingested. Phosphate stabilization is routinely used to treat metals in soil for disposal purposes. The technology is, however, new to soil treatment for the reduction of bioavailability when soil is left in place.

The transformation of lead carbonates (a more soluble and bioavailable form of lead) to lead phosphates depends on the ability to distribute the phosphates in the soil. Solid or liquid phosphates could be applied by mixing (i.e., rototilling or discing) them into the top 6 to 10 in. of soil. This method of application requires placement of new sod following the phosphate addition. Liquid spray or dry surface application could be implemented easily and would not require any soil removal or disturbance, but its effectiveness would be limited by soil infiltration rates. Mixing technologies would be significantly more expensive than surface application. Multiple or seasonal phosphate additions could be necessary to control phosphate losses due to natural weathering, or to enable surface applications to reach lower depths.

The advantages of phosphate addition are ease of application and reduced volumes of soils requiring removal and disposal. Although recently completed bench-scale studies suggest that phosphate addition would effectively reduce the bioavailability of lead in some soils, additional treatability testing would be necessary to further evaluate the effectiveness, feasibility, and dosage requirements of this emerging technology.

4.5 SITE RESTORATION

In any areas where excavation and/or capping is conducted, site restoration will likely be required. Site restoration will consist of returning the area to its original grade, or to a grade that is compatible with the surrounding area; providing drainage measures if needed; and planting grass, native plants, or other landscaping materials suitable to the cultural and historical landscape.

5 Screening of Identified Technologies

This section presents the screening of the remedial technologies (identified in Sections 4.1 through 4.5) for further consideration in developing comprehensive remedial actions to address site risks.

5.1 INSTITUTIONAL CONTROLS

5.1.1 Site worker health education

Health education is readily implementable, and has been shown to reduce blood lead concentrations if efforts are sustained. Health education, particularly for site workers, will be retained for consideration in developing remedial alternatives to address site risks.

5.1.2 Access restrictions

Physical restrictions such as fencing, and legal restrictions such as deed notices, are not currently applicable to the buildings and surrounding grounds at DU-NE-1. Therefore, physical access restrictions will not be retained for consideration as part of an alternative to address lead contamination in soil at the site. The current and future expected use of the site as a park and historical resource is expected to include inherent controls on some types of otherwise unrestricted access (e.g., unauthorized digging). Restrictions can also be described in the facility's master plan.

5.2 EXCAVATION AND DISPOSAL

Excavation and disposal of contaminated soil is an accepted and commonly utilized technology for addressing site risks. Excavation is easily implementable with readily available equipment, and limiting the extent of excavation would aid in the preservation of buried cultural resources.

5.2.1 Complete excavation

Complete excavation would entail the excavation of soil to a predetermined depth for all unpaved surfaces within the DU-NE-1. An estimate of exposed soil surface area at DU-NE-1 is 0.46 ac, or roughly 20,038 ft^2. Assuming a complete removal of the top 6 in. of soil, the volume of soil involved in this removal action alternative is calculated as follows:

$$\text{Area } (ft^2) \times \text{Depth } (ft) = \text{Volume } (ft^3) \times 0.037037 = \text{Volume } (yd^3)$$

$$20{,}038\ ft^2 \times 0.5\ ft = 10{,}019\ ft^3 \times 0.037037 = 371.07\ yd^3$$

If excavated, the removed soil would be multiplied by a swell factor of 1.25 for a volume of 464 yd^3. Assuming that 1 yd^3 of moist soil weighs approximately 1.25 tons, the approximate weight of soil excavated during a complete removal remediation will would be 580 tons. Additional quantities of soil could be removed if post-removal testing indicated a need. For example, MTCA specifies a default soil removal depth of up to 15 ft if required to meet cleanup levels for unrestricted site use. This could increase the mass of soil to be removed by a factor of 30.

Complete excavation may not be appropriate at ESVB, as soils containing low concentrations of lead with little associated risk would be removed along with soils containing higher concentrations, and as the risk of impacting buried cultural resources would increase with the size of the area to be excavated. Complete removal is not considered further in this EE/CA because of the associated higher costs and the potential impact on buried cultural resources at the site. Removal of soil to a depth greater than 6 in. would significantly increase the cost of soil characterization, handling, transport, and disposal, but would have a disproportionately small positive effect on environmental protectiveness.

5.2.2 Focused excavation

Focused excavation refers to the removal of those portions of DU-NE-1 containing concentrations of lead above the lowest calculated site-specific cleanup level of 410 mg/kg, while leaving in place soils with concentrations of lead below the cleanup level. Focused excavation would limit the area of the site susceptible to the disturbance of potentially buried cultural resources. The drawback to focused excavation is the need for further soil screening or testing to carefully delineate the soils to be removed. Soil screening using soil samples or an in-field device, such as an X-ray fluorescence spectrometer (XRF), would be conducted prior to removal to further delineate areas within DU-NE-1 in need of focused removal, and to help determine the extent of excavation required. Confirmation samples would also be collected from the perimeters of excavation areas and submitted for laboratory analysis, to ensure any remaining soil lead concentrations were below the site-specific cleanup level. Field screening and laboratory testing costs would be offset by the lower removal, transportation, and disposal costs for smaller quantities of soil than those associated with complete removal. All excavated soils would also require characterization and appropriate disposal.

Several options have been identified for disposing of the excavated contaminated soil, including stabilization treatment for metals prior to disposal. This technology will be retained for consideration in developing remedial alternatives to address site risks. Some soil excavation and disposal would likely be needed as an adjunct to capping (Section 5.3) to provide an acceptable final top-of-ground elevation relative to existing structures (e.g., sidewalks and building entrances).

5.3 Capping Technologies

Capping site soils with clean topsoil or other suitable materials, like crushed rock, to reduce potential human and ecological exposures to contamination is less costly than excavation and disposal, and can be as effective in preventing exposure. Other types of capping, such as low-permeability clay caps, are not practical for site use. Capping with topsoil or other materials will be retained for consideration in developing remedial alternatives to address site risks.

Geotextile fabric can also be used as a physical barrier and marker to separate clean fill from contaminated soil at the bottom of excavations or caps. It can also inhibit bioturbation caused by earthworms and other soil biota between clean fill and underlying soils. This type of technology will be retained for consideration during remedial alternative development. Geomembranes are typically used to control liquid or vapor migration (not an objective of this removal action) and are much more expensive than geotextile fabrics. This technology will not be retained for further consideration.

Vegetative covers are not considered protective when used alone, but are applicable in conjunction with other remediation methods. This method will be retained for further consideration in such an application.

5.4 SOIL TREATMENT (*IN SITU* STABILIZATION)

Pozzolonic stabilization is not an appropriate technology for site soil, in that it essentially turns soil into a solid, low-permeability mass. This technology will not be considered further.

Phosphate stabilization studies conducted at other sites indicate that it may be possible to reduce the bioavailability of lead in soil such that levels of lead up to the effective treatment range can be treated and left in place, rather than excavated and disposed of or capped in place. However, a phosphate treatability study would be required at the site to assess the effectiveness of stabilizing site soils, so this technology will not be considered further as a practical technology for this site.

5.5 SITE RESTORATION

Site restoration in areas that have been excavated and/or capped is considered not only acceptable, but also necessary in order to return these areas to an acceptable grade and condition compatible with public use of ESVB. Site restoration is easily implementable with readily available equipment and materials. Site restoration is also expected to aid in the preservation of buried cultural resources. This technology will be carried forward for consideration in developing remedial alternatives to address site risks. It will be used in combination with soil excavation and/or capping as necessary.

6 Development and Evaluation of Removal Action Alternatives

This section develops and evaluates the removal action alternatives proposed to achieve the RAO identified in Section 3.5. The alternatives present different combinations of technologies presented in Section 4. The proposed removal action alternatives include:

- Alternative 1 – No action
- Alternative 2 – ICs
- Alternative 3 – Soil capping with geotextile and vegetation cover
- Alternative 4 – Soil removal, on-site treatment, and off-site disposal
- Alternative 5 – Soil removal and off-site disposal at an appropriate disposal facility

Certain ICs would still be needed for those alternatives leaving soil with chemical concentrations above the site-specific cleanup levels in place. Some limited soil removal might also be needed to accommodate cap placement, or to otherwise create an acceptable final grade upon completion of the removal action.

6.1 EVALUATION CRITERIA

As specified by EPA guidance (1993), each removal action alternative is evaluated in terms of three criteria: effectiveness, implementability, and cost. These three criteria encompass the elements required to meet NCP removal criteria, which are described below.

6.1.1 Effectiveness

The effectiveness of a proposed alternative refers to its ability to meet the response action objective, and to its degree of protectiveness of the environment and public and site worker health, both in the short and long term. The RAO for the site is:

- Minimize the potential for lead impacts on human health and the environment.

Effectiveness also includes the degree of compliance with ARARs.

6.1.2 Implementability

Implementability addresses the technical and administrative feasibility of implementing an alternative. Technical feasibility includes the difficulty of conducting the proposed response action. Administrative feasibility includes issues such as permitting, availability of services and disposal sites, and likelihood of public and regulatory acceptance.

6.1.3 Cost

The cost of each proposed alternative includes direct and indirect capital costs, as well as operations & maintenance (O&M) costs. Estimated costs for Alternatives 2 through 5 are presented in Appendix E. There are no costs associated with Alternative 1.

6.2 Alternative 1 – No Action

Alternative 1, no action, is a baseline alternative to which other alternatives may be compared. Alternative 1 involves not taking any further actions to manage environmental concerns at the site.

6.2.1 Effectiveness

The site would remain as is. Implementation of the no action alternative would not achieve the RAO.

6.2.2 Implementability

The no action alternative is technically feasible to implement. It is not administratively feasible.

6.2.3 Cost

This alternative would not involve implementing any actions at the site, and would therefore incur no associated costs.

6.3 Alternative 2 – Institutional Controls

Alternative 2 involves implementing ICs, and warning users of hazards they may encounter while visiting or using the site. ICs would include a set of written agreements for employees and contractors working in affected areas, and land use deed restrictions. ICs for recreational users would include the posting of warning and no trespassing signs. In the event that construction or an archaeological investigation is considered for the site, site workers would be trained in applicable health and safety protocols and construction best management practices (BMPs). Relative to residual soil contamination, these types of protocols would be similar to those used during previous soil sampling (Windward 2012c). Medical surveillance would not be required, as the types and concentrations of chemicals in the soil do not require the prolonged use of respirators or other measures typically triggering medical surveillance requirements under the Occupational Safety and Health Act (OSHA) and the Washington Industrial Safety and Health Act (WISHA). A 5-year review program would be implemented by NPS to evaluate whether the institutional controls were meeting the objectives of this alternative.

6.3.1 Effectiveness

Implementation of ICs would protect human health only, and would not provide protection for the environment. The potential for human exposure to lead would be reduced, given the assumption that recreational users obeyed posted closures and regulations. Applicable health and safety protocols, if followed, would limit site employee and construction worker exposure. Effectiveness of some ICs may be limited by the ability to communicate and enforce specific measures or requirements.

6.3.2 Implementability

ICs are technically feasible with no expected difficulties. The site is located on land managed by NPS, and thus no access agreements would be required. Access restrictions would not be anticipated to limit site users' access to specific areas of ESVB, only to limit digging activities, which are already strictly controlled by NPS due to the presence of buried cultural resources. As NPS has the authority to oversee and manage all excavation activities at the site, ICs related to restrictions on subsurface excavation should be technically feasible to implement.

Site users would be expected to comply with temporary closures of certain areas of ESVB as needed; it is anticipated that, in lieu of extensive excavation activities that could disturb or destroy cultural resources, the public would support limited use of ICs. It is not typically feasible to record a land use covenant for a site owned or under the control of the federal government. As a result, other mechanisms are generally used to ensure that future land use will be compatible with the levels of contamination that may remain on a property. Such mechanisms may include recording required special safeguards and procedures as part of the facility's master plan. Placing several "call before you dig" signs in the site vicinity and specifying the appropriate NPS name and contact number would also be beneficial.

6.3.3 Cost

Costs for the implementation of ICs are presented in Appendix E. The estimated total cost for implementation of ICs is $47,100.

6.4 Alternative 3 – Soil Capping with Geotextile and Vegetation Cover

Alternative 3 involves capping contaminated soils with topsoil imported to the site and restoring capped areas by seeding them with grass or planting other types of plants, as appropriate to the location. A geotextile barrier overlain by a layer of topsoil, crushed rock, mulch, or other suitable material no less than 6 in. thick would be placed on all unpaved surfaces at DU-NE-1 to establish a barrier between existing lead in soil and humans. Desired grassy areas would be hydroseeded with a combination of mulch and grass seed to complete the barrier; areas requiring other types of landscaping (e.g., decorative plantings adjacent to buildings) would receive an additional layer of mulch, bark, or other decorative ground cover. Certain ICs (e.g., delineation of the capped location in the facility's master plan and placement of signs) would be required to ensure the long-term maintenance and preservation of the capped area, and to prevent human exposure to underlying soil. A 5-year review by NPS would be needed to evaluate whether the integrity of the cap was meeting the objectives of this alternative. Selective soil removal might also be required in places where the cap needed to be accommodated without unduly raising or changing the surface grade.

6.4.1 Effectiveness

Capping with soil and additional geotextile and vegetation cover, such as grass, would achieve the RAO.

6.4.2 Implementability

Soil capping with geotextile and vegetation cover is technically feasible to implement with no anticipated technical challenges. It is administratively feasible, but will require ICs to ensure proper maintenance of capped areas, as well as protection of these areas from disturbance by the public.

6.4.3 Cost

Costs for the implementation of topsoil and vegetation capping are presented in Appendix E. The estimated total cost for implementation of this alternative is $133,900.

6.5 Alternative 4 – Soil Removal, On-site Treatment, and Off-site Disposal

Alternative 4 involves the on-site treatment and removal of lead-contaminated soils. An example of such a soil treatment system is the synthetic metals mineralization system (SMMS), which consists of mixing targeted soils with an application of apatite-based stabilization reagents. The SMMS treatment process creates an isomorphic mineral complex that reduces the leachability of lead in soils to non-hazardous concentrations, as determined by TCLP lead concentrations of less than 5.0 ppm.

A staging area of approximately 0.25 ac would be established adjacent to DU-NE-1 for the stockpiling and treatment of soils, with the intent of treating all soils to a depth of 6 in. The excavated soils would be moved to this on-site staging area for treatment. Confirmation samples would be collected from the excavated surface to determine that all contaminated soil exceeding the minimum site-specific cleanup value (e.g., lead concentration of 410 mg/kg for the protection of human health and the environment, as established in Section 2.5) had been removed. Further confirmation samples would be collected from treated soils to determine that they meet the disposal requirements to be classified as a non-hazardous material (e.g., TCLP lead < 5 ppm). Treated soils would be removed from the site and disposed of as non-hazardous material at a Subtitle D landfill facility, a less expensive process than disposing of soils with hazardous concentrations of lead. The excavated areas would be restored with topsoil imported to the site and reseeded with grass or other landscaping soil, as appropriate to the location. Native or other plants suitable to the cultural and historical landscape may also be used in site restoration.

6.5.1 Effectiveness

Soil removal, on-site treatment, and off-site disposal would achieve the RAO.

6.5.2 Implementability

Soil removal with on-site treatment is technically feasible to implement with no anticipated difficulties. However, this alternative may disturb or destroy buried cultural resources potentially located within DU-NE-1. Prior to any soil removal activities, areas to be excavated would be tested for the presence of buried cultural resources. Archaeological staff would also oversee the removal activities in order to protect and recover any exposed cultural resources. Despite these measures, there exists the very small possibility that buried cultural resources could be inadvertently lost or destroyed during excavation activities.

6.5.3 Cost

Costs for implementing Alternative 4 are presented in Appendix E. The estimated total cost for the implementation of soil removal, on-site treatment, and off-site disposal is $184,900.

6.6 Alternative 5 – Soil Removal and Off-Site Disposal at an Appropriate Disposal Facility

Alternative 5 involves the removal and subsequent disposal of soils exceeding the minimum site-specific cleanup value (e.g., lead concentration of 410 mg/kg) at an appropriate disposal facility. A staging area of approximately 0.25 ac would be established adjacent to DU-NE-1 for the stockpiling and confirmation sampling of excavated soils. Soils would be excavated and stockpiled at the staging area, segregated by area of origin, and profiled for lead concentrations prior to transport to an appropriate disposal facility. Confirmation samples would be collected from the excavated surface to determine that all contaminated soil exceeding the minimum site-specific cleanup value had been removed. Further TCLP samples would be collected from segregated stockpiled soils to determine whether they met the disposal requirements to be classified as either a non-hazardous (e.g., TCLP lead < 5 ppm) or hazardous (e.g., TCLP lead ≥ 5 ppm) waste. Soil classified as non-hazardous would be transported off-site to a licensed Subtitle D landfill facility; soil classified as hazardous waste would be transported to a licensed Subtitle C facility. The excavated areas would be restored with topsoil imported to the site, and reseeded with grass or other landscaping soil as appropriate to the location.

6.6.1 Effectiveness

Soil removal and off-site disposal at an appropriate facility would achieve the RAO.

6.6.2 Implementability

Soil removal and off-site disposal at an appropriate facility is technically feasible to implement with no anticipated difficulties. However, this alternative may disturb or destroy buried cultural resources potentially located within DU_NE-1. Prior to any soil removal activities, areas to be excavated would be tested for the presence of buried cultural resources. Archaeological staff would also oversee the soil removal activities in order to protect and recover any exposed cultural resources. Despite these measures, there exists the very small possibility that buried cultural resources could be inadvertently lost or destroyed during excavation activities.

6.6.3 Cost

Costs for the implementation of Alternative 5 are presented in Appendix E. The estimated total cost for implementing soil removal and off-site disposal varies, depending on how the excavated soil would be classified (i.e., hazardous or non-hazardous) and the depth to which the removal would extend. At the lower cost range (approximately $113,600), only shallow soil would be removed, and all soil would be designated as non-hazardous. If the same soil were classified as hazardous waste (an unlikely scenario), then the cost for this alternative could range as high as $305,300. If deeper excavation were required based on testing results, then corresponding costs would increase accordingly, particularly if high levels of lead were encountered at depth and additional soil removal was required. While it is possible that greater concentrations of contamination exceeding the site-specific cleanup level could be encountered at limited locations of greater depth, the likelihood of this occurring throughout DU-NE-1 is remote.

7 Comparative Evaluation of Removal Action Alternatives

This section provides a comparative evaluation of the five proposed response action alternatives discussed in Section 4. The ability of each proposed response action alternative to meet the criteria of effectiveness, implementability, and cost is compared to those of the other alternatives. Table 6-1 presents a side-by-side comparison of the five proposed alternatives. Additional detail about the cost of each alternative is included in Appendix E.

Table 7-1. Cost comparison of remedial alternatives

Alternative	Estimated Cost
Alternative 1 – no action	$0.00
Alternative 2 – ICs	$47,100
Alternative 3 – soil capping with geotextile and vegetation cover	$133,900
Alternative 4 – soil removal, on-site treatment, and off-site disposal	$184,900
Alternative 5 – soil removal and off-site disposal	$113,600 – $305,300[a]

[a] These costs could be higher depending on final removal depth required to meet the cleanup level.

IC – institutional control

7.1 Effectiveness Criteria

All of the alternatives were comparatively analyzed to determine which would be the most effective in obtaining compliance with the RAO (i.e., minimizing the potential for lead impacts on human health and the environment).

7.1.1 Alternative 1 – no action

This alternative would not achieve the RAO.

7.1.2 Alternative 2 – ICs

This alternative would be protective of human health, provided the public and site workers abide by the applied site restrictions, and would thus be provisionally consistent with the RAO. ICs would not be protective of the environment. This alternative would require a review by NPS every 5 years to verify that controls are in place and continue to be protective.

7.1.3 Alternative 3 – soil capping with geotextile and vegetation cover

This alternative would be protective of human health and the environment, provided the soil and vegetation caps are maintained to provide an intact barrier, and would thus be provisionally consistent with the RAO. This alternative would require a review by NPS every 5 years to verify that controls and the cap are in place, properly maintained, and continue to be protective.

7.1.4 Alternative 4 – soil removal, on-site treatment, and off-site disposal

This alternative would be protective of human health and the environment, and thus would be consistent with the RAO.

7.1.5 Alternative 5 – soil removal and off-site disposal

This alternative would be protective of human health and the environment, and thus would be consistent with the RAO.

7.2 IMPLEMENTABILITY CRITERIA

All of the alternatives were comparatively analyzed to determine which, if implemented, would obtain compliance with the RAO (i.e., minimize the potential for lead impacts on human health and the environment).

7.2.1 Alternative 1 – no action

As there are no actions associated with this alternative, it is technically feasible. However, it is not considered to be administratively feasible due to the anticipated lack of acceptance associated with not meeting the RAO.

7.2.2 Alternative 2 – ICs

This alternative is technically feasible and would use established methods and protocols. Administrative feasibility presents a few challenges, including implementing restrictions and safeguards on federal property and public acceptance and perception. However, access restrictions are anticipated to limit only digging activities, not site users' access to specific areas of ESVB. Digging activities are already strictly controlled by NPS due to the presence of buried cultural resources at the site. It is also anticipated that the limited use of ICs, in lieu of extensive excavation activities that could disturb or destroy cultural resources, would gain public support.

7.2.3 Alternative 3 – soil capping with geotextile and vegetation cover

This alternative is technically feasible and would use established methods and protocols. Implementing this alternative in the vicinity of buildings, walkways, roads, and plants of historic and cultural significance could introduce certain technical challenges at the site (e.g., elevated ground surfaces and changes in local drainage), but these could be overcome using focused soil removal and/or grading.

7.2.4 Alternative 4 – soil removal, on-site treatment, and off-site disposal

This alternative is technically feasible and would use established methods and protocols. However, it would introduce considerable technical and logistical difficulties, as it would involve disturbing of all exposed soils in the vicinity of the DU-NE-1 buildings, using soil staging and treatment zones, disposing of soils off-site, restoring of excavated areas, and protecting buried cultural resources.

7.2.5 Alternative 5 – Soil removal and off-site disposal

This alternative is technically feasible and would use established methods and protocols. It would introduce logistical difficulties, as it would involve disturbing all exposed soils in the vicinity of the DU-NE-1 buildings, staging soil for disposal profiling, disposing of soils off-site, restoring excavated areas, and protecting buried cultural resources.

7.3 COSTS

Estimated costs for all of the alternatives are presented Tables 7-1 and 7-2.

7.4 COMPARISONS

Table 7-2 presents a comparison of the proposed removal action alternatives.

Alternatives 1, 2, and 3 would not reduce lead concentrations in soil. Alternative 2 would reduce risks to human health by means of use restrictions. Alternative 3 would reduce risks to human health and the environment by imposing barrier layers between contaminated soils and site users. Alternatives 2 and 3 would require varying degrees of administration, including the use of ICs and review of the action every 5 years.

Alternatives 4 and 5 would provide similar degrees of protection to human health and the environment by means of source removal, but with higher potential costs and the possibility of irreparable damage to cultural resources associated with the area. The significant differences between these alternatives would be in logistics, disposal options, and costs. Both of these alternatives would achieve identical on-site goals. However, the soils transported off-site as part of Alternative 4 would have been treated, if determined necessary by additional TCLP testing, to reduce the leachability of lead to non-hazardous concentrations. The treatment area for Alternative 4 would require 0.25 ac of additional ground disturbance, and a temporary on-site storage area would be necessary during soil treatment and disposal profiling. Likewise, Alternative 5 would require additional ground disturbance for stockpiling, as well as temporary on-site storage during disposal profiling. Alternatives 4 and 5 could both have a profound impact on buried cultural resources potentially located at the DU, as all surface soils to a depth of 6 in. or more would be removed.

Table 7-2. Comparison of action alternatives

Criteria	Alternative 1: No Action	Alternative 2: Institutional Controls	Alternative 3: Soil Capping with Geotextile and Vegetation Cover	Alternative 4: Soil Removal, On-site Treatment, and Off-site Disposal	Alternative 5: Soil Removal and Off-site Disposal
Effectiveness					
RAO: minimizing the potential impact of lead in soil on human health and the environment	Not effective: baseline conditions would remain unaffected.	Partially effective: the potential for human exposure to lead in soil would be reduced, given the assumption that the public would obey posted access restrictions and other regulations. Site worker exposure would be limited by following health and safety protocols. ICs would not affect exposure of the environment to lead in soil, would require review by NPS every 5-years.	Partially effective: capping contaminated soil would limit exposure, assuming that caps are maintained intact. Site worker exposure would be limited by following health and safety protocols, would require review by NPS every 5-years.	Effective: removal of contaminated soil would achieve the RAO.	Effective: removal of contaminated soil would achieve the RAO.
Implementability					
Technical feasibility	yes	yes	yes	yes	yes
Availability of goods and services	No goods or services are required.	All goods and services are available.	All goods and services are available.	All goods and services are available.	All goods and services are available.
Difficulty	nothing to implement	Production and installation of signage would not be difficult. Access restriction documentation and site worker health education materials are not difficult to prepare for a single federal agency. Other designations of necessary controls (e.g., restrictions on digging in capped areas) can be included in the facility's master plan.	Preparation of site surfaces for the installation of topsoil and grass would pose minimal difficulty. Some selective soil removal or grading might be required in places where the cap needs to be accommodated without unduly raising or changing the surface grade.	The logistics of on-site treatment would pose some difficulty. Soils would need to be treated to non-hazardous levels, with TCLP confirmation testing prior to disposal. Extensive soil removal could disturb or destroy buried cultural resources.	The logistics of segregating soils for disposal would pose some difficulty. Soil would need to be TCLP tested to determine its eligibility for disposal as non-hazardous or hazardous material. Extensive soil removal could disturb or destroy buried cultural resources.

Criteria	Alternative 1: No Action	Alternative 2: Institutional Controls	Alternative 3: Soil Capping with Geotextile and Vegetation Cover	Alternative 4: Soil Removal, On-site Treatment, and Off-site Disposal	Alternative 5: Soil Removal and Off-site Disposal
Impacts on site users and the public	No further impact: site would remain in its current state.	Impacts on site users would depend upon the public's compliance with posted warnings. Impacts on site workers would be regulated by health and safety protocols.	Impacts on the public and site workers would be virtually eliminated. The site is not currently in active use, thus limiting potential impacts during topsoil and grass installation.	Impacts on the public and site workers would be virtually eliminated. The site is not currently in active use, thus limiting potential impacts during removal actions. Truck traffic would not increase significantly enough to affect local roads.	Impacts on the public and site workers would be eliminated. The site is not currently in active use, thus limiting potential impacts during removal actions. Truck traffic would not increase significantly enough to affect local roads.
Administrative feasibility					
Public acceptance	not likely	possible	likely	likely	likely
Regulatory acceptance	not likely	not likely	possible	likely	likely
Cost	**$0.00**	**$47,100**	**$133,900**	**$184,900**	**$113,600 – $305,300**

IC – institutional control

NPS – National Park Service

RAO – removal action objective

TCLP – toxicity characteristic leaching procedure

8 Recommended Removal Action Alternative

This section provides the recommendation for the preferred removal action Alternative for DU-NE-1. The recommended removal action is a combination of Alternatives 3 and 5, involving the focused removal of currently uncapped contaminated soils. This combination was selected due to its effectiveness, implementability, and potential cost savings. The following work tasks will be conducted as part of the preferred removal action:

- The currently uncapped soils (i.e., areas without pavement, concrete or buildings) within DU-NE-1 will be further characterized using field instruments to determine concentrations of lead laterally and at depth. Such characterization will result in a division of the DU into smaller sub-DUs.
- Based on the results of the soil characterization, exposed (e.g., not paved) portions of sub-DUs that exceed the lowest site-specific cleanup level for lead in soil (410 mg/kg) will be cleared of grass and vegetation, except for large trees and shrubbery key to the cultural landscape.[4] Soil will be removed from these areas to a minimum depth of 6 in. and replaced with clean soil.
- To determine potential impacts on subsurface resources, archeological testing will be conducted in the areas recommended for excavation. Capping will be implemented in areas determined to hold cultural or natural resources that must remain in place within contaminated soils, or in areas where contamination is observed to extend deeper than the planned removal depth.
- Contaminated soil to be excavated will undergo cultural monitoring, and will be stockpiled in segregated piles based on area of origin.
- Stockpiled soils will be profiled by TCLP analysis to determine an appropriate disposal destination.
- All stockpiled soils will be disposed of at an appropriate off-site facility; soils will be profiled as required by the disposal facility (likely by TCLP analysis) to determine appropriate disposal criteria.
- Excavated soil surfaces will be analyzed with field instruments; soil samples will be analyzed in the laboratory and confirmed against established site-specific cleanup levels.
- Potentially contaminated sub-DUs unable to be excavated, or with contamination deeper than 6 in., may be capped. Any remaining soil contamination exceeding site-specific cleanup levels will be covered with geotextile fabric. This barrier will

[4] NPS will determine which plantings are considered to be significant to the cultural landscape, and these will be protected from damage during excavation and capping activities. If significant plantings are lost or damaged, they will be replaced in-kind.

act as both a marker between undisturbed soils and imported capping materials, and as an obstruction to migration of soil biota between underlying undisturbed soils and restored surface soil. Sub-DUs with potentially contaminated soil below existing caps (i.e., pavement or concrete) will be routinely maintained and mapped to ensure any future development accounts for possible contamination.

- Excavated sub-DUs will be restored with topsoil and native plants or other landscaping materials, as appropriate to the location's cultural landscape.

The combination of Alternatives 3 and 5 will affect the estimated cost for the removal action, depending on the total area of the sub-DUs that can be addressed by:

- Removing shallow (i.e., < 6 in.) soil and disposing of it off-site. Alternative 5 would incur a slightly lower cost per square foot, assuming soils are excavated to a depth of 6 in. and are non-hazardous.
- Soil capping with a geotextile barrier and vegetation cover. Alternative 3 would incur a slightly higher cost per square foot when applied, where needed, to address deeper contamination.

The range of total costs estimated for each alternative is between $113,000 and $133,000, assuming none of the removed soil requires handling as state-designated dangerous waste or hazardous waste.

Portions of the sub-DUs that receive a geotexile barrier and cover will require proper protection and maintenance measures. Designation of such areas on the facility's master plan and advisements regarding digging (e.g., as may be associated with archaeological or utility-related work) should be sufficient to provide protection. In order to meet the substantive requirements of a 5-year review under CERCLA, FOVA staff should inspect and document the conditions of covered areas where remaining soil exceeds the site-specific cleanup level once every 5 years.

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