

**Camp Bonneville
Expanded Site Inspection**

Vancouver, Washington

Technical Direction Document Number: 11-02-0010

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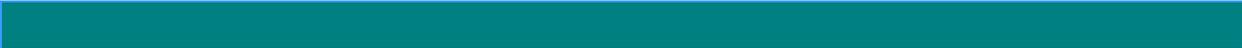
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List of Abbreviations and Acronyms

<u>Acronym</u>	<u>Definition</u>
%R	Percent Recovery
1,1,1-TCA	1,1,1-trichloroethane
1,1-DCE	1,1-Dichloroethene
AEM	Atlanta Environmental Management, Inc.
amsl	Above mean sea level
AST	Aboveground Storage Tank
ATSDR	Agency for Toxic Substances and Disease Registry
Baker	Michael Baker Jr. Inc.
BCRRT	Bonneville Conservation Restoration and Renewal Team
bgs	below ground surface
BRAC	Base Realignment and Closure
BS	Blank Spike
BTEX	Benzene, Toluene, Ethylbenzene, Xylene
CAP	Cleanup Action Plan
CCC	Civilian Conservation Corps
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CERFA	Community Environmental Response Facilitation Act
cfs	Cubic feet per second
CITA	Central Impact Target Area
CLP	Contract Laboratory Program
CMTC	Citizens Military Training Camps
COCs	Contaminants of Concern
COPCs	Chemicals of Potential Concern
Corps	United States Army Corps of Engineers
CRQL	Contract Required Quantitation Limit
CVF	Central Valley Floor
DA	Decision Area
DOC	Dissolved Organic Carbon
DOD	United States Department of Defense
DQOs	Data Quality Objectives
E & E	Ecology and Environment, Inc.
EBS	Environmental Baseline Survey
Ecology	Washington State Department of Ecology
EPA	United States Environmental Protection Agency
ESI	Expanded Site Inspection
ESU	Evolutionarily Significant Unit
FBI	United States Federal Bureau of Investigation

List of Abbreviations and Acronyms (cont.)

<u>Acronym</u>	<u>Definition</u>
GPS	Global Positioning System
GSAI	Gary Struthers Associates, Inc.
HE	High Explosive
ICs	Institutional Controls
ID	Identification
IDW	Investigation-Derived Waste
LRA	Local Redevelopment Authority
MC	Munitions Constituents
MCL	Maximum Contaminant Level
MD	Munitions Debris
MEC	munitions and explosives of concern
MEL	Manchester Environmental Laboratory
mg/kg	milligrams per kilogram
mm	millimeters
MS/MSD	Matrix Spike/Matrix Spike Duplicate
MTCA	Model Toxics Control Act
ng	nanograms
NPL	National Priorities List
OB/OD	Open Burn/Open Detonation
OE	Ordnance and Explosives
PA	Preliminary Assessment
PAHs	Polyaromatic hydrocarbons
Parsons	Parsons Engineering Science, Inc.
PCBs	Polychlorinated biphenyls
Pentec	Pentec Environmental, Inc.
PETN	pentaerthritol tetranitrate
PID	Photoionization Detector
POLs	Petroleum, oils and lubricants
PPE	Probable Point of Entry
ppm	parts per million
PRGs	Preliminary Remediation Goals
QA/QC	Quality Assurance/Quality Control
RAUs	Remedial Action Units
RBCs	Risk Based Concentrations
RCRA	Resource Conservation and Recovery Act
RDX	hexahydro-1,3,5-trinitro-1,3,5-triazine
RI/FS	Remedial Investigation/Feasibility Study
ROD	Record of Decision
ROTC	Reserve Officer Training Corps
RPC	Reuse Planning Committee
RPD	Relative Percent Difference
RSF	Range Safety Fans
RWAs	Remedial Work Areas
SOW	Statement of Work
SPAF	Sample Plan Alteration Form

List of Abbreviations and Acronyms (cont.)

<u>Acronym</u>	<u>Definition</u>
SQAP	Sampling and Quality Assurance Plan
SQL	Sample Quantitation Limit
SSI	Supplemental Site Investigation
START	Superfund Technical Assessment and Response Team
SVOCs	Semivolatile Organic Compounds
SWI	Shannon and Wilson Inc.
TDL	Target Distance Limit
TLPE	Teflon-lined polyethylene
TOC	Total Organic Carbon
TPH	Total Petroleum Hydrocarbons
TSS	Total Suspended Solids
UST	Underground Storage Tank
UXBI	UXB International, Inc.
UXO	Unexploded Ordnance
VOCs	Volatile Organic Compounds
WAC	Washington Administrative Code
WDNR	Washington Department of Natural Resources

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1

Introduction

Ecology and Environment, Inc., (E & E) was tasked by the United States Environmental Protection Agency (EPA) to provide technical support for completion of an Expanded Site Inspection (ESI) at the Camp Bonneville site in Vancouver, Washington. E & E completed ESI activities under Technical Direction Document Numbers 10-03-0010 and 11-02-0010, issued under EPA, Region 10, Superfund Technical Assessment and Response Team (START)-3 Contract Number EP-S7-06-02.

The specific goals for the Camp Bonneville ESI, identified by the EPA, are to:

- Determine the potential threat to public health or the environment posed by the site;
- Determine the potential for a release of hazardous constituents into the environment; and
- Determine the potential for placement of the site on the National Priorities List (NPL).

The ESI is not intended to include extensive or complete site characterization, contaminant fate determination, or quantitative risk assessment.

Completion of the ESI included reviewing existing site information, determining regional characteristics, collecting and analyzing environmental media samples to determine whether hazardous substances are present at the site and are migrating to the surrounding environment, executing a sampling plan, and producing this report. The report is organized as follows:

- Section 1, Introduction – Authority for performance of this work, goals for the project, and summary of the report contents;
- Section 2, Background – Site description, site operations and waste characteristics, a summary of previous investigations, and a summary of investigation locations;

- Section 3, Field Activities and Analytical Protocol – Summary of the field effort;
- Section 4, Quality Assurance/Quality Control (QA/QC) – Summary of the laboratory data;
- Section 5, Analytical Results Reporting and Background Samples – Discussion of results reporting criteria, background sample locations, and analytical results;
- Section 6, Potential Sources – Discussion of site sources, sample locations, and analytical results;
- Section 7, Migration/Exposure Pathways and Targets – Discussion of the migration/exposure pathways, sample locations, and analytical results;
- Section 8, Summary and Conclusions – Summary of the investigation and recommendations for the site based on the information gathered during the investigation; and
- Section 9, References – Alphabetical listing of the references cited throughout the text.

The ESI was conducted in conjunction with EPA's response to a formal Preliminary Assessment (PA) Petition submitted by the Rosemere Neighborhood Association and Columbia Riverkeeper under Section 105(d) of Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), 42 U.S.C. § 9605(d). A copy of the PA Petition dated February 3, 2009, is provided in Appendix A.

2

Site Background

This section describes the background of the site including location, description, ownership history, operations and source characteristics, previous investigations, and a summary of the site investigation locations.

2.1 Site Location

Site Name:	Camp Bonneville
EPA Site ID Number:	WAN001002030
Site Address:	23201 NE Pluss Road Vancouver, Washington 98682
Latitude:	45° 41' 29.338" North (at center of site)
Longitude:	122° 24' 0.144" West (at center of site)
Legal Description:	Township 3 North, Range 3 East, Sections 34 and 35 Township 2 North, Range 3 East, Sections 1, 2, 3, and 10
County:	Clark
Congressional District:	3
Site Owner:	Clark County, Washington
Site Contact:	Jerry Barnett Clark County Department of Public Works Camp Bonneville 23201 NE Pluss Road Vancouver, Washington 98682 (360) 566-6992

2.2 Site Description

Camp Bonneville is located in Clark County, approximately 5 miles northeast of Vancouver, Washington (Figure 2-1). Generally, Lacamas Creek flows through the middle of the site with a number of tributaries that feed it. The general topography of the site is flat in the Lacamas Creek Valley; the remainder of the site consists of gently rolling hills. Camp Bonneville is a sub-installation of the Vancouver Barracks (located approximately 12 miles southwest of Camp Bonneville in Vancouver, Washington), which is a sub-installation of Fort Lewis (located approximately 100 miles north of Camp Bonneville in Tacoma, Washington). Camp Bonneville consists of approximately 3,840 acres of land that historically was used by the United States Department of Defense (DOD) to provide training for active Army, Army Reserve, National Guard, Marine Corps Reserve, Navy Reserve, Coast Guard Reserve units, and other DOD personnel. The installation consists of two cantonment areas, Bonneville cantonment and Killpack cantonment, 25 firing ranges, former sewage lagoons, and four historic landfills (Figures 2-2 through 2-4; WC 1997).

Camp Bonneville is located on the western slope of the Cascade Mountains in the Lacamas Creek Valley. The terrain is generally rolling. Elevations range from 289 feet above mean sea level (amsl) in Lacamas Creek at the southwest corner of the site to 1,000 feet amsl at the northwest corner, 1,350 feet amsl at the southeast corner, and 1,452 feet amsl at the south central boundary (WC 1997).

In 1910, the federal government entered into a lease with a purchase option on approximately 3,000 acres of land to use for military training. The lease expired in 1915, and the War Department acquired the land in 1918 by purchase and condemnation. The site was briefly declared surplus in the mid-1940s, but in May 1947, Camp Bonneville was removed from surplus status. In the early 1950s, the Defense Department leased an additional 840 acres from the State of Washington Department of Natural Resources (WDNR), and in 1957, the federal government returned 20 acres of the overall property to the State of Washington. From 1957 until placement on the Base Realignment and Closure (BRAC) list in 1995, the remaining 3,839 acres remained under the military's jurisdiction (Parsons 2004). Following is a more detailed time-line of uses at Camp Bonneville.

- **Pre-World War II Era:** Troops from Vancouver Barracks began to use the land for a target range in 1910 due to the near-level range floor that was protected from wind by the foothills of the Cascade Mountains. The plateau-valley (350 yards wide by 2,000 yards long) contained the Army's 14 short-range and 7 long-range small arms ranges. The federal government did not own the land at this time but had an option on the property. In 1912, the government obtained another option, but after it expired in 1915, the army began conducting its target practice at an Oregon National Guard range near Clackamas, Oregon. The acquisition of the original reservation (consisting of approximately 3,000 acres)

occurred in 1918 by purchase and condemnation. When the Army resumed activities at Camp Bonneville in 1918, the valley contained 24 targets. The installation was officially named Camp Bonneville in 1926. At some point prior to 1929, a machine gun range was added to the training facilities. The Camp Bonneville cantonment area was built in the late 1920s and in 1935 the Civilian Conservation Corps (CCC) built and occupied the Camp Killpack cantonment area. These facilities included barracks, kitchens and mess halls, an infirmary, latrines, administration and recreation buildings, and a library. Several organizations other than the garrison at Vancouver Barracks used the facilities at Camp Bonneville. Citizens Military Training Camps (CMTC) and the Reserve Officer Training Corps (ROTC) used the camp. The ROTC program prepared college students for a commission in the army and CMTC exposed high-school-aged males to military discipline and training. (Parsons 2004)

- **World War II Era:** Camp Bonneville continued to be used as a training area for the Vancouver Barracks during World War II. In 1946, the War Department declared the property excess. In May 1947, the military withdrew the camp from surplus citing a continued need for its training facilities. The ranges activated during the World War II era were the 0.22-caliber, 0.30-caliber, and 0.45-caliber small arms ranges.
- **Post World War II (1950s Era):** The army refurbished many of the buildings and systems at the cantonment areas along with the ranges on the installation in 1950. This project was performed in preparation for training by the US Army Reserve units in southern Washington and northern Oregon. During this time, the National Guard and the Marine Corps also expressed an interest in training at Camp Bonneville. In the early 1950s, the DOD arranged to lease an additional 840 acres from the WDNR to expand the training facilities at Camp Bonneville. The Army returned 20 acres of the leased land to WDNR in 1957. In 1959, Vancouver Barracks became a sub-installation of US Army, Fort Lewis. As a result, Fort Lewis assumed responsibility for Camp Bonneville. By 1959, the property inventory included a known distance range, a pistol range (20 targets), a submachine gun range (21 targets), a live hand grenade range, and a mortar training range. Targets and target storage buildings for machine gun and anti-aircraft ranges were inventoried; however, the actual ranges could not be located (the purpose of the inventory is not known). Two demolition areas of unknown chronology were also mentioned. These demolition areas were approximately located in the southwest quadrant of the site along Lacamas Creek and in the northwest quadrant of the site near Little Elkhorn Mountain. These demolition areas had been used for destruction of unserviceable munitions since the late 1950s. Since 1993, the destruction of unserviceable munitions by any method (burning or detonation) has not been permitted.

- **Late 1960s through 1995:** Camp Bonneville provided training areas for a variety of military units as well as federal, state, and local law enforcement agencies until selection for closure under the BRAC process in 1995. From 1969 to 1985, artillery units had conducted live firing exercises about twice a year with each training session resulting in the firing of approximately 50 rounds. During the 1970s, the military switched to sub-caliber rounds for training purposes. Additional training maneuvers, bivouacking, and tactics were practiced on the many preexisting training areas at Camp Bonneville, and occasionally vehicles would support this training with the use of smoke or riot control agents. These training areas utilized land from previously established ranges. No new range installation occurred during this time. During the period from 1987 to 1991, three new ranges were introduced at Camp Bonneville. The ranges included an M16 rifle range and two M203 ranges. The M203 ranges were used for troop training in the use of 40-mm rifle grenades. One range was reportedly used solely for inert, practice 40-mm training, while the second range was used for High Explosive (HE) 40-mm training. (Parsons 2004)

In 1996, following the selection of Camp Bonneville for closure (in 1995) under the BRAC authorization, all active military training units ceased operations at the camp. All out-grants for use of the facilities were cancelled with the exception of the Federal Bureau of Investigation (FBI) firing range. (SWI 1999a)

2.3 Site Ownership History

In 1910, the federal government entered into a lease for approximately 3,000 acres of land. In 1912, the government obtained another option which expired in 1915. The land was obtained in 1918 through purchase and condemnation. An additional 840 acres was added through a lease with WDNR and approximately 20 of these acres were returned to WDNR in 1957. In October 2006, the Army transferred ownership of the property to Clark County in an “early transfer,” under which the DOD continued to provide funding for cleanup of the site. Clark County then transferred ownership of the land to the Bonneville Conservation Restoration and Renewal Team LLC (BCRRT), an organization managing a team of contractors in the cleanup and removal of hazardous wastes and unexploded ordnance (UXO). From 2006 to July 2010, the property was owned and operated by BCRRT. From July 2010 to November 2011, Clark County operated the site under lease with BCRRT. From November 3, 2011 to present, Clark County has been both owner and operator.

2.4 Site Operations and Source Characteristics

Historical operations at the site have included the storage of pesticides, maintenance of vehicles, storage of diesel fuel for building heating, sewage lagoons, at least four landfills (one landfill, Landfill 1 has been reported and identified on maps; however, it has not been visually located), various caliber

firing ranges, and troop maneuvers. All of these historical operations are discussed in detail in the “Previous Investigations” section below.

Current operations include continuing evaluation of contamination in one landfill (Demolition Area 1/Landfill 4; discussed below), and clearing of UXO. The status of cleanup is described in the October 2011 Ecology Fact Sheet contained in Appendix B. Ecology has provided oversight for investigations and cleanup activities since 2003.

2.5 Previous Investigations

This section discusses previous investigations that concern the discovery, classification, or sampling of areas or features which may have involved the use, storage, disposal, or spilling of hazardous substances. A complete administrative record of all reports relating to the site is available at the Washington State University – Vancouver library.

2.5.1 U. S. Army Corps of Engineers Environmental Baseline Survey

In 1997, Woodward Clyde completed an Environmental Baseline Survey (EBS) report for the United States Army Corps of Engineers (Corps). The purpose of the survey report was to classify discrete areas of property associated with Camp Bonneville subject to transfer or lease into one of the standard environmental condition types as defined in the Community Environmental Response Facilitation Act (CERFA) guidance and the DOD BRAC Cleanup Plan Guidebook. The standard environmental condition of property types are presented below (WC 1997):

- **Category 1:** Areas where no storage of hazardous substances or petroleum products has occurred for 1 year or longer and no release or disposal of hazardous substances or petroleum products has occurred (including no migration of these substances from adjacent properties). Additionally, Category 1 includes areas where no evidence exists for the release, disposal, or migration of hazardous substances or petroleum products; however, the area has been used to store less than reportable quantities of hazardous substances (40 CFR 302.4) or 600 or fewer gallons of petroleum products.
- **Category 2:** Areas where only storage of hazardous substances in amounts exceeding their reportable quantity or petroleum products exceeding 600 gallons has occurred, but no release, disposal, or migration has occurred.
- **Category 3:** Areas where storage, release, disposal, or migration of hazardous substances or petroleum products has occurred, but at concentrations that do not require a removal or remedial action.

- **Category 4:** Areas where storage, release, disposal, or migration of hazardous substances or petroleum products has occurred, and all removal or remedial actions to protect human health and the environment have been taken.
- **Category 5:** Areas where storage, release, disposal, or migration of hazardous substances or petroleum products has occurred, and removal or remedial actions are under way, but all required actions have not yet been implemented.
- **Category 6:** Areas where storage, release, disposal, or migration of hazardous substances or petroleum products has occurred, but required removal or remedial actions have not yet been initiated.
- **Category 7:** Areas that are not evaluated or require additional evaluation.

Areas that are designated Category 1 through 4 are suitable for property transfer or lease, subject to consideration of the qualifiers. Areas that are designated Category 5 through 7 are not suitable for transfer, but may be suitable for lease (WC 1997). The designation of site areas identified under the BRAC Cleanup Plan and the basis for their designation is presented in Table 2-1. The reference map for this survey is provided on Figure 2-5. No samples were collected as part of the Corps' environmental baseline survey.

2.5.2 Base Realignment and Closure Cleanup Plan

In 1996, Woodward Clyde prepared a BRAC Cleanup Plan for the Corps. The BRAC Cleanup Plan included a brief history of site operations and outlined the areas of concern with regard to environmental cleanup and disposal, and reuse of the site. The objectives of the cleanup plan were to: summarize the current status of Camp Bonneville environmental restoration programs; present a comprehensive strategy for implementing response actions necessary to protect human health and the environment; and present schedules for restoration and compliance activities. (WC 1995)

Twenty areas of concern for restoration or assessment were identified in the Corps' BRAC Cleanup Plan; of these 20 areas, 10 consisted of known or suspected disposal areas (Figure 2-6). A summary of these areas is provided below:

- **Landfill 1:** A cultural resources survey performed in 1980 located a landfill east of the Bonneville cantonment and north of the sewage lagoon (Figure 2-2). The cultural resources survey described the disposal area as a 4-meter by 5-meter shallow depression and stated that bottle fragments contained in the landfill date its use to the early 1900s. Neither the length of use nor a comprehensive list of the quantities and types of trash disposed of in this landfill is known (WC 1995).

- **Landfill 2:** This landfill, located northeast of the Bonneville cantonment, was reported to have been partially excavated during the construction of the sewage lagoon in approximately 1978 (Figure 2-2). According to an interview conducted for the EBS, fill material was unearthed at the eastern and northern borders of the sewage lagoon. Neither the type nor quantity of material disposed of in this landfill is known. The period of use is estimated at 1940 to 1950 (WC 1995).
- **Landfill 3:** This landfill, which is suspected to have been used as a trash burial area, is located south of Landfill 2 and the sewage lagoon (Figure 2-2). According to an interview conducted for the EBS, this area contains a refrigerator and a locker. Neither the length of use nor a comprehensive list of the quantities and types of trash is known. The period of disposal is estimated to have been in the 1970s (WC 1995).
- **Three Grease Pits:** Two grease pits are located at the Bonneville cantonment north of Building 1828 (Figure 2-3), and one is located at the Killpack cantonment east of Building 4389 (Figure 2-4). The pits are composed of corrugated metal tubes, approximately 2 feet in diameter, that extend into gravel-filled pits to an unknown depth. The pits reportedly received cooking grease and oils from the mess halls. An interview conducted for the EBS indicated there was a potential for the uncontrolled disposal of potentially hazardous substances in these pits. The period of disposal is estimated to have been from 1935 to shortly before base closure (WC 1995).
- **Drum Disposal Area:** A suspected drum disposal site was identified in May 1996 by an anonymous telephone caller, identifying himself as a former Camp Bonneville facility employee. The suspected drum disposal area was located southeast of the Killpack cantonment and east of the gravel road (Figure 2-2). Metal anomalies have been confirmed at this location (WC 1995).
- **Paint/Solvent Disposal Area:** A suspected paint/solvent disposal area was identified in May 1996 by an anonymous telephone caller, identifying himself as a former Camp Bonneville facility employee. The suspected paint/solvent disposal area was located southeast of the Killpack cantonment and west of the gravel road (Figure 2-2). It was reported by the caller that paint, pesticides, and solvents were disposed of in this area (WC 1995).
- **Two Wash Racks:** The first wash rack, associated with Building 4475 at the Killpack cantonment, was identified in one of the previous environmental compliance inspections performed at Camp Bonneville. The wash rack does not have an oil/water separator. The second wash rack, associated with Building 4476, is an open gravel-covered area that

gently slopes toward the road (Figure 2-4). The wash racks may have received waste oil and antifreeze during their period of use (WC 1995).

- **Maintenance Pit:** Building 4475 at the Killpack cantonment reportedly had a maintenance pit located west of the building that is now covered with concrete (Figure 2-4). The pit was an unlined excavation in the ground that potentially received vehicle fluids such as oil or antifreeze for an unknown period of time. Additionally, the ground south of the building in an area measuring approximately 4 feet by 85 feet was noted during the EBS to have stressed vegetation and red staining. This area received runoff from the galvanized steel roof of Building 4475 (WC 1995).
- **Chemical Warfare Burial Area:** The Department of the Army informed the BRAC Cleanup Team that chemical warfare burial sites had been identified at training facilities with similar utilizations and construction dates as Camp Bonneville. There had been no documentation at the time of this report that chemical warfare material was buried on the property; however, the potential was recognized and noted (WC 1995).
- **Burn Area:** The burn area is located north of Landfill 3 (Figure 2-2). The area had been repeatedly used on an infrequent basis to burn wood and debris. Wood debris was observed to have been disposed of in this area (WC 1995).

2.5.3 U. S. Army Corps of Engineers Endangered Species Survey

In 1994, Pentec Environmental, Inc. (Pentec) conducted an endangered species survey for the Corps. The objective of the survey was to determine the presence of plant and animal species that were Federally- or State-listed as endangered or threatened, or were candidates for such listing, and to estimate the relative abundance of these species within the boundaries of the site. Five target species were identified within the Camp Bonneville boundaries. None of the species were Federally-listed threatened or endangered. Among the animals, two were State candidate species and one was a Federal candidate species. Among the plants, one was a State endangered species and one was a State sensitive species. The survey report recommended monitoring of invasive species and implementation of control measures. The hairy-stemmed checker-mallow population was deemed at risk because of its roadside location. It was recommended to install permanent markers around the plants to ensure that the area is not mowed or sprayed with herbicides. (Pentec 1995)

2.5.4 U. S. Army Corps of Engineers Archives Search Report

In July 1997, the Corps conducted an archives search to determine the types, quantities, and probable locations of ordnance items abandoned by DOD prior to relinquishing ownership of Camp Bonneville. Information in the report was based on a review of existing historical documents and maps, interviews, a site inspection, and descriptions of known or suspected contamination. The

conclusions and recommendations from the archives search report are discussed below in the following subsections. (Corps 1997)

2.5.4.1 Ranges and Training Areas

The Army started target practice on a rifle range at Camp Bonneville in 1910. The Army placed 14 short-range and seven long-range targets in the valley, which was 350 yards wide and 2,000 yards long. In 1918, the range contained 24 targets. At some time prior to 1929, a machine gun and howitzer range was added to the training facilities. The 1959 property inventory includes the following ranges: a known distance range, a pistol range (20 targets), a submachine gun range (21 targets), a live hand grenade range, and a mortar training shell range. Artillery units conducted firing exercises about twice a year from 1969 to 1985, resulting in approximately 50 rounds being fired into the impact area during each training session. Sometime in the 1970s, however, the military switched to sub-caliber rounds for training purposes. Historical maps dated between 1926 and 1994 identified many additional ranges and firing points throughout Camp Bonneville. These included the following:

- Rifle Range;
- Machine Gun Range;
- Anti-Aircraft Range – 500 inches miniature;
- Pistol Range;
- 1,000 inches Rifle and Light Machine Gun Range;
- Infiltration Course;
- Sub-machine Gun Range;
- Artillery Impact Area;
- Field Firing Area;
- Record Firing Range;
- 1,000 inches and Moving Target Range;
- Artillery Firing Points;
- Mortar Training Shell Course;
- Practice Grenade Range;
- Live Grenade Range;
- Rifle Grenade;
- Rocket Launcher;
- TF-1 25M;
- Free Firing .30-caliber Machine Gun Range Mortar Positions;
- Close Combat Course;
- Night Fire, KD Range;
- M60 and 25M Range;
- 14.5 Range;
- LAW, Sub-caliber, and M203 Practice Range 25-Meter Range;
- M16 Qualification Range;
- FBI Range;
- ARF Range;
- Combat Pistol Range;

- M203 Grenade Launcher (HE) Range M-31 Field Artillery Range; and
- Known Distance and Training Fire Range 25-Meter and Machine Gun Range.

Additional training in maneuvers, bivouacking, and tactics were accomplished on the many training areas at Camp Bonneville. Occasionally, vehicles would support this training, and the use of smoke or riot control agents would be authorized.

The Corps concluded in its archives search report that it was possible that unserviceable munitions may have been burned in the demolition areas. A 1971 agreement between the Army and Air Force stated that all munitions had to be destroyed by burning or detonation. A 1986 amendment allowed unserviceable munitions to be destroyed by a high order detonation only, and later in 1993, the destruction of unserviceable munitions by any method was not permitted.

2.5.4.2 Ammunition and Storage Facilities

A building list from 1946 listed two ammunition magazines buildings, 2950 and 3754. The property inventory produced in 1959 when Camp Bonneville became a sub-installation of Fort Lewis shows that building 2950 was still used as an ammunition storage facility, but it does not show a building 3754. The archives search report indicated that the EBS building list noted three ammunition bunkers, buildings 2950-52, and it listed their construction date as 1976.

2.5.4.3 Chemical Warfare Service Activities

The Corps' archives search report referenced several documents from the 1930s that discussed the expenditure of detonating gas identification (ID) sets from the Vancouver Barracks' supply. The gas ID sets consisted of a chemical agent placed in glass ampoules, vials, or bottles to train soldiers in the safe handling, identification, and decontamination of chemical warfare agents (CMA 2007). These documents all referred to the use of one set per instance, but they did not specify the location or extent of the training involved. The Corps' archives search report indicated it was known; however, that Camp Bonneville could have been the location of this activity. Camp Bonneville had two gas chambers, and it also had a 100-yard by 100-yard mustard training area. An undated map from the Real Estate Office at Fort Lewis was reviewed. It had a hand-written note in the mustard training area which read, "Gas ID." Other historical Chemical Warfare Service items mentioned in the archives search report included gas masks, smoke pots, demustardizing agents and apparatuses, tear gas capsules, and land mines. It was reported that the old gas chamber was burned in the 1970s. The two possible locations for the second gas chamber are Buildings 1834 and 1864, both of which are located in the Bonneville cantonment.

2.5.4.4 Potential and Confirmed Ordnance Presence

The Corps' archives search report concluded that the potential for ordnance existed throughout most of the installation. Figure 2-6 identifies the areas

recommended for further action with respect to ordnance. The types of UXO determined to possibly be present at the site ranged from small arms ammunition to 155-millimeter (mm) artillery rounds, up to 4.2-inch mortars, 2.36-inch and 3.5-inch rockets, and grenades (hand and rifle). Training devices were also expected to be found throughout the site.

Ordnance confirmed to be present throughout the site included one 2.36-inch rocket, which was found near the sewage treatment facility, 3.5-inch rockets, 40-mm grenades (HE), 3-inch Trench Mortar (sandfilled), 10-mm and 155-mm phosphorous grenades, and several pieces of small arms ammunition. Based on interviews with people knowledgeable about Camp Bonneville, it was determined that ordnance items also have been found off post near the post's eastern boundary and north of the Bonneville cantonment area.

2.5.4.5 Archives Search Report Recommendations

The Corps' archives search report recommended that statistical sampling for UXO be conducted to delineate the areas containing UXO. The areas with the greatest potential for UXO were depicted on an Areas Recommended for Further Action figure (Figure 2-6).

2.5.5 U. S. Army Corps of Engineers Surface Water Investigation of Lacamas Creek and Tributaries

In 1998, Hart Crowser performed a limited surface water investigation of Lacamas Creek and its tributaries for the Corps. The objectives of the investigation were to determine where constituents of concern (COCs) were entering Camp Bonneville via tributaries of Lacamas Creek; and whether COCs were exiting Camp Bonneville via Lacamas Creek and potentially impacting Lacamas Lake (HC 1998). The sample locations for this investigation are provided on Figure 2-7.

A total of six surface water samples (HC-H1 through HC-H5 and HC-D1) and one blind duplicate sample (HC-D10) were collected during the investigation. Five samples were collected from near the headwaters of various tributaries to Lacamas Creek near their entry points to the post to determine concentrations upstream of the post: sample HC-H1 was collected from East Fork Lacamas Creek, sample HC-H2 was collected from an unnamed tributary to David Creek, sample HC-H3 was collected from David Creek, sample HC-H4 was collected from North Fork Lacamas Creek, and sample HC-H5 was collected from an unnamed tributary to the North Fork Lacamas Creek (Figure 2-7). Samples HC-H1 through HC-H5 were composited at the laboratory into one sample. One sample was collected from Lacamas Creek downstream of the post (HC-D1) just before the creek exits the post.

The samples were analyzed for hardness (EPA Method 6010), total suspended solids (EPA Method 160.2), cyanide (EPA Method 9012), nitrate (EPA Method 300.0), nitrate/nitrite (EPA Method 353.2), total phosphorus (EPA Method

365.4), orthophosphate (EPA Method 365.2), fecal coliform (SM 9331E), fecal streptococcus (SM 9330C), total and dissolved priority pollutant metals and barium (EPA Method 6020/7470), total petroleum hydrocarbons (TPH; Methods NWTPH-Gx and NWTPH-Dx), semivolatile organic compounds (SVOCs; EPA Method 8270C), pesticides/polychlorinated biphenyls (PCBs; EPA Method 8081A/8082), organophosphorous pesticides (EPA Method 8141A), pentaerthritol tetranitrate (PETN; EPA Method 8330), and ammonium picrate/picric acid (AP/PA, LTL 8303).

The report concluded that site activities had not impacted the water quality of Lacamas Creek. (HC 1998)

2.5.6 Camp Bonneville Reuse Plan

In September 1998, a Reuse Plan was published for future possible uses of the site. The plan was prepared by the Camp Bonneville Local Redevelopment Authority (LRA) with the assistance of Otak, Inc. The plan was subsequently updated in February 20, 2003 and November 15, 2005. When the military closes a base, it asks the local community to form an LRA to prepare a reuse plan for the property. The LRA typically includes any jurisdictions, such as cities and counties, in which the military base is located. Since Camp Bonneville is in Clark County and is not within any city boundaries, Clark County formed the officially recognized Camp Bonneville LRA in November 1995. (LRA 1998)

Figure 2-8 illustrates the future possible uses of the site as outlined in the Preferred Reuse Plan.

To assist with the community-based planning effort, the Clark County Board of County Commissioners appointed a five-member Reuse Planning Committee (RPC) to oversee the reuse planning process. The RPC established six subcommittees made up of community representatives to assist in preparing planning options. The LRA RPC established seven guiding principles for planning, which required the reuse plan to be self-sustaining, locally focused and directed, an open process, considerate of impacts to the surrounding neighborhoods, addressed to overall community need, based on cooperation and consensus building, and environmentally conservative (LRA 1998). The preferred reuse plan components are discussed in the following subsections.

2.5.6.1 Regional Park

A regional park was proposed that would comprise approximately 1,000 acres along the western portion of the property. The public park would provide opportunities for the local community to enjoy both active and passive recreational activities. The park would be managed and maintained by Clark County and would provide the following recreational opportunities:

- Recreation trails (for hiking, mountain biking, and equestrian use);
- Group picnic areas and picnic shelters;

- Amphitheater and stage (for outdoor school and small local events);
- Restroom facilities;
- Tent camping facilities;
- Recreational vehicle camping facilities;
- Public firing range;
- Archery practice range;
- Park watch person's residences;
- Vehicle access road;
- Designated parking area;
- Ponds for recreational use and environmental education;
- Native American cultural center in the Bonneville cantonment area;
- Environmental study area; and
- Orienteering.

2.5.6.2 Law Enforcement Training Center

A law enforcement training center was proposed at the property to serve the regional needs of law enforcement agencies of southwest Washington. At this facility, police officers would receive basic training, learn new skills, and learn firearms techniques. The training center would be located in the Killpack cantonment. A new training building would be constructed to provide three to six classrooms for use by Clark College and county law enforcement for environmental and law enforcement training. Additionally, local law enforcement firing ranges were proposed east of Lacamas Creek in the southwest corner of the property. An equestrian riding ring was proposed in the general vicinity of the Killpack cantonment, and would be open to the general public when not being used for local law enforcement training. A physical fitness course and canine training areas were also proposed in the area. Proposed firing ranges would include a handgun range, a rifle range, and an area for the future construction of an indoor firing range.

2.5.6.3 Rustic Retreat Center/Outdoor School

A Rustic Retreat Center/Outdoor School was proposed at the property as the primary reuse of the barracks areas. The retreat center/outdoor school would reuse many of the existing structures after upgrades were completed for compliance with applicable building codes, and structural and utility service improvements. New buildings such as a meeting hall would be located within the existing Bonneville cantonment area.

2.5.6.4 Native American Cultural Center

Rattling Thunder, a non-profit Native American cultural group representing area tribes, provides training (drums, art, Native American culture) to Native American youth in the region and assists in coordinating tribal activities such as regional powwows. Rattling Thunder requested use of a barracks building and access to kitchen and meadow areas at Camp Bonneville for a Native American Cultural Center. The center would also be open to the general public visiting the regional park and outdoor school. The Cowlitz Indian Tribe and the Confederated

Tribes of Grand Ronde were also involved in the planning process and were supportive of the development of a Native American Cultural Center at Camp Bonneville.

2.5.6.5 Clark College Environmental Field Station

Approximately 50 to 60 acres of the property were proposed to be designated for environmental studies in the southwest corner of the property. This area was selected due to the various ecosystems in this creek watershed area and its suitability for water quality research, wildlife habitat studies, and native plant community preservation and restoration programs. A new classroom building at the Killpack cantonment would also be constructed to provide three to six classrooms for use by Clark College and county law enforcement for environmental and law enforcement training.

2.5.6.6 Trails and Nature Area

Approximately 2,000 acres of the property were proposed to be maintained for trails and nature areas in the central and eastern portions of the property. The public would access this area through hiking trails, mountain bike trails, and equestrian riding trails. Environmental learning areas would be developed for use by all age groups. Most of these recreational trails would utilize gravel and unpaved roads and cart tracks that already exist throughout the property; however, additional trails would be created as funding became available. Trails in these natural areas would also be utilized by trail maintenance staff, timber management crews, and emergency response personnel such as firefighters.

2.5.6.7 Federal Bureau of Investigation Firing Range

An area immediately adjacent to the law enforcement firing ranges was identified for lease by the FBI. Noise studies indicate that firing ranges must be located no closer than 2,000 feet from neighborhoods and public use areas. Because of this, the FBI had been asked (and had agreed) to move its range to an area that would meet this criterion. Due to safety issues, the FBI was supportive of the LRA's requirement that the relocated FBI range be baffled. The FBI estimated past usage to be 60 to 80 days per year, with usage (except for emergency training) usually able to be scheduled in advance. It was determined to be essential for the viability of the regional park that FBI use of the firing range be limited to solely meeting the FBI's needs, particularly during the peak months for park and outdoor school usage at the nearby meadow areas. The FBI was willing to share range usage with law enforcement agencies when FBI agents are available to oversee the usage.

2.5.6.8 Timber Resource Management Area

The property has significant forested areas that provide valuable wildlife habitat, stream water quality and watershed protection, and open space. Timber thinning was recommended as part of the management plan to maintain the health of this forest environment, reduce potential fire hazards, and provide a revenue product from timber sales. Forest management goals would include, but not be limited to:

simulating an old growth timber stand structure by generating an older age class of Douglas fir; and optimizing growth, yield, and forest health. The county forestry staff planned to use several silvicultural techniques to accomplish this, which would be addressed in detail in a forest management plan that would span a 50-year period. The Timber Resource Management Area was divided into two phases. Phase 1 would consist of the western portion of the property, most of which is proposed as a county regional park. Phase 2 would include the balance of the property, the majority of which would be designated as open space greenway.

2.5.6.9 Wetland/Riparian Area Restoration/Enhancement and Habitat Restoration

The plan proposed the restoration and enhancement of existing wetland and riparian areas. Additionally, it was intended that the reuse development process would enhance the entire site for wildlife, fish, and native plants. Clark County would work with the Washington State Department of Fish and Wildlife and the United States Fish and Wildlife Service to explore opportunities on the site to enhance fish population and reintroduce native species.

2.5.7 U. S. Army Corps of Engineers Multi-Sites Investigation

In 1999, Shannon and Wilson, Inc. (SWI) conducted a Multi-Sites Investigation for the Seattle District Corps. The overall objective was to identify contaminated areas and determine the next appropriate step toward restoration of those areas. The areas that were investigated included the three landfills, two suspected disposal areas, the former burn area, the former vehicle maintenance pit, the two former vehicle wash racks, and two hazardous material storage buildings. During the investigation, each of the areas was characterized and samples were collected, with the exception of Landfill 1, which could not be located by SWI. The analyses and methods applied are presented in Table 2-2.

Ground water sample results were compared to federal maximum contaminant levels (MCLs), EPA Region 3 tap water standards, and Model Toxics Control Act (MTCA) Method B standards for ground water protection. Soil sample results were compared to EPA Region 3 risk-based concentrations for residential soil exposure levels, MTCA Method A and Method B cleanup levels, and statewide background concentrations for metals. Additionally, a number of background soil samples were collected to determine background metals concentrations for the site (SWI 1999a). Each of the areas assessed is discussed below in the following subsections. Figures 2-9 through 2-16 provide illustrations of the exploration plan areas.

2.5.7.1 Landfill 2

This former landfill was discovered in about 1978 during excavation for construction of the sewage lagoon. According to an interview conducted during the Environmental Baseline Survey performed by Woodward Clyde in 1997, landfill material was unearthed at the eastern and northern borders of the sewage lagoon. No description was found of the materials encountered during construction of the sewage lagoon. There is no record of the type or quantity of material that was placed in this landfill, and the dates of use are not known.

The general landfill area is bounded by the existing sewage lagoon to the northwest and wooded areas to the south and east (Figure 2-9). The landfill area slopes gently southward toward Lacamas Creek. Although most of the site area is relatively flat, portions of the area are bumpy and uneven. The area between the sewage lagoon and the gravel road to the south is covered with native grasses.

During the Corps' investigation, sixty-four soil gas samples were collected in the Landfill 2 area. The soil gas sample locations were not depicted on the report map. The samples were submitted for off-site fixed laboratory analysis for halogenated hydrocarbons and benzene, toluene, ethylbenzene, and xylenes (BTEX) compounds by EPA Methods SW8010 and SW8020. These data were used as a screening tool to determine whether volatile constituents were present in and escaping from the landfill, rather than to provide a reliable quantitation of concentrations. Analytical results from this sampling event were below the method detection limits for all soil gas samples with the exception of chloroform. Trace concentrations of chloroform were detected in two samples at 4 nanograms (ng) in sample L2-SG-40 and 6 ng in sample L2-SG-58. The report states that these trace concentrations of chloroform may be due to contamination from sampling or analytical procedures.

Three soil borings (L2-SB01, L2-SB02, and L2-SB03) were drilled in the Landfill 2 area during July 1998 (Figure 2-9). Monitoring wells were installed in all three borings (L2-MW01, L2-MW02, and L2-MW03). The monitoring wells were installed at locations assumed to be upgradient (one well) and downgradient (two wells) of the landfill. The locations were determined based on area topography and surface drainage. For safety purposes, each soil boring was initially advanced by the UXO specialists to a depth of approximately 5 to 7 feet below ground surface (bgs), which is also below the water table. The drilling rig was then moved over the hole (or immediately adjacent to it), and drilling continued by the hollow-stem auger method. One soil sample was collected for chemical analysis at or immediately above the water table in each of the downgradient soil borings. No ground water was encountered in the upgradient boring. Because the UXO specialists were required to advance the holes to depths below the water table, soil samples for chemical analysis were collected from the hand auger barrel in the two downgradient borings. A soil sample was collected from the anticipated wet season water table zone at the upgradient boring (L2-SB03) using a split-spoon sampler.

The samples were submitted for off-site fixed laboratory analysis for TPH, volatile organic compounds (VOCs), SVOCs, pesticides/PCBs, nitroaromatic and nitramine explosives, PETN, picric acid, cyanide, total organic carbon (TOC), and priority pollutant metals. In the soil samples, arsenic, barium, beryllium, chromium, copper, and thallium were detected at concentrations that exceeded one or more of the regulatory criteria. Of these, copper was detected at a concentration that exceeded the background concentration in one of the soil samples. PETN was detected above the instrument detection limit in one of the samples; however, there are no regulatory criteria for this constituent and the background sample was not analyzed for PETN.

Due to the suspect landfill material that was found to extend to and slightly within a dense stand of trees south of the gravel road, the two downgradient monitoring wells (L2-MW01 and L2-MW02) were installed to the south of the trees, as close to the landfill as possible (Figure 2-9). These two wells were installed to depths of 13.3 feet and 12.7 feet bgs, respectively. The upgradient well (L2-MW03) was installed to a depth of 10.4 feet bgs, near the northwest corner of the sewage lagoon, to allow for potential seasonal monitoring of ground water. This depth corresponded with the top of the bedrock, which is expected to perch shallow ground water during the rainy season.

Ground water samples were collected from both downgradient monitoring wells and were submitted for off-site fixed laboratory analysis for TPH, VOCs, SVOCs, PETN, picric acid, explosives, pesticides/PCBs, total metals, dissolved metals, and cyanide. Sample results indicate that both total and dissolved arsenic were detected at concentrations that exceeded one or more of the regulatory criteria in both ground water samples.

2.5.7.2 Landfill 3

This former landfill was located southeast of the existing sewage lagoon, near Lacamas Creek, and approximately 300 feet southeast of Landfill 2 (Figure 2-9). The site was described by the previous Camp Bonneville Facility Manager as having been used as a trash burial area from the mid- to late 1970s to the early mid-1980s. The landfill reportedly was approximately 40 feet long by 12 feet wide by 8 feet deep, and trended north-south. Objects such as a refrigerator, a locker, wallboard, and paint cans were reportedly buried here. Soil had been scraped from nearby and pushed onto the landfill, creating a broad mound that marked the location of the landfill in an otherwise fairly flat area on the Lacamas Creek floodplain. Lacamas Creek flows along the eastern and southern sides of the area. At its closest point, Lacamas Creek was approximately 20 feet east of the landfill area.

During the Corps' investigation, eleven soil gas samples were installed in and around the perimeter of the Landfill 3 area to screen for halogenated hydrocarbons and BTEX compounds. The analyses were performed by EPA

Methods SW8010 and SW8020. Analytical results for the soil gas samples were below the detection limits for all analytes in every sample.

Five soil borings (L3-SB01 through L3-SB05) were drilled in the Landfill 3 area during July 1998. The borings were drilled to characterize the shallow subsurface conditions and to evaluate potential pathways for contaminant migration from the landfill. For safety purposes, each soil boring was initially advanced by the UXO specialists to a depth of approximately 5 feet bgs. The drilling rig was then moved over the hole, and drilling continued by the hollow-stem auger method. One soil sample was collected at or immediately above the water table in each soil boring to characterize the shallow ground water pathway. Because the water table was shallow and safety provisions required the UXO specialists to advance the holes to depths of approximately 5 feet bgs using hand augers, soil samples for chemical analysis were collected from the hand auger rather than from split-spoon samplers advanced by the drilling rig. The samples were submitted for off-site fixed laboratory analysis for TPH, VOCs, SVOCs, pesticides/PCBs, nitroaromatic and nitramine explosives, PETN, picric acid, cyanide, TOC, and priority pollutant metals. Sample results indicate that arsenic, barium, beryllium, chromium, copper, and thallium were detected at concentrations that exceeded at least one of the regulatory criteria.

Four ground water samples (L3-MW01 through L3-MW04) were collected from the monitoring wells installed in Landfill 3. All samples were submitted for off-site fixed laboratory analysis for TPH, VOCs, SVOCs, nitroaromatic and nitramine explosives, PETN, picric acid, pesticides/PCBs, cyanide, and priority pollutant metals (total and dissolved). Sample results indicate that arsenic was detected at concentrations that exceeded at least one of the regulatory criteria and the background concentration in all of the ground water samples.

2.5.7.3 Burn Area

The former Burn Area was located immediately north of Landfill 3, to the southeast of the sewage lagoon (Figure 2-9). A pile of wooden debris approximately 20 feet long by 15 feet wide marked the area. The use of the area to burn wood and debris was reportedly infrequent and there is no record of the period of use or list of materials burned. This area has not been used for burning material since the mid-1980s.

During the Corps' investigation, surface and near-surface soil samples were collected from five locations in and adjacent to the former Burn Area (Figure 2-9). The samples were collected to evaluate the potential for contamination resulting from past disposal and burning activities. Three locations (BA-SS-03, BA-SS-04, and BA-SS-05) were sampled within the former Burn Area. The other two locations (BA-SS-01 and BA-SS-02) were upslope (background) and downslope of the Burn Area, respectively. Two samples were collected from each location to assess the vertical extent of contamination: one from the 0 to 1-foot bgs interval, and one from the 1- to 2-foot bgs interval. Each sample was

submitted for off-site fixed laboratory analysis for TPH, VOCs, SVOCs, pesticides/ PCBs, nitroaromatic and nitramine explosives, PETN, picric acid, and priority pollutant metals. Sample results indicate that arsenic, beryllium, chromium, copper, and thallium were detected at concentrations that exceeded at least one regulatory criterion. Of these, thallium was also detected at a concentration slightly above the background concentration.

2.5.7.4 Former Buildings 1962 and 1983

Buildings 1962 and 1983 were located near the southeastern corner of the Bonneville cantonment (Figure 2-10). They were burned in place, and the burn debris was removed to an unknown location. The report does not indicate when the buildings were burned, only that they had been burned in the past. Both buildings were constructed in the 1930s with wooden frames, walls, floors, and wooden post/concrete pillar foundations and rolled composition roofs. Based on the age and type of construction, it was assumed that lead-based paint may have been used in the buildings. Lead from the paint may have been released to soil when the buildings were burned. Additionally, asbestos and SVOCs may have been present in the composition roofing materials and, therefore, released to the soils when the buildings were burned.

During the Corps' investigation fifteen soil samples (BD-SS01-01, BD-SS02-01, BD-SS03-01, BD-SS04-03, BD-SS05-01, BD-SS06-01, BD-SS06-02, BD-SS07-01, BD-SS07-02, BD-SS08-01, BD-SS08-02, BD-SS09-01, BD-SS09-02, BD-SS10-01, and BD-SS10-02) were collected from 10 locations at the Former Buildings 1962 and 1983 areas. The samples were submitted for off-site fixed laboratory analysis for SVOCs, asbestos, and lead. No SVOCs or asbestos was detected in any of the samples. Lead was not detected at concentrations that exceeded the regulatory criteria.

2.5.7.5 Drum Disposal Area

A suspected drum burial area was identified in May 1996 by an anonymous caller to the Camp Bonneville Facility Manager. The caller, who claimed to be a former employee at the camp, reported that pesticides, paints, and solvents were disposed of in this area (and in the Paint and Solvent Disposal Area, described in Section 2.5.7.6). The Drum Disposal Area reportedly was located south of the Killpack cantonment, east of the gravel road leading south from the main east-west roadway through the facility (Figure 2-11). Following the anonymous call, the Facility Manager located suspected buried metal in this area using a metal detector.

Borings DB-SB01 and DB-SB02 were advanced immediately north and south of the disposal area, respectively (Figure 2-11). The UXO contractors advanced the borings to a total depth of 5 feet bgs. Downhole magnetometer readings were obtained every 2 feet. Refusal of the hand auger was encountered at shallow depth because cobbles were present. Therefore, a shovel was used to excavate a large hole to a depth of approximately 4 feet bgs at each location. A hand auger was then used to collect the samples from the 4- to 5-foot bgs interval

(approximately 1 foot below the estimated depth of the buried drums). Soil samples from various depths were screened using a photoionization detector (PID) during excavation of the borings/holes. The soil sample was submitted for off-site fixed laboratory analysis for TPH, VOCs, SVOCs, pesticides/PCBs, nitroaromatic and nitramine explosives, PETN, picric acid, and priority pollutant metals.

Sample results indicate that antimony, arsenic, beryllium, chromium, and copper were detected at concentrations that exceeded at least one of the regulatory criteria, and antimony, barium, and copper also exceeded the background concentration.

2.5.7.6 Paint and Solvent Disposal Area

The suspected Paint and Solvent Disposal Area was identified in May 1996 by an anonymous caller to the Camp Bonneville Facility Manager. The caller, who claimed to be a former employee at the camp, reported that pesticides, paints, and solvents were disposed of in this area and in another nearby location (the Drum Disposal Area, discussed in Section 2.5.7.5). The Paint and Solvent Disposal Area was reportedly located south of the Killpack cantonment, in an open area where a (covered) tractor shed currently exists (Figure 2-12). Following the anonymous call, the Facility Manager used a metal detector in this area to locate suspected buried metal.

During the Corps' investigation, two soil borings were advanced adjacent to each of the two identified disposal locations. The UXO contractors advanced the borings to their total depths with a hand auger. Refusal of the hand auger was encountered at shallow depths in all boring locations because of cobbles; therefore, a shovel was used to excavate a large hole to the top of the sampling interval. A hand auger was then used to collect the samples from the desired interval. One soil sample was collected from each of the four soil borings (PD-SB01 through PD-SB04). The samples were collected from depths estimated to be just below the base of the debris. Soil samples were screened using a PID during excavation of the borings/holes. All soil samples collected at the Paint and Solvent Disposal Area were submitted for off-site fixed laboratory analysis for TPH, VOCs, SVOCs, pesticides/PCBs, nitroaromatic and nitramine explosives, PETN, picric acid, and priority pollutant metals. Sample results indicate that an unknown hydrocarbon, arsenic, barium, beryllium, chromium, and copper were detected at concentrations that exceeded at least one of the regulatory criteria. None of these analytes, however, were detected at concentrations that exceeded the background concentration (the background sample was analyzed only for metals).

2.5.7.7 Maintenance Pit

The Maintenance Pit was located beneath the concrete floor slab under the west end of Building 4475, in the Killpack cantonment (Figure 2-13). Building 4475 was used as the Camp Bonneville shop office. The Maintenance Pit reportedly was an unlined excavation; the exact size, depth, and location are not known. The

pit may have received vehicle fluids, such as gasoline, waste oil, lubricants, and antifreeze, as well as solvents, for an unknown period of time. In addition, pesticides may have been handled in front of the building. Building 4475 and the Maintenance Pit were bounded by Wash Rack No. 1 and a small stream to the west, a gravel drive and storage buildings to the north, and a ditch and the main road to the south. The building extends east of the Maintenance Pit area over a former underground storage tank (UST) location, which was remediated. A heating oil aboveground storage tank (AST) was located along the front (north) wall of the building. A chain link fence surrounds the entire shop office area, including the wash rack, a Hazardous Material Accumulation Point associated with the building, and a number of smaller buildings. The fence runs between Building 4475 and the ditch to the south. Numerous underground and aboveground utilities run through the area immediately west of the building. The surrounding ground surface is a mix of gravel (to the north and south) and soil (to the west). Much of this area appeared to have been filled to provide a level work area. Stressed vegetation was noted around this area. Potential causes of the vegetative stress include metals contamination from roof runoff, or other unknown factors.

During the Corps' investigation, six soil samples were collected from two soil borings at the Maintenance Pit area. An attempt was made to advance soil borings at three locations in the Maintenance Pit area. One soil boring (MP-SB01) was drilled on the northeast side of the building, near the front door. Boring MP-SB01 was drilled and sampled to 11.5 feet bgs, using a hollow-stem auger drilling rig and split-spoon sampler. Three soil samples were collected from boring MP-SB01 at depths of 0, 2.5, and 10 feet bgs for laboratory analysis. Samples from boring MP-SB01 were not analyzed for pesticides/PCBs as originally planned. Therefore, a second boring (MP-SB01A) was drilled and sampled adjacent to the original boring. Boring MP-SB01A was advanced and sampled using a Geoprobe™ sampling system. Samples were collected from this boring for PCB/pesticide analyses only. Boring MP-SB02 was attempted inside of the shop office building at the Maintenance Pit location. A hole was cut in the concrete floor, and a hand auger was used to attempt to dig down to the bottom of the pit. No samples were collected from boring MP-SB02 because rubble that had apparently been placed in the pit when it was abandoned prohibited drilling and sampling. Boring MP-SB03 was drilled and sampled behind (south of) the building. Because access was limited, a Geoprobe™ sampling system was used. Three soil samples were collected from this boring for laboratory analyses: at the ground surface, starting at 1.5 feet bgs, and starting at 3.5 feet bgs. All samples were submitted for off-site fixed laboratory analysis for TPH, SVOCs, pesticides/PCBs, and priority pollutant metals. Subsurface samples were also analyzed for VOCs. Sample results indicate that an unknown hydrocarbon, one VOC (vinyl chloride), five pesticides (4,4,-DDE, 4,4-DDD, 4,4-DDT, alpha chlordane, and gamma chlordane), and six metals (arsenic, barium, beryllium, chromium, copper, and lead) were detected at concentrations that exceeded at least one of the regulatory criteria. Of the metals, copper and lead were detected

at concentrations above the background concentration (the background sample was analyzed only for metals).

2.5.7.8 Wash Rack Number 1

The Wash Rack No. 1 area is located immediately west of the shop office building (Building 4475) in the Killpack cantonment (Figure 2-13). The wash rack was used for vehicle washing, reportedly between approximately 1978 and 1994. The wooden wash rack structure consisted of a two-track vehicle ramp. This area was initially identified as a concern during an environmental compliance inspection because it did not drain to an oil-water separator. Instead, wash water was discharged via uncontrolled overland flow to a nearby ditch. Potential contaminants at the Wash Rack No. 1 site include vehicle fluids, such as gasoline, waste oil, lubricants, and antifreeze; as well as solvents that may have been used during cleaning activities.

Except for a 1-inch thickness of asphalt at the extreme north end of the wash rack, the area was not paved and was covered with grass. The wash rack area is bounded by gravel (with minor asphalt) driving surfaces to the north and west. To the east of the area were a culvert and small stream, and Building 4475 (which includes the former Maintenance Pit). The wash rack structure abuts the chain-link fence that surrounds the shop office area. Most of the wash water discharge from the site would have flowed to the unnamed stream that crosses the site. The stream emerges from a culvert located below the gravel fill pad, between the shop office building and the wooden ramps of the wash rack. It flows aboveground for about 15 feet before entering another culvert running southward under the main road. A ditch that runs along the north side of the road also joins the stream and runs under the road through the same culvert. The wash rack area slopes downward to the east and south, toward the stream and ditch, respectively.

During the Corps' investigation, surface soil samples (WR-SS-01-01 and WR-SS-02-01) were collected from two locations at the wash rack to evaluate potential contamination from the wash rack area. One soil boring (WR-SB01) was drilled between the two ramps of the wash rack. The boring was drilled to a depth of 11.5 feet bgs using a hollow-stem auger. Three soil samples were collected from this boring using a split-spoon sampler. All samples were submitted for off-site fixed laboratory analysis for TPH, SVOCs, and priority pollutant metals. In addition, the two subsurface soil samples were analyzed for VOCs, and the two surface soil samples were analyzed for pesticides/PCBs. Sample results indicate that an unknown hydrocarbon, arsenic, barium, beryllium, cadmium, chromium, copper, and lead were detected at concentrations that exceeded at least one of the regulatory criteria. Of the metals, cadmium, copper, and lead also exceeded the background concentration.

2.5.7.9 Grease Pits

Three grease pits were identified: two located in the Bonneville cantonment north of Buildings 1828 and 1920 (Figure 2-10), and one located in the Killpack

cantonment northeast of Building 4389 (Figure 2-13). Each of the grease pits consisted of a gravel-filled excavation with a corrugated metal pipe extending vertically down into the gravel. The grease pits were used for disposal of waste cooking greases and oils from nearby mess halls. Use of the pits reportedly began around 1935.

During the Corps' investigation, four soil samples (GP-SB02-01, GP-SB02-02, GP-SB03-01, and GP-SB03-02) were collected from the grease pits at depths ranging from 3 to 9 feet bgs. The samples were submitted for off-site fixed laboratory analysis for TPH, SVOCs, pesticides/PCBs, VOCs, and priority pollutant metals. Sample results indicate the presence of arsenic, barium, copper, and thallium in at least one of the four samples at concentrations that exceeded the regulatory cleanup criteria.

2.5.7.10 Pesticide Mixing/Storage Building

The pesticide mixing/storage building (number 1864) is located in the Bonneville cantonment (Figure 2-10). The building was reportedly built in 1955 and was used for pesticide mixing and storage from 1977 to 1980. A small unnamed creek, located approximately 130 feet east of the building, flows south towards Lacamas Creek. A sink inside the building was located during the investigation and found to discharge to a dry well along the eastern side of the building.

During the Corps' investigation, two surface soil samples (PM-SS01 and PM-SS02) were collected from the south side of the building. Additionally, four boring locations (PM-SB01 through PM-SB04) were drilled around the building. Boring PM-SB03 was advanced using a hand auger due to the presence of overhead power lines. Samples were collected from three intervals in each of the borings. Monitoring wells were installed in these borings and ground water samples were collected. Samples were submitted for off-site fixed laboratory analysis for TPH, VOCs (only on subsurface samples), SVOCs, Pesticides/PCBs, organophosphorus pesticides, chlorinated herbicides, and priority pollutants metals. Sample results for the soil samples indicate an unknown hydrocarbon, one SVOC (hexachlorobenzene), two pesticides (4,4-DDE and 4,4-DDT), and eight metals (arsenic, barium, beryllium, cadmium, chromium, copper, lead, and thallium) were detected at concentrations that exceeded at least one of the regulatory criteria. Of the metals, arsenic, cadmium, copper, and lead were detected at concentrations that also exceeded the background concentration. Sample results for the ground water samples did not indicate the presence of analytes above the regulatory criteria.

2.5.7.11 Aboveground Storage Tanks

A total of 26 ASTs were present at Camp Bonneville. Three were located in the Killpack cantonment and 23 were located in the Bonneville cantonment. During the investigation, no evidence of releases from the tanks was discovered; however, incidental spillage was reported to have occurred during tank filling. Each of the AST locations was inspected for evidence of leaks or spills. Stained

soils and/or elevated PID readings were discovered at eight ASTs. During the Corps' investigation, one soil sample was collected from each of the eight areas and submitted for off-site fixed laboratory analysis of TPH. Sample results indicate the presence of diesel or hydrocarbons in all eight samples at concentrations that exceeded the regulatory criteria.

2.5.7.12 Former Sewage Pond

The sewage pond was located south of the Bonneville cantonment area (Figure 2-14). The exact location and dimensions of the pond were not documented. Anecdotal information indicates that the pond was an unlined lagoon that was pumped out and filled with clean soil from a local source when the lagoon was abandoned in 1978. The general area of the former sewage pond is on the Lacamas Creek floodplain and within approximately 200 feet of the creek.

During the Corps' investigation, five soil borings were advanced in the former sewage pond area. Borings SP-SB01, SP-SB02, and SP-SB03 were drilled within the apparent former pond area. Additionally, borings SP-SB04 and SP-SB05 were advanced for the installation of monitoring wells: one at an upgradient location (SP-SB04) and one at a downgradient location (SP-SB05). Ground water was encountered at a depth of 4 to 5.5 feet bgs. A total of 15 subsurface soil samples were collected from these boring locations. All samples were submitted for off-site fixed laboratory analysis for TPH, SVOCs, VOCs, pesticide/PCBs, and priority pollutant metals; however, the water samples were not analyzed for pesticides/PCBs. In the soil samples, arsenic, beryllium, chromium, copper, and thallium were detected at concentrations above one or more of the regulatory criteria. Arsenic, copper, and thallium were detected at concentrations that also exceeded the background concentration. In the ground water samples, arsenic was detected at a concentration that exceeded at least one of the regulatory criteria. This detection was in the upgradient well.

2.5.7.13 Ammunition Storage Magazines

The Ammunition Storage Magazines are located east of the Bonneville cantonment and southwest of the sewage treatment lagoon (Figure 2-15). The three magazines are designated as Buildings 2950, 2951, and 2953. These small structures were constructed of concrete with heavy metal doors, and each was covered with a mound of soil. The buildings are reported to have been constructed in 1976. The magazines were used to store munitions of various types that were brought to Camp Bonneville for training. The area was surrounded by a chain-link barbed wire-topped fence. Lacamas Creek is located immediately south of the fence.

During the Corps' investigation, 15 surface soil samples (AS-SS01 through AS-SS15) were collected from areas around the magazines. Additionally, one soil boring (AS-SB01) was advanced in the area to a total depth of 6 feet bgs. Samples were submitted for off-site fixed laboratory analysis for priority pollutant

metals, nitroaromatic and nitramine explosives, PETN, and picric acid. Sample results indicate that arsenic, barium, beryllium, cadmium, chromium, copper, nickel, thallium, and zinc were detected at concentrations that exceeded at least one of the regulatory criteria.

2.5.7.14 Hazardous Materials Accumulation Point

The Hazardous Material Accumulation Point, Building 4476, is located in the northeast corner of the Camp Bonneville shop area, in the Killpack cantonment (Figure 2-13). The building is a three-walled structure, built in 1990, with cement masonry block walls and a concrete slab floor. The open front of the structure is secured with locking metal gates. The structure, also referred to as the Covered Vehicle Maintenance Storage, has been used for the storage of drums containing liquids such as antifreeze and waste oil. It may have been used for temporary storage of drums of other hazardous materials. The concrete floor of the building is sloped toward a sump in the middle of the floor. The sump measures approximately 2 feet square and is approximately 2 feet deep. No drains are present in the sump. No evidence or reports of spills at this location were found. The building is bounded by a gravel driving surface to the south and east, small storage buildings and equipment to the west, and woods to the north. A vehicle fuel AST, covered and within a concrete containment structure, is located immediately west of the building. The chain-link fence that surrounds the shop office area runs along the north and east sides of the building. The area is fairly flat. Drainage from the area likely flows to the ditch running parallel to the main access road, south of the fenced shop area.

During the Corps' investigation, two surface soil samples (HM-SS-01 and HM-SS-02) were collected from the area. Additionally, one liquid sample (HM-SU01-01) was collected from the sump. The samples were submitted for off-site fixed laboratory analysis for TPH, SVOCs, Pesticides/PCBs, and priority pollutant metals. Soil sample results indicate that arsenic and beryllium were detected at concentrations above one of the regulatory criteria but not above the background concentration. For the liquid sample, an unknown hydrocarbon, one SVOC [bis(2-ethylhexyl)phthalate], and five metals (antimony, arsenic, beryllium, lead, and zinc) were detected at concentrations that exceeded at least one regulatory criterion and, in the case of metals, also exceeded the background concentration.

2.5.7.15 Former CS Training Building

The former CS training building was located south of the Bonneville cantonment and north of Lacamas Creek (Figure 2-16). The building burned to the ground sometime in the 1970s. CS gas (aka tear gas) is the common name for 2-chlorobenzalmalonitrile.

During the Corps' investigation, five soil borings were drilled at the CS training building area and 10 samples were collected. All samples were submitted for off-site fixed laboratory analysis for tear gas and cyanide; additionally, one sample from each boring was submitted for SVOC and lead analysis. Sample results

indicate that one SVOC [benzo(b)fluoranthene] and lead were detected above the regulatory criteria in at least one of the samples.

2.5.7.16 Wash Rack Number 2

The former Wash Rack Number 2 (or former maintenance rack site) is located in the Killpack cantonment at the northeast corner of the shop office area, near Building 4476 (Figure 2-13). No visible signs of contamination were noted. The wash rack was demolished in the 1980s.

During the Corps' investigation, four subsurface soil samples (W2-SB01-01, W2-SB01-2, WS-SB02-01, and W2-SB02-02) were collected from the Wash Rack Number 2 area. The samples were submitted for off-site fixed laboratory analysis for TPH, SVOCs, and priority pollutant metals. Sample results indicate the presence of an unknown hydrocarbon, arsenic, barium, beryllium, chromium, and copper at concentrations that exceeded at least one of the regulatory criteria. None of the metals were detected at concentrations that exceeded the background concentrations.

2.5.7.17 Investigation Recommendations

The Multi-Sites Investigation report prepared by Shannon and Wilson, Inc. for the Seattle District Corps of Engineers recommended no further action for various locations because either no evidence of contamination was detected or constituents of concern were detected at concentrations below the project screening level. The locations where no further action was recommended are:

- Landfill Number 1 (existence could not be substantiated by the Army Corps);
- Landfill Number 2;
- Landfill Number 3;
- Burn area;
- Paint and Solvent Disposal Area;
- Hazardous Materials Accumulation Point; and
- Wash Rack Number 2.

Locations where remedial action was recommended are:

- Drum disposal area; and
- Wash Rack Number 1.

One area, the Maintenance Pit, was recommended for additional investigation (SWI 1999a). The Multi-Sites Investigation report did not provide the recommendations for the former CS training building, ammunition storage magazines building, sewage pond, ASTs, pesticide mixing/storage building (1862), grease pits, and Buildings 1962 and 1983.

2.5.8 U. S. Army Corps of Engineers Demolition Area 1/Landfill 4 Investigation

In December 1998, Shannon and Wilson Inc. conducted an investigation of Demolition Area 1/Landfill 4 as part of the Corps' Multi-Sites Investigation. A demolition area is an area used to destroy unserviceable, excess, or obsolete munitions and/or energetic (i.e., explosive) materials by methods such as open burning and/or open detonation. A delay in the investigation of Demolition Area 1/Landfill 4 was necessary to complete UXO clearance at the landfill. The investigation of Demolition Area 1/Landfill 4 included UXO avoidance, geophysical surveying, collection of surface and subsurface soil samples, installation of monitoring wells, and collection of ground water samples from the monitoring wells. It was reported that building demolition debris was deposited in the landfill during the mid-1960s. The facility manager (at the time of the SWI report) indicated that firearms were also disposed at the landfill; however, the time frame of this disposal was not reported. (SWI 1999b)

During the Corps' investigation, two surface soil samples (L4-SS01 and L4-SS02) were collected in an area of discolored soil. The samples were submitted for analysis of SVOCs, pesticides/PCBs, nitroaromatic and nitramine explosives, PETN, picric acid, and priority pollutant metals. Sample locations are depicted on Figure 2-17. No background samples were collected during the investigation; however, the surface soil samples were compared to the background samples collected during the Multi-Sites Investigation. Soil samples were compared to background, EPA Region 3 risk-based concentrations for residential exposure to soil, and MTCA Method A, Method B, and Method B protection of ground water criteria. The report does not specify if these are unrestricted land use or industrial use. Arsenic, barium, beryllium, chromium, and copper were detected at concentrations that exceeded one or more cleanup criteria but were below the site background concentrations. No other analytes were detected above the instrument detection limit in the surface soil samples. Five soil borings (L4-MW01, L4-MW02, L4-SB03, L4-SB04, and L4-SB05) were drilled and monitoring wells (L4-MW01 and L4-MW02) were installed in two of the borings. Boring locations are depicted on Figure 2-17.

Three soil samples were collected from each of the borings and were submitted for off-site fixed laboratory analysis of TPH, SVOCs, pesticides/PCBs, nitroaromatic and nitramine explosives, PETN, picric acid, and priority pollutant metals. Additionally, the two deep samples were submitted for VOC analysis. Barium, chromium, and copper were detected at concentrations that exceeded one or more of the cleanup criteria and background concentrations. No other analytes were detected at concentrations that exceeded cleanup criteria. Finally, two ground water samples were collected from the monitoring wells and were submitted for off-site fixed laboratory analysis of TPH, VOCs, SVOCs, pesticides/PCBs, nitroaromatic and nitramine explosives, PETN, picric acid, and priority pollutant metals (total and dissolved). No background ground water samples were collected during the investigation. Sample results were compared

to EPA MCLs, EPA Region 3 risk-based concentrations for tap water, and MTCA Method A and Method B cleanup criteria. Sample results indicated the presence of hexahydro-1,3,5-trinitro-1,3,5-triazine (RDX) at concentrations that exceeded at least one cleanup criteria. No other analytes were detected at concentrations that exceeded cleanup criteria. (SWI 1999b)

Based on the sample results, it was recommended that additional monitoring well installation occur at the landfill in order to further characterize potential contamination associated with it. It was also recommended that surface water and sediment samples from North Fork Lacamas Creek be collected to determine if contamination was migrating from the landfill to the creek. (SWI 1999b)

2.5.9 Base Realignment and Closure Hazardous, Toxic, and Radioactive Waste Site Closure Report

In September 2000, URS completed a site closure report for the United States Army Corps of Engineers. The objectives of the site closure report were to document that past work at eight locations within Camp Bonneville met cleanup requirements of the Camp Bonneville BRAC cleanup team, and to prepare closeout documentation for the eight separate locations within Camp Bonneville that require no further action to meet CERCLA requirements. The closure report pertained only to the hazardous, toxic, and radioactive waste components of the locations and did not include UXO (URS 2000b).

In order to achieve the objectives of the closure report, previous investigations that had been performed at the facility were reviewed, existing data was compared to cleanup levels, and potential exposure pathways and receptors were evaluated in conceptual site models.

The eight locations evaluated and recommended for closure in the report include:

- Landfill 1;
- Landfill 2;
- Landfill 3;
- Former Burn Area;
- Buildings 1962 and 1983;
- Grease Pits at the Camp Bonneville and Killpack cantonments;
- Former Sewage Pond; and
- Hazardous Materials Accumulation Point.

The site closure report prepared by URS presents the rationale for no further action at these eight locations. The rationale stated in the report is provided below.

- **Landfill Number 1:** The landfill was not located by reconnaissance and geophysical methods. Previously collected information is interpreted to be

consistent with the presence of a small debris pile associated with a former residence (URS 2000b).

- **Landfill Number 2:** The soil gas survey indicated no impact to air and no evidence of VOCs in the landfill materials. Metals were the only constituents detected in downgradient borings, and none were detected at concentrations above the screening criteria and background. Both total and dissolved arsenic were detected in both ground water wells sampled at concentrations exceeding risk-based criteria but below the MCL. Arsenic concentrations in area wells are typically slightly elevated, which may be related to background conditions (URS 2000b).
- **Landfill Number 3:** The soil gas survey indicated no impact to air and no evidence of volatile organics in the landfill materials. Metals were the only constituents detected in downgradient borings, and none were detected at concentrations above the screening criteria and background. Total and dissolved arsenic were detected in the downgradient ground water wells at concentrations exceeding risk-based criteria but below the MCL. Total and dissolved arsenic concentrations in area wells are typically slightly elevated, which may be related to background conditions (URS 2000b).
- **Burn Area:** Metals were the only constituents detected in soil in downgradient borings, and only thallium was found at a concentration above the screening criteria and background. Thallium was detected in one surface soil sample at a concentration slightly above background and the MTCA Method B ground water protection criterion, but less than two times background. Slightly elevated thallium levels, detected in one surface soil sample, may not exceed the actual natural concentration in site soils. Arsenic was detected in one nearby downgradient landfill ground water well at a concentration exceeding risk-based criteria, but below the MCL. The burn area does not appear to pose a threat to ground water. Arsenic concentrations in area wells are typically slightly elevated, which may be related to background conditions (URS 2000b).
- **Former Buildings 1962 and 1983:** Only lead was detected in the surface and near-surface soil samples. Concentrations detected did not exceed the screening criteria (URS 2000b).
- **Camp Bonneville Grease Pits:** No organics in soil were detected at concentrations above the screening criteria. Barium and copper were detected in soil above the MTCA Method B ground water protection level and slightly above background levels in soil, but less than two times background. Ground water was not encountered in the boring, which extends to volcanic rock (URS 2000b).

- **Camp Killpack Grease Pit:** No organics were detected at concentrations above the screening criteria in soil. Arsenic was detected in one soil sample at a concentration above the screening criteria and slightly above background, but less than two times background. Thallium was detected at a concentration above the MTCA Method B ground water criterion and slightly above background in one soil sample, but less than two times background. Ground water was not encountered in the boring (URS 2000b).
- **Former Sewage Pond:** Thallium was detected in one soil sample at a concentration above the MTCA Method B ground water protection level and slightly above background, but less than two times background. Arsenic was detected in one soil sample at a concentration above the screening levels and slightly above background, but less than two times background. Copper was detected above the MTCA Method B ground water protection criterion and slightly above background in one subsurface soil sample from the upgradient boring, but less than two times background. Arsenic, copper, and thallium, detected in only one soil sample each at concentrations only slightly above background, may be representative of natural conditions. No organic compounds were detected in ground water samples. The only metal detected in ground water above screening criteria was arsenic in the upgradient well. The ground water arsenic concentration exceeded both MTCA and EPA Region 3 risk-based criteria but was well below the MCL. Arsenic was not detected in the downgradient ground water well. Arsenic concentrations in ground water at Camp Bonneville typically appear to be slightly elevated and may be related to background conditions (URS 2000b).
- **Hazardous Materials Accumulation Point:** The only organics detected in surface soil samples were low concentrations of TPH and bis(2-ethylhexyl)phthalate (below screening levels). No metals were detected at concentrations above the screening levels or background (URS 2000b).

2.5.10 Environmental Restoration – Multi-Sites

In 2000, Gary Struthers Associates, Inc. (GSAI) conducted remedial environmental restoration in areas that had been recommended for remedial work during the 1991 SWI Multi-Sites Investigation and prepared the areas for closure. The scope of the work conducted included the remediation of identified hazards at each of seven designated sites to meet regulatory cleanup standards and allow for unrestricted use of the property. The closure for each location included the excavation and stockpiling of suspected contaminated soil; screening of the in-place soil for the analytes of concern, followed by additional excavation (as needed); and concluded with confirmation sampling and fixed laboratory analysis (GSAI 2000). The soil samples were compared to MTCA Method B, when no established criteria was available in MTCA Method B, then Method A values were used. The seven areas remediated during this investigation are described

below. The remedial environmental restoration report prepared by GSAI does not address the recommendations/disposition of the ASTs, ammunitions building, or Wash Rack 2.

2.5.10.1 Drum Disposal Area

Initial concerns with contamination in this area were raised prior to conducting excavation activities due to the discovery of surficial drum debris not previously documented. Upon commencement of the backhoe excavation activities, numerous pieces of metallic debris were found and removed, including a locker, a large sink, an apparent bookshelf, numerous rusted-through buckets, and a bumper. These items and other debris were excavated and stockpiled. Upon further excavation, a solvent-like odor was noted. Excavation immediately ceased, and field screening was conducted with a PID on the freshly exposed soil. The PID readings from the exposed area were as high as 150 parts per million (ppm).

A total of 26 test pits were excavated from the area (Figure 2-18). The test pits were numbered 1 to 26 in the approximate sequence in which they were dug. Each of these test pits had an approximate footprint of 4 feet by 6 feet and was advanced to approximately 4 feet. Water was observed in several of the test pits. While digging in Test Pit #25, the backhoe bucket pulled up a relatively intact paint bucket (approximately 5-gallon size) containing fresh paint. The paint bucket was damaged by the time it was brought to the surface, and paint was dripping from it. The bucket of paint was placed upon a separate visqueen staging area. Another item of concern, which was discovered during the test pit activities, was an apparent clay tile drain line running through the area from the general direction of the Killpack cantonment. Two soil samples and three ground water samples were collected from the 26 test pits. The samples were submitted for off-site fixed laboratory analysis of VOCs, SVOCs, pesticides/PCBs, herbicides, and metals (not all samples were analyzed for all constituents). Sample results indicated that concentrations for all analytes detected were below the site-specific cleanup criteria. Restoration at this site included placement of plastic sheeting into each of the exposed test pits prior to backfilling the test pits with the excavated soil.

2.5.10.2 Paint and Solvent Disposal Areas

The remediation activities for this area began with a geophysical survey to attempt to identify and delineate the extent of buried drums or metal debris. The geophysical survey uncovered two disposal areas each to a limited extent. Based on the survey, two soil borings were drilled at each location (Figure 2-12). Samples were analyzed for TPH, VOCs, SVOCs, pesticides/PCBs, nitroaromatic and nitramine explosives, PETN, picric acid, and priority pollutant metals. Sample results indicated the presence of arsenic, barium, beryllium, chromium, and copper at concentrations that exceeded the regulatory criteria; however, all results were below the background concentrations. Restoration of this area

consisted of returning the excavated soil, less the debris, to the excavations and regrading of the area.

2.5.10.3 Wash Rack Number 1

The remediation activities for this area began with the dismantling of the timbers that formed the wash rack. Once the wash rack was removed, a backhoe was used to excavate the footprint of the area (Figure 2-19). The area was excavated to a depth of 3 feet bgs, and a soil sample (H1) was collected from the floor of the excavation for Hanby field analysis (which detected TPH). An additional field sample (H2) was collected from the 3.6-foot bgs depth of the excavation floor. A third field sample (H3) was collected from the 3.5-foot depth interval of the west sidewall of the excavation. These three field Hanby analyses revealed screening level concentrations of 0 ppm, 10 ppm, and 0 ppm, respectively.

Confirmation samples were collected and analyzed for diesel- and heavy oil-range TPH, cadmium, and lead. The results from the initial confirmation samples indicated that additional excavation of the northern and western sidewalls was needed due to the presence of elevated levels of diesel-range TPH. Additional excavation of 3 feet was conducted in the area. A total of eight soil samples (including one duplicate sample) were collected and submitted for off-site fixed laboratory analysis of TPH, VOCs, SVOCs, pesticides/PCBs, and metals (not all samples were submitted for all analyses). Sample results indicated that concentrations for all analytes detected were below the screening criteria. Restoration of this area included hauling in imported backfill material to match the native material, and regrading of the area.

2.5.10.4 Maintenance Pit

Remediation of the area included excavation of the footprint of the maintenance pit to a depth of 0.8 feet bgs and collection of soil samples H4 and H5 from the eastern portion of the excavation floor, and sample H6 from the western portion of the floor (Figure 2-19). The samples were submitted for off-site fixed laboratory analysis for diesel- and heavy oil-range TPH, vinyl chloride, PCBs, DDD, DDE, DDT, and lead. Sample results indicated that additional excavation was required due to the presence of TPH and lead. The excavation was advanced to approximately 2.7 feet bgs and expanded in the northern, eastern, southern, and western sidewalls by approximately 2, 4.3, 0.5, and 5.6 feet, respectively. A total of 12 soil samples were collected and submitted for off-site fixed laboratory analysis of TPH, VOCs, SVOCs, pesticides/PCBs, and metals (not all samples were submitted for all analyses). Sample results indicated that concentrations for all analytes detected were below the established cleanup levels. Restoration of this area included hauling in imported backfill material to match the native material, and regrading the area.

2.5.10.5 Former CS Training Building Area

During the investigation by GSAI, five soil samples were collected from the former CS training building area (Figure 2-20). Samples were submitted for off-

site fixed laboratory analysis for VOCs, SVOCs, and metals. Sample results indicated that lead was detected at concentrations that exceeded the regulatory criteria in two of the samples. Restoration of this area included hauling in imported backfill material to match the native material, and regrading the area.

2.5.10.6 Pesticide Mixing/Storage Building

Excavation was conducted south of the entry of the building (number 1864) and continued to a depth of 2.5 feet bgs (Figure 2-21). A total of eight soil samples (including one duplicate) were collected and submitted for off-site fixed laboratory analysis of TPH, VOCs, SVOCs, pesticides/PCBs, chlorinated herbicides, and metals (not all samples were submitted for all analyses). Sample results indicated that concentrations for all analytes detected were below the established cleanup levels. No remediation was conducted at this location.

2.5.10.7 Selected Aboveground Storage Tank Locations

A total of eight AST locations were selected for remedial action. Soil around the ASTs was excavated until visual observation and field screening by Hanby analysis indicated that residual contamination above regulatory criteria had likely been removed. Confirmation samples were collected and submitted for off-site fixed laboratory analysis of TPH. Upon confirmation that no more contamination was present above regulatory criteria, the excavations were restored by hauling in imported backfill material to match the native material and regrading the area. The AST support blocks were reset at the original location and the ASTs were placed on them. The excavations are described for each of the ASTs below.

- **AST #1 – Building T-1833:** The excavation in this area reached approximately 2 feet bgs. The confirmation sample from this area indicated additional contamination. Based on these results, further excavation was conducted to 4 feet bgs. Again, confirmation samples were collected and submitted for analysis. Sample results indicated no TPH above regulatory criteria.
- **AST #2 – Building T-1837:** The excavation in this area reached approximately 5 feet bgs. Confirmation sample results indicated no TPH above regulatory criteria.
- **AST #3 – Building T-1828:** The excavation in this area reached approximately 5 feet bgs. Confirmation sample results indicated no TPH above regulatory criteria.
- **AST #4 – Building T-1940 (Day Room):** The excavation in this area reached approximately 2.5 feet bgs. Confirmation sample results indicated no TPH above regulatory criteria.
- **AST #5 – Building T-1922:** The excavation in this area reached approximately 2.3 feet bgs. Confirmation sample results indicated no TPH above regulatory criteria.

- **AST #6 – Building T-1922:** The excavation in this area reached approximately 4.5 feet bgs. Confirmation sample results indicated no TPH above regulatory criteria.
- **AST #7 – Building T-1942:** The excavation in this area reached approximately 4.5 feet bgs. Confirmation sample results indicated no TPH above regulatory criteria.
- **AST #8 – Building T-1980:** The excavation in this area reached approximately 2.5 feet bgs. The confirmation sample from this area indicated additional contamination. Based on these results; further excavation was conducted to 5 feet bgs. Again, confirmation samples were collected and submitted for analysis. Sample results indicated no TPH above regulatory criteria.

2.5.10.8 Summary and Recommendations

The GSAI study results from the confirmation sampling data indicated that the paint and solvent disposal area, Wash Rack Number 1 area, the maintenance pit area, the former CS training building, the pesticide mixing/storage building, and the eight AST locations were in compliance with the site clean-closure levels. Additionally, results of this remedial activity indicated that further investigation of the drum disposal area and surrounding fields was necessary prior to continuing remedial actions in that area.

2.5.11 U. S. Army Corps of Engineers Supplemental Site Investigation

In 2000, URS completed a supplemental site investigation (SSI) for the Corps at two locations near the Killpack cantonment. The objectives of the SSI were to: evaluate chemicals of potential concern (COPCs) in surface soil and in flooring material of Building 4126 at the Pesticide Storage Area that had not previously been investigated; evaluate COPCs in surface and subsurface soil and ground water at the largest Ammunition Storage Magazine (Building 2953); and evaluate potential exposure to human and ecological receptors based on a conceptual site model (URS 2000a).

Sample results were compared to MTCA Method A and B cleanup levels, natural background soil metals concentrations in Washington State, and the background soil metals concentrations that were calculated in the 1999 SWI investigation. The following subsections provide a discussion of the specific areas included in the supplemental site investigation performed by URS.

2.5.11.1 Pesticide Storage Area

The Pesticide Storage Area (Building 4126) is located on the edge of a small, flat, grassy field approximately 75 feet south of the gravel road in front of the Killpack cantonment (Figure 2-22). Overall, the ground surface in this area slopes very gently to the south, away from the road. The building is approximately 4 feet west of an approximately 8-foot by 8-foot concrete pad. A surface soil sample (SS04) was collected from an exposed strip of soil between the building entrance and the building, and a surface soil sample (SS05) was collected from the south side of the building. Additionally, a flooring material sample (FS01) was collected.

The soil samples were submitted to an off-site fixed laboratory for analysis of petroleum hydrocarbons, organochlorine pesticides/PCBs, metals, and herbicides. Sample results indicated that 4,4-DDT and 2,4,5-T were detected at concentrations that exceeded the screening criteria. Based on these results, it was recommended that the building be demolished and that surface soil to approximately 1 foot bgs beneath the footprint of the building and to a distance of approximately 4 feet outside the footprint of the building be excavated and disposed.

2.5.11.2 Ammunition Storage Magazines

The Ammunition Storage Magazines (Buildings 2950, 2951, and 2953 as previously discussed in Section 2.5.7.13) are located approximately 2,000 feet northeast of the Pesticide Storage Area on the south side of the road leading into the facility from the Killpack cantonment (Figure 2-15). They are positioned on a flat, graded terrace approximately 10 feet below the elevation of the road. The SSI investigated soil near the largest magazine, Building 2953 (Figure 2-23). An approximately 10-foot-wide by 50-foot-long access road descends from the main gravel road on the west side of Building 2953 and ends in front of the magazine entrance on the south side. Overall, the ground surface in this area slopes away from the road and continues to descend toward the south away from the terrace.

Three surface soil samples (SS01, SS02, and SS03) were collected in three locations in front of the magazine door. Subsurface soil samples were collected from soil boring SB-01 approximately 15 feet south of the bunker. Ground water was not encountered in the boring location. The samples were submitted to an off-site fixed laboratory for analysis of priority pollutant metals, SVOCs, ordnance, and propellants. Sample results indicated that antimony, cadmium, lead, and 2,4-dinitrotoluene were detected at concentrations that exceeded the screening criteria.

Based on these sample results, it was recommended to dispose of soil (0 to 1-foot bgs) along the short footpath leading to the door of Building 2953. This included an approximately 4-foot-wide area along the approximately 6-foot-long path. In addition, it was recommended that soil (0 to 1-foot bgs) at Buildings 2950 and

2951 be excavated and disposed of in areas where metals concentrations exceeded screening values during the 1999 SWI investigation.

2.5.12 Geophysical Survey

In October 2000, Parsons Engineering Science, Inc. (Parsons) conducted a geophysical survey of a suspected drum burial area (Figure 2-24). The survey was conducted using a G-858 portable cesium magnetometer/gradiometer. Eleven anomalies were encountered during the investigation that indicated the possibility of buried drums. These anomalies were mostly encountered in the suspect drum burial area, which was estimated to be approximately 10 to 15 feet across. The total depth was not determined. (Parsons 2001)

2.5.13 Ordnance and Explosive Removal Action

In October 2000, UXB International, Inc. (UXBI) completed a Removal Report for Ordnance and Explosives Removal at Camp Bonneville (UXBI 2000). The objectives of the removal were to safely locate, identify, and dispose of all surface and subsurface live and inert ordnance related scrap to a depth of 2 feet in two former M203 and 40mm grenade launcher ranges (Figure 2-25). Additionally, geophysical mapping of the two ranges was performed before and after the removal activities. The ranges were further subdivided into grids that measured no larger than 100 feet by 100 feet. The material encountered was further categorized as UXO (ordnance items, complete or partial, containing an explosive filler or propellant), ordnance and explosive related scrap (non-explosive ordnance material), and non-ordnance related scrap (miscellaneous material not related to ordnance). During the anomaly investigation, UXBI acquired and excavated anomalies, identified them, and determined their appropriate disposition. When UXO was encountered, it was blown in-place. Nine UXO items were encountered and disposed during the investigation. Ordnance and explosives related scrap was inspected, explosively demilitarized (if necessary), and certified as free of explosive. A total of 3,888.25 pounds of ordnance and explosives related scrap was removed. Finally, 683.85 pounds of non-ordnance related scrap was recovered from the ranges. Based on this work, UXBI recommended that the area's investigation be "opened to unlimited use/activities to a depth of 4 feet." (UXBI 2000)

2.5.14 Environmental Restoration – Pesticide Storage Area and Ammunition Storage Magazines

Based on the results and recommendations of the SSI in 2001 (discussed in Subsection 2.5.10), GSAI performed a remediation environmental restoration for the Pesticide Storage Area (Building 4126) and the Ammunition Storage Magazines (Buildings 2950, 2951, and 2953; GSA 2001).

2.5.14.1 Pesticide Storage Area

Work on the Pesticide Storage Area (Building 4126) began with characterization and sampling of the physical structure. Following sampling, the structure was dismantled. After demolition was completed, a backhoe was used to excavate the

footprint of the building and its drip-line to a depth of 1 foot bgs. Samples were collected from each side wall of the excavation as well as the floor. The results from the samples indicated that no additional excavation was required. Clean backfill was imported and the excavation area filled and graded.

2.5.14.2 Ammunition Storage Magazines

A backhoe was used to excavate the footprint of three magazines (2950, 2951, and 2953) to a depth of 1 foot bgs. Confirmation samples were collected from the four side walls as well as the floor in each of the magazines. Results from the samples indicated that no additional excavation was required. Clean fill material was imported and the areas were filled and graded.

2.5.15 Environmental Restoration – Drum Burial Area

Based on information contained in previous reports, an environmental restoration was performed at the drum burial area in 2002, by GSAI for the Corps. During the investigation, soil from the drum burial area (as discussed in Subsections 2.5.9.1 and 2.5.11) was excavated and stockpiled. Confirmation soil samples were collected for fixed laboratory analysis of Resource Conservation and Recovery Act (RCRA) metals plus copper, VOCs, SVOCs, polyaromatic hydrocarbons (PAHs), pesticides/PCBs, and TPH. Following receipt of sample results that were below the cleanup criteria established under previous investigations, the area was backfilled and was no longer considered an environmental concern. The environmental restoration report does not indicate the depth of the excavation (GSAI 2002).

2.5.16 Small Arms Range Reconnaissance

In 2002, Parsons conducted a reconnaissance of 24 small arms ranges for the Corps. The objectives of the reconnaissance activities were to confirm the existence of each range, document the location of the ranges, and record information and characteristics of any remaining features associated with the ranges. If no discernible features were present to indicate the existence of a range, only general terrain data were collected. Information collected included: type of firing point; type and height of berm structure (if present); type of munitions used; type of targets used; and general terrain information. The locations of the ranges are presented on Figure 2-31. Many of the ranges overlap one another and, therefore, some of the information collected from one range may apply to another range located in the same area. (Parsons 2002)

2.5.16.1 Rifle Ranges 1 and 2

Rifle Ranges 1 and 2 are located east of the Bonneville Cantonment (Figure 2-26). These ranges are described as two distinct ranges in the Corps' archives search report: Rifle Range 1 is the main range, and Rifle Range 2 is the safety fan. Both were first used in the 1920s for live fire training using M1 Rifles (.30-caliber). A pond adjacent to the target area was created when soil was removed to build an Automated Record Fire Range in the late 1980s. Features noted during the reconnaissance by Parsons included: pop-up targets on berms; six concrete firing

positions/foxholes; firing line post markers; a control tower; and down-range boundary pole markers. It is unclear if these features are part of the Automated Record Fire Range or the historic Rifle Ranges. (Parsons 2002)

2.5.16.2 Field Fire Rifle Ranges 1 and 2

Field Fire Ranges 1 and 2 are located east of the Bonneville Cantonment (Figure 2-26). The Corps' archives search report describes two Field Fire Rifle Ranges: Range 1 is the Field Fire Rifle Range, and Range 2 is the safety fan. The ranges were first used in the late 1950s for .30- and .50-caliber weapons. Pop-up targets at varying distances were used and are the same targets as identified in Rifle Range 1. The features noted for these ranges are the same as Rifle Ranges 1 and 2. (Parsons 2002)

2.5.16.3 Field Firing Ranges 1 and 2 and Pistol Range

Field Firing Ranges 1 and 2 and the Pistol Range are located southeast of the Bonneville Cantonment (Figure 2-26). The Corps' archives search report describes these ranges as two distinct areas: Field Firing Range 1 is the main firing range and Field Firing Range 2 is the safety fan for Range 1. Field Firing Ranges 1 and 2 were first used in the late 1950s for live fire training using the M1 Rifle (.30-caliber). The Pistol Range was first used in the mid-1980s for live fire training using the M1911A1 Pistol (.45-caliber). The firing point for the Pistol Range is located in the same area as the Field Firing Ranges. The areas encompassing the noted features were surrounded by berms to the north and east. Features noted include: berms; a firing point area with multiple concrete firing positions; an observation tower; boundary poles; and fixed paper type target stands. (Parsons 2002)

2.5.16.4 1000-Foot Range, 1000-Foot Machine Gun Range, and Moving Target Range

The 1000-Foot Range, 1000-Foot Machine Gun Range and Moving Target Range are located south of the Bonneville Cantonment (Figure 2-27). The 1000-Foot Range began operation in 1943, and the machine gun and moving target ranges were added in 1958. The ranges used the M1 rifle and the M1919 machine gun, both .30-caliber. The features noted during the reconnaissance by Parsons included: two berms; two trenches; and a possible moving target. (Parsons 2002)

2.5.16.5 25-Meter Record Fire Field Range and Field Firing Range

The 25-Meter Record Fire Field Range and Field Firing Range are located to the south of the Bonneville Cantonment (Figure 2-27). The 25-Meter Record Fire Field Range was first used in 1958 for measuring accuracy with .30- and .50-caliber weapons. The Field Firing Range, which extends beyond the 25-Meter Range, was added in 1950 and also was used for both .30- and .50-caliber weapons; however, this range was not intended for accuracy testing. Features associated with these ranges noted during the reconnaissance by Parsons included: multiple 3-foot high berms; an area suspect of being a firing point; and one

concrete bunker with a turning cable wheel system (the purpose of the cable wheel system was not noted). Parsons 2002

2.5.16.6 Close Combat Range

The Close Combat Range is located in the northern portion of the site near Demolition Area 1/Landfill 4 (Figure 2-28). The Close Combat Range was first used sometime in the early 1970s for live fire training with .30- and .50-caliber weapons in an automated pop-up target course. The features noted during the reconnaissance by Parsons included: a collapsed observation stand; a safety lane sign nailed to a tree near the tower; concertina wire on the upper line near the safety sign electrical post with lines running underground; 4-foot by 12-foot wooden boxes containing the pop-up silhouette targets, with some containing three electrical outlets; and a circular exit sign nailed to a tree at the end of the range. (Parsons 2002)

2.5.16.7 Submachine Gun Range

The Submachine Gun Range is located just south of Demolition Area 1/Landfill 4 and northeast of the Bonneville Cantonment (Figure 2-28). The Submachine Gun Range was first used sometime in the late 1950s for M3 submachine gun (.45-caliber) training. Features noted during the reconnaissance by Parsons included: two mortar positions; one mock satellite dish; two BRDM mock armored vehicles; concertina wire; multiple silhouette small arms targets, and a bunker with mock guided anti-aircraft missiles. (Parsons 2002)

2.5.16.8 TF Range

The TF Range is located due east of the Bonneville Cantonment along the south edge of the Lagoon Ponds (Figure 2-26). The TF Range was used in the 1950s for record firing of small arms (.22-, .30-, and .50-caliber, and 7.62-mm) and machine gun firing. No range related features were observed during the reconnaissance by Parsons. (Parsons 2002)

2.5.16.9 25-Meter M60 Range and Pistol Range

The 25-Meter M60 Range and Pistol Range are located northeast of the Bonneville Cantonment, due north of the Lagoon Ponds (Figure 2-28). The Pistol Range was first used in the late 1950s as a non-record fire range using the M1911A1 (.45-caliber) pistol. The 25-Meter M60 Range was added in the early 1970s and was used for firing the .30-caliber carbine, the M16 rifle, the M14 rifle, and the .50-caliber machine gun. Features identified during the reconnaissance included: a 10-foot berm; two small target areas; .45-caliber bullet casings; a concrete wall, and a firing line. (Parsons 2002)

2.5.16.10 Combat Pistol Range

The Combat Pistol Range is located south of the Bonneville Cantonment and south of Buck Creek (Figure 2-28). The Combat Pistol Range was first used in the late 1980s and included the use of the M1911 (.45-caliber), M9 (9-mm), and .38 Special handguns. It is not known if the range was a free fire or record fire

range. Features noted during the reconnaissance by Parsons included: a control tower; firing point positions; and range boundary poles. (Parsons 2002)

2.5.16.11 25-Meter Machine Gun Range

The 25-Meter Machine Gun Range is located south of the Bonneville Cantonment near the southern installation boundary (Figure 2-29). The 25-Meter Machine Gun Range was first used in the 1960s for live fire exercises with weapons such as the M1 Rifle (.30-caliber) and the M14 Rifle (7.62-mm). According to the Corps' archives search report, this range was also used for live fire training using .30-caliber machine guns. Features noted during the reconnaissance by Parsons included: the firing point; an observation tower; one short berm; one tall berm; and a covered firing line. (Parsons 2002)

2.5.16.12 South and North Machine Gun Ranges

The South Machine Gun Range is located in the southwest corner of the installation and the North Machine Gun Range is located southeast of the Killpack Cantonment north of the former Commanding Officer's residence (Figure 2-30). The South Machine Gun Range was first used in the mid-1920s for free firing training using the M1919 Machine Gun (.30-caliber). The North Machine Gun Range was first used in the mid-1950s for free firing training using .30-caliber machine guns. No features indicating the presence of former machine gun ranges were noted during the reconnaissance. (Parsons 2002)

2.5.6.13 North and South Infiltration Courses

The North Infiltration Course is located southeast of the Bonneville Cantonment in the vicinity of Field Firing Ranges 1 and 2 and the Pistol Range (Figure 2-26). The South Infiltration Course is located directly south of the 3.5-Inch Rocket Range near the southern installation boundary (Figure 2-29). The North Infiltration Course was first used in the early 1940s for live fire training using the M1919 Machine Gun (.30-caliber). The South Infiltration Course was first used in the early 1970s where the use of .30-caliber carbines, M16 Rifles (5.56-mm), M14 Rifles (7.62-mm), and .50-caliber machine guns were used for live fire training. No evidence of the North Infiltration Course was noted during the reconnaissance by Parsons. Features identified with the South Infiltration Course included a berm along the northwest edge of the range and a nose cone to a 3.5-inch rocket (M29 practice version); however, these features were later attributed to the 25-Meter Range and the 3.5-Inch Rocket Range located adjacent to the eastern portion of the South Infiltration Course. No evidence of the South Infiltration Course was identified during the reconnaissance. (Parsons 2002)

2.5.16.14 M31 Sub-Caliber Ranges 1 and 2

The M31 Sub-Caliber Ranges are located in the southwestern portion of the site (Figure 2-30). These ranges are described as two distinct ranges in the Corps' archives search report: Range 1 is the main range, and Range 2 is the safety fan. The M31 Sub-Caliber Ranges were first used in the 1970s. Features identified during the reconnaissance by Parsons included: multiple vehicle tires with the

outer edges painted; multiple concrete walls; multiple earth mounds; two large holes or pits; an observation tower; and four firing point concrete pads at the north end of the range. (Parsons 2002)

2.5.16.15 500-Inch Anti-Aircraft Range and Anti-Aircraft Range

The Anti-Aircraft Ranges cover a large area of the central and southwestern portions of the site. The firing point for both ranges is located in a flat area between the Rifle Ranges and Lacamas Creek (Figure 2-27). The Anti-Aircraft and 500-inch Anti-Aircraft Ranges were first used in the early 1940s for pedestal mounted machine gun (.22-caliber) fire training on overhead targets, parachute targets, climbing and diving targets, and horizontal targets. No features associated with these ranges were noted during the reconnaissance by Parsons. (Parsons 2002)

2.5.16.16 1952-TEC-22

An area identified from a 1952 aerial photograph labeled as 1952-TEC-22 was investigated as part of the reconnaissance. It is believed to be an undocumented small arms range. The area is located on the western edge of the Bonneville Cantonment. Features identified that are associated with the undocumented range included: multiple flat silhouette small arms targets nailed to trees or lying on the ground surface; and a possible berm oriented east to west. (Parsons 2002)

2.5.16.17 Conclusions

Twenty-four individual documented ranges were investigated as part of the reconnaissance by Parsons. Features documented as part of the ranges generally included berms, firing points, control towers, targets, boundary poles, and training equipment. No recommendations were included in the reconnaissance results report prepared by Parsons. (Parsons 2002)

2.5.17 U. S. Army Corps of Engineers Record of Decision – Multi-Sites

In August 2002, URS completed a Record of Decision (ROD) for multiple sites for the Corps. The sites included in the ROD were Landfill 1, 2, and 3; the former Burn Area; Buildings 1962 and 1983; the Grease Pits; the former Sewage Pond; the Hazardous Materials Accumulation Point; the Drum Disposal Area; the Paint and Solvent Disposal Area; Wash Rack 1; the Maintenance Pit, Wash Rack 2; the Pesticide Mixing/Storage Building 1864; the ASTs; the CS Gas Training Building; the Pesticide Storage Area Building 4126; and the Ammunition Storage Magazines 2950, 2951, and 2953. Based on analysis from previous investigations, COPCs either were not detected or were detected below the regulatory cleanup levels at some of the areas. The remaining areas contained contaminants above regulatory cleanup levels. At these areas, remediation had been conducted and contaminants had been removed. Subsequent confirmation sampling at these areas determined that contaminants were below established cleanup levels. Because contaminants were either not present or had been removed, it was determined that no risk to human health or the environment was

posed at these areas. The EPA, Washington State Department of Ecology (Ecology), and the Army determined that no further action would be required at these locations (URS 2002).

2.5.18 Washington Department of Ecology Enforcement Order

On February 4, 2003, an Enforcement Order 03TCPHQ-5286 was issued by Ecology under the state's cleanup law to the Army for Camp Bonneville cleanup. The enforcement order divided the site into three remedial action units (RAUs). The RAUs are described below (Ecology 2003).

- **RAU 1:** This RAU consists of the 20 acres where hazardous substances other than military munitions had been located (Figure 2-31). This RAU contained the majority of the areas previously discussed in this ESI report.
- **RAU 2:** This RAU consists of the areas where hazardous substances have been located, but not addressed through remedial actions. This RAU has been further divided into three subunits.
 - **RAU2A:** This RAU consists of the 21 small arms range areas (Figure 2-31).
 - **RAU2B:** This RAU consists of Demolition Areas (DA) 2 and 3 (Figure 2-33).
 - **RAU2C:** This RAU consists of the Demolition Area 1/Landfill 4 area (Figure 2-34).
- **RAU 3:** This RAU consists of any area where military munitions may have come to be located (Figure 2-35).

The status of cleanup at these RAUs, as of October 2011, is discussed in the Ecology Fact Sheet contained in Appendix B.

The Ecology enforcement order dictated the work and work schedule to be performed in each of the RAUs. Ecology has provided oversight for investigations and cleanup activities since 2003.

2.5.19 U. S. Army Corps of Engineers Expanded Site Inspection – Demolition Area 1/Landfill 4

In 2003, URS Corporation (URS) completed an ESI of Demolition Area 1/Landfill 4 for the Corps. The ESI was conducted in response to the discovery of RDX above screening criteria in two monitoring wells that were installed during the 1999 SWI Multi-Sites investigation. During the ESI, a total of eight new monitoring wells (L4-MW01B, L4-MW02B, L4-MW03A, L4-MW03B, L4-MW04A, L4-MW05A, L4-MW06A, and L4-MW07B) were installed at the landfill (Figure 2-36). One of these wells (L4-MW06A) was not developed due to lack of water. Other activities associated with the ESI included: well slug tests, a topographic survey from the landfill to North Fork Lacamas Creek, and ground

water sampling from the new monitoring wells as well as two previously existing monitoring wells. Ground water sampling of the new wells was conducted approximately 2 weeks after installation and in July 2001, October 2001, January 2002, and April 2002. Additionally, monitoring wells L4-MW01A and L4-MW02A, previously installed in 1999, also were sampled in these months (URS 2003).

Ground water data from this investigation was compared to MTCA Method A (for TPH only) and Method B cleanup levels for ground water, National Ambient Water Quality Criteria, EPA Region 9 Preliminary Remediation Goals (PRGs), and EPA Region 10 risk-based concentrations (RBCs). The ground water samples were analyzed for VOCs (EPA SW-846 Method 8260B), SVOCs (EPA SW-846 Method 8270C), herbicides (EPA SW-846 Method 8151A), total and dissolved metals (EPA SW-846 Method 6010B), TPH-Gx (Method NWTPH-Gx), TPH-Dx (Method NTWPH-Dx), water quality (alkalinity – SM 2320; sulfate, chloride, nitrite and nitrate – EPA Method 300.0; total cyanide – EPA Method 335.2; total suspended solids – EPA Method 160.2; and total and dissolved TOC – EPA Method 415.1), explosives (EPA SW-846 Method 8330A), nitroguanidine (EPA SW-846 Method 8330A modified), and ammonium perchlorate (Method 314.0) (URS 2003).

Analytical results for water samples from monitoring well MW-01A indicated the presence of perchlorate above regulatory criteria in January 2002; and total arsenic, total copper, and total lead above regulatory criteria in October 2001. Although there were detections above the method detection limits, there were no other results above regulatory criteria. Analytical results for water samples from monitoring well MW-01B did not indicate concentrations above the regulatory criteria during any of the sampling events (URS 2003).

Analytical results for water samples from monitoring well MW-02A indicated RDX and perchlorate above regulatory criteria in all sampling rounds. No other analytes were detected above the regulatory criteria. Analytical results for water samples from monitoring well MW-02B indicated the presence of 2,4-Dinitrotoluene, RDX, perchlorate, 1,1,1-trichloroethane (1,1,1-TCA), 1,1-dichloroethene (1,1-DCE) and dichlorofluoromethane, above regulatory criteria for all sampling rounds. Additionally the following analytes were detected above the regulatory criteria on the specified sample dates: benzene in July 2001; tetrachloroethene in July 2001, October 2001, and April 2002; total arsenic, total copper, and total lead in July 2001 and April 2002; and dissolved arsenic in October 2001 (URS 2003).

Analytical results for water samples from monitoring well MW-03A indicated RDX and perchlorate were detected above the regulatory criteria in all sampling rounds. Total iron was detected above the regulatory criteria in the sample collected in January 2002; and dissolved lead was detected above the regulatory criteria in the sample collected in October 2001. Analytical results for water

samples from monitoring well MW-03B indicate that perchlorate was detected above regulatory criteria in all sampling rounds; RDX was detected above the regulatory criteria in all but the sample collected in July 2001; total arsenic was detected above the regulatory criteria in the samples collected in October 2001 and January 2002; total copper was detected above the regulatory criteria in all the samples collected except for July 2001; total iron was detected above the regulatory criteria in the samples collected in January and April 2002; and total lead was detected above the regulatory criteria in the sample collected in April 2002 (URS 2003).

Analytical results for water samples from monitoring well MW-04A indicated RDX, perchlorate, total iron, and total copper were detected above the regulatory criteria in all sampling rounds. Total arsenic was detected above the regulatory criteria in the samples collected in July and October 2001; and total lead was detected above the regulatory criteria in the sample collected in April 2002.

Analytical results for water from monitoring well MW-05A indicated RDX and perchlorate were detected above the regulatory criteria in all sampling rounds. Also, total copper was detected above the regulatory criteria in the sample collected in October 2001.

Analytical results for water samples from monitoring well MW-07B indicated the presence of total and dissolved arsenic above the regulatory criteria in the sample collected in January 2003 (URS 2003).

2.5.20 Small Arms Ranges Site Inspection

In September 2003, Atlanta Environmental Management, Inc. (AEM) conducted a site inspection of the small arms ranges for the Corps. The locations of the small arms ranges that were part of this investigation are presented on Figure 2-37. The purpose of the investigation was to (AEM 2003):

- Determine the concentration of lead residues in the top 0–6 inches of soil at 307 one-half acre grids within the firing ranges;
- Determine the background concentrations of lead in the top 0–6 inches of soil at 20 undisturbed/unused locations within Camp Bonneville;
- Determine the concentrations of explosive residues, including picric acid and PETN, in soil in the muzzle blast area of the firing ranges where the firing location is known; and
- Determine the concentrations of explosive residues, perchlorate residues, and metals in soil samples from Demolition Areas 2 and 3.

The sample results were compared to MTCA cleanup levels (the report does not specify Method A or Method B) and EPA Region 9 PRGs. Additionally, a total of 20 background soil samples were collected. Sampling grids that measured

approximately 80 feet by 80 feet were created at each of the small arms ranges. Soil samples were collected from the center of the grid and one each from locations approximately 40 feet north, south, east, and west of the center. A total of 1,535 soil samples were collected from the grids and submitted to an off-site fixed laboratory for analysis of lead using EP Method 7420. Ten locations randomly selected from the range grids and from two randomly selected background locations from Demolition Area 2 and Demolition Area 3 were submitted for off-site fixed laboratory analysis of Priority Pollutant Metals by EPA Method 6010.

Arsenic and barium were detected at concentrations that exceeded at least one of the regulatory criteria. Additionally, samples were analyzed for explosive residues using EPA Method 8330 modified. The numbers of samples submitted for this analysis are not indicated in the report. Explosive residues were detected in the samples collected from the muzzle blast zone at the 25-meter and machine gun ranges but not above the regulatory criteria. Samples were collected from Demolition Area 2 and Demolition Area 3 (the number of samples is not specified in the report) and were submitted for off-site fixed laboratory analysis of perchlorate using EPA Method 314. Perchlorate was not detected above the method detection limit in any of the samples. No conclusions were included in the report prepared by AEM.

2.5.21 U. S. Department of the Army Interim Removal Action – Demolition Area 1/Landfill 4

In 2004, Tetra Tech, Inc. (Tetra Tech) conducted an interim removal action at Demolition Area 1/Landfill 4 for the U.S. Department of the Army. The primary purpose of the removal action was to remove source contamination (2.5-acre footprint) within the landfill that was impacting downgradient ground water. The secondary objective was the removal and disposal of open burn/open detonation (OB/OD) ordnance and landfill materials and associated contaminated soils to meet regulatory requirements to gain a declaration of “no further action” from Ecology for the landfill debris/soils. Cleanup action levels were established in accordance with MTCA Cleanup Regulations for the protection of ground water. Part of the removal action included a report that provided a compilation of ground water monitoring data and historical ground water information related to Demolition Area 1/Landfill 4. The report consisted of a review of ground water monitoring data at Demolition Area 1/Landfill 4 and established a baseline concentration for the primary ground water contaminants at the site. These contaminants included RDX, perchlorate, 1,1,1-TCA, 1,1-DCA, 1,1-DCE, total chromium, total copper, and total zinc. It was recommended that ground water monitoring continue at the landfill following the removal of the 2.5 acre foot-print (Tetra Tech 2006).

The removal action at Demolition Area 1/Landfill 4 was completed from May through December 2004. In designing the removal action, it was assumed that Demolition Area 1/Landfill 4 was constructed using normal landfill

characteristics which typically do not include excavation below the water table. For this reason, it was assumed that contaminated soil would not be present below the saturated zone. Likewise, it was assumed that demolition activities which were conducted after landfill operations ceased were unlikely to have included excavation through landfill debris to the water table for the purpose of destroying munitions. Based on these assumptions, the removal action was designed to terminate excavation activities once native soil was encountered. (Tetra Tech 2006)

Prior to the removal of contaminated soils, UXO avoidance was conducted. Munitions discovered during the avoidance were removed from the area and staged near the Camp Bonneville cantonment for off-site disposal. One phase of this removal included a “mag and dig” (the process of manually clearing smaller areas with the aid of shovels and handheld metal detectors) phase of munitions and explosives of concern (MEC) support work. During this work, a total of 21 pits/trenches were excavated. The locations of these pits/trenches are depicted on Figure 2-38. (Tetra Tech 2006)

It was discovered that four of the pits (pits 6, 11, 15, and 16) were used for open burn disposal of munitions constituents (MC). These pits contained remnants of burned military flares and rocket mortars along with practice ordnance, ammunition, casings, and other munitions debris (MD). Blackened soil and/or fuel-related odors were noted at each of these pits. Six additional pits (pits 7 through 10, 12, and 17) contained MC, MD, and scrap metal that had been disposed of by burial. These pits were classified as disposal pits rather than burn pits because there was no visual or olfactory signs of burning. These pits contained bomb casings, empty or inert material filled projectiles, rocket pods and tubes, missile sections, empty casings of various sizes, practice landmines, and practice rockets. These pits were generally located near the outer estimated boundary of the landfill. Finally, seven of the pits (pits 1, through 5, 13, and 14) were used for open burn disposal of civilian fireworks and other ordnance-like items. The fireworks disposal areas were generally clustered in the central portion of the landfill and sometimes overlapped. The areas used to burn fireworks were characterized by a black layer of waste containing items such as whole bottle rockets, star shells, and whirligigs, along with civilian flares, and tear gas/mace canisters. All of the fireworks burn pits/trenches exuded a diesel fuel odor indicating the use of an initiating fuel for the burn. The maximum depth of all of the trenches was between 13 feet bgs and 18 feet bgs. (Tetra Tech 2006)

Following completion of MEC/MC removal activities, excavation of contaminated soil and other debris was conducted. Soil was removed until confirmation samples indicated that perchlorate was at concentrations below MTCA Method B soil cleanup levels for protection of ground water of 0.5 milligrams per kilogram (or 500 micrograms per kilogram). In one area, on the western boundary of the landfill, excavation continued to approximately 27 feet bgs where saturated soils were encountered, and sample results indicated that

perchlorate levels continued to exceed the cleanup criteria. Excavation at this location was ceased due to safety concerns. Ecology determined that residual contamination remaining at this depth would be remediated during a ground water remediation phase of work. The areas where perchlorate contamination remained in soils are presented on Figure 2-39. It was estimated that 13,333 cubic yards of material were removed from the landfill. (Tetra Tech 2006)

2.5.22 U. S. Army Corps of Engineers Remedial Investigation/Feasibility Study of Remedial Action Unit 3

In 2004, Parsons Infrastructure and Technology Group (Parsons) conducted a remedial investigation/feasibility study (RI/FS) for the Corps of RAU3, which was any area where military munitions may have come to be located (Figure 2-35). The purpose of the RI/FS was to document and present MEC; site characterization processes and findings; development of appropriate MEC risk assessment methods and results; develop MEC remediation levels; identification and screening of various cleanup actions; and rationale for selection of proposed cleanup action(s) for the different areas investigated. A total of six alternatives for cleanup were developed during this investigation. The cleanup alternative, or remedy, recommended for each area investigated was based on the specific characteristics of the area. The alternatives were as follows (Parsons 2004):

- **Alternative 1 – No Further Action:** No cleanup action would be implemented to reduce the potential explosive safety risk posed by different areas located within Camp Bonneville. This alternative, if implemented, would involve the continued use of the areas in their current condition.
- **Alternative 2 – Institutional Controls:** Institutional Controls (ICs) are measures undertaken to limit public exposure to residual explosives materials at Camp Bonneville. These preventive measures may include educational awareness and training programs, legally enforceable restrictions on future land use, and physical access controls.
- **Alternative 3 - Surface Clearance with Institutional Controls:** Surface clearance would require clearance of MEC items located on the ground surface. Prior to performing any MEC clearance activities at the site, control points would be established by a land surveyor for the areas that would undergo surface clearance. UXO-qualified personnel would perform a magnetometer-assisted surface sweep to locate metallic objects. The sweep would be performed in fixed width intervals. During the surface sweep, metallic objects located on the ground surface would be identified as either benign metallic scrap or MEC items and removed.
- **Alternative 4 - Clearance to Frost Depth (14 inches) with Institutional Controls:** Clearance to frost depth would require clearance of MEC items located on the ground surface and within 14 inches bgs. Clearance to the published frost penetration depth of 14 inches was determined to be

necessary due to the potential for frost heave to push buried items at or above this depth to the surface. Based on the minimal amount of UXO recovered to date, all being less than 18 inches bgs, it was anticipated that the majority of remaining UXO at the site was within this frost depth interval. During MEC clearance activities at the site, control points would be established by a land surveyor for the areas that would undergo surface clearance. Brush clearing crews would clear sufficient undergrowth so that the MEC clearance crews could adequately perform their work. The brush clearance crews would be accompanied by UXO-qualified safety personnel.

- **Alternative 5 - Subsurface Clearance with Institutional Controls:** Subsurface clearance would require clearance of MEC items to a specified depth based on the projected end use of the site and the resulting potential for exposure to MEC. Under this alternative, each anomaly would be intrusively investigated until the anomaly was identified or until the site-specific risk-based specified depth was reached. Implementation of this alternative would involve land surveying and brush clearing operations. This alternative would also involve a magnetometer-assisted surface sweep to remove all surface clutter which includes benign metallic scrap items and MEC items. The surface sweep would be performed by experienced UXO-qualified personnel.
- **Alternative 6 – Subsurface Clearance and Restoration:** Subsurface clearance and restoration would require excavation of the complete area in order to remove all metallic and MEC items located at the area. Under this alternative, prior to excavating any site soils all existing vegetation, including tree cover, would be cleared. No geophysical survey would be performed for this alternative. All the soils located at the site would be excavated to a depth of 10 feet and would be sifted to identify MEC items for proper disposal (based on the reuse of the site as being recreational). The soils free of any MEC items would be reused at the site for backfilling the excavations. As a result of the process, this alternative would require extensive repair of all ecological damages during the MEC removal action.

The remedy (cleanup alternative) recommended for selection by Parsons for each area within RAU3 is discussed in the following subsections along with the rationale for making the selection.

2.5.22.1 Target Areas

The five Target Areas investigated included the 3.5-inch Rocket Range Target, the Rifle Grenade Range Target, the HE Range Target, the M203 HE Range Target, and the 2.36-inch Rocket Range Target (Figure 2-40). Of these areas, the 3.5-inch Rocket Range Target, the Rifle Grenade Range Target, the HE Range Target, and the 2.36-inch Rocket Range Target were deemed to have the highest relative explosive safety risk based on the type and likelihood of MEC

occurrence. For all areas except the M203 HE Target Area, alternative 4 (clearance to frost depth and institutional controls) was selected. For the M203 HE Target Area, alternative 2 (institutional controls) was selected. The clearance action was recommended to be conducted in the footprint of each of the target areas. The area and extent of the targets was based upon prior characterization and reconnaissance efforts. It was recommended to begin at the presumed center of the areas and proceed outward in a grid-based manner. The calculated total area for the removal action was approximately 10.6 acres and the total area of ICs was approximately 14.6 acres (Parsons 2004).

2.5.22.2 Central Impact Target Area

The Central Impact Target Area (CITA) Ordnance and Explosive Area is located in the central portion of Camp Bonneville (Figure 2-41) and is comprised of three adjacent target areas known as the West Impact Area Car Target 2, Combined Impact Area 1, and Combined Impact Area 2. This CITA was deemed to have a high relative explosive risk based on the type and likelihood of MEC occurrence. There are no future reuse activities planned for this area. Alternative 2 (institutional controls) was selected for this area and included the construction of signage to inform the public of previous uses, and land use controls in the form of restrictive covenants to prohibit any future development and/or forestry activities in the area. The implementation of this alternative was recommended for the footprint of the area for a total of 83 acres (Parsons 2004).

2.5.22.3 Demolition Areas

The demolition areas were used as OB/OD areas to destroy and/or dispose of unserviceable munitions and/or energetic (i.e., explosive) materials. The three areas are known as Demolition Area 1, Demolition Area 2, and Demolition Area 3 (Figure 2-42). A wide range of explosives and ordnance were reportedly disposed of in the demolition areas. Demolition Area 1 is a low future reuse area as it is located in the proposed Wildlife Management Area. Demolition Area 2 is a high future reuse area since Clark County is proposing a “Logging Camp” for this area. Intrusive activities may be conducted in the logging camp. Demolition Area 3 is a medium future reuse area as it is near to the planned Environmental Study Area.

No subsurface clearance cleanup was recommended for Demolition Area 1 since it is co-located with Landfill 4-Demolition Area 1 and the entire 2.5 acre footprint had been removed. Alternative 5 (subsurface clearance with institutional controls) was recommended for Demolition Areas 2 and 3 because it would eliminate substantially all of the explosive exposure risk. In addition, Alternative 3 was recommended as a “buffer area” surrounding all three demolition areas to address the potential from kick-out (which is the unintended dispersal of explosives during disposal activities and/or the inadvertent release of submunitions). The subsurface clearance was recommended to be performed in a 300-foot by 300-foot grid centered over the Demolition Areas 2 and 3. The removal was proposed to begin in the center and proceed outward in a grid-based

manner. The total area of subsurface clearance for Demolition Areas 2 and 3 was estimated to be two acres each for a total of four acres (Parsons 2004).

2.5.22.4 Firing Points

The Firing Points MEC source area consist of six mortar firing positions, seven artillery firing positions, one rifle grenade range firing point, one 3.5-inch rocket range firing point, and one M20340-mm HE range (Figure 2-43). These areas have a medium relative explosive safety risk based on the type and likelihood of MEC occurrence. The firing points are accessible based on their proximity to roads and trails. The activities proposed for future reuse are surficial and non-intrusive. Alternative 2 (institutional controls) was selected for these areas because it would substantially eliminate the explosive exposure risk. The implementation of institutional controls would also provide the necessary public awareness of the former military use of the site to park visitors. The clearance action would be conducted in the footprint of each of the firing points. Although Alternative 2 does not include clearance actions, they were recommended for the firing points in addition to Alternative 2. The total area for the removal would be approximately 19 acres (Parsons 2004).

2.5.22.5 Training Areas

One training area (the M203 Practice Range co-located with the Mortar Practice Range) was determined to pose a potential MEC risk. Alternative 2 (institutional controls) was determined to be appropriate for this area. No further information regarding the recommendations for the implementation of this alternative in this area is provided in the report (Parsons 2004).

2.5.22.6 Range Safety Fans

The Range Safety Fans (RSF) Ordnance and Explosive (OE) area consists of a total of 16 range safety fans associated with each of the 16 Firing Point Locations. The majority of Camp Bonneville is overlain by one or more RSFs. The RSFs are designed to contain those single event items that fall at some distance from their intended targets. The likelihood of encountering UXO in an RSF is negligible, because of the infrequency of historical artillery firing practices and the large size of the RSFs. The report indicates that most of the proposed future reuse of the areas is considered low, except those areas that overlie a High Reuse Intensity Area. For these areas, Alternative 5 (subsurface clearance with institutional controls) was selected (Parsons 2004).

2.5.22.7 Storage Magazines/Transfer Points

The solitary Storage Magazine/Transfer Point MEC source is Building 2950 (Figure 2-44), consisting of three bunkers located approximately 1,000 feet northeast of the Bonneville cantonment. The likelihood of any non-deployed military munitions in this area is remote; therefore, it has a low relative explosive safety risk. Alternative 2 (institutional controls) was selected for this area (Parsons 2004).

2.5.22.8 Maneuver Areas

The Maneuver Areas MEC sources are those areas that were not specifically identified as troop training areas. Maneuver Areas overlay the vast majority of the site and included the roads and trails, bivouac, and maneuver areas, including the Camp Killpack and Bonneville cantonments. These areas were determined to have a very low relative explosive safety risk. Alternative 2 (institutional controls) was selected to remediate these areas (Parsons 2004).

2.5.22.9 Central Impact Target Area

The Central Impact Target Area is approximately 458 acres and comprised of the 83 acre CITA and 375 acres of associated RSFs. The area is fenced with a three-strand barbed wire fence encircling the entire area. Additionally, signage warning of the potential danger to trespassers is in place. People are not expected to venture into this area due to the fencing, signage, and steep terrain; therefore, the number of potential human receptors was determined to be negligible. Alternative 2 (ICs) was determined appropriate for remediation in this area (Parsons 2004).

2.5.22.10 Roads and Trails

There are approximately 46 miles of roads and trails throughout the site, of which 25 miles are located within the proposed Regional Park (Figure 2-45). The roads and trails have the same munitions related historical use and characteristics as the Maneuver Areas. The roads and trails have a low relative explosive safety risk. Alternative 4 (clearance to frost depth and institutional controls) was determined to be the most appropriate remediation. The clearance was recommended to include geophysical mapping of roads and trails. Area-specific institutional controls that were recommended included signs along the roads and trails to inform the public about past military use of the site (Parsons 2004).

2.5.22.11 High Intensity Reuse Areas

Areas of the proposed Regional Park that are High Intensity Reuse Areas comprise approximately 210 acres. It was assumed that future visitors would conduct a wide range of recreational and educational activities within the footprint of the High Intensity Reuse Areas. Alternative 5 (subsurface clearance with institutional controls) was selected as the best remediation method for these areas, with some locations being cleared to 14 inches and some to 4 feet. The total area estimated for conducting the 14-inch clearance is approximately 160 acres. The area estimated for requiring the 4-foot clearance is approximately 50 acres and includes the following proposed future uses within the park: Rustic Retreat Future Expansion, Logging Camp, Tent and Yurt Camping sites, and an estimated additional 5 acres for other construction areas (Parsons 2004).

2.5.22.12 High Accessible Medium Intensity Reuse Areas

Areas of the proposed Regional Park that are High-Accessible Medium Intensity Reuse Areas comprise those areas that are located between the High Intensity Reuse Areas, have a gentle topographic slope and low vegetative cover, and

therefore provide the opportunity to draw people together for informal recreational activities. These areas cover approximately 180 acres along the Lacamas Creek valley floor. Alternative 4 (clearance to frost depth and institutional controls) was selected for remediation efforts in these locations. The clearance action was recommended to be conducted in the footprint of the High-Accessible Medium Intensity Reuse Areas. The total area for conducting the clearance is approximately 180 acres (Parsons 2004).

2.5.22.13 Remaining Medium Reuse Intensity Areas

The remaining Medium Reuse Intensity Areas of the proposed Regional Park consist of those areas that are located between specific designated reuse areas, and do not have the high accessibility characteristics of gentle slope and low vegetation. These remaining Medium Reuse Intensity Areas comprise approximately 770 acres. Alternative 2 (institutional controls) was selected for these areas, including signage that would serve to inform visitors of the past military history of the site (Parsons 2004).

2.5.22.14 Wildlife Management Area

The Wildlife Management Area is comprised of approximately 2,000 acres in the eastern portion of the site and includes the WDNR leased lands (Figure 2-51). The Wildlife Management Area does not include the Central Impact Target Area nor the roads and trails located in the Wildlife Management Area. The majority of the Wildlife Management Area was used as maneuver areas and, therefore, has a low relative explosive safety risk. Alternative 2 (ICs) was recommended for remediation in this area (Parsons 2004).

2.5.23 Cultural and Historical Resources Protection Plan

In November 2006, Michael Baker Jr. Inc. (Baker) prepared a cultural and historical resources protection plan for the BCRRT. The goals and objectives of the protection plan included protecting and preserving the cultural resources at the site; implementation of cultural resource preservation as a regular component of site planning; identification of procedures to follow in the event that conservation actions have the potential to adversely affect cultural resources; and ensure that the identification of previously unidentified cultural resources at the site is comprehensive and consistent with state and federal regulations. The Cowlitz Indian Tribe declared the presence of a series of historic and prehistoric Indian villages, burial ground, and trails on or near the site that are considered sacred ground. The Cultural and Historical Resources Protection Plan indicated that any actions in these areas would not be endorsed by the Cowlitz Indian Tribe to take place without consultation with the tribe. The plan also concluded that the buildings associated with the Camp Bonneville and Killpack cantonments were not eligible for listing in the National Register of Historical Places (Baker 2006c).

2.5.24 BCRRT Remedial Investigation Demolition Areas 2 and 3

In 2006, Baker conducted an RI at Demolition Areas 2 and 3 for the BCRRT. The purpose of the remedial investigation was to determine the presence or

absence of contamination in ground water discharging from Camp Bonneville at the base's boundary and at locations downgradient from Demolition Areas 2 and 3; to determine the presence or absence of contamination in ground water in the vicinity of Demolition Areas 2 and 3; to determine the presence or absence of soil contamination in Demolition Areas 2 and 3; and to determine the geologic/hydro-geologic conditions in the investigation areas (Figure 2-45). To meet these stated objectives, the investigation included the installation and sampling of 16 monitoring wells located in three areas and soil sampling in Demolition Areas 2 and 3. Three wells were installed in the shallow alluvium/weathered bedrock in a line normal to the direction of flow from Demolition Area 2 (Figure 2-47). One well pair (shallow and deep) and three shallow wells were installed at four compass points surrounding the Demolition Area 3 crater (Figure 2-48). In addition, four well pairs (shallow and deep) were installed in a transect across the Lacamas Creek valley near the boundary of Camp Bonneville and downgradient of Demolition Area 3 (Figure 2-49). Surface and subsurface soil samples were collected from Demolition Areas 2 and 3 (Baker 2006b).

2.5.24.1 Demolition Area 2

The ground water from three shallow wells in Demolition Area 2 were sampled and analyzed for explosives, perchlorate, total and dissolved metals, and water quality parameters [chloride sulfate, total alkalinity, dissolved organic carbon (DOC), nitrite/nitrates as nitrogen, TOC and total suspended solids (TSS)]. Additionally, five soil samples at the ground surface, two feet bgs, and five feet bgs were collected (one from the center of DA 2 and one each from approximately 100 feet north, south, east, and west of the center) and were submitted for analysis of explosives, perchlorate, and metals. Sample results were compared to MTCA Method A cleanup levels for residential land use, MCLs, and EPA PRGs (Baker 2006b).

No explosives, perchlorate, or total and dissolved metals were detected at concentrations at or above the regulatory criteria in the ground water samples. No explosives or perchlorate were present in the soil samples above the reporting limit. Arsenic was detected at concentrations that exceeded the regulatory criteria in all 15 of the soil samples; however, they were below the background concentration established for Clark County, Washington (Baker 2006b).

2.5.24.2 Demolition Area 3

Five wells were installed in this demolition area, four shallow and one deep. Ground water samples were analyzed for explosives, perchlorate, total and dissolved metals, and water quality parameters [chloride sulfate, total alkalinity, dissolved organic carbon (DOC), nitrite/nitrates as nitrogen, TOC and total suspended solids (TSS)]. Soil samples were collected during the drilling of wells in Demolition Area 3. The soil samples were collected at the ground surface and at depths of two feet, five feet, and 15 feet bgs; however, the 15-foot interval was not sampled in one of the monitoring wells. Soil samples were analyzed for explosives, perchlorate, and total metals. Sample results were compared to

MTCA Method A cleanup levels for residential land use, MCLs, and EPA PRGs (Baker 2006b).

No explosives or total metals were detected at concentrations at or above the regulatory criteria in the ground water samples. Perchlorate and nitrate were detected above the regulatory criteria in one of the wells. As perchlorate may produce a false negative, additional samples were collected and submitted to two different laboratories for reanalysis. These analyses did not indicate the presence of perchlorate or nitrate above the regulatory criteria. It was determined that the initial analysis had reported a “false positive”. Results for the soil samples did not indicate the presence of explosives, perchlorate, or metals at concentrations above the regulatory criteria (Baker 2006b).

In addition, four well pairs (shallow and deep) were installed in a transect across the Lacamas Creek valley near the boundary of Camp Bonneville and downgradient of Demolition Area 3. Sample results did not indicate the presence of any metals or perchlorate at concentrations that exceeded the regulatory criteria.

During the RI, an area where corroded drums and shell debris had been encountered was excavated. Samples were collected from the sidewalls and bottom of the excavation area. The samples were analyzed for explosives, perchlorate, and picric acid. None of these constituents were detected in the excavation samples. (Baker 2006b)

2.5.24.3 BCRRT Remedial Investigation Conclusions and Recommendations

The constituents detected in ground water and soils in Demolition Areas 2 and 3 were deemed to be present at “relatively low concentrations that do not pose a threat to human health or the environment”. It was recommended that Demolition Areas 2 and 3 be considered for no further action (Baker 2006b).

2.5.25 BCRRT Remedial Investigation/Feasibility Study – Small Arms Ranges

In 2006, Baker conducted a remedial investigation and feasibility study (RI/FS) for 17 small arms ranges at Camp Bonneville for the BCRRT. The RI was conducted to characterize soils at 17 Small Arms Ranges in order to provide data upon which to base decisions for further actions. Based on the results of the RI, the FS was conducted to identify and evaluate cleanup action alternatives and select a cleanup action for the Small Arms Ranges (Baker 2006a).

Surface soil samples were collected from half-acre grids across the Small Arms Ranges. All range samples were analyzed for lead by EPA Method 7420. A total of 307 half-acre plots were sampled. Each of the grids consisted of five grab soil sample collected from 0 to 6 inches bgs. Samples were collected from near the center of each grid and at 40 feet from the center of four compass points. A total

of 1,535 soil samples were collected from the grids. At ten of the Small Arms Range grid locations, ten samples were randomly selected from the range soils and analyzed for Priority Pollutant Metals by EPA Method 6010B (Baker 2006a).

For ranges where the firing line had been determined, a muzzle blast zone was designated as a strip in front of and parallel to the firing line. Samples were collected along the strip at approximately 30-foot intervals and within 10 feet of the firing line. These samples were analyzed for explosive residues including picric acid and PETN by EPA Method 8330 Modified. Twenty soil samples were collected and analyzed to identify the background levels of lead in the soil by EPA Method 6010. The soil samples collected from the Small Arms Ranges were compared to MTCA Method A cleanup criteria. Sample results indicated the presence of lead above the regulatory cleanup level at 14 of the 17 ranges. Approximately 12% of the samples collected had concentrations that exceeded the cleanup criteria. None of the samples collected from the muzzle blast zone contained concentrations of explosive residues at concentrations that exceeded the EPA Region 9 PRGs (there are no established MTCA criteria for explosive residues; Baker 2006a).

As part of the investigation, five remedial alternatives were developed. The alternatives included no further action (Alternative 1), implementation of institutional controls such as signage (Alternative 2), capping (Alternative 3), consolidation and capping (Alternative 4), and excavation and off-site disposal or recycling (Alternative 5). Alternative 5 was recommended as the most permanent solution for the contaminated soils at the Small Arms Ranges (Baker 2006a).

2.5.26 BCRRT Soil and Sediment Investigation – Artillery/Mortar Firing Points, Artillery/Mortar Impact Areas, and “Pop-up” Pond

In October 2007, Baker conducted a soil and sediment investigation of the artillery/mortar firing point, the artillery/mortar impact areas, and the “pop-up” pond for BCRRT. The report generated as an outcome of this work was reviewed by Ecology. The objectives of the artillery points and target areas were to determine the presence or absence of explosive constituents in surficial soil and to determine the likelihood that these contaminants are impacting site ground water. The objective of the “pop-up” pond investigation was to determine the presence or absence of lead in sediments within the pond for the purpose of determining if cleanup actions are necessary. The pop-up pond was used in the 1970s for live-fire training with 30- and 50-caliber weapons in an automated pop-up target course.

A total of 435 soil samples were collected from 15 firing points. The samples were analyzed for explosives by EPA Method SW-8330. Additionally, the samples from the 3.5-inch Rocket Range Firing Point were analyzed for perchlorate by EPA Method 314.0. The sample results were compared to MTCA Method A, and when no value for a constituent was available, the results were

compared to the EPA Region 3 RBCs. No analytes were detected at concentrations that exceeded the regulatory criteria for any of the soil samples. Based on the sample results, a determination of “No Further Action” was recommended for all of the artillery/mortar firing points and the artillery/mortar impact areas sampled.

A total of 10 sediment samples were collected from the pop-up pond (Figure 2-50). The samples were analyzed for lead by EPA Method SW-846 6010. The sample results were compared to the MTCA Screening Level for the Ecological Indicator Soil Concentrations for protection of Terrestrial Plants and Animals. Lead was detected above instrument detection limits in all 10 of the samples; however, only one sample’s result exceeded the most conservative screening criteria. Based on the sample results, a determination of “No Further Action” was recommended for the pop-up pond.

2.5.27 Environmental Study Area Interim Action

In November 2007 and February 2008, an interim action was performed by BCRRT in the Environmental Study Area. The objectives of the action were to locate and remove MEC and MD. During the action, a total of four MEC items (all 3-inch Stokes mortars, fired and unfuzed) were identified and demilitarized. The MEC were disposed of by detonation. A total of 32 MD findings were recorded and were relocated to on-site storage to be consolidated with other MD found at the site for future disposal. During the MEC surface clearance activities, several items were discovered that indicated the presence of a former homestead. These items were collected and submitted to the Clark County staff archeologist. (BCRRT 2009c)

2.5.28 ATSDR Public Health Assessment

In 2008, the Agency for Toxic Substances and Disease Registry (ATSDR) completed a public health assessment for the site as a result of a public petition. As part of the assessment, ATSDR met with the petitioner and community members. Based on these meetings, ten areas of concern were identified. These concerns are presented in the Public Health Assessment report for the Camp Bonneville Military Reservation prepared by ATSDR and are discussed below:

- **Concern 1 – Potential physical hazards from exposure to UXO**
The Public Health Assessment states “UXO is present on Camp Bonneville. However, there are several factors that limit the public’s access to the ordnance, including the location of the UXO, fences with warning signs, and UXO removal. Despite these efforts there is a small potential for people to encounter UXO. Therefore, it is very important to educate those who visit the future regional park about the dangers posed by UXO.” (ATSDR 2008)

▪ **Concern 2 – Exposure to soil and ground water contamination for residents living within the Artillery Impact Fan and Range Safety Fan areas**

The Public Health Assessment states “There was some discrepancy regarding the location of range safety fans at Camp Bonneville. Current maps do not show safety fan areas extending beyond Camp Bonneville’s property line. However, older maps show safety fans extending offsite onto the property of residents living to the east of Camp Bonneville. Understandably, this has caused confusion and concern for the residents neighboring Camp Bonneville to the east. According to the WDOE, the historical maps showing range safety fans extending offsite contain cartographical errors and the safety fans never extended offsite. Therefore, there are no residents living within the Artillery Impact Fan and Range Safety Fan areas. In addition those residents to the east of Camp Bonneville are upgradient of any known ground water contamination.” (ATSDR 2008)

▪ **Concern 3 – Exposure to ground water contamination (specifically, perchlorate and RDX plumes)**

The Public Health Assessment states “Ground water was sampled from 18 sites at Camp Bonneville. The only area found to contain ground water contamination was Landfill 4-Demolition Area 1. The plume at Landfill 4-Demolition Area 1 contains RDX, perchlorate, and 1,1,-dichloroethene. However, no one is drinking water from this area. Therefore, exposure to ground water contamination is an incomplete pathway.” (ATSDR 2008)

▪ **Concern 4 – Exposure to contaminated soil (specifically, at the sewage pond/lagoon areas and the small arms firing areas)**

The Public Health Assessment states “Soil at the Former Sewage Pond and Landfill 2 was sampled in 1998. None of the contaminants were detected at levels of health concern. People are not being exposed to the soil at the CITA because the area is fenced. Further, remediation is being conducted to remove soil containing elevated levels of lead around the former targets at the small arms firing ranges.” (ATSDR 2008)

▪ **Concern 5 – Exposure to surface water and sediment contamination in Lacamas Creek, Lacamas Lake, and the Columbia River**

The Public Health Assessment states “In 1998, a surface water investigation was conducted on Lacamas Creek and its tributaries at Camp Bonneville. The investigation concluded that, in general, site activities have not impacted the water quality of Lacamas Creek. Due to limited use of the creek and the minimal contamination found, ATSDR does not expect harmful health effects to result from exposure to surface water and sediment in Lacamas Creek.” (ATSDR 2008)

- **Concern 6 – Exposure to runoff water and standing rainwater, particularly near the Open Burn/Open Detonation sites**
The Public Health Assessment states “Even though standing water is sometimes seen in and around the Open Burn/Open Detonation (OB/OD) sites, exposure to it would be short-term and infrequent. Further, soil, ground water, and surface water at the OB/OD sites have been sampled and no chemicals were detected at levels of health concern.” (ATSDR 2008)
- **Concern 7 – Inhalation exposure to agents used during past chemical warfare testing and training activities**
The Public Health Assessment states “CS gas was the only chemical warfare agent used during training. It decomposes quickly and has no persistent metabolites. Therefore, ATSDR does not expect that past inhalation exposure to CS gas occurred off site. Further, the building and soil surrounding the gas chambers were sampled and no residual hazardous substances were detected.” (ATSDR 2008)
- **Concern 8 – Hunting and eating wildlife on Camp Bonneville**
The Public Health Assessment states “Hunting may have occurred on Camp Bonneville in the past, but is not expected to occur currently or in the future. Because of the lack of site data, it is indeterminate whether eating wildlife from Camp Bonneville in the past is expected to have caused harmful health effects. However, based on studies conducted at Army ammunition plants, it is unlikely that the wildlife at Camp Bonneville would have accumulated harmful levels of contaminants.” (ATSDR 2008)
- **Concern 9 – Early property transfer as a public regional camping facility and potential exposures to future site users**
The Public Health Assessment states “Camp Bonneville was transferred from DOD to Clark County, Washington in October 2006, prior to the completion of environmental cleanup (i.e., early transfer). BCRRT is responsible for continuing the cleanup of Camp Bonneville, with oversight by Ecology. The redevelopment or reuse of the facility is not likely to contribute to any existing release or threatened release, interfere with any remedial actions, or increase health risks at or in the vicinity of the site.” (ATSDR 2008)
- **Concern 10 – Fire response and suppression at Camp Bonneville**
The Public Health Assessment states “Even though UXO is present on Camp Bonneville, the Washington State Department of Natural Resources will respond to wildfires at the property in close coordination with BCRRT. There may be some areas (e.g., the CITA) that are too dangerous for fire fighters to enter, however, in those cases, the fires will be carefully

monitored and other methods of fire suppression may be employed.”
(ATSDR 2008)

Based on the health evaluation of each of these concerns, the recommendations by ATSDR state:

- “ATSDR recommends that Clark County educate future visitors to the regional park about the appearance of UXO and what to do if they encounter it. It should be emphasized that UXO should never be handled.”
- “ATSDR recommends that ground water in the vicinity of ground water contamination at Demolition Area 1/Landfill 4 not be used for drinking water in the future, and that ground water monitoring in the area continue. ATSDR also recommends continued monitoring of sentinel wells to prevent contamination of off-site drinking water wells.”
- “Because hunting was not recommended as a future use of Camp Bonneville in the reuse plan, ATSDR recommends that “No Hunting” signs be posted on the Camp Bonneville property.”
- “ATSDR does not recommend firing ranges as a future use in the regional park.” (ATSDR 2008)

2.5.29 BCRRT Remedial Investigation/Feasibility Study for Remedial Action Unit 3

In 2008, BCRRT prepared an RI/FS for RAU 3 (Figure 2-35). The report deals exclusively with explosives safety of MEC resulting from prior actions at the site. As part of this investigation, a total of 207 MEC sampling grids, covering approximately 40 acres, were geophysically mapped and sampled. During previous investigations, over 2,400 acres of the site had been characterized for the presence of MEC-related activities including all of the known and suspected MEC source sites; all of the proposed regional park reuse areas; all of the existing trails and roads, and the entire 1,200-acre area of the proposed future regional park. (BCRRT 2008)

The RI/FS subdivided the MEC concerns into eight Remedial Work Areas (RWAs) requiring MEC surface and/or subsurface clearance cleanup. The RWAs are depicted on Figure 2-50 and include:

- Target Areas;
- CITA targets and Non-Target Zone;
- Demolition Areas;
- Firing Points;
- Roads and Trails;
- Central Valley Floor (CVF);

- Regional Park Western Slopes Area; and
- Wildlife Management Area.

Five cleanup action alternatives were evaluated for each of the MEC source types and proposed reuse areas:

- ICs;
- Surface clearance with ICs;
- Clearance to frost depth (14 inches) with ICs;
- Subsurface clearance (24 to 48 inches) with ICs; and
- Excavation and Restoration.

The recommended cleanup actions presented were based on the potential degree to which a MEC source and receptor interaction was likely to occur. A remediated MEC site generally means that a site is cleaned to a point that the likelihood for MEC source and receptor interaction is negligible. For each of the site types, a preferred alternative was selected as the most “practicable permanent solution” to reduce the explosive hazard. The cleanup actions recommended are as follows:

- Target Areas – Frost depth clearance;
- Firing Points – Subsurface clearance;
- Demolition Areas – Surface clearance (approximately 5 acres at each area);
- High Intensity Reuse Areas – Subsurface clearance and frost depth clearance depending on the proposed future reuse; and
- Medium Intensity Reuse Areas – Confirmatory investigation via surface clearance transects.

In addition to clearance activities, site-specific ICs consisting of signage and/or fencing were recommended.

2.5.30 BCRRT Remedial Action Unit 3 Supplemental Remedial Investigation/Feasibility Study

In May 2009, BCRRT prepared a supplemental RI/FS for RAU 3 (BCRRT 2009b). The Supplemental RI/FS addresses the additional MEC and MD findings since the RI/FS was finalized in 2008. During the MEC and MD removal, new remedial work areas were discovered. The discovery of these additional work areas resulted in either changing the area’s classification and associated MEC cleanup requirements, or identifying additional areas requiring MEC cleanup. The cleanup actions for the newly discovered areas included:

- MEC subsurface clearance for the entire CVF and associated wetlands (previously designated as the Accessible High and Medium Intensity Reuse Area in the Final RI/FS). This decision was based on the determination that the CVF and associated wetlands are an extensively

used direct and indirect fire weapon target area, and an extensively used training area due to the number of subsurface anomalies and surface MEC and MD discovered. The MEC and MD discovered areas are depicted on Figure 2-51 and include:

- Stokes Mortar Target Area;
 - Demolition Areas;
 - 37-mm Artillery Stokes Mortar Target Area;
 - Rifle Grenade Target Area;
 - 2.36-Inch Rocket Target Area near the Former Sewage Lagoons; and
 - MEC Disposal Area (burial pit; although identified in the report, it was not depicted on a figure).
- MEC surface clearance, access limitations based on steep slopes, and ICs are being required for the Regional Park Western Slopes Area. The Western Slopes had been designated as the Limited Access Medium Intensity Reuse in the Final RI/FS.
 - Expansion of the CITA fence line northward to encompass an additional 107 acres believed to have been impacted by artillery and mortar firing.
 - MEC surface clearance of Demolition Area 1/Landfill 4 kick-out area encompassing 104 acres.

This work has not been conducted as of this writing. A Cleanup Action Plan (CAP) has been prepared by BCRRT and submitted for public review. The final CAP describes details and next steps for cleanup within each of the RAU-3 RWAs and includes MEC and MD findings to date; accessibility, reuse, and hazard ranking considerations; cleanup action evaluation and selection; and the recommended cleanup action(s).

2.5.31 Environmental Protection Agency Preliminary Assessment

In 2009, EPA conducted a PA of the Camp Bonneville site. The PA was conducted under the authority of CERCLA as amended by the Superfund Amendments and Reauthorization Act of 1986 (SARA). During the PA, historical documents were reviewed, a site visit was conducted, and a PA report was prepared. Based on the review of available information and an evaluation of migration pathways and receptors, further investigation of the site was recommended. (E & E 2010)

2.6 Summary of EPA Expanded Site Inspection Locations Investigated

Sampling by EPA and its authorized contractor, Ecology and Environment, Inc. (E & E) under the Camp Bonneville ESI was conducted at possible sources of CERCLA –regulated substances and at areas (i.e., targets/receptors) that may have been contaminated through the migration of hazardous substances from site sources. The features identified for investigation under the ESI were determined

based on multiple site visits, interviews with regulatory agencies, interviews with current site workers, and a review of background information. These features are discussed below:

Potential Sources:

- **Demolition Area 1/Landfill 4:** This potential source consists of approximately 2.5 acres (108,900 square feet). The 2.5 acres of Demolition Area 1/Landfill 4 have been removed; however, ground water contamination is still present at this source area. Historical sample results indicate the presence of perchlorate, 1,1,1-trichloroethane, 1,1-dichloroethane, chromium, copper, zinc, RDX, and HMX. A perchlorate and RDX plume is known to exist in the area of Demolition Area 1/Landfill 4. The EPA ESI will assist in determining if this plume is impacting adjacent North Fork Lacamas Creek. Potential contaminants of concern associated with this potential source include TAL metals, SVOCs, VOCs, perchlorate, and nitroaromatics/nitramines.
- **Pop-Up Pond:** This potential source measures approximately 175 feet across by 100 feet wide (17,500 square feet) and consists of contaminated sediments. Samples previously collected from the pond indicate the presence of lead contamination. It is not known if other contaminants are present in the Pop-Up Pond, as only lead was evaluated historically. The EPA ESI will assist in determining if other constituents are present in the Pop-Up pond. Potential contaminants of concern associated with this potential source include TAL metals, perchlorate, and nitroaromatics/nitramines.
- **Pop-Up Pond Targets:** One target area consists of the 1,000-Yard Range.
- **Demolition Areas:** In addition to Demolition Area 1/Landfill 4, there are two other demolition areas at the site. It is possible that residual contamination is present at these areas. The EPA ESI will assist in determining if contamination is present at Demolition Areas 2 and 3. Potential contaminants of concern associated with these potential sources include TAL metals, perchlorate, and nitroaromatics/nitramines.
- **Central Impact Target Area:** The CITA is a known source of deposited munitions. The EPA ESI will assist in determining if hazardous substances are present. Potential contaminants of concern associated with this potential source include TAL metals, perchlorate, and nitroaromatics/nitramines.

Targets/Receptors:

- **Ground Water:** Ground water in Demolition Area 1/Landfill 4 is historically known to be contaminated. The EPA ESI will assist in determining if contamination is still present in the ground water and if contaminated ground water has migrated to the adjacent North Fork Lacamas Creek.
- **Lacamas Creek and its Tributaries:** Contaminants from on-site sources may be impacting sediments and sensitive environments in Lacamas Creek and its tributaries. The EPA ESI will assist in determining whether surface water and sediments are being impacted by on-site contamination.

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EPA ESI Field Activities and Analytical Protocol

A sampling and quality assurance plan (SQAP) for the Camp Bonneville ESI was developed by Ecology and Environment, Inc (E & E), an authorized contractor for the EPA, prior to field sampling (E & E 2011a, 2011b). The SQAP describes the sampling strategy, sampling methodology, and analytical program used to investigate potential hazardous substance sources and potential targets/receptors. With few exceptions, the ESI field activities were conducted in accordance with the approved SQAP. Deviations from the SQAP are described, when applicable, in this section and in the sampling location discussions in Section 6 (source areas) and Section 7 (target/receptor areas). All deviations to this SQAP were pre-approved by the EPA Task Monitor during the field sampling event.

The ESI field sampling event was conducted in two phases. The first phase was conducted from May 16, 2011 through May 21, 2011. The second phase was conducted from August 22, 2011 through August 26, 2011. During Phase I, subsurface soil samples, sediment samples, and ground water samples were collected. During Phase II, surface soil, surface water, and sediment samples were collected. A total of 182 samples were collected during both sampling events for the ESI, including 23 ground water samples, 13 subsurface soil samples, 51 sediment samples, 78 surface soil samples, 11 surface water samples, and 6 QA (2 rinsate and 4 trip blank) samples. Sample types and methods of collection are described below. Sample collection activities were recorded in sample-specific field collection forms and summarized in the project management logbook. Additionally, a sample collection log was used to record all applicable sample collection methods and sample numbers. The field collection forms, sample collection log, and field logbook are presented in Appendix C. A list of all samples collected for laboratory analysis under the EPA ESI is contained in Table 3-1. Photographic documentation of ESI field activities is included as Appendix D.

Alphanumeric identification numbers applied to each sample location (e.g., LF01SB) by the START are used in the report as the sample location identifiers. The sample coding table is presented in Table 3-2.

3. EPA ESI Field Activities and Analytical Protocol

This section describes anomaly avoidance, sampling methodology, analytical protocol, global positioning system (GPS), and investigation-derived waste (IDW).

3.1 Anomaly Avoidance

Anomaly avoidance was conducted by the EPA START-3 contractor, TechLaw, Inc. (TechLaw). The TechLaw UXO specialists used a Schonstedt fluxgate magnetometer to ensure no anomalies were present along the access paths to sample locations. Copies of the trip reports generated by TechLaw are provided in Appendix E.

During the Phase I field event, several foot trails were created using anomaly avoidance near Demolition Area 1/Landfill 4; the E & E field personnel were then safely escorted to the sampling locations. All support protocols were in compliance with Clark County requirements for UXO escorts. During the Phase I field event, approximately 12 anomalies were detected and clearly marked, and the field team was briefed regarding potential hazards associated with the anomalies.

During the Phase II field event, the UXO specialists used magnetometers to ensure no anomalies were present along access paths to the sampling locations. The access paths were screened following Clark County requirements for UXO escorts providing this type of support. During the Phase II field event, approximately 80 anomalies were encountered, and the field team was briefed regarding potential hazards associated with the anomalies.

3.2 Sampling Methodology

Grass, leaves, and other vegetative material, rocks, and other debris unsuitable for analysis were removed from samples before being placed into sample containers. Samples were stored on ice in coolers continuously maintained under the custody of START personnel. Chain-of-custody documentation is presented in Appendix F. Sampling methods used for each sample type are described below.

3.2.1 Subsurface Soil Sampling

A total of 13 subsurface soil samples were collected during the Phase I field event. All subsurface soil samples were collected using a decontaminated hand auger bucket. Subsurface soil sample depths ranged from 0.3 foot bgs to 2.3 feet bgs. Collected material was transferred to a dedicated stainless steel bowl or plastic bowl, thoroughly homogenized, and placed into pre-labeled sample containers. Rocks and other detritus were removed prior to homogenization. If the material was firm enough, the VOC aliquot was collected from the auger bucket. If the material was not firm enough, the aliquot was collected from the sample bowl prior to homogenization. Homogenization was conducted with dedicated stainless steel spoons. Chain-of-custody documentation is presented in Appendix F.

3. EPA ESI Field Activities and Analytical Protocol

The hand auger was decontaminated after each use. Gross decontamination was conducted by dipping the auger into North Fork Lacamas Creek then spraying it with analconox/deionized water mixture. The auger was then scrubbed with a brush and sprayed again with deionized water. A rinsate sample (RS02WT) was collected from the hand auger.

3.2.2 Ground Water Sampling

A total of 14 shallow ground water samples were collected during the Phase I field event. Shallow temporary ground water well points were planned to be collected using a Solinst™ sampling device from the subsurface soil locations. During use, the device was consistently becoming plugged with silt and water and could not be used to collect ground water samples [see approved Sample Plan Alteration Form (SPAF) in Appendix G]. A decontaminated stainless steel hand auger was used to bore a new hole adjacent to the corresponding subsurface soil sample location, then one of two methods were used to collect the ground water sample:

1. Dedicated Teflon-lined polyethylene (TLPE) tubing was placed directly into the open borehole. A peristaltic pump was used to pump water from the hole until turbidity lessened and water quality parameters had stabilized. If enough water was not present to allow for purging, then a sample was collected without purging the hole.
2. A 4-foot long 1-inch diameter Geoprobe™ well screen was placed into the open borehole. Dedicated TLPE tubing was placed in the hole, and a peristaltic pump was used to pump water from the hole until turbidity lessened and water quality parameters had stabilized. If enough water was not present to allow for purging, then a sample was collected without purging the hole.

The water was collected into pre-labeled sample containers. The VOC aliquot was preserved prior to sample collection. The TAL metals aliquot was preserved following sample collection. The perchlorate aliquot was filtered during sample collection using 0.45 micron filters. No other chemical preservation or filtering was required for the remaining aliquots.

The hand auger and Geoprobe™ well screens were decontaminated after each use. Non-dedicated equipment was decontaminated by dipping the equipment into North Fork Lacamas Creek and then spraying it with deionized water. Rinsate samples were collected from both pieces of equipment. Sample RS01WT was collected from the well screen and, as mentioned above, sample RS02WT was collected from the hand auger.

A total of nine existing permanent monitoring wells were sampled during the Phase I field event. The existing permanent monitoring wells were sampled using dedicated submersible bladder pumps. The wells were purged of three well

3. EPA ESI Field Activities and Analytical Protocol

volumes of water in the casing. Parameters were allowed to stabilize. Then, the sample was collected into pre-labeled sample containers. The VOC aliquot was preserved prior to sample collection. The TAL metals aliquot was preserved following sample collection. The perchlorate aliquot was filtered during sample collection using 0.45 micron filters. No other chemical preservation or filtering was required for the remaining aliquots.

At some wells where large purge volumes were required, low flow sampling techniques were employed. For these samples, dedicated TLPE tubing was lowered to the center of the screened interval. The wells were pumped using a peristaltic pump until water quality parameters had stabilized. The samples were then collected as described above.

3.2.3 Surface Soil Sampling

A total of 78 surface soil samples were collected during the Phase II field event. All surface soil samples were collected with dedicated stainless steel spoons. Collected material was placed into dedicated stainless steel bowls. The material was thoroughly homogenized and placed into pre-labeled sample containers. Sample depths ranged from 0 to 6 inches bgs. In some areas of the site, where soil was extremely compact and hard, shovels and picks were used to loosen soil. A dedicated stainless steel spoon was then used to remove soil from the location to avoid cross-contamination. The sample was then collected with a dedicated stainless steel spoon.

3.2.4 Surface Water Sampling

A total of 11 surface water samples were collected during the Phase II field event. Surface water samples were collected by directly dipping the pre-labeled sample containers into the water. The VOC aliquot (when collected) was preserved prior to sample collection. The TAL metals aliquot was preserved following sample collection and the dissolved TAL metals aliquot was also field filtered using a 0.45 micron filter. The perchlorate aliquot was field filtered using a 0.45 micron filter following sample collection. No other chemical preservation or field filtering were required on other aliquots. In some instances, the co-located sediment samples were off-set by approximately 5 feet so that the surface water and sediment samples could be collected simultaneously without causing disturbed sediments to influence the surface water sample.

3.2.5 Sediment Sampling

A total of 51 sediment samples were collected (2 during the Phase I field event and 49 during the Phase II field event). The samples were collected using dedicated stainless steel or plastic scoops. Collected material was placed into dedicated stainless steel bowls. The material was thoroughly homogenized and placed into pre-labeled sample containers. The VOC aliquots were collected directly from the bowl into 5-gram Core-N-One™ samplers prior to sample homogenization. All sediment samples were collected from 0 to 6 inches bgs.

3.3 Analytical Protocol

Analytical protocols applied to the ESI samples included off-site fixed laboratory analysis of nitroaromatics/nitramines, TAL total metals, TAL dissolved metals, TOC, SVOCs, VOCs, perchlorate, and grain size. Additionally, field screening for the presence of perchlorate was used during Phase I, and field screening for the presence of metals using the XRF was conducted during Phase II. Some samples were not analyzed for all of the analytical methods listed above. Analyses applied to individual samples are presented in Table 3-1.

The following samples were submitted to the EPA laboratory, EPA Contract Laboratory Program (CLP), or subcontract laboratories for analysis:

- **Nitroaromatics/Nitramines (EPA SW-846 Method 8330B):** A total of 178 samples (78 surface soil samples; 13 subsurface soil samples; 51 sediment samples, 23 ground water samples, 11 surface water samples, and 2 QA/QC samples) were submitted for off-site fixed laboratory analysis to Manchester Environmental Laboratory (MEL), an EPA laboratory which is located in Port Orchard, Washington.
- **Perchlorate (EPA SW-846 Method 6860):** A total of 178 samples (78 surface soil samples; 13 subsurface soil samples; 51 sediment samples, 23 ground water samples, 11 surface water samples, and 2 QA/QC samples) were submitted for off-site fixed laboratory analysis to Test America Denver, a START subcontracted laboratory, which is located in Arvada, Colorado.
- **Perchlorate Field Screening (modified Corps field screening method for perchlorate):** A total of 14 samples (12 subsurface soil samples and 2 sediment samples) were field screened in the EPA mobile laboratory. The SQAP indicated ground water samples were also to be field screened; however, the method used could not achieve the desired detection limits with the desired level of accuracy. No water samples were field screened with this method. The SPAF documenting this change is presented in Appendix G.
- **TAL Metals [EPA SW-846 Method 6010, EPA CLP Statement of Work (SOW) ISM01.2, including lithium, molybdenum, strontium, tin, and titanium]:** A total of 178 samples (78 surface soil samples; 13 subsurface soil samples; 51 sediment samples, 23 ground water samples, 11 surface water samples, and 2 QA/QC samples) were collected during the Phase I and Phase II field event. The samples collected during the Phase I field event were submitted for off-site fixed laboratory analysis to MEL, an EPA laboratory, which is located in Manchester, Washington. The samples collected during the Phase II field event were submitted for off-site fixed laboratory analysis to A4 Scientific, an EPA CLP laboratory, which is located in The Woodlands, Texas.

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- **XRF Field Screening (EPA SW-846 Method 6200):** A total of 32 surface soil samples were field screened for antimony, arsenic, and lead. A subset of these samples (18 samples) was submitted for off-site fixed laboratory sampling.
- **TAL Dissolved Metals (EPA CLP SOW ISM01.2, including lithium, molybdenum, strontium, tin, and titanium):** A total of 11 surface water samples were submitted for off-site fixed laboratory analysis to A4 Scientific, an EPA CLP laboratory, which is located in The Woodlands, Texas.
- **SVOCs (EPA CLP SOW SOM01.2):** A total of 57 samples (13 subsurface soil samples, 12 sediment samples, 23 ground water samples, 7 surface water samples, and 2 QA/QC samples) were submitted for off-site fixed laboratory analysis to KAP Laboratories, an EPA CLP laboratory, which is located in The Woodlands, Texas.
- **VOCs (EPA CLP SOW SOM01.2):** A total of 61 samples (13 subsurface soil samples, 12 sediment samples, 23 ground water samples, 7 surface water samples, and 6 QA/QC samples) were submitted for off-site fixed laboratory analysis to KAP Laboratories, an EPA CLP laboratory, which is located in The Woodlands, Texas.
- **Grain Size Distribution (ASTM D-422):** A total of 34 sediment samples were submitted for off-site fixed laboratory analysis to Test America Denver, a START subcontracted laboratory, which is located in Arvada, Colorado.
- **Total Organic Carbon (EPA SW-846 Method 9060):** A total of 34 sediment samples were submitted for off-site fixed laboratory analysis to Test America Denver, a START subcontracted laboratory, which is located in Arvada, Colorado.

3.4 Global Positioning System

Phase I GPS coordinates were collected utilizing a Trimble™ Geo XH handheld unit with a Zephyr™ external antenna. During Phase II, GPS coordinates were collected using either a Trimble™ Geo XH handheld unit or a Trimble ProXR™ with a TDC1 data logger. During Phase II, some sample points had to be off-set or approximated due to dense canopy and lack of reception to the unit. The locations which were off-set and the distance and direction of correction are noted on the field sample collection forms. The field sample collection forms are presented in Appendix C. GPS locations for both Phase I and Phase II are presented in Appendix H.



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3.5 Investigation-Derived Waste

The START field team members made every effort to minimize the generation of IDW during both phases of the field event. IDW generated during the ESI investigations included disposable personal protective equipment and sampling equipment. All IDW was rendered unusable by tearing (when appropriate), bagged in opaque plastic garbage bags, and disposed at a local municipal landfill.

Materials that could be recycled (plastic, cardboard, and paper) were segregated from trash and IDW and picked up by Waste Management from the EPA warehouse in Seattle, Washington.

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4

Quality Assurance/ Quality Control

QA/QC data are necessary to determine precision and accuracy and to demonstrate the absence of interferences and/or contamination of sampling equipment, glassware, and reagents. Specific QC requirements for laboratory analyses are incorporated in the *Contract Laboratory Program Statement of Work for Organic Analyses* (EPA 2007) and the *Contract Laboratory Program Statement of Work for Inorganic Analyses* (EPA 2010a). These QC requirements or equivalent requirements found in the analytical methods were followed for analytical work on the EPA ESI project. This section describes the QA/QC measures taken for the project and provides an evaluation of the usability of data presented in this report.

Data from the START subcontracted commercial laboratory were reviewed and validated by a START chemist. Data qualifiers were applied as necessary according to the following guidance:

- EPA (2008) USEPA Contract Laboratory Program National Functional Guidelines for Superfund Organic Methods Data Review.
- EPA (2010b) USEPA Contract Laboratory Program National Functional Guidelines for Inorganic Superfund Data Review.

In the absence of other QC guidance, method- and/or SOP-specific QC limits were also utilized to apply qualifiers to the data.

4.1 Satisfaction of Data Quality Objectives

The following EPA (EPA 2000) guidance document was used to establish data quality objectives (DQOs) for this project:

- Guidance for the Data Quality Objectives Process (EPA QA/G-4), EPA/600/R-96/055.

The EPA TM determined that definitive data without error and bias determination would be used for the sampling and analyses conducted during the field activities. The data quality achieved during the field work produced sufficient data that met

the DQOs stated in the SQAP/SSSP (E & E 2011). A detailed discussion of accomplished project objectives is presented in the following sections.

4.2 Quality Assurance/Quality Control Samples

Rinsate blank QA samples were collected for each of the 20 samples using non-dedicated sampling equipment. One trip blank QA sample was collected for each sample cooler that contained samples to be analyzed for VOCs. QC samples included matrix spike/matrix spike duplicate (MS/MSD) and/or blank spike (BS) samples at a rate of one MS/MSD and/or BS per 20 samples per matrix.

4.3 Project-Specific Data Quality Objectives

The laboratory data were reviewed to ensure that DQOs for the project were met. The following describes the laboratories' abilities to meet project DQOs for precision, accuracy, and completeness and the field team's ability to meet project DQOs for representativeness and comparability. The laboratories and the field team were able to meet DQOs for the project.

4.3.1 Precision

Precision measures the reproducibility of the sampling and analytical methodology. Laboratory and field precision is defined as the relative percent difference (RPD) between duplicate sample analyses. The laboratory duplicate samples or MS/MSD samples measure the precision of the analytical method. The RPD values were reviewed for all commercial laboratory samples. A total of 60 sample results (approximately 0.4% of the data) were qualified based on precision outliers; therefore, the project DQO for precision of 90% was met.

4.3.2 Accuracy

Accuracy indicates the conformity of the measurements to fact. Laboratory accuracy is defined as the surrogate spike percent recovery (%R) or the MS/MSD/BS %Rs for all laboratory analyses. A total of 76 sample results (approximately 0.6% of the data) were qualified as estimated quantities (J or UJ) based on surrogate outliers.

The %R values were reviewed for all MS/MSD/BS analyses. A total of 562 sample results (approximately 4.4% of the data) were qualified based on MS and/or BS outliers; therefore, the project DQO for accuracy of 90% was met.

4.3.3 Completeness

Data completeness is defined as the percentage of usable data (usable data divided by the total possible data). All laboratory data were reviewed for data validation and usability. A total of 17 results (approximately 0.1% of the data) were rejected; therefore, the project DQO for completeness of 90% was met.

4.3.4 Representativeness

Data representativeness expresses the degree to which sample data accurately and precisely represent a characteristic of a population, parameter variations at a sampling point, or environmental condition. The number and selection of samples were determined in the field to accurately account for site variations and sample matrices. The DQO for representativeness was met.

4.3.5 Comparability

Comparability is a qualitative parameter expressing the confidence with which one data set can be compared to another. Data produced for this site followed applicable field sampling techniques and specific analytical methodology. The DQO for comparability was met.

4.4 Laboratory Quality Assurance/Quality Control Parameters

The laboratory data also were reviewed for holding times/temperatures/sample containers, laboratory blank samples, serial dilution analyses, rinsate blanks, and trip blanks. These QA/QC parameters are summarized below.

4.4.1 Holding Times/Temperatures/Samples Containers/Percent Moisture

All holding times, sample temperatures, containers, and percent moisture results were acceptable, except 121 results (approximately 0.9% of the results) that were qualified as based on percent moisture outliers and 39 results (approximately 0.3% of the results) based on holding time/temperature outliers.

4.4.2 Laboratory Blanks

All laboratory blanks met the frequency criteria. The following potential contaminants of concern were detected in the laboratory blanks:

- Inorganics: Sodium
- Miscellaneous: Total Organic Carbon
- VOCs: Bromomethane, chloromethane, methylene chloride, and toluene

See the data validation memoranda for results qualified based on blank contamination.

4.4.3 Serial Dilution Analyses

Serial dilution analyses met the frequency criteria. A total of 516 sample results (approximately 3.8% of the data) were qualified based on serial dilution outliers.

4.4.4 Rinsate Blanks

Rinsate blank analyses were performed at a frequency of one per 20 samples collected using non-dedicated sampling equipment. There were no detections in the rinsate blank analyses that affected sample results.

4.4.5 Trip Blanks

Trip blank analyses were performed at a frequency of one per cooler containing samples to be analyzed for VOCs. There were no detections in the trip blank samples.

4.5 Field and Fixed Laboratory Correlation

A START chemist performed a correlation study using field and fixed laboratory data for perchlorate and lead. For sample results less than the reporting limit, the value used for correlation was one-half of the reporting limit. The same sample aliquots used for perchlorate and XRF field analyses were submitted to the fixed laboratory for analysis. Field results were adjusted for percent moisture using values determined at the fixed laboratory.

A total of 16 samples were analyzed in the field for perchlorate, and 14 of the 16 samples were also analyzed for perchlorate at a fixed laboratory. The correlation coefficient for the 14 perchlorate sample pairs was determined to be -0.083 (Table 4-1), indicating a slightly negative correlation. All but one of the field results was below the detection limit; the fixed laboratory results for the 14 samples were also all below the field laboratory detection limit, indicating good agreement with the field analysis for low concentration samples.

A total of 50 samples were analyzed for lead in the field using the portable XRF instrument. Nine of the 50 samples were also analyzed at a fixed laboratory for lead. The correlation coefficient for the nine pairs of lead results was determined to be 0.506 (Table 4-1), indicating a moderate correlation.

Both of these correlation coefficients were below the value of 0.700 required for the field data to be considered screening level data. However, for a data set to be regarded as statistically significant, the sample population should include a minimum of 30 data points, so these correlations should not be considered valid, although useful information was obtained.

5

EPA ESI Analytical Results Reporting and Background Samples

This section describes the reporting and methods applied to analytical results presented in Sections 6 (sources) and 7 (targets/receptors) of this report, and discusses background locations and sample results. Table 3-1 lists all samples collected for laboratory analysis.

5.1 Analytical Results Evaluation Criteria

Analytical results presented in the summary tables of Sections 6 and 7 show all analytes detected above laboratory detection limits in bold type. Analytical results indicating significant/elevated concentrations of contaminants in source samples (Section 6) and target/receptor samples (Section 7), with respect to background concentrations, are shown underlined and in bold type. For the purposes of this investigation, significant/elevated concentrations are those concentrations that are:

- Equal to or greater than the sample's Contract Required Quantitation Limit (CRQL) or the Sample Quantitation Limit (SQL) when a non-CLP laboratory was used; and
- Equal to or greater than the background sample's CRQL or SQL when the background concentration was below detection limits; or
- At least three times greater than the background concentration when the background concentration equals or exceeds the detection limits.

The analytical summary tables present all detected compounds, but only those detected analytes at potential sources and targets/receptors meeting the significant/elevated concentration criteria are discussed in the report text. All detected concentrations are discussed for the background samples. When samples were diluted for re-analysis at a laboratory, the dilution results were considered for evaluation and are provided in the tables.

Sample concentration maps are provided in Sections 6 and 7 for significant/elevated concentrations of nitroaromatics/nitramine and perchlorate.

5. EPA ESI Analytical Results Reporting and Background Samples

Additionally, lead and strontium are also depicted. Lead is depicted as it has historically been a hazardous substance of concern at the site and strontium is included because it is can be an indicator of pyrotechnic colorant.

5.1.1 Sample Results Reporting

The analytes aluminum, calcium, iron, magnesium, potassium, and sodium are common earth crust elements. Based on EPA Region 10 policy, these common earth crust elements will not be discussed in this report.

5.2 Background Samples

Background samples were collected for each of the naturally occurring media from which ESI samples were collected. These media are surface soil, subsurface soil, ground water, surface water, and sediment. Results for the appropriate background samples are shown in the first column of the analytical results summary tables in Sections 6 and 7 for comparison against source or target/receptor results. During the ESI investigation, attempts were made to collect background samples outside the influence of site sources; however, given the facility's widespread operations and the length of time that it operated, it is possible that background samples are somewhat impacted by site activities.

5.2.1 Background Surface Soil

5.2.1.1 Sample Location

One background surface soil sample (BG01SS) was collected during the Phase II field event. The background surface soil sample was collected from the northeast portion of the site (Figure 7-10). The sample was collected approximately 50 feet north of a 4-wheel drive access road. The sample consisted of dry, medium brown loam with no discernible odor or staining in the area. The sample was submitted for off-site fixed laboratory analysis of nitroaromatics/nitramines, TAL metals, and perchlorate.

5.2.1.2 Sample Results

Sample results are presented in Table 6-2. Sample results indicate the presence of twelve TAL metals including arsenic, barium, chromium, cobalt, copper, lead, lithium, manganese, strontium, titanium, vanadium, and zinc. No nitroaromatics/nitramines or perchlorate were detected in the background surface soil sample above the instrument detection limit.

5.2.2 Background Subsurface Soil

5.2.2.1 Sample Location

One background subsurface soil sample (BG01SB) was collected during the Phase I field event. The background subsurface soil sample was collected approximately 1,000 feet northeast of Demolition Area 1/Landfill 4 (Figure 6-1). The sample was collected from this area as it was assumed to be outside the influence of the contaminants associated with Demolition Area 1/Landfill 4. The sample was collected from 2.6 feet bgs. The sample was submitted for off-site fixed laboratory analysis of nitroaromatics/nitramines, TAL metals, perchlorate,

5. EPA ESI Analytical Results Reporting and Background Samples

SVOCs, and VOCs. Additionally, the background sample was field analyzed for perchlorate.

5.2.2.2 Sample Results

Sample results are presented in Table 6-1. Sample results indicated the presence of 17 TAL metals (arsenic, barium, beryllium, chromium, cobalt, copper, lead, lithium, manganese, mercury, nickel, selenium, strontium, thallium, titanium, vanadium, and zinc) above the instrument detection limit. No VOCs, SVOCs, perchlorate, or nitroaromatics/nitramines were detected in the background subsurface soil sample.

5.2.3 Background Ground Water

5.2.3.1 Sample Location

Three background ground water samples were collected during the Phase I field event. One background ground water sample was collected from the background subsurface soil borehole (BG01GW) [Figure 6-1]. Two background monitoring well samples were collected during the Phase I field event from existing monitoring wells L4-MW01A (shallow well) and L4-MW01B (deep well) [Figure 7-5]. The background monitoring wells were chosen as they historically have been designated as the background wells and are assumed to be upgradient of ground water flow direction. The background ground water samples were submitted for off-site fixed laboratory analysis of nitroaromatics/nitramines, TAL metals, perchlorate, SVOCs, and VOCs.

5.2.3.2 Sample Results

Sample results for background ground water sample (BG01GW) are presented in Table 7-2. Analytical results indicate the presence of perchlorate, five TAL metals (barium, manganese, strontium, titanium, and zinc), and one SVOC (bis[2-ethylhexyl]phthalate) above the instrument detection limit. No VOCs or nitroaromatics/nitramines were detected in this background ground water sample.

Sample results for background shallow monitoring well sample (L4-MW01A) are presented in Table 7-3. Analytical results indicate the presence of perchlorate, four TAL metals (barium, manganese, strontium, and titanium), and one SVOC [bis(2-ethylhexyl)phthalate] above the instrument detection limit. No VOCs or nitroaromatics/nitramines were detected in the background shallow monitoring well sample.

Sample results for background deep monitoring well sample (L4-MW01B) are presented in Table 7-4. Analytical results indicate the presence of perchlorate and one TAL metal (strontium) above the instrument detection limit. No VOCs, SVOCs, or nitroaromatics/nitramines were detected in the background deep monitoring well sample.

5. EPA ESI Analytical Results Reporting and Background Samples

5.2.4 Background Surface Water

5.2.4.1 Sample Location

One background surface water sample was collected during the Phase II field event (BG04SW). The sample was co-located with the background sediment sample (Figure 7-7). The background location is upgradient of Demolition Area 1/Landfill 4. The sample was clear with no odor or sheen noted. The background surface water sample was submitted for off-site fixed laboratory analysis of nitroaromatics/nitramines, TAL total metals, TAL dissolved metals, perchlorate, SVOCs, and VOCs.

5.2.4.2 Sample Results

Surface water sample results are presented in Table 7-9. Sample results indicate the presence of total and dissolved strontium. No nitroaromatics/ nitramines, SVOCs, VOCs, or perchlorate were detected above the instrument detection limit.

5.2.5 Background Sediment

5.2.5.1 Sample Locations

A total of five background sediment samples were collected. One during Phase I (BG01SD) and four during Phase II. Background sediment sample BG01SD was collected and co-located with the background borehole previously discussed (Figure 6-1). Sample BG01SD-2 was collected from approximately 20 feet upstream of the CITA fence line on David Creek (Figure 6-3). Sample BG02SD was collected from Buck Creek (Figure 7-9). Upstream of the CITA on Buck Creek, but within the site boundary line, is a series of beaver ponds. Background sediment sample BG02SD was collected downgradient of the beaver ponds. Sample BG03SD was collected approximately 50 feet west of the site boundary fence from East Fork Lacamas Creek (Figure 7-8). Sample BG04SD was co-located with sample BG04SW and was in the same location as the background sediment sample collected during the Phase I field event (Figure 7-7). The background sediment samples were submitted for off-site fixed laboratory analysis of nitroaromatics/nitramines, TAL metals, perchlorate, grain size, and TOC. Additionally, two background sediment samples (BG01SD and BG04SD) were submitted for off-site fixed laboratory analysis for SVOCs and VOCs.

5.2.5.2 Sample Results

Sample results for the sediment samples are presented in Table 7-8 and Tables 7-10 through 7-14. Sample results for BG01SD collected during Phase I indicate the presence of 16 TAL metals including barium, beryllium, chromium, cobalt, copper, lead, lithium, manganese, mercury, nickel, selenium, strontium, thallium, titanium, vanadium, and zinc, and the VOC acetone. No nitroaromatics/nitramines, SVOCs, or perchlorate were detected in this sample above the instrument detection limit.

Sample results for all four background sediment samples collected during Phase II indicate the presence of 12 TAL metals including arsenic, barium, chromium, cobalt, copper, lead, lithium, manganese, strontium, titanium, vanadium and zinc.



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In addition, nickel was detected in sample BG01SD-2 and BG03SD. Nitroaromatics/nitramines and perchlorate were not detected above the instrument detection limit in any of the background Phase II sediment samples. No SVOCs or VOCs were detected in sample BG04SD.

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6

Potential Sources

This section describes potential sources, sample locations, and analytical results of samples obtained from potential sources during the Phase I and Phase II EPA ESI field events. Field sampling forms and logs are presented in Appendix C. SPAFs are presented in Appendix G. Laboratory data sheets of analytical results for all samples are provided in Appendix I. Sample results are reported as significant with respect to background concentrations.

6.1 Demolition Area 1/Landfill 4

An historic perchlorate and RDX plume has been documented in the area of Demolition Area 1/Landfill 4. This area consists of the historic landfill and a demolition area. The demolition area has historically been referred to as either OB/OD Area 1 or Demolition Area 1. Demolition Area 1/Landfill 4 was an open burn/open detonation area used to destroy and/or dispose of unserviceable munitions and energetic (e.g., explosive) materials. As discussed in Section 2.5.21 of this report, a removal of the landfill material and buried fireworks was conducted by the Corps; however, all of the contamination could not be removed, as the excavation area began filling with water and the machinery began to sink. The removal operations were stopped and the area was backfilled with clean material. Numerous previous sampling events have been conducted at this source (see previous investigations sections).

This ESI was designed to determine if the ground water contamination plume at Demolition Area 1/Landfill 4 has migrated to North Fork Lacamas Creek.

This source consists of more than 2.5 acres (greater than 108,900 square feet). Approximately 2.5 acres of Demolition Area 1/Landfill 4 have been removed; however, ground water contamination is still present at the source area, indicating that additional soil contamination below the ground water table is still present. During the 2004 removal at Demolition Area 1/Landfill 4, the excavation area became unstable and began filling with water. Due to these factors all of the contamination associated with Demolition Area 1/Landfill 4 was not removed.

6.1.1 Sample Locations

A total of 12 discrete subsurface soil samples (LF01SB through LF09SB, and LF12SB through LF14SB) were collected from between Demolition Area

1/Landfill 4 and Lacamas Creek (Figure 6-1). Samples were not collected from locations LF10SB and LF11SB due to lack of soil recovery; therefore, these sample locations are not depicted on the sample location map. The soil samples were submitted for off-site fixed laboratory analysis of nitroaromatics/nitramines, perchlorate, TAL metals, SVOCs, and VOCs. Additionally, the soil samples were field screened for perchlorate. The samples were collected from varying depths (based on the depth to ground water) ranging from 0.3 to 2.3 feet bgs.

6.1.2 Sample Results

Subsurface soil analytical results are presented in Table 6-1. Sample results indicate the presence of RDX at a significant concentration in one sample (LF08SB). Perchlorate was detected at significant concentrations in 3 of the 12 subsurface soil samples (LF04SB, LF05SB, and LF06SB). Significant concentrations of nitroaromatics/nitramines and perchlorate are presented on Figure 6-2. One TAL metal (lead) was detected at significant concentrations in two of the samples (LF08SB and LF09SB). One SVOC [bis(2-ethylhexyl)phthalate] was detected at significant concentrations in four of the samples (LF02SB, LF04SB, LF05SB, and LF13SB). One VOC (acetone) was detected at significant concentrations in two of the samples (LF13SB and LF14SB).

6.2 Central Impact Target Area

The CITA is a known source of deposited munitions, some of which may be unexploded. The CITA consists of approximately 83 acres (equivalent to 3,615,480 square feet). The area has been fenced with a three-strand barbed wire fence encircling the area. EPA's investigation of this area was designed to determine if contamination is present within the CITA and if it may be migrating to David Creek, Buck Creek, East Fork Lacamas Creek, and Lacamas Creek. Portions of both Buck Creek and David Creek flow through the CITA. East Fork Lacamas and Lacamas Creek flow adjacent to the CITA.

6.2.1 Sample Locations

A total of 11 surface soil samples (CT01SS through CT011SS) were collected from the CITA (Figure 6-3). The SQAP provided for up to 10 surface soil samples. At the direction of the TM, an additional sample was collected (see the SPAF, Appendix G). Samples CT01SS through CT04SS were collected from a previous target area. The areas were noted to have little underbrush compared to nearby areas, indicating they had previously been cleared of UXO. Sample CT02SS was collected from below a pile of sandbags which are indicative of a detonation area (Figure 6-3). Sample CT05SS was collected from a drainage ditch that was a possible overland pathway to David Creek (Figure 6-3). Samples CT06SS through CT10SS were collected from a previous target area (Figure 6-3). Metal fragments and sandbags, indicative of a previous detonation point, were noted in the area of sample CT06SS. Sample CT07SS was collected from the center of a 6- to 7-foot impact crater. The area surrounding this sample point was noted to be lacking underbrush compared to the surrounding area. Sample

CT08SS was collected from the middle of metal and glass debris area. The EPA-contracted UXO specialist identified this material as a target that had been destroyed. Sample CT09SS was collected from the center of a 4-foot impact crater. A small metal fragment was unearthed at this location at approximately 3 feet bgs. Sample CT11SS was collected from an impact crater where a metal fragment was observed. No soil staining or odor was noted in any of these samples.

6.2.2 Sample Results

Sample results are presented in Table 6-2. Sample results indicate the presence of one nitroaromatic/nitramine (3,5-dinitrobenzenamine), two TAL metals (lead and nickel), and perchlorate at significant concentrations in at least one surface soil sample from the CITA. Significant concentrations of nitroaromatics/nitramines, perchlorate, and lead are presented on Figure 6-4. Of these analytes, nickel was detected at significant concentrations in all but two of the samples.

6.3 Demolition Areas

Three demolition areas are present at the site. Demolition Area 1 (also, in some historical reports, referred to as OB/OD Area 1) is associated with Landfill 4 and is therefore, not discussed in this section. Demolition Area 2 (referred to in historical reports as OB/OD Area 2) is located adjacent to the western portion of the CITA. Demolition Area 3 (referred to in historical reports as OB/OD Area 3) is located in the most southwestern portion of the site. When combined, Demolition Areas 2 and 3 are estimated at 110 acres (equivalent to 4,791,600 square feet). EPA's investigation of these areas was designed to determine if contamination was present at these areas and potentially impacting nearby Lacamas Creek. Demolition Area 3 was noted to be a 30-foot diameter 8-foot deep crater with standing water. There were no discernible craters or features associated with Demolition Area 2.

6.3.1 Sample Locations

A total of nine surface soil samples (OB01SS through OB09SS) were collected from Demolition Areas 2 and 3. Samples OB01SS through OB05SS were collected from Demolition Area 3 (Figure 6-5). Four monitoring wells were noted in the area of Demolition Area 3. These wells were part of historic ground water sampling events and are no longer sampled. Samples OB06SS through OB09SS were collected from Demolition Area 2 (Figure 6-3). No soil staining or odors were noted in these samples. It was planned that five surface soil samples would be collected from each demolition area; however, after a discussion with the TM, it was decided that four samples would be collected from Demolition Area 2 (see the SPAF, Appendix G).

6.3.2 Sample Results

Sample results are presented in Table 6-3. Sample results from Demolition Area 2 indicate the presence of four TAL metals (lead, nickel, strontium, and tin) and one nitroaromatic/nitramine (4-amino,2,6-dinitrotoluene) at significant

concentrations in at least one of the surface soil samples. Significant concentrations of lead, strontium, nitroaromatics/nitramines and are presented on Figure 6-4. Of these, nickel was detected at significant concentrations in all four of the samples and lead was detected at significant concentrations in two of the four samples.

Sample results from Demolition Area 3 indicate the presence of two TAL metals (nickel and strontium) and perchlorate at significant concentrations in at least one of the surface soil samples. Significant concentrations of perchlorate and strontium are presented on Figure 6-6. Of these, strontium was detected at significant concentrations in three of the five samples and perchlorate was detected at significant concentrations in two of the five samples.

6.4 Firing Ranges and Firing Points

There are 31 firing ranges and/or firing points that are awaiting remediation. Seven of these firing ranges/firing points were selected for sampling based on their proximity to Lacamas Creek. The locations that were selected for sampling included:

- M203 HE Grenade Range;
- 1,000-Inch Range;
- 1,000-Yard Range;
- Artillery Position 5;
- Artillery Position 6;
- Artillery Position 7; and
- Former Artillery Position 1/Stokes Mortar Target Area.

The 1,000-Yard Range was determined to be the same as the west pop-up target area and was, therefore, not sampled as a firing range. These locations and results will be discussed below. Artillery Position 5 and the Former Artillery Position 1/Stokes Mortar Target Area were combined after consultation with the TM and site workers who indicated there was no distinct position difference. Changes to the sample plan are provided in the SPAFs presented in Appendix G.

6.4.1 Firing Range Sample Locations

A total of 16 samples were collected from the two ranges. Eight surface soil samples (FR01SS through FR08SS) were collected from the perimeter of the 1,000-Inch Range (Figure 6-7). Eight surface soil samples (FR09SS through FR16SS) were collected near the perimeter of the M203 HE grenade range (Figure 6-9). A number of mounds were noted on this firing range. Samples were collected from the mounds. The samples from each of the ranges were collected in areas designed to maximize the potential area of contamination present at the ranges. No soil staining or discernible odors were noted in these samples.

6.4.2 Firing Range Sample Results

Sample results are presented in Table 6-4. Sample results from the 1,000-Inch Range indicate the presence of four TAL metals (copper, lead, nickel, and strontium) and perchlorate at significant concentrations in at least one of the surface soil samples. Significant concentrations of lead and perchlorate are presented on Figure 6-8. Of these, lead was detected at significant concentrations in all eight samples, and nickel was detected at significant concentrations in all but one of the samples.

Sample results from the M203 HE grenade range indicate the presence of one nitroaromatic/nitramine (3,5-dinitrobenzenamine) and one TAL metal (nickel) at significant concentrations in at least one of the samples. Significant concentrations of the nitroaromatics/nitramines are present on Figure 6-10.

6.4.3 Firing Point Sample Locations

A total of 16 surface soil samples (FP01SS through FP16SS) were collected from the three firing ranges. Five samples (FP01SS through FP05SS) were collected from Artillery Position 7 (Figure 6-5). The samples were collected from the perimeter of the artillery position. No special features were noted at this artillery position. Five surface soil samples (FP06S through FP10SS) were collected from Artillery Position 6 (Figure 6-5). The samples were collected from the perimeter of the artillery position. A gas line easement is present running west-southwest of the artillery position. No other additional features were noted in this area. Six surface soil samples (FP11SS through FP16SS) were collected from Artillery Position 5 (Figure 6-9). The samples were collected from the perimeter of the artillery position. A grounding stake was noted near sample location FP15SS. Additionally, a concrete block, identified by the EPA-contracted UXO technician as a mortar target, was present adjacent to the southern portion of sample location PF16SS. The samples were collected from areas that would maximize the potential area of contamination. No soil staining or discernible odors were noted in these samples.

6.4.4 Firing Point Sample Results

Sample results are presented in Table 6-5. Sample results from Artillery Position 7 indicate the presence of two TAL metals (beryllium and nickel) at significant concentrations in at least one of the surface soil samples. Of these, nickel was detected at significant concentrations in all five of the samples. Nitroaromatics/nitramines and perchlorate were not detected above the instrument detection limit in any of the samples from Artillery Position 7.

Sample results from Artillery Position 6 indicate the presence of two TAL metals (lead and nickel) at significant concentrations in one of the surface soil samples (FP10SS). Significant concentrations of lead are presented on Figure 6-6. Nitroaromatics/nitramines and perchlorate were not detected above the instrument detection limit in any of the samples from Artillery Position 6.

Sample results from Artillery Position 5 indicate the presence of two nitroaromatics/nitramines (2,4-dinitrotoluene and 3,5-dinitrobenzenamine), two TAL metals (beryllium and nickel), and perchlorate at significant concentrations in at least one of the surface soil samples. Significant concentrations of the nitroaromatics/nitramines and perchlorate are presented on Figure 6-10. Of these, nickel was detected at significant concentrations in all six samples.

6.5 Firing Bank

A firing bank adjacent to the 1,000-Inch Range was discovered during the Phase II field event. Samples were not planned to be collected from this feature in the SQAP; however, the TM decided to collect samples due to the proximity and potential overland flow pathway to Lacamas Creek from this feature (see the SPAF, Appendix G).

The firing bank appears to be a natural hillside at the southern edge of the 1,000-Inch Range. The bank is approximately 12 feet tall and 200 feet long.

6.5.1 Sample Locations

Six surface soil samples (FB01SS through FB06SS) were collected from the firing bank associated with the 1,000-Inch Range (Figure 6-7). The samples were collected near the perimeter of the bank to maximize the potential area of contamination associated with this source. No soil staining or discernible odors were noted in these samples. No notations of metal fragments or bullets were noted in the field sampling forms (Appendix C).

6.5.2 Sample Results

Sample results are presented in Table 6-6. Sample results indicate the presence of four TAL metals (antimony, copper, lead, and nickel) at significant concentrations in at least one of the surface soil samples. Significant concentrations of lead are presented on Figure 6-8. Of these, nickel was detected at significant concentrations in all samples and lead was detected at significant concentrations in all but one of the samples. Nitroaromatics/nitramines were not detected above the instrument detection limit and perchlorate was not detected at significant concentrations in any of the samples.

6.6 Pop-Up Pond and Targets

A Pop-Up Pond and associated targets are present west of the CITA and adjacent to the southern portion of Lacamas Creek. The Pop-Up Pond is estimated to be approximately 2.26 acres. A number of outfall pipes around the pond were noted during the Phase II field event. It appears that all outfalls discharge into David Creek.

6.6.1 Pop-Up Pond Sample Locations

A total of 12 samples (PU01SD through PU12SD) were collected from the Pop-Up Pond (Figure 6-11). Nine samples were collected from the perimeter of the pond, and three samples were collected from an island present in the center of the

pond. The SQAP included collecting 10 sediment samples from the perimeter of the pond. The TM decided that it would be prudent to determine if the island was a potential source of contamination. Based on this, three of these 10 sediment samples (PU04SD, PU05SD, and PU06SD) were collected from the island. Additionally, during a reconnaissance of the pond to determine sample locations, an outfall leading from the pond to David Creek (Outfall 1) was discovered. It was decided that one of the sediment samples (PU08SD) would be placed near this outfall. Furthermore, during additional reconnaissance and in the midst of sample collection, two additional outfalls (Outfall 2 and Outfall 3, which consist of a series of three pipes) were discovered. The TM decided that two additional sediment samples (PU10SD near Outfall 2 and PU12SD near Outfall 3) would be added. These samples were collected from the pond immediately under the outfall.

6.6.2 Pop-Up Pond Sample Results

Sample results from the Pop-Up Pond are presented in Table 6-7. Significant concentrations of lead and strontium are presented on Figure 6-12. Sample results of the Pop-Up Pond perimeter sediment samples (PU01SD through PU3SD, PU07SD, PU09SD, and PU11SD) indicate the presence of two TAL metals (lead and strontium) at significant concentrations in at least one of the six samples. Of these, strontium was detected at significant concentrations in four of the sediment samples. Nitroaromatics/nitramines and perchlorate were not detected above the instrument detection limit in any of these samples.

Sample results for the Pop-Up Pond island samples (PU04SD through PU06SD) indicate the presence of two TAL metals (beryllium and strontium) at significant concentrations in at least one of the sediment samples. Of these, strontium was detected at significant concentrations in all three samples. Nitroaromatics/nitramines and perchlorate were not detected above the instrument detection limit in any of the samples.

Sample results for the outfall sediment samples (PU08SD, PU10SD, and PU12SD) indicate the presence of two TAL metals (beryllium and strontium) at significant concentrations in at least one of the sediment samples. Of these, strontium was detected at significant concentrations in all three samples.

Strontium was detected at significant concentrations, with respect to the background concentration, in 10 of the 12 sediment samples collected from this potential source.

6.6.3 Pop-Up Targets Sample Locations

A west and east Pop-Up Targets area were identified for sampling in the SQAP. Upon examination in the field, the west Pop-Up Target area was observed to be within the 1,000-Yard Range. The Pop-Up Target areas were identified in the SQAP for field screening using the field-portable XRF. Forty field screening locations were planned in the SQAP; however, 32 locations were selected for

screening with the field-portable XRF as directed by the TM (see the SPAF, Appendix G). Readings for antimony, arsenic, and lead were collected on XRF collection forms. These forms are presented with the Pop-Up Targets field forms in Appendix C. GPS locations for all field screened locations were also collected. These locations are presented in Appendix H. The project manager and TM reviewed the XRF readings and determined the locations with the highest readings and providing the largest possible potential area of contamination would be selected for fixed laboratory analysis. The field team then sampled these selected locations. A total of nine samples (PT10SS through PT18SS) were collected from the 1,000-Yard Range (Figure 6-11). At sample location PT11SS, the land surface was barren of vegetation for at least 6 feet in all directions. It was noted that around all pop-up target bases, soil appeared to have been removed to a depth of approximately 6 to 8 inches (though some locations were deeper than eight inches) in a 12-foot diameter around the bases (Appendix D; Pop-up Targets Photographs 12 and 16 through 18).

Ten XRF locations were planned in the east targets area. Readings for antimony, arsenic, and lead were collected on XRF collection forms. These forms are presented with the Pop-Up Targets field forms in Appendix C. GPS locations for all field screened locations were also collected. These locations are presented in Appendix H. The project manager and TM reviewed the XRF readings and determined the locations with the highest readings and providing the largest possible potential area of contamination would be selected for fixed laboratory analysis. The field team then sampled these selected locations. A total of nine samples (PT01SS through PT09SS) were collected from the east targets area (Figure 6-11). It was noted that excavation had occurred extensively throughout this area.

6.6.4 Pop-Up Targets Sample Results

Surface soil samples results for the 1,000-Yard Range and Pop-Up Target are presented in Table 6-8. Sample results from the east target indicate the presence of three TAL metals (copper, lead, and nickel) at significant concentrations in at least one of the nine surface soil samples. Of these, lead and nickel were detected at significant concentrations in all nine samples. Perchlorate was not detected at significant concentrations in any of the east target samples. Nitroaromatics/nitramines were not detected above the instrument detection limit in any of the samples.

Sample results for the 1,000-Yard Range indicate the presence of two TAL metals (lead and nickel) at significant concentrations in at least one of the nine surface soil samples. Significant concentrations of lead are presented on Figure 6-12. Of these, nickel was detected at significant concentrations in all nine samples. Nitroaromatics/nitramines and perchlorate were not detected above the instrument detection limit in any of the samples.

7

Migration/Exposure Pathways and Targets/Receptors

The following subsections describe migration pathways and potential targets/receptors within the site's range of influence (Figures 7-1 and 7-2). This section discusses the ground water migration pathway, the surface water migration pathway, the soil exposure pathway, and the air migration pathway. Sample results are discussed as elevated with respect to background concentrations for the ESI samples.

7.1 Ground Water Migration Pathway

The target distance limit (TDL) for the ground water migration pathway is a 4-mile radius that extends from the sources at the site. Figure 7-1 depicts the ground water 4-mile TDL.

7.1.1 Geologic Setting

Camp Bonneville lies within the Willamette Lowland portion of the Willamette Valley and Puget Sound Physiographic Province. The Willamette Lowland lies between the Cascade Mountains to the east and the Coast Range to the west. The Willamette Valley is part of an elongate alluvial plain that has an elevation near sea level in Portland, Oregon and at the Columbia River (Orr and Orr 1999).

Camp Bonneville is located along the eastern edge of the Willamette Lowland near the foothills of the Cascade Mountains. The U.S. Geological Survey published a geologic map of the Lacamas Creek 7.5-minute quadrangle in 2006 (Evarts 2006). This map provides a more detailed description of the geology in the Camp Bonneville area. The following geologic units are present at Camp Bonneville in order from oldest to youngest: Basaltic Andesite of the Elkhorn Mountain, Sandy River Mudstone, Lower (Conglomerate) member of the Troutdale Formation, Landslide Deposits, and Alluvial Sediments (Evarts 2006).

The geologic history of the area includes the accretion of a submarine oceanic island archipelago (Orr and Orr 1999) as evidenced through the presence of Oligocene age tholeiitic basaltic andesite and basalt flows and flow breccia (Basaltic Andesite of Elkhorn Mountain) (Evarts 2006). The Basaltic Andesite of the Elkhorn Mountain unit is present as bedrock throughout Camp Bonneville. The uppermost bedrock is severely weathered as characterized by clay-rich materials described in boring logs from throughout the site (Orr and Orr 1999).

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The Sandy River Mudstone unconformably overlies the basaltic andesite and was formed when the Portland Basin was a lake fed by the ancestral Columbia and Willamette Rivers (Orr and Orr 1999; Evarts 2006). The mudstone is characterized in boring logs from throughout Camp Bonneville by clayey siltstone and fine-grained sandstone. At Camp Bonneville, the Sandy River Mudstone is present in a small valley that extends between Camp Killpack and Camp Bonneville cantonments (BCRRT 2009a)

The Troutdale Formation is the result of deposition of western flowing streams that crossed the Cascade Range, including the ancestral Columbia River. An older conglomerate member of the Troutdale Formation is present along the west-southwest portion of Camp Bonneville (Evarts 2006). In addition, a remnant of the conglomerate is present at Demolition Area 1/Landfill 4. At Camp Bonneville, the conglomerate is deeply weathered. It is described as a weakly to moderately cemented pebble and cobble conglomerate with lenses of coarse sandstone (BCRRT 2009a).

Recent alluvium and landslide deposits are present along Lacamas Creek, East Fork Lacamas Creek, North Fork Lacamas Creek, and David Creek (Evarts 2006). The alluvial deposits consist of unconsolidated silt, sand, and gravel. Well-rounded quartzite pebbles from the Troutdale Formation are present in these deposits (BCRRT 2009a). Recent landslide deposits consist of diamictons of bedrock and surficial material that has been transported downslope. These landslide deposits are located in areas of steep bedrock terrain and appear to be the result of failed weathered, clay-rich, flow breccias (BCRRT 2009a).

7.1.2 Aquifer System

Camp Bonneville lies within the Portland Basin portion of the Willamette Lowland Aquifer System. The Portland Basin is bounded to the east by the Cascade Mountains, to the north by the Lewis River, and to the west by the Coast Range.

The Basaltic Andesite of the Elkhorn Mountain unit generally has little capacity to store or transmit water. Where water is present, it is located at the soil/rock interface or in fractured zones within the rock (McFarland and Morgan 1996). At Camp Bonneville, this unit is not considered to be a productive aquifer, with some exceptions where potable water has been encountered in fracture zones.

The Sandy River Mudstone is a low permeability unit. As described in the geology section above, this unit is only present in a small valley that extends between Camp Killpack and Camp Bonneville cantonments. It is not present at Demolition Area 1/Landfill 4.

The Troutdale Conglomerates are generally considered excellent water-bearing units and commonly serve as water sources for municipal, industrial, and

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irrigation supplies (McFarland and Morgan 1996). In 2006, EPA designated the Troutdale aquifer a sole-source aquifer in the Clark County, Washington area. This aquifer system provides approximately 99% of the available drinking water to the residents living over it. There are no other available drinking water sources that would be economically feasible to supply these residents (EPA 2006). At Camp Bonneville, the Conglomerate Member of the Troutdale Formation is present along the west-southwest portion of Camp Bonneville (Evarts 2006). In addition, a remnant of the conglomerate is present at Demolition Area 1/Landfill 4. The remnant is disconnected/isolated from the Troutdale Conglomerate located at the west-southwest property line of Camp Bonneville. The remnant was most likely isolated from the rest of the unit to the west-southwest by the downcutting of Lacamas Creek. Camp Bonneville lies within the Streamflow Source Area of the Troutdale Aquifer. The Streamflow Source Area is defined by EPA as “the upstream headwaters area of streams that flow into the recharge area of the aquifer” (EPA 2006).

Movement of ground water in the Portland Basin is primarily controlled by topography (Morgan and McFarland 1996). Topography also appears to control ground water flow at Camp Bonneville (BCRRT 2009a). Ground water typically discharges to Lacamas Creek and its tributaries. However, EPA has described ground water pumping in the Lacamas Creek watershed that has resulted in a lowering of the potentiometric surface. This lowering of ground water levels has resulted in the loss of reaches of Lacamas Creek and its tributaries. (EPA 2006)

7.1.2.1 Troutdale and Unconsolidated Alluvium Aquifer System Sole Source Aquifer Designation

In November 2005, a petition was submitted to EPA to designate the Troutdale and Unconsolidated Alluvium Aquifer as a sole source of drinking water in the area of Clark County, Washington. The petitioners included Columbia Riverkeeper, Rosemere Neighborhood Association, and eight independent Clark County citizens. (EPA2006)

The Sole Source Aquifer Program is authorized by the Safe Drinking Water Act of 1974. EPA defines a sole or principal source aquifer as “an aquifer or aquifer system which supplies at least 50% of the drinking water consumed in the area overlying the aquifer, and for which there is no alternative source or combination of alternative drinking water sources which could physically, legally, and economically supply those dependent upon the aquifer.” For convenience, all EPA designated sole or principal source aquifer systems are often referred to simply as “sole source aquifers.” (EPA 2006)

The aquifer system boundaries that were originally petitioned were slightly extended in the southern, eastern, and northern sections of the area, as recommended by EPA during their review of the petition. The final boundaries are presented on Figure 7-4. The Columbia River forms the southern and western boundaries of the Troutdale aquifer system. The northern boundary follows the

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North Fork of the Lewis River from its confluence with the Columbia River, east to the confluence of Cedar Creek. Cedar Creek is used as the northeast boundary between the Troutdale unit and the older rocks unit, and the creek also most likely acts as a local ground water divide for the upper parts of the aquifer system. The aquifer boundary follows Cedar Creek east where the boundary turns southeast and follows the mapped geologic contact between the Troutdale Formation and the older rock unit. The eastern boundary follows the geologic contact south to the Little Washougal River, then follows the Little Washougal River to its confluence with the Washougal River. The boundary then follows the Washougal River south to Woodburn Hill, where it turns northwest and follows the geologic contact along a small outcrop of the older rocks unit. The boundary follows the geologic contact through the City of Camas, and meets the Columbia River. In the northern part of the area, the aquifer system boundary is drawn around Bald Mountain, which is excluded from the aquifer system because it is composed of the older rocks unit (EPA 2006).

Based on the information included in the petition and findings during its review, the EPA concluded “A sole source aquifer system must supply at least 50% of the drinking water consumed within the natural boundaries of the aquifer system, and there can be no economically or legally available alternative source that could supply the entire population living in the area. The Troutdale Aquifer System supplies over 99% of the drinking water to people living in the petitioned area, and there are no economically and legally available alternative sources of water. The political and legal constraints on available water supplies in the area cause even potentially adequate volumes to be unattainable within any reasonable timeframe. Given these conditions, the Troutdale Aquifer System meets the EPA criteria of a sole or principle source aquifer under Section 1424(e) of the Safe Drinking Water Act.” (EPA 2006)

7.1.2.2 On-Site Ground Water Monitoring

Twenty-seven monitoring wells exist at Camp Bonneville. Of these 27 wells, 19 are currently monitored. Monitoring wells at Demolition Area 2 and Demolition Area 3 are no longer sampled after previous quarters’ sampling events resulted in no exceedances of MTCA cleanup levels for site contaminants of concern. The majority of these monitoring wells are located in the valley that follows Lacamas Creek through Camp Bonneville (Central Valley). As described in *Ground Water Sampling and Analysis Report for Camp Bonneville for the 4th quarter of 2006* (PBS 2007), the following wells are currently monitored at the site:

- Base Boundary at Lacamas Creek
 - Paired wells: LC-MW01S and LC-MW01D
 - Paired wells: LC-MW02S and LC-MW02D
 - Paired wells: LC-MW03S and LC-MW03D
 - Paired wells: LC-MW04S and LC-MW04D

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- Demolition Area 1/Landfill 4 (A – shallow, B – deep)
 - Paired wells: L4-MW01A and L4-MW01B
 - Paired wells: L4-MW02A and L4-MW02B
 - Paired wells: L4-MW03A and L4-MW03B
 - L4-MW04A
 - L4-MW05A
 - L4-MW07B
 - L4-MW17 (bedrock)
 - L4-MW18 (alluvium)

Quarterly ground water sampling at Camp Bonneville includes well depth data as well as static water level data in each monitoring well. In addition, ground water samples collected from Base Boundary at Lacamas Creek monitoring wells were analyzed for field measurements (pH, specific conductance, temperature, and total dissolved solids), TPH-Gx (gasoline), TPH-Dx (diesel), VOCs, SVOCs, explosive compounds (including HMX, RDX, NG, and PETN), picric acid, perchlorate, priority pollutant metals (total and dissolved), TOC, DOC, TSS, alkalinity, and inorganic ions.

Ground water samples collected from Demolition Area 1/Landfill 4 monitoring wells are analyzed for field measurements (pH, specific conductance, temperature, and total dissolved solids), VOCs, explosive compounds (including HMX, RDX, NG, and PETN), and perchlorate.

Based on the quarterly monitoring report (PBS 2007) for Base Boundary wells at Lacamas Creek, metals concentrations have decreased over the period of monitoring. Petroleum hydrocarbons have not been detected in any samples over the period of monitoring, with the exception of a single detection of diesel range petroleum hydrocarbons (0.14 milligrams per liter in January 2006). Perchlorate concentration trends in ground water samples have been variable despite Interim Removal Actions that have occurred at Demolition Area 1/Landfill 4.

Based on the 4th quarter 2006 monitoring report (PBS 2007), depth to ground water in the area of Demolition Area 1/Landfill 4 ranged from approximately 11 feet to 30.8 feet (note: all depths to ground water are described from top of casing rather than the land surface). Depth to ground water in monitoring well L4-MW07B located downgradient of the landfill was approximately 30.32 feet. Depth to ground water in monitoring wells L4-MW17 and L4-MW18, along North Fork Lacamas Creek at the base of the stream ravine and downgradient of Demolition Area 1/Landfill 4 was 9.63 feet and 10.14 feet, respectively.

Monitoring of the ground water wells was ceased for approximately 1 year. Monitoring of the ground water resumed in January 2011.

Based on the most recent round of ground water sampling for which results are available (3rd Quarter 2010), sample results indicate perchlorate concentrations

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remain in excess of MTCA Method B Cleanup values at six monitoring locations at Demolition Area 1/Landfill 4. Also at these same locations, HMX concentrations exceeded MTCA Method B values. The highest levels of HMX, RDX, and perchlorate continue to be at the paired monitoring wells MW02A and MW02B, consistent with historical results. (PBS 2010)

7.1.3 Drinking Water Targets/Receptors

Approximately 9,627 people use ground water for drinking water purposes within the 4-mile TDL. A combination of Group A and Group B community water systems and domestic wells are present. The Washington Administrative Code (WAC) defines the group designation for community water systems. The definitions, as provided by the Washington State Department of Health, include:

- **Group A:** (WAC 246-290) Group A water systems are those with 15 or more service connections, regardless of the number of people; or systems serving an average of 25 or more people per day for 60 or more days within a calendar year, regardless of the number of service connections. Group A water systems do not include systems serving fewer than 15 single-family residences, regardless of the number of people.
- **Group B:** (WAC 246-291) Group B water systems serve less than 15 residential connections and less than 25 people per day; or 25 or more people per day fewer than 60 days per year. Group B water systems are those public water systems that do not meet the definition of a Group A water system.

DOH maintains records of all active public water systems. Public water systems, regardless of group designation, indicate the total number of wells in the system, the number of connections, and the total population served. A search of the DOH Sentry Internet database revealed the presence of 18 Group A community wells serving a total population of 830 people, and 182 Group B community wells serving a total population of 1,083 people (WDOH 2009).

Domestic drinking water well logs are maintained by Ecology. A search of the Ecology well log database revealed the presence of a total of 3,269 domestic wells within the 4-mile TDL. Domestic wells do not record the actual number of people served by each well; therefore, each well is assigned the average number of people per household for Clark County, Washington of 2.67, for a total population of 7,715 people served by domestic wells (Census 2011; Ecology 2009). The nearest well is located from 0 to ¼ mile of the site. Population figures were rounded the nearest whole integer for reporting purposes. The number of drinking water wells and associated population within the 4-mile TDL by distance ring is presented in Table 7-1.

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Given the surrounding land use, it is assumed that ground water is used for the irrigation of commercial livestock within the TDL. A wellhead protection area is present within the 4-mile TDL.

7.1.4 Ground Water Sample Locations and Results

A total of 11 ground water samples (LF01GW through LF07GW, and LF12GW through LF15GW) were collected from the boreholes between Demolition Area 1/Landfill 4 and the adjacent North Fork Lacamas Creek during the Phase I field event (Figure 6-1). The samples were submitted for off-site fixed laboratory analysis of nitroaromatics/nitramines, perchlorate, TAL metals, SVOCs, and VOCs.

Ground water analytical results are presented in Table 7-2. Sample results indicated the presence of RDX at elevated concentrations in 6 of the 11 samples. Perchlorate was detected at elevated concentrations in 10 of the 11 samples (only location LF12GW did not have a detection of perchlorate). A total of 12 TAL metals (barium, chromium, cobalt, copper, lithium, manganese, mercury, nickel, strontium, titanium, vanadium, and zinc) were detected at elevated concentrations in at least one of the ground water samples. Elevated concentrations of nitroaromatics/nitramines, perchlorate, and strontium are presented on Figure 6-2.

One SVOC [bis(2-ethylhexyl)phthalate] was detected at an elevated concentration in one of the ground water samples. RDX, perchlorate, lead, and bis(2-ethylhexyl)phthalate were also detected at significant concentrations in the co-located subsurface soil samples (see Section 6). No VOCs were detected above the instrument detection limit in any of the ground water samples.

7.1.5 Monitoring Well Sample Locations and Results

Five shallow existing monitoring wells (L4-MW02A through L4-MW05A and MW-17) and four deep existing monitoring wells (L4-MW02B, L4-MW03B, L4-MW07B, and MW-18) were selected for sampling during the Phase I field event (Figure 7-5). These nine wells are all associated with Demolition Area 1/Landfill 4. The samples were submitted for off-site fixed laboratory analysis for nitroaromatics/nitramines, perchlorate, TAL metals, SVOCs, and VOCs.

Shallow monitoring well analytical sample results are presented in Table 7-3. Sample results indicate the presence of HMX at an elevated concentration in one well (L4-MW02A). RDX was detected at elevated concentrations in four of the five wells. Perchlorate was detected at an elevated concentration in one shallow well (L4-MW02A). Elevated concentrations of nitroaromatics/nitramines and perchlorate are presented on Figure 7-6. It should be noted that the background shallow monitoring well (L4-MW01A) also contained perchlorate at a fairly high concentration. Finally, one SVOC (bis[2-ethylhexyl]phthalate) was detected at an elevated concentration in one shallow well (MW-17). No TAL metals or VOCs were detected at elevated concentrations in the shallow well samples.

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Deep monitoring well analytical sample results are presented in Table 7-4. Sample results indicate the presence of HMX at an elevated concentration in one deep monitoring well (L4-MW02B). RDX was detected at elevated concentrations in two of the four deep monitoring wells (L4-MW02B and L4-MW03B). Perchlorate was detected at elevated concentrations in three of the four deep monitoring wells (L4-MW02B, L4-MW03B, and L4-MW07B). Elevated concentrations of nitroaromatics/nitramines and perchlorate are presented on Figure 7-6. Four TAL metals (barium, manganese, titanium, and vanadium) were detected at elevated concentrations in at least one of the deep monitoring wells. Of these, manganese was detected at elevated concentrations in three of the four deep monitoring wells. One SVOC [bis(2-ethylhexyl)phthalate] was detected at an elevated concentration in one of the deep monitoring wells. Five VOCs (1,1,1-trichloroethane, 1,1,2-trichloro-1,2,2-trifluoroethane, 1,1-dichloroethane, chloroform, and dichlorodifluoromethane) were detected at elevated concentrations in at least one of the deep monitoring wells. All of these, except for chloroform, were detected in one deep well (LF-MW02B).

7.2 Surface Water Migration Pathway

The surface water migration pathway TDL begins at the probable point of entry (PPE) of surface water runoff from the site to a surface water body and extends downstream for 15 miles. Figure 7-2 depicts the surface water migration TDL.

The average annual precipitation for Vancouver, Washington is 39.48 inches (WRCC 2009). The 2-year 24-hour rainfall event for Vancouver, Washington is 2.5 inches (NOAA 1973). Portions of the site are located in a 100-year flood plain (FEMA 1991).

Soils at the site consist of Hesson clay loam (0 to 8% slopes) and McBee silty clay loam (0 to 3% slopes). The Hesson clay loam is the predominant soil type in the county. In a typical soil profile, the surface layer is a reddish-brown clay loam approximately 8 inches thick. The subsurface layer is dark reddish-brown clay loam approximately 4 inches thick. Below this layer is friable, dark reddish-brown clay loam approximately 10 inches thick. The next layer to a depth of approximately 91 inches is reddish-brown clay. The Hesson clay loam is well drained and has moderately slow permeability. The McBee clay loam occurs on depressions that are sometimes subject to flooding from nearby streams. In a typical profile, the surface layer is a silty clay loam approximately 11 inches thick. It is very dark brown in the upper portion and dark brown in the lower portion. The next layer is approximately 41 inches thick and is comprised as follows: 10 inches of friable very dark reddish-brown silty clay loam; 11 inches of firm dark brown silty clay loam; and the lower 20 inches is firm grayish-brown and dark yellowish-brown silty clay loam. The underlying material to a depth of approximately 65 inches is gray and brown clay. The McBee silty clay loam is somewhat poorly drained and moderately permeable (USDA 1972).

7. Migration/Exposure Pathways and Targets/Receptors

7.2.1 Overland Pathway

Camp Bonneville is located within the Lacamas Creek watershed, more specifically Upper Lacamas Creek. Lacamas Creek is fed by numerous tributaries that run through Camp Bonneville. There are four major tributaries to Lacamas Creek that run through the site: North Fork Lacamas Creek, East Fork Lacamas Creek, David Creek, and Buck Creek. Numerous PPEs are present within the site on Lacamas Creek and on various tributaries. The PPEs are presented below by water body:

- **North Fork Lacamas Creek:** Overland flow from Demolition Area 1/Landfill 4;
- **East Fork Lacamas Creek:** Overland flow from the CITA;
- **David Creek:** Overland flow from the CITA (including the entire portion that flows through the CITA), Outfalls 1 through 3 from the Pop-Up Pond, and overland flow from Demolition Area 2;
- **Buck Creek:** Overland flow from the 1,000-Inch Range; and
- **Lacamas Creek:** Overland flow from Demolition Area 3, the 1,000-Yard Range, the Firing Bank, the M203 HE Grenade Range, Artillery Position 5, and Artillery Position 6.

The 15-mile TDL begins at the most upstream PPE associated with Demolition Area 1/Landfill 4 on North Fork Lacamas Creek through Camp Bonneville to the most downstream PPE associated with Demolition Area 3 on Lacamas Creek then continues approximately 12.61 miles downstream (through Lacamas Lake, which is approximately 9 miles downstream) to its confluence with the Washougal River. From this location, the TDL continues approximately 1.43 miles downstream to the confluence with the Columbia River and concludes approximately 0.96 mile downstream in the Columbia River.

Flow rates are not available for Lacamas Creek or Lacamas Lake. The flow rate for the Washougal River as measured at Washougal, Washington (near the confluence of Lacamas Creek and the Washougal River) is 800.5 cubic feet per second (cfs) and the flow rate for the Columbia River at Vancouver, Washington is reported to be 215,900 cfs (USGS 2009). The flow rate for Lacamas Creek was noted to be less than 10 cfs on the Phase II Field Sampling Form (Appendix C).

7.2.1.1 Sample Locations and Results

One overland pathways sample (OP01SS) was collected from a drainage ditch from Artillery Positions 6 and 7, Demolition Area 3 (discussed in sources section), and Lacamas Creek.

Sample results are presented in Table 7-5. No analytes were detected at elevated concentrations in the overland pathway sample.

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7.2.2 Drinking Water Targets/Receptors

Surface water is not used for drinking water purposes within the TDL. The Columbia River is a major recreation area.

7.2.3 Human Food Chain Targets/Receptors

Two artificial impoundments on Lacamas Creek were created to support a trout sports fishery (WC 1997). These impoundments are no longer fished; however, they were actively used when the site was in operation. Fish catch is not reported for Lacamas Creek or Lacamas Lake; however, it was reported that these water bodies are known fishing locations for human consumption (Reynolds 2009). It is estimated that greater than 1 to 100 pounds of fish are caught annually from the creek or the lake for human consumption. Fishing is not known, nor expected, to occur above Lacamas Lake due to the presence of a dam which does not contain fish ladders to allow the passage of fish from the lake to the creek.

The most current sport catch data are from 2000 to 2001 (WDFW 2005). Fishing is reported for the entire Washougal River, of which approximately 1% lies within the TDL. Fish catch data is presented in numbers of fish caught; therefore, the average weight of each fish is used to determine the pounds of fish caught within the TDL. The total pounds of each fish species is then multiplied by 1% to determine the pounds of fish caught within the TDL. Fish catch for the Columbia River is reported from the Bonneville Dam to the Columbia River, of which approximately 0.5% is within the TDL. The same process for determining pounds of fish within the TDL as discussed above is used here. Fish catch data is presented in Table 7-6. In this table, fish catch estimates have been rounded to the nearest whole number.

7.2.4 Environmental Targets/Receptors

State- and Federal-listed threatened and endangered species are present within the TDL. The Federal-listed threatened Lower Columbia River Evolutionarily Significant Unit (ESU) Steelhead (*Oncorhynchus mykiss*), the Lower Columbia River ESU Chinook salmon (*Oncorhynchus tshawytscha*), and the Lower Columbia River ESU Chum salmon (*Oncorhynchus keta*) are present within Lacamas Creek, the Washougal River, and the Columbia River. The Federal-listed endangered Bradshaw's Lomatium (*Lomatium bradshawii*) is present within Lacamas Creek. Additionally, the State-listed threatened Dense Sedge (*Carex densa*), Hall's aster (*Aster hallii*), the Oregon coyote thistle (*Eryngium petiolatum*), and the Western Wahoo (*Euonymus occidentalis*) are present on Lacamas Creek (Hanson 2011). Table 7-7 provides a summary of the environmental targets within the TDL.

A total of 18.03 miles of wetland frontage are present along the TDL (Hanson 2011). Wetland frontages by surface water body within the TDL are depicted on Figure 7-7 and are as follows:

7. Migration/Exposure Pathways and Targets/Receptors

- Lacamas Creek – 17.86 miles (of which 6.44 miles are within the boundaries of the site);
- Washougal River – 0.09 mile, and
- Columbia River – 0.08 mile.

7.2.5 Sample Locations and Results

7.2.5.1 North Fork Lacamas Creek

Two sediment samples (LF01SD and PP01SD) were collected from North Fork Lacamas Creek during the Phase I field event. Sample LF01SD was collected at a seep that was discovered to be emanating from Demolition Area 1/Landfill 4. Sample PP01SD was collected from North Fork Lacamas Creek adjacent to the seep. The Phase I sediment samples were submitted for off-site fixed laboratory analysis of TAL metals, perchlorate, nitroaromatics/nitramines, SVOCs, VOCs, grain size, and TOC. Additionally, the PPE sample was field screened for perchlorate.

Six surface water (NF02SW through NF05SW, NF07SW, and NF09SW) and nine sediment samples (NF01SD through NF09SD) were collected from North Fork Lacamas Creek during the Phase II field event (Figure 7-8). The Phase II samples were collected in order from downstream toward upstream locations to avoid cross-contamination. Sample NF01SD was collected approximately 300 feet upstream of the confluence of East Fork Lacamas Creek. Samples NF02SW/SD was collected 1,600 feet upstream of sample NF01SD on North Fork Lacamas Creek. Samples NF03SW/SD were collected approximately 210 feet upstream of sample NF02SW/SD in proximity to sample PP01SD which was collected during the Phase I field sampling event. Samples NF04SW/SD were collected approximately 300 feet upstream of sample NF03SW/SD in proximity to sample location LF05SB/GW which was collected during the Phase I field event. Samples NF05SW/SD were collected approximately 100 feet upstream of sample NF04SW/SD. Sample NF06SD was collected approximately 60 feet upstream of sample NF05SW/SD in proximity to samples LF04SB/GW which were collected during the Phase I field event. Samples NF07SW/SD were collected approximately 118 feet upstream of sample NF06SD in proximity to LF02GW which was collected during the Phase I field event. Sample NF08SD was collected approximately 188 feet upstream of sample NF07SW/SD. Finally, samples NF09SW/SD were collected approximately 285 feet upstream of sample NF08SD. Based on the map, it appears this sample was collected from an unnamed stream; however, during the field event, it was thought this was North Fork Lacamas Creek.

The Phase II surface water and sediment samples were submitted for off-site fixed laboratory analysis of TAL metals, perchlorate, nitroaromatics/nitramines, SVOCs, and VOCs. Additionally, the sediment samples were submitted for off-site fixed laboratory analysis for TOC and grain size.

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Sediment sample results from the Phase I field event are presented in Table 7-8. Perchlorate was detected in the seep sample collected from along North Fork Lacamas Creek (LF01SD) at an elevated concentration of 1.5 µg/kg. Elevated concentrations of perchlorate and strontium are presented on Figure 7-9. Sample results indicate the presence of two TAL metals (arsenic and strontium), perchlorate, and one SVOC [bis(2-ethylhexyl)phthalate] at elevated concentrations in at least one of the two samples collected.

Surface water sample results from the Phase II field event are presented in Table 7-9. Sample results indicate the presence of total and dissolved manganese, perchlorate, one SVOC (diethylphthalate), and one VOC (toluene) at elevated concentrations. Perchlorate was detected at elevated concentrations in two of the samples (NF02SW/D at 0.13 µg/L and NF03SW/D at 0.086 µg/L). Elevated concentrations of perchlorate are presented on Figure 7-9. Total manganese was detected at elevated concentrations in four of the six surface water samples, and dissolved manganese was detected at elevated concentrations in all six of the surface water samples. Diethylphthalate and toluene were not likewise detected in the Demolition Area 1/Landfill 4 subsurface soil or ground water samples and, therefore the concentrations of diethylphthalate and toluene detected in NF02SW/D and NF03SW/D, respectively, may not be associated with this source. Manganese was not detected at significant concentration in the subsurface soil samples, but was detected in the ground water samples collected from Demolition Area 1/Landfill 4. Perchlorate was detected at significant concentrations in the subsurface soil samples and at elevated concentrations in the ground water samples collected from Demolition Area 1/Landfill 4.

Sediment sample results from the Phase II field event are presented in Table 7-10. Sediment sample results indicate the presence of one nitroaromatic/nitramine (3-nitrotoluene), one TAL metal (nickel), and two VOCs (2-butanone and acetone) at elevated concentrations in at least one of the samples. Elevated concentrations of 3-nitrotoluene are presented on Figure 7-9. Acetone was also detected at significant concentrations in the subsurface soil samples. Nickel was not detected at significant concentrations in the subsurface soil samples; however, it was detected at elevated concentrations in the Demolition Area 1/Landfill 4 ground water samples.

7.2.5.2 East Fork Lacamas Creek

Three sediment samples (EF01SD through EF03SD) were collected from East Fork Lacamas Creek during the Phase II field event (Figure 7-10). Sample EF03SD was collected approximately 100 feet upstream of the confluence of East Fork Lacamas Creek and Lacamas Creek. Sample EF01SD was collected approximately 1,429 feet upstream of location EF03SD. Sample EF02SD was collected adjacent to the North Fence Road which runs alongside the CITA and approximately 1,076 feet upstream of sample EF01SD. No discernible staining or odors were noted in the samples. The samples were submitted for off-site fixed

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laboratory analysis for TAL metals, perchlorate, nitroaromatics/nitramines, TOC, and grain size.

East Fork Lacamas Creek sediment sample results are presented in Table 7-11. Sample results do not indicate the presence of any analyte at elevated concentrations.

7.2.5.3 David Creek

Four sediment samples (DC01SD through DC04SD) were collected from David Creek during the Phase II field event (Figure 6-3). Sample DC01SD was collected from David Creek near Outfall 3. Sample DC02SD was collected from David Creek near Outfall 2, and sample DC03SD was collected from David Creek near Outfall 1. Finally, sample DC04SD was collected from David Creek inside the CITA fence line.

David Creek sediment sample results are presented in Table 7-12. The samples were analyzed for TAL metals, TOC, perchlorate, and grain size. The sample results did not indicate the presence of any analytes at elevated concentrations.

7.2.5.4 Buck Creek

One sediment sample (BC01SD) was collected from Buck Creek approximately 100 feet from the confluence with Lacamas Creek during the Phase II field event (Figure 7-11). The sample was collected upstream of an access road to the 1,000-Inch Range.

Buck Creek sediment sample results are presented in Table 7-13. The Buck Creek sediment sample was analyzed for TAL metals, perchlorate, TOC, and grain size. Sample results do not indicate the presence of any analytes at elevated concentrations.

7.2.5.5 Lacamas Creek

Four surface water samples (LC03SW, LC11SW, LC14SW, and LC15SW) and 15 sediment samples (LC01SD through LC15SD) were collected from Lacamas Creek during the Phase II field event (Figures 7-12 and 7-14). The samples were collected in order from downstream toward upstream locations to avoid cross-contamination. The surface water samples were co-located with their respective sediment samples (e.g., LC11SW was co-located with sample LC11SD).

Sample LC01SD was collected 0.8 mile from the western border of Camp Bonneville at the 217th Street bridge. Sample LC02SD was collected at the western border of Camp Bonneville. Samples LC03SW/LC03SD were collected from Lacamas Creek at the confluence of the drainage ditch associated with the overland pathway sample (OP01SS). This sample is the PPE for Demolition Area 3 and Artillery Positions 6 and 7. Sample LC04SD was collected 2,475 feet upstream of sample LC03SD on Lacamas Creek. Sample LC05SD was collected 1,542 feet upstream of sample LC04SD on Lacamas Creek. Sample LC06SD was

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collected 1,277 feet upstream of sample LC05SD and is the PPE for Firing Position 5. Sample LC07SD was collected 825 feet upstream of sample LC06SD. Sample LC08SD was collected 1,792 feet upstream of sample LC07SD and is the PPE for the M203 HE Hand Grenade Range Target. Sample LC09SD was collected 557 feet upstream of sample LC08SD. Sample LC10SD was collected 689 feet upstream of sample LC09SD and approximately 30 feet downstream of the confluence with Buck Creek. Samples LC11SW/SD were collected 698 feet upstream of sample LC10SD in Lacamas Creek and is the PPE for the 1,000-Inch Range. Sample LC12SD was collected 2,223 feet upstream of sample LC11SD on Lacamas Creek. Sample LC13SD was collected 1,165 feet upstream of sample LC12SD and approximately 50 feet downstream of the confluence of David Creek. A blue sheen was observed on the west bank of the creek adjacent to the sample location. Samples LC14SW/SD were collected 1,165 feet upstream of sample LC13SD and approximately 30 feet upstream of the confluence with David Creek. Samples LC15SW/SD were collected 2,757 feet upstream of sample LC15SD and were collected approximately 20 feet downstream of the confluence with East Fork Lacamas Creek and 10 feet downstream of the confluence with North Fork Lacamas Creek.

Surface water samples results are presented in Table 7-9. The samples were analyzed for nitroaromatics/nitramines, total TAL metals, dissolved TAL metals, and perchlorate. Surface water sample results indicate the presence of total manganese at elevated concentrations in two of the four samples, dissolved manganese at elevated concentrations in three of the four samples, and perchlorate at elevated concentrations in all four of the surface water samples collected from Lacamas Creek. Concentrations of perchlorate detected in surface water samples collected from Lacamas Creek range from 0.079 $\mu\text{g/L}$ to 0.13 $\mu\text{g/L}$. Elevated concentrations of perchlorate are presented on Figures 7-13 and 7-15. Manganese; however, was not likewise detected at significant concentrations in any of the source samples collected. No nitroaromatics/nitramines were detected at elevated concentrations.

Sediment sample results are presented in Table 7-14. The sediment samples were analyzed for nitroaromatics/nitramines, TAL metals, perchlorate, TOC, and grain size. Samples LC15SD, LC14SD, and LC13SD were compared to the background samples collected from East Fork Lacamas Creek (BG03SD) and North Fork Lacamas Creek (BG04SD). Samples LC12SD and LC11SD were also compared to the background sample collected from Buck Creek (BG02SD). The remainders of the samples (LC01SD through LC10SD) were compared to these three background samples as well as the background sample collected from Buck Creek (BG02SD). For comparison purposes, the highest detected background concentration of an analyte was used to determine if Lacamas Creek sample results were elevated. The results did not indicate the presence of any elevated concentrations in Lacamas Creek sediment samples relative to their respective background concentrations.

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7.3 Soil Exposure Pathway

The soil exposure pathway is evaluated based on the threat to resident and nearby populations from soil contamination within the first 2 feet of the surface.

7.3.1 Site Setting and Exposed Sources

The site is surrounded by a maintained fence and security. The current use of the site does not include any recreational use.

7.3.2 Targets/Receptors

A total of 2,780 people reside within a 1-mile travel distance of the site (Hanson 2011). The nearest residence is located on site. This residence is populated by two people. A total of between 2 and 30 people work at the site. Table 7-15 provides a summary of the population within the 4-mile TDL.

The site is not used for commercial agriculture, commercial silviculture, commercial livestock production, or commercial livestock grazing.

The State-listed endangered Hairy-stemmed checker-mallow (*Sidalcea hirtipes*) is present on site (Hanson 2011).

7.3.2.1 Sample Locations and Results

Surface soil samples were collected at the site. Please refer to Section 6 of this document for information regarding the locations and analytical results of these samples.

7.4 Air Migration Pathway

The air migration pathway TDL is a 4-mile radius that extends from the sources at the site (Figure 7-1).

7.4.1 Human Targets

A total of 35,845 people reside within the 4-mile TDL. The population by distance ring is presented in Table 7-15. Additionally, five schools with a total population of students and teachers of 3,319 people are present from 3 to 4 miles of the site.

Commercial agriculture, commercial silviculture, or a major or designated recreation area is not present within the 4-mile TDL.

7.4.2 Environmental Targets

Federal- and State-listed threatened and endangered species and wetlands are present within the 4-mile TDL. The Federal-listed threatened Lower Columbia River ESU Steelhead, the Lower Columbia River ESU Chinook salmon, the Lower Columbia River ESU Chum salmon, and the Federal-listed endangered Bradshaw's Lomatium are present within the TDL. Additionally, the State-listed threatened Dense Sedge, Hall's aster, the Oregon coyote thistle, the Western Wahoo, the Western Gray Squirrel (*Sciurus griseus*), and the State-listed



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endangered Hairy-stemmed checker-mallow (*Salsalcea hirtipes*) are present within the TDL (Hanson 2011). Table 7-7 provides a summary of the environmental targets within the TDL.

A total of 1,489.77 acres of wetlands are present within the TDL (Hanson 2011). Wetland acreage by distance ring is presented in Table 7-15.

8

Summary and Conclusions

Camp Bonneville is a former military training facility which was in operation from 1910 through 1995 when it was selected for closure by the BRAC committee. It was used from 1910 to 1995 for firing range practice. During that time, military munitions were stored and/or used at the site including artillery ammunition, mortar ammunition, air-launched rockets, shoulder-fired rockets, guided missiles, bombs, land mines, practice grenades, fuses, and small arms ammunition (Ecology 2011). Other historical operations at the site have included the storage of pesticides, maintenance of vehicles, storage of diesel fuel for building heating, sewage lagoons, at least four landfills (one landfill, Landfill 1, has been reported and identified on maps; however, it has not been visually located), various caliber firing ranges, and troop maneuvers.

Since its closure in 1995, numerous investigations have been conducted which have documented the presence of contamination above regulatory cleanup criteria. Additionally, a number of removals have occurred throughout various areas of the site. The planned future use of the site is as a regional park.

EPA's expanded site inspection included the collection of surface soil, subsurface soil, ground water, surface water and sediment samples from various locations throughout the site to determine the presence or absence of contamination associated with potential contaminant source areas such as Demolition Area 1/Landfill 4, firing ranges, firing points, the Pop-Up Pond, Demolition Areas 2 and 3, and receptors such as Lacamas Creek and its tributaries.

8.1 Sources

The sources selected for sampling as part of this investigation were chosen because they have been identified by previous studies and investigations as still requiring remediation. These sources include:

- Demolition Area 1/Landfill 4;
- CITA;
- Various Firing Ranges and Firing Points;
- A firing bank; and
- The Pop-Up Pond and targets.

A total of 101 source samples were collected during the investigation. All source areas that were sampled were determined to contain hazardous substances at significant concentrations as defined in Section 5. A summary of hazardous substances by source area is further outlined below.

8.1.1 Demolition Area 1/Landfill 4

Analytical results of subsurface soil samples collected from this source indicate the presence of RDX, perchlorate, lead, one SVOC and one VOC at elevated concentrations in at least one sample collected. Sample results are presented in Table 6-1. Sample locations are depicted in Figure 6-1.

8.1.2 Central Impact Target Area

Analytical results of surface soil samples collected from this source indicate the presence of one nitroaromatics/nitramine (3,5-Dinitrobenzenamine), nickel, and perchlorate at significant concentrations in at least one sample collected. Sample results are presented in Table 6-2. Sample locations are depicted in Figure 6-2.

8.1.3 Demolition Areas 2 and 3

8.1.3.1 Demolition Area 2

Analytical results of surface soil samples collected from this source indicate the presence of one nitroaromatics/nitramine (4-amino,2,6-Dinitrotoluene) and four TAL metals at significant concentrations in at least one sample. Sample results are presented in Table 6-3. Sample locations are depicted in Figure 6-2.

8.1.3.2 Demolition Area 3

Analytical results of surface soil samples collected from this source indicate the presence of three nitroaromatics/nitramine (2,4,6-Trinitrotoluene, 2-amino,4,6-Dinitrotoluene, and 3,5-Dinitrobenzenamine), two TAL metals (nickel and strontium), and perchlorate at significant concentrations in at least one sample collected. Sample results are presented in Table 6-3. Sample locations are depicted in Figure 6-3.

8.1.4 Firing Ranges

8.1.4.1 1,000-Inch Range

Analytical results of surface soil samples collected from this source indicate the presence of two TAL metals and perchlorate at significant concentrations in at least one sample collected. Lead was detected at significant concentrations in all eight samples and nickel was detected at significant concentrations in all but one of the samples. Sample results are presented in Table 6-4. Sample locations are depicted in Figures 6-4 and 6-5.

8.1.4.2 M203 HE Grenade Range

Analytical results of surface soil samples collected from this source indicate the presence of one nitroaromatics/nitramine (3,5-Dinitrobenzenamine), one TAL metal (nickel), and perchlorate at significant concentrations in at least one of the

samples collected. Sample results are presented in Table 6-4. Sample locations are depicted in Figure 6-5.

8.1.5 Artillery Positions

8.1.5.1 Artillery Position 5

Analytical results of surface soil samples collected from this source indicate the presence of two nitroaromatics/nitramines (2,4-Dinitrotoluene and 3,5-Dinitrobenzenamine), two TAL metals (beryllium and nickel), and perchlorate at elevated concentrations in at least one sample collected. Sample results are presented in Table 6-5. Sample locations are depicted in Figure 6-5.

8.1.5.2 Artillery Position 6

Analytical results of surface soil samples collected from this source indicate the presence of two TAL metals at elevated concentrations (lead and nickel). Sample results are presented in Table 6-5. Sample locations are depicted in Figure 6-3.

8.1.5.3 Artillery Position 7

Analytical results of surface soil samples collected from this source indicate the presence of two TAL metals (beryllium and nickel) at significant concentrations. Of these, nickel was detected at significant concentrations in all five surface soil samples. Sample results are presented in Table 6-5. Sample locations are depicted in Figure 6-3.

8.1.6 Firing Bank

Analytical results of surface soil samples collected from this source indicate the presence of four TAL metals (antimony, copper, lead, and nickel) at significant concentrations. Sample results are presented in Table 6-6. Sample locations are depicted in Figure 6-4.

8.1.7 Pop-up Pond

Samples associated with this source were collected from the perimeter of the pond, from the island in the pond, and from three outfalls associated with the pond. Analytical results of sediment samples collected from this source indicate the presence of three TAL metals (beryllium, lead, and strontium) detected at significant concentrations. Of these, strontium was detected at significant concentrations in four of the six samples collected from the perimeter of the pond, all three samples collected from the island, and all three samples collected at the outfalls. Sample results are presented in Table 6-7. Sample locations are depicted in Figure 6-6.

8.1.8 Pop-up Targets

Analytical results of surface soil samples collected from the Pop-up Targets east area indicate the presence of three TAL metals (copper, lead, and nickel) were detected at significant concentrations in at least two of the surface soil samples collected. Of these, both lead and nickel were detected at significant concentra-

tions in all nine surface soil samples. Sample results are presented in Table 6-8. Sample locations are depicted in Figure 6-6.

Analytical results of surface soil samples collected from the 1,000-Yard Range area indicate the presence of two TAL metals (lead and nickel) at significant concentrations. Of these, nickel was detected at significant concentrations in all nine surface soil samples. Sample results are presented in Table 6-8. Sample locations are depicted in Figure 6-6.

8.2 Targets/Receptors

This investigation was designed to determine if contamination associated with site sources is impacting targets/receptors including ground water associated with Demolition Area 1/Landfill 4, surface water, sediments, and wetlands associated with Lacamas Creek and its tributaries. Wetlands are present along the entire frontage of Lacamas Creek throughout the site.

A total of 64 target/receptor samples were collected during this investigation, including 20 ground water samples, 10 surface water samples, 33 sediment samples, and one surface soil sample. The sample results show that contamination from on-site sources is migrating and has reached these targets/receptors.

Perchlorate contamination associated with on-site sources is migrating and has reached North Fork Lacamas Creek and Lacamas Creek within the site boundaries.

Perchlorate was detected at elevated concentrations in all four of the surface water samples collected from Lacamas Creek and from two of the six surface water samples collected from North Fork Lacamas Creek (NF02SW and NF03SW). Targets/receptors associated with these sample locations include wetlands.

Additionally, both total and dissolved manganese were detected at elevated concentrations in the surface water samples associated with Demolition Area 1/Landfill 4; however, these contaminants were not likewise detected at significant concentrations in the subsurface soil samples collected during the Phase I field sampling event.

Sediments in David Creek, Buck Creek, and East Fork Lacamas Creek do not appear to be impacted by site sources based on analytical results.

8.3 Conclusions

Based on sample results, contamination is present at on-site sources at significant concentrations. Contamination is migrating and has reached surface water in North Fork Lacamas Creek and Lacamas Creek. Analytical results of samples collected at the site also show that contamination continues to impact ground water.

9

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