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LIST OF ACRONYMS AND ABBREVIATIONS

AEM	Atlantic Environmental Management, Inc.
bgs	below ground surface
BCT	BRAC Cleanup Team
BCRRT	Bonneville Conservation, Restoration and Remediation Team, LLC
BRAC	Base Realignment and Closure
ca	carcinogen
CFR	Code of Federal Regulations
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
COPC	chemicals of potential concern
DA1	Demolition Area 1
DA2	Demolition Area 2
DA3	Demolition Area 3
DQO	data quality objective
EO	exploded ordnance
EPA	U.S. Environmental Protection Agency
FBI	Federal Bureau of Investigation
FSP	Field Sampling Plan
GIS	geographic information system
HASP	health and safety plan
HMX	octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine
µg/L	micrograms per liter
MDL	method detection limit
MRL	method reporting limit
MTCA	Model Toxics Control Act
NC	nitrocellulose
NC	noncarcinogen
NG	nitroglycerine
NGVD	National Geodetic Vertical Datum
NQ	nitroguanadine
OB	open burning
OD	open detonation
PA	picric acid
PCBs	polychlorinated biphenyls
PE	performance evaluation
PETN	pentaerythitol tetranitrate
PPC	Project Performance Corporation
PRG	Preliminary Remediation Goal
Pt	Troutdale formation
PVC	polyvinyl chloride
Qa	quaternary flood plain
QAPP	Quality Assurance Project Plan
QA/QC	quality assurance/quality control
Qls	quaternary landslide deposit

RI	Remedial Investigation
RDX	hexahydro-1,3,5-trinitro-1,3,5-triazine
SAP	sampling and analysis plan
SOW	Statement of Work
SVOC	semi-volatile organic compound
TBD	To Be Determined
TCRA	Time Critical Removal Action
TNT	2,4,6-trinitrotoluene
TPH	total petroleum hydrocarbons
Tv	volcanic bedrock
UCL	95th percentile upper confidence limit
USACE	U.S. Army Corps of Engineers
USCHPPM	U.S. Army Center for Health Promotion and Preventive Medicine
USCS	Unified Soil Classification System
UST	underground storage tank
URS	URS Greiner Woodward Clyde
UXO	unexploded ordnance
VOC	volatile organic compound
WAC	Washington Administrative Code
WDOE	Washington State Department of Ecology

1.0 INTRODUCTION

This document presents the results of a Remedial Investigation (RI) of Remedial Action Unit (RAU) 2B Demolition Areas 2 and 3 at the Camp Bonneville Military Reservation (Camp Bonneville). The RI was conducted to determine if a release of contaminants has occurred at RAU 2BDemolition Areas 2 and 3, and if so, to characterize soil and groundwater conditions at the two demolition areas in order to determine if further actions are required. The RI was conducted by the U. S. Department of the Army (Army) consistent with it's mandate to comply with the National Contingency Plan (NCP) under the Comprehensive Environmental Restoration, Compensation, and Liability Act (CERCLA) and in accordance with the requirements of the Model Toxics Control Act (MTCA), which is contained in Chapter 173-340 of the Washington Administrative Code (WAC 173-340).

The original formation of this document was completed under the Army's Fort Lewis, Washington GSA Contract Number GS-10F-0028J for the Washington Department of Ecology (WDOE) in March 2005. The original preparers were Calibre Systems, Inc. The document has been modified by the Bonneville Conservation, Restoration, and Renewal Team, LLC (BCRRT) in order to reflect the changes in consultant and ownership of the Camp Bonneville property. This final version of the report has been prepared to incorporate responses to comments received from United States Environmental Protection Agency (USEPA) and dated December 6, 2006. These responses have been previously reviewed by the Washington State Department of Ecology (WDOE).

The following RI report provides the RAU 2B background, setting, and investigation results for soil samples and 15 quarterly groundwater monitoring events that indicate that no release of chemicals of potential concern has occurred at either DA2 and DA3 that would require collecting additional data.

1.1 Site Background

Camp Bonneville is located in southwestern Washington and comprises approximately 3,840 acres (see **Figure 1**). Camp Bonneville is located approximately five miles east of the Vancouver City Limits in Clark County.

Camp Bonneville is more particularly described in U.S. Public Land Survey terminology as follows:

- The site is located in Range 3 East relative to the Willamette Primary Meridian. It includes the following parcels in Township 2 North:
  - Section 1 – all (640± acres) – owned
  - Section 2 – all (640± acres) – owned
  - Section 3 – all [except for two parcels along the western boundary of Section 3] (618± acres) – owned
  - Section 10 – North ½ (320± acres) – owned
  - Section 11 – Northwest ¼ [except for the southeast triangular ½ of southeast ¼ of this ¼ and the northwest ¼ of northeast ¼] (175± acres) – leased from Washington State Department of Natural Resources

- The following parcels are located in Township 3 North:
  - Section 34 – Southeast ¼ (160± acres) – owned
  - Section 35 – all (640± acres) – owned
  - Section 36 – all (640± acres) – leased from Washington State Department of Natural Resources

Between 1910 and 1995, the Army used Camp Bonneville for live fire of small arms, assault weapons, artillery, and field and air defense artillery. In the early 1950s, the Defense Department arranged to lease an additional 840 acres from the State of Washington to expand training possibilities off of the post. The facility has been used for weekend and summer training by the U.S. Army Reserve units in Southern Washington and Northern Oregon and is currently a sub-installation of Fort Lewis. In addition, the facility has been used by other Reserve and National Guard components, as well as the Federal Bureau of Investigation (FBI) and other local law enforcement units.

In July of 1995, Camp Bonneville was selected for closure under the 1995 Base Realignment and Closure (BRAC) process. Since the Camp was officially closed, investigations have been conducted by the Army and its consultants in order to characterize the nature and extent of contamination at the site and to develop a plan for potentially transferring ownership. Clark County (County) expressed interest in the site and began the process for obtaining the property by developing a Reuse Plan. The Reuse Plan developed called for the majority of Camp Bonneville to be transferred to the County for the public benefit – education, law enforcement, and parks, with no financial gain to the County. Over the intervening years, several unsuccessful attempts were made to transfer Camp Bonneville from the Army to Clark County.

In October 2006, the Army transferred ownership of the property to the County which immediately transferred the land to the BCRRT. BCRRT will hold the deed of the property during investigation and clean-up activities at the site. After the property is cleaned to WDOE standards, BCCRT will transfer the property back to the County. The County will then begin implementing the Reuse Plan.

For administrative reasons, the Camp Bonneville site was divided into three Remedial Action Units (RAUs), which include the following:

- Remedial Action Unit 1: This RAU consists of 20 areas around buildings and other structures where hazardous substances (other than munitions and explosives contaminants) have been found.

- Remedial Action Unit 2: This RAU is divided into three subunits, as follows:
  - Remedial Action Unit 2A consists of the small arms range areas.
  - Remedial Action Unit 2B consists of the two demolition areas known as Demolition Areas 2 and 3 (DA2 and DA3)—the subject of this RI report.
  - Remedial Action Unit 2C is the site of a former combined landfill and demolition area known as Landfill 4 / Demolition Area 1.

- Remedial Action Unit 3: The RAU includes the entire site where Munitions and Explosives of Concern (MEC), including unexploded ordnance, may remain.

1.2 Objectives of the RI

During 2002 and 2003, the Army implemented RI activities at DA2 and DA3. The objectives of these investigations were to:

- Determine if a release of chemicals of potential concern (COPC) has occurred to soil and/or groundwater at DA2 or DA3.
- Collect data necessary to determine if a response action is required, and if so, adequately characterize the DA2 and DA3 for the purpose of developing and evaluating cleanup action alternatives [WAC 173-340-350(7)(a)].
- Obtain a better understanding of the local geology and hydrogeology.

These objectives and planned data uses from the RI were identified by the BRAC Cleanup Team (BCT) in a meeting in early May 2002. The specific actions conducted to obtain the data required to meet the RI objectives and the results of the investigations are presented in **Section 3.0**, Field Investigations.

The purpose of this RI is to present the results of the investigations and quarterly monitoring conducted at DA2 and DA3 with the ultimate goal of obtaining WDOE approved closure of remedial action units DA2 and DA3. This report presents the information necessary to obtain the closure approval and is considered to be the final document for RAUs DA2 and DA3.

1.3 General Site Information

This section contains the following general facility information:

Project title: Site Investigation Report for RAU 2B Demolition Areas 2 and 3

Project coordinators: Name: Michael Gage
Address: Bonneville Conservation Restoration and Renewal Team, LLC
23201 Northeast Pluss Road
Vancouver, WA 98682
Phone number: (360)566-6990

Facility location: DA2 and DA3 are within the boundaries of Camp Bonneville which is located in southwestern Washington; approximately 5 miles east of the Vancouver City limits in Clark County (see **Figure 1**). DA2 and DA3 are located within Camp Bonneville as shown on **Figure 1**.

Dimensions of facility: Camp Bonneville consists of approximately 3,840 acres. DA2 consists of an approximately 60-foot diameter suspect area within a wooded area of approximately 10 acres. DA3 appears to be a detonation crater approximately 20 feet in diameter and 10 feet deep.

Present owner and operator: Camp Bonneville and DA2 and DA3 are owned and operated by the by BCRRT.

Chronological listing of past owners and operators and operational history: Since the early 1900's, the Department of the Army has owned and operated the Camp Bonneville site. Until the facility was closed in 1995, it was used for weekend and summer training by the U.S. Army Reserve units in Southern Washington and Northern Oregon. In October 2006, the Army transferred ownership of the property to the County, which subsequently transferred the land to the BCRRT. BCRRT will hold the deed of the property during investigation and clean-up activities at the site. After the property is cleaned to WDOE standards the BCCRT will transfer the property back to the County

1.4 Report Organization

Section 1.0 of this RI report presents introductory information, including background on the activities leading up to the RI, the objectives of the RI, the purpose of the RI, and general site information. **Section 2.0** presents information on site conditions. This information includes information that was developed during this RI as well as information developed during previous investigations at Camp Bonneville. Field activities that were conducted during this RI are described in **Section 3.0**. **Section 4.0** presents the conclusions and recommendations. References are listed in **Section 5.0**.

2.0 STUDY AREA CONDITIONS

This section presents descriptions of site conditions relevant to the RI. **Section 2.1** discusses general site conditions. **Sections 2.2** through **2.7** address specific site characteristics such as geology and hydrogeology. Many of these conditions have been characterized by previous investigations at Camp Bonneville. As appropriate, the results of investigations at the sites are summarized in the following section. When required information was not available from previous investigations, additional data were obtained from RI activities, including the field investigations described in **Section 3.0**.

2.1 General Site Conditions

This section presents a summary of site conditions at Camp Bonneville and at DA2 and DA3. Site maps for DA2 and DA3 are provided in **Figures 2 and 3.**

Camp Bonneville comprises approximately 3,840 acres and is located in southwestern Washington approximately five miles east of the Vancouver City limits in Clark County. Camp Bonneville was officially closed in 1995 and was managed as a sub-installation of Fort Lewis from 1995 until the site was transferred to Clark County and then to BCRRT in October 2006. Between 1909 and 1995, the Army used Camp Bonneville for live fire exercises with small arms, assault weapons, field artillery and air defense artillery. A portion of the property (840 acres) is leased from the State of Washington. The facility has been used for weekend and summer training by the U.S. Army Reserve units in Southern Washington and Northern Oregon. In addition, other Reserve and National Guard components, as well as the FBI and other local law enforcement units have used the facility. Camp Bonneville was included on the 1995 BRAC list.

Camp Bonneville is mostly undeveloped forested hillsides and creek side drainages. Former military barracks and training facilities are concentrated at the Camp Killpack and Camp Bonneville cantonment areas, which cover approximately 30 acres. Other developed areas include firing ranges, a paved two-lane road connecting the main gate with the two containment areas, and a network of unpaved roads. The main gate to Camp Bonneville is located on the western boundary of the camp, approximately one mile north of Pluss Road.

Demolition Area 2

The exact location and historical activities at DA2 are unknown, and site walks/field inspections have not resulted in the identification of specific suspect areas. Site workers reported that DA2 was historically used for destruction of unwanted ordinance. The general suspect area was identified through interpretation of historic aerial photographs and is located on the southwest-facing side slope at the head of Lacamas Creek Valley (see **Figure 2**). The DA2 area is approximately 60 feet in diameter, forested with dense under-story vegetation on steep slopes.

The investigative approach was to monitor groundwater in the downgradient area to determine if groundwater contamination was present and to sample surface and subsurface soil in the suspect area. Three wells were installed in the shallow water-bearing zone in a line perpendicular to the likely ground water flow path downgradient from the suspected location of DA2 as shown in **Figure 2**. The locations for these wells were based on the topographic/drainage features in the area and on the expectation that the groundwater flow direction would generally follow the surface topography in this immediate area. The well locations were selected in order to intercept groundwater from the larger area around the suspected location of DA2 due to the lack of reliable information regarding the exact location of DA2. Soil samples were collected from selected locations within the suspected area of DA2 (see **Figure 6**). Detailed descriptions of the installation of monitoring wells and of the sampling of groundwater and soil are presented in **Section 3.0**.

Demolition Area 3

Demolition Area 3 is a location where a surficial depression exists that may be a detonation crater. The location is about 2,000 feet upstream of the Base boundary in Lacamas Creek Valley (see **Figure 3**). The crater is approximately 20 feet in diameter and 10 feet deep. DA3 is located west of the gas pipeline right-of-way that crosses Camp Bonneville. DA3 may have been used for detonation of unwanted ordinance. The crater is situated several hundred feet south of Lacamas Creek in an area where the valley is wide and relatively flat. The ground surface at DA3 is hummocky with seasonal wetland vegetation.

The crater reportedly fills with water as the water table rises throughout the winter, and becomes dry in the summer as the water table drops during low-precipitation years. During the pre-investigation site walk, the depression was found to be dry for the first time in recent years and was observed to contain a corroded barrel in which small caliber rounds had apparently been burned. During the RI soil sampling conducted in February 2003, the crater was filled with water. Supplemental RI soil sampling was conducted during November 2003, following the removal of the corroded barrel and small caliber rounds from the center of the depression at DA3.

The investigative approach at DA3 was to monitor groundwater surrounding the crater and sample soils in and around the crater. Five monitoring wells were installed at DA3 (see **Figure 3**). Eight monitoring wells were installed at the base boundary in the anticipated direction of downgradient direction of groundwater flow from Camp Bonneville (See **Figures 1 and 3**). These eight downgradient boundary wells were installed to determine if groundwater migrating from DA3 and/or other areas of Camp Bonneville has been impacted by site activities. Detailed descriptions of the installation of these 13 monitoring wells and of the sampling of groundwater and soil are presented in **Section 3.0**.

2.2 Geology and Hydrogeology

A detailed summary of existing information on the geology and hydrogeology of the Camp Bonneville area has been prepared in previous investigation reports. The following sections provide relevant excerpts of the information previously prepared (URS 2001) and information collected during the RI at DA2 and DA3 at Camp Bonneville.

2.2.1 Regional Geology and Physiography

Camp Bonneville is situated on the margin of the western foothills of the southern Cascade Range and the Portland Basin physiographic provinces of Washington. The

Portland basin is characterized by low topographic relief with exposures of the Columbia River basalt at the edges of the basin. The basin was filled with sediments by the ancestral Columbia River followed by a period of volcanism 2.6 to 1.3 million years ago (Ma). About 12,700 to 15,300 years ago deposits of poorly sorted sand, clay, and gravel accumulated in the basin as a result of the Missoula floods as the Columbia River gorge burst and flooded the area. The Cascade Mountains divide Washington into two distinct parts, which consists of the wet west side with moderate temperatures and the semi-arid east with greater temperature extremes. The peaks and ridges of the range are at about 6,000 to 8,000 feet elevation with some volcanic peaks over 10,000 feet. The south Cascade Range that borders the site to the east consists of Tertiary age volcanic and sedimentary rocks. Figure 4 presents the geologic mapping for camp Bonneville.

The area surrounding Camp Bonneville is sparsely populated with scattered residences and is used primarily for agriculture and livestock grazing. The nearest town is Proebstel, an unincorporated community about 2.5 miles to the southwest of the western entrance to the camp. The two cantonments, Camp Killpack and Camp Bonneville, are located on the valley floor (see **Figure 1**). The remainder of Camp Bonneville consists of moderately steep, heavily vegetated slopes that have been used primarily as firing ranges. The valley floor is a relatively narrow floodplain, which ranges from an elevation of about 290 feet National Geodetic Vertical Datum (NGVD) on the western end of Camp Bonneville to about 360 feet NGVD on the east. The adjoining slopes rise moderately steeply to elevations between approximately 1,000 and 1,500 feet NGVD along ridge tops within the property boundaries. Except for portions of the valley floor, the entire installation is heavily vegetated.

2.2.2 Regional Hydrogeology

Camp Bonneville is located in the Lacamas Creek Watershed. **Figure 5** shows the Lacamas Creek Watershed and major components. This watershed is about 67 square miles that includes forest, farm, residential, commercial and industrial land. Lacamas Creek flows about 12.5 miles from relatively undisturbed headwaters into Lacamas and Round Lakes dropping through a series of waterfalls into the Washougal River. Non-point pollution sources including agriculture, septic systems, construction, and residential and urban activities have resulted in declines in stream health and in Lacamas Lake. Fecal coliform, nutrients including phosphorus, nitrate, and ammonia levels are high in many areas of the watershed. Warm water temperatures and low dissolved oxygen during the summer have negatively impacted the health of Lacamas Lake. These conditions are largely due to eroded sediments and nutrients conveyed to the lake by Lacamas Creek.

Camp Bonneville is situated in Upper Lacamas Creek which forms the easternmost part of the watershed. As shown in **Figure 5**, Upper Lacamas Creek is described as being in good health due in large part to the predominance of forested land and limited development. Data available from the Ecology March, 1996 report, for the Upper Lacamas creek watershed, show ammonia levels ranging up to 0.06 mg/L, nitrate up to about 1.5 mg/L, soluble reactive phosphorus up to 0.01 mg/L, total phosphorus up to about 0.12mg/L, dissolved oxygen ranging from 7.8 to12 mg/L and temperature ranging from 6 to 21°C. The United States Geological Survey (USGS) National Water Information System, WDOE and Clark County Water Resources data bases were searched for updated data for this portion of Lacamas Creek however, none were found.

Eight hydrogeologic units comprise the Portland Basin aquifer system (USEPA July, 2006) including:

1) the unconsolidated sedimentary aquifer,
2) the Troutdale gravel aquifer,
3) confining unit 1,
4) the Troutdale sandstone aquifer,
5) confining unit 2,
6) the sand and gravel aquifer, and
7) older rocks.
8) is fine-grained sediment that occurs in the basin where the Troutdale sandstone and the sand and gravel aquifer are absent

The unconsolidated sedimentary aquifer and the Troutdale gravel aquifer are the primary source of drinking water in the area. The unconsolidated sedimentary unit (1) ranges from 50 to 100 feet thick and up to 300 feet in some areas. Yields from wells in this unit range from 1,000 to 6,000 gallon per minute (gpm). The Troutdale gravel unit (2) has a maximum thickness of about 800 feet and wells yield up to 3,000 gpm. The Troutdale sandstone unit (4) ranges from 100 to 200 feet thick with well yields up to 2500 gpm. The consolidated gravel aquifer unit (6) ranges from 100 to 400 feet thick with yields up to 1,000gpm. The older rocks unit is made up of low permeability Miocene and older volcanic and marine sedimentary rock that underlie and bound the basin-filling sediments. Groundwater in the Troutdale gravel aquifer moves southward toward the Columbia River (USEPA July 2006) with generally the highest water levels in the eastern part of Clark County along the western flank of the Cascades. The Troutdale Aquifer shown in Figure 1, is a designated “sole source aquifer” by the USEPA. The USEPA defines this 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”.

Camp Bonneville overlies both the Troutdale Aquifer System Sole Source Aquifer Area and its Streamflow Source Area as shown in Figure 1. The USEPA defines the Streamflow Source Area as “the upstream headwaters area of streams that flow into the recharge area of the aquifer.” According to the USEPA, groundwater pumping has lowered the groundwater levels in the Lacamas Creek Watershed causing water in the rivers to recharge the aquifer system

2.2.3 Surface Water and Sediments

The principal surface water feature in the vicinity of DA2 and DA3 is Lacamas Creek, which flows southward from the confluence of two branch streams in the north-central part of Camp Bonneville, exiting the installation at its southwest corner. From the southwestern property boundary, Lacamas Creek flows southwestward to Proebstel, where it turns toward the southeast and continues to its confluence with the Columbia River at the town of Camas. Numerous minor tributaries drain adjacent uplands and flow into Lacamas Creek. Buck Creek and David Creek (see **Figure 1**), the largest of these tributary streams, drain the southeastern hills of Camp Bonneville.

There are no locations on the Property where site activities are known to have affected the quality of surface water. The water quality of Lacamas Creek is monitored at Demolition Area 1/Landfill 4, where contaminants have been detected in groundwater, by collecting groundwater samples from monitoring wells located down gradient of Demolition Area 1/Landfill 4, and before reaching Lacamas Creek. Also, according to the March 2000 *Final Project Completion Report, Surface Water Investigation of Lacamas Creek, Camp Bonneville, Vancouver, Washington*, the results of water samples collected from Lacamas Creek indicate that Demolition Area 1/Landfill 4 has not impacted the water quality of Lacamas Creek.

Historically, two artificial impoundments of Lacamas Creek, with a total surface area of less than 4,600 square feet, were created to support a trout sports fishery. Since the base closure, the impoundments have been drained.

Sediments of concern at Camp Bonneville only include the sediments within the Pop-up Pond (see **Figure 1**) that are being investigated as part of RAU 3 and will be reported under separate cover.

2.2.4 Geology and Soils

The geology of Camp Bonneville and the vicinity is known primarily from geologic mapping by Mundorff (1964) and Phillips (1987), a limited number of well logs available from the general area, and a Multi-Sites Investigation conducted by Shannon & Wilson (1999a). **Figure 4** shows the geology of the Camp Bonneville area.

The geology at Camp Bonneville can be divided into three general areas (looks like four areas on the map, not three) that correspond approximately to topographic divisions (see **Figure 4**). The area west of Lacamas Creek is composed of a series of predominantly gravel and semi-consolidated conglomerate layers with scattered lenses and stringers of sand (Upper Troutdale Formation). Underlying the Troutdale Formation and comprising the area to the north and east of Lacamas Creek are predominantly basalt flows and flow breccia, with some pyroclastic and andesitic rocks that are folded and faulted (the Stream Flow Source Area [see **Figure 1**]). The bottomland along Lacamas Creek is composed of unconsolidated silt, sand, and gravel valley fill, with some clay (within the Troutdale Sole Source Aquifer Area [see **Figure 1**]). Because of the thick soil and dense vegetation, faults have not been identified within Camp Bonneville (Environmental Science and Engineering, Inc. [ESE] 1983).

The Camp Bonneville soils are mainly low-permeability clays, which results in considerable runoff after storms and occasional minor flooding of Lacamas Creek. Upland soils have mainly developed from basalt and are generally gravelly or stony and fairly shallow. Bottomland soils along Lacamas Creek tend to be clayey (Geo Recon International 1981).

Shannon & Wilson (1999a) described the four distinctive stratigraphic units that underlie Camp Bonneville:

- Quaternary floodplain and stream channel alluvium and lacustrine deposits, which mantle the Lacamas Creek valley floor (Qa)
- Quaternary landslide deposits (Qls) of surface soils and bedrock displaced from the steep slope along David Creek
- Thick sequences of Quaternary to Pliocene-age gravel, fine-grained sand, and cobbley and bouldery sand known as the Troutdale Formation (Pt), which underlie areas to the west of the Bonneville cantonment.
- Oligocene volcanic bedrock (Tv), which is exposed at the surface in the eastern part of Camp Bonneville.

Quaternary alluvium deposits comprise the shallow surface soils of the Lacamas Creek valley floor, which is composed of stream channel, floodplain, and alluvial fan sediments. These deposits are expected to consist of a thin layer of clay and silt, underlain by layers of sand/silt and clay. During drilling and excavation activities associated with the removal of an underground storage tank (UST) in the Camp Killpack Cantonment (Hart Crowser 1996), at least 25 feet of silty clay was encountered and interpreted to be older alluvium. Borings from the Multi-Sites Investigation (Shannon & Wilson 1999a) also encountered alluvial clays and silts overlying a relatively thick, silty clay deposit in the Camp Bonneville Cantonment. These clayey soils probably originated as water borne sediments that were deposited on the valley floor in Quaternary period as a result of catastrophic flooding along the Columbia River (Shannon & Wilson 1999a).

The Troutdale Formation, which underlies the western-most portion of the camp, ranges from a poorly consolidated sand and gravel to a well-indurated conglomerate in its upper part (Shannon & Wilson 1999a). Based on regional boring logs, the Upper Troutdale Formation locally is about 150 feet thick and consists of cemented sand, gravel, sandy clay, and boulders. It is underlain by up to 150 feet of the Lower Troutdale Formation, which contains considerably more clay interspersed with sandy and gravelly layers. There is considerable variation in the lithology and thickness of the Troutdale Formation. In general, the formation thins in the eastern part of Camp Bonneville where the underlying bedrock is exposed at the surface (see **Figure 4**). The lower part of the formation reportedly is typically coarser grained where it thins out (Mundorff 1964).

The bedrock is exposed at the surface in the eastern part of Camp Bonneville and consists of Oligocene-age andesite and basaltic andesite flows, minor flow breccias, tuffs, and volcaniclastic sandstones (Stream Flow Source Area [see **Figure 1**]). According to the logs of borings from the Multi-Sites Investigation (Shannon & Wilson

1999a), the uppermost bedrock is severely weathered. This weathered bedrock tends to form surface soils, which contain basaltic gravel. During drilling for the Multi-Sites Investigation, bedrock was encountered in 10 soil borings at depths ranging from approximately 6 to 37 feet below ground surface (bgs).

2.2.5 Site Groundwater

2.2.5.1 Site Hydrology

Most prior work throughout Clark County has focused on the Troutdale Formation (as described in Mundorff 1964). Camp Bonneville is located over the eastern edge of the Troutdale Formation where it is pinched out by the underlying bedrock as described above. There are three drinking water wells at Camp Bonneville: a 385 feet bgs well at the Camp Bonneville Cantonment and a 193 feet bgs well at the Camp Killpack Cantonment (ESE 1983). The latter well is apparently different from the third well which is a 516 feet bgs well at the Camp Killpack Cantonment described by Mundorff (1964). In addition, a well was drilled at the FBI range during 1998, which extends to a depth of 105 feet bgs (Shannon & Wilson 1999b). See **Figure 1** for locations of these wells. Based on regional information from Mundorff (1964) and the reported depths of the wells at Camp Bonneville, water supply wells in the area generally extend into the Troutdale Formation or underlying bedrock. Most of the local wells obtain groundwater from depths of 150 to as much as 500 feet bgs.

The elevation of the water table in the alluvial valley areas of Camp Bonneville is relatively shallow (in the range of 5-20 feet bgs) based on the presence of shallow bedrock, multiple creeks, tributaries, and boggy areas and fluctuates seasonally by several feet. A rising water table occurs in the early fall through spring during the rainy season, and a declining water table occurs throughout the summer (see **Appendix B** Table 1).

Groundwater flow within the shallow alluvium and Upper Troutdale Formation follows the topographic contours within the Lacamas watershed with the general groundwater flow toward the southwest (along the Lacamas Creek Valley) leaving Camp Bonneville where Lacamas Creek exits the western boundary of the camp (see **Figures 1, 2 and 3**). A site-wide groundwater flow assessment for the entirety of Camp Bonneville was not part of the RI for the DA2 and DA3.

Based on monitoring wells installed at DA3, downgradient of DA2, and the base boundary wells the following observations were made:

- A mild downward vertical gradient occurs in wells located along the western boundary where the Upper Troutdale Formation is exposed at the surface and is unconfined.

- Where the shallow weathered bedrock unit transitions from the slopes to the valley floor and is confined by overlying alluvium (near DA3), an upward gradient (artesian) was observed during the wet season.

- Depths to water are approximately 10 feet bgs at the boundary area wells, 12 feet bgs at DA3, and approximately 5 feet bgs at DA2.

- Shallow groundwater in the localized areas adjacent to DA 2 and DA 3 generally follows the local topography in each area and flows towards nearby tributaries and creeks.

2.2.5.2 Site-Wide Groundwater Quality

Monitoring wells have been installed in strategic areas on the Camp Bonneville to assess the groundwater quality on an installation-wide and site-specific basis for potential impacts associated with past site activities. In addition to the monitoring wells downgradient of DA2, at DA3, and the boundary area, wells have been installed at Building 1864 (Pesticide Storage/Mixing Building) and at Demolition Area 1/Landfill 4.

Groundwater was sampled from two monitoring wells near Building 1864 to investigate the potential for pesticide contamination. Chemical analyses of the groundwater from these wells did not indicate any measurable concentrations of pesticides.

Groundwater downgradient of DA2, at DA3, and at the outlet of Lacamas Creek on the installation boundary was first monitored in 2003. Eleven quarterly rounds of sampling have been conducted on these monitoring wells, including chemical analyses for explosives, propellants, total and dissolved heavy metals, volatile organic compounds and water quality parameters. Additionally the boundary wells included semi-volatile organic compounds, and gasoline/diesel/oil range petroleum hydrocarbons. After eleven quarters of groundwater monitoring, there are no chemicals of concern with concentrations that would trigger further investigations or further monitoring. Detailed discussions of these results are provided in **Section 3.0**

The groundwater at Demolition Area 1/Landfill 4 (RAU 2C) has been affected by past site activities. Explosives and propellants (DNT, RDX, and perchlorate) were detected in the soil and groundwater at concentrations that exceed screening criteria. The 2005 interim removal action (excavation and offsite disposal of approximately 5,000 cubic yards of contaminated soil) included the source area where the explosives and propellant compounds were affecting the groundwater. Groundwater monitoring and evaluations continue at RAU 2C.

Two on-site wells are available for potable water use at Camp Bonneville. Recent drinking water samples from both wells are summarized on **Table 2-1** below:

TABLE 2-1 ON-SITE DRINKING WATER WELL SAMPLE RESULTS, CAMP BONNEVILLE

Sample Location		Camp Killpack water well	Camp Bonneville water well	Command Post outdoor faucet	Range Headquarters kitchen faucet
Analyses	*MCL or Action Level*	Date collected: 11/2/2006			
Explosive compounds	*NE*	ND	ND	nt	nt
Perchlorate	*NE*	ND	ND	nt	nt
Arsenic (mg/L)	*0.01*	0.0048	0.0032	0.0031	0.0052
Lead (mg/L)	*0.015 mg/L*	ND	ND	0.0017	ND
Sodium (mg/L)	*NE*	17	8.6	8.7	16
Magnesium (mg/L)	*NE*	0.22	1.8	1.8	0.21
Calcium (mg/L)	*NE*	10	23	23	10
Turbidity (NTU)	*5*	0.2	0.2	0.3	0.4
Hardness (mg/L)	*NE*	27	64	66	27
Conductivity (umhos/cm)	*NE*	190	180	180	140
Total Coliform Bacteria	*0 for public water systems*	ND	ND	ND	3 per 100 ml

Notes:
Inorganic and explosive compound analyses are shown only for those that exceed the laboratory detection limit. See Laboratory data sheets for full list of tested parameters
NE = Not established by EPA or State of Washington
ND = Not detected above laboratory detection limit
nt = Not tested
mg/L = milligrams per liter
* NTU for turbidity is the unit of measure for the MCL established for a public drinking water source and is a measure of how clear water looks.
MCL = Maximum contaminant level; regulated by State of Washington (WAC 246-290-72012)
Action Level is set by EPA for drinking water based on the 90th percentile level of tap water samples; i.e., the MCL cannot be exceeded in more than 10% of tested samples.

2.3 Air

Camp Bonneville, including DA2 and DA3, is located in air quality maintenance areas for ozone and carbon monoxide. Hazardous substances at DA2 and DA3 are generally not of concern with respect to impacts to air quality. These areas are heavily vegetated and it is unlikely that wind would release soil particles to the air. COPC identified at the DA2 and DA3 are not volatile and are not likely to be released to the atmosphere and were all less than MTCA action levels.

2.4 Natural Resources and Ecology

Camp Bonneville is located at the tip of a portion of prairie habitat that extends into the foothills of the Cascade Mountains (Clark County, 1998). The Washington Cooperative Fish and Wildlife Research Unit of the University of Washington (Seattle) have mapped the area of Camp Bonneville. The majority of the site is in the "Westside western hemlock" vegetation zone (University of Washington, 1998). Forested areas on the installation occur on the higher elevations. These areas are densely wooded and provide an excellent habitat for existing wildlife.

Camp Bonneville has been designated by Clark County as a "Forest Tier 1 Area". A Forest Tier 1 area is defined as an area that is potentially capable of sustaining "long-term production of commercially significant forest products" (Clark County, 1998). The U.S. Army has managed the forests and other vegetation on Camp Bonneville since 1957. Vegetation has been controlled by scarification and replanting after fires that occurred in 1902, 1938, and 1951 (Hunter 1991 in Clark County, 1998). Timber has not been actively managed since 1981; however, a timber valuation report has been published for the area by Clark County (Forest Resource Management, Inc., November 12, 1997, in Clark County, 1998). Selective thinning has been recommended to utilize the forest resources on the site in order to help fund the reuse plan, optimize tree growth, simulate succession of the original Douglas fir community, maximize forest health, and minimize fire hazards. The Clark County forester conducted a detailed evaluation of the site in January 1999 to identify forest parcels that are essential to complete the reuse plan successfully. The county forester prioritized the site into five phases of activities. The first two phases identify areas along the western half of Camp Bonneville for thinning. Phase three identifies an area along the northern boundary east of the demolition area for selective thinning to promote future yields. Phases four and five were identified for thinning west of Lacamas Creek in the southwest portion of the site.

The majority of Camp Bonneville is forested, interspersed with streams and open fields. This provides an excellent habitat for all forms of wildlife, including mammals, birds, reptiles, amphibians, and aquatic life. Detailed studies of wildlife of Camp Bonneville have not been published. The following information is based on a review of available literature and information provided in the Reuse Plan (Clark County, 1998).

A partial baseline survey of nesting raptors at Camp Bonneville was conducted by Stalmaster and Associates (1994). Thirty-three raptors were sighted, including red-tailed hawks, Northern harriers, great horned owls, turkey vultures, and a raven. A single osprey was observed, and was described as a probable migrant. Due to limitations on field research time and poor road conditions, complete coverage of Camp Bonneville was not possible (Stalmaster and Associates 1994).

Aquatic habitats in the site are associated with Lacamas, Main Stem, North and East Forks, Buck, and David Creeks. These creeks are expected to provide good quality aquatic habitats that support diverse fish and invertebrate populations based on the condition of the overall area.

An endangered species survey was performed in 1995 by Pentec Environmental, Inc. (Pentec 1995a,b /in Woodward and Clyde 1996). Field surveys were conducted by Pentec for amphibians, reptiles, mammals, songbirds, marsh birds, game birds waterfowl and water birds, raptors, fish, and rare plants. None of these surveyed species were defined as being federal- or state-listed as threatened or endangered. This species investigation has been updated in the United States Army Corps of Engineers (USACE) St. Louis District Final Archives Search Report (ASR) (1997). The St. Louis District conducted correspondence with the United States Fish and Wildlife Service (USFWS) and the Washington State Department of Fish and Wildlife regarding the occurrence of threatened and endangered species on Camp Bonneville (USACE, 1997). **Table 2-2** summarizes this information, as well as information on likely habitats for each species.

TABLE 2-2
LIST OF STATE AND FEDERALLY LISTED THREATENED AND ENDANGERED SPECIES LIKELY TO OCCUR ON THE CAMP BONNEVILLE SITE*

Name	Status	Likely Habitat and Occurrence
Bald Eagle (Haliaeetus leucocephalus)	Federal Threatened Species	Occasional visitor through area
Northern Spotted Owl (Strix occidentalis)	Federal Endangered; State Endangered	Throughout site

*Based on Summary of Agency Correspondence provided in USACE Final Archives Search Report, 1997

2.5 Hazardous Substance Sources

The source of potential contaminants present at the demolition sites, would be residual explosives, explosive degradation compounds, and metals that may have resulted from demolition and disposal activities at the DA2 and DA3. Historically, stockpiles of excess and unserviceable munitions were destroyed through burning and detonation. These areas typically generate high concentrations of waste metals and explosive compounds because of the concentration of detonations. When conventional high-explosives munitions detonate, they release a large variety of chemical compounds and metals into the environment. Explosive contamination from low-order detonations (when shells blow up without fully combusting the high explosives) may be the principle source of explosive compounds at demolition areas. Royal demolition explosives (RDX) (hexahydro-1,3,5-trinitro-1,3,5-triazine) is a common explosive found at demolition and impact areas because it degrades more slowly than TNT (2,4,6-trinitrotoluene). Several isomers of 2,4,6-TNT and dinitrotoluene (DNT), and a variety of other compounds, are also of concern at demolition and impact areas. In addition, munitions constituents may contain as much as one or two percent heavy metals such as lead, cadmium, chromium, nickel, copper, and barium. Metals persist in the soil and water and over time, measurable quantities can accumulate in the environment.

Propellants are the chemicals that propel munitions forward. They include double-based propellants, consisting primarily of binary combinations of nitroglycerine (NG), nitrocellulose (NC), and nitro guanidine (NQ). These propellants were commonly used in artillery, mortars, and small arms. Composite propellants, typically consisting of aluminum and ammonium perchlorate, were used in rockets of all sizes. Perchlorate is a common contaminate of concern that may be detected in demolition and impact areas. It migrates through soil to groundwater and does not readily degrade in the environment. In addition to those COPC discussed above volatile organic compounds (VOCs) were included due to detections at LF4/DA1. A summary of chemicals of potential concern is provided in **Tables 2-3 and 2-4.**

TABLE 2-3 CHEMICALS OF POTENTIAL CONCERN

Sampling Area	Munition Compound Classes	High Explosives and Organic Compounds	Artillery Propellants	Other
Landfill Demolition Area Firing Ranges	• Artillery Propellants • HE • Missile / Rocket Propellants	• TNT • RDX • PETN • PA • HMX • NG	• Black Powder (nitrate) • Plasticizers • Stabilizers • AP	• Priority Pollutant Metals • TPH • SVOCs • VOCs

Notes:
AP = ammonium perchlorate
Black powder is a mixture of potassium or sodium nitrate, charcoal, and sulfur.
Plasticizers = dibutylphthalate, diethylphthalate
Stabilizers = diphenylamine, N-nitrosodiphenylamine
HE = high explosives; 2,4 DNT, 2,6 DNT
HMX = octahydro - 1,3,5, 7 -tetranitro~ 1,3,5, 7-tetrazocine
NG = nitroglycerine PA = picric acid PETN = pentaerythritol tetranitrate
PA = picric acid
PETN = pentaerythritol tetranitrate
RDX = hexahydro- 1,3,5-trinitro- 1,3,5-triazine
SVOCs = semivolatile organic compounds(see Table 2-4)
TNT = 2,4,6-trinitrotoluene
TPH = total petroleum hydrocarbons
VOCs = volatile organic compounds (see Table 2-4)

TABLE 2-4 VOC and SVOC CHEMICALS OF POTENTIAL CONCERN

Volatile Organic Compounds	Semi-Volatile Organic Compounds	
• 1,1,1-Trichloroethane	• 1,2,4-Trichlorobenzene	• Benzo(b)fluoranthene
• 1,1,2,2-Tetrachloroethane	• 1,2-Dichlorobenzene	• Benzo(g,h,i)perylene
• 1,1,2-Trichloroethane	• 1,2-Diphenylhydrazine	• Benzo(k)fluoranthene
• 1,1-Dichloroethane	• 1,3-Dichlorobenzene	• Benzoic acid
• 1,1-Dichloroethene	• 1,4-Dichlorobenzene	• Benzyl alcohol
• 1,2-Dichloroethane	• 2,4,5-Trichlorophenol	• Bis(2-chloroethoxy)methane
• 1,2-Dichloropropane	• 2,4,6-Trichlorophenol	• Bis(2-Chloroethyl)ether
• 2-Butanone	• 2,4-Dichlorophenol	• Bis(2-chloroisopropyl)ether
• 2-Hexanone	• 2,4-Dimethylphenol	• Bis(2-ethylhexyl)phthalate
• 4-Methyl-2-pentanone	• 2,4-Dinitrophenol	• Butylbenzylphthalate
• Acetone	• 2,4-Dinitrotoluene	• Carbazole
• Benzene	• 2,6-Dinitrotoluene	• Chrysene
• Bromodichloromethane	• 2-Chloronaphthalene	• Dibenzo(a,h)anthracene
• Bromoform	• 2-Chlorophenol	• Dibenzofuran
• Bromomethane	• 2-Methylnaphthalene	• Diethylphthalate
• Carbon disulfide	• 2-Methylphenol	• Dimethylphthalate
• Carbon tetrachloride	• 2-Nitroaniline	• Di-n-butylphthalate
• Chlorobenzene	• 2-Nitrophenol	• Di-n-octylphthalate
• Chloroethane	• 3 & 4-Methylphenol	• Fluoranthene
• Chloroform	• 3,3'-Dichlorobenzidine	• Fluorene
• Chloromethane	• 3-Nitroaniline	• Hexachlorobenzene
• cis-1,2-Dichloroethene	• 4,6-Dinitro-2-methylphenol	• Hexachlorobutadiene
• cis-1,3-Dichloropropene	• 4-Bromophenyl-phenyl ether	• Hexachlorocyclopentadiene
• Dibromochloromethane		• Hexachloroethane
• Dichlorodifluoromethane	• 4-Chloro-3-methylphenol	• Indeno(1,2,3-cd)pyrene
• Ethylbenzene	• 4-Chloroaniline	• Isophorone
• m,p-Xylene	• 4-Chlorophenyl-phenylether	• Naphthalene
• Methylene chloride	• 4-Nitroaniline	• Nitrobenzene
• o-Xylene	• 4-Nitrophenol	• N-Nitroso-di-n-propylamine
• Styrene	• Acenaphthene	• N-Nitrosodiphenylamine
• Tetrachloroethene	• Acenaphthylene	• Pentachlorophenol
• Toluene	• Anthracene	• Phenanthrene
• trans-1,2-Dichloroethene	• Benzidine	• Phenol
• trans-1,3-Dichloropropene	• Benzo(a)anthracene	• Pyrene
• Trichloroethene	• Benzo(a)pyrene	
• Trichlorofluoromethane		
• Vinyl chloride		
• Xylenes, Total		

2.6 Regulatory Classifications

Camp Bonneville, including DA2 and DA3, is located in an air quality maintenance area for ozone and carbon monoxide. As described in **Section 2.3**, hazardous substances present at the site are not likely to be released to the atmosphere. It is possible that future activities at the site could involve remedial actions that have the potential to emit hazardous substances to the air (e.g., dust from soil removal activities or vapors from groundwater remediation).

The creeks and tributaries at Camp Bonneville are classified as Class A water bodies under WAC 173-201A-120 (6). These include Lacamas Creek, Buck Creek, David Creek, and tributary streams. Water quality of this class is designated as "excellent" and shall meet or exceed the requirements for all or substantially all uses. Class A water bodies must support a variety of uses, including fish and shellfish migration, rearing, spawning, and harvesting; recreation; and commerce and navigation. Cleanup actions or no action for DA2 and DA3 would be based on protecting water quality and supporting these uses.

Groundwater at the site is used to provide service to the two cantonment areas. There are three wells, two reservoirs, and two independent water systems serving the Camp Killpack and Camp Bonneville cantonments. Figure 1, the Site Conditions Map, shows the well locations. Another groundwater well exists at the active FBI firing range facility. The water quality from these systems is regulated under the local health department requirements.

3.0 STUDY AREA INVESTIGATIONS

This section describes the actions implemented to meet the objectives of the RI (RI objectives are listed in Section 1.2), identifies specific field activities undertaken during RI activities, and presents the results of the investigations at DA2 and DA3. RI activities for DA2 consisted of the installation of groundwater monitoring wells and collection and analysis of groundwater and soil samples. RI activities at DA3 consisted of soil sampling and analysis in the demolition area, installation and sampling of groundwater monitoring wells, and additional soil sampling following removal of debris from the center of the crater at DA3. In addition, wells were installed downgradient of DA2, at DA3, and near the boundary of Camp Bonneville in the Lacamas Creek valley.

To meet the objectives of the RI specified in **Section 1.2**, field work included installation and sampling of 16 monitoring wells located in these three areas and soil sampling at DA2 and DA3:

- Three wells were installed in the shallow water-bearing zone in a line normal to the direction of groundwater flow from the suspected location of DA2.
- One well pair (shallow and deep) and three shallow wells were installed at four compass points surrounding the DA3 crater.
- Four wells pairs (shallow and deep) were installed in a transect where the Lacamas Creek valley exits the Camp Bonneville boundary.
- Groundwater samples were collected and analyzed, for the COPC, from each of the monitoring wells.
- Surface and subsurface soil samples were collected and analyzed from DA2 and DA3.

U.S. Army Center for Health Promotion and Preventive Medicine (CHPPM) conducted well installation and soil and groundwater sampling during November 2002 and January 2003. The locations for the 16 wells installed and sampled are shown on **Figures 2 and 3.** The RI activities completed by CHPPM were conducted in accordance with the Work Plan for Analysis of Site-Wide Groundwater (CHPPM 2002).

Additional soil sampling was conducted at DA2 and DA3 in February 2003 by Atlanta Environmental Management (AEM 2003). AEM's soil sampling and analytical results are described in the Site Investigation Report for the Small Arms Ranges and Demolition Areas 2 and 3 (AEM 2003a).

Project Performance Corporation (PPC) conducted additional groundwater sampling and analysis of monitoring wells at DA3 and the boundary area during April 2003. During November 2003, additional soil sampling was conducted at DA3 following removal of the debris from the center of the crater.

PBS Engineering and Environment (PBS) conducted the quarterly groundwater monitoring beginning in December 2003.

The following sections describe the monitoring well installations (**Section 3.1**), the geologic and hydrologic conditions encountered (**Section 3.2**), sampling and analysis (**Section 3.3**), quarterly sampling and analysis **(Section 3.4**), soil and groundwater analytical results and a summary of the nature and extent of contamination (**Section 3.5**), quality assurance (**Section 3.6**), and potential risks to human health and ecological receptors (**Section 3.7)**.

3.1 Monitoring Well Installations

During November 2002, 16 monitoring wells were installed pursuant to the ground-water study Work Plan (CHPPM 2002). These sixteen wells are located as follows:

- Three shallow wells are located downgradient of DA2.
- Five wells (four shallow and one deep) are located around the depression of DA3.
- Eight wells (four well pairs, each with one shallow and one deep well) are located near the point where Lacamas Creek crosses the western boundary of Camp Bonneville.

All wells were constructed of two-inch diameter PVC with 5 to 15 feet of 0.010 inch slotted screen. Sand pack around the screened interval of each well consisted of sieve size 10-20 silica sand. Bentonite seals were placed from two feet above the sand pack to two feet bgs. Above ground monuments were installed at each wellhead. Wells were installed in the shallow alluvium to monitor the first groundwater encountered, while deeper wells were installed to monitor groundwater in the deeper alluvium or in the Troutdale Formation. Borehole and well construction logs for the 16 wells installed by CHPPM are presented in **Appendix A**.

After the wells were completed, developed, and surveyed, water levels were measured to determine the horizontal and vertical hydraulic gradients, and hence, flow directions. The first round of water level measurements also included other nearby/relevant monitoring wells from previous investigations in Camp Bonneville.

A summary of the monitoring well installations downgradient of DA2, at DA3, and the boundary area are provided below.

Demolition Area 2

The approach at DA2 was to install monitoring wells based on the topographic/drainage features and the expectation that the groundwater flow direction generally follows the surface topography in the immediate area., Due to the level of uncertainty of the location of DA2, wells were placed in the downgradient area to determine if groundwater contamination was present in the general vicinity. As shown in Figure 2 the wells were placed down slope of the suspected location of DA2, and upslope and on either side of the Pop-up pond. These locations would be the most likely to intercept contaminants, if present, migrating from the upslope area. Three wells (LC-MW-09S, LC-MW-10S, and LC-MW-11S) were installed in the shallow alluvium as shown in **Figure 2**. These three wells were installed to total depths ranging from approximately 17 to 24 feet bgs with top of well screens at approximately 7 to 9 feet bgs. A summary of the well construction details is provided in **Table 3-1** along with depth to water measurements collected on January 20, 2003.

Demolition Area 3

At DA3, four shallow monitoring wells (LC-MW-05S, LC-MW-06S, LC-MW-07S, and LC-MW-08S) were installed at four compass point locations around the depression. Well locations are shown on **Figure 3**. At the eastern compass point location, a deep well (LC-MW-05D) was also installed. The shallow wells were installed to total depths ranging from approximately 15 to 37 feet bgs with top of well screens at approximately 8 to 22 feet bgs. The deep well was installed adjacent to LC-MW-05S to 62 feet bgs with the top of screen at 52 feet bgs. A summary of the well construction details is provided in **Table 3-1** along with depth to water measurements collected on January 20, 2003.

Boundary Area

Four monitoring well pairs were installed along the western Lacamas Creek Valley just south of Lacamas creek along the boundary of Camp Bonneville. Wells installed included LC-MW-01S (shallow), LC-MW-01D (deep), LC-MW-02S, LC-MW-02D, LC-MW-03S, LC-MW-03D, LC-MW-04S, and LC-MW-04D. These wells were installed to establish a general flow net for these areas and to determine if contaminant plumes exist at the boundary where they could potentially impact off-site water wells. The locations of the eight wells installed along the boundary are presented on **Figures 1 and 3**. Each well pair included one well installed near the depth where the water table is encountered and a second well installed at a deeper depth. Cobbles and boulders indicative of the Upper Troutdale formation were encountered starting near the ground surface during drilling of these wells. The well pairs were installed in a transect in the valley as shown in **Figures 1 and 3**. The shallow wells were installed to total depths ranging from approximately 14 to 20 feet bgs with top of well screens at approximately 9 to 13 feet bgs. The deep wells were installed to total depths ranging from approximately 35 to 40 feet bgs with the top of screens at 25 to 30 feet bgs. A summary of the well construction details is provided in **Table 3-1** along with depth to water measurements collected on January 20, 2003. Well construction and borehole logs are presented in **Appendix A** for all 16 wells installed.

3.2 Geologic and Hydrogeologic Conditions Encountered

A summary of the geologic and hydrogeologic conditions encountered during well drilling and borehole sampling is presented in this section.

Demolition Area 2

The three wells at DA2 were completed in the highly variable alluvium consisting of clayey silt to gravely silt. The depth of the borings ranged from 17 feet to 24 feet bgs. Groundwater was encountered at approximately five feet bgs in the boring for well LC-MW-09S, at 14 feet in LC-MW-10S and at the ground surface in LC-MW-11S. However, saturated subsoil was not encountered in MW-11S as it had been in the other two boreholes. During drilling of the shallow wells, the Upper Troutdale formation was not encountered. Groundwater elevations for these wells and nearby wells are shown in **Figure 2** for January 2003. As shown in the figure shallow groundwater flows toward Lacamas Creek..

Demolition Area 3

Weathered bedrock was encountered during drilling of borehole LC-MW-05D at approximately 45 feet bgs. Initially, this stratum was thought to be part of the Troutdale Formation, but the flow and matrix characteristics are not similar to the Troutdale and are now recognized to be weathered bedrock. The soil above the weathered bedrock was predominately silty clay to clayey silt with varied amounts of gravel. Groundwater was encountered in the wells at DA3 at approximately 12 feet bgs. During the January sampling event, well LC-MW-05D was found to be artesian; therefore, a weep hole was drilled into the steel monument to allow artesian overflow to drain from the casing. The well pair at DA3, LC-MW-05S and LC-MW-05D, exhibited a strong upward gradient where the deep well is confined by overlying alluvium.

Groundwater elevation data calculated from depth to water measurements collected on January 21, 2003 are depicted on **Figure 3**. As shown on the figures, groundwater within the shallow alluvium and weathered bedrock flows towards Lacamas Creek from upland areas of the Lacamas Creek valley. Groundwater flows southwest through the Lacamas Creek valley and leaves Camp Bonneville through the west boundary where Lacamas Creek exits the camp and where the boundary area monitoring wells were installed.

Boundary Area

The boundary area well boreholes encountered cobbles and boulders indicative of the Upper Troutdale Formation starting near the ground surface. Soils varied in the amount of silt, sand and clay content with gravel predominating. In the eight wells installed along the boundary area, groundwater was encountered from about 9 to 14 feet below the ground surface in the borings. At the boundary well pairs a slight downward vertical gradient was observed where the Upper Troutdale Formation is exposed at the surface and is unconfined.

Groundwater elevations in the DA2 wells were approximately 340 feet mean sea level (msl). Approximately 1 ¾ mile downgradient at DA3 the groundwater elevations were approximately 302 feet msl. The groundwater elevations at the boundary area wells were approximately 286 feet msl approximately ½ mile downgradient of DA3.

3.3 Sampling and Analysis

This section describes the groundwater and soil sampling conducted at DA2 and DA3 wells and the groundwater sampling and analysis conducted at the boundary area wells. **Table 3-2** presents a summary of soil and groundwater sampling and analyses conducted during the RI.

Demolition Area 2

The three shallow downgradient wells at DA2 were sampled on January 19 and 20, 2003 by CHPPM. 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, total organic carbon (TOC), and total suspended solids (TSS)].

On February 27, 2003, soil samples were collected from DA2, by AEM, at the following locations; one soil sample from the approximate center of DA2, and one sample each from approximately 100 feet north, south, east, and west of the center. Soil samples were collected using stainless steel hand augers from depths of 0-6 inches below ground surface (bgs), 2.5 feet bgs, and five feet bgs if conditions allowed. Rock and groundwater were encountered prior to the five feet bgs sample at the north and west locations so no deep soil samples were collected as these depths. The east location had groundwater at a depth of four feet and so the sample was collected from this depth instead of the five foot interval. Soil sampling locations for soil samples collected by AEM are shown on **Figure 6**. Samples were analyzed or explosives, perchlorate, and metals.

Soil samples were also collected by AEM from a soil berm located adjacent to the road along the south side of the demolition area. Three samples were collected from the berm at depths of approximately two feet bgs with one collected from the center of the berm, one from 15 feet northeast of the center, and one from 15 feet southwest of the center. All soil samples collected by AEM were analyzed for explosives, perchlorate, and metals. A summary of the sampling and analyses conducted at DA2 is presented in **Table 3-2**.

Demolition Area 3

The five wells at DA3, four shallow and one deep well, were sampled on January 18 and 19, 2003 by CHPPM. Samples were analyzed for explosives, perchlorate, total and dissolved metals, and water quality parameters. A second round of sampling and analysis was performed by Project Performance Corporation (PPC) on all DA3 monitoring wells and selected boundary area wells on April 15, 2003 as a result of the invalidation of some analytical data. This is discussed in more detail in **Section 3.5**.

On November 25, 2003, a corroded barrel and small caliber rounds were removed from the crater at DA3 by Army UXO specialists. Following the debris removal, the Army and PPC collected soil samples from the sides and bottom of the remaining hole in the center of the crater. Samples were analyzed for explosives, perchlorate, and metals.

Soil samples were collected during drilling of wells at DA3. Soil samples were collected at the ground surface, and at depths of two feet, five feet, and 15 feet bgs in boreholes at LC-MW-05S, LC-MW-07S, and LC-MW-08S. In borehole LC-MW-06S, samples were collected at the ground surface, and at depths of two feet and five feet bgs. Soil samples were analyzed for explosives, perchlorate, and total metals.

Soil samples were collected by AEM at DA3 on February 27, 2003. Soil samples were collected at the north, south, east, and west compass points surrounding the depression crater at DA3. Samples were collected from 0-6 inches bgs and 2.5 feet bgs on the outer depression berm using a stainless steel hand auger. Due to the presence of standing water in the center of the depression crater, no soil sample could be collected so a water sample was collected from the standing water. Soil samples and the one surface water sample were analyzed for explosives, perchlorate, and total metals. The sample locations for samples collected at DA3 by AEM are shown on **Figure 7**.

A summary of the sampling and analyses conducted at DA3 is presented in **Table 3-2**.

Boundary Area

The eight boundary area wells, four shallow and four deep, were sampled between January 14 and 19, 2003 by CHPPM. Groundwater samples were analyzed for total petroleum hydrocarbons (TPH), TPH-diesel range organics (TPH-DRO), TPH-gasoline range organics (TPH-GRO), explosives, perchlorate, total metals, dissolved metals, semi-volatile organic compounds (SVOCs), volatile organic compounds (VOCs), and water quality parameters including chloride, sulfate, total alkalinity, dissolved organic carbon (DOC), nitrite/nitrates as nitrogen, total organic carbon (TOC), and total suspended solids (TSS).

Selected boundary area wells were sampled on April 15, 2003 by PPC. Boundary area wells sampled by PPC included LC-MW-01S, LC-MW-01D, LC-MW-02S, and LC-MW-02D. A summary of the sampling and analyses conducted at the boundary area wells is provided in **Table 3-2.**

3.4 Quarterly Groundwater Sampling and Analyses

Starting with the fourth quarter of 2003, PBS Engineering and Environmental (PBS) collected, analyzed, and reported results for groundwater samples from the three monitoring wells at DA2, the five monitoring wells at DA3, and the eight monitoring wells at the Boundary Area on a quarterly basis. The specific sampling events were conducted on the following dates:

- Fourth quarter 2003: December 10 – 16, 2003
- First quarter 2004: March 11 – 17, 2004
- Second quarter 2004: June 15 – 22, 2004
- Third quarter 2004: September 14 – 20, 2004
- Fourth quarter 2004: December 2 – 8, 2004
- First quarter 2005: March 22 – 24, 2005
- Second quarter 2005: June 23 – 28, 2005
- Third quarter 2005: September 14 – 16, 2005
- Fourth quarter 2005: January 23 – 27, 2006
- First quarter 2006: March 21 – 23, 2006
- Second quarter 2006: June 21 – 27, 2006

These samples were analyzed for the following constituents:

- All samples were analyzed for total and dissolved metals (antimony, arsenic, beryllium, cadmium, chromium, copper, lead, mercury, nickel, selenium, silver, thallium, and zinc)

- The samples from the eight wells at the site boundary were analyzed for VOCs and SVOCs for all sampling events. The samples from the three wells at DA2 and five wells at DA3 collected from the first three quarterly sampling events – the fourth quarter of 2003 through the second quarter of 2004 – were analyzed for VOCs and SVOCs; later samples were not analyzed for these constituents because these earlier sample results were "non detect" for these constituents and because there was no evidence to suggest their potential presence at these two locations.

- The samples from the eight wells at the site boundary were analyzed for petroleum hydrocarbons for all sampling events. The samples from the three wells at DA2 and five wells at DA3 collected from the first three quarterly sampling events – the fourth quarter of 2003 through the second quarter of 2004 – were analyzed for petroleum hydrocarbons; later samples were not analyzed for these constituents because these earlier sample results were "non detect" for these constituents and because there was no evidence to suggest their potential presence at these two locations.

- All samples were analyzed for ordnance and explosives related compounds (HMX, RDX, nitroglycerin, PETN, picric acid, and perchlorates).

The groundwater analytical results from these 11 quarterly sampling events are presented in **Appendix B**.

These eleven groundwater sampling and analyses events were conducted in accordance with the WDOE–approved Groundwater Sampling and Analysis Plan (SAP) prepared by PBS and dated December 19, 2003. The Plan includes a Quality Assurance Project Plan (QAPP), also prepared by PBS with the same date. The protocols for field and laboratory quality control, including duplicate, blank, and rinsate samples and sample preservation, handling, and holding times were implemented during each of these eleven sampling events. A WDOE-approved laboratory conducted the analyses.

3.5 Analytical Results and Nature and Extent of Contamination

This section describes the results of the analyses conducted on samples collected from DA2, DA3, and the boundary area wells for the initial remedial investigation sampling and the subsequent quarterly monitoring. The sampling results are discussed below and are also summarized in tables presented in this section.

Elevated levels of nitrite/nitrate were present in several DA2, DA3, and boundary area monitoring wells at levels exceeding the federal drinking water standard of 10 mg/L. When archived samples were reanalyzed for nitrate, the high levels could not be reproduced. Subsequent review of procedures suggested the original samples might have been compromised by the addition of preservatives. As a consequence, resampling and analysis was performed in April 2003 by PPC for nitrite/nitrate at nine wells (5 wells at DA3 and 4 boundary wells). Perchlorate was also reanalyzed during the April 2003 resampling event as it was detected in some wells at significant levels.

3.5.1 Demolition Area 2

Groundwater

The initial well sampling was conducted in January, 2003. Based on these sampling and analyses conducted by CHPPM, no explosives, perchlorate, or total and dissolved metals were detected at concentrations at or above regulatory screening or cleanup standards (see **Table 3-3**). However, nitrite/nitrate results were detected in 2 wells at 18 and 17 mg/L, which exceed the federal drinking water level of 10 mg/L. As stated above, the resampling and analysis results confirmed that the initially reported results were anomalous and consequently rejected and were not subsequently reanalyzed.

The eleven quarterly samples collected and analyzed to date from each of the three wells downgradient of DA2 present no evidence of contaminant releases into site groundwater from this area (see **Appendix B**.) No explosives related compounds or perchlorates and no petroleum hydrocarbons were found above laboratory detection limits. In addition, during the three rounds for which the samples were analyzed for VOCs and SVOCs, no compounds in these categories were found above laboratory detection limits.

Low levels of metals (in the ppb range) were reported in the laboratory analysis results in samples from all three of the wells downgradient of DA2. These reported concentrations were generally higher in samples that also presented higher levels of suspended solids. The comparable filtered sample analysis results for metals in many of these samples were lower, a fact which indicates that the elevated total metals readings were artifacts of acid preservative having dissolved these metals from the soil particles suspended in the unfiltered samples.

With two exceptions, the analytical results for both total and dissolved metals were below the MTCA Method A or Method B criteria for those metals for which these criteria have been established by WDOE. In one sampling event, (March 2005), the results for total concentrations of arsenic, chromium, and lead exceeded the MTCA Method A criteria in Well LC- MW-09S. In September 2005, the total lead concentration (22.6 ppb) exceeded the MTCA Method A criterion (15 ppb) in Well LC-MW-10S. In both of these exception cases, the results for the filtered or dissolved metals were below the applicable MTCA Method A criteria. As noted above, these elevated values for total metals appear to be artifacts of sample turbidity and not indicators of contamination.

Soil

Based on results of soil sampling and analyses conducted by AEM at DA2, no explosives or perchlorate residues are present above the reporting limits. Soil results for DA2 are shown on **Tables 3-5** and **3-6**. Arsenic was the only metal detected at concentrations that exceed screening levels or cleanup standards. The arsenic concentration in the 15 soil samples collected at DA2 ranged from < 20.7 to 30.1 mg/kg (see **Table 3-6**). Arsenic in six of the samples exceeded the MTCA Method A cleanup level of 20 mg/kg. However, all arsenic concentrations were significantly below the natural background levels in Clark

County based on EPA Method 6010, Inductively Coupled Plasma (ICP) Atomic Emission Spectroscopy that was used to analyze the samples (WDOE 1994). The 90 percentile value for arsenic concentration using ICP analytical methods in Clark County is 60.8 mg/kg (WDOE 1994). Therefore, arsenic concentrations detected in soil at DA2 are comparable to background concentrations of arsenic in Clark County. In addition, the 95% of the UCL on the mean arsenic concentration for 15 soil samples from DA2 is 22 mg/kg. Based on the analyses conducted on soil samples from DA2, there are no COPC in soil at DA2.

3.5.2 Demolition Area 3

Groundwater

Based on sampling and analyses conducted by CHPPM at DA3, no explosives or total metals were detected at concentrations at or above regulatory screening or cleanup standards (see **Table 3-7**). Analytical data from samples collected by CHPPM did detect perchlorate at 12 ug/L in well LC-MW-07S, which exceeds the Preliminary Remediation Goal (PRG) of 3.6 ug/L as well as nitrate levels similar to those for DA2 wells. Because the nitrate levels were determined to be invalid and the perchlorate analysis is known to produce false positive results, perchlorates were reanalyzed along with nitrate in the subsequent effort conducted by PPC. Samples were sent to two different laboratories as a quality control check.. Results from all DA3 monitoring wells showed actual perchlorate concentrations were below the reporting limit of 2 ug/L based on analyses at the two independent laboratories (see **Table 3-4**). Based on these additional perchlorate analyses, CHPPM perchlorate data from January 2003 were determined not to be valid and rejected.

Dissolved arsenic was detected in well LC-MW-08S at a concentration of 9.86 ug/L. This concentration is exceeds the most stringent screening or cleanup standard of 5 ug/L; however, the concentration is below the proposed EPA MCL of 10 ug/L.

The eleven quarterly samples collected and analyzed from each of the five wells at DA3 present no evidence of any contaminant release into site groundwater from this area (see **Appendix B**.) No explosives related compounds or perchlorates and no petroleum hydrocarbons were found which exceeded laboratory detection limits. In addition, during the three rounds for which the samples were analyzed for VOCs and SVOCs, none were found exceeding the laboratory detection limits.

Low levels of metals (in the ppb range) were found in samples from all five of the wells at DA3. The concentrations were generally higher in samples that also had higher levels of suspended solids. The filtered samples metal results for many of these samples were lower, a fact which indicates that the elevated total metals readings were artifacts of acid preservative having dissolved these metals from the soil particles suspended in the unfiltered samples. Without exception, the analytical results for both total and dissolved metals were below the MTCA Method A or Method B criteria for those metals for which these criteria have been established by WDOE.

Soil

Soil samples collected during drilling of the well boreholes at DA3 had low levels of four explosives detected in surface and subsurface samples collected by CHPPM. The concentrations detected were significantly less than 1 mg/kg and less than any listed PRG. Two explosive compounds, 2-Am 4,6-DNT and 4-Am 2,6-DNT, were detected at 0.22 and 0.14 mg/kg, respectively (see **Table 3-13**). There are no PRGs listed for these compounds; however, the concentrations detected are well below the EPA Region 3 Residential Risk-based concentration of 4.7 mg/kg for both of these compounds. These concentrations are consistent with the discovery of spent shells in the corroded drum observed in DA3 during the dry season and are likely the traces left behind from leaching of those shells while submerged during the wet season.

Soil sampling and analyses conducted by AEM, in February 2003, at DA3 determined no explosives or perchlorate were present above the reporting limits in the eight surface and subsurface soil samples collected (see **Figure 7**). A water sample from standing water in the center of the DA3 crater was non-detect for explosives, perchlorate, and metals.

During November 2003, six soil samples were collected from the soils beneath and surrounding the area where the corroded drum and shell debris was removed from the center of the crater. Samples were collected from the sidewalls and bottom of the excavated drum area. One sample from each of the four sides of the excavation (north, south, east and west) and two samples and one duplicate sample were collected from the bottom of the excavation. No explosives, perchlorate, or picric acid were detected in any of the six samples from the excavation.

Soil sample results for samples collected from boreholes during well drilling are presented in **Table 3-8**. Soil sample results for sampling conducted by AEM are presented in **Tables 3-9** (explosives) and **3-10** (metals). The results of the soil samples collected following the corroded drum removal in the center of crater are presented in **Tables 3-9** and **3-10**.

Metals analyses on soil samples collected from DA3 by AEM, CHPPM, and the Army detected metals at background levels and/or below screening or cleanup levels (see **Table 3-13**). Therefore, there are no COPC in the soil at DA3.

3.5.3 Boundary Area Wells

Groundwater

Groundwater results from sampling of boundary wells are presented in **Table 3-11**.
No VOCs, SVOCs, and TPH-GRO were detected above the detection limit in any of the boundary area wells. TPH was detected at 0.20 mg/L in LC-MW-01S and TPH-diesel was detected in LC-MW-04D at 0.051 mg/L. Both of these detections are well below the 0.5 mg/L and 1.0 mg/L MTCA standards for TPH and TPH-diesel, respectively.

Analytical data from samples collected by CHPPM did detect low concentrations of perchlorates (< 1 ug/L) in both shallow and deep wells at LC-MW-01. Elevated levels of nitrite/nitrate exceeding the federal drinking water standard (10 mg/L) were detected in several of the boundary area wells. These perchlorate and nitrite/nitrate data were suspect as noted in preceding sections and could not be duplicated. PPC resampled selected wells and results indicated perchlorate was non-detect (< 1 to < 2 ug/L) and the maximum nitrite/nitrate concentration (< 0.61 mg/L) was well below the drinking water standard (see **Table 3-4**).

The eleven quarterly samples collected and analyzed from each of the eight wells at the site boundary present no evidence of any contaminant release into site groundwater from this area (see **Appendix B**.) No explosives compounds or petroleum hydrocarbons were detected in the laboratory analyses of these samples except as discussed below.

Perchlorate was detected at the laboratory reporting limit of 1 ppb in two samples – well LC-MW-02S in September 2004, and well LC-MW-02D in June 2005. Upon review by the laboratory, the September, 2004 report was determined to have been a false positive. The result for June, 2005 is also considered a false positive since perchlorate was not detected in a duplicate sample from this well. Perchlorate was not detected in any other sample from these wells or in any other wells at the boundary.

Low concentrations of bis(2-ethylhexyl)phthalate and acetone have been reported on an infrequent basis during some of these eleven sampling events. The results were "J flagged" as estimates because they were at or below the laboratory reporting limit for these compounds or "B flagged" because the compound was also detected in the associated laboratory blank sample. Both of these compounds have been detected in some field equipment rinsate samples. Further, both of these compounds are common laboratory contaminants.

Low levels of metals (in the ppb range) were reported in the laboratory analysis results in samples from all eight of the wells at the boundary. These reported concentrations were generally higher in samples that also had higher levels of suspended solids. The comparable filtered sample analysis results for metals in many of these samples were lower, a fact which indicates that the elevated total metals readings were artifacts of acid preservative having dissolved these metals from the soil particles suspended in the unfiltered samples. Without exception, the analytical results for both total and dissolved metals were below the MTCA Method A or Method B criteria for those metals for which these criteria have been established by WDOE.

3.5.4 Summary of Nature and Extent of Contamination

Table 3-12 presents the maximum concentrations of constituents detected in groundwater downgradient of DA2, at DA3, and the boundary area wells. The maximum groundwater concentrations detected are compared to maximum contaminant levels, MTCA Method A groundwater cleanup levels, EPA Region 3 Residential Risk-Based Concentrations, and/or EPA Region 9 PRGs. The constituents detected in groundwater include naturally occurring metals and low concentrations of TPH and TPH-diesel. None of the constituents detected in groundwater from DA2, DA3, and boundary area wells exceeds any of the groundwater screening criteria in **Table 3-12**, except for one detection of dissolved arsenic. The dissolved arsenic detected (9.86 ug/L) is however, below the proposed MCL for arsenic of 10 ug/L. The concentrations of constituents detected in groundwater do not warrant additional action because they are at concentrations that are below MCLs, cleanup levels, and/or PRGs and are at concentrations that are protective of human health.

Table 3-13 presents the maximum concentrations of constituents detected in soils from DA2 and DA3. Several naturally occurring metals were detected in the soils along with low levels of four compounds associated with explosive residue. None of the explosive residues detected exceed the screening criteria. Arsenic is the only constituent detected that exceeds any of the screening criteria. A surface soil sample at DA2 contained arsenic at 30.1 mg/kg which is greater than the MTCA Method A soil cleanup standard for unrestricted land use (20 mg/kg). A total of six soil samples from DA2 exceeded 20 mg/kg. As discussed in **Section 3.5.1**, the arsenic concentration detected at DA2 is considered to be below the natural background levels of arsenic in soils of Clark County based on similar analytical methods. The concentrations of constituents detected in soil samples are considered protective of human health and do not require additional action.

Additional evaluation of the concentrations of constituents detected at DA2 and DA3 is presented in **Section 3.7**, Potential Risks to Human Health and Ecological Receptors

3.6 Quality Assurance

With the exception of perchlorate and nitrite/nitrate analyses discussed previously, the analytical data quality assurance (QA) and quality control (QC) activities conducted on samples collected by CHPPM during the RI indicated no concerns with respect to the usability of the RI data. A summary of all QA/QC for analyses conducted on samples collected by CHPPM are presented in **Appendix C**. As discussed previously, the perchlorate and nitrite/nitrate data were rejected for the initial round of sampling conducted in January 2003. All other QA/QC goals were met and within the project QA/QC goals specified in the project QAPP/FSP (CHPPM 2002).

The analytical QA/QC activities for soil samples collected by AEM in February 2003 indicated no concerns with respect to the usability of the RI data. Complete analytical results and laboratory QA/QC data are presented in the AEM Site Investigation Report (AEM 2003a). All data quality objectives were met as specified in the project QAPP (AEM 2003b) and no data were rejected because of QC deviation. All data were maintained in accordance with the Data Management Plan (AEM 2003b).

The sampling and analysis conducted on samples collected by PPC were reported in a Field Report (PPC 2003). All laboratory and analytical method QA/QC criteria were met from both laboratories as described in the Field Report. **Appendix E** presents the PPC laboratory data report and QA/QC summary.

The laboratory analysis of soil samples collected from the center of the crater at DA3 in November 2003 was conducted by Columbia Analytical Services of Kelso, Washington. The laboratory Case Narrative and laboratory sample data are presented in **Appendix F**. The complete laboratory report, including raw data (1,200 pages), is available on request. No analytical data were rejected and all data are considered acceptable for their intended use.

3.7 Potential Risks to Human Health and Ecological Receptors

MTCA requires that site conditions are protective of natural resources and ecological receptors [(WAC 173-340-350(7)(F)]. In addition, the conditions at the sites must be protective of human health.

The current conditions in groundwater at DA2 and DA3 are protective of human health because no concentrations of constituents detected exceed MCLs and/or EPA PRGs for groundwater. Sites with groundwater constituents below MCLs and/or MTCA Method A groundwater standards provide protection of human health because they are established to be protective of human health. A quantitative human health risk assessment is not required since there are no detections in groundwater that exceed human health criteria at DA2 and DA3.

WAC 173-340-7490 specifies the terrestrial ecological evaluation procedures for sites where a release of a hazardous substance has occurred. Because of the prime ecological habitat at Camp Bonneville, DA2 and DA3 do not qualify for an exclusion (WAC 173-340-7491) or a simplified terrestrial ecological evaluation (WAC 173-340-7492). Therefore, a site-specific terrestrial ecological evaluation is required under WAC 173-340-7493.

The first step in conducting a terrestrial ecological evaluation is to complete a “problem formulation”. Problem formulation begins with a determination of the chemicals of ecological concern at the affected areas. This evaluation may eliminate hazardous substances from further consideration where the maximum or the upper 95th percentile upper confidence limit (UCL) on the mean soil concentration found at the site does not exceed ecological indicator concentrations published in MTCA Table 749-3. The table specifies ecological indicator soil concentrations for plants, soil biota, and wildlife. The ecological indicator concentrations for metals detected at DA2 and DA3 are presented in **Table 3-14**. Consideration is also given to background values for naturally occurring constituents.

There are no ecological indicator concentrations for the explosives detected in soil at DA3. Given the low concentrations, limited number of detections of explosives in soil and the small areas affected, they are not considered chemicals of concern to ecological receptors. The low concentrations of constituents detected in groundwater at DA2 and DA3 are not considered in the ecological evaluation because there is not a complete exposure pathway for ecological receptors.

Table 3-14 lists the 95th percentile on the mean of the upper confidence limit (UCL) for the constituents detected in soil at DA2 and DA3. The soil data sets consist of only 15 samples at DA2 and 14 samples at DA3; therefore, it should be noted that the UCLs are skewed high. Following are discussions of the constituents detected at DA2 and DA3 that exceed the most stringent ecological indicator concentrations. The 95th percentile on the mean UCL calculations was conducted using MTCA stat 97 statistics program. The statistical reports generated by this program are presented in **Appendix D**.

3.7.1 Soils at Demolition Area 2

The 95th percentile UCL on the mean (UCL) for arsenic at DA2 is 22 mg/kg and the mean value is 18.1 mg/kg. These concentrations are above the ecological indicator concentration for plants of 10 mg/kg. The arsenic concentrations at DA2 were determined using ICP analytical methods. The background concentration of arsenic in Clark County using ICP methods was determined to be 60.8 mg/kg (WDOE 1994). In addition, the background concentration for arsenic in Washington State ranges up to 130 mg/kg (Dragun 1991). Therefore, the arsenic concentrations detected at DA2 are within background levels and arsenic at these concentrations are not considered a threat to ecological receptors.

The UCL for barium at DA2 is 262 mg/kg and the mean value is 216 mg/kg. These concentrations exceed the ecological indicator concentration for wildlife (102 mg/kg). The barium concentrations detected at DA2 are almost equal to the background concentration of barium (257 mg/kg) at Camp Bonneville (Shannon & Wilson 1999a). This background study presented in the report included determining the 90th percentile of the distribution of the metal concentrations from 20 site-specific background samples from Camp Bonneville. In addition, these values are well within the statewide background range (Dragun 1991). Therefore, barium at concentrations detected at DA2 are equivalent to or less than background concentrations and are not considered a potential threat to ecological receptors.

The UCL for copper at DA2 is 112 mg/kg and the mean value 99.3 mg/kg. These values exceed the ecological indicator concentration for soil biota (50 mg/kg, respectively). In addition, the UCL exceeds the ecological indicator concentration for wildlife (102 mg/kg). The copper UCL concentration at DA2 is less than the background concentration of copper (114 mg/kg) at Camp Bonneville (Shannon & Wilson 1999a). Therefore, the copper UCL concentration at DA2 is below the background level for soil at the site and is not considered a potential threat to ecological receptors.

3.7.2 Demolition Area 3

At DA3 the metals with UCLs above the most stringent ecological indicator concentration include barium, copper, and mercury.

The UCL for barium at DA3 is 195 mg/kg and the mean value 152 mg/kg. These values exceed the ecological indicator concentration for wildlife (102 mg/kg). The barium concentration calculated for DA3 is below background concentration of barium (257 mg/kg) at Camp Bonneville (Shannon and Wilson 1999a). In addition, they are well below the statewide background concentration (Dragun 1991). Therefore, barium at concentrations detected at DA3 are similar to or consistent with background concentrations and are not considered a potential threat to ecological receptors.

The UCL for copper at DA3 is 129 mg/kg and the mean value is 119 mg/kg. These values exceed the ecological indicator concentrations for plants (100 mg/kg) and soil biota (50 mg/kg). The copper UCL concentration at DA3 is not significantly above the background concentration of copper (114 mg/kg) at Camp Bonneville (Shannon & Wilson 1999a). The copper UCL is skewed high because of the concentrations detected in a small area in the center of the crater where the corroded debris was removed. The impacted soil area is estimated at less than one cubic yard, which is minimal. Therefore, copper concentrations in soil at DA3 are not considered a potential threat to ecological receptors.

The UCL for mercury at DA3 (0.32 mg/kg) exceeds the ecological indicator concentrations for plants and soil biota (0.3 and 0.1 mg/kg, respectively). The mercury UCL is skewed high because of the concentrations detected in two of six samples from the small area in the center of the crater where the corroded debris was removed. The impacted soil area is estimated at less than one cubic yard, which is minimal. Therefore, mercury concentrations in soil at DA3 are not considered a potential threat to ecological receptors.

3.7.3 Summary of Potential Risks to Human Health and Ecological Receptors

The results of the RI have determined that there are no releases of contaminants at DA2 and DA3 that require response actions. The concentrations of constituents in groundwater and soil are at concentrations that are protective of human health. That is, concentrations detected are below MTCA Method A for residential land use, and/or MCLs and EPA PRGs. The cleanup standards (MTCA Method A), MCLs, and screening criteria (PRGs) are based on protection of human health. Therefore, the concentrations detected at DA2 and DA3 are protective of human health and there are no potential risks to human health from constituents in groundwater or soil at the demolition areas.

The concentrations of metals detected are in the range of naturally occurring concentrations of metals in soil at Camp Bonneville and/or are so limited in area and volume they are not considered a significant threat to ecological receptors. Therefore, there are no COPC at DA2 and DA3 that are considered to be a potential risk to ecological receptors. Based on the outcomes of the above “problem formulation”, no further site-specific terrestrial ecological evaluation is necessary because the there are no COPC impacts to ecological receptors.

Table 3-1 Well Construction Summary

Well Number	**LC-MW-01S**	**LC-MW-01D**	**LC-MW-02S**	**LC-MW-02D**	**LC-MW-03S**	**LC-MW-03D**	**LC-MW-04S**	**LC-MW-04D**
Height of casing above ground level	3	2.67	2.7	3.1	2.35	2.48	2.8	2.63
Total length of well from top of casing	23	42.5	17.7	38.1	20.35	39.65	16.8	37.3
Total depth of well below ground level	20	39.83	15	35	18	37.17	14	34.67
Depth to top of well screen below ground level	10	29.83	10	25	13	27.17	9	24.67
Well screen length	10	10	5	10	5	10	5	10
Well screen slot size	0.010 inch	0.010 inch	0.010 inch	0.010 inch	0.010 inch	0.010 inch	0.010 inch	0.010 inch
Well diameter	2 inch	2 inch	2 inch	2 inch	2 inch	2 inch	2 inch	2 inch
Monitoring well casing material	PVC	PVC	PVC	PVC	PVC	PVC	PVC	PVC
Monitoring well screen material	PVC	PVC	PVC	PVC	PVC	PVC	PVC	PVC
Grout thickness below ground level	--	22	--	20	--	19	--	16.5
Depth to top of bentonite seal below ground level	2	24.08	2	19	2	21	2	18.5
Bentonite seal thickness	6	3.67	6	3	9	4	7	3.33
Depth to top of sand pack from ground level	8	27.75	8	22	11	25	9	21.83
Elevation-top of monitoring well casing	290.16	290.25	291.19	291.59	290.91	290.98	291.63	291.79
Elevation at ground level	287.16	287.58	288.49	288.49	288.56	288.50	288.83	289.16
Depth to static water level								
Date measured	20-Jan-03	20-Jan-03	20-Jan-03	20-Jan-03	20-Jan-03	20-Jan-03	20-Jan-03	20-Jan-03
From top of monitoring well casing	4.84	5.29	5.16	5.74	4.56	4.77	4.51	5.20
From ground level	1.84	2.62	2.46	2.64	2.21	2.29	1.71	2.57
Ground-water elevation	285.32	284.96	286.03	285.85	286.35	286.21	287.12	286.59
Date measured	21-Jan-03	21-Jan-03	21-Jan-03	21-Jan-03	21-Jan-03	21-Jan-03	21-Jan-03	21-Jan-03
From top of monitoring well casing	4.85	5.30	5.21	5.76	4.60	4.79	4.53	5.24
From ground level	1.85	2.63	2.51	2.66	2.25	2.31	1.73	2.61
Ground-water elevation	285.31	284.95	285.98	285.83	286.31	286.19	287.10	286.55

Table 3-1 Well Construction Summary (Continued).

Well Number	**LC-MW-05S**	**LC-MW-05D***	**LC-MW-06S**	**LC-MW-07S**	**LC-MW-08S**	**LC-MW-09S**	**LC-MW-10S**	**LC-MW-11S**
Height of casing above ground level	3.7	--	2.84	3.8	3.68	2.4	1.8	3
Total length of well from top of casing	40.7	--	17.84	40.8	40.68	19.9	26.05	19.8
Total depth of well below ground level	37	62	15	37	37	17.5	24.25	16.8
Depth to top of well screen below ground level	22	52	8	22	22	7.5	9.25	6.8
Well screen length	15	10	7	15	15	10	15	10
Well screen slot size	0.010 inch	0.010 inch	0.010 inch	0.010 inch	0.010 inch	0.010 inch	0.010 inch	0.010 inch
Well diameter	2 inch	2 inch	2 inch	2 inch	2 inch	2 inch	2 inch	2 inch
Monitoring well casing material	PVC	PVC	PVC	PVC	PVC	PVC	PVC	PVC
Monitoring well screen material	PVC	PVC	PVC	PVC	PVC	PVC	PVC	PVC
Grout thickness below ground level	17	41.92	--	15	17	--	--	--
Depth to top of bentonite seal below ground level	--	45.92	2	17	--	2	2	2
Bentonite seal thickness	--	2.91	4	3	--	3	6	3
Depth to top of sand pack from ground level	19	48.83	6	20	19	5	8	5
Elevation-top of monitoring well casing	310.10	309.94	308.27	308.92	309.78	347.31	351.47	345.72
Elevation at ground level	306.4	--	305.43	305.12	306.1	344.91	349.67	342.72
Depth to static water level								
Date measured	20-Jan-03	20-Jan-03	20-Jan-03	20-Jan-03	20-Jan-03	20-Jan-03	20-Jan-03	20-Jan-03
From top of monitoring well casing	7.75	Overflowing*	5.57	8.18	7.56	5.7	10.26	7.25
From ground level	4.05	Artesian*	2.73	4.38	3.88	3.3	8.46	4.25
Ground-water elevation	302.35	309+	302.7	300.74	302.22	341.61	341.21	338.47
Date measured	21-Jan-03	21-Jan-03	21-Jan-03	21-Jan-03	21-Jan-03	21-Jan-03	21-Jan-03	21-Jan-03
From top of monitoring well casing	7.60	overflowing	5.69	8.1	7.51	5.69	9.7	7.24
From ground level	3.9	Artesian	2.85	4.3	3.83	3.29	7.9	4.24
Ground-water elevation	302.50	309+	302.58	300.82	302.27	341.62	341.77	338.48

* LC-MW-05D was a flowing artesian well during sampling.

Table 3-1 Well Construction Summary (Continued).

Well Number	**SP-MW-01**	**SP-MW-02**	**PM-MW-01**	**PM-MW-02**	**L3-MW-04**	**L3-MW-01**	**L2-MW-03**
Height of casing above ground level	3.1	2.98	3.37	3.0	3.18	3.3	3.0
Total length of well from top of casing	18.1	21.98	32.37	23.1	33.88	18.4	13.52
Total depth of well below ground level	15.0	19.0	29.0	21.5	30.7	15.1	10.5
Depth to top of well screen below ground level	2.6	3.1	3.4	4.2	--	1.7	3.0
Well screen length	9.8	13.6	23.6	15.7	--	9.8	7.2
Well screen slot size	0.008"	0.008"	0.008"	0.008"	0.008"	0.008"	0.008'
Well diameter	8.0	8.0	8.0	8.0	8.0	8.0	8.0
Monitoring well casing material	PVC	PVC	PVC	PVC	PVC	PVC	PVC
Monitoring well screen material	PVC	PVC	PVC	PVC	PVC	PVC	PVC
Grout thickness below ground level	--	--	--	--	--	--	--
Depth to top of bentonite seal below ground level	1.0	1.0	1.0	1.0	--	1.0	1.0
Bentonite seal thickness	1.0	1.0	2.0	2.0	--	0.5	1.0
Depth to top of sand pack from ground level	2.0	2.0	3.0	3.0	--	1.5	2.0
Elevation-top of monitoring well casing	332.99	337.18	387.87	356.36	341.18	340.32	367.26
Elevation at ground level	329.9	334.2	384.5	353.4	338.0	337.0	364.2
Depth to static water level							
Date measured	20-Jan-03	20-Jan-03	20-Jan-03	20-Jan-03	20-Jan-03	20-Jan-03	20-Jan-03
From top of monitoring well casing	4.89	5.75	18.15	11.84	4.73	6.60	12.54
From ground level	1.79	2.77	14.78	8.84	1.55	3.3	9.54
Ground-water elevation	328.1	331.43	369.72	344.52	336.45	333.72	354.72
Date measured	21-Jan-03	21-Jan-03	21-Jan-03	21-Jan-03	21-Jan-03	21-Jan-03	21-Jan-03
From top of monitoring well casing	4.91	5.18	18.14	11.88	4.74	6.58	12.56
From ground level	1.81	2.20	15.04	8.88	2.04	3.38	9.56
Ground-water elevation	328.08	332.00	369.73	344.48	336.44	333.74	354.70

Table 3-2 Summary of Sampling and Analyses

Investigation Area and Sample Types and Identification/Location	Laboratory Analysis	Analytical Method (SW 846, EPA, or State of Washington Department of Ecology approved)
DEMOLITION AREAS 2/3		
14-20 January 2003 (CHPPM) **Groundwater Samples** Wells:		
LC-MW-09S	Explosives[b]	USACHPPM CAD 13.2
LC-MW-10S	PETN	USACHPPM CAD 13.2
LC-MW-11S	Picric Acid	USACHPPM CAD 63
LC-MW-5D	NG	USACHPPM CAD 13.2
LC-MW-5S	NQ	USACHPPM CAD 45
LC-MW-6S	Perchlorate	EPA 314.0
LC-MW-7S	Total Metals[a],	EPA 6020/EPA 7470/7471 for Mercury
LC-MW-8S	Dissolved Metals[a]	EPA 6020/EPA 7470/7471 for Mercury
	Chloride, Sulfate	EPA 300.0
	Total Alkalinity,	EPA 310.1
	Nitrite/Nitrates as Nitrogen,	EPA 353.3
	TOC, DOC,	EPA 415.1
	TSS	EPA 160.2
27 February 2003 **AEM** **Soil Samples**	Explosives	EPA 8330
	Picric Acid	EPA 8330
	PETN	EPA 8330
Center of Area and 100 feet N, S, E, and W at surface, 2 ft. and 5 ft. bgs; and Berm Samples (DA2) Four boreholes, four compass points around crater, berm and sides and bottom of hole from barrel removal.(DA3)	Perchlorate	EPA 314
	Metals[c]	EPA 6010B

Investigation Area and Sample Types and Identification/Location	Laboratory Analysis	Analytical Method (SW 846, EPA, or State of Washington Department of Ecology approved)
BOUNDARY AREA		
14-19 January 2003 (CHPPM) **Groundwater Samples**		
Wells:	TPH	NWTPH-HCID
LC-MW-01S	TPH-DRO	NWTPH-Dx
LC-MW-01D	TPH-GRO	NWTPH-Gx
LC-MW-02S	Explosives	USACHPPM CAD 13.2
LC-MW-02D	PETN	USACHPPM CAD 13.2
LC-MW-03S	Picric Acid	USACHPPM CAD 63
LC-MW-03D	NG	USACHPPM CAD 13.2
LC-MW-04S	NQ	USACHPPM CAD 45
LC-MW-04D	Perchlorate	EPA 314.0
	Total metals	EPA 6020/EPA 7470/7471 for Mercury
	Dissolved Metals	EPA 6020/EPA 7470/7471 for Mercury
	SVOCs	
	VOCs	EPA 8270B
	Chloride, Sulfate	EPA 8260B
	Total Alkalinity,	EPA 300.0
	Nitrite/Nitrates as	
	Nitrogen,	EPA 310.1
	TOC, DOC,	
	TSS	EPA 353.3
		EPA 415.1
		EPA 160.2
15 April 2003 (PPC) **Groundwater Samples for boundary area and DA3**	Perchlorate	EPA 314.0
	Nitrite/Nitrates as Nitrogen	EPA 353.3
Wells: LC-MW-01S,LC-MW-01D LC-MW-02S,LC-MW-02D LC-MW-5S, LC-MW-5D LC-MW-6S, LC-MW-7S LC-MW-8S		

Notes:

[a] CHPPM Metal analyses included: antimony, arsenic, beryllium, cadmium, chromium, copper, lead, mercury, nickel, selenium, silver, thallium, and zinc.

[b] The CAD-13, CAD-45 and CAD-63 procedures have been developed by CHPPM as a slightly modified version of the EPA Method 8095. The procedures are based on analysis of energetics using gas chromatography (GC) with electron capture detection (ECD), these methods were developed to provide greater sensitivity than the traditional EPA Method 8330. Detection limits for Method 8095 are typically lower than Method 8330 for comparable extracts.

Ammonium perchlorate is analyzed by ion chromatography using EPA Method 314.
[c] AEM Metals included: antimony, arsenic, barium, cadmium, chromium, copper, lead, nickel, and zinc.
PETN = pentaerythritol tetranitrate
SVOCs = semi-volatile organic compounds
TPH = total petroleum hydrocarbons
VOCs = volatile organic compounds
NQ = Nitroguanadine
NG = Nitroglycerine

Table 3-3 Analytical Results - Groundwater at Demolition Area 2

Analytical Results for Demolition Area 2 Wells CHPPM data from January 19 - 20, 2003					
Constituent	**Units**	**Well: 9S**	**10S**	**10S Dup.**	**11S**
Chloride	mg/L	1.5	1.5	1.5	ND (filtered)
Sulfate	mg/L	ND	1.6	1.8	ND (filtered)
Total Alkalinity	mg/L as CaCO3	24	22	23	ND (filtered)
Dissolved Organic Carbon	mg/L	ND	0.5	ND	4.2 (filtered)
Nitrate/Nitrite – N [a]	mg/L	18 R	6.4 R	17 R	15 R(filtered)
Total Organic Carbon	mg/L	ND	0.5	ND	5.1 (filtered)
Total Suspended Solids	mg/L	13	340	282	No Results
PH	units	5.8	5.46		6.58
Temperature	Degrees C	8.4	9.9		10.6
Dissolved Oxygen	% saturation	26.1	58.6		1.3
Redox	mV	271	182		16
Conductivity	us/cm	61	36		443
Turbidity	NTU	21.8	196		2.32
Explosives/PETN/Pitric Acid [C]	ug/L	ND	ND	ND	ND
Perchlorate [a]	ug/L	ND R	0.17 R	0.25 R	ND R
Total Arsenic	ug/L	ND	ND	ND	ND
Dissolved Arsenic	ug/L	ND	ND	ND	ND
Total Copper	ug/L	ND	11.5	7.82	ND
Dissolved Copper	ug/L	ND	ND	ND	ND
Total Lead	ug/L	ND	5.14	ND	ND
Dissolved Lead	ug/L	ND	ND	ND	ND
Total Zinc	ug/L	13.3	14.3	11.6	11
Dissolved Zinc	ug/L	ND	ND	ND	ND
All other Metals[b]	ug/L	ND	ND	ND	ND

Notes:

[a] Nitrite/Nitrates and Perchlorate analyses by CHPPM were determine to be invalid for this sample set Perchlorate data collected during subsequent 11 quarters of groundwater sampling are included in Appendix B.

[b] Non Detect values for metals analyzed are as follows: Antimony (5 ug/L), Arsenic (4 ug/L), Beryllium (2 ug/L), Cadmium (4 ug/L), Chromium (4 ug/L), Copper (5 ug/L), Lead (4 ug/L), Mercury (0.20 ug/L), Nickel (10 ug/L), Selenium (4 ug/L), Silver (2 ug/L), Thallium (4 ug/L), and Zinc (5 ug/L).

[C] A complete list of explosives and reporting limits is presented on page A-46 of Appendix C.

ND- indicates a non-detect at detection limit and/or reporting limit.
R- indicates result is invalid and rejected
J – indicates result is an estimate and below method detection limit
Dup – duplicate sample
Bold values are above MTCA and/or EPA Region 9 PRGs
All reporting limits (ND values) are presented in Appendix C

Table 3-4 Analytical Results – Groundwater at Boundary Area and Demolition Area 3

Project Performance Corporation 15 April 2003									
Well	**Field Data**						**Laboratory Data**		
	Ground-water Elev. Ft. (amsl)	Temp (°C)	PH	DO (mg/L)	Conductivity (uS/cm)	Turbidity (NTU)	Perchlorate ARI STL (ug/L)		Nitrite/ Nitrate (mg/L)
	Boundary Wells								
LC-MW-01S	286.21	10.0	6.15	4.89	107	18	< 2	< 1	< 0.61
LC-MW-01D	285.82	10.7	6.50	4.69	119	48	< 2	< 1	< 0.61
LC-MW-02S	286.46	10.0	6.55	5.61	121	60	< 2	< 1	< 0.61
LC-MW-02D	286.53	10.6	6.55	5.75	125	20	< 2	< 1	< 0.61
	Demo Area 3 Wells								
LC-MW-05S	303.62	10.6	7.17	0 R[a]	474	90	< 2	< 1	1.11
LC-MW-05D	309.73	11.1	6.87	0 R[a]	202	126	< 2	< 1	1.16
LC-MW-06S	303.30	9.4	6.82	0 R[a]	432	112	< 2	< 1	< 0.61
LC-MW-07S	301.92	10.5	7.18	0 R[a]	511	73	< 2	< 1	0.59
LC-MW-08S	303.35	10.5	7.00	0R[a]	2,200	38	< 2	< 1	2.23

Notes:

[a] Dissolved oxygen concentrations were observed during purging, but were zero (0) just prior to sample collection and could have been due to faulty DO probe.

ARI – samples analyzed by Analytical Resources Inc.

STL – samples analyzed by Severn Trent Laboratories

ND- indicates a non-detect at detection limit and/or reporting limit.

R- indicates result was invalid and rejected

J – indicates result is an estimate and below method detection limit

Dup – duplicate sample

Bold values are above MTCA and/or EPA Region 9 PRGs

All reporting limits (ND values) are presented in Appendix E

Table 3-5 Analytical Results - Soil at Demolition Area 2 – Explosives

AEM Results February 2003									
Sample ID	S70130227C	S70230227C	S70330227C	S70430227C	S70530227C	S70630227C	S70730227C	S70830227C	S70930227C
Sample Location	Center			100 ft. North			100 ft. South		
Sample Depth	Surface	2.5 ft	5 ft	Surface	2.5 ft	5 ft	Surface	2.5 ft	5 ft
Constituent	**Concentration (mg/Kg)**								
Octahydro-1,3,5,7, -tetranitro-1,3,5,7-tetrazocine (HMX)	<2.8	<2.6	Not Sampled (NS)	<2.7	<2.8	Not Sampled (NS)	<2.5	<2.7	<3.0
Hexahydro-1,3,5-trinitro-1,3,5-triazine (RDX)	<2.8	<2.6	NS	<2.7	<2.8	NS	<2.5	<2.7	<3.0
1,3,5-Trinitrobenzene (1,3,5-TNB)	<2.8	<2.6	NS	<2.7	<2.8	NS	<2.5	<2.7	<3.0
1,3-Dintirobenzene (1,3-DNB)	<2.8	<2.6	NS	<2.7	<2.8	NS	<2.5	<2.7	<3.0
Methyl-2,4,6-trinitrotoluene (Tetryl)	<2.8	<2.6	NS	<2.7	<2.8	NS	<2.5	<2.7	<3.0
Nitrobenzene (NB)	<2.8	<2.6	NS	<2.7	<2.8	NS	<2.5	<2.7	<3.0
2,4,6-Trinitrotoluene (2,4,6-TNT)	<2.8	<2.6	NS	<2.7	<2.8	NS	<2.5	<2.7	<3.0
4-Amiro-2,6-dintrotoluene (4-Am-DNT)	<2.8	<2.6	NS	<2.7	<2.8	NS	<2.5	<2.7	<3.0
2-Amiro-4,6-dinitrotoluene (2-Am-DNT)	<2.8	<2.6	NS	<2.7	<2.8	NS	<2.5	<2.7	<3.0
2,4-Dinitrotoluene (2,4-DNT)	<2.8	<2.6	NS	<2.7	<2.8	NS	<2.5	<2.7	<3.0
2,6-Dinitrotoluene (2,6-DNT)	<2.8	<2.6	NS	<2.7	<2.8	NS	<2.5	<2.7	<3.0
2-Nitrotoluene (2-NT)	<2.8	<2.6	NS	<2.7	<2.8	NS	<2.5	<2.7	<3.0
3-Nitrotoluene (3-NT)	<2.8	<2.6	NS	<2.7	<2.8	NS	<2.5	<2.7	<3.0
4-Nitrotoluene (4-NT)	<2.8	<2.6	NS	<2.7	<2.8	NS	<2.5	<2.7	<3.0
Picric Acid	<10	<10	NS	<10	<10	NS	<10	<10	<10
Pentaerthritol Tetranitrate (PETN)	<14	<13	NS	<14	<14	NS	<13	<14	<15
Perchlorate	<0.033	<0.033	NS	<0.33	<0.33	NS	<0.33	<0.33	<0.33

Table 3-5 Analytical Results - Soil at Demolition Area 2 – Explosives (Continued)

AEM Results February 2003									
Sample ID	S71030227C	S71130227C	S71230227C	S71330227C	S71430227C	S71530227C	S71630227C	S71730227C	S71830227C
Sample Location	100 ft. East of Center			100 ft. West of Center			Berm-SW	Berm-Center	Berm-NE
Sample Depth	Surface	2.5 ft	4 ft	Surface	2.5 ft	5 ft	2 ft.	2 ft.	2 ft.
Constituent	**Concentration (mg/Kg)**								
Octahydro-1,3,5,7, -tetranitro-1,3,5,7-tetrazocine (HMX)	<3.1	<2.7	<3.2	<2.9	<2.5	Not Sampled (NS)	<2.8	<2.7	<2.5
Hexahydro-1,3,5-trinitro-1,3,5-triazine (RDX)	<3.1	<2.7	<3.2	<2.9	<2.5	NS	<2.8	<2.7	<2.5
1,3,5-Trinitrobenzene (1,3,5-TNB)	<3.1	<2.7	<3.2	<2.9	<2.5	NS	<2.8	<2.7	<2.5
1,3-Dintirobenzene (1,3-DNB)	<3.1	<2.7	<3.2	<2.9	<2.5	NS	<2.8	<2.7	<2.5
Methyl-2,4,6-trinitrotoluene (Tetryl)	<3.1	<2.7	<3.2	<2.9	<2.5	NS	<2.8	<2.7	<2.5
Nitrobenzene (NB)	<3.1	<2.7	<3.2	<2.9	<2.5	NS	<2.8	<2.7	<2.5
2,4,6-Trinitrotoluene (2,4,6-TNT)	<3.1	<2.7	<3.2	<2.9	<2.5	NS	<2.8	<2.7	<2.5
4-Amiro-2,6-dintrotoluene (4-Am-DNT)	<3.1	<2.7	<3.2	<2.9	<2.5	NS	<2.8	<2.7	<2.5
2-Amiro-4,6-dinitrotoluene (2-Am-DNT)	<3.1	<2.7	<3.2	<2.9	<2.5	NS	<2.8	<2.7	<2.5
2,4-Dinitrotoluene (2,4-DNT)	<3.1	<2.7	<3.2	<2.9	<2.5	NS	<2.8	<2.7	<2.5
2,6-Dinitrotoluene (2,6-DNT)	<3.1	<2.7	<3.2	<2.9	<2.5	NS	<2.8	<2.7	<2.5
2-Nitrotoluene (2-NT)	<3.1	<2.7	<3.2	<2.9	<2.5	NS	<2.8	<2.7	<2.5
3-Nitrotoluene (3-NT)	<3.1	<2.7	<3.2	<2.9	<2.5	NS	<2.8	<2.7	<2.5
4-Nitrotoluene (4-NT)	<3.1	<2.7	<3.2	<2.9	<2.5	NS	<2.8	<2.7	<2.5
Picric Acid	<10	<10	<10	<10	<10	NS	<10	<10	<10
Pentaerthritol Tetranitrate (PETN)	<16	<14	<16	<15	<13	NS	<14	<4	<13
Perchlorate	<0.033	<0.033	<0.033	<0.33	<0.33	NS	<0.33	<0.33	<0.33

Table 3-6 Analytical Results - Soil at Demolition Area 2 – Metals.

Sample Location	**Center of Area**			**100 ft. North of Center**			**100 ft. South of Center**		
Sample Depth	Surface	2.5 ft.	5 ft.	Surface	2.5 ft.	5 ft.	Surface	2.5 ft.	5 ft.
Sample Number	S70130227C	S70230227C	S70330227C	S70430227C	S70530227C	S70630227C	S70730227C	S70830227C	S70930227C
Priority Pollutant Metal	**Concentration (mg/Kg)**								
Antimony	<10.9	<10.9	NS	<10.7	<11.9	NS	<11.3	<11.5	<10.9
Arsenic	<21.8	<21.8	NS	<21.3	<23.7	NS	<22.6	<23.0	28.5
Barium	152.0	121.0	NS	208.0	215.0	NS	166.0	180.0	123.0
Cadmium	<1.1	<1.1	NS	<1.1	<1.2	NS	<1.1	<1.2	<1.1
Chromium	43.0	42.3	NS	25.3	36.7	NS	33.3	33.6	43.6
Copper	87.7	82.4	NS	70.7	127.0	NS	96.2	90.6	105.0
Lead	17.8	16.6	NS	17.6	23.9	NS	16.4	16.6	28.2
Nickel	<21.8	<21.8	NS	<21.3	<23.7	NS	<22.8	<23.0	<21.8
Zinc	101.0	52.6	NS	86.8	75.5	NS	61.1	76.2	73.7
Sample Location	**100 ft. East of Center**			**100 ft. West of Center**			**Berm-SW**	**Berm-Center**	**Berm-NE**
Sample Depth	Surface	2.5 ft.	5 ft.	Surface	2.5 ft.	5 ft.	2 ft.	2 ft.	2 ft.
Sample Number	S71030227C	S71130227C	S71230227C	S71330227C	S71430227C	S71530227C	S71630227C	S71730227C	S71830227C
Priority Pollutant Metal	**Concentration (mg/Kg)**								
Antimony	<11.7	<11.4	<11.6	<10.5	<11.1	NS	<10.4	<11.6	<11.8
Arsenic	<23.4	29.4	23.6	30.1	29.7	NS	<20.7	<23.3	29.3
Barium	228.0	262.0	454.0	181.0	130.0	NS	264.0	246.0	313.0
Cadmium	<1.2	<1.1	<1.2	<1.1	<1.1	NS	<1.0	<1.2	<1.2
Chromium	36.8	39.0	34.9	30.1	31.2	NS	30.3	34.2	37.1
Copper	117.0	120.0	160.0	77.4	63.8	NS	92.6	94.9	104.0
Lead	27.2	27.8	28.5	21.6	15.0	NS	16.8	22.3	24.9
Nickel	<23.4	<22.9	<23.1	<21.0	<22.1	NS	36.5	<23.3	<23.6
Zinc	84.7	66.2	81.2	69.4	50.0	NS	74.6	68.1	75.5

Table 3-7 Analytical Results – Groundwater at Demolition Area 3

Analytical Results from Demolition 3 Area Wells						
CHPPM data January 14 - 20						
Constituent	**Units**	**Well: 5D**	**5S**	**6S**	**7S**	**8S**
Chloride	mg/L	13	240	73	47	780
Sulfate	mg/L	17	220	14	23	640
Total Alkalinity	mg/L as CaCO3	74	82	144	115	79
Dissolved Organic Carbon	mg/L	0.9	0.7	1.4	1.5	1.3
Nitrate/Nitrite – N [a]	mg/L	9.8 R[a]	9.7 R[a]	13 R[a]	4.4 R[a]	14 R[a]
Total Organic Carbon	mg/L	0.8	0.5	1.2	1.5	1
Total Suspended Solids	mg/L	29	3	140	4	4
PH	units	7.31	7.24	7.01	7.4	7.31
Temperature	Degrees C	11.5	10	9.5	10.6	10.7
Dissolved Oxygen	% saturation	38.7	22.6	13.1	20.6	48.3
Redox	mV	159	169	89	155	164
Conductivity	uS/cm	212	1570	614	499	1512
Turbidity	NTU	14	3.6	15.5	13.2	11.8
Explosives/PETN/Pitric Acid[C]	ug/L	ND	ND	ND	ND	ND
Perchlorate	ug/L	1 R[a]	ND R[a]	ND R[a]	12 R[a]	ND R[a]
Total Arsenic	ug/L	ND	ND	ND	ND	ND
Dissolved Arsenic	ug/L	ND	ND	ND	4.08	9.86
Total Copper	ug/L	5.79	ND	ND	ND	ND
Dissolved Copper	ug/L	ND	ND	ND	ND	ND
Total Lead	ug/L	5.29	ND	ND	ND	4.65
Dissolved Lead	ug/L	ND	ND	ND	ND	ND
Total Zinc	ug/L	16.1	8.2	25.7	27.6	9.45
Dissolved Zinc	ug/L	ND	ND	7.17	ND	11.7
All other Metals[b]	ug/L	ND	ND	ND	ND	ND
VOCs/SVOCs	ug/L	ND	ND	NA	NA	NA
Total Petroleum Hydrocarbons	mg/L	ND	ND	NA	NA	NA
TPH - Gasoline	mg/L	ND	ND	NA	NA	NA
TPH – Diesel	mg/L	0.080J	0.037J	NA	NA	NA

Notes:
[a] Nitrate/Nitrite and Perchlorate analyses by CHPPM were determind to be in valid and resampling and analyses were conducted by PPCin April 2003 (see Table 3-4)
[b] Non Detect values for metals analyzed are as follows: Antimony (5 ug/L), Arsenic (4 ug/L), Beryllium (2 ug/L), Cadmium (4 ug/L), Chromium (4 ug/L), Copper (5 ug/L), Lead (4 ug/L), Mercury (0.20 ug/L), Nickel (10 ug/L), Selenium (4 ug/L), Silver (2 ug/L), Thallium (4 ug/L), and Zinc (5 ug/L).
[C] A complete list of explosives and reporting limits is presented on page A-46 of Appendix C.
ND- indicates a non-detect at detection limit and/or reporting limit.
NA – not analyzed
R- indicates result is invalid and rejected
J – indicates result is an estimate and below method detection limit
Dup – duplicate sample
All reporting limits (ND values) are presented in Appendix C
Bold values are above MTCA and/or EPA Region 9 PRGs

Table 3-8 Analytical Results – Soil at Demolition Area 3 - Well Boreholes

CHPPM results								
Sample ID	LC-MW-05S-0	LC-MW-05S-0 Dup	LC-MW-05S-2	LC-MW-05S-5	LC-MW-05S-15	LC-MW-06S-0	LC-MW-06S-2	LC-MW-06S-5
Sample Location	Borehole LC-MW-05S					Borehole LC-MW-06S		
Sample Date	15-Nov-02	15-Nov-02	15-Nov-02	15-Nov-02	15-Nov-02	16-Nov-02	16-Nov-02	16-Nov-02
Sample Depth	Surface	Surface	2 ft	5 ft	15 ft	Surface	2 ft	5 ft
Explosives (ug/g)								
2,4,6-TNT	ND	ND	ND	ND	ND	ND	ND	ND
RDX	ND	ND	ND	ND	ND	0.027 J	ND	ND
4AM26DNT	ND	ND	ND	ND	ND	ND	ND	ND
2AM46DNT	ND	ND	ND	ND	ND	ND	ND	ND
Other Explosives and Perchlorate [a]	ND	ND	ND	ND	ND	ND	ND	ND
Total Metals (mg/Kg)								
Arsenic	2.22	1.79	3.17	2.58	ND	2.46	6.08	3.92
Chromium	17.6	17.4	14.5	15.3	12.2	17.7	24.8	15.1
Copper	32.8	34.8	104	144	52.6	31.5	49.3	122
Lead	13.1	12	8.27	4.97	8.7	12.8	14	10.6
Mercury	0.0545	0.0782	0.0518	ND	ND	0.0644	ND	ND
Nickel	10.3	9.09	11	12.7	4.4	10.8	13.4	1.32
Zinc	72.3	58.1	79.3	85.3	39.3	74.4	61.8	90.9
Other Metals (Antimony, Beryllium, Cadmium, Selenium, Silver, and Thallium)	ND	ND	ND	ND	ND	ND	ND	ND

Notes:
[a] A list of explosives and reporting limits is presented on page A-75 in Appendix C. Perchlorate was not detected at the reporting limits of 0.0040 – 0.0052 mg/kg.
ND- indicates a non-detect at detection limit and/or reporting limit.
J – indicates result is an estimate and below method detection limit
Dup – duplicate sample
Bold values are above MTCA and/or EPA Region 9 PRGs.
All reporting limits (ND values) are presented in Appendix C.
Maximum Reporting Limits for Other Metals are as follows: Antimony (1.57 mg/kg), Beryllium (1.57 mg/kg), Cadmium (1.57 mg/kg), Selenium (3.14 mg/kg), Silver (1.57 mg/kg), and Thallium (1.57 mg/kg). See page A-107 in Appendix C for sample specific reporting limits.

Table 3-8 Analytical Results – Soil at Demolition Area 3 - Well Boreholes (Continued)

CHPPM results									
Sample ID	LC-MW-07S-0	LC-MW-07S-0DUP	LC-MW-07S-2	LC-MW-07S-5	LC-MW-07S-15	LC-MW-08S-0	LC-MW-08S-2	LC-MW-08S-5	LC-MW-08S-15
Sample Location	Borehole LC-MW-07S					LC-MW-08S-0			
Sample Date	16-Nov-02	16-Nov-02	16-Nov-02	16-Nov-02	16-Nov-02	16-Nov-02	16-Nov-02	16-Nov-02	16-Nov-02
Sample Depth	Surface	Surface	2 ft	5 ft	15 ft	Surface	2 ft	5 ft	15 ft
Explosives (ug/g)									
2,4,6-TNT	0.51	ND	ND	ND	ND	ND	ND	ND	ND
RDX	0.047 J	ND	0.036 J	0.030 J	0.048 J	0.032 J	ND	ND	0.27
4AM26DNT	0.11	0.12	ND	ND	ND	ND	ND	ND	ND
2AM46DNT	0.22	0.14	ND	ND	ND	ND	ND	ND	ND
Other Explosives and Perchlorate [a]	ND	ND	ND	ND	ND	ND	ND	ND	ND
Total Metals (mg/Kg)									
Arsenic	1.99	2.93	2.92	2.67	ND	2.24	5.42	2.59	ND
Chromium	19.5	19.6	16.4	19.8	9.57	17.3	24	18.2	14.9
Copper	41.4	41.8	125	182	166	31.9	49.3	104	108
Lead	13.8	14.3	7.79	5.61	9.73	12.3	14.1	10.9	9.31
Mercury	ND	0.0586	ND	ND	ND	ND	ND	ND	ND
Nickel	11.6	11.8	13.9	19.9	5.71	8.74	23	12.8	5.26
Zinc	76.3	79.5	100	97.8	30	65.6	72.9	87.7	49
Other Metals (Antimony, Beryllium, Cadmium, Selenium, Silver,and Thallium)	ND	ND	ND	ND	ND	ND	ND	ND	ND

Notes:
[a] A list of explosives and reporting limits is presented on page A-75 in Appendix C. Perchlorate was not detected at the reporting limits of 0.0040 – 0.0052 mg/kg.
ND- indicates a non-detect at detection limit and/or reporting limit.
J – indicates result is an estimate and below method detection limit.
Dup – duplicate sample
All reporting limits (ND values) are presented in Appendix C.
Maximum Reporting Limits for Other Metals are as follows: Antimony (1.57 mg/kg), Beryllium (1.57 mg/kg), Cadmium (1.57 mg/kg), Selenium (3.14 mg/kg), Silver (1.57 mg/kg), and Thallium (1.57 mg/kg).
See page A-107 in Appendix C for sample specific reporting limits.

Table 3-9 Analytical Results – Soil at Demolition Area 3 – Explosives

AEM Data									
Sample ID	S80330227C	S80430227C	S80530227C	S80630227C	S80730227C	S80830227C	S80930227C	S81030227C	WDA230321P
Sample Location	Periphery North		Periphery South		Periphery East		Periphery West		Water Standing in Crater
Sample Depth	Surface	2.5 ft	Surface	2.5 ft	Surface	2.5 ft	Surface	2.5 ft	
Constituent	**Concentration (mg/Kg)**								**Concentration (ug/L)**
Octahydro-1,3,5,7 -tetranitro-1,3,5,7-tetrazocine (HMX)	<2.8	<2.5	<3	<2.6	<2.5	<2.5	<2.7	<2.5	<3
Hexahydro-1,3,5-trinitro-1,3,5-triazine (RDX)	<2.8	<2.5	<3	<2.6	<2.5	<2.5	<2.7	<2.5	<3
1,3,5-Trinitrobenzene (1,3,5-TNB)	<2.8	<2.5	<3	<2.6	<2.5	<2.5	<2.7	<2.5	<3
1,3-Dintirobenzene (1,3-DNB)	<2.8	<2.5	<3	<2.6	<2.5	<2.5	<2.7	<2.5	<3
Methyl-2,4,6-trinitrophenylnitramine (Tetryl)	<2.8	<2.5	<3	<2.6	<2.5	<2.5	<2.7	<2.5	<3
Nitrobenzene (NB)	<2.8	<2.5	<3	<2.6	<2.5	<2.5	<2.7	<2.5	<3
2,4,6-Trinitrotoluene (2,4,6-TNT)	<2.8	<2.5	<3	<2.6	<2.5	<2.5	<2.7	<2.5	<3
4-Amiro-2,6-dintrotoluene (4-Am-DNT)	<2.8	<2.5	<3	<2.6	<2.5	<2.5	<2.7	<2.5	<3
2-Amiro-4,6-dinitrotoluene (2-Am-DNT)	<2.8	<2.5	<3	<2.6	<2.5	<2.5	<2.7	<2.5	<3
2,4-Dinitrotoluene (2,4-DNT)	<2.8	<2.5	<3	<2.6	<2.5	<2.5	<2.7	<2.5	<3
2,6-Dinitrotoluene (2,6-DNT)	<2.8	<2.5	<3	<2.6	<2.5	<2.5	<2.7	<2.5	<3
2-Nitrotoluene (2-NT)	<2.8	<2.5	<3	<2.6	<2.5	<2.5	<2.7	<2.5	<3
3-Nitrotoluene (3-NT)	<2.8	<2.5	<3	<2.6	<2.5	<2.5	<2.7	<2.5	<3
4-Nitrotoluene (4-NT)	<2.8	<2.5	<3	<2.6	<2.5	<2.5	<2.7	<2.5	<3
Picric Acid	<10	<10	<10	<10	<10	<10	<10	<10	<3
Pentaerythritol Tetranitrate (PETN)	<14	<13	<15	<13	<13	<13	<14	<13	<3
Perchlorate	<0.33	<0.033	<0.033	<0.33	<0.33	<0.33	<0.33	<0.33	<3

Table 3-9 Analytical Results – Soil at Demolition Area 3 – Explosives (Continued)

Center of Crater - November 2003							
Sample ID/Location	Center - North	Center - East	Center - South	Center - West	Bottom 1	Bottom 2	Bottom 2 (Duplicate)
Sample Depth	Surface	Surface	Surface	Surface	Surface	Surface	Surface
	Concentrations (mg/Kg), except Perchlorate (ug/Kg)						
Octahydro-1,3,5,7 -tetranitro-1,3,5,7-tetrazocine (HMX)	< 2.8	< 3.5	< 2.6	< 3.1	< 2.4	< 2.7	< 2.6
Hexahydro-1,3,5-trinitro-1,3,5-triazine (RDX)	< 2.8	< 3.5	< 2.6	< 3.1	< 2.4	< 2.7	< 2.6
1,3,5-Trinitrobenzene (1,3,5-TNB)	< 2.8	< 3.5	< 2.6	< 3.1	< 2.4	< 2.7	< 2.6
1,3-Dintirobenzene (1,3-DNB)	< 2.8	< 3.5	< 2.6	< 3.1	< 2.4	< 2.7	< 2.6
Methyl-2,4,6-trinitrophenylnitramine (Tetryl)	< 2.8	< 3.5	< 2.6	< 3.1	< 2.4	< 2.7	< 2.6
Nitrobenzene (NB)	< 2.8	< 3.5	< 2.6	< 3.1	< 2.4	< 2.7	< 2.6
2,4,6-Trinitrotoluene (2,4,6-TNT)	< 2.8	< 3.5	< 2.6	< 3.1	< 2.4	< 2.7	< 2.6
4-Amiro-2,6-dintrotoluene (4-Am-DNT)	< 2.8	< 3.5	< 2.6	< 3.1	< 2.4	< 2.7	< 2.6
2-Amiro-4,6-dinitrotoluene (2-Am-DNT)	< 2.8	< 3.5	< 2.6	< 3.1	< 2.4	< 2.7	< 2.6
2,4-Dinitrotoluene (2,4-DNT)	< 2.8	< 3.5	< 2.6	< 3.1	< 2.4	< 2.7	< 2.6
2,6-Dinitrotoluene (2,6-DNT)	< 2.8	< 3.5	< 2.6	< 3.1	< 2.4	< 2.7	< 2.6
2-Nitrotoluene (2-NT)	< 2.8	< 3.5	< 2.6	< 3.1	< 2.4	< 2.7	< 2.6
3-Nitrotoluene (3-NT)	< 2.8	< 3.5	< 2.6	< 3.1	< 2.4	< 2.7	< 2.6
4-Nitrotoluene (4-NT)	< 2.8	< 3.5	< 2.6	< 3.1	< 2.4	< 2.7	< 2.6
Picric Acid (mg/Kg)	< 16	< 18	< 15	< 16	< 14	< 16	< 14
Pentaerythritol Tetranitrate (PETN) (mg/Kg)	< 14	< 18	< 13	< 16	< 12	< 14	< 13
Perchlorate (ug/Kg)	< 180	< 180	< 180	< 180	< 180	< 180	< 180

Table 3-10 Analytical Results – Soil at Demolition Area 3 – Metals

AEM Data								
Sample Location	Periphery-North		Periphery-South		Periphery-East		Periphery-West	
Sample Depth	Surface	2.5 ft.	Surface	2.5 ft.	Surface	2.5 ft.	Surface	2.5 ft.
Sample Number	S80330227C	S80430227C	S80530227C	S80630227C	S80730227C	S80830227C	S80930227C	S81030227C
Priority Pollutant Metal	**Concentration (mg/Kg)**							
Antimony	<11.0	<10.5	<10.5	<10.7	<11.1	<10.5	<11.2	<10.6
Arsenic	<22.1	<21.1	<20.9	<21.3	<22.1	<21.0	<22.5	<21.2
Barium	198.0	116.0	143.0	109.0	221.0	108.0	206.0	116.0
Cadmium	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1
Chromium	17.6	15.8	13.2	21.4	14.9	18.5	19.0	18.0
Copper	140.0	40.0	55.8	42.7	79.7	50.4	113.0	44.4
Lead	11.6	8.6	10.4	11.7	13.3	11.8	18.7	9.3
Nickel	<22.1	<21.1	<20.9	<21.3	<22.1	<21.0	<22.5	<21.2
Zinc	69.1	56.0	56.1	44.3	55.5	54.4	73.2	53.7

Sample Location	Water in Center of Crater
Sample Depth	Surface
Sample Number	WDA230321P
Priority Pollutant Metal	**Concentration (ug/L)**
Antimony	<50
Arsenic	<100
Barium	<5.0
Cadmium	<5.0
Chromium	<5.0
Copper	<10.0
Lead	<50
Nickel	<20
Zinc	<10

Table 3-10 Analytical Results – Soil at Demolition Area 3 – Metals (Continued)

Center of Crater - November 2003						
Sample Location	Center - North	Center - East	Center - South	Center - West	Bottom 1	Bottom 2
Sample Depth	Surface	Surface	Surface	Surface	Surface	Surface
Sample Number	D3N	D3E	D3S	D3W	D3B1	D3B2
Metals (mg/kg)	**Concentration (mg/Kg)**					
Antimony	11.7	8.6	10.3	8.7	7.6	< 6.6
Arsenic	3.8	10.4	3.9	5.0	3.3	5.5
Beryllium	0.26	0.35	0.52	0.40	0.52	0.34
Cadmium	1.0	0.5	< 0.2	0.7	< 0.2	0.5
Chromium	17.7	21.4	18.7	21.8	23.0	20.4
Copper	164	363	104	151	141	178
Lead	6.1	120	7.6	10.1	8.3	22.0
Mercury	0.95	1.19	0.04	0.35	0.33	0.94
Nickel	12.8	14.8	13.6	15.5	13.6	14.1
Selenium	< 0.2	< 0.2	< 0.2	< 0.1	< 0.2	< 0.2
Silver	<2.2	< 1.9	< 2.3	< 2.2	< 2.3	< 2.2
Thallium	0.3	0.3	0.4	0.4	0.4	0.4
Zinc	97.4	144	77.4	106	89.7	123

Table 3-11 Analytical Results – Groundwater at Boundary Wells.

Analytical Results for Boundary Area Wells

CHPPM data from January 14 - 19, 2003

Analysis	**Units**	**Well: 1S**	**1D**	**1D Dup**	**2S**	**2D**	**3S**	**3D**	**4S**	**4D**
Chloride	mg/L	1.3	1.2	1.2	2.1	3.1	1.8	2.6	1.9	5.5
Sulfate	mg/L	ND	2.6	2.5	ND	6.9	ND	3	ND	6.9
Total Alkalinity	mg/L as CaCO3	52	52	51	53	51	63	61	44	67
Dissolved Organic Carbon	mg/L	ND	ND	ND	ND	ND	ND	ND	ND	ND
Nitrate/Nitrite – N [a]	mg/L	8.6 R [a]	8.8 R [a]	7.4 R [a]	4.5 R [a]	4 R [a]	12 R [a]	11 R [a]	10 R [a]	9.1 R [a]
Total Organic Carbon	mg/L	ND	ND	ND	ND	ND	ND	ND	ND	ND
Total Suspended Solids	mg/L	ND	ND	ND	ND	ND	ND	ND	7	3
PH	units	6.36	6.69		6.72	6.62	6.48	6.71	6.13	6.98
Temperature	Degrees C	10.7	11		10.5	10.5	9.7	9.3	9.7	9.5
Dissolved Oxygen	% saturation	61.3	53.7		77.5	57.2	93.9	60.9	58	25
Redox	mV	174	163		180	186	230	177	239	298
Conductivity	us/cm	89	98		113	120	10.2	130	91	163
Turbidity	NTU	0	5		0.5	11	1	9.3	6.6	12
Explosives/PETN/ Pitric Acid [C]	ug/L	ND	ND	ND	ND	ND	ND	ND	ND	ND
Perchlorate	ug/L	0.26R [a]	0.72R [a]	0.71R [a]	ND R [a]	ND R [a]	ND R [a]	ND R [a]	ND R [a]	ND R [a]
Total Copper	ug/L	ND	ND	ND	ND	ND	ND	ND	ND	ND
Dissolved Copper	ug/L	ND	ND	ND	ND	ND	ND	ND	ND	14.9
Total Lead	ug/L	ND	ND	ND	ND	ND	ND	ND	ND	ND
Dissolved Lead	ug/L	ND	ND	ND	ND	ND	ND	ND	ND	ND
Total Zinc	ug/L	22.6	16.1	9.7	15.2	12	5.7	7.22	18.7	29.2
Dissolved Zinc	ug/L	ND	ND	ND	ND	ND	ND	ND	ND	93
All other Metals[b]	ug/L	ND	ND	ND	ND	ND	ND	ND	ND	ND
VOCs/SVOCs	ug/L	ND	ND	ND	ND	ND	ND	ND	ND	ND
Total Petroleum Hydrocarbons	mg/L	0.2	ND	ND	ND	ND	ND	ND	ND	0.36
TPH - Gasoline	mg/L	ND	ND	ND	ND	ND	ND	ND	ND	ND
TPH - Diesel	mg/L	ND	0.041J	0.031J	ND	ND	ND	0.045J	ND	0.051J

Notes:

[a] Nitrate/Nitrite and Perchlorate analyses by CHPPM were determine not to be valid and resampling and analyses were conducted by PPC in April 2003 (see Table 3-4)

[b] Non Detect values for metals analyzed are as follows: Antimony (5 ug/L), Arsenic (4 ug/L), Beryllium (2 ug/L), Cadmium (4 ug/L), Chromium (4 ug/L), Copper (5 ug/L), Lead (4 ug/L), Mercury (0.20 ug/L), Nickel (10 ug/L), Selenium (4 ug/L), Silver (2 ug/L), Thallium (4 ug/L), and Zinc (5 ug/L).

[C] A complete list of explosives and reporting limits is presented on page A-46 of Appendix C.

ND- indicates a non-detect at detection limit and/or reporting limit.

R- indicates result is invalid and rejected

J – indicates result is an estimate and below method detection limit

Dup – duplicate sample

Bold values are above MTCA and/or EPA Region 9 PRGs

All reporting limits (ND values) are presented in Appendix C.

Table 3-12 Summary of Maximum Concentrations of Constituents Detected in Groundwater at DA2, DA3, and Boundary Area Wells.

Constituent	Sample Location	Maximum Concentration Detected (ug/L)	Screening or Cleanup Level (ug/L)	Regulatory Reference
Metals				
Arsenic	DA3 Well LC-MW-08S	9.86 ug/L (dissolved)	5 10	MTCA Method A EPA Proposed MCL
Copper	Boundary Well LC-MW-04D	14.9 ug/L (Dissolved)	1300	MCL Goal
Lead	DA3 Well LC-MW-05D	5.29 ug/L (Total)	15	MTCA Method A and MCL Treatment Technique Action Level
Zinc	Boundary Area Well LC-MW-04D	29.2 ug/L (Total)	500	Secondary MCL
Explosives				
Perchlorate	DA3 Well LC-MW-07S	< 2 ug/L*	3.6	EPA Region 9 PRG
Petroleum Hydrocarbons				
TPH-Diesel	Well LC-MW-04D	51 J ug/L	500 ug/L	MTCA Method A
TPH	Well LC-MW-04D	200 ug/L	1000 ug/L	MTCA Method A

Notes:
MCLs and Washington Board of Health values from CLARC Version 3.1- Potable Water -ARARs
PRGs – EPA Region 9 Preliminary Remediation Goals for Residential Soil.
MTCA values from Table 720-1 Method A Cleanup Levels for Ground Water
* The first perchlorate analysis (12ug/L) was determined to be invalid, resampling and analyses by two independent laboratories determined perchlorate concentration was < 2 ug/L.
J = Estimated value

Table 3-13 Summary of Maximum Concentrations of Constituents Detected in Soils at DA2 and DA3.

Constituent	Sample Location	Maximum Concentration Detected (mg/kg)	Screening or Cleanup Level (mg/kg)	Regulatory Reference
Metals				
Antimony	DA3 Center – North In Crater	11.7 mg/kg	31	EPA Region 9 PRG
Arsenic	DA2 100 feet W of Center, Surface	30.1 mg/kg	20	MTCA Method A
Barium	DA2 100 ft. E of Center, 5 ft. bgs	454 mg/kg	5400	EPA Region 9 PRG
Beryllium	DA3 Bottom 1 Center Crater	0.52 mg/kg	150	EPA Region 9 PRG
Cadmium	DA3 Center – North In Crater	1.0 mg/kg	2	MTCA Method A
Chromium	DA2 100 ft. S of Center, 5 ft. bgs	43.6 mg/kg	210	EPA Region 9 PRG
Copper	DA3 Center – East In Crater	363 mg/kg	2900	EPA Region 9 PRG
Lead	DA3 Center – East In Crater	120 mg/kg	250	MTCA Method A
Mercury	DA3 Center East In Crater	1.19 mg/kg	2 (inorganic)	MTCA Method A
Nickel	DA2 Berm SW 2 ft. bgs	36.5 mg/kg	1600	EPA Region 9 PRG
Thallium	DA3 Center of Crater	0.4 mg/kg	5.2	EPA Region 9 PRG
Zinc	DA3 Center – East In Crater	144 mg/kg	23000	EPA Region 9 PRG
Explosives				
2,4,6-TNT	DA3 Borehole LC-MW-07S, Surface	0.51 mg/kg	16	EPA Region 9 PRG
4-Am 2,6-DNT	DA3 Borehole LC-MW-07S, Surface	0.12 mg/kg	4.7	EPA Region 3 Residential Risk-Based Concentration
2-Am 4,6-DNT	DA3 Borehole LC-MW-07S, Surface	0.22 mg/kg	4.7	EPA Region 3 Residential Risk-Based Concentration
RDX	DA3 Borehole LC-MW-7S, 15 ft. bgs	0.048 mg/kg	4.4	EPA Region 9 PRG

Notes:
Soil Values from MTCA Table 740-1, Method A Soil Cleanup Levels for Unrestricted Land Use.
PRGs – EPA Region 9 Preliminary Remediation Goals for Residential Soil.

Table 3-14 Comparisons of RAU 2B Reporting Values for Soils to Background Data and Regulatory or Ecological Indicator Values

Data Source	Arsenic				Barium				Copper			
	Range	Arithmetic Mean	95% UCL	No. of Samples	Range	Arithmetic Mean	95% UCL	No. of Samples	Range	Arithmetic Mean	95% UCL	No. of Samples
	mg/kg	mg/kg	mg/kg		mg/kg	mg/kg	mg/kg		mg/kg	mg/kg	mg/kg	
RAU 2B Data												
Demolition Area 2	10.7 - 30.1	18.1	22	15	121 - 454	216	262	15	63.8 - 160	99.3	112	15
Demolition Area 3	3.3 - 10.4	8.4	NA	14	108 - 221	152	195	8	104 - 363	119	129	14
Background Data												
Dragun 1991 (Contiguous USA/ includes USGS 1984)	ND - 97	7.2		1,257	10 - 5,000	580		1,319	ND - 700	25		1,311
Dragun 1991 (Washington State)	0.4 - 130	4.5		22	120 - 1,000	586		22	15 - 100	36		22
WDOE 1994 (state-wide)			7		Not Reported						36	
WDOE 1994 (Clark County)			6		Not Reported						34	
Shannon & Wilson 1999 (Camp Bonneville)	1.6 - 2.9	2.2		14	75 - 353	163		14	17 - 125	59.5		14
Lacamas Creek Wells	ND - 6.08	3.1		17	Not Reported				31.5 - 182	84		17
Comparison Values												
MTCA Method A		20										
USPA Region 9 PRG						5,400				2,900		
Ecological Indicator for Plants*		10				500				100		
Ecological Indicator for Soil Biota*		60				NA				50		
Ecological Indicator for Wildlife*		132				102				217		

Notes:
Ecological Indicator Concentrations are for Arsenic V
95th percentile on the mean upper confidence limit calculated with MTCA stat 97 using one-half the non-detect values were appropriate, see Appendix D for MTCA stat 97 report statistics calculations.
Background Concentrations in Soils in Clark County (WDOE 1994) or as noted
Background Concentrations in soils at Camp Bonneville (Section 5 of the Camp Bonneville Multi-Sites Investigation Report, Shannon & Wilson 1999a)
Ecological Indicator values from the Washington administrative code model toxics control.

4.0 CONCLUSIONS AND RECOMMENDATIONS

Remedial investigations were conducted for DA2 and DA3 at Camp Bonneville beginning in late 2002, with quarterly groundwater sampling continuing through June 2006. The RI conducted for DA2 included installation of three monitoring wells downgradient of the suspected location of DA2, sampling and analyses of groundwater from these three monitoring wells, and sampling and analyses of surface and subsurface soil. The constituents detected in groundwater and soils at DA2 are present at relatively low concentrations that do not pose a threat to human health or the environment. It is recommended that Demolition Area 2 be considered for no further action per WAC 173-340-350(8) (a).

The RI conducted at DA3 included installation of five monitoring wells around the crater at DA3, sampling and analyses of groundwater from these five monitoring wells, removing a corroded drum of shells, and sampling and analyses of surface and subsurface soil. The constituents detected in groundwater and soils at DA3 are present at relatively low concentrations that do not pose a threat to human health or the environment. It is recommended that Demolition Area 3 be considered for no further action per WAC173-340-350(8)(a).

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