FINAL
SITE INVESTIGATION REPORT
DEMOLITION AREAS 2 AND 3

CAMP BONNEVILLE
VANCOUVER, WASHINGTON

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PREPARED FOR
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LIST OF ACRONYMS AND ABBREVIATIONS

AEM	Atlantic Environmental Management, Inc.
bgs	below ground surface
BCT	BRAC Cleanup Team
BRAC	Base Realignment and Closure
ca	carcinogen
CFR	Code of Federal Regulations
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
COPC	chemical of potential concern
DA1	Demolition Area 1
DA2	Demolition Area 2
DA3	Demolition Area 3
DQO	data quality objective
Ecology	Washington State Department of Ecology
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
Pt	Troutdale formation
PVC	polyvinyl chloride
Qa	quaternary flood plain
QAPP	Quality Assurance Project Plan
QA/QC	quality assurance/quality control

LIST OF ACRONYMS AND ABBREVIATIONS (CONTINUED)

Qls	quaternary landslide deposit
RI	Remedial Investigation
RDX	hexahydro-1,3,5-trinitro-1,3,5-triazine
SAP	sampling and analysis plan
SI	Site Investigation
SOW	Statement of Work
SVOC	semivolatile organic compound
TBD	To Be Determined
TCRA	Time Critical Removal Action
TNT	2,4,6-trinitrotoluene
TPH	total petroleum hydrocarbons
Tv	volcanic bedrock
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

Site Investigation Report for Demolition Areas 2 and 3

1.0 Introduction

This document presents the results of a site investigation (SI) of Demolition Areas 2 and 3 at the Camp Bonneville Military Reservation (Camp Bonneville). The SI was conducted to determine if a release of contaminants has occurred at Demolition 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 SI was conducted by the Department of the Army (Army) consistent with its mandate to comply with the National Contingency Plan 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).

1.1 Site Background

The Camp Bonneville Military Reservation Site (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. 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 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. Camp Bonneville was included on the 1995 Base Realignment and Closure (BRAC) list.

Since the camp was officially closed, investigations have been ongoing to characterize the nature and extent of any contaminant releases at Camp Bonneville and to develop a plan for potentially transferring ownership. This SI report describes the findings of site investigation studies conducted at Demolition Areas 2 and 3.

For administrative reasons, the Camp Bonneville site was divided into three Remedial Action Units. Demolition Areas 2 and 3 (DA2 and DA3) are located within Remedial Action Unit 2. The Remedial Action Units established at Camp Bonneville include the following:

- Remedial Action Unit 1: The area consists of 20 acres where hazardous substances (other than ammunitions) have been found.

- Remedial Action Unit 2: The area consists of 21 small arms range areas, 3 demolition areas (DA1, DA2, and DA3), and 1 landfill.

- Remedial Action Unit 3: The area includes the entire site where ammunition (including unexploded ammunition) may remain.

In addition to the investigation findings presented in this document, the Army is investigating and determining cleanup needs at other areas within Camp Bonneville that include areas within other Remedial Action Units.

1.2 Objectives of the SI

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

- Determine if a release to soil and/or groundwater has occurred 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;
- Identify the direction of groundwater flow and vertical/horizontal hydraulic gradients; and
- Evaluate the soil and groundwater for the presence of chemicals of potential concern (COPCs) that exceed MTCA Method A cleanup levels at and/or down gradient from DA2 and DA3.

These objectives and planned data uses from the SI 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 SI objectives and the results of the investigations are presented in Section 3.0, Field Investigations. The data collected during the SI at DA2 and DA3 were used in preparing this SI report. The following describes the purpose of this SI for DA2 and DA3.

The purpose of the SI is to:

- Provide data needed to determine whether actions are required because of soil and/or groundwater contamination at DA2 and DA3; and

- If actions are required, to provide data needed to evaluate alternatives and select the preferred actions.

1.3 General Site Information

This section contains the following general facility information:

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

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Facility location: Demolition Areas 2 and 3 are within the boundaries of Camp Bonneville that 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 2. Camp Bonneville is located in Sections 34 and 35, Township 3 North, Range 3 East and Section 1, 2, 3, and 10, Township 2 North, Range 3 East.

Dimensions of facility: Camp Bonneville consists of approximately 3,840 acres. DA2 consists of a suspect wooded area that covers an 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 Department of the Army, Headquarters, I Corps and Fort Lewis, Fort Lewis, Washington.

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.

1.4 Report Organization

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

2.0 Site Conditions

This section presents descriptions of site conditions relevant to the SI. Section 2.1 presents the general site conditions . Sections 2.2 through 2.7 address the 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 this section. Where required information was not available from previous investigations, additional data were obtained from SI activities, including the field investigations described in Section 3.0.

2.1 General Site Conditions

This section presents a summary of site conditions, including a site conditions map.. The DA2 and DA3 sites consist of the portions of Camp Bonneville site impacted by activities conducted at these demolition areas. Site condition maps for DA2 and DA3 are provided in Figures 2, 3, and 4.

Camp Bonneville comprises approximately 3,840 acres and is located in southwestern Washington approximately 5 miles east of the Vancouver City limits in Clark County. Camp Bonneville was officially closed in 1995 and is currently a sub-installation of Fort Lewis. Between 1909 and 1995, the Army used Camp Bonneville for live fire of small arms, assault weapons, artillery, and field 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, 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. Camp Bonneville was included on the 1995 Base Realignment and Closure (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. The known site conditions of Demolition Areas 2 and 3 investigated during the SI and the general investigation strategies are as follows:

Demolition Area 2 (DA2)
The exact location of historical activities at DA2 is unknown and site walks/field inspections have not resulted in the identification of specific suspect areas. It was reported by site workers 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 Figures 2 and 3). The DA2 area is approximately 60 feet in diameter, forested with dense understory vegetation on mostly steep slopes.

The investigative approach was to monitor groundwater in the downgradient area to determine if

groundwater contamination is present and to sample surface and subsurface soil in the suspect area. Three wells were installed in the shallow alluvium/weathered bedrock zone in a line perpendicular to the likely flow path downgradient from DA2 as shown in Figure 3. The location for these wells was based on the topographic/drainage features in the area and the expectation that the groundwater flow direction will generally follow the surface topography in the immediate area. Descriptions of the installation of monitoring wells and sampling of groundwater and soil are presented in Section 3.0.

Demolition Area 3 (DA3)
Demolition Area 3 is a location where a surficial depression exists that may be an excavation or possibly a detonation crater. The location is about 2,000 feet upstream of the Base boundary in Lacamas Creek Valley (see Figures 2 and 4). The crater is approximately 20 feet in diameter and 10 feet deep. DA3 is located west of the gas line 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 SI soil sampling the crater was filled with water. Supplemental SI soil sampling was conducted during November 2003 following the removal of the corroded barrel and small caliber rounds from the center of the crater 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 and eight monitoring wells were installed downgradient of DA3 near the base boundary (see Figure 5). Downgradient boundary wells were installed to determine if groundwater migrating from DA3 and/or other areas of Camp Bonneville have impacted site-wide groundwater. Descriptions of the installation of monitoring wells and 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 prior investigation reports. The following sections provide excerpts of the information previously prepared (URS 2001) and information collected during conduct of the SI at Camp Bonneville.

2.2.1 Regional Geology and Physiography

Camp Bonneville is situated on the margin of the western foothills of the southern Cascades in

the transition zone between the Puget Trough and the Willamette Trough Provinces. The geology of this area generally consists of Eocene and Miocene volcanic and sedimentary rock types overlain by unconsolidated clays, silts, sands, and gravels of the Troutdale Formation (Phillips 1987).

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. 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. The entire installation is heavily vegetated.

2.2.2 Surface Water and Sediments

The principal surface water feature in the vicinity of the investigation area 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 that drain adjacent uplands, flow into Lacamas Creek. Buck Creek and David Creek, the largest of these streams, drain the southeastern hills of Camp Bonneville.

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 base closure, the impoundments have been drained. Previous investigation has determined that Lacamas Creek upstream and downstream from Landfill #4 has not been impacted by previous facility activities (Hart Crowser 2000). Sediments of concern at Camp Bonneville only include the sediments within the Popup Pond that are being investigated and will be reported under separate cover.

2.2.3 Geology and Soils

Camp Bonneville is situated along the structural and physiographic boundary between the western flank of the southern Cascade Mountains and the Portland-Vancouver Basin. The geology of the Camp Bonneville 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).

The geology at Camp Bonneville can be divided into three general areas that correspond approximately to topographic divisions. 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 bottomland along Lacamas Creek is composed of unconsolidated silt, sand, and gravel valley fill, with some clay. 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)
- A Quaternary landslide deposit (Qls) of surface soils and bedrock displaced from the steep slope along David Creek
- A thick sequence of Quaternary to Pliocene-age gravel, fine-grained sand, and cobbly and bouldery sand known as the Troutdale Formation (Pt), which underlies 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 Camp Killpack (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 time 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. 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 eastward against the underlying bedrock, and the

lower part of the formation reportedly is typically coarser grained toward the east (Mundorff 1964).

The bedrock that underlies the alluvial deposits and Troutdale Formation is exposed at the surface in the eastern part of Camp Bonneville. This bedrock consists of Oligocene-age andesite and basaltic andesite flows, minor flow breccias, tuffs, and volcaniclastic sandstones. 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 that contain gravel of basalt lithology. 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).

2.2.4 Regional Hydrogeology

Limited information is available about the hydrogeology of Camp Bonneville. Most prior work throughout the Clark County area has focused on the Troutdale Formation (as described in Mundorff 1964). Camp Bonneville resides over the eastern edge of the Troutdale Formation where it is pinched out by the underlying bedrock. There are two drinking water wells at Camp Bonneville: a 385-foot-deep well at the Camp Bonneville cantonment and a 193-foot-deep well at the Camp Killpack cantonment (ESE 1983). The latter well is apparently different from the 516-foot-deep well at the Camp Killpack cantonment described by Mundorff (1964). In addition, a well was drilled at the Federal Bureau of Investigation (FBI) range during 1998, which extends to a depth of 105 feet bgs (Shannon & Wilson 1999b). Several groundwater monitoring wells associated with the sewage lagoon are located east of the Camp Bonneville cantonment. Based on regional information from Mundorff (1964) and the reported depths of the wells at the camp, water supply wells in the area generally extend into the Troutdale Formation or underlying bedrock. Most of the nearby wells apparently obtain groundwater from depths of 150 to as much as 500 feet below ground surface (bgs).

The water table is typically within a few feet of the ground surface in areas underlain by alluvium and appears to fluctuate 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. The localized groundwater flow generally follows local topography toward tributaries and creeks.

Generally, groundwater flows from the uplands towards Lacamas Creek. The elevation of the water table in the alluvial valley areas of Camp Bonneville is expected to be relatively shallow (in the range of 5-20 feet bgs) based on the presence of shallow bedrock, multiple creeks, tributaries, and boggy areas.

A total of 8 monitoring wells (5 shallow and 3 deep) were installed as part of the investigation of Landfill 4, an upland area of camp Bonneville. The depths to water in the wells ranged from 10.4 feet bgs to 18.8 feet bgs. The groundwater elevation data indicate groundwater flow to and

down the Lacamas drainage, which is consistent with the surface topography.
Previous upgradient investigations (Landfill 4) detected explosive residues, perchlorate, and volatile organic compounds (VOCs) in groundwater samples collected from specific wells. Other upgradient land uses that could have contributed COPCs include firing ranges, and open burning and open detonation grounds. Specific geologic and hydrogeologic data obtained during the SI at Demolition Areas DA2 and DA3 are presented in the following sections.

2.2.4.1 Groundwater Flow

Groundwater within the shallow alluvium and Upper Troutdale Formation flows horizontally toward Lacamas Creek from upland areas within the Lacamas Creek valley, which encompasses most of Camp Bonneville. The general groundwater flow is to the southwest through the Lacamas Creek Valley and groundwater leaves Camp Bonneville where Lacamas Creek exits the western boundary of the camp. A small area north of the Lacamas watershed appears to drain west into another watershed.

Based on monitoring wells recently installed in the area where Lacamas Creek intercepts the western boundary, and upgradient wells installed at Demolition Areas 2 and 3, 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 Demolition Area 3), an upward gradient (artesian well) 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.

- Horizontal groundwater flow within the Upper Troutdale and alluvium typically follows the topographic contours within the Lacamas watershed and groundwater exits Camp Bonneville near the Lacamas Creek boundary area.

2.2.4.2 Groundwater Quality

Previous investigations at Landfill 4 detected explosive residues (RDX and HMX), perchlorate, and volatile organic compounds (VOCs) in groundwater samples collected from specific wells. Other upgradient land uses that could have contributed chemicals of potential concern (COPCs) include firing ranges, impact areas, open burning and open detonation grounds, and one or more underground storage tanks that have been removed. Groundwater sampling and analyses conducted at DA2 and DA3 as part of the SI are discussed in Section 3.0. Eight monitoring wells near the base boundary and Lacamas were installed and sampled as part of the SI. These

wells were installed to determine if contaminants have been released from DA2 and/or DA3, and if so, whether they are migrating downgradient to the base boundary and potentially impacting off-site groundwater. Results of the sampling and analyses of these wells are presented in Section 3.0. Currently, additional monitoring of these wells is being conducted, and the results of the groundwater monitoring will be reported when available.

2.3 Air

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. Chemicals of potential concern (COPCs) at the demolition areas are not volatile and are not likely to be released to the atmosphere. Camp Bonneville and the Demolition Areas 2 and 3 are located in air quality maintenance areas for ozone and carbon monoxide.

2.4 Conceptual Site Model

A conceptual site model (CSM) identifying sources of hazardous substances, pathways for contaminant migration, and potential receptors is provided in Figure 6. The information used to develop this CSM and conclusions drawn from this CSM are presented in the following sections.

The CSM is intended as a schematic representation of potential pathways by which receptors (humans or other ecological endpoint species) may be exposed to chemicals at or released from a source. The purposes of the CSM are to provide a framework for problem definition, to identify exposure pathways that may result in adverse effects to human health or other ecological receptors, to aid in identifying data gaps, and, if necessary, to aid in identifying applicable cleanup measures targeted at significant contaminant sources and exposure pathways. The exposure pathways in the CSM are shown in Figure 6.

An exposure pathway describes a specific environmental pathway by which chemicals may be transported to human or other ecological receptors. A complete exposure pathway requires each of the following six elements:

- Source of chemicals
- Mechanism of chemical release
- Environmental transport medium
- Exposure point
- Intake route
- Human or other ecological endpoints

If one of these elements is absent, then the pathway is incomplete and exposure cannot occur. Incomplete pathways, as well as negligible pathways that would not contribute to overall risk estimates, are not expected to result in adverse effects to human health or the environment.

2.4.1 Potential Release and Transport Mechanisms

Contaminants may be contacted directly in surface and near surface soil. Contaminants may also migrate from near the soil surface to deeper soils and have the potential to enter groundwater and surface water. Because COPCs at DA 2 and 3 are not volatile, the main release mechanisms for these sites are:

- Leaching from potentially contaminated soil into deeper soils,
- Infiltration to groundwater, and
- Suspension of particulate-bound contaminants by stormwater runoff or wind and transport to down slope/downwind areas.

2.4.2 Potential Human Receptors

Potential human receptors include current and future on-site workers, future users of the site for recreation and training, current and future on-site workers and visitors, and off-site residents who could potentially use affected groundwater. Hypothetical future on-site workers/visitors and off-site residents are assumed to have unrestricted access to groundwater and are included in the CSM. The potential exposure mechanisms to COPCs in groundwater consist of dermal contact and ingestion.

2.4.3 Potential Ecological Receptors

Camp Bonneville is a heavily wooded area with Douglas fir, western red cedar, western hemlock, and red alder as the dominant tree species. Depending primarily on moisture gradients, the understory is composed of salal, Oregon grape, vine maple, and sword fern (Larson 1980). Several species of small mammals and birds reside on the site including cottontail rabbits, ground squirrels, mice, and shrews. Large mammals such as deer, bears, and cougars are present at Camp Bonneville. There are also several special-status species present at or near Camp Bonneville. These species confirmed at or near Camp Bonneville include:

- Plants — Hairy-stemmed checker-mallow (state endangered species)
Small-flowered trillium (state sensitive species)
- Amphibians — Northern red-legged frog (federal species of concern)
- Birds — Vaux's swift (state candidate species)
Pileated woodpecker (state candidate species)
- Mammals — Brush Prairie (Northern) pocket gopher (state candidate species)
- Fish — Coastal Cutthroat Trout: federal species of concern.

Potential primary receptors on site include terrestrial animals that may be exposed to COPCs in surface and subsurface soils (i.e. burrowing animals). Terrestrial plants and waterfowl could be exposed to COPCs in soils. Terrestrial animals and plants, benthic invertebrates, aquatic plants, and fish could be exposed to COPCs in surface water. Potential offsite exposure would involve ingestion of groundwater that has migrated from the site. The potential exposure mechanisms to COPCs in soil consist of dermal contact, ingestion, inhalation, and uptake (plants).

2.5 Natural Resources and Ecology

A number of plant and vertebrate animal species that are either federally or state-listed as endangered or threatened, or are candidates for such listing, have either been documented at Camp Bonneville or are likely to occur there. These species are described in Section 2.4.3. No known mineral deposits or other resources of economic value have been reported at Camp Bonneville.

2.6 Hazardous Substance Sources

As shown in the CSM, the source of the contaminants present at the demolition sites (if contamination exists),would be residual explosives, degradates there from, and metals that may have resulted from demolition and disposal activities at the DA2 and DA3, as follows:

Demolition Areas

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 nitroguanidine (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. COPCs released at the demolition areas could potentially migrate downward through the vadose zone and into the groundwater. The SI at DA2 and DA3 was conducted to determine if COPCs are present, and if so, at what concentrations in soil and groundwater.

2.7 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 classed 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 two well sites, two reservoirs, and two independent water systems serving Camp Killpack and Camp Bonneville cantonment. 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 objectives of the SI, identifies specific field activities undertaken during SI activities, and presents the results of the investigations at DA2 and DA3. SI activities at DA 2 consisted of the installation of groundwater monitoring wells and collection and analysis of groundwater and soil samples. SI 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 and DA3 near the boundary of Camp Bonneville in the Lacamas Creek valley.

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The objectives of the investigations at DA2 and DA3 are as follows:

- Determine the presence or absence of contamination in groundwater discharging from Camp Bonneville at the site boundary downgradient from DA2 and DA3;
- Determine the presence or absence of contamination in groundwater in the vicinity and downgradient of DA2 and DA3;
- Determine the presence or absence of contamination in soils at DA2 and DA3; and
- Determine the geologic/hydrogeologic conditions in the investigation areas.

To meet the objectives of the SI, field characterization/sampling included installation and sampling of 16 monitoring wells located in three areas and soil sampling at DA2 and DA3:

- Three wells were installed in the shallow alluvium/weathered bedrock zone in a line normal to the direction of flow from DA2.
- One well pair (shallow and deep) and three shallow wells were installed at four compass points surrounding the DA3 crater. In addition, four wells pairs (shallow and deep) were installed in a transect across the Lacamas Creek valley near the boundary of Camp Bonneville and down gradient of DA3.
- Surface and subsurface soil samples were collected 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 3, 4, and 5. The SI activities conducted 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.

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

3.1 Monitoring Well Installations

During November 2002, 16 monitoring wells were installed pursuant to the ground-water study Work Plan (CHPPM 2002). 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 within the Lacamas Valley area. The gradients were used to verify/determine the direction of groundwater flow.

A summary of the monitoring wells constructed at DA2, DA3, and the boundary area are as follows:

Demolition Area 2

The approach at DA2 was to install monitoring wells downgradient of the suspected area to determine if groundwater contamination was present. Three wells, LC-MW-09S, LC-MW-10S (shallow), and LC-MW-11S were installed in the shallow alluvium/weathered bedrock zone in a line across the downgradient direction from DA2 as shown in Figure 3. The location for these wells was based on the topographic/ drainage features in the area and the expectation that the

groundwater flow direction generally follows the surface topography in the immediate area. The three wells were installed to total depths ranging from approximately 17 to 24 feet below ground surface (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 crater. . Well locations are shown on Figure 4. At the eastern compass point location, a deep well (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 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 Figure 5. 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 across the valley as shown in Figure 5. 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. Groundwater was encountered at approximately 5 feet bgs in 2 of the 3 wells. Moist soil was encountered during drilling of LC-MW-10S near the ground surface; however, saturated soil was not encountered as it was in the other two boreholes at DA2. During drilling of these shallow wells, the Upper Troutdale formation was not encountered.

Demolition Area 3

Weathered bedrock was encountered during drilling of borehole LC-MW-05D at approximately 45 feet bgs. Initially, this strata was thought to be part of the Troutdale Formation, but the flow and matrix characteristics do not comport with theTroutdale and are now recognized to be weathered bedrock. The soil above the gravel zone, was predominately silty clay to clayey silt with low 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 Figures 7 (shallow groundwater) and Figure 8 (deeper groundwater). 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

Near the west Camp Bonneville property boundary near Lacamas Creek, cobbles and boulders indicative of the Upper Troutdale Formation were encountered starting near the ground surface. In the eight wells installed along the boundary area, groundwater was encountered at approximately 10 feet below the ground surface and a zone of sticky silt or clayey silt was encountered at approximately 35 feet bgs. The four deep wells were screened above this silt layer to prevent penetration of the potential confining layer and possible cross-contamination with deeper aquifer zones. 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. Some vertical downward flow from the shallow aquifer to the deeper formations may occur where the Upper Troutdale is unconfined along the west property boundary.

Groundwater contours in the areas of DA2, DA3, and the boundary area wells are based on groundwater elevation data collected on 21 January 2003 during the groundwater sampling

event. Groundwater contours are shown on Figures 7 and 8.

Groundwater elevations at DA2 wells were approximately 340 feet amsl. Approximately 1 ¾ mile downgradient at DA3 the groundwater elevations were approximately 302 feet amsl. The boundary area wells are approximately ½ mile downgradient of DA3. The groundwater elevations at the boundary area wells were approximately 286 feet amsl. Groundwater gradient from the DA2 well locations to the boundary area wells is approximately 0.005 foot per foot.

3.3 Sampling and Analysis

This section describes the groundwater and soil sampling conducted at DA2 and DA3 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 SI.

Demolition Area 2

The three shallow wells at DA2 were sampled on 19 and 20 January 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 5 feet bgs if conditions allowed. Rock and groundwater were encountered prior to the 5 foot 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 4 feet and so the sample was collected from this depth instead of 5 feet. Soil sampling locations for soil samples collected by AEM are shown on Figure 9. 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 2 feet bgs. Of the three samples collected one was 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 18 and 19 January 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 15 April 2003 to verify the presence of these contaminants. On 25 November 2003, the 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 2 feet, 5 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 2 feet and 5 feet bgs. Soil samples were analyzed for explosives, perchlorate, and total metals.

Soil samples were collected by AEM at DA3 on 27 February 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 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 10. A summary of the sampling and analyses conducted at DA3 is presented in Table 3-2.

Boundary Area

The eight boundary area wells, 4 shallow and 4 deep, were sampled between 14 and 19 January 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, semivolatile 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 resampled on 15 April 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 Analytical Results

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

3.4.1 Demolition Area 2

Groundwater

Based on sampling and analyses conducted at DA2 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). Elevated levels of nitrite/nitrate were present in several DA2, DA3, and boundary area monitoring wells above 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 may have been compromised by the addition of preservatives. As a consequence, resampling and analysis was performed by PPC for nitrite/nitrate at nine of these wells. Results of that effort confirmed that previously reported results were anomalous and nitrite/nitrate concentrations in the ground water are consistent with regional groundwater values, well below drinking water standards (see Table 3-4).

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 was detected above the MTCA Method A cleanup level for arsenic 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 (Ecology 1994). The 90 percentile value for arsenic concentration using ICP analytical methods in Clark County is 60.8 mg/kg (Ecology 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.

3.4.2 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, above the PRG of 3.6 ug/L as well as nitrate levels similar to those at DA2. Because the nitrate levels were determined to be spurious 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 to shed further light on the issue. 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 was determined not to be valid. The groundwater elevations during the April 15, 2003 PPC sampling of DA3 and boundary area wells ranged from approximately 0.5 to 1.1 feet higher than during the January 2003 CHPPM sampling event.

Elevated levels of nitrite/nitrate were present in several DA2, DA3, and boundary area monitoring wells above 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 may have been compromised by the addition of preservatives. As a consequence, resampling and analysis was performed by PPC for nitrite/nitrate at nine of these wells. Results of that effort confirmed that previously reported results were anomalous and nitrite/nitrate concentrations in the ground water are consistent with regional groundwater values, well below drinking water standards (see Table 3-7).

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

Soil

During drilling of wells at DA3, low levels of four explosives were detected in surface and subsurface soil samples collected by CHPPM. The concentrations detected were significantly below 1 mg/kg and below 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 EPA Region 3 Residential Risk-based concentration of 4.7 mg/kg for both 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 at DA3 determined no explosives or perchlorate were present above the reporting limits in the eight surface and subsurface soil samples collected. 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 werecollected from the soils beneath and surrounding the area where the corroded drum and shell debris were removed. Samples were collected from the sidewalls and bottom of the excavated drum area. Each of the four sides of the excavation (N ,E, S, & W) were sampled along with two regular and one duplicate sample from the bottom of the excavation. No explosives, perchlorate, or picric acid were detected in any of the six samples from the center of the crater.

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 debris 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 COPCs in the soil at DA3.

3.4.3 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 above 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). As noted earlier, the groundwater elevations during the April 15, 2003 PPC sampling event, ranged from approximately 0.5 to 1.1 feet higher than during the January 2003 CHPPM sampling event.

Total and dissolved metal concentrations were normal and no metal concentrations exceeded

regulatory screening criteria. Therefore, there are no COPC in the eight boundary area monitoring wells that are downgradient of DA2 and DA3 and there is no indication of any site-wide groundwater contamination.

3.4.4 Summary of Nature and Extent of Contamination

Tables 3-12 and 3-13 present the maximum concentrations of constituents detected in groundwater and soil, respectively, at DA2 and DA3 and groundwater at 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 total petroleum hydrocarbons (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 3.4.1, 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 3.6, Potential Risks to Human Health and Ecological Receptors

3.5 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 SI indicated no concerns with respect to the usability of the SI data. A summary of all QA/QC for analyses conducted on samples collected by CHPPM are presented in Appendix B. As discussed previously, the perchlorate and nitrite/nitrate data were rejected. All other QA/QC goals were met and within the project QA/QC goals specified in the project QAPP/FSP (CHPPM 2002). The analytical data quality assurance (QA) and quality control

(QC) activities conducted on samples collected by AEM during the SI indicated no concerns with respect to the usability of the SI 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 D 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 were conducted by Columbia Analytical Services of Kelso, Washington. The laboratory Case Narrative and laboratory sample data are presented in Appendix E. 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.

3.6 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 COPC in groundwater at the 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, Demolition Areas 2 and 3 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 completing the “problem formulation step”. The first problem formulation step is to determine 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 described 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 and 3-15, respectively. 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.

Tables 3-14 and 3-15 list the 95th percentile on the mean of the upper confidence limit (UCL) for the constituents detected in soil at DA2 and DA3. At DA2 the metals with UCLs above the most stringent ecological indicator concentration include arsenic, barium, and copper. The soil data set consists of only 15 samples; 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 were conducted using MTCA stat 97 statistics program. The statistical reports generated by this program are presented in Appendix C

3.6.1 Demolition Area 2

The arsenic concentration at DA2, based on the 95th percentile UCL on the mean is 22 mg/kg. This concentration is 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 (Ecology 1994). Therefore, the arsenic concentrations detected at DA2 are well within background levels for Clark County and arsenic at these concentrations are not considered a threat to ecological receptors.

The UCL for Barium (262 mg/kg) at DA2 exceeded 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 presented in the Camp Bonneville Multi-Sites Investigation Report (Shannon & Wilson 1999a). The 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. Therefore, barium at concentrations detected at DA2 are equivalent to background concentrations and are not considered a potential threat to ecological receptors.

The UCL for Copper (112 mg/kg) exceeds the ecological indicator concentrations for plants and soil biota (100 and 50 mg/kg, respectively). The copper UCL concentration at DA2 is less than the background concentration of copper (114 mg/kg) at Camp Bonneville presented in the Camp Bonneville Multi-Sites Investigation Report (Shannon & Wilson 1999a). Therefore, the copper UCL concentration at DA2 is below the level detected in background soil and is not considered a potential threat to ecological receptors.

3.6.2 Demolition Area 3

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

The arsenic concentration at DA3, based on the 95th percentile UCL on the mean is 7.7 mg/kg. The UCL of 7.7 mg/kg was calculated on the entire data set of 31 samples. The UCL using ICP analytical data (10.4 mg/kg) is based on 14 samples and the UCL concentration using GFAA analytical data (3.6 mg/kg) is based on 17 samples. The UCL calculated on the entire data set is less than the arsenic indicator concentration for plants of 10 mg/kg. The UCL calculated based on the ICP data (14 data points) is skewed high due to the small data set. Therefore, the arsenic concentrations detected at DA3 are similar to background levels for Clark County and arsenic is not considered a COPC or a potential threat to ecological receptors.

The UCL for Barium (195 mg/kg) at DA3 exceeds the ecological indicator concentration for wildlife (102 mg/kg). The barium concentration calculated for DA3 are below background concentration of barium (257 mg/kg) at Camp Bonneville presented in the Camp Bonneville Multi-Sites Investigation Report. 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 (129 mg/kg) exceeds the ecological indicator concentrations for plants and soil biota (100 and 50 mg/kg, respectively). The copper UCL concentration at DA3 is not significantly above the background concentration of copper (114 mg/kg) at Camp Bonneville presented in the Camp Bonneville Multi-Sites Investigation Report (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. Therefore, the copper UCL concentration at DA3 is not significantly above background soil concentrations at Camp Bonneville and the volume impacted 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 copper 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. Therefore, the mercury UCL concentration at DA3 is only slightly above the ecological indicator concentration for plants and the volume impacted is minimal; therefore, mercury concentrations in soil at DA3 are not considered a potential threat to ecological receptors.

3.6.3 Summary of Potential Risks to Human Health and Ecological Receptors

The results of the SI have determined that there are no releases of contaminants at Demolition Areas 2 and 3 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.

Sections 3.6.1 and 3.6.2 describe why the naturally occurring metal concentrations in soil are not considered a potential risks or threat to ecological receptors. The concentrations 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 COPCs at DA2 and DA3 that are considered to be a potential risk to ecological receptors. After reviewing the above "problem formulation step", no further site-specific terrestrial ecological evaluation is necessary because the there are no COPC 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 AREA 2		
19-20 January 2003 (CHPPM)		
Groundwater Samples		
Well: 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
	NG	USACHPPM CAD 13.2
	NQ	USACHPPM CAD 45
	Perchlorate	EPA 314.0
	Total Metals[a],	EPA 6020/EPA 7470/7471 for Mercury
	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		
Center of Area and 100 feet N, S, E, and W at surface, 2 ft. and 5 ft. bgs; and Berm Samples (3)	Explosives	EPA 8330
	Picric Acid	EPA 8330
	PETN	EPA 8330
	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**		
Well: LC-MW-01S	TPH	NWTPH-HCID
LC-MW-01D	TPH-DRO	NWTPH-Dx
LC-MW-02S	TPH-GRO	NWTPH-Gx
LC-MW-02D	Explosives	USACHPPM CAD 13.2
LC-MW-03S	PETN	USACHPPM CAD 13.2
LC-MW-03D	Picric Acid	USACHPPM CAD 63
LC-MW-04S	NG	USACHPPM CAD 13.2
LC-MW-04D	NQ	USACHPPM CAD 45
	Perchlorate	EPA 314.0
	Total metals	EPA 6020/EPA 7470/7471 for Mercury
	Dissolved Metals	EPA 6020/EPA 7470/7471 for Mercury
	SVOCs	EPA 8270B
	VOCs	EPA 8260B
	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
15 April 2003 (PPC) **Groundwater Samples**		
Well: LC-MW-01S	Perchlorate	EPA 314.0
LC-MW-01D	Nitrite/Nitrates as Nitrogen	EPA 353.3
LC-MW-02S		
LC-MW-02D		

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 = semivolatile 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 [a]	6.4 [a]	17 [a]	15 [a] (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 [a]	0.17J [a]	0.25J [a]	ND [a]
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 not to be valid and resampling and analyses were conducted by PPC (see Table 3-7)

[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 B.

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 B

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 (ug/L)	Perchlorate 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 [a]	474	90	< 2	< 1	1.11
LC-MW-05D	309.73	11.1	6.87	0 [a]	202	126	< 2	< 1	1.16
LC-MW-06S	303.30	9.4	6.82	0 [a]	432	112	< 2	< 1	< 0.61
LC-MW-07S	301.92	10.5	7.18	0 [a]	511	73	< 2	< 1	0.59
LC-MW-08S	303.35	10.5	7.00	0 [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.
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 D

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

NS – not sampled

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 [a]	9.7 [a]	13 [a]	4.4 [a]	14 [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 [a]	ND [a]	ND [a]	12 [a]	ND [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 determine not to be valid and resampling and analyses were conducted by PPC (see Table 3-6)

[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 B.

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

NA – not analyzed

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

Dup – duplicate sample

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

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 B. 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 B.

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 B 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 B. 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 B.

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 B 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
Constituent	**Concentration (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
Ntrate/Nitrite – N [a]	mg/L	8.6 [a]	8.8 [a]	7.4 [a]	4.5 [a]	4 [a]	12 [a]	11 [a]	10 [a]	9.1 [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	0.26J [a]	0.72J [a]	0.71J [a]	ND [a]	ND [a]	ND [a]	ND [a]	ND [a]	ND [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 (see Table 3-6)

[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 B.

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 B.

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 not be valid, 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 Concentrations of Metals in Soils at DA2 and Ecological Indicator Concentrations.

Constituent	Sample Location	Concentrations (mg/kg)			Ecological Indicator Concentration (mg/kg)		
Metals		**Maximum**	**95th % UCL on Mean[3]**	**Background Concentrations[4]**	**Plants**	**Soil Biota**	**Wildlife**
Arsenic[1]	DA2 100 feet W of Center, Surface	30.1	22	60.8 (ICP) 7 (GFAA)	10	60	132
Barium	DA2 100 ft. E of Center, 4 ft. bgs	454	262	257[5]	500	NA	102
Chromium[2]	DA2 100 ft. S of Center, 5 ft. bgs	43.6	38	27	42	42	67
Copper	DA2 100 ft. E of Center, 4 ft. bgs	160	112	114[5]	100	50	217
Lead	DA2 100 ft. E of Center, 4 ft. bgs	28.5	24	17	50	500	118
Nickel	DA2 Berm SW 2 ft. bgs	36.5	16	21	30	200	980
Zinc	Center of DA2, Surface Soil	101	78	96	86	200	360

Notes:

[1] Ecological Indicator Concentrations are for Arsenic V

[2] Ecological Indicator Concentrations are for total Chromium

[3] 95th percentile on the mean upper confidence limit calculated with MTCA stat 97 using one-half the non-detect values were appropriate. MTCA stat 97 reports for statistics calculations are presented in Appendix C

[4] Background Concentrations in Soils in Clark County (Ecology 1994) or as noted (see "5")

[5] Background Concentrations in soils at Camp Bonneville (Section 5 of the Camp Bonneville Multi-Sites Investigation Report, Shannon & Wilson 1999a)

Table 3-15 Concentrations of Metals and Explosives in Soils at DA3 and Ecological Indicator Concentrations.

Constituent	Sample Location	Concentrations (mg/kg)			Ecological Indicator Concentration (mg/kg)		
Metals		**Maximum Concentration**	**95th % UCL on Mean[3]**	**Background Concentrations[4]**	**Plants**	**Soil Biota**	**Wildlife**
Antimony	DA3 Center – North In Crater	11.7 mg/kg	4.6	0.12[5]	5		
Arsenic[1]	DA3 Center- East In Crater	10.4 10.4 6.1	7.7 (ICP & GFAA) 10.4 (ICP data) 3.6 (GFAA data)	60.8 (ICP) 7 (GFAA)	10	60	132
Barium	DA3 100 ft. E. of Center, Surface	221	195	257[5]	500		102
Beryllium	DA3 Bottom 1& Center South	0.52 mg/kg	NC	2	10		
Cadmium	DA3 Center – North In Crater	1.0 mg/kg	NC	1	4	20	14
Chromium[2] (total)	DA3 Borehole LC-MW-08S, 2 ft. bgs	24.8	19.1	27	42	42	67
Copper	DA3 Center – East In Crater	363 mg/kg	129	114[5]	100	50	217
Lead	DA3 Center – East In Crater	120 mg/kg	20.6	17	50	500	118
Mercury	DA3 Center East In Crater	1.19 mg/kg	0.32	0.04	0.3	0.1	5.5
Nickel	DA3 Borehole LC-MW-08S, 2 ft. bgs	23	14.5	21	30	200	980
Thallium	DA3 Center of Crater	0.4 mg/kg	NC	0.27[5]	1		
Zinc	DA3 Center – East In Crater	144 mg/kg	83.9	96	86	200	360

Table 3-15 Concentrations of Metals and Explosives in Soils at DA3 and Ecological Indicator Concentrations (Continued).

Explosives							
2,4,6-TNT	DA3 Borehole LC-MW-07S, Surface	0.51 mg/kg	NA	NA	NA	NA	NA
4-Am 2,6-DNT	DA3 Borehole LC-MW-07S, Surface	0.12 mg/kg	NA	NA	NA	NA	NA
2-Am 4,6-DNT	DA3 Borehole LC-MW-07S, Surface	0.22 mg/kg	NA	NA	NA	NA	NA
RDX	DA3 Borehole LC-MW-7S, 15 ft. bgs	0.048 mg/kg	NA	NA	NA	NA	NA

Notes:
[1] Ecological Indicator Concentrations are for Arsenic V
[2] Ecological Indicator Concentrations are for total Chromium
[3] 95th percentile on the mean upper confidence limit calculated with MTCA stat 97 using one-half the non-detect values were appropriate. MTCA stat 97 reports for statistics calculations are presented in Appendix C
[4] Background Concentrations in Soils in Clark County (Ecology 1994) or as noted (see "[5]")
[5] Background Concentrations in soils at Camp Bonneville (Section 5 of the Camp Bonneville Multi-Sites Investigation Report, Shannon & Wilson 1999a)
NC Not Calculated because maximum concentration detected is below Ecological Screening Level
NA Not Available

4.0 Conclusions and Recommendations

Site Investigations were conducted at Demolition Area 2 and 3 at Camp Bonneville during late 2002 and early 2003. The SI conducted at Demolition Area 2 included installation of 3 monitoring wells downgradient of the suspected location of DA2, sampling and analyses of groundwater from the 3 monitoring wells, and sampling and analyses of surface and subsurface soil. Based on results of the SI sampling, there are no chemicals of potential concern in groundwater or soil at DA2. 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 SI conducted at Demolition Area 3 included installation of 5 monitoring wells around the crater at DA3, sampling and analyses of groundwater from the 5 monitoring wells, removing a corroded drum of shells, and sampling and analyses of surface and subsurface soil. Based on results of the SI sampling, there are no chemicals of potential concern in groundwater or soil at DA3. In addition, no COPCs were detected in boundary area wells downgradient of DA3. 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 WAC 173-340-350(8)(a).

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