FINAL

LONG-TERM MONITORING NETWORK

OPTIMIZATION EVALUATION

FOR

OPERABLE UNIT 2
BUNKER HILL MINING AND METALLURGICAL COMPLEX
SUPERFUND SITE
IDAHO

January 2006

PARSONS
1700 Broadway, Suite 900
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AWQC	ambient water quality criteria
bgs	below ground surface
Bunker Hill	Bunker Hill Mining and Metallurgical Complex Superfund Site
CIA	Central Impoundment Area
CLP	Contract Laboratory Program
COC	contaminant of concern
COV	coefficient of variation
CSM	conceptual site model
EMP	Environmental Monitoring Plan
ESRI	Environmental Systems Research Institute, Inc.
ft/day	foot per day
ft/ft	foot per foot
GIS	geographical information system
HU	hydrostratigraphic unit
LTM	long-term monitoring
LTMO	long-term monitoring optimization
µg/L	microgram(s) per liter
MCL	maximum contaminant level
MNO	monitoring network optimization
ND	not detected
OU	Operable Unit
PQL	practical quantitation limit
RAO	remedial action objective
ROD	Record of Decision
SCA	Smelter Closure Area
SFCDR	South Fork Coeur d'Alene River
USEPA	United States Environmental Protection Agency

SECTION 1

INTRODUCTION

Groundwater monitoring programs typically have two primary objectives (U.S. Environmental Protection Agency [USEPA], 1994; Gibbons, 1994):

1. Evaluate long-term temporal trends in contaminant concentrations at one or more points within or outside the remediation zone as a means of monitoring the performance of the remedial measure (*temporal objective*) and

2. Evaluate the extent to which contaminant migration is occurring, particularly if a potential exposure point for a susceptible receptor exists (*spatial objective*).

The relative success of any remediation system and its components (including the monitoring network) must be judged based on the degree to which it achieves the stated objectives of the system. Designing an effective groundwater monitoring program involves locating monitoring points and developing a site-specific strategy for groundwater sampling and analysis to maximize the amount of relevant information that can be obtained while minimizing incremental costs. Relevant information is that required to effectively address the temporal and spatial objectives of monitoring. The effectiveness of a monitoring network in achieving these two primary objectives can be evaluated quantitatively using statistical techniques. In addition, there may be other important considerations associated with a particular monitoring network that are most appropriately addressed through a qualitative assessment of the network. The qualitative evaluation may consider such factors as hydrostratigraphy, locations of potential receptor exposure points with respect to a dissolved contaminant plume, and the direction(s) and rate(s) of contaminant migration.

This report presents a description and evaluation of the groundwater and surface water monitoring program associated with the Bunker Hill Mining and Metallurgical Complex Superfund Site (Bunker Hill) Operable Unit (OU) 2. A monitoring network consisting of 77 groundwater monitoring wells and 18 surface water stations was evaluated to assess its overall effectiveness at achieving the OU2-specific monitoring objectives, and to (1) identify potential opportunities to streamline monitoring activities while still maintaining an effective monitoring program, and (2) identify data gaps that may require the addition of additional monitoring points. A three-tiered approach, consisting of a qualitative evaluation, a statistical evaluation of temporal trends in contaminant concentrations, and a spatial statistical analysis (groundwater only), assessed the degree to which the monitoring network addresses the objectives of the monitoring program, as well as other important considerations. The results of the three evaluations were combined and used to assess the optimal frequency of monitoring and the spatial distribution of the components of the monitoring network. The results of the analysis were then used to develop recommendations for optimizing the monitoring program at OU2.

SECTION 2

SITE BACKGROUND INFORMATION

The location, operational history, environmental setting (*i.e.*, geology, hydrogeology, and surface water hydrology), and remediation history of OU2 are briefly summarized in the following subsections. These topics are discussed in detail in the draft OU2 conceptual site model (CSM) report (CH2M Hill, 2005a), which is the primary source of the information presented below.

2.1 SITE LOCATION AND OPERATIONAL HISTORY

Bunker Hill Mining and Metallurgical Complex Superfund Site is within one of the largest historical mining districts in the world. Commercial mining for lead, zinc, silver, and other metals began in this portion of the Coeur d'Alene River Basin (known as the "Silver Valley") in 1883. Heavy metals contamination in soil, sediment, surface water, and groundwater from over 100 years of commercial mining, milling, smelting and associated modes of transportation has impacted both human health and environmental resources in many areas throughout the site.

The Bunker Hill Superfund Site was listed on the National Priorities List in 1983. The Site includes mining-contaminated areas in the Coeur d'Alene River corridor, adjacent floodplains, downstream water bodies, tributaries, and fill areas, as well as the 21-square mile Bunker Hill "Box" located in the area surrounding the historic smelting operations. The USEPA has designated three OUs for the Site:

- The populated areas of the Bunker Hill Box (OU1),
- The non-populated areas of the Bunker Hill Box (OU2), and
- Mining-related contamination in the broader Coeur d'Alene Basin (OU3).

OU2 of the Bunker Hill Mining and Metallurgical Complex Superfund Site is the focus of this report and consists of the non-populated areas of a rectangular 7-mile by 3-mile area known as the Bunker Hill "Box" with the exception of the South Fork Coeur d'Alene River (SFCDR) and the Pine Creek drainage (see Figure 2.1 of this report and Figures 2-1 and 2-2 of the draft CSM report [CH2M Hill, 2005a] which are included in Appendix A). The populated areas of the Bunker Hill Box and the SFCDR/Pine Creek drainage are included in OU1 and OU3, respectively.

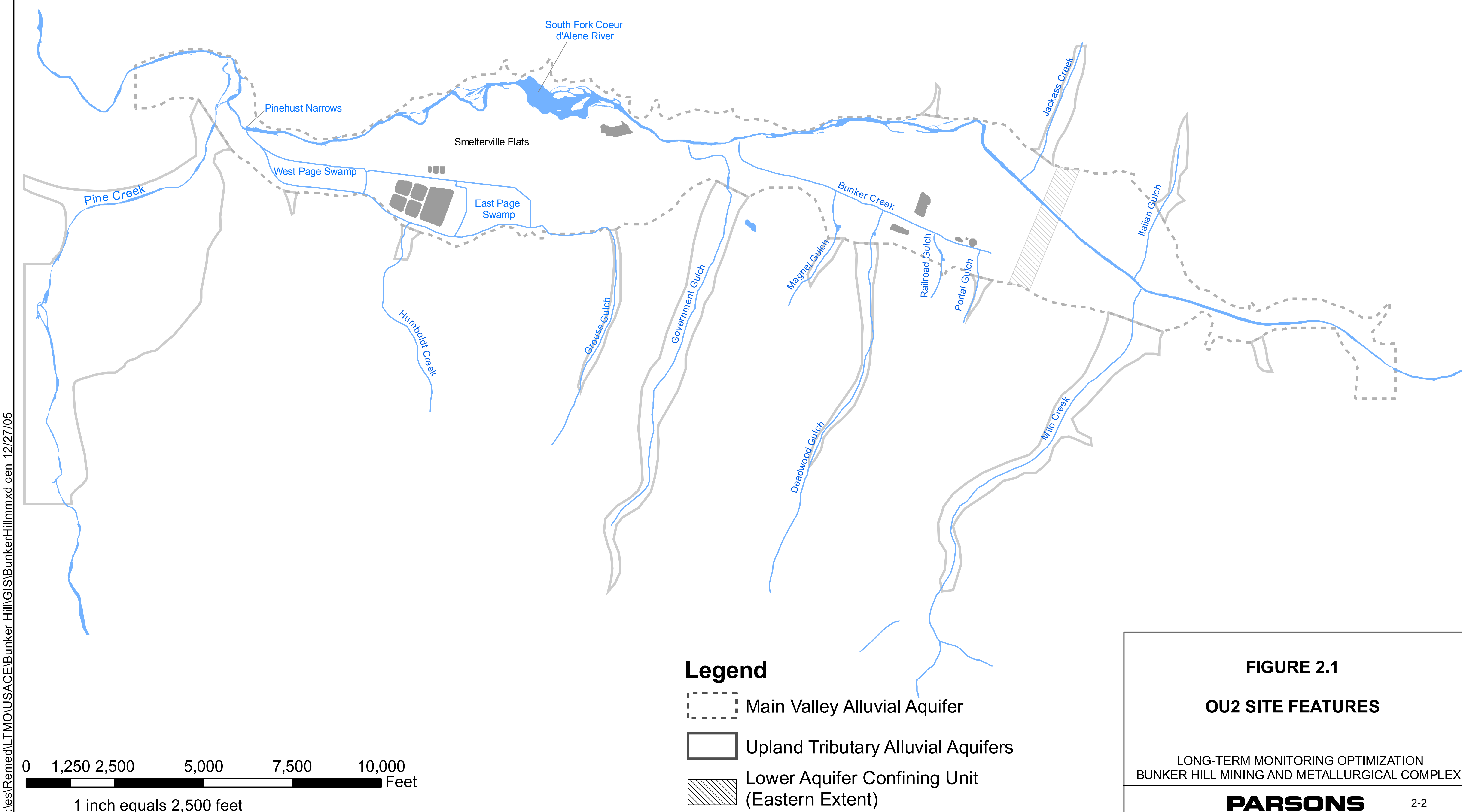

FIGURE 2.1

OU2 SITE FEATURES

LONG-TERM MONITORING OPTIMIZATION
BUNKER HILL MINING AND METALLURGICAL COMPLEX

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Fifty-two mines and mine-related sites were identified within OU2. The primary ores mined during the early stages of mining activity were galena (a source of lead and silver) and tetrahedrite (a source of silver). Later stages of mining activity also targeted sphalerite (a source of zinc that also contained manganese, cadmium, and other metals). Mining activities began in 1885 and large-scale mining operations within OU2 ceased in 1991. Small-scale operations are still ongoing at the Bunker Hill Mine and several other mines are still in operation upstream of OU2.

The draft CSM report (CH2M Hill, 2005a) states that "the long history of mining activities within and upstream of the Bunker Hill site, combined with the dynamic and complex hydrologic system and anthropogenic effects to that system, have resulted in widespread and commingled sources of contamination." For example, mine tailings generated in OU2 were, for many years, deposited directly to the SFCDR, its tributaries, and their associated floodplains, resulting in wide dispersal of tailings throughout the valley floor within OU2. Anthropogenic and natural processes have resulted in the mixing of the tailings with the underlying natural alluvium (*e.g.*, to depths of up to 15 feet in portions of Smelterville Flats). According to the draft CSM report (CH2M Hill, 2005a), historical events left a layer of tailings mixed with alluvium generally 4 to 7 feet thick across the majority of OU2. In addition, tailings, tailings mixtures, and mine waste rock were used as fill in construction projects throughout OU2 over time (*e.g.*, towns, industrial facilities, railroad grades, and road grades).

The OU2 Record of Decision (ROD) issued in 1992 set forth priority cleanup actions to protect human health and the environment. Cleanup actions included a series of source removals, surface capping, reconstruction of surface water creeks, demolition of abandoned milling and processing facilities, engineered closures for waste consolidated onsite, revegetation efforts, and treatment of contaminated water collected from various site sources.

In 1995, with the bankruptcy of the Site's major Potentially Responsible Party, the USEPA and the State of Idaho defined a path forward for phased remedy implementation in OU2. Phase I of remedy implementation includes extensive source removal and stabilization efforts, all demolition activities, all community development initiatives, development and initiation of an institutional controls plan, future land use development support, and public health response actions. Also included in Phase I are additional investigations to provide the necessary information to resolve long-term water quality issues, including technology assessments and pilot studies, evaluation of the success of source control efforts, development of site-specific water quality and effluent-limiting performance standards, and development of a defined operation and maintenance plan and implementation schedule. Interim control and treatment of contaminated water and acid mine drainage is also included in Phase I of remedy implementation. Phase I remediation began in 1995, and source control and removal activities are near completion.

Phase II of the OU2 remedy will be implemented following completion of source control and removal activities and evaluation of the impacts of these activities on meeting water quality improvement objectives. Phase II will consider any shortcomings encountered in implementing Phase I and will specifically address long-term water quality and environmental management issues. The evaluation of the effectiveness of the

Phase I source control and removal activities at meeting the water quality improvement objectives outlined in the 1992 OU2 ROD will be used to determine appropriate Phase II implementation strategies and actions.

2.2 ENVIRONMENTAL SETTING

2.2.1 Geology

This brief summary focuses on the thick sequence of unconsolidated deposits overlying bedrock within OU2, given that all of the groundwater monitoring wells evaluated are screened within these deposits. An east-west-oriented longitudinal geologic cross-section, shown on Figure 3-8 of the draft CSM report (CH2M Hill, 2005a), aids in the visualization of the stratigraphic units described in this subsection. The location of this cross-section is depicted on Figure 3-7 of the CSM report; both figures are included in Appendix A.

The primary stratigraphic units that are relevant to this monitoring network optimization (MNO) evaluation include an upper alluvial sand and gravel unit, a lacustrine silt/clay unit that underlies the upper sand and gravel, and lower sand and gravel unit that underlies the silt/clay. The lacustrine silt/clay that separates the upper and lower sand and gravel units is present throughout the central and western portions of OU2; this unit thins to the east and is not present in the eastern portion of OU2, most likely starting between Milo and Portal Gulches (see Figure 2.1).

Sedimentary deposits in the upland tributary gulches are highly variable in composition and consist of coarse-grained deposits (*i.e.*, sand and gravel) that were deposited in higher-energy depositional environments and a heterogeneous mixture of fine- to coarse-grained colluvium and slope-wash materials. Transitional depositional environments are found predominantly near the mouths of gulches and along the main valley/hillside interface. These transitional deposits consist of a mixture of colluvial and slopewash materials intermixed with main valley alluvial sediments.

2.2.2 Hydrogeology

The primary groundwater-bearing units of concern in the MNO evaluation include the upper and lower alluvial sand and gravel units present beneath the main SFCDR valley and the upland tributary colluvial/alluvial unit that is associated with the hillsides and gulches that discharge to the main SFCDR valley groundwater system. The upper alluvial sand and gravel aquifer is mostly unconfined and is perched on top of the lacustrine silt/clay unit, which acts as an aquitard. However, the upper aquifer may be locally confined where it is overlain by a relatively fine-grained mixture of alluvium and tailings. The thickness of this upper aquifer ranges from less than 10 feet near the valley walls to nearly 40 feet. The lower alluvial sand and gravel aquifer is confined by the overlying lacustrine silt/clay aquitard, and ranges from 20 to 40 feet in thickness. In the eastern portion of OU2, where the aquitard is not present, the upper and lower sand and gravel units are combined into a single thick (up to 60 feet) unconfined alluvial aquifer.

The depth to the water table generally ranges from approximately 8 to 10 feet below ground surface (bgs) in the eastern portion of OU2 to approximately 10 to 25 feet bgs in the central and western portions; however some variability exists. Water table elevations fluctuate seasonally due to temporal variations in precipitation and snowmelt.

As indicated on Figures 3-37 through 3-40 of the draft CSM report (CH2M Hill, 2005a) (Appendix A)**,** regional groundwater flow in the main SFCDR valley is generally from east to west, although local variations in flow direction (*e.g.*, either toward or away from major surface water drainages due to the presence of gaining and losing reaches) exist. The geometric mean hydraulic conductivity values for the upper and lower alluvial sand and gravel aquifers beneath the SFCDR valley, derived from single-well aquifer tests performed by CH2M Hill and reported in 'Single Well Pumping Test Methods and Results (CH2M Hill, 2004), are 103 feet per day (ft/day) and 117 ft/day, respectively. The geometric mean hydraulic conductivity value for the upland tributary aquifer is 5.6 ft/day. The average hydraulic gradient in the upper and lower alluvial sand and gravel aquifers, measured across the Bunker Hill Box, is 0.0046 foot per foot (ft/ft) (CH2M Hill, 2005a). Government Gulch is the only upland tributary aquifer with sufficient monitoring wells to allow calculation of a hydraulic gradient. The measured average hydraulic gradient in the upland aquifer along the length of Government Gulch, derived from groundwater elevation maps contained in the draft CSM report (CH2M Hill, 2005a, see Appendix A), is 0.054 ft/ft. Using the above-described hydraulic conductivity and hydraulic gradient values and estimated values for effective porosity of 0.25 for the main upper and lower alluvial sand and gravel aquifers and 0.20 for the upland aquifer, the average groundwater seepage velocity in OU2 was calculated to range from 1.5 ft/day in the Government Gulch upland aquifer to 2 ft/day in the main valley alluvial aquifers.

With a few exceptions, vertical hydraulic gradients are generally downward in the eastern portion of OU2 and upward in the western portion of OU2 downgradient of the Government Gulch vicinity. Vertical gradients do not appear to be seasonally variable.

2.2.3 Surface Water Hydrology

The main surface water body within OU2 is the SFCDR, which is depicted along with its tributaries on Figure 2.1. The draft CSM report states that the interaction of groundwater and surface water is a significant factor affecting contaminant fate and transport within OU2, and the potential exposure of human and ecological receptors to contaminants of concern (COCs) (CH2M Hill, 2005).

The approximate locations of gaining and losing reaches of the SFCDR within OU2 are shown on Figure 3-41 of the draft CSM report (Appendix A). The gaining and losing conditions were observed under base flow conditions, in which flow in the SFCDR is composed primarily of groundwater discharge. The interaction between surface water and groundwater under different hydrologic conditions is not well-defined.

2.3 NATURE AND EXTENT OF CONTAMINATION

The primary COCs at OU2 are arsenic, cadmium, lead, and zinc, given their elevated concentrations in OU2 groundwater, surface water, soil, and sediment; their potential to have significant negative impacts on potential receptors; or both. Within OU2, arsenic is present in surface water at concentrations toxic to aquatic organisms and other wildlife. Cadmium is widely distributed within OU2, and is relatively mobile in aquatic environments. Lead is present within OU2 at concentrations toxic to waterfowl and other wildlife via ingestion of contaminated soil or sediment. Ambient water quality criteria (AWQC) for zinc are exceeded throughout OU2, generally at levels toxic to aquatic organisms. Zinc is one of the most mobile of the heavy metals and is readily transported in most natural waters. Of these four COCs, cadmium and zinc are, by far, the metals that have the most widespread distribution and highest magnitude of exceedances of cleanup goals in OU2 groundwater.

The primary source for dissolved metals in groundwater within OU2 is metal-rich sediment within the vadose zone. The two release and transport mechanisms for metals from this source are unsaturated flow downward through the vadose zone and the seasonal rise and fall of the water table. The magnitude of dissolved metal release by these mechanisms is related to the magnitude of the hydrologic event. Major hydrologic events, such as occurred in 1996 to 1997, can result in a relatively large influx of metals into the groundwater system due to enhanced flushing of metals out of the vadose zone.

The upper portion of the SFCDR valley essentially constitutes one large source area, preventing delineation of discrete contaminant plumes in OU2 groundwater. Rather, elevated metal concentrations are found in groundwater and surface water throughout OU2. Given the near-surface locations of contaminant sources (*e.g.*, mine tailings), elevated metal concentrations are more prevalent in the surficial aquifers than at deeper depths. Specifically, the upper alluvial sand and gravel aquifer beneath the SFCDR valley and the upland aquifer present in Government Gulch (and perhaps other tributary valleys north and south of the SFCDR valley) tend to have relatively high metal concentrations. In contrast, elevated metal concentrations are less prevalent in the lower alluvial sand and gravel aquifer beneath the lacustrine silt/clay aquitard. This indicates that the silt/clay aquitard has minimized downward migration of metals to the lower alluvial aquifer, despite the presence of a downward vertical hydraulic gradient throughout a sizable portion of OU2.

SECTION 3

LONG-TERM MONITORING PROGRAM AT OU2

The existing groundwater and surface water monitoring program at OU2 was examined to to assess its overall effectiveness at achieving the OU2-specific monitoring objectives, and to (1) identify potential opportunities to streamline monitoring activities while still maintaining an effective monitoring program, and (2) identify data gaps that may required the addition of additional monitoring points. The monitoring program at OU2 is reviewed in the following subsections.

3.1 DESCRIPTION OF MONITORING PROGRAM

The OU2 monitoring program examined during this long-term monitoring optimization (LTMO) evaluation consists of 77 groundwater monitoring wells and 18 surface water monitoring stations. The wells and surface water stations included in this analysis are listed in Tables 3.1 and 3.2, respectively. The groundwater wells are shown on Figure 3.1 classified by hydrostratigraphic unit (HU), and the 18 surface-water monitoring stations are shown on Figure 3.2. These wells and stations were included in the LTMO analysis based on their "Active" status in the draft Environmental Monitoring Plan (EMP) (CH2M Hill, 2005b) and discussions with Bunker Hill site personnel. This evaluation did not include new wells proposed in the EMP or surface water monitoring stations associated with treatment plant outfalls. Monitoring point information listed in Tables 3.1 and 3.2 includes "basecase" sampling frequency (generally quarterly), first used and most recent sampling events, HU for groundwater wells, and location for surface water stations.

The objectives of the groundwater monitoring program at OU2 are outlined in the draft OU2 EMP (CH2M Hill, 2005b) and listed below:

1. Evaluate groundwater within OU2 for compliance with federal maximum contaminant levels (MCLs);

2. Evaluate the nature of groundwater/surface water interaction and the impact of groundwater discharge on surface water quality;

3. Evaluate the cumulative effects of Phase I remedial actions;

4. Provide data for five-year reviews of remedy implementation as required by CERCLA; and

TABLE 3.1
BASECASE GROUNDWATER MONITORING PROGRAM
LONG-TERM MONITORING OPTIMIZATION
BUNKER HILL MINING AND METALLURGICAL COMPLEX SUPERFUND SITE

Well Name	Hydrogeologic Unit	Current Sampling Frequency	Earliest Sampling Data Used	Most Recent Data Used
Deadwood Gulch Upland Aquifer				
BH-DW-GW-0001	Upland	Quarterly	3/16/2000	4/7/2004
Government Gulch Upland Aquifer				
BH-GG-GW-0001	Upland	Quarterly	4/17/2000	10/19/2004
BH-GG-GW-0002	Upland	Quarterly	4/17/2000	10/19/2004
BH-GG-GW-0003	Upland	Quarterly	4/17/2000	10/19/2004
BH-GG-GW-0004	Upland	Quarterly	4/17/2000	10/19/2004
BH-GG-GW-0005	Upland	Quarterly	2/24/2000	10/19/2004
BH-GG-GW-0006	Upland	Quarterly	2/24/2000	10/19/2004
BH-GG-GW-0007	Upland	Quarterly	4/4/2003	10/14/2004
BH-GG-GW-0008	Upland	Quarterly	4/4/2003	10/18/2004
Upland Aquifer between Deadwood and Railroad Gulches				
BH-ILF-GW-0001	Upland	Quarterly	4/25/2001	1/15/2003
Upland Aquifer at the Smelter Closure Area				
BH-SCA-GW-0001	SCA	Quarterly	2/23/2000	10/13/2004
BH-SCA-GW-0002	SCA	Quarterly	2/23/2000	10/12/2004
BH-SCA-GW-0005	SCA	Quarterly	2/23/2000	10/18/2004
BH-SCA-GW-0006	SCA	Quarterly	2/23/2000	10/18/2004
BH-SCA-GW-0007	SCA	Quarterly	2/23/2000	10/12/2004
Transect 1				
BH-SF-E-0001	Single	Quarterly	3/31/2003	10/11/2004
BH-SF-E-0002	Single	Quarterly	4/1/2003	10/11/2004
BH-SF-E-0003	Single	Quarterly	4/1/2003	10/11/2004
Transect 1 to Transect 2				
BH-SF-E-0101	Single	Quarterly	4/15/2000	10/11/2004
BH-SF-E-0201	Single	Quarterly	4/21/2000	10/11/2004
Transect 2				
BH-SF-E-0301-U	Upper	Quarterly	4/15/2000	10/12/2004
BH-SF-E-0302-L	Lower	Quarterly	4/15/2000	10/12/2004
BH-SF-E-0305-U	Upper	Quarterly	4/2/2003	7/14/2004
BH-SF-E-0306-L	Lower	Quarterly	4/2/2003	10/11/2004
BH-SF-E-0309-U	Upper	Quarterly	4/1/2003	10/12/2004
BH-SF-E-0310-L	Lower	Quarterly	4/1/2003	4/7/2004
BH-SF-E-0311-U	Upper	Quarterly	4/2/2003	10/12/2004
Transect 2 to Transect 3				
BH-SF-E-0314-U	Upper	Quarterly	10/20/2000	10/26/2004
BH-SF-E-0315-U	Upper	Quarterly	10/20/2000	10/26/2004
BH-SF-E-0316-U	Upper	Quarterly	10/23/2000	10/13/2004
BH-SF-E-0317-U	Upper	Quarterly	4/15/2000	10/26/2004
BH-SF-E-0318-U	Upper	Quarterly	10/24/2000	10/13/2004
BH-SF-E-0320-U	Upper	Quarterly	4/15/2000	7/19/2004
BH-SF-E-0321-U	Upper	Quarterly	4/15/2000	10/26/2004

TABLE 3.1 (Continued)
BASECASE GROUNDWATER MONITORING PROGRAM
LONG-TERM MONITORING OPTIMIZATION
BUNKER HILL MINING AND METALLURGICAL COMPLEX SUPERFUND SITE

Well Name	Hydrogeologic Unit	Current Sampling Frequency	Earliest Sampling Data Used	Most Recent Data Used
BH-SF-E-0322-U	Upper	Quarterly	5/1/2003	10/13/2004
BH-SF-E-0402-U	Upper	Quarterly	4/15/2000	10/26/2004
BH-SF-E-0403-U	Upper	Quarterly	4/15/2000	10/26/2004
BH-SF-E-0407-U	Upper	Quarterly	5/1/2003	10/13/2004
BH-SF-E-0408-U	Upper	Quarterly	10/24/2000	10/13/2004
BH-SF-E-0409-U	Upper	Quarterly	10/24/2000	10/13/2004
BH-SF-E-0410-U	Upper	Quarterly	2/23/2000	10/12/2004
Transect 3				
BH-SF-E-0423-U	Upper	Quarterly	4/15/2000	10/26/2004
BH-SF-E-0424-L	Lower	Quarterly	4/7/2003	10/26/2004
BH-SF-E-0425-U	Upper	Quarterly	4/7/2003	10/12/2004
BH-SF-E-0426-L	Lower	Quarterly	4/7/2003	10/12/2004
BH-SF-E-0427-U	Upper	Quarterly	2/23/2000	10/12/2004
BH-SF-E-0428-L	Lower	Quarterly	4/7/2003	10/12/2004
Transect 3 to Transect 5				
BH-SF-E-0429-U	Upper	Quarterly	2/24/2000	10/26/2004
BH-SF-E-0501-U	Upper	Quarterly	2/23/2000	10/18/2004
BH-SF-E-0502-U	Upper	Quarterly	4/19/2000	10/20/2004
BH-SF-E-0503-U	Upper	Quarterly	1/18/2001	10/26/2004
BH-SF-E-0504-U	Upper	Quarterly	1/18/2001	10/26/2004
Transect 5				
BH-SF-W-0001-U	Upper	Quarterly	4/8/2003	10/19/2004
BH-SF-W-0002-L	Lower	Quarterly	4/8/2003	10/19/2004
BH-SF-W-0003-U	Upper	Quarterly	4/9/2003	10/18/2004
BH-SF-W-0004-L	Lower	Quarterly	4/9/2003	10/18/2004
BH-SF-W-0005-U	Upper	Quarterly	4/18/2000	10/25/2004
BH-SF-W-0006-L	Lower	Quarterly	4/9/2003	10/25/2004
BH-SF-W-0007-U	Upper	Quarterly	4/18/2000	10/25/2004
Transect 5 to Transect 6				
BH-SF-W-0008-U	Upper	Quarterly	4/19/2000	7/27/2004
BH-SF-W-0009-U	Upper	Quarterly	4/19/2000	10/20/2004
BH-SF-W-0010-U	Upper	Quarterly	4/18/2000	10/25/2004
BH-SF-W-0011-L	Lower	Quarterly	4/18/2000	10/25/2004
BH-SF-W-0019-U	Upper	Quarterly	4/18/2000	10/26/2004
BH-SF-W-0018-U	Upper	Quarterly	4/19/2000	10/20/2004
BH-SF-W-0020-U	Upper	Quarterly	4/18/2000	10/26/2004
BH-SF-W-0104-U	Upper	Quarterly	4/19/2000	10/20/2004
BH-SF-W-0111-U	Upper	Quarterly	4/20/2000	10/20/2004
BH-SF-W-0118-U	Upper	Quarterly	2/22/2002	10/20/2004
BH-SF-W-0119-U	Upper	Quarterly	2/22/2002	10/25/2004
BH-SF-W-0121-U	Upper	Quarterly	4/20/2000	10/20/2004
BH-SF-W-0122-L	Lower	Quarterly	4/20/2000	10/20/2004

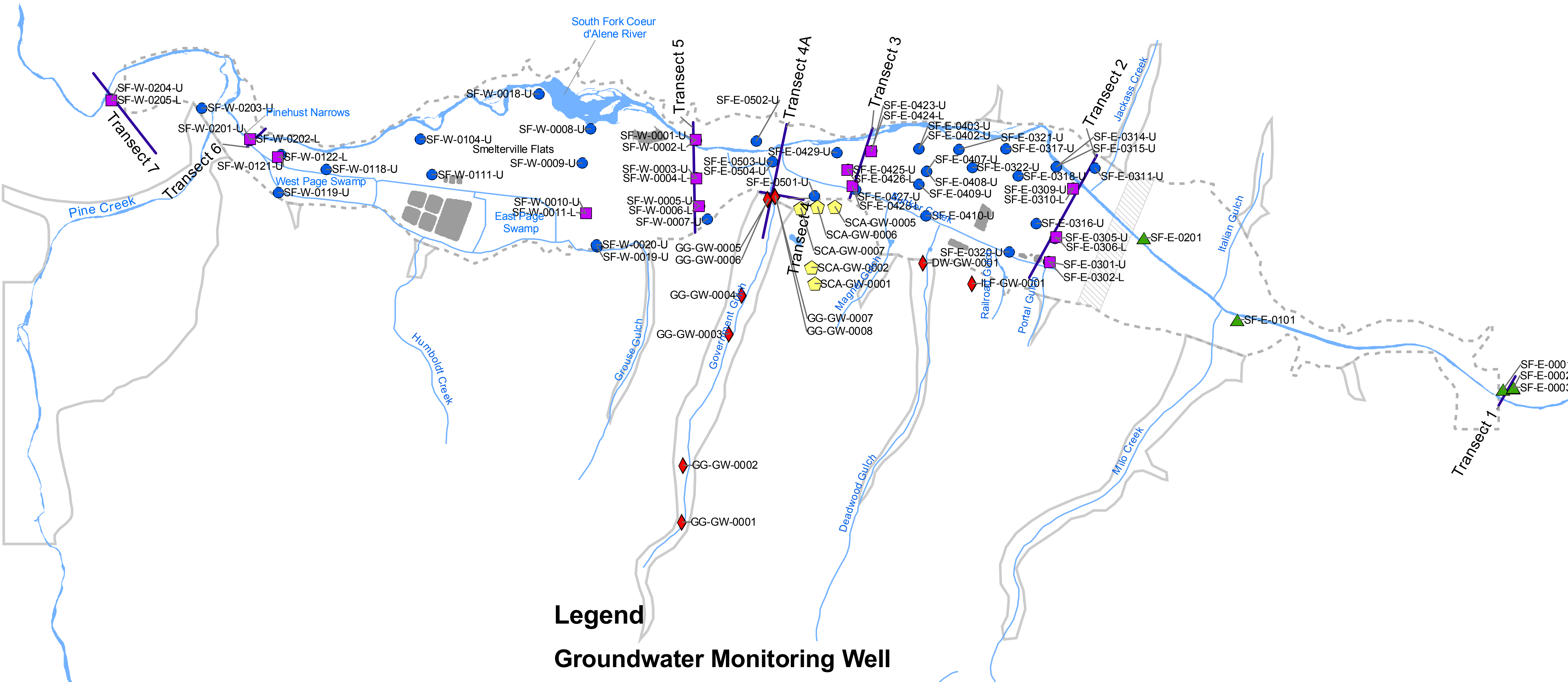
TABLE 3.1 (Continued)
BASECASE GROUNDWATER MONITORING PROGRAM
LONG-TERM MONITORING OPTIMIZATION
BUNKER HILL MINING AND METALLURGICAL COMPLEX SUPERFUND SITE

Well Name	Hydrogeologic Unit	Current Sampling Frequency	Earliest Sampling Data Used	Most Recent Data Used
Transect 6				
BH-SF-W-0201-U	Upper	Quarterly	4/8/2003	10/20/2004
BH-SF-W-0202-L	Lower	Quarterly	4/3/2003	10/20/2004
Transect 6 to Transect 7				
BH-SF-W-0203-U	Upper	Quarterly	4/21/2000	10/25/2004
Transect 7				
BH-SF-W-0204-U	Upper	Quarterly	4/8/2003	10/25/2004
BH-SF-W-0205-L	Lower	Quarterly	4/8/2003	10/25/2004

TABLE 3.2
BASECASE SURFACE WATER MONITORING PROGRAM
LONG-TERM MONITORING OPTIMIZATION
BUNKER HILL MINING AND METALLURGICAL COMPLEX SUPERFUND SITE

Surface Water Station Name	Location	Current Sampling Frequency	Earliest Sampling Data Used	Most Recent Data Used
BH-BC-0001	Bunker Creek	Quarterly	2/17/00	10/29/04
BH-CS-0001	Seeps North of CIA	Quarterly	3/17/00	10/28/04
BH-DW-0001	Magnet Gulch	Quarterly	4/25/00	10/29/04
BH-GC-0001	Grouse Creek	Quarterly	11/14/01	10/28/04
BH-GG-0001	Gov't Creek at Gulch Mouth	Quarterly	4/25/00	10/28/04
BH-HC-0001	Humboldt Creek	Quarterly	3/22/03	10/28/04
BH-IG-0001	Italian Gulch	Quarterly	3/22/03	4/10/03
BH-JC-0001	Jackass Creek	Quarterly	3/22/03	4/22/04
BH-MC-0001	Old Milo Creek Outfall	Quarterly	5/1/02	10/29/04
BH-MC-0002	New Milo Creek Outfall	Quarterly	2/17/00	10/29/04
BH-MG-0001	Deadwood Gulch	Quarterly	4/25/00	10/29/04
BH-PG-0001	Portal Gulch	Annual[a/]	4/24/00	2/20/02
BH-RR-0001	Railroad Gulch	Annual[a/]	3/22/03	3/22/03
BH-WP-0001	West Page Swamp Outfall	Quarterly	4/24/00	10/28/04
PC-339	Pine Creek below Amy Gulch	Quarterly	4/24/00	4/20/04
SF-268	SFCDR at Elizabeth Park	Quarterly	4/25/00	4/22/04
SF-270	SFCDR at Smelterville	Quarterly	4/21/04	4/21/04
SF-271	SFCDR at Pinehurst	Quarterly	4/24/00	4/20/04

[a/] Station sampled during high-flow events.



Legend

Groundwater Monitoring Well

Hydraulic Unit

- Lower
- SCA
- Single Unconfined
- Upland
- Upper

- Monitoring Well Transect
- Main Valley Alluvial Aquifer
- Upland Tributary Alluvial Aquifers
- Lower Aquifer Confining Unit (Eastern Extent)

*Note that the "BH-" at the beginning of all the wells has been omitted from the labels on this figure.

0 1,250 2,500 5,000 7,500 10,000 Feet

1 inch equals 2,500 feet

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FIGURE 3.1

GROUNDWATER MONITORING WELLS

LONG-TERM MONITORING OPTIMIZATION
BUNKER HILL MINING AND METALLURGICAL COMPLEX

PARSONS

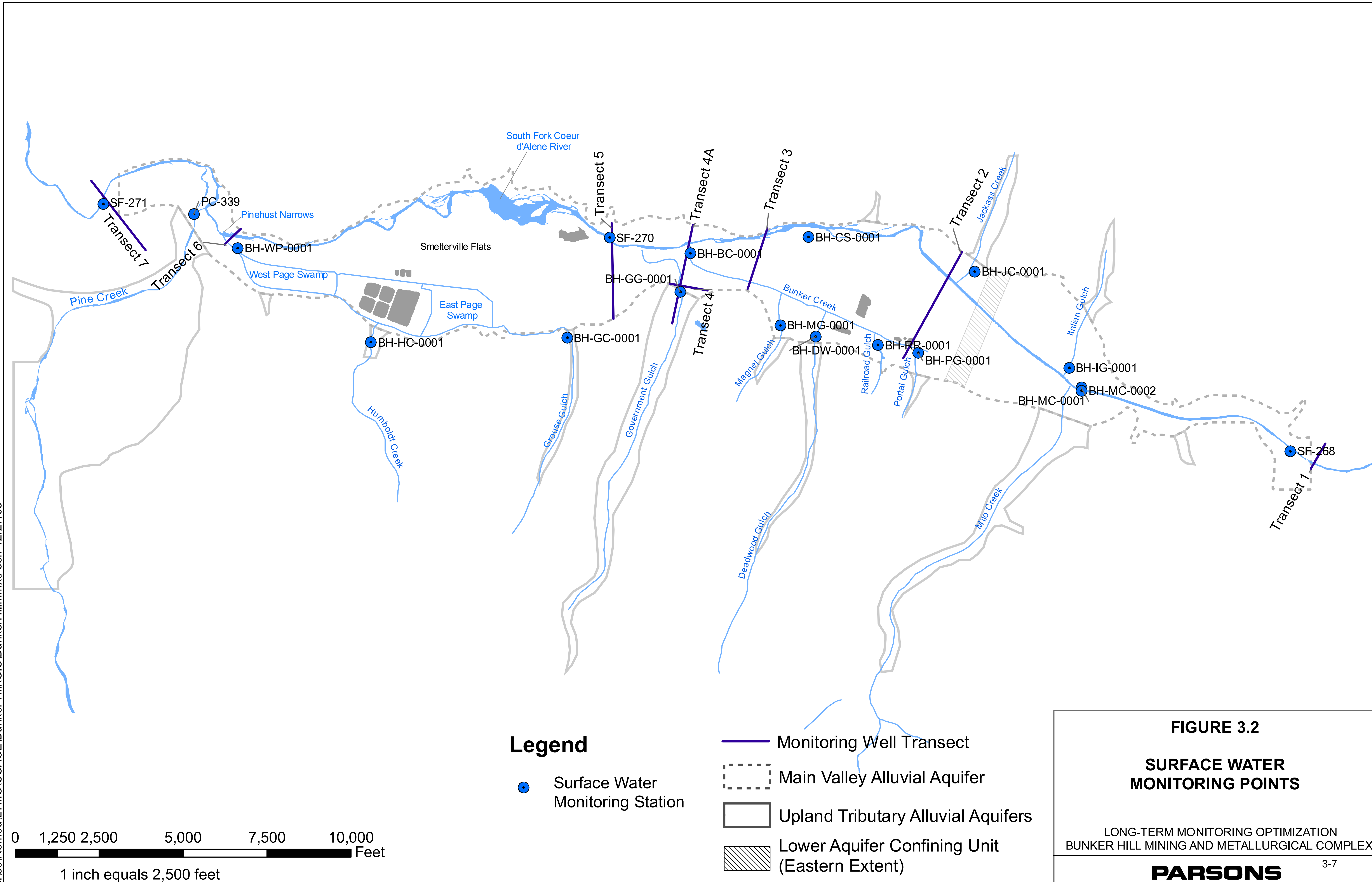

FIGURE 3.2

SURFACE WATER MONITORING POINTS

LONG-TERM MONITORING OPTIMIZATION
BUNKER HILL MINING AND METALLURGICAL COMPLEX

PARSONS

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5. Improve understanding of processes and variability within OU2 to assist in Phase I remedial action evaluations and Phase II remedial design and implementation.

The objectives of the surface water monitoring program are also outlined in the draft OU2 EMP (CH2M Hill, 2005b) and listed below:

1. Evaluate tributaries to the SFCDR within OU2 with respect to compliance with the AWQC;

2. Evaluate potential impacts to SFCDR water quality from tributaries and groundwater within OU2; and

3. Evaluate the cumulative effects of Phase I remedial actions with respect to water quality goals and objectives.

Four of the surface water monitoring stations listed in Table 3.2 (PC-339, SF-268, SF-270, and SF-271) are sampled as part of the environmental monitoring plan for OU3 (Coeur d'Alene Basin). However, results generated from sampling of these stations are also used during the analysis and evaluation of OU2 monitoring results. Consequently, OU2 surface water data needs were considered when the OU3 monitoring plan was developed.

3.2 SUMMARY OF ANALYTICAL DATA

The monitoring program for OU2 groundwater and surface water stations were evaluated using results for sampling events performed from February 2000 through October 2004 to represent the time period after Phase I remedial actions were implemented. The Phase I remedial actions resulted in substantial changes to site conditions that were expected to impact groundwater and surface water quality. Therefore, use of data collected prior to Phase I remediation could potentially have resulted in misleading trends that are not representative of recent site conditions. The database was processed to remove duplicate data by retaining the "normal" result for each duplicate sample pair (*i.e.*, excluding the duplicate value). As discussed in Section 2.3, the COCs identified for OU2 include zinc, cadmium, arsenic, and lead (both total and dissolved for surface water stations). Tables 3.3 and 3.4 present summaries of the occurrence of potential COCs based on the data collected from OU2 monitoring points for groundwater and surface water, respectively. Tables 3.3 and 3.4 show that although arsenic and lead have high percentages of detections, cadmium and zinc are more significant COCs at the site based on their widespread and relatively high concentrations compared to their respective MCLs or AWQCs.

Figures 3.3 through 3.6 display the **most recent** (typically October 2004, but the most recent event for wells BH-DW-GW-0001 and BH-SF-E-0310-L [April 2004]; BH-ILF-GW-0001 [Jan 2003]; and BH-SF-E-0305-U, BH-SF-E-0320-U, and BH-SF-W-0008-U [July 2004] occurred prior to October 2004) concentrations of arsenic, cadmium, lead, and zinc respectively for the groundwater monitoring wells classified by MCL exceedance ratio. Table 3.5 presents the corresponding most recent COC concentrations for each monitoring well and associated sampling date. The most recent samples from 51

TABLE 3.3
SUMMARY OF OCCURRENCE OF GROUNDWATER CONTAMINANTS OF CONCERN
LONG-TERM MONITORING OPTIMIZATION
BUNKER HILL MINING AND METALLURGICAL COMPLEX SUPERFUND SITE

Parameter	Total Samples[a/]	Range of Detects (mg/L)[b/]			Number of Detects	Percentage of Detects	Percentage of Samples with MCL Exceedances	MCL (mg/L)	Number of Wells with Results[c/]	Number of Wells with Detections	Number of Wells with MCL Exceedances
Dissolved Arsenic	1330	0.00004	-	0.119	389	29.2%	17.1%	0.01[d/]	77	74	40
Dissolved Cadmium	1330	0.00001	-	2.13	1003	75.4%	66.2%	0.005	77	77	60
Dissolved Lead	1330	0	-	0.54	372	28.0%	9.5%	0.015	77	72	15
Dissolved Zinc	1327	0.002	-	60.5	1268	95.6%	50.6%	5[e/]	77	77	44

[a/] Analytical data analyzed includes sampling results from February 2000 through October 2004.

[b/] mg/L = milligrams per liter.

[c/] Data includes 77 sampling points shown on Table 3.1

[d/] Arsenic MCL based on new EPA standard that became effective on February 22, 2002. (Compliance January 23, 2006)

TABLE 3.4
SUMMARY OF OCCURRENCE OF SURFACE WATER CONTAMINANTS OF CONCERN
LONG-TERM MONITORING OPTIMIZATION
BUNKER HILL MINING AND METALLURGICAL COMPLEX SUPERFUND SITE

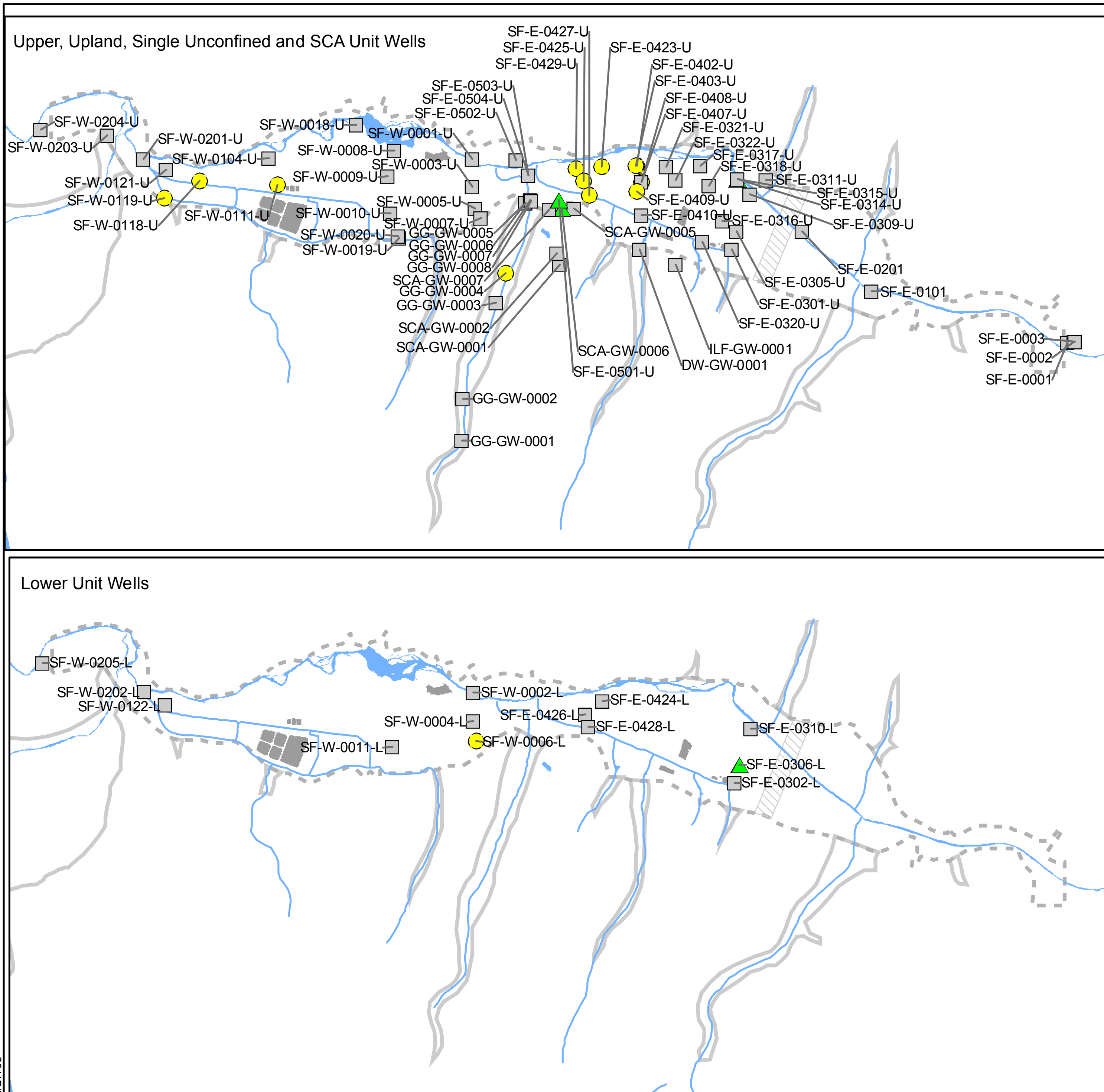
Parameter	Total Samples[a/]	Range of Detects (mg/L)[b/]			Number of Detects	Percentage of Detects	Percentage of Samples with AWQC Exceedances	AWQC[c/] (mg/L)	Number of Stations with Results[c/]	Number of Stations with Detections	Number of Stations with AWQC Exceedances
Arsenic	230	8E-05	-	0.1	134	58.3%	58.3%	0.000018	17	15	15
Dissolved Arsenic	245	0.0001	-	0.11	132	53.9%	53.9%	0.000018	18	16	16
Cadmium	230	5E-05	-	1.04	177	77.0%	72.2%	0.001	17	16	13
Dissolved Cadmium	252	5E-05	-	0.26	192	76.2%	68.7%	0.001	18	17	14
Lead	230	0.0003	-	3.18	185	80.4%	69.6%	0.0025	17	17	14
Dissolved Lead	245	6E-05	-	0.79	151	61.6%	44.9%	0.0025	18	18	15
Zinc	230	0.0024	-	34.8	228	99.1%	90.9%	0.105	17	17	15
Dissolved Zinc	252	0.0041	-	34.5	250	99.2%	87.3%	0.105	18	18	16

[a/] Analytical data analyzed includes sampling results from February 2000 through October 2004.

[b/] mg/L = milligrams per liter.

[c/] AWQCs are hardness dependant. AWQCs shown assume a hardness of 100 mg/L

[c/] Data includes 18 sampling points shown on Table 3.2



Note: Majority of wells "most recent" sampling event occured in October 2004; wells BH-DW-GW-0001, BH-SF-E-0310-L [April 2004], BH-SF-E-0305-U, BH-SF-E-0320-U, BH-SF-W-0008-U [July 2004], and BH-ILF-GW-0001 [Jan 2003], most recent sampling event occurred previously.

Specific concentrations and sampling dates shown in Table 3.5

Legend

Arsenic Concentrations (MCL = 0.01mg/L)

- ■ Non-Detect
- ▲ <MCL
- ● 1 to 10 times MCL

0 1,250 2,500 5,000 7,500 10,000 Feet

FIGURE 3.3

MOST RECENT DISSOLVED ARSENIC CONCENTRATIONS IN GROUNDWATER

LONG TERM MONITORING OPTIMIZATION
BUNKER HILL MINING AND METALLURGICAL COMPLEX

PARSONS

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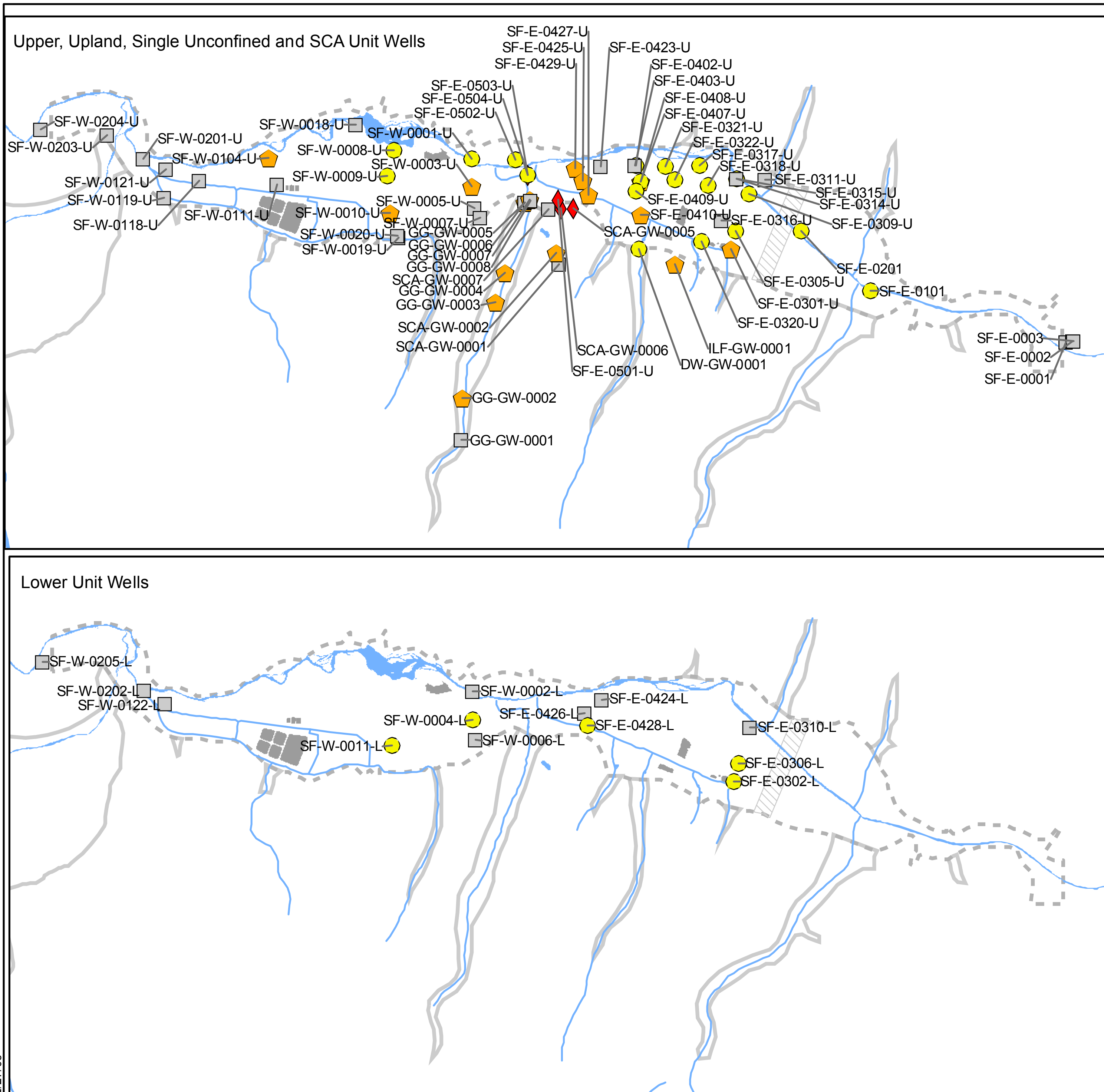

Note: Majority of wells "most recent" sampling event occured in October 2004; wells BH-DW-GW-0001, BH-SF-E-0310-L [April 2004], BH-SF-E-0305-U, BH-SF-E-0320-U, BH-SF-W-0008-U [July 2004], and BH-ILF-GW-0001 [Jan 2003], most recent sampling event occurred previously.

Legend

Cadmium Concentration (MCL=0.005mg/L)

- Non-Detect
- <MCL
- 1-10 times MCL
- 10-100 times MCL
- >100 times MCL

Specific concentrations and sampling dates shown in Table 3.5

0 1,250 2,500 5,000 7,500 10,000 Feet

FIGURE 3.4

MOST RECENT DISSOLVED CADMIUM CONCENTRATIONS IN GROUNDWATER

LONG TERM MONITORING OPTIMIZATION
BUNKER HILL MINING AND METALLURGICAL COMPLEX

PARSONS

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