Phase I Remedial Action Assessment Report Operable Unit 2

Bunker Hill Mining and Metallurgical Complex Superfund Site

Prepared for

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Executive Summary

ES.1 Purpose and Scope

This document presents an assessment of the Phase I remedial actions conducted within Operable Unit 2 (OU2) of the Bunker Hill Mining and Metallurgical Complex Superfund Site (Figure ES-1). These actions were designed to meet water quality-based remedial action objectives (RAOs) and performance standards identified in the 1992 OU2 Record of Decision (ROD) (EPA, 1992) and other OU2 decision documents.

The purpose of this document is to serve as one of the tools used by decision makers to identify potential shortcomings of the OU2 Phase I remedy with respect to water quality. The findings of this document will be used by decision makers to consider the potential need for Phase II remedial actions within OU2 to address long-term water quality, ecological, and environmental management issues.

This document assesses the effectiveness of Phase I remedial actions conducted within OU2 toward meeting water quality-based RAOs and performance standards. Although all OU2 Phase I remedial actions are addressed in this document, the focus of this document is on those Phase I remedial actions with water quality-based RAOs that were intended to have a substantial impact on water quality. These Phase I remedial actions are understood to include those actions conducted at the Central Impoundment Area (CIA), Bunker Creek, the Smelter Closure Area (SCA), Government Gulch, and Smelterville Flats. To the extent practicable, water quality impacts associated with other Phase I remedial actions conducted within OU2 are assessed. In addition, OU2-wide water quality is assessed to evaluate the cumulative impact of Phase I remedial actions and the status of OU2-wide groundwater and surface water quality with respect to OU2-wide water quality RAOs identified in the 1992 OU2 ROD.

ES.2 Background

Implementation of the remedy within OU2 has been conducted using a phased approach developed and agreed upon by the U.S. Environmental Protection Agency (EPA) and State of Idaho in the State Superfund Contract (SSC) (IDHW, 1995). Following the bankruptcy of the key potentially responsible party (PRP) in 1994, responsibility for implementation of the selected remedy identified in the 1992 OU2 ROD shifted to the EPA and State of Idaho. The selected remedy identified in the 1992 OU2 ROD focused on long-term treatment remedial approaches developed by the PRPs. The State of Idaho determined that the PRP-proposed remedy implementation strategy for OU2 was unacceptable under the statutory constraints of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), whereby the State is responsible for one hundred percent of the operations and maintenance (O&M) costs after the remedy is complete. As a result, the EPA and State of Idaho negotiated the phased approach to OU2 remedy implementation that focused more on permanent remedial techniques such as source control, removal, and containment, and less on the long-term treatment remedial approaches developed by the PRPs.

Phase I of remedy implementation within OU2 is largely complete and consists of extensive source removals, demolition activities, closure and installation of low permeability caps at the two primary waste consolidation areas within OU2 (the SCA and the CIA), community development initiatives, development and initiation of the Institutional Controls Program (ICP), future land use development support, and several public health response actions. Phase I also includes additional investigations to provide the necessary information to resolve long-term water quality and effluent-limiting performance standards, and development of a defined O&M and implementation schedule. Interim treatment of contaminated water at the Central Treatment Plant (CTP) is also included in Phase I.

Phase II remedy implementation will begin after the completion of Phase I source control and removal activities and evaluation of the effectiveness of these activities in meeting water quality objectives (the focus of this report). In Phase II, Phase I remedy shortcomings are to be addressed, followed by a coordinated program to address long-term water quality, ecological, and environmental management issues. In addition, the ICP and future development programs will be reevaluated as part of Phase II.

The effectiveness of Phase I source control and removal activities to meet the water quality improvement objectives of the 1992 OU2 ROD will be used to determine the appropriate Phase II implementation strategies and actions. In addition, although the 1992 OU2 ROD goals did not include protection of ecological receptors, additional actions may be considered within the context of site-wide ecological cleanup goals. Both 1992 OU2 ROD and SSC amendments will be required prior to the implementation of any Phase II remedial actions.

ES.3 Phase I Remedial Action Assessments

This section presents a summary of the findings of the Phase I remedial action-specific assessments presented in Sections 3 through 14 of this document, with particular attention to the Phase I remedial actions intended or believed to have the greatest impact on water quality conducted at the CIA, Bunker Creek, SCA, Government Gulch, and Smelterville Flats. It is important to remember that the majority of remedial actions conducted within OU2 during Phase I were focused on eliminating or reducing exposure pathways for human receptors and were therefore not intended to have a significant impact on water quality. This is reflected in the lack of water quality-based RAOs and performance standards for many of these actions. Section 15 addresses miscellaneous remedial actions that had little or no impact on or had insufficient data to make determinations regarding surface water or groundwater quality.

Table ES-1 presents a summary of Phase I remedial actions presented in Sections 3 through 14 of this document. In Table ES-1, the water quality-based RAOs, performance standards, and/or the overall intent of the Phase I remedial action are identified, along with a brief description of the remedial actions performed. The findings of the assessment with respect to the water quality-based RAOs, performance standards, and/or the overall intent of the remedial action are also presented in Table ES-1.

ES.3.1 Central Impoundment Area

The CIA (Figure ES-1) served as one of the main repositories for contaminated materials generated from Phase I remedial actions conducted within OU2. Prior to remediation, approximately 25.6 million cubic yards of contaminated materials were contained within the CIA above the main South Fork Coeur d'Alene River (SFCDR) valley floor. Until 1996, the CIA was used as an impoundment for acid mine drainage (AMD) from the Bunker Hill Mine and process water and stormwater from various industrial facilities. During Phase I, approximately 2.5 million cubic yards of contaminated materials were added to the CIA from removal actions conducted within OU2. The CIA was closed in 2000. Closure of the CIA consisted of the installation of a low permeability (1 x 10^{-7} cm/sec) geomembrane cover system, surface water drainage systems, and revegetation and armoring of the CIA side slopes. The focus of the Phase I remedial action conducted at the CIA was to provide a repository for contaminated materials removed from other areas within OU2 and to reduce infiltration of water through these materials. The interception of contaminated groundwater from the discrete seepage locations north of the CIA in the south bank of the SFCDR identified in the 1992 OU2 ROD was deferred until the impact of the Phase I remedial action could be assessed.

As shown in Table ES-1, the CIA Phase I remedial action is meeting the RAOs and performance standards identified in the 1992 OU2 ROD for the portions of the remedy that were not deferred. Monitoring wells completed within CIA materials above the main SFCDR valley floor have been dry since their installation following the placement of the CIA cap.

The Phase I remedial action conducted at the CIA was not intended to address sources of contamination located in the subsurface below the main SFCDR valley floor, or groundwater contamination in the vicinity of the CIA. However, water quality in the upper aquifer in the vicinity of the CIA appears to be improving and suggests that the CIA Phase I remedial action has had a positive impact on water quality. It should be noted that the majority of the benefit to water quality in the vicinity of the CIA is likely derived from the cessation of AMD impoundment on the CIA in 1996. Capping of the CIA materials would be responsible for reducing the amount of precipitation and snowmelt infiltrating through the CIA materials. In comparison to the volumes of AMD, process water, and stormwater placed on top of the CIA prior to 1996, the volume of water from precipitation and snowmelt is relatively small.

During the post-remediation time period, the majority of monitoring wells exhibiting a statistically significant trend in the upper aquifer in the vicinity of the CIA exhibit decreasing dissolved cadmium and dissolved zinc concentration trends (Figures ES-2a and ES-3a). A number of increasing trends for both metals were observed in monitoring wells located between the CIA and the SFCDR. Increases in dissolved cadmium and dissolved zinc concentrations in this area may be a result of removal and rechannelization work conducted in the SFCDR between 1999 and 2003 (Section 15). Disturbances to the river bed and banks may have increased the amount of surface water infiltrating from the SFCDR through contaminated materials in this area, resulting in increasing concentrations.

Prior to remediation, high concentrations of dissolved arsenic and dissolved lead were present in the upper aquifer in the vicinity of the CIA. During the post-remediation time period, the dissolved arsenic and dissolved lead concentrations in the upper aquifer in the vicinity of the CIA have decreased substantially and the areal extent of monitoring wells with concentrations greater than the Maximum Contaminant Level (MCL) has been reduced.

Surface water quality in the SFCDR in the vicinity of the CIA has improved significantly following the implementation of the CIA Phase I remedial action. Prior to remediation, the net gain in dissolved zinc loading in this reach of the SFCDR was between 180 and 245 lbs/day under low flow conditions. During the post-remediation time period, the net gain in dissolved zinc loading in this same reach has been between 70 and 90 lbs/day.

ES.3.2 Bunker Creek

Following the relocation of the SFCDR to the north side of the valley between 1910 and 1937, a man-made channel (Bunker Creek) was constructed to convey discharge from hillsides tributaries and to provide a location to discharge water from the CIA and process water from Bunker Hill concentrators. Phase I remedial actions conducted within the Bunker Creek corridor consisted of the partial removal of contaminated materials and reconstruction of the channel and floodplain, revegetation, and the installation of culverts at road crossings.

Significant decreases in dissolved cadmium and dissolved lead concentrations measured at the mouth of Bunker Creek between the pre- and post-remediation time periods have occurred. However, Bunker Creek surface water is currently not in compliance with Ambient Water Quality Criteria (AWQC) for dissolved cadmium and dissolved zinc.

Surface water discharge measurements collected at various locations within Bunker Creek under low flow (October 2006) and high flow (March 2007) conditions indicate that a significant amount of interaction between Bunker Creek surface water and underlying groundwater is occurring. Under low flow conditions, Bunker Creek loses discharge to the groundwater system as it flows along the southern margin of the CIA, and gains discharge from groundwater from the southwest corner of the CIA downstream to the SFCDR. Under high flow conditions the losing reach of Bunker Creek along the southern margin of the CIA is smaller, but losses are still significant. The amount of discharge lost from Bunker Creek suggests that the soils under the Bunker Creek channel are not of a sufficiently low permeability to prevent significant losses of discharge to the underlying aquifer.

Groundwater in monitoring wells in the immediate vicinity of Bunker Creek has shown significant improvement following the implementation of the Bunker Creek Phase I remedial action. Dissolved metal concentrations in the majority of these monitoring wells have shown a significant decrease between the pre- and post-remediation time periods. In addition, a significant number of monitoring wells exhibit decreasing post-remediation concentration trends for dissolved cadmium and dissolved zinc (Figures ES-2a and ES-3a). One increasing post-remediation trend for dissolved lead was detected at BH-SF-E-0301-U located near the headwaters of Bunker Creek.

The degree to which the Bunker Creek Phase I remedial action is responsible for changes in groundwater quality in the vicinity of Bunker Creek cannot be quantified with available data, given the number of other Phase I remedial actions that have occurred in the area.

ES.3.3 Smelter Closure Area

Prior to remediation, the SCA (Figure ES-1) was the site of the Lead Smelter Complex. The Lead Smelter and its associated buildings were demolished during the Phase I remedial action and the foundations of these buildings were used to develop a repository for contaminated materials, soil, and demolition debris from removal actions conducted within OU2. In addition, the principal threat material (PTM) monocell was located within the SCA and under the SCA cap. The SCA was closed in 1998 and capped with a low permeability (1 x 10^{-7} cm/sec) geomembrane liner and soil, and revegetated.

The Phase I remedial action conducted at the SCA is acting to control the migration of contaminants from SCA materials to surrounding surface water and groundwater. Groundwater quality in monitoring wells located at the SCA has shown improvement over time and decreasing concentration trends for dissolved cadmium (Figure ES-2b) and dissolved zinc (Figure ES-3b) during the post-remediation time period have been detected at monitoring wells located at the downgradient edge of the SCA.

Surface water run-on and run-off control systems at the SCA are providing an effective means to channel runoff from the SCA and into perimeter ditches. The toe drain installed along the northern edge of the closure area to collect underdrain flow has had no discharge since its installation. However, discharge is present from old stormwater lines associated with the Lead Smelter that were not completely sealed during development of the SCA. These stormwater lines are located beneath the Lead Smelter foundations (below SCA materials) and act as a drain tile and do not allow groundwater elevations below the SCA to increase to a point where groundwater can come into contact with SCA materials. Water from the old stormwater lines and leachate from the PTM monocell is collected and conveyed to the Lined Pond for treatment at the CTP.

At the West Canyon surface water diversion, groundwater elevations have not increased or decreased following the installation of the structure. The RAO for the West Canyon surface water diversion was to decrease groundwater elevations at this location. However, because groundwater elevations in the vicinity of the West Canyon have remained constant and therefore below the original ground surface elevation, no contact between groundwater from the West Canyon and SCA materials is assumed to be occurring.

Groundwater elevations at the downgradient edge of the SCA remain below the elevation of SCA materials. Groundwater elevations at the central and western downgradient edges of the SCA have not changed since the SCA was capped. Groundwater elevations at the eastern downgradient edge of the SCA have exhibited an increasing trend during the post-remediation time period. The reason for the increase in groundwater elevations at this location is unknown and additional investigation is required.

ES.3.4 Government Gulch

Government Gulch was the location of several ore processing and acid/fertilizer producing facilities. Contamination on the floor of Government Gulch was widespread and extended to considerable depths. The selected remedy identified for Government Gulch in the 1992 OU2 ROD consisted of minimal removals and the capture and conveyance of contaminated water for treatment. As part of the phased approach to remediation, these remedial actions were deferred in favor of extensive source removals within Government Gulch.

Approximately 370,000 cubic yards of the estimated 760,000 cubic yards of contaminated materials within Government Gulch were removed during Phase I.

The removal of approximately 370,000 cubic yards of highly contaminated materials (typically with lead concentrations greater than 10,000 mg/kg) from the Government Gulch floor resulted in a significant reduction in the mass of contaminated materials within Government Gulch.

Improvements in surface water and groundwater quality between the pre- and post-remediation time periods have occurred at the majority of Government Gulch monitoring locations. In many instances, contaminant concentrations have decreased up to an order of magnitude.

During the post-remediation time period, dissolved cadmium (Figure ES-2b) and dissolved zinc (Figure ES-3b) concentration trends in groundwater are decreasing at the majority of monitoring locations, suggesting that the full positive benefit of the Phase I remedial action on Government Gulch water quality has not yet been fully realized.

Increasing dissolved cadmium and dissolved zinc concentration trends were detected at BH-GG-GW-0008 completed in the lower portion of the Government Gulch aquifer at the mouth of the gulch. Dissolved cadmium concentrations at this location have recently begun to exceed the MCL. Dissolved zinc concentrations at this location remain well below the MCL. Additional investigation of the increasing dissolved cadmium concentration trend at this location will be required.

Concentrations of dissolved cadmium and dissolved zinc in groundwater measured at piezometers located at the downgradient edge of the former Zinc Plant foundations are among the highest concentrations measured within OU2 during the post-remediation time period. Limited removals of contaminated materials occurred in this area.

ES.3.5 Smelterville Flats

In 1910, a plank and pile dam was constructed at Pinehurst Narrows at the western end of Smelterville Flats to contain tailings and other mine wastes discharged directly to the SFCDR. This resulted in a significant amount of deposition of contaminated materials in the Smelterville Flats area. In 1933, the plank and pile dam failed as a result of flooding and tailings were washed downstream and reworked into the SFCDR floodplain in the Smelterville Flats area. Attempts to recover these tailings by dredging resulted in additional mixing of the tailings with native alluvium in Smelterville Flats.

In the 1992 OU2 ROD, limited removals of contaminated materials in the Smelterville Flats area were identified in order to construct wetland treatment systems for groundwater and surface water collected within OU2. Investigations conducted by the U.S. Bureau of Mines (USBM) (1998) showed that the wetland treatment systems were not capable of meeting the required treatment standards. As part of the phased approach to remediation, the EPA and State of Idaho decided to conduct extensive source material removals and floodway reconstruction actions in Smelterville Flats. During Phase I, approximately 1.6 million cubic yards of the approximately 4.2 million cubic yards of contaminated materials present within Smelterville Flats were removed and consolidated in the CIA.

Water quality in the SFCDR in the Smelterville Flats has improved with respect to dissolved zinc concentrations, AWQC ratios, and loading. Prior to remediation, the net dissolved zinc loading to the SFCDR within Smelterville Flats was approximately 250 lbs/day (September 1987) under low flow conditions. Following remediation, the net dissolved zinc loading to the SFCDR in Smelterville Flats was approximately 59 lbs/day (October 2006) under low flow conditions. This suggests that the Smelterville Flats Phase I remedial action is meeting its RAO of reducing the migration of contaminants to the SFCDR within Smelterville Flats.

In groundwater, decreasing metal concentrations occurred between the pre- and post-remediation time periods and decreasing post-remediation concentration trends for dissolved cadmium (Figure ES-2a) and dissolved zinc (Figure ES-3a) were detected at many monitoring locations. Several of the decreasing concentration trends were detected in monitoring wells located near the SFCDR in the eastern portion of Smelterville Flats. Decreasing concentration trends at these locations may be more indicative of changes in recharge to groundwater from the SFCDR and the impacts of upstream remedial actions. However, decreasing trends were also detected in a number of monitoring wells located in the western portion of Smelterville Flats and these would suggest that the Smelterville Flats Phase I remedial action is having a positive impact on groundwater quality and that the full positive benefit of the remedial action has not yet been fully realized.

ES.3.6 Other Phase I Remedial Actions

This section presents a brief summary of the findings of the assessments conducted for the Phase I remedial actions presented in Sections 8 through 14 of this document and summarized in Table ES-1. The majority of these Phase I remedial actions did not have water quality-based RAOs or performance standards.

Milo Gulch

Milo Gulch is the original location of the majority of mining activities conducted within OU2. Prior to remediation, tailings and waste rock were located in the Milo Creek channel and resulted in significant downstream contaminant migration under high flow conditions. During the Phase I remedial action, water control and conveyance structures were installed at the Reed Landing area to allow Milo Creek to pass through the Reed Landing area.

Between the pre- and post-remediation time periods, dissolved cadmium and dissolved zinc concentrations in Milo Creek have increased considerably. In 2005, AMD from the Reed and Russell mine workings were observed in the Reed Landing area. The flows from the mine adits were entering the Milo Creek conveyance system below the Reed Landing area. The AMD discharge in this area has not been addressed and the acidic nature and high metals content of the AMD appears to be having a negative impact on Milo Creek water quality.

Railroad Gulch

During Phase I, the Railroad Gulch drainage was reconstructed, which has resulted in a significant reduction in erosion potential within the gulch. Although it is not quantifiable with available data, these actions have likely resulted in a positive impact on surface water quality in the Railroad Gulch area.

Mine Operations and Boulevard Areas

During Phase I, a significant amount of highly contaminated materials was removed from the Mine Operations Area (MOA) and Boulevard Area. Although the removals were not complete, the reduction in overall contaminant mass in the MOA and Boulevard Area would be expected to result in water quality improvements. Data are not available to evaluate water quality in the MOA and Boulevard Areas.

Upper Magnet Gulch

Prior to remediation, Upper Magnet Gulch contained approximately 230,000 cubic yards of contaminated materials consisting of gypsum, tailings, and PTMs. During Phase I approximately 210,000 cubic yards of contaminated materials were removed from Upper Magnet Gulch and placed in the SCA.

The Upper Magnet Gulch Phase I remedial action appears to have had a significant positive impact on groundwater and surface water quality. Dissolved cadmium and dissolved lead concentrations in Magnet Creek have decreased between the pre- and post-remediation time periods. Dissolved metal concentrations in Upper Magnet Gulch groundwater are significantly lower in the post-remediation time period than those observed prior to remediation.

A-4 Gypsum Pond

During active mining operations, the A-4 Gypsum Pond was an impoundment for gypsum from acid- and fertilizer-producing facilities located in Government Gulch. The A-4 Gypsum Pond remedial action was performed by a PRP (Stauffer Chemical) and consisted of improving drainage channels for Magnet Creek and Deadwood Creek to keep the surface water from entering the A-4 Gypsum Pond, and capping the A-4 Gypsum Pond with a vegetated soil cover.

No pre-remediation groundwater quality data are available for the A-4 Gypsum Pond; therefore, it is difficult to determine changes between the pre- and post-remediation time periods. Dissolved cadmium and dissolved zinc concentrations measured at the A-4 Gypsum Pond during the post-remediation time period are among the highest observed within OU2. The presence of elevated dissolved cadmium and dissolved zinc concentrations in groundwater in the A-4 Gypsum Pond area suggests that either the A-4 Gypsum Pond continues to act as a considerable source of groundwater contamination, or a previously undocumented source of contamination is located in the A-4 Gypsum Pond area. Gypsum materials within the A-4 Gypsum Pond would be expected to contain trace amounts of cadmium and zinc. However, the significantly high concentrations observed in groundwater in this area suggest that a source other than the gypsum materials is present in this area.

Grouse Gulch

Phase I remedial actions conducted in Grouse Gulch focused on the removal of contaminated materials from the Grouse Creek channel and floodplain and the stabilization of tailings piles and mine dumps.

Prior to remediation, dissolved cadmium and dissolved zinc exceeded the AWQC in Grouse Creek. Following remediation, neither has exceeded the AWQC.

ES.4 OU2-Wide Water Quality

The 1992 OU2 ROD identified RAOs for groundwater and surface water quality within OU2. For groundwater, the RAO is compliance with MCLs. For surface water, the RAO is compliance with AWQC in OU2 tributaries. The SFCDR is not included in OU2 because of the large amount of contamination entering OU2 in the SFCDR from upstream sources located in the upper portions of OU3. However, one of the overall goals of the OU2 remedy is to reduce contamination to the SFCDR from sources within OU2.

Prior to remediation, approximately 50 million cubic yards of contaminated materials were estimated to be present within OU2. During the implementation of Phase I remedial actions, approximately 4 million cubic yards of contaminated materials were removed from various areas within OU2. These contaminated materials were consolidated with existing contaminated materials in one of four repositories within OU2 (CIA, SCA, Borrow Area Landfill (BAL), and Page Ponds). Phase I remedial actions resulted in the isolation of approximately 29 million cubic yards of contaminated materials from contact with contaminant release mechanisms by consolidation in the CIA and SCA repositories. Both the CIA and SCA were capped with low permeability (1 x 10-7 cm/sec) covers that effectively limited exposure of these contaminated materials. This is a total reduction of approximately 60 percent of the mass of contaminated materials within OU2 that was exposed to contaminant release and transport to the environmental system.

ES.4.1 Tributary Water Quality

Prior to remediation, contaminant concentrations in all OU2 tributaries consistently exceeded the AWQC, with the exception of Italian Gulch and Jackass Creek located on the north side of the SFCDR in the eastern portion of OU2.

During the post-remediation time period, dissolved metal concentrations in the majority of OU2 tributaries continue to exceed the AWQC. However, significant decreases between pre- and post-remediation dissolved metal concentrations have occurred in tributaries where water quality-oriented Phase I remedial actions were implemented (Bunker Creek and Government Creek). The post-remediation concentrations continue to decrease, so the full positive benefit of the OU2 Phase I remedial actions has not been fully realized.

The presence of uncontrolled discharges of AMD from the Reed and Russell mine workings in Milo Gulch has resulted in a degradation in Milo Creek water quality between the pre- and post-remediation time periods.

ES.4.2 Groundwater Quality

The extent and concentration of dissolved arsenic and dissolved lead concentrations in OU2 have decreased substantially between the pre- and post-remediation time periods. The majority of dissolved arsenic and dissolved lead concentrations greater than the MCL during both time periods occurred in the upper aquifer below and downgradient of the CIA. Prior to remediation, no groundwater monitoring was conducted in the A-4 Gypsum

Pond area. During the post-remediation time period, high concentrations of dissolved lead have been detected in monitoring wells in the A-4 Gypsum Pond area.

Prior to remediation, dissolved cadmium and dissolved zinc concentrations consistently exceeded the MCL in groundwater throughout the majority of OU2. During the post-remediation time period, dissolved cadmium and dissolved zinc concentrations continue to exceed the MCL in OU2 groundwater. However, significant reductions in concentration between the pre- and post-remediation time periods have occurred. In addition, a large number of decreasing post-remediation concentration trends for dissolved cadmium (Figure ES-2a and ES-2b) and dissolved zinc (Figure ES-3a and ES-3b) are present in monitoring wells throughout OU2. This suggests that the positive benefits of Phase I remedial actions on OU2 groundwater quality have not yet been fully realized.

Increasing dissolved cadmium and dissolved zinc trends have also been detected in some areas within OU2, particularly in monitoring wells located between the SFCDR and CIA. Increases in dissolved cadmium and dissolved zinc concentrations in this area may be the result of removal and rechannelization work conducted in the SFCDR between 1999 and 2003 (Section 15). Disturbances to the river bed and banks may have increased the amount of surface water infiltrating through contaminated materials in this area, resulting in increasing concentrations at these monitoring wells.

Data gaps are present in the OU2 groundwater monitoring network that prevent a fuller understanding of groundwater quality and contaminant fate and transport in groundwater within OU2. No groundwater monitoring wells are currently located within the Page Ponds area. The hydrologic system of the Page Ponds area is poorly understood and requires further investigation. In addition to the Page Ponds area, monitoring well coverage in the eastern portion of OU2 is minimal. Although a number of monitoring wells are located on the south side of the SFCDR, no monitoring wells are located on the north side of the SFCDR in Kellogg, or between the SFCDR and the southern margin of the aquifer. Given the significant amount of contamination present in groundwater upgradient of the CIA, additional characterization of the groundwater system in these areas is needed.

ES.4.3 SFCDR Water Quality

The impacts of Phase I remedial actions on SFCDR water quality are best viewed by evaluating low flow monitoring data where groundwater is the primary source of recharge and thus contaminants to the SFCDR within OU2.

The net gain in dissolved zinc load from groundwater to the SFCDR prior to remediation was similar to loading during the post-remediation time period (Figure ES-4). However, discharge measured during the pre-remediation sampling event in September 1987 was substantially lower than during the post-remediation sampling events in October 2003 and October 2006.

The net gain in dissolved zinc load in September 1987 in the SFCDR in the vicinity of the CIA was substantially higher than dissolved zinc loading in this same area in October 2003 and October 2006. As is noted above in the CIA discussion, this is most likely driven by changes in AMD management beginning in 1996 and the capping of the CIA in 2000.

Dissolved zinc AWQC ratios in the SFCDR have decreased substantially between the pre- and post-remediation time periods (Figure ES-5). Decreases in the AWQC ratios occur at both the eastern (SF-268) and western (SF-271) boundaries of OU2. The decreases observed at SF-268 are most likely the result of remedial actions conducted upstream of OU2. Decreases observed at the western boundary of OU2 at SF-271 are also related to some degree to upstream remedial actions. However, the reductions in AWQC ratios at this location would not likely have occurred to the same magnitude without the implementation of Phase I remedial actions within OU2.

Dissolved metal concentrations and AWQC ratios in the SFCDR at SF-268 and SF-271 exhibited decreasing trends for both the full period of record (1987 to 2007) and the post-remediation time period (2000 through 2007). The decreasing trends observed at SF-271 are corroborated by trend evaluations conducted by the U.S. Geological Survey (USGS) (Donato, 2006).

ES.5 Conclusions

As a result of the bankruptcy of the major PRPs for OU2 and the shift in responsibility for OU2 remedy implementation to the EPA and State of Idaho, the EPA and State of Idaho developed a phased approach to remedy implementation within OU2. Phase I remedial actions conducted within OU2 included a series of large- and small-scale source removals, re-establishment of stable creek channels, demolition of abandoned milling and processing facilities, the engineered closures of waste consolidation facilities located onsite, and significant revegetation efforts. The focus of Phase I remedial actions within OU2 was on the reduction of exposure pathways to human receptors, and addressing water quality issues through the extensive source removal, consolidation, and isolation of contaminated materials. The Phase I remedial actions implemented in OU2 focused on the application of long-term, permanent remedial technologies that would reduce long-term O&M costs associated with the treatment technologies identified by the PRPs. Under the phased approach to remedy implementation, remedial actions implemented during Phase I would be evaluated with respect to their ability to meet water quality RAOs and performance standards identified in the 1992 OU2 ROD. In a potential Phase II, Phase I remedy shortcomings are to be addressed followed by a coordinated program to address long-term water quality, ecological, and environmental management issues.

Substantial control of contaminated materials has been accomplished by implementation of Phase I remedial actions within OU2. Prior to implementation of Phase I actions, approximately 50 million cubic yards of contaminated materials were present within OU2 and were exposed to contaminant release and transport mechanisms. During Phase I, approximately 29 million cubic yards or 60 percent of contaminated materials were isolated from contaminant release mechanisms by placing them under low permeability caps.

The assessment of Phase I remedial actions and OU2-wide water quality within OU2 has led to the following conclusions:

- Only a limited number of Phase I remedial actions conducted within OU2 had RAOs or performance standards associated with groundwater or surface water quality. However, the majority of these actions are meeting their RAOs and performance standards.

- An overall improvement in groundwater and surface water quality has occurred in OU2 between the pre- and post-remediation time periods. However, the improvement in water quality has not resulted in achievement of AWQC or MCLs in OU2.
- The presence of a large number of decreasing concentration trends in groundwater during the post-remediation time period suggest that the full positive benefits of Phase I remedial actions on OU2 groundwater quality has not yet been fully realized, given the relatively short time period since the Phase I remedial actions were completed.
- The interaction of surface water and groundwater within OU2 represents a significant contaminant transport pathway. This is especially important in the main SFCDR valley where contaminant sources are widespread and present to significant depths.
- Uncontrolled discharges of AMD from the Reed and Russell mine working in Milo Gulch to Milo Creek are resulting in a significant degradation in Milo Creek and potentially SFCDR water quality.
- The hydrologic system and contaminant conditions in the Page Ponds area are poorly understood and additional investigation of this area will be required to more fully understand and address water quality in the western portion of OU2.
- Some of the highest dissolved metal concentrations within OU2 during the post-remediation time period were detected in the vicinity of the A-4 Gypsum Pond and near the Zinc Plant foundations within Government Gulch. Additional investigation of these areas will be required to more fully understand potential contaminant sources within OU2.
- The hydrologic system and contaminant conditions in the eastern portion of OU2 in the vicinity of Kellogg are poorly understood and additional investigation of this area will be required to more fully understand and address water quality issues in the single unconfined aquifer and the upper and lower aquifers east of the CIA.

Following completion of this document, the OU2 Source Areas of Concern Loading Analysis Report will be developed. The OU2 Source Areas of Concern Loading Analysis Report will identify and rank the remaining sources of contamination within OU2 based on relative metal loading to surface water and groundwater within OU2, impacts to the environment, and other relevant criteria. Following the development of the OU2 Source Areas of Concern Loading Analysis Report, the most significant sources will undergo an assessment to identify and conceptually evaluate potential remedial actions that may be appropriate to implement under a possible Phase II of OU2 remedy implementation.

Table ES-1
Phase I Remedial Action RAOs and Performance Standards and Assessment Results
Phase I Remedial Action Assessment Report
Bunker Hill Superfund Site OU2

RAO/Performance Standard	Decision Document	Assessment Result
Central Impoundment Area – Main repository for contaminated materials. Closed in 2000 with a low permeability geomembrane cover system, surface water drainage system, and revegetation and armoring of the CIA sideslopes.		
Minimize releases from source materials in the CIA	1992 OU2 ROD	Performing as intended. Monitoring wells completed within CIA materials have consistently been dry following their installation in 2000 following capping of the CIA.
Prevent direct contact with, and minimize infiltration through, contaminated media with a 1x10-6 cm/sec (modified to 1x10-7 cm/sec) permeability cap.	1992 OU2 ROD (modified in the 1998 OU2 ESD)	Performing as intended. Monitoring wells completed within CIA materials have consistently been dry following their installation in 2000 following capping of the CIA.
Maximize efficient interception of groundwater from discrete seepage locations north of the CIA in the south bank of the SFCDR	1992 OU2 ROD	This action was deferred until the impacts of the CIA Phase I remedial action on water quality could be evaluated.
Positive impact on groundwater quality.	Phase I remedial action intent	Water quality in the upper aquifer in the vicinity of the CIA appears to be improving. However, the majority of the benefit to water quality in the vicinity of the CIA is likely derived from the cessation of AMD impoundment on the CIA. Capping of the CIA would be responsible for reducing the amount of precipitation infiltrating through contaminated materials.
Bunker Creek – Partial removal of contaminated materials during reconstruction of the channel and floodplain, revegetation, and the installation of culverts at road crossings.		
Meet AWQC in Bunker Creek at monitoring location BH-BC-0001 (prior to discharging to the SFCDR)	1992 OU2 ROD	Bunker Creek surface water at BH-BC-0001 is not in compliance with AWQC for dissolved cadmium and dissolved zinc. However, significant decreases in dissolved cadmium and dissolved lead have occurred between the pre- and post-remediation time periods.
Limit Bunker Creek surface water interaction and potential contaminant migration to the underlying groundwater system.	1992 OU2 ROD	Based on the evaluation of recent discharge data in Bunker Creek, a substantial amount of discharge is being lost from Bunker Creek to underlying groundwater under low flow conditions along the southern boundary of the CIA and under high flow conditions in a smaller reach along the southern boundary of the CIA. Groundwater quality in the upper aquifer in the vicinity of Bunker Creek has shown significant improvement following the Phase I remedial action. However, the degree to which these improvements are associated with the Bunker Creek Phase I remedial action and other remedial actions in the area cannot be determined.
Smelter Closure Area – Repository for contaminated materials and demolition debris. The PTM monocell is located within the SCA under the SCA cap. The SCA was closed in 1998 and capped with a 1x10-7 cm/sec geomembrane liner and revegetated.		
Control migration of contaminants from the SCA to surrounding surface water and groundwater.	1992 OU2 ROD	The SCA Phase I remedial action has resulted in positive impacts to groundwater quality in the vicinity of the SCA. No discharge from the SCA toe drain has occurred since its installation. Discharge from old stormwater lines located beneath the SCA is present, but is collected and conveyed to the Lined Pond for treatment at the CTP.
Reduce groundwater elevations in the West Canyon upgradient of the SCA by diverting West Canyon surface water	1996 OU2 ROD Amendment	Groundwater elevations in the vicinity of the West Canyon have neither increased nor decreased following the installation of the West Canyon diversion. Because groundwater elevations in the vicinity of the West Canyon have remained constant, no contact between groundwater from the West Canyon and SCA materials is assumed to be occurring.
Reduce infiltration through SCA materials with the placement of a 1x10-7 cm/sec cap	1996 OU2 ROD Amendment	Groundwater elevations at the downgradient edge of the SCA remain below SCA materials. Groundwater elevations at the central and western downgradient edges of the SCA have not changed since the SCA was capped. Groundwater elevations at the eastern downgradient edge of the SCA have exhibited an increase. The reason for the increase in groundwater elevation at this location is unknown and additional investigation is required.

Table ES-1 (continued)
Phase I Remedial Action RAOs and Performance Standards and Assessment Results
Phase I Remedial Action Assessment Report
Bunker Hill Superfund Site OU2

RAO/Performance Standard	Decision Document	Assessment Result
Government Gulch - Demolition of industrial facilities within the Gulch and extensive source removals and reconstruction of a natural channel and floodplain for Government Creek.		
Reduce groundwater and surface water contamination levels	Phase I remedial action intent	During the development of Phase I remedial actions in OU2, a number of remedial actions identified for Government Gulch in the 1992 OU2 ROD were deferred in favor of extensive source removal activities. The removal of approximately 400,000 cubic yards of contaminated materials with lead concentrations typically greater than 10,000 mg/kg from the gulch floor has significantly reduced the mass of contamination within the gulch. Improvements in surface water and groundwater quality between the pre- and post-remediation time periods occur at the majority of monitoring locations. In many instances, contaminant concentrations have decreased up to an order of magnitude. Following remediation, groundwater concentration trends are decreasing at the majority of monitoring locations suggesting that the full positive benefit of the Phase I remedial action has not yet been fully realized.
Smelterville Flats – Approximately 1.6 million cubic yards of contaminated materials were removed from Smelterville Flats during Phase I.		
Minimize migration of contaminants to groundwater and surface water in the Smelterville Flats area.	1998 OU2 ESD	SFCDR water quality appears to have improved with respect to dissolved zinc concentrations, AWQC ratios, and loading in the Smelterville Flats area. This suggests that the Phase I remedial action is acting to reduce dissolved zinc migration from Smelterville Flats groundwater to the SFCDR. Decreases in contaminant metal concentrations in groundwater were observed in many of the monitoring wells in Smelterville Flats between the pre- and post-remediation time periods. Decreasing post-remediation contaminant metal concentrations trends for dissolved cadmium and dissolved zinc were detected at many monitoring locations suggesting that the full positive benefit of the Phase I remedial action on groundwater quality has not yet been fully realized.
Minimize surface water erosion and sedimentation in the SFCDR	1998 OU2 ESD	Reconstruction of portions of the SFCDR channel and floodway in Smelterville Flats coupled with the removal of unstable banks consisting of contaminated materials has greatly reduced erosion and sedimentation in this area of the SFCDR.
Milo Gulch – Water control and conveyance structures were installed at the Reed Landing area within Milo Gulch		
Minimize contact between Milo Creek surface water and tailings and waste rock in the upper portions of the gulch floor, reduce contaminant transport to the SFCDR as suspended sediment during runoff events, and minimize surface water infiltration into the Bunker Hill Mine workings immediately below the main Milo Creek channel.	1992 OU2 ROD	Surface water quality in Milo Creek consistently exceeds the AWQC for dissolved cadmium, dissolved lead, and dissolved zinc. An increase in dissolved cadmium and dissolved zinc concentrations between the pre- and post-remediation time periods has occurred. The increase in dissolved cadmium and dissolved zinc concentrations between the pre- and post-remediation time periods is believed to be the result of uncontrolled AMD discharge from the Reed and Russell tunnels within Milo Gulch to Milo Creek.
Railroad Gulch – Reconstruction of Railroad Gulch drainage.		
Reduce erosion of the drainage channel and improve the drainage channel to reduce flooding under high-flow conditions	Phase I remedial action intent	Although not quantifiable, the reconstruction and armoring of the Railroad Gulch drainage channel has likely resulted in a significant reduction in erosion and increase in the ability of the drainage to convey high flows in comparison to pre-remediation conditions.
Mine Operations and Boulevard Areas – Demolition of industrial structures and partial removal of highly contaminated materials from within both areas.		
Demolition of industrial structures and removal of contaminated materials with lead concentrations greater than 1,000 mg/kg	1992 OU2 ROD	During the implementation of Phase I remedial actions, soil excavation goals could not be achieved because of the depth and extent of contamination within the MOA and Boulevard Area. Water quality data are not available to quantify the impact of this action on water quality. However, the removal of highly contaminated materials would be expected to result in water quality improvements.

Table ES-1 (continued)
Phase I Remedial Action RAOs and Performance Standards and Assessment Results
Phase I Remedial Action Assessment Report
Bunker Hill Superfund Site OU2

RAO/Performance Standard	Decision Document	Assessment Result
Upper Magnet Gulch – Extensive removal of contaminated materials from within Upper Magnet Gulch.		
Positive water quality impacts	Phase I remedial action intent	The Upper Magnet Gulch Phase I remedial action appears to have ad a significant positive impact on groundwater and surface water quality in Upper Magnet Gulch. Dissolved cadmium and dissolved lead concentrations in Magnet Creek have decreased between the pre- and post-remediation time periods. Dissolved metal concentrations in Upper Magnet Gulch groundwater are significantly lower than those observed during the pre-remediation time period.
A-4 Gypsum Pond – Capping of the A-4 Gypsum Pond with a soil cover and creation of channels for Deadwood Creek and Magnet Creek		
Limit the possibility of contaminant mobilization to surface water and groundwater	1992 OU2 ROD	Because of the lack of pre-remediation water quality data for the A-4 Gypsum Pond area, it is difficult to determine changes between the pre- and post-remediation time periods. The presence of elevated dissolved cadmium and dissolved zinc concentrations in groundwater in the A-4 Gypsum Pond area suggest that either the A-4 Gypsum Pond continues to act as a considerable source of groundwater contamination or that a previously undocumented source of contamination upgradient of the A-4 Gypsum Pond is present.
Grouse Gulch – Removal of contaminated materials form the Grouse Creek channel and floodplain and the stabilization of tailings piles and mine dumps.		
Positive water quality impacts	Phase I remedial action intent	Prior to remediation dissolved cadmium and dissolved zinc exceeded the AWQC in Grouse Creek. Following remediation, neither has exceeded the AWQC.

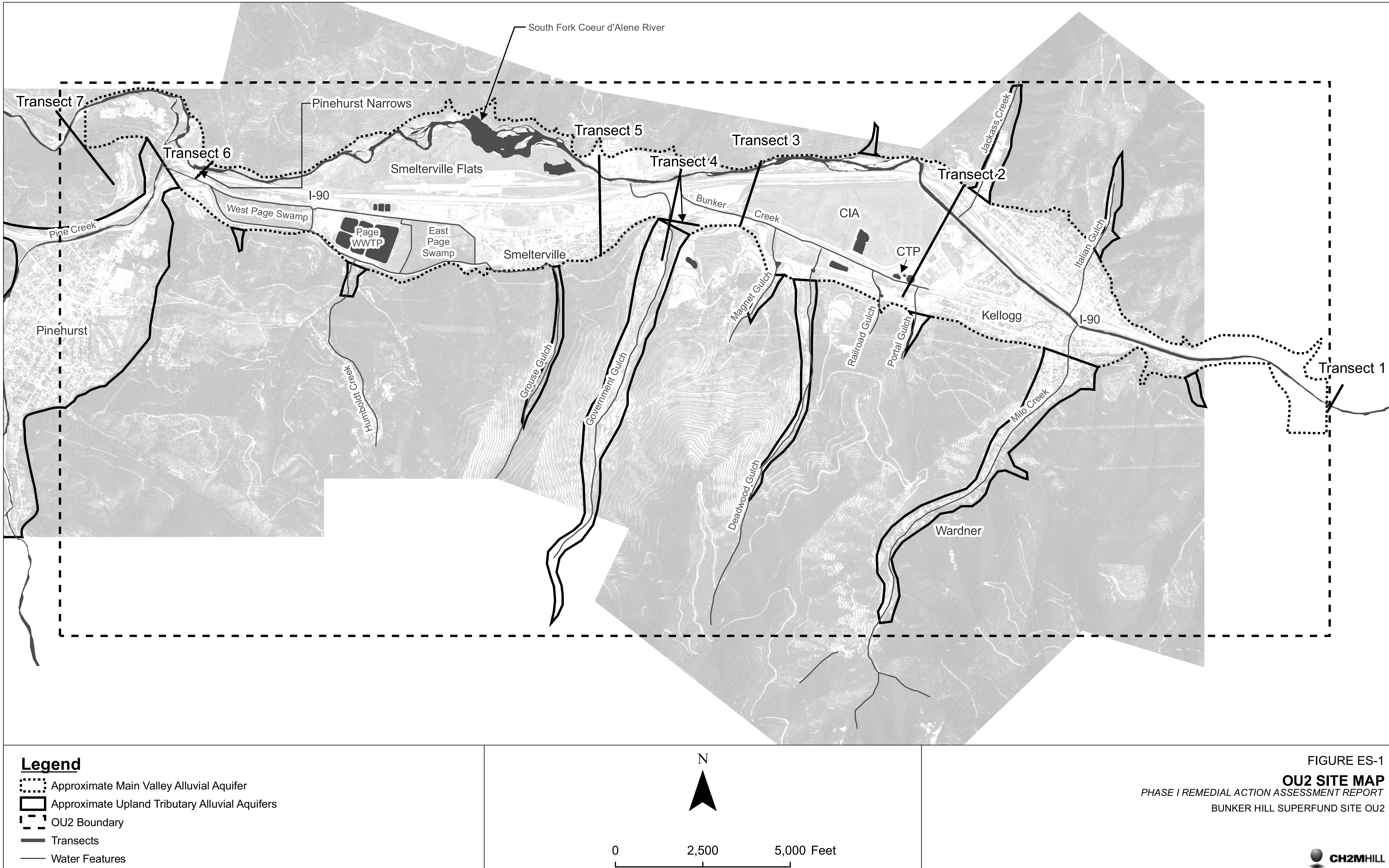

FIGURE ES-1

OU2 SITE MAP

PHASE I REMEDIAL ACTION ASSESSMENT REPORT

BUNKER HILL SUPERFUND SITE OU2

CH2MHILL

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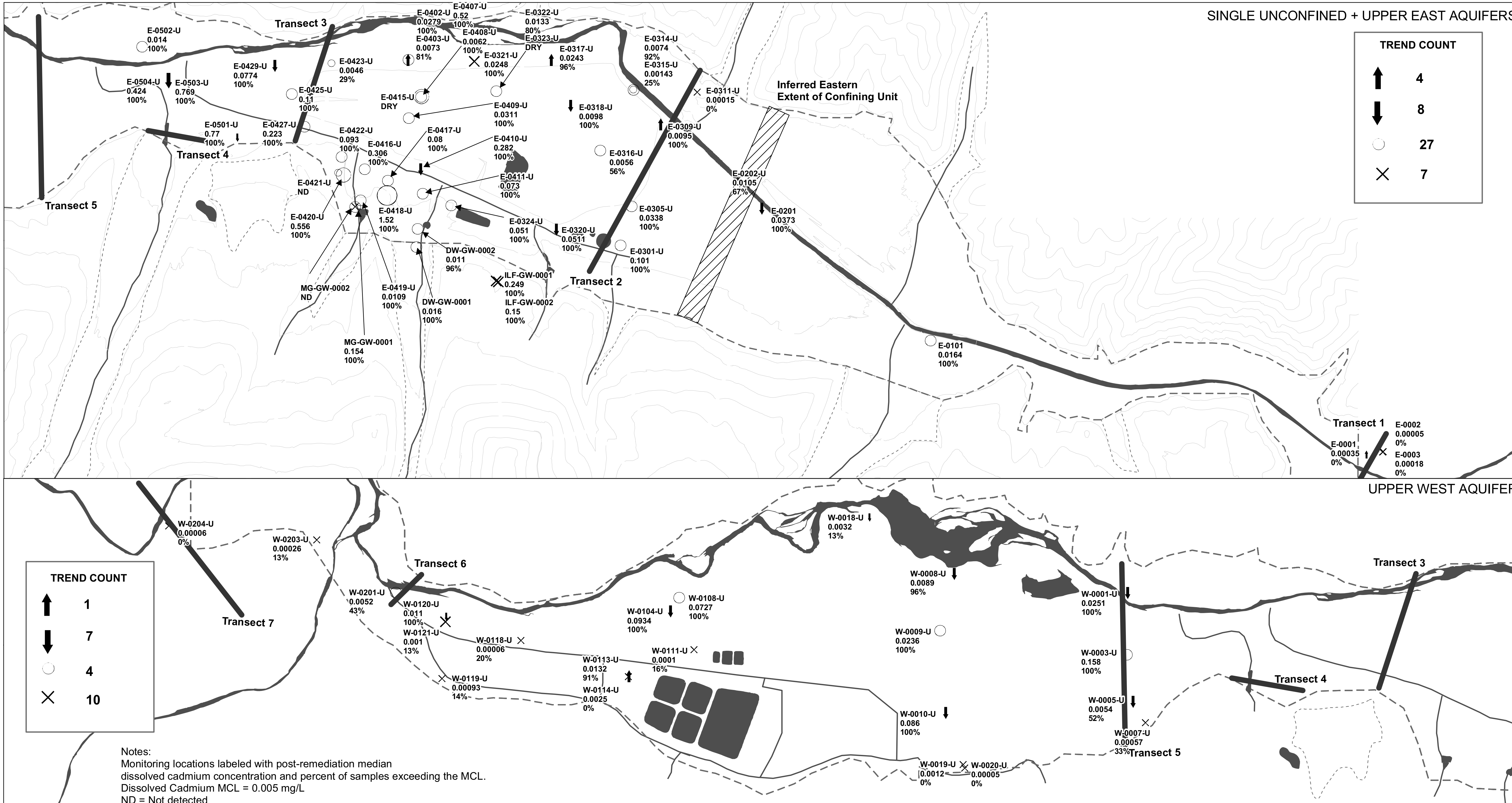


Notes:
Monitoring locations labeled with post-remediation median
dissolved cadmium concentration and percent of samples exceeding the MCL.
Dissolved Cadmium MCL = 0.005 mg/L
ND = Not detected

Legend

DissolvedCadmiumRatio

Decreasing Trend	Increasing Trend	Insufficient Data for Test	No Significant Trend
Less Than MCL	Less Than MCL	Less Than MCL	Less Than MCL
1 to 10 Times MCL	1 to 10 Times MCL	1 to 10 Times MCL	1 to 10 Times MCL
100 to 200 Times MCL	100 to 200 Times MCL	100 to 200 Times MCL	100 to 200 Times MCL
Greater Than 200 Times MCL	Greater Than 200 Times MCL	Greater Than 200 Times MCL	Greater Than 200 Times MCL

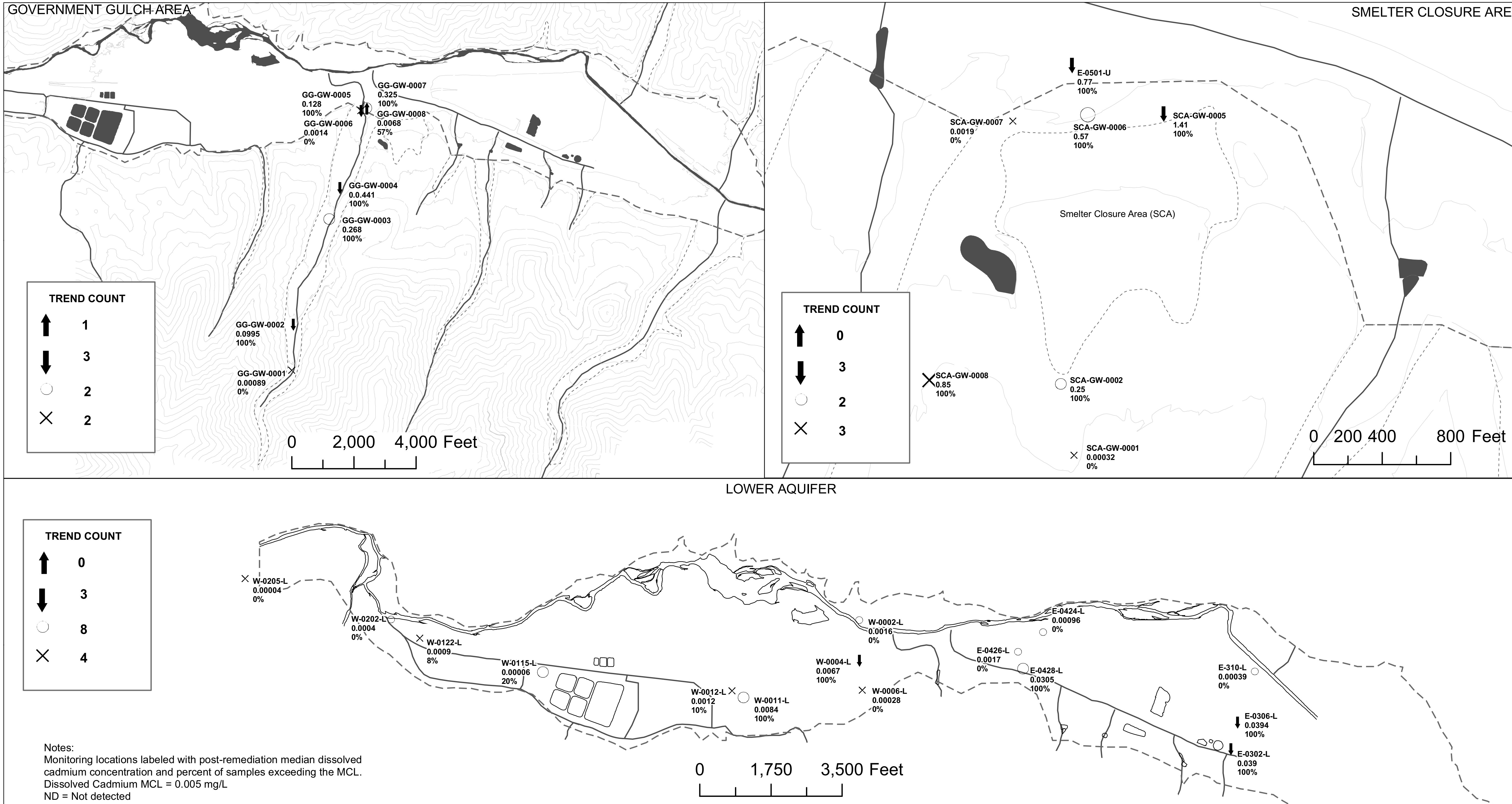
N

0 3,000 6,000 Feet

FIGURE ES-2a
POST-REMEDIATION DISSOLVED CADMIUM TRENDS IN GROUNDWATER

PHASE I REMEDIAL ACTION ASSESSMENT REPORT
BUNKER HILL SUPERFUND SITE OU2

CH2MHILL



Notes:
Monitoring locations labeled with post-remediation median dissolved cadmium concentration and percent of samples exceeding the MCL.
Dissolved Cadmium MCL = 0.005 mg/L
ND = Not detected

Legend

DCd

Decreasing Trend
- Less Than MCL
- 1 to 100 Times MCL
- 100 to 1000 Times MCL
- Greater Than 1000 Times MCL

No Significant Trend
- Less Than MCL
- 1 to 100 Times MCL
- 100 to 1000 Times MCL
- Greater Than 1000 Times MCL

Insufficient Data for Test
- Less Than MCL
- 1 to 100 Times MCL
- 100 to 1000 Times MCL
- Greater Than 1000 Times MCL

Increasing Trend
- Less Than MCL
- 1 to 100 Times MCL
- 100 to 1000 Times MCL
- Greater Than 1000 Times MCL

N

Scale Varies

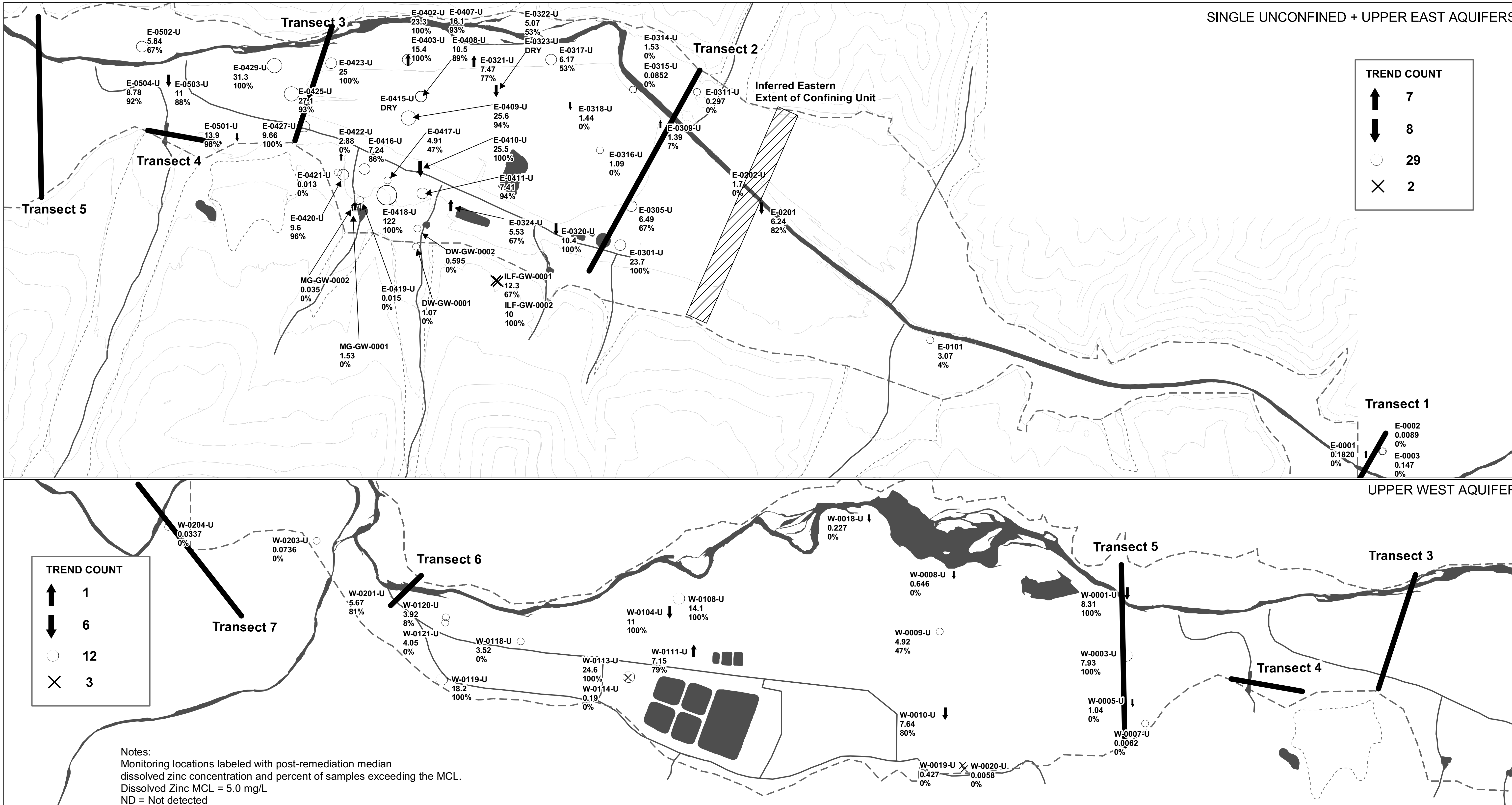
FIGURE ES-2b

POST-REMEDIATION DISSOLVED CADMIUM TRENDS IN GROUNDWATER

PHASE I REMEDIAL ACTION ASSESSMENT REPORT

BUNKER HILL SUPERFUND SITE OU2

CH2MHILL



Legend

DissolvedZincRatio

Decreasing Trend	Increasing Trend	Insufficient Data for Trend	No Significant Trend
Less Than MCL	Less Than MCL	Less Than MCL	Less Than MCL
1 to 5 Times MCL	1 to 5 Times MCL	1 to 5 Times MCL	1 to 5 Times MCL
5 to 10 Times MCL	5 to 10 Times MCL	5 to 10 Times MCL	5 to 10 Times MCL
Greater Than 10 Times MCL	Greater Than 10 Times MCL	Greater Than 10 Times MCL	Greater Than 10 Times MCL

N

0 3,000 6,000 Feet

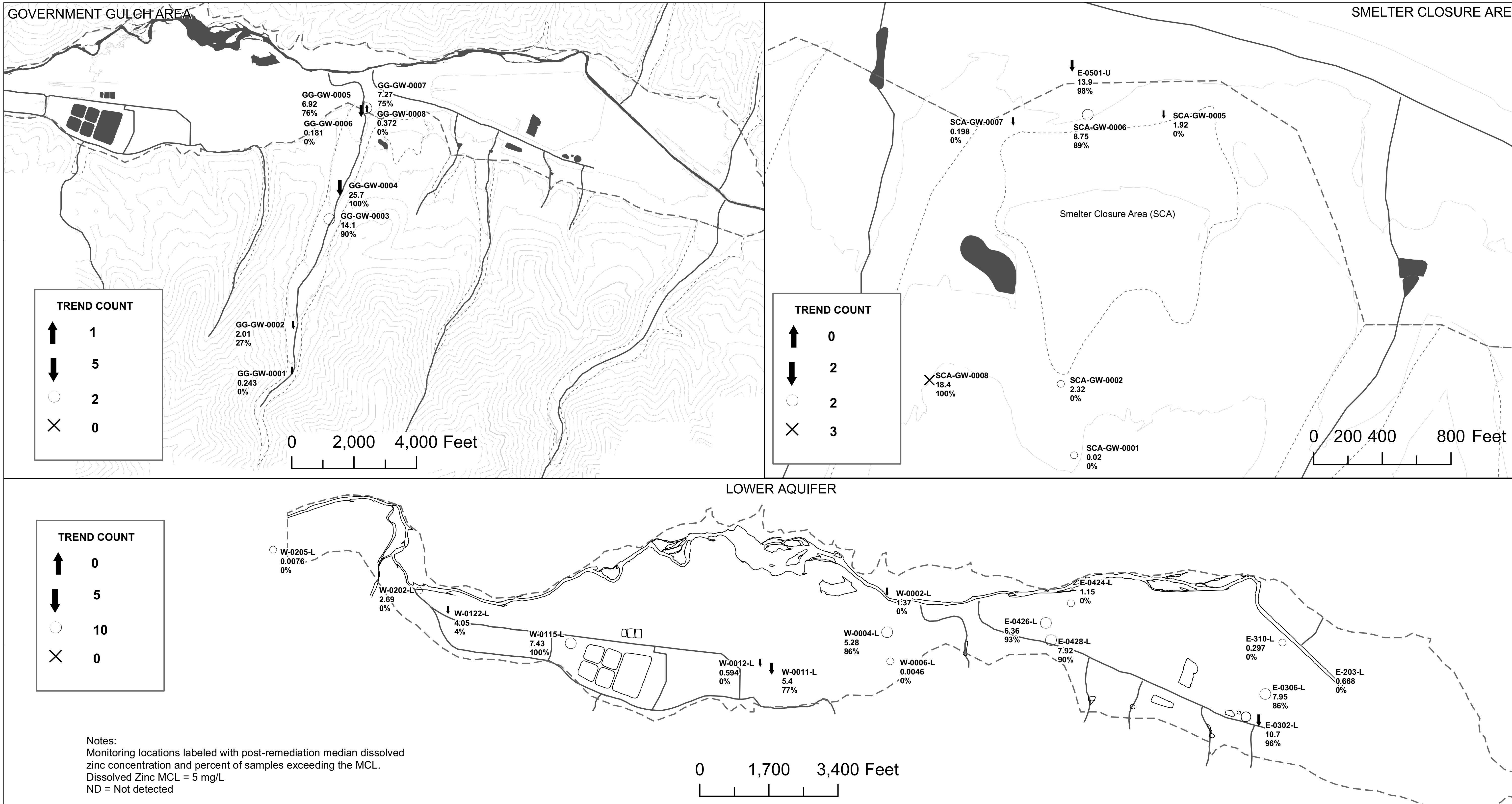
FIGURE ES-3a

POST-REMEDIATION DISSOLVED ZINC TRENDS IN GROUNDWATER

PHASE I REMEDIAL ACTION ASSESSMENT REPORT

BUNKER HILL SUPERFUND SITE OU2

CH2MHILL



Legend

DZn	DZn No Signficant Trend	DZn Increasing Trend	Insufficient Data for Test
Decreasing Trend	Decreasing Trend		
Less Than MCL	Less Than MCL	Less Than MCL	Less Than MCL
1 to 5 Times MCL	1 to 5 Times MCL	1 to 5 Times MCL	1 to 5 Times MCL
5 to 10 Times MCL	5 to 10 Times MCL	5 to 10 Times MCL	5 to 10 Times MCL

N

Scale Varies

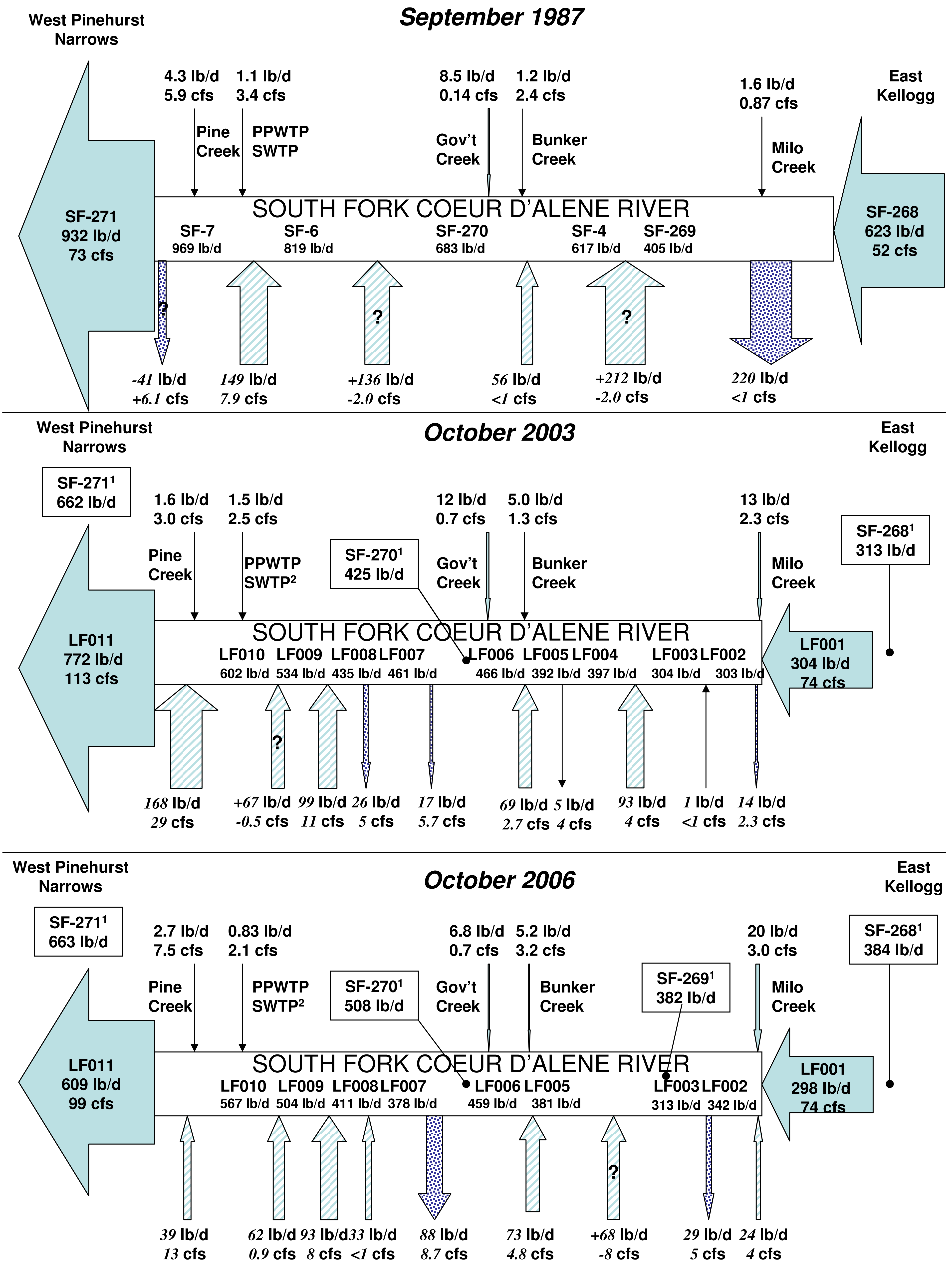
FIGURE ES-3b

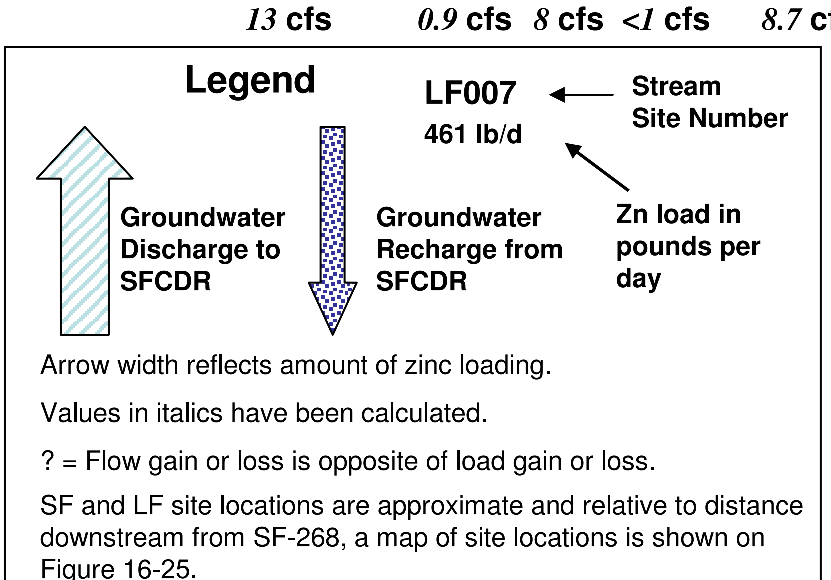
POST-REMEDIATION DISSOLVED ZINC TRENDS IN GROUNDWATER

PHASE I REMEDIAL ACTION ASSESSMENT REPORT

BUNKER HILL SUPERFUND SITE OU2

CH2MHILL





[1] Data for "SF" sites were collected by USGS as part of BEMP on different dates than the "LF" sites. In 2003, BEMP sites were sampled one week prior to the LF sites.

[2] Loading and flow data are a monthly average from October 2004 and 2006, data were not available for 2003. PPWTP and SWTP concentrations and loading calculations were based on total Zinc concentrations, dissolved Zinc concentrations were not available.

Figure created by Terragraphics (unpublished)

FIGURE ES-4
SFCDR DISSOLVED ZINC LOADING MASS BALANCE PRE-REMEDIATION (1987) AND POST-REMEDIATION (2003 & 2006)
PHASE I REMEDIAL ACTION ASSESSMENT REPORT
BUNKER HILL SUPERFUND SITE OU2

Figure ES-5
Dissolved Zinc AWQC Ratios Over Time at SF-268 and SF-271
Phase I Remedial Action Assessment Report
Bunker Hill Superfund Site OU2