Appendix C
Summary of Soil Removal Alternatives Evaluation and Mining Visualization System Model Development

Summary of Soil Removal Alternatives Evaluation at the East Helena Former ASARCO Smelter Site

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This technical memorandum (TM) presents a summary of evaluations conducted by the Montana Environmental Trust Group, LLC, Trustee of the Montana Environmental Custodial Trust (Custodial Trust) in 2013 as part of the Corrective Measures Study. Three soil removal corrective measures alternatives for the East Helena former ASARCO Smelter site (former Smelter site) (Figure 1) were evaluated in terms of technical feasibility, constructability, contaminant mass removed, and rough order of magnitude (ROM) cost.

Background Information

This section provides background information pertinent to the soil removal alternative evaluations.

Interim Measures

The Custodial Trust proposed three interim measures (IMs), each to be implemented in phases, as described in *Former ASARCO East Helena Facility Interim Measures Work Plan—Conceptual Overview of Proposed Interim Measures and Details of 2012 Activities* (CH2M HILL, 2012a). The primary purpose of the IMs is to reduce the migration of contaminants in groundwater from the operating area of the former Smelter site and contribute to the protection of public health and the environment. The three IMs are summarized as follows:

- The South Plant Hydraulic Control IM (SPHC IM) has been proposed to reduce the migration of inorganic contaminants in groundwater by changing the hydrogeological conditions at the southern end of the former Smelter site.
- The Source Removal IM has been proposed to reduce the mass loading of contaminants to groundwater by reducing the volume of soil with high concentrations of inorganic contaminants that are in direct contact with surface water and are leaching to groundwater.
- The Evapotranspiration Cover System IM (ET Cover System IM) is proposed to further reduce the potential for inorganic soil contaminants leaching to groundwater by eliminating or substantially reducing the amount of precipitation that would infiltrate through contaminated materials without a site cover. The ET Cover System IM will also eliminate human and ecological receptor exposure to inorganic-contaminated soil.

Purpose of Soil Removal Alternatives Evaluation

The soil removal alternatives evaluation discussed herein is intended to be a screening-level evaluation. It focuses specifically on excavation and backfill activities that could be conducted at the former Smelter site by the Custodial Trust consistent with the purpose of the Source Removal IM. Excavation volume estimates presented and used for costing are based on mass estimates calculated with a 3-dimensional model constructed using Mining Visualization System (MVS) software (see details provided below and in Attachment 1). This evaluation does not include other means by which source control could be achieved, such as by groundwater pump-and-treat or barrier walls.

An evaluation of removal actions for the Tito Park Area (TPA) was conducted separately from this source removal evaluation as part of the IM assessment and design work. Three options for source removal in TPA were evaluated with consideration to (1) the potential for this area to be flooded by future high-flow events in Prickly Pear Creek (PPC), and (2) the changes in grades necessary for the PPC realignment and other SPHC IM requirements. The results of this evaluation and the description of the recommended removal action are documented in *Former ASARCO East Helena Facility Interim Measures Work Plan—2014* (IM Work Plan 2014; CH2M HILL, 2013). The Custodial Trust currently plans to implement a grading plan that excavates all of the TPA (Tito Park, Upper Ore Storage Area, and the Acid Plant Sediment Drying [APSD] Area) down to the projected groundwater levels after the implementation of the SPHC IM PPC Temporary Bypass, as well as the top 1 to 2 feet (ft) of Lower Lake sediment.

Comparison of Mass in Soil Addressed by Interim Measure Implementation

Inorganic contaminants are broadly distributed in soil at the former Smelter site and represent the remaining source of contamination to groundwater. For the purpose of corrective and interim measures evaluations, the extent of arsenic and selenium is considered to be representative of the extent of all inorganic contaminants for the former Smelter site. Previous investigations (refer to draft *Phase II RCRA Facility Investigation—East Helena Facility* [GSI Water Solutions, Inc., 2011]) have shown other inorganic contaminants are generally co-located with arsenic and selenium, and a remedial action such as removal of arsenic and selenium would address the other inorganic contaminants as well. Arsenic and selenium are the two constituents of potential concern (COPCs) in soil that are also primary COPCs in groundwater.

To estimate the overall contaminant mass, as well as the mass to be addressed by each IM, CH2M HILL modeled inorganic contaminant distributions using the MVS software, with a focus on arsenic and selenium. Attachment 1 describes the MVS model development activities, the data interpolation (kriging) process and assumptions used, as well as various model quality reviews performed.

Arsenic and selenium fate and transport in groundwater are complex processes and are expected to be a function not only of contaminant concentrations, but also of leach ability of the contaminant mass in soil and geochemical conditions (e.g., pH and oxidation-reduction potential) in the subsurface. A full evaluation of these issues is beyond the intent of this TM. Therefore, the soil removal evaluation focuses on contaminant mass removal estimates.

To help visualize site conditions, the MVS model provided graphical illustrations of mass distributions for arsenic and selenium (Figures 2 through 4). Table 1 presents the total estimated mass of arsenic and selenium in soil beneath the former Smelter site relative to how it is addressed by each IM. Note that the estimates presented exclude the mass associated with the slag pile and soil beneath the slag pile. Additionally, there is greater certainty in the mass estimates presented for arsenic than for selenium because more arsenic than selenium data are available from soil sampling. The following observations are based on the MVS modeling, the tabulated data, and the graphical representations.

- The majority of contaminant mass at the former Smelter site is present in the vadose zone, above groundwater, and this source material will be addressed by the ET Cover System. Mass in the vadose zone is subject to contaminant leaching from vertical infiltration of water from precipitation and other sources. Based on MVS model estimates, approximately 60 percent of total arsenic and 75 percent of total selenium mass are present in vadose zone soil. The ET Cover System will effectively isolate the contaminant mass in the vadose zone by minimizing infiltration of precipitation. For the purpose of this screening-level evaluation, the mass estimates were calculated with the simplifying assumption that the capillary fringe is not significant, and therefore negligible mass is associated with the capillary fringe.
- The remaining 40 percent of the total arsenic contaminant mass is present in saturated zone soil, is subject to leaching from direct contact with groundwater, and will be partially addressed by the SPHC IM. Implementation of the SPHC IM will lower existing groundwater levels, particularly in the southern portion of the former Smelter site and reduce the amount of contaminant mass leaching to

groundwater. Based on projected groundwater levels pre- and post-SPHC IM implementation and MVS model estimates, the majority of mass present in the saturated zone soil (approximately 30 percent of total arsenic and 15 percent of total selenium) no longer come in contact with groundwater. In other words, the ET Cover System in combination with the SPHC IM is estimated to control approximately 90 percent of the arsenic and 90 percent of the selenium in soil that are currently a source of contamination to groundwater.

- Therefore, the Source Removal IM would address the remaining mass in saturated zone soil after the implementation of the SPHC IM. Based on MVS model estimates, approximately 10 percent of both the total arsenic and total selenium mass would remain in the saturated zone following SPHC IM implementation and be subject to leaching from contact with groundwater.

Soil Removal Alternatives Evaluation and Action Levels

Based on the current conceptual site model, and for the purpose of estimating total contaminant mass, arsenic was used as the primary measure of contamination in soil. Recognizing that arsenic and selenium behavior in the subsurface may be different, the soil removal evaluation assumes that the volumes identified for removal based on arsenic estimates would be adequate to address selenium. Investigations have shown arsenic and selenium contamination is generally co-located with each other, and although there are distinct differences, the majority of the arsenic sources appear to be sources of selenium as well.

For the soil removal evaluation, three concentration thresholds for arsenic were considered:

1) The Montana Department of Environmental Quality (MDEQ) has established a 40-milligram-per-kilogram (mg/kg) arsenic concentration as representative of naturally occurring conditions in native surface soil (between 0 and 2 ft deep) for the purpose of determining an action level for residential surface soil in the Helena Valley (MDEQ, 2005). The 40-mg/kg number is being used here as a surrogate for the background concentration of arsenic in soil, which has not been formally established for the East Helena Facility at this time. The second concentration threshold considered is the U.S. Environmental Protection Agency (USEPA) Soil Screening Level (SSL) of 0.29 mg/kg for arsenic in soil that would be protective of groundwater (USEPA, 2012), resulting in arsenic concentrations in groundwater at or below the maximum contaminant level (MCL). The SSL is a conservative value, expected to be significantly lower than the naturally occurring concentrations.
2) The MDEQ action level for arsenic in subsurface soil, defined as soil greater than 2 ft deep, is 300 mg/kg (MDEQ website: http://www.deq.mt.gov/StateSuperfund/FrequentlyAskedQuestions.mcpx); the level is calculated using an excavation scenario similar to that included in *Montana Tier 1 Risk-Based Corrective Action Guidance for Petroleum Releases* (MDEQ, 2009) that is protective of typical construction and utility workers.

For contouring, as well as mass and volume estimates, the following arsenic concentration ranges and color zones (representing the concentration ranges) were used:

- Less than (<) 0.29 mg/kg: dark blue. This zone would represent soil with concentrations of arsenic below the USEPA SSL, which is a conservative concentration calculated to be protective of groundwater.
- 0.29-2.9 mg/kg: light blue.
- 2.9-40 mg/kg: green. This zone, as well as the light blue and dark blue zones, would represent soil with concentrations of arsenic less than the 40-mg/kg concentration being used as a surrogate for naturally occurring background levels.
- 40-290 mg/kg: yellow. This zone, as well as the green, light blue, and dark blue zones, would approximate the volume of soil with concentrations of arsenic below MDEQ's action level of 300 mg/kg for subsurface soil.
- 290-2,900 mg/kg: orange.

- Greater than (>) 2,900 mg/kg: red.

Description of Soil Removal Alternatives

This TM summarizes the evaluation of three soil removal alternatives. The alternatives are briefly described below. Additional details regarding evaluation steps and results are provided in the subsequent sections.

- Alternative 1—Scrape/excavate shallow soil with arsenic concentrations greater than or equal to (≥) 40 mg/kg and consolidate the soil under the ET Cover System. This alternative was identified to determine whether it is possible to reduce the size of the ET Cover System by "scraping" near-surface soil and consolidating the soil on a smaller area within the Area of Contamination (AOC).
- Alternative 2—Excavate soil in the post-SPHC saturated zone with arsenic concentrations ≥290 mg/kg. This alternative is intended to address soil with arsenic concentrations greater than the MDEQ action level for subsurface soil (≥300 mg/kg) that remains in the saturated zone and would have the potential to leach to groundwater. Excavated soil would be consolidated within the AOC, beneath the ET Cover System.
- Alternative 3—Excavate soil in the post-SHPC saturated zone with arsenic concentrations ≥40 mg/kg. This alternative is intended to address soil with concentrations greater than what would be expected of naturally occurring levels that remain in the saturated zone. Excavated soil would be consolidated within the AOC, beneath the ET Cover System.

Evaluation Steps

The process used to evaluate the three alternatives consisted of the following basic steps:

1. Identify the zones for removal based on the concentrations of arsenic in soil (as entered in the project database and modeled with the MVS software).
2. Estimate the volume of material to be removed.
3. Assess the technical feasibility and constructability.
4. Develop a ROM estimate of the cost of removal.

Table 2 provides the neat volume estimates for Alternatives 1 through 3, and Table 3 provides the volume and quantity estimates for Alternative 2 based on more typical construction methods. The term "neat" refers to volumes estimated assuming vertical cuts, rather than the sloped sides typical of excavations up to 20 ft in depth. The neat volume estimates reflect the minimum volume of soil that would need to be removed. The estimated excavation and backfill volumes presented in Table 3 consider more typical constructability requirements and result in volumes greater than the neat volumes presented in Table 2.

ROM Class 5 implementation cost estimates are provided for each alternative. The accuracy of cost estimates for remedial construction is a function of the site characterization data available, as well as the level of design detail. A ROM Class 5 estimate indicates that only a concept-level design is available. Cost estimate results are discussed in the "Screening-Level Evaluation Results" section below. Cost estimating assumptions and details are provided in Attachment 2. Table 4 provides estimated cost summaries for Alternatives 2 and 3.

Alternative 1—Soil Scrape/Shallow Excavation

The first step in Alternative 1 would be to locate areas of the main plant site where only removal of near-surface soil would be needed to address the source of contamination to groundwater. The field of candidate areas was narrowed to those where excavation of 6 ft of soil or less would be sufficient to remove soil with arsenic at concentrations that could leach inorganic contaminants to groundwater. Areas with deeper soil contamination would not be considered reachable by a soil "scrape." The MVS model was used to help determine candidate areas for soil scrape/shallow excavation, and to help estimate the depth and volume of soil to be scraped/excavated. Figure 2 presents MVS model-generated concentration contours, at 1-ft increments from ground surface down to 8 ft below ground surface (bgs). The MVS model results suggest that the following areas had soil contamination exceeding the surrogate arsenic background concentration of 40 mg/kg at depths of no more than 6 to 8 ft:

- Western portion of the former Lower Ore Storage Area (LOSA)
- Area east and north of the former Ore Storage Building
- Northwesternmost area of the former Smelter site, near Chemet

Areas with deep soil contamination that would require containment beneath the ET Cover System even if a soil scrape were conducted (discussed under Alternative 2 below and illustrated in Figure 3) were not considered. Only the approximately 5.5-acre area along the western portion of the former LOSA met this criterion (see Figure 4). In this area, arsenic concentrations appear to transition to mostly <40 mg/kg (primarily green color zone) at a depth of 6 ft bgs (Figure 2), and the MVS model results do not indicate the presence of deeper soil contamination.

Earthwork activities in the former LOSA could be conducted using scraper/bulldozer equipment removing an estimated 57,000 cubic yards (CY) of soil (54,000 CY of targeted soil and 3,000 CY of soil for layback excavation), and then the scraped area backfilled with the same volume of native/clean fill. A final cover, consisting of 8 inches of growth material with seeding, would be constructed over this area and integrated into the ET Cover System.

Alternative 2—Excavation of Saturated Zone Soil with Arsenic Concentrations ≥290 mg/kg

Alternative 2 would remove saturated zone soil with arsenic concentrations exceeding the MDEQ action level for subsurface soil of 300 mg/kg. For the purpose of this evaluation, the 290-mg/kg contour line established by MVS was used to define the area of excavation. The MVS model was used to calculate the estimated arsenic mass and volume of contaminated soil in the saturated zone targeted for removal, and the volume of overburden soil to be excavated in order to remove the targeted soil. Figure 3 presents MVS model-generated arsenic concentration contours, at 2-ft and then 5-ft increments from the projected post-SPHC groundwater surface down to 25 ft below groundwater. As noted above, Table 2 presents the neat volumes of the targeted soil and the overburden soil to be excavated to reach the targeted soil (approximately 24,000 CY of targeted soil and 208,000 CY of overburden soil), and Table 3 presents the quantities estimated based on more typical construction methods.

Figure 5 presents a conceptual excavation plan for Alternative 2, showing the site layout of six separate excavation areas (labeled as: A, B1, B2, C, D, and E), and Figure 6 provides typical cross-sectional views of two of the excavation areas (B1 and D). The basic construction approach is as follows:

- In areas with potentially significant remaining foundations/slabs/footings (for example, former process areas of the main plant site, generally south of the former Ore Storage Building), remove foundations/slabs/footings and process before any excavation or installation of sheet pile walls.
- Use a combination of techniques to excavate overburden soil and reach the targeted soil in the saturated zone, employing layback excavation or layback excavation and sheet pile wall installation. The installation of sheet pile walls would be supported either with tie-backs or cantilevers.
- Stockpile the excavated overburden soil in the former LOSA; to the extent practicable, segregate higher-concentration from lower-concentration soil. These materials will be used to backfill the upper levels of the excavation, above the post-SPHC saturated zone.
- Isolate the saturated zone targeted soil using sheet pile walls.
- Within the sheet pile walls, dewater prior to excavation of the targeted soil.
- Treat the pumped groundwater onsite with a packaged plant, because the high-density sludge water treatment plant will not be available.

- Excavate the dewatered targeted soil and consolidate beneath the ET Cover System and within the boundaries of the AOC.
- Sample and analyze (using for example, field X-ray fluorescence technique) soil samples collected from the bottom of the excavation to determine whether the targeted soil has been removed.
- Once the saturated zone excavation is completed, backfill saturated zone with native/clean fill.
- Backfill the remaining excavation with previously removed and stockpiled overburden soil, to the extent practicable placing soil with the highest contaminant concentrations closer to the surface; as appropriate, backfill with any processed concrete foundations/slabs/footings deemed usable.
- Pull sheet pile walls and finish to grade.

For Alternative 2, the technical feasibility and constructability of the various components – excavation, shoring/sheet pile installation, dewatering and water treatment, stockpiling, and backfilling – are described in Table 5. The arsenic mass removed is also presented in the table.

Alternative 3—Excavation of Saturated Zone Soil with Arsenic Concentrations $\geq$40 mg/kg

Alternative 3 assumes all soil in the saturated zone with arsenic concentrations exceeding the surrogate background level of 40 mg/kg are excavated, and the alternative was evaluated against the same criteria as Alternative 2. As shown in Figure 3, Alternative 3 would require excavation and backfilling of a much greater volume of soil and would involve excavating in the saturated zone below nearly half of the main plant site. The MVS model estimated the minimum, neat volumes of targeted soil in the saturated zone to be over 600,000 CY and the volume of overburden soil that would have to be removed to reach the targeted soil to be approximately 1.5 million CY [Table 2]). Given the large quantities associated with the minimum, neat volumes, a more detailed concept excavation plan (which would have resulted in increases in removal volumes due to excavation side slopes) for Alternative 3 was not prepared. Table 5 presents evaluation results for Alternative 3 and compares the two saturated zone excavation alternatives.

Screening-Level Evaluation Results

Alternative 1—Soil Scrape/Shallow Excavation

This alternative is both technically feasible and constructable. Construction of Alternative 1 would employ readily available earthwork techniques. Because the work would involve excavating soil at relatively shallow depths (6 ft deep or less) and not in the saturated zone, only minor construction dewatering (water from stormwater runoff) and subsequent treatment of water would be necessary. Any adjustments necessary to the design and construction of the ET Cover System due to a reduction in its size could be readily made as part of the detailed design.

Construction of a soil cover over this area is recommended even if soil in this portion of the former LOSA were removed. Although a full ET Cover System may not be necessary, infiltration in this area could still contribute to leaching and contaminant loading to groundwater. Based on monitoring well and soil boring information, the area is underlain by what appears to be a topographic high of the Tertiary ash/clay layer. Any infiltrated water could flow away, including to the east once the water reaches the relatively low-permeability layer. Groundwater just east of the candidate area is contaminated by arsenic and selenium at concentrations well above their respective MCLs (see IM Work Plan 2014 [CH2M HILL, 2013] for plume maps of arsenic and selenium concentrations in groundwater). The soil cover and final surface grading of the scraped area would need to account for drainage considerations to minimize vertical infiltration.

The ROM Class 5 estimated cost of implementing Alternative 1 is approximately $1 million (Attachment 2, Cost Information Details for Alternative 1). Based on the ROM Class 5 cost for ET Cover System construction prepared by CH2M HILL in 2012, the cost to construct a 5.5-acre ET Cover System is approximately $750,000 (CH2M HILL, 2012b).

Alternatives 2 and 3—Excavations of Saturated Zone Soil

The merits of the two saturated zone excavation alternatives are compared against each other below, and the evaluation results are summarized in Table 5.

Technical Feasibility and Constructability. Although implementing these two alternatives would require a major undertaking, both of these alternatives are technically feasible and constructable. The required earthwork and related construction techniques are standard construction practices. These include: removal of remaining foundations/slabs/footings of structures in the main plant site; shoring/sheet pile installation for trench and sidewall stabilization, excavation, stockpiling, and backfilling; and construction dewatering and treatment of the water. The removal depths, presence of groundwater, and large material volumes to be handled all combine to increase both the degree of difficulty and costs estimated for these alternatives.

Based on MVS modeling results, the volumes of soil to be excavated are estimated as follows:

- Alternative 2 – 78,000 CY (actual volume) of targeted soil in the saturated zone and 400,300 CY (actual volume) of overburden soil.
- Alternative 3 – 610,000 CY (neat volume) of targeted soil in the saturated zone and 1,487,000 CY (neat volume) of overburden soil; the actual volumes would be greater than these estimates of neat volumes.

Alternative 3 would be more difficult to construct than Alternative 2 because of the depth of excavation; at the northern end of the former Smelter site, the depth to groundwater approaches 40 ft and the depth of the saturated zone soil excavations approaches 20 ft below groundwater. Alternative 3 would require the excavation of much greater volumes of soil (both the targeted soil in the saturated zone and overburden soil that would need to be removed to reach the targeted soil below groundwater) and would affect the majority of the main plant site. Safely dewatering, staging, stockpiling, and disposing of large volumes of soil in a relatively limited area within the boundaries of the main plant site would be logistically difficult to execute and require substantial coordination and planning for implementation.

Mass Removal. Based on MVS model results, it is estimated that Alternative 2 would remove about 29,000 pounds (11 percent) and Alternative 3 would remove 210,000 pounds (82 percent) of the total estimated post-SPHC arsenic mass in contact with groundwater.

ROM Class 5 Cost Estimates. The estimated cost of implementing Alternative 2 is approximately $30 million (Attachment 2, Cost Information Details for Alternative 2) and assumes that all foundations/slabs/footings removed can be processed and reused onsite.

Based on the detailed estimate for Alternative 2, estimated unit costs were developed for use in evaluating Alternative 3. The estimated unit cost for excavating targeted saturated zone soil is $151/CY and the unit cost for overburden soil is $47/CY.

Using these unit costs, the minimum estimated cost for Alternative 3 is approximately $162 million. Because this is based on the neat excavation volumes, implementation of Alternative 3 using more typical construction techniques (including excavation side slopes), the soil removal volumes would be greater than the neat volume estimates, and therefore estimated costs are expected to be significantly higher than the $162 million noted above.

Preliminary Recommendations

Alternative 1, soil scrape/shallow soil excavation, is technically feasible and constructable, but is not recommended for further evaluation because the estimated cost of removal is greater than the estimated savings associated with reducing the size of the ET Cover System. The cost of implementing Alternative 1 is approximately $1 million, and the savings associated with reducing the size of the ET Cover System by 5.5 acres is approximately $750,000.

Alternative 2, excavation of post-SPHC saturated zone soil with arsenic concentrations $\geq$290 mg/kg, is technically feasible and constructable. However, this alternative is not recommended because the estimated cost is disproportionate to the potential environmental benefit:

- Implementation of Alternative 2 is estimated to cost approximately $30 million and would require over 15 calendar months (equivalent to two construction seasons) to complete.
- Removal of the soil would reduce arsenic mass in the post-SPHC saturated zone soil by an estimated 10 percent, but is not expected to be sufficient to reach MCLs in groundwater.

Localized excavation of individual excavation areas of Alternative 2 may be considered in the future if groundwater evaluations suggest that significant improvements in groundwater quality and/or plume stability can be achieved with smaller removal actions.

Alternative 3, excavation of post-SPHC saturated zone soil with arsenic concentrations $\geq$40 mg/kg, is technically feasible and constructable, but is not recommended for further evaluation because the estimated cost is well beyond the financial resources available to the Custodial Trust. The cost of implementing Alternative 3, based on minimum, neat volume estimates, is approximately $162 million and would pose safety and logistical challenges that are much greater than those of Alternative 2. The construction work would require several calendar years and double the number of construction seasons to complete. Logistical issues concerning safely dewatering, staging, stockpiling, and disposing of large volumes of soil in a relatively limited area would require substantial coordination and planning and would result in significant changes to the topography of the site due to the large volume of material removed from the saturated zone and consolidated under the ET Cover.

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Tables

TABLE 1

Comparison of Mass in Soil Potentially Addressed by the Three Proposed Interim Measures

Proposed IM	Arsenic Mass		Selenium Mass	
	(lb)	**(percent)**	**(lb)**	**(percent)**
Total Mass Beneath Main Plant Site	2,489,000	100	48,100	100
Mass in Vadose Zone Soil				
ET Cover System IM[a]	1,465,000	59	35,200	73
Mass in Saturated Zone Soil				
SPHC IM[b]	768,000	31	8,000	17
Source Removal IM[c]	256,000	10	4,900	10

Notes:

[a] Addresses mass in vadose zone soil.

[b] Addresses mass in saturated zone soil that would be exposed once groundwater is lowered after implementation of SPHC.

[c] Addresses mass in saturated zone soil that would remain in contact with groundwater after implementation of SPHC.

Abbreviations:

ET = evapotranspiration
IM = interim measure
lb = pound
SPHC = South Plant Hydraulic Control

TABLE 2

Excavation Alternatives - Neat Volumes[a]

Description	Overburden Soil (CY)	Targeted Soil (CY)
Alternative 1 – Soil Scrape/Shallow Excavation	0	54,000
Alternative 2 – Excavation of Saturated Zone Soil with Arsenic ≥290 mg/kg	208,000	24,000
Alternative 3 – Excavation of Saturated Zone Soil with Arsenic ≥40 mg/kg	1,487,000	610,000

Notes:

[a] Neat volumes are estimated assuming vertical cuts, and represent the minimum soil volumes that could be excavated and backfilled. Actual volumes may be greater than neat volumes.

Abbreviations:
CY = cubic yard
mg/kg = milligram per kilogram

TABLE 3

Alternative 2 Concept Excavation Plan Quantity Estimates

Component	Excavation Area[a]						Total[b]
	A	B1	B2	C	D	E	
Soil Excavation – Overburden Soil (CY)	90,800	41,000	56,000	88,200	61,300	63,100	400,300
Soil Excavation – Targeted Soil (CY)	18,700	5,800	10,100	22,200	10,300	10,900	78,000
Installation of Sheet Pile Walls							
Perimeter of Sheet Pile Walls (LF)	1,510	920	940	1,270	750	630	6,030
Exposed Area of Sheet Pile Walls (ft^2)	18,600	14,400	20,400	39,100	5,900	7,600	106,000
Construction Dewatering/Water Treatment (gallon)	1,696,000	531,000	915,000	2,020,000	932,000	990,000	7,000,000
Backfill Below Groundwater (CY)	18,700	5,800	10,100	22,200	10,300	10,900	78,000
Backfill Above Groundwater (CY)	90,800	41,000	56,000	88,200	61,300	63,100	400,300

Notes:

[a] See Figure 5 for location of excavation areas.

[b] Totals may not equal the sum of the quantity estimates for individual areas due to rounding.

Abbreviations:

CY = cubic yard
ft^2 = square feet
LF = linear foot

TABLE 4

Cost Estimates for Alternatives 2 and 3, Saturated Zone Soil Excavations

Cost Description	Alternative 2[a]	Alternative 3[b]
Total Cost	$30,400,000[c]	$162,000,000
Targeted Soil		
Subtotal Cost	$11,800,000	$92,100,000
Unit Cost	$151/CY	$151/CY
Overburden Soil		
Subtotal Cost	$18,600,000	$69,900,000
Unit Cost	$47/CY	$47/CY

[a] The total cost estimate and unit costs for Alternative 2 are based on a detailed concept excavation plan and actual quantity estimates.

[b] The total cost estimate for Alternative 3 is based on neat soil volume estimates and the unit costs developed for Alternative 2. The cost estimate based on actual quantities is expected to be higher.

[c] The total cost estimate for Alternative 2 assumes that all foundations/slabs/footings removed can be processed and reused onsite. The same is assumed for Alternative 3.

Abbreviation:

CY = cubic yard

TABLE 5

Comparative Analysis of Saturated Zone Excavation Alternatives 2 and 3—Detailed Evaluation

Evaluation Criterion	Alternative 2	Alternative 3
	This alternative is intended to address contaminated soil with arsenic concentrations greater than the MDEQ action level for subsurface soil ($\geq$290[a] mg/kg) that remains in the saturated zone and would have the potential to leach to groundwater. The contaminated soil would be a result of past activities at former process areas of the main plant site and any subsequent migration of COPCs in groundwater. Neat volumes of overburden and targeted soil for this alternative are listed in Table 2. Actual quantity estimates for each excavation area shown in Figure 5 are listed in Table 3. Total quantity estimates discussed below for Alternative 2 are actual quantity estimates and for the combined six excavation areas.	This alternative is intended to address soil with arsenic concentrations greater than what would be expected of naturally occurring levels ($\geq$40 mg/kg) of soil that remains in the saturated zone. Neat volumes of overburden and targeted soil for this alternative are listed in Table 2. Actual quantity estimates were not estimated for Alternative 3, but are expected to be much greater than those for Alternative 2.
Technical Feasibility and Constructability		
Excavation	For Alternative 2, existing foundations, slabs, and footings, in particular in the former process areas in the central and southern portions of the main plant site, would need to be removed and processed (concrete could be crushed for reuse) before the primary excavation could proceed. Readily available earthwork techniques could be employed to excavate 400,300 CY of overburden soil in order to reach the targeted soil (78,000 CY). A combination of excavation support techniques could be used to excavate overburden soil to reach the targeted soil in the saturated zone, either layback excavation or installation of sheet pile walls (using a cantilever system or tie-backs for support). Assuming a 2:1 (horizontal:vertical) side slope, the excavation layback option would generate relatively large volumes of overburden soil and would be constrained in areas without adequate space. See below for discussion on "Shoring/ Sheet Pile Installation."	Similar excavation considerations and constraints facing Alternative 2 would apply to Alternative 3. However, given the much greater quantities of overburden and targeted soils (neat volumes of 1,487,000 CY and 610,000 CY, respectively) that would need to be excavated, staging of work and space limitations would pose considerably more challenges under this alternative.
Shoring/Sheet Pile Installation	In areas with space constraints, excavation of overburden soil could be accomplished within sheet pile walls. Installation of sheet pile walls would generate less overburden soil than the layback excavation option, but may be hampered in coarse-grained soil with cobbles and boulders, as well as subsurface debris. Support techniques could be employed, using either a cantilever system or tie-backs, depending on the depth of excavation below water. In order to isolate the targeted soil and to facilitate its dewatering in the saturated zone, installation of sheet pile walls would be the most effective technique. For this alternative, using a combination of layback excavation and installation of sheet pile walls, the total perimeter length of sheet pile walls would be slightly more than 6,000 LF, and the total exposed surface area would be 106,000 ft^2.	Similar sheet pile installation considerations and constraints facing Alternative 2 would apply to Alternative 3. However, much greater use of sheet pile walls would be required to isolate the targeted soil (neat volume of 610,000 CY) and facilitate dewatering, and thus would pose considerably more challenges under this alternative.
Construction Dewatering and Water Treatment	Because the targeted soil is in the saturated zone, construction dewatering and treatment of the water would be required. To minimize seepage into the targeted soil excavation zone, the sheet pile walls would need to be keyed into the underlying Tertiary ash/clay layer. For Alternative 2, it is estimated that over 7 million gallons would be generated and require treatment. Because the HDS water treatment plant is expected to be decommissioned, a stand-alone packaged plant could be brought to the site and used to treat the water before discharge. Co-precipitation and lime softening are assumed for the treatment of dissolved arsenic, and RO for the treatment of dissolved selenium.	For Alternative 3, it is estimated that over 50 million gallons of water would be generated and require treatment. The greater volume of water may require additional treatment units and/or temporary storage capacity under this alternative.

TABLE 5

Comparative Analysis of Saturated Zone Excavation Alternatives 2 and 3—Detailed Evaluation

Evaluation Criterion	Alternative 2	Alternative 3
Stockpile/Backfill	The excavated soil would be temporarily stockpiled in the former LOSA and managed during construction. The excavated saturated zone targeted soil (78,000 CY) would be replaced with native/clean fill from nearby sources, including the East Bench and potentially the Valley View Landfill stockpile. The excavated vadose zone overburden soil (400,300 CY) would be backfilled with the same materials excavated and temporarily stockpiled at the former LOSA. To the extent practicable, soil with the highest inorganic concentrations could be placed closer to the surface when backfilling.	Similar stockpile and backfill considerations and constraints facing Alternative 2 would apply to Alternative 3. However, given the much greater quantities of excavated overburden and targeted soil (neat volumes of 1,487,000 CY and 610,000 CY, respectively) that would need to be stockpiled and managed during construction, staging of work and space limitations would pose considerably more challenges under this alternative. Also, additional sources of borrow fill would need to be identified and secured.
Construction Time Required	Based on a preliminary detailed schedule, implementing Alternative 2 would require approximately 15 months or two construction seasons to complete.	A preliminary detailed schedule was not prepared for the implementation of Alternative 3. However, the time required to complete Alternative 3 would be on the order of two to three times longer than for Alternative 2.
Mass Removal[b]	By implementing Alternative 2, 29,400 lb of arsenic would be removed from targeted soil in the saturated zone. The mass removed would represent 11 percent of the total arsenic mass (256,200 lb) estimated to be present in the post-SPHC saturated zone beneath the main plant site.	In contrast, by implementing Alternative 3, 210,000 lb of arsenic would be removed from targeted soil in the saturated zone. The mass removed would represent 82 percent of the total arsenic mass (256,200 lb) estimated to be present in the post-SPHC saturated zone beneath the main plant site.
Cost Estimate	\$30,400,000 (Based on detailed concept excavation plan and actual quantity estimates. See Tables 3 and 4.)	\$162,000,000 (Based on neat soil volume estimates and the unit costs developed for Alternative 2. The cost estimate based on actual quantities is expected to be higher. See Tables 2 and 4.)

Notes:

[a] The MDEQ action level for arsenic in subsurface soil is 300 mg/kg; however, for the purpose of this evaluation, results for 290 mg/kg and 300 mg/kg are assumed to be similar.

[b] Mass removal is based on neat volume estimates.

Abbreviations:

COPC = constituent of potential concern
CY = cubic yard
ET = evapotranspiration
HDS = high-density sludge
lb = pound
LF = linear feet
LOSA = Lower Ore Storage Area
ft^2 = square feet
MDEQ = Montana Department of Environmental Quality
mg/kg = milligram per kilogram
PPC = Prickly Pear Creek
RO = reverse osmosis
SPHC = South Plant Hydraulic Control

Figures

Attachment 1
Mining Visualization System (MVS)
Model Development

MVS Model Development in Support of Evaluations of Soil Removal Alternatives at the East Helena Former ASARCO Smelter Site

PREPARED FOR: Custodial Trust

PREPARED BY: CH2M HILL

DATE: November 12, 2013

A three-dimensional model was developed using soil data and Mining Visualization System (MVS; C Tech Development Corporation, 2006) software in support of Corrective Measures Study evaluations at the East Helena former ASARCO Smelter site (former Smelter site). The soil data were developed during the Phase II RCRA Facility Investigation (RFI) and previous site investigations (refer to draft *Phase II RCRA Facility Investigation—East Helena Facility* [GSI Water Solutions, Inc., 2011]).

The MVS is a tool for visualizing soil data in three dimensions and calculating volumes of soil within defined concentration zones of inorganic contaminants. The model provides an estimate of the lateral and vertical inorganic contaminant distributions based on existing data with a focus on the operating area of the former Smelter site, and is a useful screening-level tool to support ongoing soil removal evaluations.

MVS Model Development

Initial MVS model development began in November 2012. Model development activities consisted of: definition of data needs, identification of data sources, input of data to the model, and quality review of model inputs.

The MVS model framework is defined by a series of surfaces. These surfaces were based on field data (see section below titled “Data Inputs”) that were kriged (see explanation of the process and assumptions used in sections below titled “Data Processing” and “Kriging Process and Assumptions Used”) by MVS to estimate soil concentrations in the areas between data points. The model surfaces are defined to represent: ground and top of slag pile surfaces; groundwater elevations representing different times and site conditions; and the top of the Tertiary ash/clay layer, which forms the bottom of the model.

Data Inputs

Data inputs to the MVS model were based on existing information developed during the Phase II RFI and previous site investigations. Data incorporated in the MVS model are:

- Site topographic data based on aerial surveys completed in 2012.
- Site features (for example, Upper Lake; Lower Lake; slag pile; various plant features, such as Tito Park, Acid Plant Sediment Drying Area, Lower Ore Storage Area). These features were based on interpretation of aerial photographs.
- Geologic information corresponding to the Tertiary ash/clay layer from logs of soil borings and monitoring well boreholes.
- Surveyed groundwater elevation data from 2010 and 2012. The groundwater elevation data represent the following three sets of conditions:
  - October 2010 – Represents average site groundwater conditions before the full implementation of the proposed South Plant Hydraulic Control (SPHC) Interim Measure (IM).
  - January 2012 – Represents site groundwater conditions near the beginning of the Upper Lake drawdown test.

  - July 2012 – Represents site groundwater conditions when Upper Lake was at its lowest elevation based on passive draining of the lake.

- Projected post-SPHC groundwater potentiometric surface. This surface was developed based on professional judgment and using groundwater elevation data measured in July 2012.
- Soil and slag pile chemistry data for four inorganic contaminants (arsenic, cadmium, lead, and selenium). Chemistry data were compiled from the existing project analytical database. Note that more data are available for arsenic, cadmium, and lead than for selenium (samples were analyzed for selenium since about 2007).

Model Boundaries

Figure 1 shows an oblique view of the basic structure of the MVS model. The top of the model corresponds to ground surface and top of the slag pile. The bottom of the model is defined by the top of the Tertiary ash/clay layer. Figure 2 shows a plan view of the area where inorganic contaminant concentrations were estimated. Figure 2 also shows specific sample locations; for illustration purposes, those for arsenic are shown. Thus, although the evaluation is focused on the former Smelter site, the data used to estimate concentrations extend beyond the former Smelter site boundary.

Data Processing

The former Smelter site soil and slag pile samples were processed separately, given the distinct differences in the soil versus slag materials and the manner in which they were deposited. The convention used defines samples collected from within the slag pile as “slag samples,” whereas all other samples (i.e., those collected outside of the slag pile) are defined as “site samples.” Note that the actual lateral extent of the slag pile extends beyond the point the surface expression would suggest. This is because some slag deposits were either buried or graded during construction activities. Data from soil borings and monitoring well boreholes were used to delineate both the lateral and vertical extents of the slag pile.

Input data were pre-processed by separating the different types of data (for example, ground and top of slag pile surface elevations, groundwater elevations, soil chemistry) and reformatting them into the proper text file formats for use within MVS. In MVS, each data type is input to the model in a different file format.

Input data are available for individual sampled locations. The MVS model interpolates these data by mathematically converting a series of data points into a continuous data field where data values (for example, arsenic concentrations in soil, groundwater elevations) are defined at every point within the interpolated domain. A variety of interpolation algorithms are available in MVS. The interpolation method known as “kriging” is the most robust and is generally considered the industry standard. See the additional explanation of kriging performed and the assumptions used in the section below titled “Kriging Process and Assumptions Used.”

Chemistry data were logarithmically transformed by MVS, kriged, and the estimated concentrations back-transformed. Non-detected (ND) values were assigned concentrations of one-tenth the detection limit; for example, an ND value of less than 10 milligram per kilogram (mg/kg) was assigned a concentration of 1 mg/kg. For this screening-level evaluation, estimates for arsenic and selenium are provided because the two contaminants are constituents of concern (COCs) in soil and also are primary COCs in groundwater. Note that there is greater certainty in the estimates presented for arsenic than for selenium because more arsenic than selenium data are available from sampling.

Kriging Process and Assumptions Used

Grid Size and Resolution

The kriging domain for the main plant site was divided into a grid of 175 cells in each of the x, y, and z directions, resulting in a grid size of 20 feet by 29 feet, and generally less than 1 foot thick. The kriging domain for the slag was divided into a grid of 125 cells in each of the x, y, and z directions, resulting in a grid size of 17 feet by 18 feet, and approximately 1 foot thick. A higher grid resolution may capture finer details, but would result in greater computation time. The selected grid resolution strikes a balance between a resolution that is high enough such that the interpolation results do not change significantly, while maintaining a reasonable computation time (slightly less than an hour per analyte). The selected grid resolution estimates concentrations in a mesh of nearly 2 million points. A value of 200 data points was set as the maximum number of points considered for the parameter estimation at each model node. This value, determined through experimentation, produced an interpolation that was sufficiently smooth (free of estimation artifacts) without a prohibitively long computation time.

Kriging Parameters and Semivariograms

Once the kriging domain was defined, specific kriging parameters were required for interpolation. In the initial MVS model, the MVS-determined default parameters were used. As part of the model refinement, site and slag sample data were evaluated to calculate site-specific kriging parameters for arsenic and selenium. The foundation of the kriging process is a statistical measure known as the semivariance, which is a measure of the degree of spatial dependence between observations of a variable, such as concentration. When semivariances are calculated for different distances between the samples and the results plotted, a graph known as the semivariogram is produced. From the semivariogram, the distance over which the variable of interest is spatially related is estimated.

For arsenic and selenium, two semivariograms were produced: (1) one for samples within 1.5 feet of the ground surface, and (2) the second for samples within the elevation interval of 3,880 and 3,900 feet above mean sea level, which is the approximate range of post-SPHC IM groundwater elevations for the main plant site. These semivariograms do not include samples from the slag pile, as the slag samples were analyzed separately. The two semivariograms were produced to investigate how the spatial relationship among samples change with depth and to determine whether a single semivariogram was sufficient for kriging the entire data set for each inorganic contaminant.

Figures 3 and 4 show the semivariograms for arsenic and selenium using site sample data, respectively, along with the modeled semivariogram that was fit to the data. Although different data-fit models exist, a spherical semivariogram model was chosen to fit the data. A discussion on the appropriateness of the different semivariogram models is beyond the scope of this attachment; a detailed discussion of kriging and semivariogram models can be found in Davis (2002).

Figure 3 shows that the two arsenic semivariograms for the different depth intervals are similar, with a spatial correlation distance (denoted as “range” in the figure) estimated between 250 and 220 feet. In contrast, Figure 4 shows the two selenium semivariograms are different; in addition, the selenium data indicate no spatial correlation at depth, which may be partly due to the low selenium data density with depth. For both arsenic and selenium, the semivariograms produced using the near-surface samples were used to krige the respective data sets. For arsenic, the near-surface semivariogram was chosen for kriging (assumes a spatial correlation distance of 250 feet) because this semivariogram represents the greatest data density, and differences in the semivariograms between the two depth ranges are expected to be minor such that the resulting interpolations would be similar. For selenium, the near-surface semivariogram was also chosen for kriging (assumes a spatial correlation distance of 2,000 feet) because a spherical model fits the near-surface field data well. The deeper data did not return a reasonable data-fit against the preferred spherical semivariogram model, so the spatial correlation distance of 2,000 feet was assumed instead of the MVS-determined default spatial correlation distance (4,230 feet).

A three-dimensional semivariogram analysis was also performed for the slag samples for arsenic and selenium (Figure 5). For both inorganic contaminants, the analysis showed a relatively short distance over which samples were spatially dependent (less than 100 feet for arsenic and less than 50 feet for selenium). Kriging the slag samples with such short correlation distances resulted in visually odd, high-concentration columns surrounding the borings. The short correlation distances are likely a result of either the low data density within the slag pile or the heterogeneous data density (i.e., much higher data density vertically than laterally). Thus, the MVS-determined default semivariograms were used instead.

Other Assumptions Used in Kriging

The following lists additional assumptions used:

- The distributions of arsenic and selenium were modeled with a horizontal to vertical anisotropy ratio of 10:1.
- All resulting arsenic and selenium contours assume that there is a 50 percent chance that an estimated value is either above or below the modeled value.

MVS Model Quality Review

Verification of Kriged Data

As a measure of the quality of the kriging, observed versus kriged site sample data for arsenic at 22 locations across the site were compared. Table 1 shows the results, which indicate there is excellent agreement (within 1 percent discrepancy) at all locations except for one (RC-SS11; approximately 5 percent discrepancy). The range of discrepancy observed is well within reason to support the screening-level evaluations of the soil removal alternatives.

High-concentration Arsenic in Saturated Zone Soil versus Groundwater Plume

As a separate measure to ascertain the robustness of the MVS model with respect to potential arsenic source areas to groundwater, the June 2013 groundwater plume map for arsenic (Figure 6) is overlaid on top of the areas identified as having arsenic ≥290 mg/kg in saturated zone soil. These areas should be correlated with groundwater concentrations. Except for Area B2, all areas identified fell within the general footprint of the arsenic plume. In addition, the highest arsenic concentrations observed in groundwater generally coincide with the high-concentration areas identified. This suggests the areas may be continuing sources of arsenic contamination in groundwater.

Use of Arsenic as a Surrogate for Selenium

Arsenic and selenium fate and transport in groundwater are complex processes and are expected to be a function of leachability of the contaminant mass in soil, as well as geochemical conditions (for example, pH, oxidation-reduction potential) in the subsurface. A full evaluation is beyond the intent of this screening-level evaluation. A simplifying assumption of the soil removal evaluation used arsenic as a surrogate for selenium because investigations have shown arsenic and selenium contamination is generally co-located with each other; although there are distinct differences, the majority of the arsenic sources appear to be those for selenium as well. To determine whether this is a reasonable assumption, the June 2013 groundwater plume map for selenium (Figure 7) is also overlaid on top of the areas identified as having arsenic ≥290 mg/kg in saturated zone soil. In contrast to the arsenic plume, fewer of the areas (a portion of Area A, Areas B1, C, and D) identified, which are potential source areas, fell within the general footprint of the selenium plume. However, because the majority of the areas fell within the general footprint of the selenium plume, this suggests that for a screening-level evaluation, arsenic can serve as a surrogate for selenium.

References

C Tech Development Corporation. 2006. For additional information on MVS software visit the website: http://www.ctech.com/products/mvsevs-product-suite/mvs.

Davis, JC. 2002. *Analysis of sequences of data*. In: Statistics and Data Analysis in Geography (Davis JC, ed). 3rd ed. New York: John Wiley & Sons, 159–292.

GSI Water Solutions, Inc. (GSI). 2011. *Phase II RCRA Facility Investigation Report*, *East Helena Facility*. Draft. May 2011.

Tables

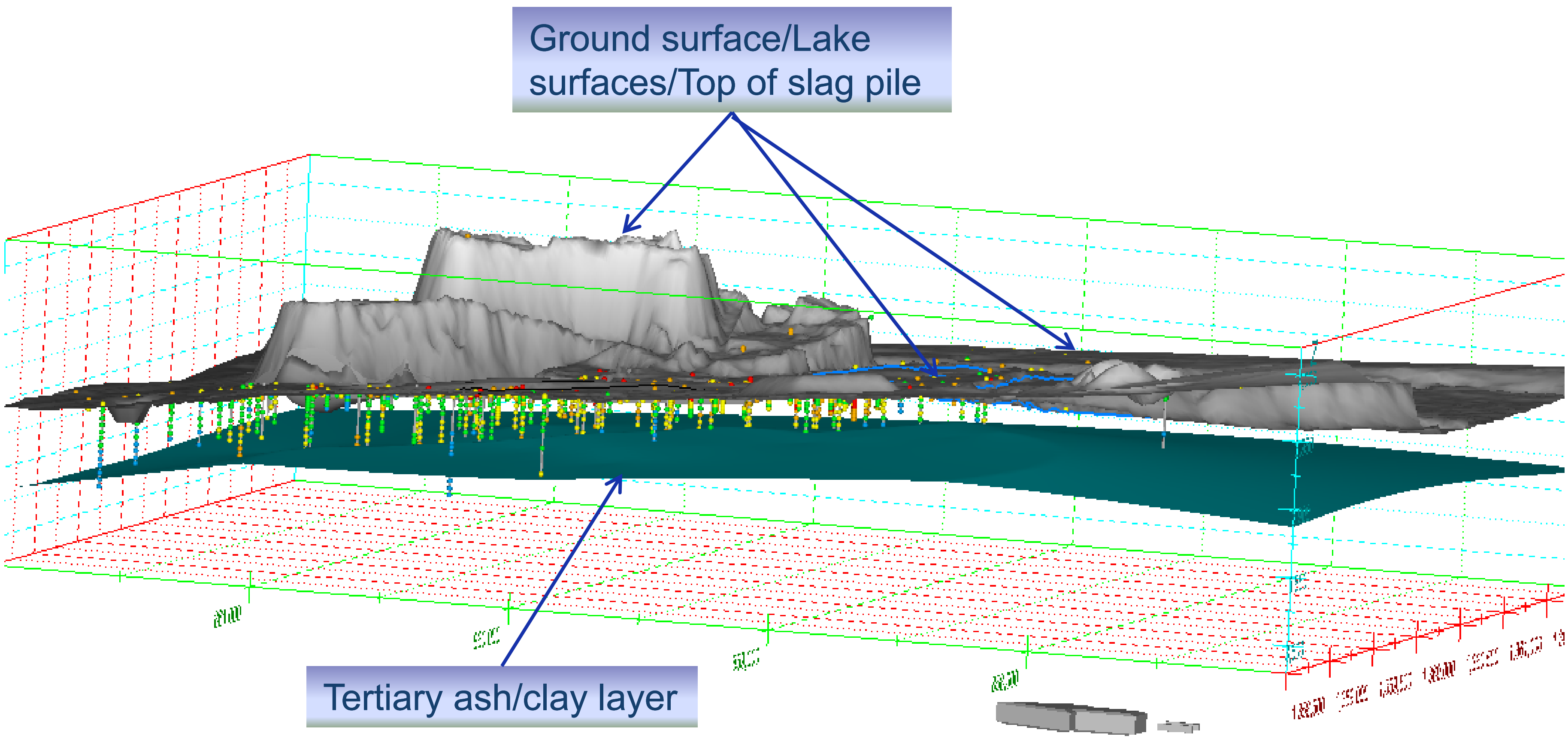
TABLE 1

Arsenic Site Samples - Observed versus Kriged Data

Sample Location ID	X Coordinate	Y Coordinate	Depth (feet)	Ground Surface Elevation (feet amsl)	Sample Elevation (feet amsl)	Observed Data: Arsenic Concentration (mg/kg)	Observed Data: Log of Arsenic Concentration	Kriged Data: Arsenic Concentration (mg/kg)	Difference in Arsenic Concentration (mg/kg)	Difference in Arsenic Concentration (Percent)
DH-67S	1359098.23	861659.37	1.00	3899.77	3898.77002	117	2.07	117.0	-0.03	0.03
RC-SS11	1359141.966	861245.7698	0.17	3906.10	3905.93457	1153	3.08	1207.2	-54.23	4.70
SC-3	1359162.103	860739.0458	1.00	3914.02	3913.01758	6.8	0.83	6.8	0.00	0.02
RC-SS07A	1359479.631	860102.7191	0.17	3919.39	3919.229	4744.8	3.68	4745.9	-1.14	0.02
RC-SS12	1359832.991	859384.8075	0.17	3927.60	3927.43726	58	1.76	58.0	0.00	0.00
BLF1	1360032.019	859123.4189	0.17	3929.47	3929.30762	3580	3.55	3580.2	-0.21	0.01
UL-24-SED	1360366.109	858764.7194	0.00	3919.80	3919.80005	353	2.55	353.0	0.00	0.00
ULM-4-SED	1360618.108	858060.5099	0.00	3920.10	3920.09619	108	2.03	108.0	0.00	0.00
UOP-SS21	1361612.669	858845.6691	0.17	3924.29	3924.12573	387	2.59	390.6	-3.61	0.93
LL-BK-4	1360908.706	859156.9146	0.25	3920.73	3920.48486	15.5	1.19	15.5	0.00	0.00
DH-70	1360349.54	859740.32	1.00	3918.94	3917.93994	146	2.16	146.0	0.00	0.00
RFI2SB-15	1360486.318	860348.2539	0.25	3914.40	3914.1499	3550	3.55	3548.7	1.30	-0.04
UOP-SS12	1359847.462	861788.6364	0.17	3892.9795	3892.81274	124	2.09	124.0	-0.01	0.01
DH-50	1359574.48	861386.98	1.00	3904.76	3903.76001	19	1.28	19.0	0.00	0.00
RFI2SB-12	1359975.07	860871.46	0.25	3900	3899.75	3700	3.57	3701.3	-1.26	0.03
UPS-SS13	1360096.476	860268.0603	0.17	3912.97062	3912.80396	1748	3.24	1748.1	-0.07	0.00
SPDR-3	1360114.455	860146.0577	0.00	3914.89124	3914.89136	3200	3.51	3200.0	0.01	0.00
BLF7	1360179.893	859792.2218	0.17	3912.09439	3911.92944	1720	3.24	1724.5	-4.46	0.26
DH-47	1360404.74	859461.74	1.50	3922.33	3920.83008	1294	3.11	1293.7	0.25	-0.02
APSD-P8	1360374.518	859186.5346	4.00	3924.65103	3920.65112	3169.5	3.50	3169.3	0.23	-0.01
UL-BK-3	1360410.599	858986.321	0.00	3920.96127	3920.96118	272	2.43	272.0	0.00	0.00
RC-SS04	1359138.652	860892.8001	0.17	3912.81165	3912.64673	6171	3.79	6205.3	-34.32	0.56

Notes:
amsl = above mean seal level
ID = identification
mg/kg = milligram per kilogram

Figures



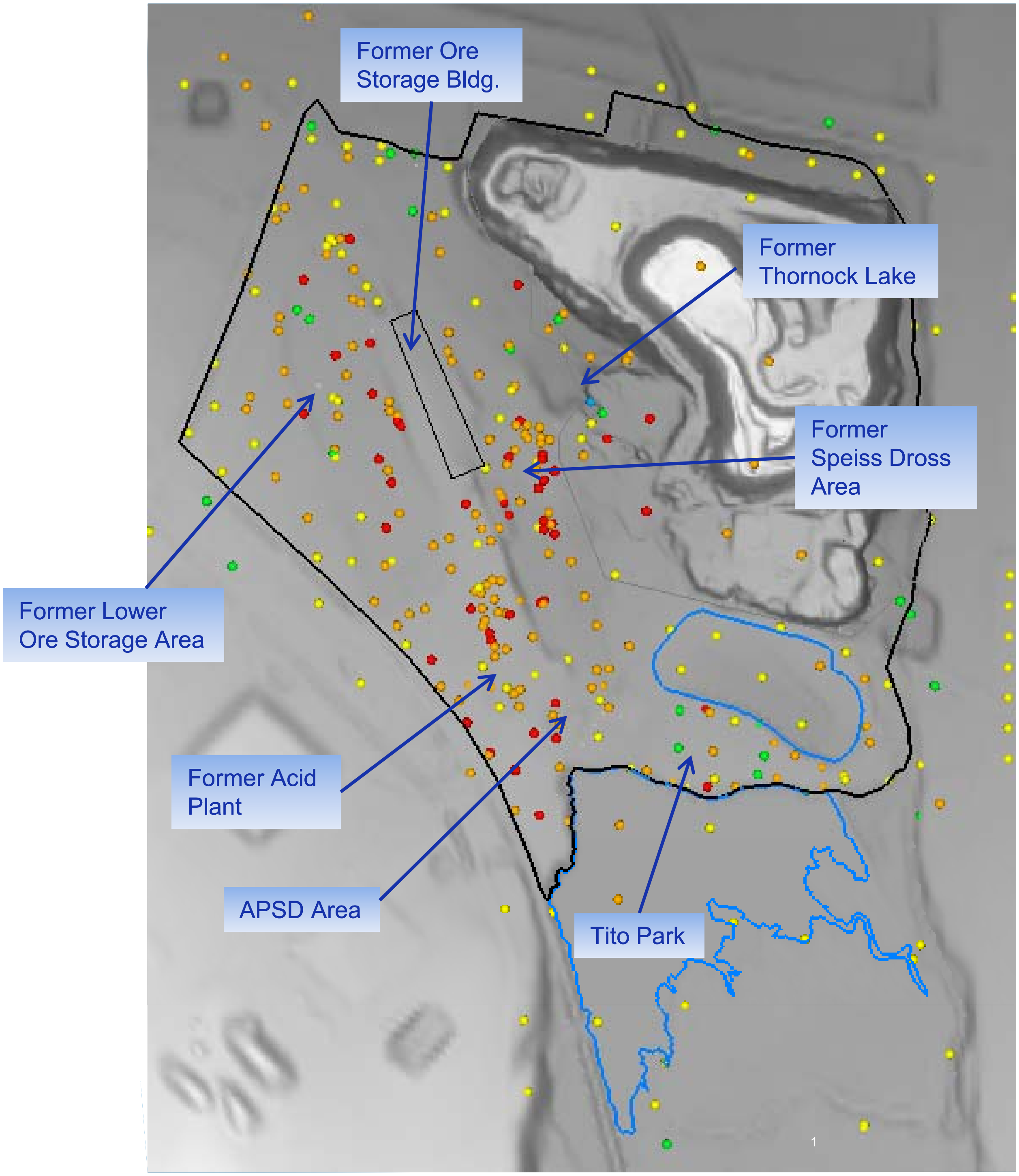
LEGEND

Arsenic Concentrations

- Dark Blue: <0.29 mg/kg
- Light Blue: 0.29 - 2.9 mg/kg
- Green: 2.9 - 40 mg/kg
- Yellow: 40 - 290 mg/kg
- Orange: 290 - 2,900 mg/kg
- Red: >2,900 mg/kg

FIGURE 1
MVS Model Basic Structure
East Helena, Montana

CH2MHILL.



LEGEND

Arsenic Concentrations

Dark Blue: <0.29 mg/kg	Yellow: 40 - 290 mg/kg	0.29 mg/kg = SSL Protective of GW MCL
Light Blue: 0.29 - 2.9 mg/kg	Orange: 290 - 2,900 mg/kg	16.5 mg/kg = Helena Valley mean soil concentrations
Green: 2.9 - 40 mg/kg	Red: >2,900 mg/kg	40 mg/kg = Montana DEQ action level (surface soil)

FIGURE 2
MVS Model Sample Locations (Arsenic)
East Helena, Montana

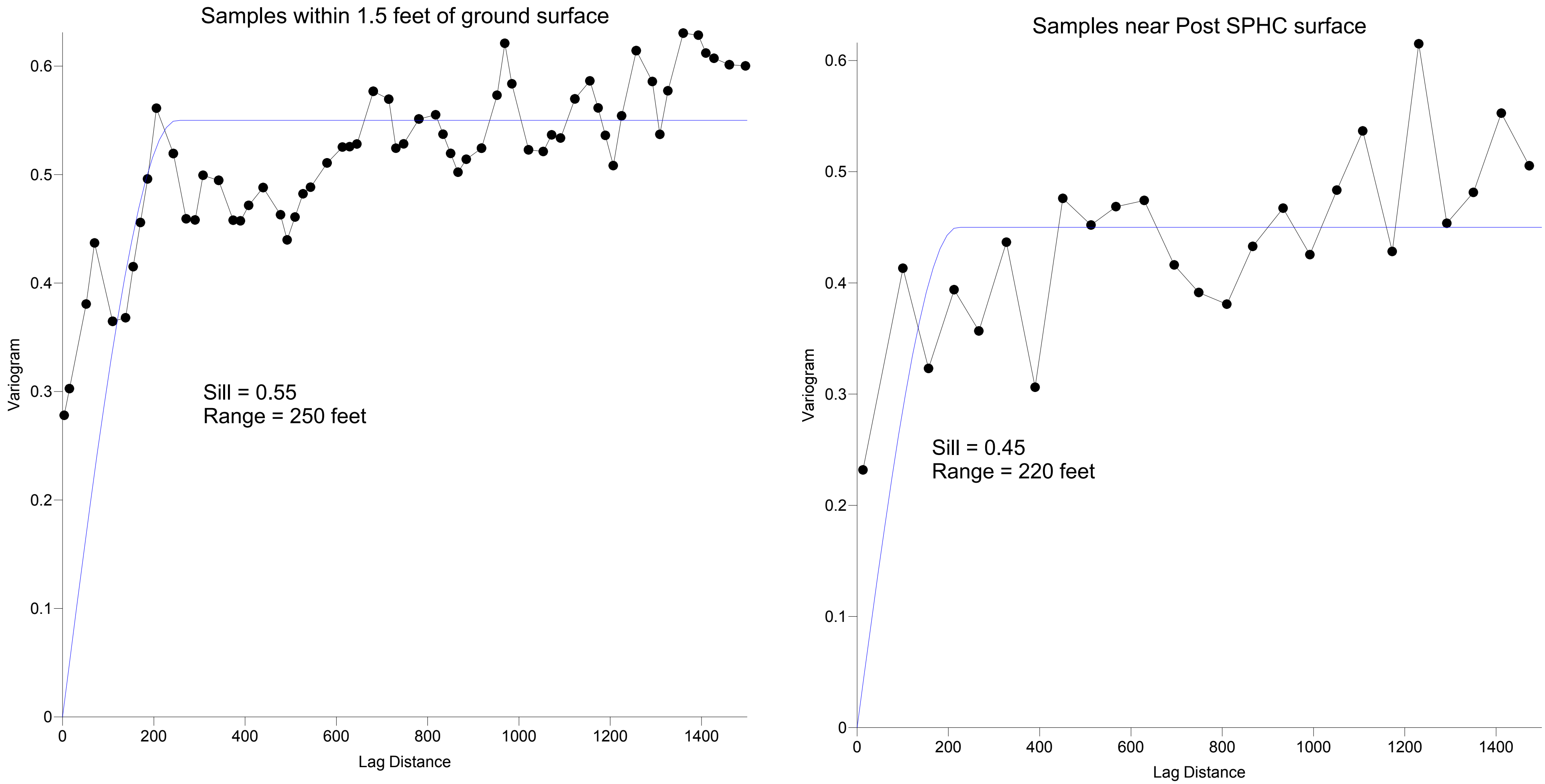
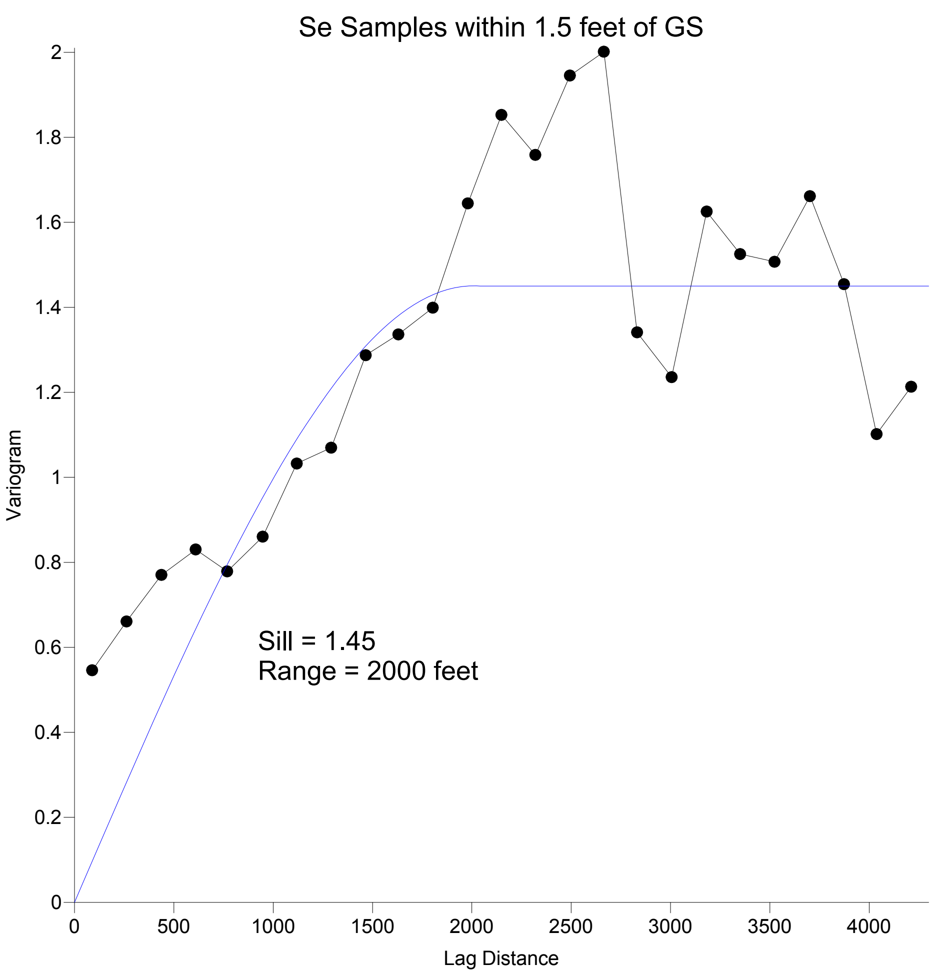


FIGURE 3
Semivariograms for Arsenic Site Sample Data
East Helena, Montana



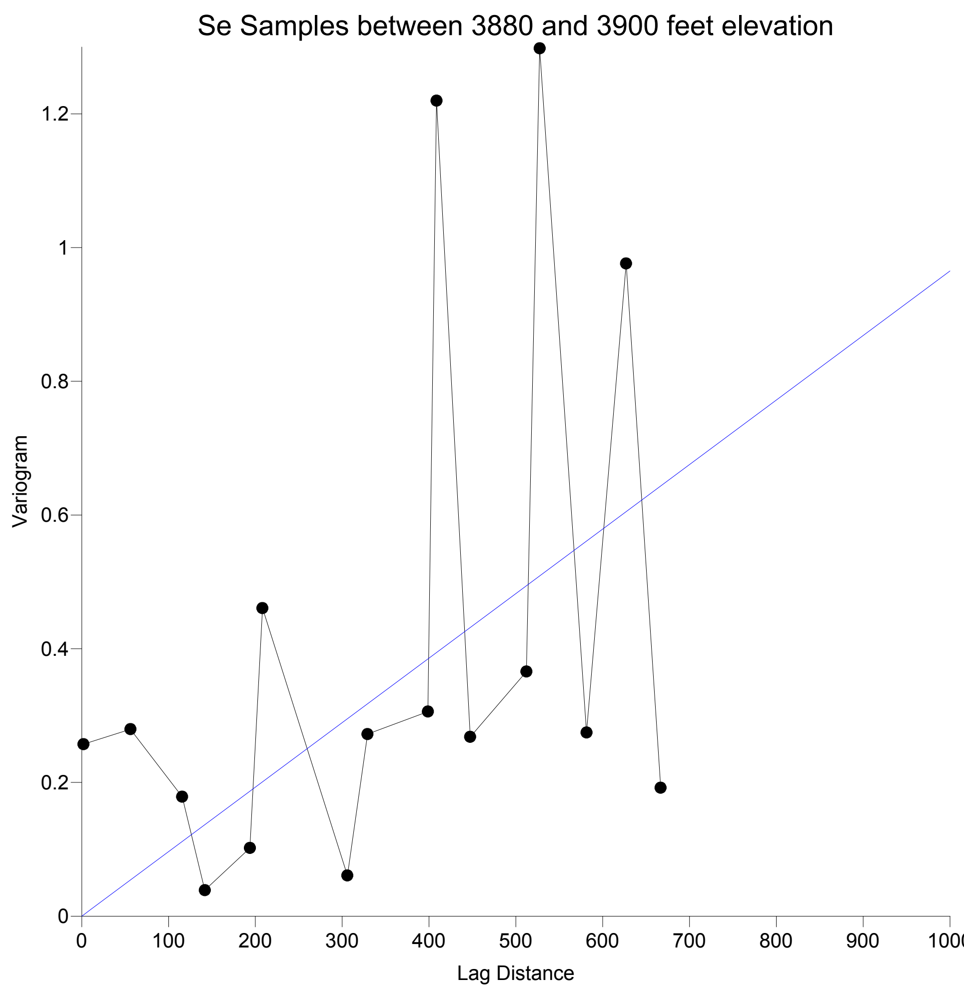
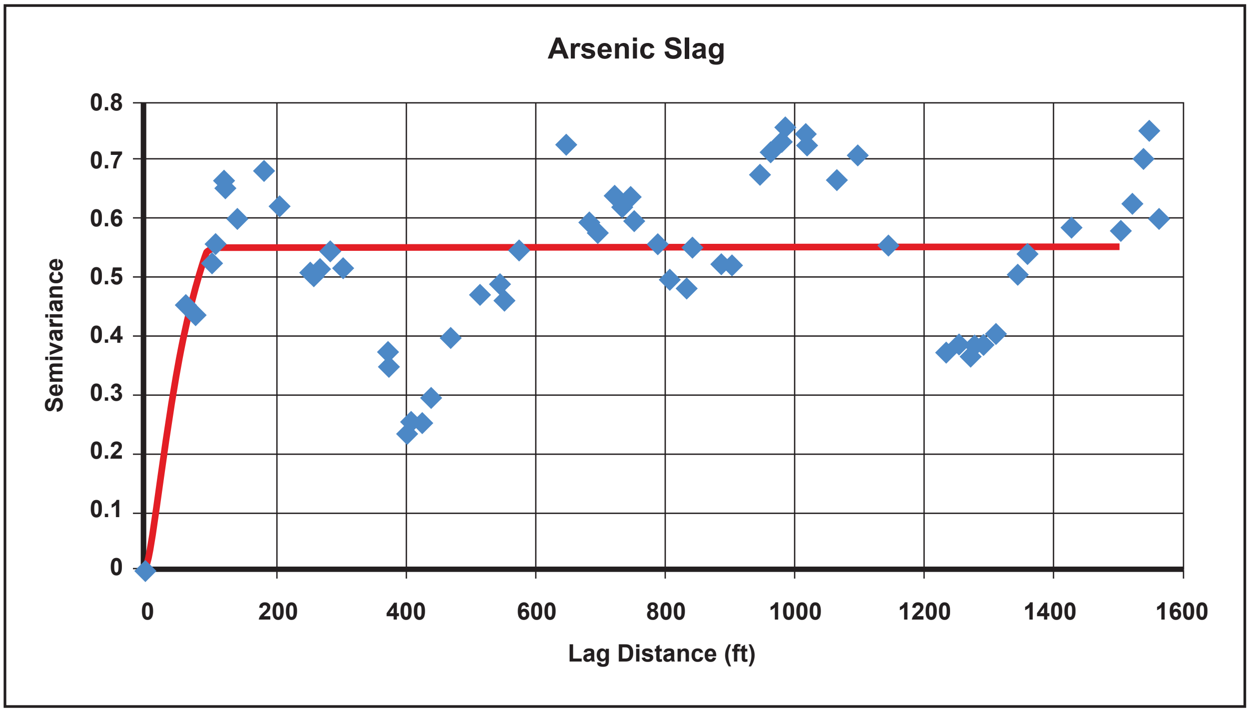


FIGURE 4
Semivariograms for Selenium Site Sample Data
East Helena, Montana



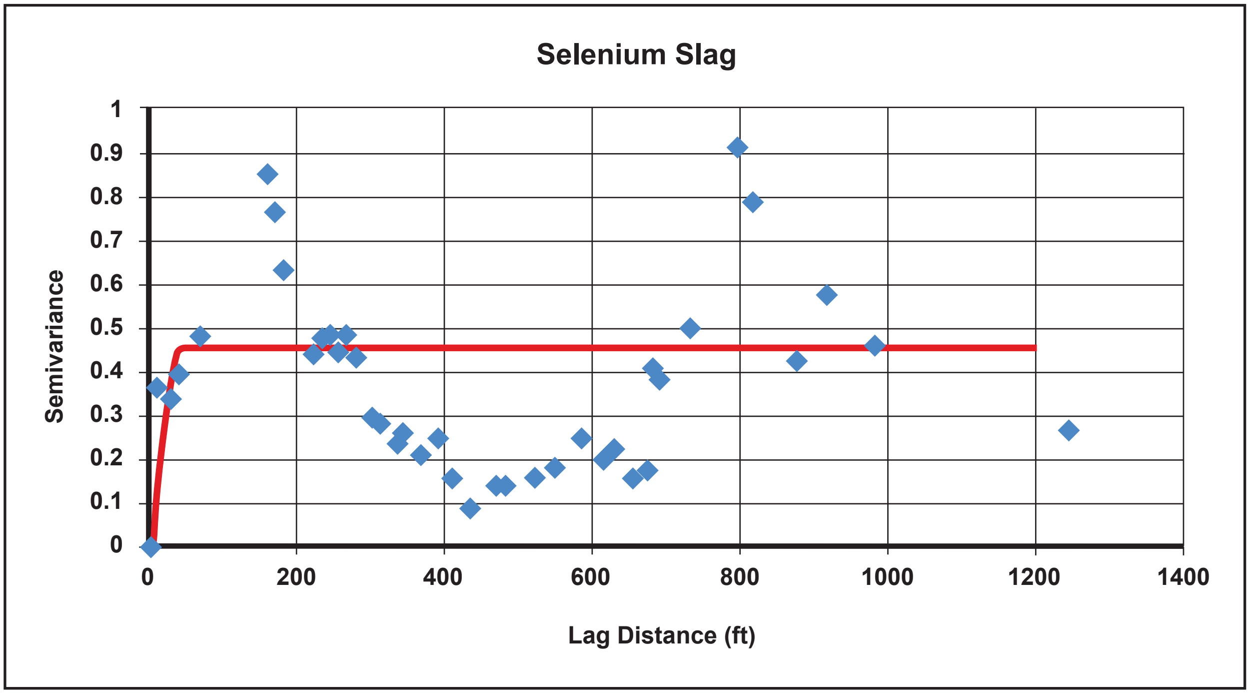


FIGURE 5
Semivariograms for Arsenic and Selenium Slag Sample Data
East Helena, Montana

ES081313034307PDX 467300.35.02.02 v1 12-23-13 lh

LEGEND - Arsenic Contours

- 1.01 -5.00 mg/L
- 5.01 -10.0 mg/L
- 10.1 - 20.0 mg/L
- > 20 mg/L

Jay Dehner
JD
PJK
PK

METG
Montana Environmental Trust Group

CH2MHILL

FIGURE 6
Alternative 2: Arsenic High-Concentration Areas – Overlay of Arsenic Groundwater Plume Map
East Helena, Montana

1"=100'

BAR IS ONE INCH ON ORIGINAL DRAWING.
0 1"

01-05-12
420947
FIGURE 3

FILENAME: SOILREMOVAL FIGURE 6.DWG PLOT DATE: 30-Oct-13 PLOT TIME: 12:04 PM

ES081313034307PDX 467300.35.02.02 v2 12-24-13 lh

LEGEND - Selenium Contours

- 0.101 -0.500 mg/L
- 0.501 -1.0 mg/L
- 1.01 -3.0 mg/L
- >3.0 mg/L

Jay Dehner
JD
PJK
PK

METG
Montana Environmental Trust Group

CH2MHILL

FIGURE 7
Alternative 2: Arsenic High-Concentration Areas –
Overlay of Selenium Groundwater Plume Map
East Helena, Montana

1"=100'

BAR IS ONE INCH ON ORIGINAL DRAWING.
0 1"

01-05-12
420947
FIGURE 3

30-Oct-13
PLOT TIME: 12:22 PM

Attachment 2
Cost Estimating Assumptions and Details

Cost Estimating Assumptions and Details for Soil Removal at the East Helena Former ASARCO Smelter Site

PREPARED FOR: The Custodial Trust

PREPARED BY: CH2M HILL

DATE: November 12, 2013

This technical memorandum (TM) presents cost estimating assumptions and details for three soil removal corrective measures alternatives at the East Helena former ASARCO Smelter site. The soil removal alternatives are focused on the operating area of the former Smelter site. Detailed cost estimate summaries for Alternatives 1 and 2 are provided in the attachment to this TM.

Cost Estimating Accuracy

Rough order of magnitude (ROM) cost estimates were prepared as a screening-level evaluation of three excavation alternatives. Construction cost data were estimated in accordance with guidance provided by the American Association of Cost Engineers (AACE) using various estimating tools, including engineering and planning documents, historical data, and direct experience. The cost estimates are of ROM Class 5 (-50/+100 percent and reflecting a conceptual design with minimal details) accuracy, per AACE guidance.

All estimates are in 2013 dollars with no escalation for inflation. The estimates were prepared from the information available at the time of the estimates. The final costs of the project and resulting feasibility and constructability will depend on actual labor and material costs, competitive market conditions, actual site conditions, final project scope, implementation schedule, continuity of personnel and engineering, and other variable factors. Therefore, the final project costs will vary from the estimates presented here. In addition, the final cost estimates of the alternatives will be developed to reflect the actual design.

Note that the quantities and assumptions developed for Alternatives 1 and 2 are based on preliminary conceptual excavation plans. Alternative 3 cost estimating assumptions are based on the excavation concepts developed for Alternative 2, as described further in a subsequent section of this TM. Quantity estimates for Alternative 2 were based on “neat” volumes and volumes associated with standard construction practices. Neat volumes were estimated assuming vertical cuts, and represent the theoretical minimum soil volumes that could be excavated and backfilled. The quantities estimated for standard construction practices account for actual site constraints and constructability requirements such as excavation side slopes. The use of these two methods for estimating excavation volumes results in a reasonable minimum-maximum range. Alternative 3 quantity estimates were based on “neat” volumes, and the resulting minimum volume was so large there was little value in estimating the volumes based on standard construction practices. Therefore, the estimated excavation and backfill quantities presented for Alternative 3 are expected to be lower than what would actually be required to complete the construction using standard methods.

Soil Removal Alternatives

The following is a brief summary of each alternative. More complete descriptions are provided in the main TM to which this document is attached:

- Alternative 1–Scrape/excavate shallow soil in a 5.5-acre portion of the former Lower Ore Storage Area (LOSA) with arsenic concentrations greater than or equal to ($\geq$) 40 milligrams per kilogram (mg/kg) and consolidate the soil under the Evapotranspiration (ET) Cover System.

- Alternative 2–Excavate soil in the post-South Plant Hydraulic Control (SPHC) saturated zone with arsenic concentrations ≥290 mg/kg.
- Alternative 3–Excavate soil in the post-SHPC saturated zone with arsenic concentrations ≥40 mg/kg.

Cost Estimating Assumptions

The cost estimates are for construction activities only, and do not include design, subcontractor markup, or construction management services. Costs for long-term operation and maintenance of systems are not included in the estimates.

Cost estimating assumptions that apply to all the alternatives are as follows:

- A common soil stockpile area will be built at the former LOSA, and runoff from the stockpile area will be managed.
- A haul road will be built for the construction work.
- All excavated materials (soil and rubble) can be managed within site boundaries and therefore within the Area of Contamination. Disposal at an offsite facility will not be necessary.
- Decontamination of equipment will occur during mobilization/demobilization only.
- Equipment decontamination facilities will be provided at the main plant site at no additional cost to the subcontractor.

Specific cost assumptions for each of the alternatives are provided below.

Alternative 1

- A scraper bulldozer will be used for excavation.
- A 2:1 side slope will be used for excavation layback.
- Only minor construction dewatering (water from stormwater runoff) and subsequent treatment of water will be necessary.
- For backfilling, native/clean fill from nearby sources will be used, including the East Bench and potentially the Valley View Landfill.
- Final soil cover will consist of 8 inches of growth material with seeding.

Alternative 2

- A combination of techniques will be used to reach saturated zone targeted soil: excavation layback (2:1 side slope) and installation of sheet pile walls (for support, use tie-backs or cantilevers).
- The sheet pile walls will be keyed into the underlying Tertiary ash/clay layer to reduce construction dewatering and volume of water that will require treatment.
- A portion of the sheet pile walls used during earlier excavations will be extracted and reused.
- For the volume of water pumped during construction, 0.3 soil porosity is assumed and an overall seepage factor of 1.5 within the sheet pile walls is assumed.
- The high-density sludge water treatment plant will be decommissioned prior to this excavation work. Therefore, a packaged plant will process and treat water onsite prior to discharge. Coprecipitation and lime softening will be used to treat dissolved arsenic, and reverse osmosis will be used to treat dissolved selenium.
- The saturated zone excavations will be backfilled with native/clean fill from a nearby source, for example: East Bench and potentially the Valley View Landfill stockpile.

- The overburden excavations will be backfilled with previously removed and stockpiled overburden soil, to the extent practicable, placing soil with the highest inorganic contaminant concentrations closer to the surface. Any processed concrete foundations/slabs/footings deemed usable will be used.

Alternative 3

The same cost assumptions used for Alternative 2 were used. Although Alternative 3 quantity estimates were based on neat volumes only and not standard construction practices to include excavation side slopes, the differences are considered negligible for this screening-level evaluation.

Attachment
Cost Information Details for Alternatives 1 and 2

Alternative 1

08/01/2013 12:44

EHEL_SSE_V1 Ease Helena_Shallow Soil Excavation_V1

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This rough order-of-magnitude (ROM) cost estimate was developed to illustrate the relative cost differences between source removal alternatives. The estimate is based on a conceptual level of design and uses generic cost data derived from various cost estimating sources, including engineering and planning documents, data from recently completed construction projects at the former Smelter site, RS Means cost data, and experience. The estimate is prepared consistent with guidance provided by the American Association of Cost Engineers (AACE). The cost estimates are of ROM Class 5 (-50/+100 percent) accuracy, per AACE guidance.

BID TOTALS

Biditem	Description	Status - Rnd	Quantity	Units	Unit Price	Bid Total
10	MOBILIZATION		1.000	LS	104,352.92	104,352.92
12	BONDS & INSURANCE		1.000	LS	24,343.44	24,343.44
30	SUBMITTALS		1.000	LS	11,822.61	11,822.61
40	SURVEY		1.000	LS	9,146.64	9,146.64
50	QC		1.000	LS	5,774.39	5,774.39
70	PERMITS		1.000	LS	5,774.39	5,774.39
80	DUST CONTROL		1.000	LS	29,820.67	29,820.67
90	INSTALL SWPPP ELEMENTS		1.000	LS	33,531.02	33,531.02
100	SITE CLEARING		1.490	AC	1,419.88	2,115.62
110	CONSTRUCTION DEWATERING		1.000	LS	23,144.49	23,144.49
120	EXCAVATION and PLACEMENT IN REPOSITORY		57,000.000	CY	5.45	310,650.00
130	BACKFILL PLACEMENT		57,000.000	CY	5.66	322,620.00
140	SITE RESTORATION		5.500	AC	8,560.91	47,085.01
170	DEMOBILIZATION		1.000	LS	159,774.30	159,774.30
180	CONTRACT CLOSE OUT SUBMITTALS		1.000	LS	7,191.00	7,191.00

Bid Total ========> $1,000,000[a]

Alternative 2

08/06/2013 10:41

EHEL_EXC_V3B E Helena_In Plant Excvn_Laybacks_V3B

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BID TOTALS

Biditem	Description	Status - Rnd	Quantity	Units	Unit Price	Bid Total
	GENERAL CONDITIONS					
1010	BONDS & INSURANCE		1.000	LS	710,945.43	710,945.43
1020	SUBMITTALS		1.000	LS	11,822.69	11,822.69
1030	QC		1.000	LS	28,872.18	28,872.18
1040	PERMITS		1.000	LS	5,774.44	5,774.44
		Subtotal General Contitions				$757,414.74
	MOB and SITE PREP					
2010	Mobilize Excavation Sub		1.000	LS	169,874.18	169,874.18
2020	Mobilize Sheeting and Shoring Sub		1.000	LS	240,750.67	240,750.67
2040	Survey		1.000	LS	304,890.20	304,890.20
2050	Decon Station Construction		1.000	LS	18,364.40	18,364.40
2060	Install SWPPP Elements		1.000	LS	33,531.25	33,531.25
2070	Site Clearing		1.490	AC	9,014.09	13,430.99
		Subtotal Mob and Site Prep				$780,841.69
	SHEETING AND SHORING					
3020	Sheeting Install - Area A		1,513.000	LF	1,210.54	1,831,547.02
3021	Sheeting Install - Area B1		922.000	LF	1,516.61	1,398,314.42
3022	Sheeting Install - Area B2		944.000	LF	2,048.58	1,933,859.52
3023	Sheeting Install - Area C		1,270.000	LF	2,729.56	3,466,541.20
3024	Sheeting Install - Area D		754.000	LF	291.01	219,421.54
3025	Sheeting install - Area E		629.000	LF	294.20	185,051.80

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BID TOTALS

Biditem	Description	Status - Rnd	Quantity	Units	Unit Price	Bid Total
3030	Tieback Install - Area A		242.000	EA	2,916.09	705,693.78
3031	Tieback Install - Area B1		133.000	EA	2,916.09	387,839.97
3032	Tieback Install - Area B2		197.000	EA	2,916.09	574,469.73
3033	Tieback Install - Area C		359.000	EA	3,367.75	1,209,022.25
3034	Tieback Install - Area D		197.000	EA	2,916.09	574,469.73
3035	Tieback Install - Area E		225.000	EA	2,916.09	656,120.25
3040	Sheetpile Extract - Area A		1,513.000	LF	244.62	370,110.06
3041	Sheetpile Extract - Area B1		922.000	LF	291.94	269,168.68
3042	Sheetpile Extract - Area B2		944.000	LF	338.60	319,638.40
3043	Sheetpile Extract - Area C		1,270.000	LF	344.41	437,400.70
3044	Sheetpile Extract - Area D		754.000	LF	245.43	185,054.22
3045	Sheetpile Extract - Area E		629.000	LF	240.71	151,406.59
		Subtotal Sheeting and Shoring				$14,875,129.86

EXCAVATION TASKS

Biditem	Description	Status - Rnd	Quantity	Units	Unit Price	Bid Total
4001	Surface Clearance 5 ft - Area A		25,287.000	CY	64.30	1,625,954.10 [b]
4002	Surface Clearance 5 ft - Area B1		12,665.000	CY	64.94	822,465.10
4003	Surface Clearance 5 ft - Area B2		13,552.000	CY	64.34	871,935.68
4004	Surface Clearance 5 ft - Area C		18,957.000	CY	64.52	1,223,105.64
4005	Surface Clearance 5 ft - Area D		16,133.000	CY	64.00	1,032,512.00
4006	Surface Clearance 5 ft - Area E		15,407.000	CY	64.38	991,902.66
4010	Excavation to Top of Sheetpile - Area A		38,243.000	CY	5.09	194,656.87
4011	Excavation to Top of Sheetpile - Area B1		3,888.000	CY	4.96	19,284.48
4012	Excavation to Top of Sheetpile - Area B2		8,887.000	CY	6.51	57,854.37
4013	Excavation to Top of Sheetpile - Area C		11,438.000	CY	6.74	77,092.12
4014	Excavation to Top of Sheetpile - Area D		45,124.000	CY	5.13	231,486.12
4015	Excavation to Top of Sheetpile - Area E		47,655.000	CY	4.86	231,603.30
4020	Excavate Clean Inside Sheeting - Area A		27,254.000	CY	6.37	173,607.98
4021	Excavate Clean Inside Sheeting - Area B1		24,438.000	CY	6.31	154,203.78
4022	Excavate Clean Inside Sheeting - Area B2		33,525.000	CY	6.33	212,213.25
4023	Excavate Clean Inside Sheeting - Area C		57,850.000	CY	6.33	366,190.50
4024	Excavate Clean Inside Sheeting - Area D		0.000	CY		

Alternative 2

08/06/2013 10:41

EHEL_EXC_V3B E Helena_In Plant Excvn_Laybacks_V3B

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BID TOTALS

Biditem	Description	Status - Rnd	Quantity	Units	Unit Price	Bid Total
4025	Excavate Clean Inside Sheeting - Area E		0.000	CY		
4030	Impacted Excavation - Area A		18,660.000	CY	6.11	114,012.60
4031	Impacted Excavation - Area B1		5,844.000	CY	6.50	37,986.00
4032	Impacted Excavation - Area B2		10,067.000		7.55	76,005.85
4033	Impacted Excavation - Area C		22,226.000		9.40	208,924.40
4034	Impacted Excavation - Area D		10,256.000		7.52	77,125.12
4035	Impacted Excavation - Area E		10,895.000		7.08	77,136.60

Subtotal Excavation Tasks $8,877,258.52

BACKFILL TASKS

Biditem	Description	Status - Rnd	Quantity	Units	Unit Price	Bid Total
5010	Backfill to TOS - Area A		45,914.000	CY	3.93	180,442.02
5011	Backfill to TOS - Area B1		30,282.000	CY	3.93	119,008.26
5012	Backfill to TOS - Area B2		43,592.000	CY	3.93	171,316.56
5013	Backfill to TOS - Area C		80,076.000	CY	3.93	314,698.68
5014	Backfill - Area D		10,256.000	CY	3.93	40,306.08
5015	Backfill - Area E		10,895.000	CY	3.93	42,817.35
5020	Backfill fm TOS - Area A		44,870.000	CY	3.93	176,339.10
5021	Backfill fm TOS - Area B1		10,709.000	CY	3.93	42,086.37
5022	Backfill fm TOS - Area B2		12,372.000	CY	3.93	48,621.96
5023	Backfill fm TOS - Area C		8,169.000	CY	3.93	32,104.17
5024	Backfill fm TOS - Area D		51,001.000	CY	3.93	200,433.93
5025	Backfill fm TOS - Area E		52,167.000	CY	3.93	205,016.31
5030	Surface Fill fm Other Source - Area A		18,660.000	CY	3.93	73,333.80
5031	Surface Fill fm Other Source - Area B1		5,844.000	CY	3.93	22,966.92
5032	Surface Fill fm Other Source - Area B2		10,067.000	CY	3.93	39,563.31
5033	Surface Fill fm Other Source - Area C		22,226.000	CY	3.93	87,348.18
5034	Surface Fill fm Other Source - Area D		10,256.000	CY	3.93	40,306.08
5035	Surface Fill fm Other Source - Area E		10,895.000	CY	3.93	42,817.35

Subtotal Backfill Tasks $1,879,526.43

Alternative 2

08/06/2013 10:41

EHEL_EXC_V3B E Helena_In Plant Excvn_Laybacks_V3B

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BID TOTALS

Biditem	Description	Status - Rnd	Quantity	Units	Unit Price	Bid Total
	EXCAVATION SUPPORT TASKS					
6010	Dust Control, Road Maint, Fuel Truck		1.000	LS	539,316.95	539,316.95
6020	Construction Dewatering		1.000	LS	289,910.24	289,910.24
6030	Water Treatment		7,000,000.000	GAL	0.79	5,530,000.00
6040	Backfill Stockpile Management		176.000	DAY	2,642.69	465,113.44
6050	Impacted Stockpile Management		119.000	DAY	955.87	113,748.53
		Subtotal Excavation Support				$6,938,089.16
	DEMOBILIZATION and CLOSEOUT					
7010	Demobilize Excavation Sub		1.000	LS	159,775.44	159,775.44
7020	Demobilize Sheeting Sub		1.000	LS	122,374.75	122,374.75
7050	CONTRACT CLOSE OUT SUBMITTALS		1.000	LS	7,191.05	7,191.05
		Subtotal Demob and Closeout				$289,341.24
			Bid Total	========>		$30,400,000[c]

Notes:

[a] Reduce by approximately $100,000 to account for lower mobilization and demobilization costs, based on recent project bids. The "Mobilization" and "Demobilization" line items have been adjusted to lower the Bid Total by approximately $100,000.

[b] Reduce $4 million from line items 4001 through 4006.

[c] Reduce by $4 million since assume concrete rubble from foundations/slabs/footings can be reused and managed onsite.