FINAL

Site Investigation Report

Smoky Canyon Mine, Caribou County, Idaho

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11.0 SUMMARY AND CONCLUSIONS

A Site Investigation (SI) was conducted for the Smoky Canyon Mine Site (the Site) between the spring of 2002 and the fall of 2004, to describe environmental conditions associated with historic mine features. During the SI, necessary information was collected to characterize:

- the mine features (source areas) releasing chemicals of potential concern (COPCs) to the environment;
- the nature and extent of contamination associated with the releases;
- the mechanisms for release and pathways for transport of the COPCs locally and Site-wide; and
- the fate of the COPCs along the transport pathways, including potentially unacceptable human and ecological exposure pathways.

The role of the SI is to provide a basis and technical foundation for the development of an Engineering Evaluation/Cost Analysis (EECA). The EECA will further assess the relationship of the identified sources to current and expected future Site conditions and will develop and evaluate a focused group of removal actions to address the source areas and resultant exposure concerns.

11.1 Summary

The scope and frequency of SI activities at the Site were outlined in the SI/EECA Work Plan (MFG, 2002a). The Work Plan included a preliminary Site characterization based on the findings of an area-wide investigation previously conducted by the Idaho Department of Environmental Quality (IDEQ) (TetraTech EMI, 2002), and an abundance of Site-specific data that had been previously collected as part of the requirements for mine development and operation. The area-wide evaluations and Site-specific knowledge allowed for the early identification of potential sources of COPCs at the Site. The area-wide investigations identified weathering seleniferous waste shales in excavated overburden as being the source of elevated COPC levels in the environment. Within the Site, pit backfill and external overburden disposal areas for Panels A, D and E, including the Pole Canyon area, were specifically identified as potential source areas (Figures 3-2 through 3-4). These external overburden disposal areas contain varying amounts of seleniferous shales that may release selenium and other COPCs to the environment. As discussed later, the nature and extent of the COPC releases attributable to these source areas are dependent not only on the chemical nature of the overburden, but also on the physical settings of the overburden disposal areas.

The following summary provides the key findings regarding conditions within the Site. Details regarding the nature and extent of contamination, fate and transport of contaminants, and the resultant potential exposure concerns for ecological and human receptors can be found in Sections 7, 8, 9, and 10 of this report, respectively.

11.1.1 Nature and Extent of Contamination

The nature and extent of contamination at the Site was characterized through the collection of a broad range of Site-specific physical and chemical information. Groundwater, surface water, sediment, soil, terrestrial vegetation, aquatic vegetation, and tissue samples (small mammals, terrestrial invertebrates, fish, and benthic macroinvertebrates) were collected for analysis of COPC and other constituent concentrations. Physical information regarding Site conditions (e.g., stream flow rates, water levels, habitat conditions, and species identification, etc.) was collected at the same time. The information collected through the SI was paired with information collected through other mine development and operation activities (e.g., Environmental Impact Statement baseline studies) to provide a robust spatial and temporal characterization of the distribution of COPC concentrations in the Site media.

Based on the area-wide investigations, the investigations at the Site focused on the following COPCs: cadmium, chromium, copper, nickel, selenium, vanadium and zinc (IDEQ, 2004). To characterize the nature and extent of COPC distribution, the observed concentrations were compared to Site-specific and area-wide background concentrations as well as risk-based and regulatory screening criteria identified through the area-wide efforts (TetraTech EMI, 2002 and IDEQ, 2004).

Comparison of the Site-specific data to these criteria indicates that selenium has the widest distribution and greatest levels of exceedances of background concentrations and/or regulatory criteria across the Site media. Therefore, selenium can be used as a conservative indicator for the nature and extent of contamination, as well as for the fate and transport of COPCs at the Site.

The following sections summarize information regarding the nature and extent of contamination presented earlier in the SI report.

<u>Ground Water</u>

Groundwater monitoring, including sampling and analysis, was performed quarterly from October 2003 to November 2004. Two Wells Formation and seven alluvial system monitoring wells were constructed as part of the SI. In addition, the mine's Culinary and Industrial Wells, and a new deep monitoring well ("Consent Order" Well) screened in the Wells Formation, were included in the monitoring network. The two water-supply wells have been in place since the

early 1980s and routinely pump large volumes of water from the Wells Formation for mine and mill operations. Two existing shallow monitoring wells in the A Panel overburden disposal area were also included in the SI monitoring program. In addition, domestic water supplies present within 5 miles of the mine were sampled for COPCs on one occasion.

Shallow Alluvial Flow System

A valley-fill alluvial groundwater system exists in Sage Valley. The water table in this system is typically less than 30 feet below the ground surface and, at some locations, it is intercepted by Sage Creek. The valley system is connected with shallow alluvial deposits at the mouth of the tributary drainages. The Pole Canyon overburden disposal area is the only overburden disposal area that contributes water to the alluvial groundwater flow system.

Selenium concentrations in the alluvial system exceeded the regulatory drinking water standard of 0.050 mg/L at two of the six wells (Figure 7-1). Selenium concentrations are highest in shallow groundwater immediately downgradient of the Pole Canyon overburden disposal area adjacent to lower Pole Canyon Creek (GW-15). Selenium concentrations in alluvial groundwater decrease southward from the lower Pole Canyon area toward GW-22 in the north central portion of Sage Valley. Although water collected from a discrete interval in the well GW-22 profile exceeded the groundwater standard for selenium, when pumped across all screened intervals, the selenium concentrations are substantially below the drinking water standard. Selenium concentrations in the valley-fill alluvial system decrease with increasing distance south into lower Sage Valley.

Wells Formation

The Wells Formation is continuous throughout the mine panel areas and contains the regional Wells Formation aquifer. The Wells Formation outcrops/subcrops at the location of the overburden disposal areas. Within the mine area, the Wells Formation aquifer lies below several hundred feet, or more, of unsaturated Wells Formation limestone.

Selenium is present in the Wells Formation aquifer above the 0.050 mg/L drinking water standard at only one location, GW-16 (Figure 7-3). At three other locations in the A Panel area, the Industrial Well (GW-IW), Culinary Well (GW-CW) and the Consent Order Well (GW-CO), selenium is present above the 0.005 mg/L IDEQ monitoring action level. Selenium concentrations are not discernibly elevated in groundwater near the E Panel area (at GW-18 or MC-MW-1). Hoopes Spring water, which discharges from the Wells Formation, also contains selenium at concentrations above the Area-Wide monitoring action level for groundwater, but not above the drinking water standard.

Surface Water

Surface water quality sampling has been occurring routinely at a number of locations across the Site for over 20 years. Based on knowledge of the potential source areas, recent SI sampling focused on finer spatial and temporal coverage. Surface water quality was seasonally characterized through quarterly SI measurements of flow and COPC concentrations at a large number of locations.

Seeps and Detention Basins

Surface water sampling at the Site included surface expressions of seepage from the overburden disposal areas and detention basins that collect seepage and runoff from the pits and overburden disposal areas. Flow rates at some seeps can vary substantially seasonally, and at some locations surface seeps are only present in the spring. Selenium concentrations in seepage from the overburden disposal areas are typically well above any of the corresponding screening criteria (Figures 7-15 and 7-16). The extent of elevated selenium levels in these surface water features is limited to five overburden seep areas (AS-2, DS-7, DS-10, ES-4, ES-5) and the associated detention basin waters below those seeps (AP-2, DP-7, DP-10, EP-4, EP-5) (Figure 7-20) where the 0.201 mg/L removal action level for selenium in non-regulated surface water with transient use is exceeded. Detention basins receiving seep water from the overburden areas exhibit the highest selenium concentrations in basin water, and they are the only basins that contain water with selenium concentrations above the removal action level for non-regulated surface water. Although elevated, the basin-water selenium concentrations are lower than the selenium concentrations in the nearby seep waters.

Streams

Surface water flow in streams at the Site occurs within both the Tygee Creek and Sage Creek basins. The primary potential source area within the Tygee Creek basin is the A Panel. No surface water quality criteria were exceeded within the Tygee Creek basin. The remaining mine features are in the Sage Creek basin.

In the Sage Creek basin, several tributary streams and the main stem of Sage Creek below the confluence with the impacted tributaries exceed the stream standard of 0.005 mg/L (Figure 7-11). Other streams within the Sage Creek basin are well below the stream standard. Pole Canyon Creek downstream of the Pole Canyon overburden disposal area contained the highest measured selenium concentration (>1 mg/L). However, in recent years, Pole Canyon Creek has not had sufficient flow to reach Sage Creek and lower Pole Canyon Creek is dry for a large part of the year. Hoopes Spring discharges from the Wells Formation and has a relatively consistent year-round flow. Selenium concentrations in Hoopes Spring were consistently measured at two- to three-times the stream standard. Hoopes Spring contributes the majority of the flow in lower Sage Creek under all flow conditions and drives observed exceedances in

Sage Creek upstream of the confluence with Crow Creek. Sage Creek at the confluence with Crow Creek contains selenium typically below the stream standard, and Crow Creek selenium is well below the standard.

Sediment

Sediment samples were collected in July 2004 from each of the major stream drainages that cross the mine area and from storm water detention basins around the A, D and E Panels.

Stream Sediment

Sediment samples were collected from the stream beds at 14 of the stations used for surface water monitoring. These are the same locations where riparian vegetation and aquatic biota samples were also collected. The sediment concentrations of selenium were typically consistent with those in undisturbed areas upstream of mining impacts (Figure 7-14). Lower Pole Canyon Creek was the only stream segment that exhibited selenium concentrations at levels substantially greater than background.

The presence of high COPC concentrations in lower Pole Canyon Creek sediment samples is due to the deposition of overburden slope materials into the creek during past slope failures at the toe of the overburden disposal area. The slope has since been stabilized, but residual sediments remain in the creek bed below the overburden disposal area.

Storm Water Detention Basin Sediments

A total of 30 sediment samples were collected from the stormwater detention basins in A, D and E Panels. Most of the detention basins in the A, D, and E Panel areas contain sediment with concentrations of selenium above the area-wide removal action level of 7.5 mg/Kg DW. EP-3 is the only basin sediment that does not exceed any of the COPC screening criteria applied for sediments not supporting aquatic life. The detention basins receiving seep water from overburden disposal areas exhibit the highest selenium concentrations in sediments.

Soil and Overburden

Sampling of soil/overburden occurred primarily along transects extending across the overburden disposal areas associated with mine Panels A, D and E and onto the surrounding native soil. The mine haul roads were also characterized to evaluate the past use of shale as road-base material. Soil samples were also collected in northern Sage Valley and at overburden seep areas to evaluate the effects of selenium transport in creek and seep water on soil. Results for overburden and soil sampling are presented on Figure 7-28.

Overburden Areas

In general, surface and root-zone samples collected from overburden areas contained substantially higher selenium concentrations than the samples collected from native soil. Significant transport of selenium from surface water to soil is limited to the immediate areas of overburden seepage and was not observed in northern Sage Valley.

A total of 124 samples were collected from locations across the A Panel, Pole Canyon overburden disposal area, and D Panel. Samples collected from the overburden disposal areas typically contain higher selenium concentrations than samples collected from any other area within or around the mine. On average, the materials collected from the root zone of vegetation exhibit higher COPC concentrations than the materials collected from within 2 inches of the surface.

Sage Valley

Selenium exceeds the site-specific reference concentration (3 mg/Kg) for soil in the top 2 inches of soil at two of the twenty locations sampled in northern Sage Valley. These samples were collected at locations along the surface flow path from Pole Canyon to the north fork of Sage Creek.

Haul Roads

Samples of the haul road materials were collected at 12 locations from the top 6 to 12 inches of road base. The haul road materials generally contain COPC concentrations that are similar to the site-specific reference concentrations (for soil) except at locations RW-3 and RW-4. These two locations are on A Panel and in Pole Canyon (Figure 4-10).

Overburden Seeps

Soil samples were collected from the DS-7, DS-10/DP-10, ES-3, ES-4 and ES-5 seep areas. In general, the highest COPC concentrations in soil around each of these seep areas are found in the soil that is routinely saturated by seep water. Given these results, seeps DS-7, ES-4, and ES-5 appear to transport COPCs directly to soil where the seep discharges to the surface. DS-7 is the oldest of the overburden seeps investigated and, at this location, contamination of soil by seep water appears to be more widespread.

<u>Vegetation</u>

Terrestrial vegetation was collected at most of the same locations where soil samples were collected including: vegetation growing on overburden disposal areas and in adjacent native

soils; vegetation growing around the D and E Panel overburden seep areas; and vegetation growing in on the northern Sage Valley floor.

At each location, samples were collected to represent forbs (broad-leaf, not grass vegetation), grasses, browse (woody vegetation), forage (composite of non-browse materials) and hyperaccumulators (forb species known to hyperaccumulate selenium). Woody browse materials are not present at sample locations within the overburden areas and plant cover at those locations reflect the reclamation practices used at the mine.

Selenium concentrations in vegetation samples from A Panel and Pole Canyon overburden disposal areas contained selenium concentrations that exceed the 5 mg/Kg DW removal action level, but selenium in the vegetation on adjacent native soil typically did not exceed 5 mg/Kg (Figure 7-41). Average selenium concentrations in vegetation from D Panel overburden were below the 5 mg/Kg DW level in the south transect, and approximately equal to the action level in the north transect. Lower selenium concentrations are due to the types of reclamation activities that have been completed in these areas.

Effects of overburden seeps on vegetation selenium concentrations were highly localized to the areas where the root zone was consistently saturated with seep water. Correspondingly, riparian vegetation selenium concentrations exceeded the area-wide removal action level only in samples from the lower Pole Canyon Creek area.

Average vegetation concentrations in northern Sage Valley were well below the 5 mg/Kg DW level. The only exceptions were two samples collected along the Pole Canyon Creek flow path at locations of higher selenium concentrations in soil.

Terrestrial and Aquatic Biota

Additional biological data were collected to assess COPC uptake into biota for purposes of evaluating ecological risks. COPC concentrations were measured in fish tissues, benthic invertebrate tissues, aquatic vegetation, small mammals, and terrestrial invertebrates.

Terrestrial invertebrates were collected at 17 sample locations and small mammals were collected at 18 locations. Terrestrial invertebrate and small mammal tissue selenium concentrations from overburden and overburden seep areas are generally elevated in comparison to samples from Site-specific native soils and regional background concentrations (Figure 7-52).

Fish were collected during the July 2004 sampling effort. Twenty-seven whole body samples were submitted for analyses of the COPCs. Selenium concentrations in fish tissue are below the regional background range except at Hoopes Spring (HS) and lower Sage Creek at LSV-4 (Figure 7-54). This is consistent with data from surface water sampling which indicate that

selenium concentrations do not exceed the stream standard except at Hoopes Spring and lower Sage Creek. The mean tissue concentration in fish samples collected from Hoopes Spring exceeds the protective range by approximately two-fold. However, the mean fish tissue concentration in lower Sage Creek is near the range that is protective of salmonids.

Elevated selenium in fish from Hoopes Spring and lower Sage Creek appears to be directly correlated with surface water concentrations in these stream reaches. Dietary sources may also contribute, as concentrations in benthic macroinvertebrates at these locations were slightly elevated with respect to background (Figure 7-55). Selenium concentrations in macrophytes and periphyton also followed a similar pattern, with the highest selenium concentrations at lower Pole Canyon Creek (Figure 7-56).

11.1.2 Fate and Transport

The following transport pathways for selenium were evaluated for each source area as well as Site-wide:

- wind dispersion and air deposition;
- surface water runoff from overburden areas;
- erosion/sediment transport;
- direct uptake by plants;
- surface water discharge at overburden seeps;
- flow to groundwater in the alluvial flow system;
- flow to groundwater in the Wells Formation; and
- groundwater/surface water interactions.

With the exception of wind dispersion, all of the above pathways were identified for the Site. There is no evidence that wind dispersion has resulted in any measurable transport of selenium from the source areas.

The pathways of surface water runoff and erosion/sediment transport are limited by the coarseness of the overburden materials and the extensive network of detention ponds and other best management practices (BMPs) to control surface water and runoff. With the exception of several past events, where local failures of overburden fill resulted in overtopping of detention

basins or a direct release to lower Pole Canyon Creek, this pathway was not observed to be active. Residual sediments from the historic releases have not been subject to transport from the lower Pole Canyon area.

Uptake of selenium by vegetation growing on unreclaimed or partially reclaimed overburden presents a localized exposure pathway. Plant uptake of selenium also occurs in riparian and seep soils that are saturated with water originating from overburden seeps. However, plant uptake of selenium is confined to these discrete areas. Certain plant species have the ability to accumulate concentrations higher than observed in the soil/overburden. Ecological risks associated with the plant-uptake exposure pathway were evaluated.

The primary pathways for both local and Site-wide transport of selenium begin with the release of dissolved selenium through the weathering of the overburden materials. The weathering shales are susceptible to leaching as water from rain and snowmelt infiltrates through these materials. The dissolved selenium ions are released to the infiltrating waters and are available for further aqueous transport as generally described in Section 3.5.

The mass of selenium released and transported and the resultant concentrations in surface and groundwater are dependent upon the physical setting of the overburden disposal areas. The ratio of infiltrating water to the mass of seleniferous overburden and the length of the flow path for infiltration through the overburden are the primary factors. In general, the longer the flow path through the overburden, the greater the mass of selenium released per unit of infiltration. The influence of these factors can be seen in the difference in selenium concentrations and loads associated with seepage from the overburden areas.

11.1.2.1 Transport from Source Areas

The following provides a brief overview of the transport pathways for selenium released to infiltration at each of the source areas.

<u>A Panel</u>

Infiltration through pit backfill and the external overburden disposal area, to the underlying Wells Formation, is the primary transport pathway at the A Panel area. Most of the infiltration is expected to occur within the pit backfill area. Both the pit backfill and the external overburden disposal areas are free-draining. Infiltration from these source areas enters the unsaturated Wells Formation approximately 600 to 900 feet above the water table.

Water quality data collected at the base of the A Panel backfill area and at an ephemeral surface seep flowing from the external overburden disposal area, provide an indication of the maximum selenium concentrations in seepage water entering the unsaturated portion of the

Wells Formation. Selenium concentrations in these waters range from approximately 0.4 to 4 mg/L. Some portions of the water that migrates to the unsaturated Wells Formation from the base of the A Panel pit floor are also likely within this concentration range. Site data also indicate that selenium in seeps emanating from the edge of the external overburden disposal area may be attenuated along surface flow paths prior to vertical infiltration (Figure 8-2).

Water quality sampling at the nearby Culinary and Industrial Wells, indicates that selenium has been locally transported through over 600 feet of unsaturated Wells Formation from the A Panel area. Transport within the Wells Formation aquifer was likely accelerated by active groundwater pumping from the Industrial Well. When the Industrial Well is in use for water supply, groundwater is pumped at approximately 1,000 gallons per minute. The resultant drawdown in the water level at the well is more than 100 feet. At least a portion of the A Panel footprint area lies within the capture area of the Industrial Well. Therefore, a direct pathway for groundwater flow from the A Panel to the Industrial Well, and the nearby Culinary Well, exists. Selenium entering the Wells Formation aquifer that is not captured by these wells is available for Site-wide transport within the Wells Formation.

Pole Canyon Overburden Disposal Area

The Pole Canyon overburden disposal area is the largest contributor of selenium to the Site surface water and groundwater systems. The estimated volume of infiltration through the Pole Canyon backfill includes run on from the adjacent hillsides. Infiltration through the Pole Canyon backfill results in focused recharge to Pole Canyon Creek and the underlying groundwater units, along the narrow canyon floor. A relatively large volume of infiltration water, with a substantially elevated selenium concentration, discharges from the base of the overburden disposal area. Discharge at the base of the overburden disposal area mixes with inflowing Pole Canyon Creek water, which flows along and through the base of the overburden fill, potentially leaching additional selenium. At least a portion of the Pole Canyon Creek flow is lost to the underlying alluvial and Wells Formation groundwater systems below the overburden backfill. Pole Canyon Creek water lost to the Wells Formation must travel through several hundred feet of unsaturated formation before reaching the water table. Pole Canyon Creek continues to lose water to the alluvial system as it flows from the Pole Canyon overburden disposal area into Sage Valley and eventually dissipates prior to reaching Sage Creek. Figure 8-3 depicts these transport pathways.

The focused recharge and well-defined surface and groundwater pathways associated with the Pole Canyon overburden disposal area allow for a detailed evaluation of selenium transport from this source area. An annual water/mass balance was developed for the Pole Canyon overburden disposal area, utilizing paired groundwater and surface water information collected quarterly between May 2003 and November 2004. The paired data provide further insight into the seasonal relationship of the transport pathways depicted on Figure 8-3. The detailed

investigation and evaluation of the Pole Canyon overburden disposal area provided the following information:

Direct precipitation and run on from adjacent slopes infiltrates through the overburden disposal area annually and transports an estimated 242 pounds of selenium per year as seepage from the base of the overburden.

On an annual basis, approximately half of the selenium load leaving the overburden disposal area was estimated to report to the underlying Wells Formation. The remainder is split between loss to the alluvial groundwater flow system and Pole Canyon Creek outflow. However, further downstream the Pole Canyon Creek outflow discharges to the alluvial groundwater system. Therefore, overall transport of the selenium load released from the overburden disposal area is roughly divided between discharge to the Wells Formation (138 pounds) and the overlying alluvial deposits (104 pounds).

The overburden is free-draining and, correspondingly, a large portion of the annual selenium load is released during the spring runoff period (Figure 8-7). In the spring, the proportion of water and selenium mass load entering Pole Canyon Creek and the alluvial system is much greater than the proportion reporting to the Wells Formation. This shift reflects the fixed capacity of the unsaturated Wells Formation to accept recharge along the canyon floor.

The relatively consistent water level and selenium concentration in the Wells Formation at GW-16, immediately downstream of the Pole Canyon overburden disposal area, reflects seasonal water storage in the unsaturated portion of the Wells Formation. Water from different time periods mixes within the unsaturated zone and continues to drain from the unsaturated zone to the underlying aquifer over the fall and winter as flows in Pole Canyon Creek and the alluvial system diminish. The moderation of flow within the unsaturated portion of the Wells Formation results in a relatively uniform flow and concentration of selenium being delivered to the Wells Formation aquifer.

Selenium leaving the Pole Canyon overburden disposal area in the alluvial system joins the larger Sage Valley alluvial aquifer.

The downstream end of the Pole Canyon overburden disposal area is adjacent to the West Sage Valley Branch Fault. Selenium leaving the Pole Canyon overburden disposal area in the Wells Formation moves to the south along the West Sage Valley Branch Fault. The damage zone along the western side of the West Sage Valley Branch Fault provides a conduit to Hoopes Spring.

The West Sage Valley Branch Fault also provides a barrier to flow between the valley fill alluvial system and the Wells Formation aquifer.

D Panel

Similar to the A Panel, the D Panel source area is comprised of a pit-backfill area and an external overburden disposal area. Most of the infiltration in this area is estimated to occur through the pit backfill. The total estimated volume of infiltration through the pit backfill is substantially increased by run-on from adjacent areas. The D Panel overburden disposal areas are generally expected to be free draining, however, portions of the pit are floored by the lower permeability Phosphoria Formation. In these areas infiltration to the underlying Wells Formation may be retarded, creating locally saturated areas at the base of the pit. Approximately 150 to 300 feet of unsaturated Wells Formation is present below the D Panel overburden disposal areas.

Both the pit backfill and the external overburden disposal areas have seepage that flows laterally along the base of the overburden and discharges at the edge of the overburden disposal area. Flow rates and selenium concentrations at these seeps are variable. Selenium concentrations in the seeps range from less than 1 mg/L to almost 4 mg/L. As shown on Figure 8-2, selenium transport may be attenuated along the seep flow path.

Infiltration water entering the Wells Formation from the base of the overburden disposal areas or from surface seeps migrates through the unsaturated zone and enters the Wells Formation aquifer. Although no groundwater data are available in the immediate vicinity of the D Panel overburden disposal areas, it is expected that selenium concentrations in the Wells Formation aquifer would be locally elevated. Selenium entering the Wells Formation aquifer at the D Panel area would be available for further transport in the Wells Formation. Groundwater in the Wells Formation under the D Panel flows east toward the West Sage Valley Branch Fault and then south to Hoopes Spring.

E Panel

The E Panel source area is comprised of pit backfill and external overburden disposal areas. The E Panel area is still actively mined and represents the most recently placed overburden. Roughly two-thirds of the E Panel pit is still open and is subject to direct infiltration of precipitation. The external overburden disposal area overlies moderately steep slopes and covers several minor drainages. The pit backfill and external overburden disposal area footprints are roughly the same size, and the footprint of the external overburden disposal area is similar to the Pole Canyon overburden disposal area. The E Panel overlies roughly 200 to 300 feet of unsaturated Wells Formation. However, some portions of the pit may be floored by the lower permeability Phosphoria Formation.

As with the other overburden disposal areas, the E Panel overburden is generally thought to be free-draining. Several seeps are present along the base of the E Panel external overburden disposal area. These seeps are coincident with the underlying drainages, and their combined

annual flows represent roughly half of the estimated annual infiltration to the external overburden disposal area. Flow and selenium concentrations vary substantially between E Panel seeps. Seasonal variation can also be observed for individual E Panel seeps. Selenium concentrations in E Panel seeps ranged from less than detection (less than 0.001 mg/L) to over 13 mg/L. Data collected along the seepage flow path indicates that attenuation of selenium transport is occurring through the mechanisms depicted in Figure 8-2.

Water entering the Wells Formation below the E Panel overburden disposal area, or along the seep flow path, can migrate through the unsaturated zone and discharge to the Wells Formation aquifer. Shallow Wells Formation monitoring well GW-18 is approximately one-quarter mile away from the E-Panel in a downgradient direction. Selenium concentrations measured in well GW-18 are consistent with upgradient areas. Selenium entering the Wells Formation aquifer at the E Panel area would be available for further transport within the system. Wells Formation groundwater flows east and southeast from the E Panel area toward Hoopes Spring and South Fork Sage Creek springs.

11.1.2.2 Site-Wide Transport

Table 8-4 identifies the pathways for Site-wide selenium transport. Selenium locally released to the Sage Valley alluvial and Wells Formation groundwater flow systems is available for further transport by groundwater flow. Discharge of groundwater from those systems to springs and streams provides a pathway for further Site-wide transport.

<u>Shallow Groundwater System</u>

The Sage Valley alluvial groundwater flow system is isolated from the Wells Formation by the West Sage Valley Branch Fault that runs north and south along the western flank of Sage Valley. In essence, the valley alluvial system has the configuration of a large basin, with flow contributions coming primarily from tributaries along the west side of the valley (Figure 8-9). As the water moves down the valley, outflows from the system are limited to evapotranspiration and discharge to Sage Creek.

A substantial selenium load is transported to the Sage Valley alluvial groundwater system from the Pole Canyon overburden disposal area. Water transporting dissolved selenium released from the Pole Canyon overburden disposal area enters the Sage Valley alluvial system either as inflow from the alluvial unit at the mouth of Pole Canyon or through continued loss of water from Pole Canyon Creek as it flows onto the valley floor.

Decreasing selenium concentrations in Pole Canyon Creek along the valley floor indicate that attenuation of selenium is occurring along the creek flow path. Decreasing groundwater concentrations with distance down-valley reflect dilution of Pole Canyon Creek waters within the

aquifer and most likely additional attenuation. The valley's wet meadow environment is conducive to selenium attenuation.

Selenium that continues to move down-valley within the alluvial groundwater flow system may eventually discharge to Sage Creek. Gain-loss surveys for Sage Creek conducted in May and October 2003 identified several stream segments where discharge from the valley alluvial aquifer to Sage Creek was occurring (Figures 8-11 and 8-12). However, no increase in the Sage Creek selenium load could be attributed to discharging alluvial groundwater. This is likely due to continued attenuation and dilution of the selenium loads originating at Pole Canyon and the relatively small amount of groundwater discharge occurring in the gaining reaches.

Wells Formation

Groundwater flow in the upper Wells Formation aquifer, below the Site overburden disposal areas, is controlled by the combined effects of the West Sage Valley Branch Fault and the large discharge zone created by Hoopes Spring and South Fork Sage Creek springs (Figure 8-10). Together, these springs discharge in excess of 10 cubic feet per second, which comprises the majority of flow in lower Sage Creek under all flow conditions.

The selenium load entering the Wells Formation aquifer below the Pole Canyon overburden disposal area moves east to the West Sage Valley Branch Fault and then south towards Hoopes Spring along the relatively narrow damage zone on the west side of the fault. The observed increase in selenium concentrations in Hoopes Spring between 1997 and 2003 could be predominantly attributed to contributions from the Pole Canyon Creek area. Selenium present at Hoopes Spring may also originate by transport from the D and E Panel areas.

Selenium loads contributed to the Wells Formation aquifer from the overburden disposal areas associated with the D and E Panels will also be subject to transport to Hoopes Spring. However, several factors beyond the length of the flow path will control the rate of selenium delivery from the source areas relative to the Pole Canyon source area. In particular, the relative volume of net infiltration and corresponding selenium flux is expected to be less from these source areas than the total volume of water and corresponding selenium mass flux leaving the Pole Canyon overburden disposal area. In addition, the thickness of the unsaturated Wells Formation in the pit backfill area is greater than it is below the Pole Canyon overburden disposal area, which will moderate the rate at which selenium enters the Wells Formation aquifer. Finally, in contrast to the Pole Canyon setting, some of the selenium load from overburden seeps associated with these areas will be attenuated at the surface along the seepage flow paths and reduce the rate of selenium transport to the Wells Formation (as shown on Figure 8-2 and detailed in Sections 8.1.5 and 8.1.7).

Currently the estimated annual selenium load discharging at Hoopes Spring is roughly half the estimated load contributed to the Wells Formation by the Pole Canyon overburden disposal area. This may be due to one or more of the following factors:

- The conservative mass balance methodologies applied overestimate the actual selenium contributions from the Pole Canyon overburden;
- Transport of selenium from Pole Canyon and other source areas to Hoopes Spring has not yet reached a steady state; and
- Attenuation of selenium along the flow paths from the source areas has reduced the mass transport to Hoopes Spring.
- Only a portion of the mass load to the Wells Formation at Pole Canyon is transported south toward Hoopes Spring.

Continued monitoring of conditions at the source areas, as well as at Hoopes Spring, will provide further insight and allow for refinement of these analyses in the EECA.

Surface Water

Surface discharge of Wells Formation water at Hoopes Spring is the primary transport pathway for selenium leaving the Site (see Figure 8-22). Water discharged at Hoopes Spring contains selenium at concentrations two to three times higher than the 0.005 mg/L selenium stream standard. Given that Hoopes Spring provides the majority of flow in lower Sage Creek under all flow conditions, exceedances of the standard persist downstream until further dilution from South Fork Sage Creek reduces selenium concentrations in lower Sage Creek to less than the standard. Some portion of the Hoopes Spring selenium load appears to be attenuated in lower Sage Creek during low-flow conditions (Figure 8-17). However, on an annual basis, the majority of the selenium load is discharged to Crow Creek. The Sage Creek selenium load has little effect on selenium concentrations in Crow Creek.

11.1.3 Ecological and Human Health Risks

The findings of the ecological and human health risk evaluations (Sections 9 and 10 respectively) are briefly summarized below.

Ecological

A streamlined ecological risk evaluation was conducted using the structure established by IDEQ in the Area-Wide Risk Management Plan (Area-Wide RMP) (IDEQ, 2004). COPC

concentrations in sediment, surface water, and vegetation were compared to the risk-based removal action levels specified by IDEQ in the Area-Wide RMP. For tissue samples, COPC concentrations were compared to the exposure point concentrations (EPCs) used in the Area-Wide Human Health and Ecological Risk Assessment (Area-Wide HHERA) (TetraTech EMI, 2002) to represent relatively unaffected portions of southeast Idaho phosphate mining area. Fish tissue COPC concentrations were also compared to risk-based values from the toxicological literature. The area-wide EPCs are reflective of the exposures assumed by IDEQ in developing the Area-Wide RMP. Therefore, Site concentrations that are similar to (or less than) the area-wide EPCs represent similar risk levels and are consistent with IDEQ's guidance in the Area-Wide RMP.

The results of this ecological risk analysis are largely consistent with the conclusions of Area-Wide HHERA. Among the COPCs, risk from selenium was the most widespread and most elevated. Concentrations of other COPCs exceeded removal action levels at a limited number of locations, but usually in locations were selenium concentrations also exceeded risk criteria to a greater extent. The media that contribute most to elevated selenium exposure risks appear to be surface water and vegetation growing on overburden materials.

Some of the surface seeps and detention basins associated with the overburden disposal areas contain selenium at concentrations above the removal action levels for non-regulated surface water (0.050 mg/L for routine use and 0.201 mg/L for transitory use). Vegetation immediately adjacent to overburden seeps and detention basins may also pose limited risk.

Hoopes Spring and lower Pole Canyon Creek are the primary sources of risk to aquatic life. Selenium concentrations in surface water at both locations exceed the stream standard of 0.005 mg/L, which IDEQ has adopted as their removal action level for regulated surface water. However, over the last few years, lower Pole Canyon Creek has been dry during a large portion of the year. Hoopes Spring is also the main source of selenium downstream in lower Sage Creek. Selenium concentrations in Sage Creek, between Hoopes Spring and the confluence with Crow Creek, were slightly above the stream standard. Outside of these stream reaches, risk from selenium does not appear to be unacceptable in regulated surface water bodies. COPC concentrations in sediment exceeded removal action levels only at Pole Canyon Creek below the overburden disposal area, where a portion of the stream bed contains overburden materials.

Selenium concentrations in fish are elevated above regional EPCs only at Hoopes Spring and lower Sage Creek. These are also the only locations at which the selenium concentration in fish exceeded EPA's draft toxicity-threshold concentration of 7.9 mg/Kg DW (EPA, 2002).

Based on comparisons of vegetation selenium concentrations to removal action levels, risk to livestock from selenium in vegetation appears to be primarily restricted to sections of the

overburden disposal areas that are not fully reclaimed or were reclaimed prior to adoption of more-recent reclamation practices.

Human Health

The human health evaluation was based upon the receptors and exposure scenarios that could present elevated risks to human health, as identified in IDEQ's Area-Wide HHERA (TetraTech EMI, 2002) and the Area-Wide RMP (IDEQ, 2004) (see SI Section 10). IDEQ identified ingestion of surface soil and fish consumption at a subsistence level as the "only two exposure pathways associated with risks and hazards greater than acceptable levels." Because environmental conditions at the Site are similar to those considered in the Area-Wide HHERA and because subsistence lifestyle receptors are not present at the Site, the evaluation of potential human health risks conservatively focused on identifying areas that could present potentially unacceptable exposure scenarios. The following summarizes exposure point conditions that should be further considered in the EECA.

Groundwater

Observed and potential exceedances of the maximum contaminant levels (MCLs) for the consumption of groundwater are confined to the areas immediately below or adjacent to source areas and are limited to selenium. Substantial exceedance of the MCL for selenium (0.050 mg/L) was observed in the shallow alluvial aquifer and Wells Formation aquifer below and downgradient of the Pole Canyon overburden disposal area. Dilution within the Wells Formation appears to reduce concentrations to levels below the MCL with increasing distance from this source area. No other exceedances of the MCLs were observed for the Wells Formation. Selenium concentrations may also exceed the MCL in discrete zone(s) of the larger alluvial aquifer within the Sage Valley floor along the Pole Canyon Creek flow path. However, construction of a domestic well would not likely result in concentrations greater than the MCL (e.g., pumping from the entire screened interval of well GW-22 produced water containing 0.02 mg/L selenium).

Surface Water

Surface water features at the Site that could potentially pose a human health exposure concern (i.e., greater than drinking water standard of 0.05 mg/L selenium) are limited to Pole Canyon Creek, downstream of the Pole Canyon overburden disposal area, and a few small areas of seepage associated with the D and E Panel overburden disposal areas. These seeps do not present a likely source of drinking water for any of the receptor categories and ephemeral flow in Pole Canyon Creek downstream of the Pole Canyon overburden disposal area limits the likelihood of more than incidental exposure.

Fish

Elevated concentrations of selenium in fish tissue were identified for Hoopes Spring and lower Sage Creek (LSV-4) (3.4 to 7.3 mg/Kg WW). These values exceed the EPA screening level for subsistence exposure (2.46 mg/Kg WW), but are well below the EPA screening level for recreational exposure (20 mg/Kg WW) (EPA, 2000). The numbers and size of fish in these stream segments are limited, and sole-use subsistence is most likely not feasible.

Soil/Vegetation

According to the Area-Wide HHERA, potential human health exposure concerns could be linked to consumption of plants and incidental ingestion of soil from overburden disposal areas under sole-use subsistence scenarios. There is also the potential for exposure concerns associated with ingestion of aquatic species, such as watercress, from impacted water courses. These exposure scenarios are not currently present at the Site, and are not likely to occur on the overburden disposal areas and seeps.

11.2 Conclusions

Overall, the SI provides an adequate platform for conduct of the EECA. The SI has met the following objectives described in the Work Plan (MFG, 2002a):

- Identify and clearly define the primary sources of selenium and other COPCs released to the environment.
- Identify and describe the mechanisms for releases of selenium and other COPCs from these sources (e.g., leaching and seepage to Pole Canyon Creek).
- Characterize the current extent of transport of selenium and other COPCs from the identified sources (e.g., transport via surface flow along Pole Canyon Creek) through additional investigations of surface water, sediment, groundwater, soil and vegetation.
- Identify pathways of exposure for a range of ecological receptors and the potential for human exposure to evaluate the baseline ecological and human health risks.

Based on the SI findings, the EECA will identify and evaluate a range of removal actions to address unacceptable risks to human health and the environment.

11.2.1 Uncertainties

The data gaps identified in the SI/EECA Work Plan (MFG, 2002a) have been addressed by the SI. Although precipitation amounts during the SI were less than long-term average annual precipitation, runoff conditions were adequate to identify transport pathways and characterize the increase in COPC transport during that period. Historical data regarding flow rates and COPC concentrations during wetter periods at key locations (e.g., Pole Canyon Creek) are available to put the SI monitoring period into context.

The relative importance of each source area to selenium transport in the Site-wide surface and groundwater pathways was characterized through the SI. Although the absolute contribution of selenium cannot be defined for each source area through SI activities, the relative contributions provide an adequate basis for development of removal action alternatives to address the source areas. Ongoing routine monitoring of seeps, groundwater, and surface water at key locations will provide additional information to the EECA process regarding source area contributions.

Two pilot studies are scheduled for the summer of 2005 (NewFields, 2004c and 2004d). These studies are aimed at interim measures to reduce the potential for wildlife exposure at overburden seeps and detention ponds. The surface seep/basin will be covered with a chert cap and then vegetation from the area will be monitored to assess the effectiveness of the chert barrier.

11.2.2 Remedial Action Objectives

The Preliminary Removal Action Objectives (PRAOs) for the Site are as follows:

- Reduce risks to livestock and wildlife due to exposure to selenium in vegetation and surface soils on overburden disposal areas to acceptable levels.

- Control releases of selenium, and other COPCs, from overburden that result in exceedances of removal action levels for surface water, sediment and vegetation in regulated surface water bodies.

- Reduce risks to livestock and wildlife due to exposure to selenium in non-regulated surface water and associated vegetation and sediments to acceptable levels.

- Control releases of selenium, and other COPCs, from overburden that result in exceedances of MCLs in groundwater in the alluvial aquifer and Wells formation at the mining lease boundary.

Preliminary Remediation Goals (PRGs) will be developed based on these PRAOs for each of the source areas/exposure points and presented in the EECA.