BASELINE ECOLOGICAL RISK ASSESSMENT FOR THE STANDARD MINE SITE GUNNISON COUNTY, COLORADO

ADDENDUM

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LIST OF ACRONYMS AND ABBREVIATIONS

AUF	Area Use Factor
AWQC	Ambient Water Quality Criteria
BERA	Baseline Ecological Risk Assessment
CDOW	Colorado Department of Fish and Wildlife
COC	Chemical of Concern
COPC	Chemical of Potential Concern
DF	Dietary Fraction
EcoSSL	Ecological Soil Screening Level
EPC	Exposure Point Concentration
GLWQI	Great Lakes Water Quality Initiatives
HQ	Hazard Quotient
LOAEL	Lowest Observed Adverse Effect Level
MHRW	Moderately Hard Constituted Water
NOAEL	No Observed Adverse Effect Level
PEC	Probable Effect Concentration
RBA	Relative Bioavailability
RBP	Rapid Bioassessment Protocol
TEC	Threshold Effect Concentration
TRV	Toxicity Reference Value
UCL	Upper Confidence Limit
USEPA	United States Environmental Protection Agency

EXECUTIVE SUMMARY

PURPOSE OF THIS DOCUMENT

This document is an addendum to the Baseline Ecological Risk Assessment (BERA) for the Standard Mine Site, located in Gunnison County, Colorado. The purpose of this document is to utilize new data that have been collected at the site since the time the BERA was completed in order to help evaluate if cleanup activities that EPA has performed at the site have resulted in improved ecological conditions, and to provide an updated evaluation of the potential risks to ecological receptors posed by residual site-related environmental contamination. This information, along with other relevant information, is used by risk managers to decide whether additional remedial actions are needed to protect the environment from site-related releases.

SUMMARY OF PREVIOUS FINDINGS FROM THE BERA

Risks to Aquatic Receptors from Surface Water

Three lines of evidence (HQ calculations, fish toxicity tests and fish population studies) were evaluated to assess the potential effects of contaminated surface water on aquatic receptors. Based on these three lines of evidence, the BERA concluded that a) mining-related releases from Standard Mine into surface water are substantially toxic to fish in Elk Creek, and b) water discharged from Elk Creek into Coal Creek elevates concentrations of metals in Coal Creek but this appears to have only minimal to moderate toxicity on fish.

Risks to Aquatic Receptors from Sediment

Four lines of evidence (HQ calculations for sediment, HQ calculations for sediment porewater, benthic toxicity tests, and benthic population surveys) were evaluated to assess the potential effects of contaminated sediments on benthic macroinvertebrates. Based on these multiple lines of evidence, the BERA concluded that sediments in Elk Creek are likely to have significant adverse effects on benthic organisms residing in the sediment, especially in the upper reaches of Elk Creek, but that hazards are lower and of lesser concern in Coal Creek.

Risks to Plants and Soil Invertebrates from Soil

One line of evidence (the HQ approach) was available for evaluation of risks to plants and soil invertebrates from contaminated soil. Based on this approach, it was concluded that most metals in soil were likely to be above a level of concern to plants and/or soil invertebrates. However, the BERA noted that this conclusion is uncertain because of uncertainty in the toxicity values. In addition, data on background concentrations were too limited to draw firm conclusions as to whether some metals might be at background levels or not.

Risks to Wildlife Receptors

The BERA evaluated risks to a range of birds and mammals based on exposure from three pathways: 1) ingestion of contaminated food items, 2) incidental ingestion of soil or sediment while feeding, and 3) ingestion of on-site surface waters. Only one line of evidence (the HQ approach) was available for assessment of risks to birds and mammals from these pathways. Many receptors had no significant HQ exceedences, indicating that risk to these receptors from site-related contaminants was likely to be minimal. However, some receptors (mainly those with an assumed high soil intake) were found to have HQ values in a range of potential concern. The BERA noted that these conclusions regarding risks to birds and mammals should interpreted with caution, since calculations of exposure require a number of assumptions and approximations, and toxicity data were limited for many of the receptor types included in the assessment.

EPA RESPONSE ACTIONS AND DATA COLLECTION SINCE THE BERA

EPA has been working at the site to reduce the impact of mine waste on the environment. The following response actions have been completed since the time of the BERA:

- dewatering the on-site tailings pond
- channelization of influent surface water to pass around on-site wastes
- removal of 50,000 cubic yards of tailings and waste rock
- removal of railroad trestle
- removal of ore bins
- construction of pilot scale passive treatment bioreactor for adit water
- installation of sediment controls along Elk Creek
- restoration and realignment of Elk Creek
- re-vegetation of areas impacted by cleanup activities

EPA has also continued to collect data at the site to help evaluate whether the response actions have been effective in reducing environmental impacts of the site and to provide an improved basis for evaluating ecological risks under current site conditions. The new data span 3 additional years (2007, 2008 and 2009), and include new data of three main types:

- Concentrations of site-related contaminants in abiotic media (on-site soil, background soil, surface water, sediment, and sediment porewater)
- Fish and benthic organism population survey data
- Surface water and sediment toxicity tests

These new data have been used to help evaluate if environmental conditions for ecological receptors at the site are improving, and to derive updated risk estimates for ecological receptors, as described below.

UPDATED RISK EVALUATION FOR AQUATIC RECEPTORS

Risks from Contaminants in Surface Water

HQ Approach

HQ values in Elk Creek have been tending to decrease somewhat over time at most stations. No consistent time pattern for Coal Creek was detected. However, all HQ values for Elk Creek remain well above 1.0, and many values remain above 1.0 in Coal Creek. Panels A and B of Table ES-1 contains a summary of the primary chemicals of concern (COCs) based on the HQ evaluation. COCs are contaminants that have a high frequency and/or magnitude of HQ values above 1.0

Site-Specific Surface Water Toxicity Testing

Toxicity tests using rainbow trout fry as the test organisms indicate that risk of mortality is decreasing at most Elk Creek stations. In downstream stations in Elk Creek (Elk-05 and Elk00), water from 2006 and 2007 was highly toxic to fish, while water from 2008 and 2009 showed a consistent pattern toward decreased toxicity. In 2009, stations as high upstream as Elk-08 had statistically similar mortality to the reference location. These findings support the conclusion that surface water in Elk Creek was highly toxic to fish in previous years, but current surface water conditions at Elk-08 and below are supportive of life.

Toxicity test results for fish exposed to water from Coal Creek immediately downstream of the confluence with Elk Creek (Coal-15) show low mortality, and this level of mortality is not different from that observed in Coal Creek just upstream of Elk Creek (Coal-20). This suggests that waters from Elk Creek do not pose a risk to surface water receptors in Coal Creek.

Site-Specific Surveys of Fish Populations

Fish population surveys conducted each fall in 2006 through 2009 indicate the following:

- At any one station where data are available for more than one year, values vary substantially. Thus, the data are not considered to be sufficient to draw conclusions with regard to time trends in fish population statistics.

- For Elk Creek, some fish are present at the mouth of the creek (Elk-00), but none are present at stations further upstream (Elk-01 and Elk-08). The fish sampled at Elk-00 are probably immigrants from Coal Creek. Fish have not been detected at upstream stations

on Elk Creek, but this may be due to two 4 foot high waterfalls that may limit upstream movement of fish, limited stream flow in upper reaches during low flow periods, and cold water temperature.

- Fish density and biomass in Coal Creek appear to be slightly greater below the confluence with Elk Creek as compared to upstream of Elk Creek. This suggests that fish in Coal Creek are not impacted by releases from Elk Creek.

Habitat

In the fall of 2009, an extensive evaluation of Elk Creek habitat was performed to assess the quantity and quality of aquatic habitat on Elk Creek in order to determine how suitable the stream is to support a trout population (USEPA 2009a). The main findings of this evaluation include the following:

- The first 200-300 feet of Elk Creek currently supports a brook trout fishery.
- The lower reaches of Elk Creek (downstream of ~Elk-06) have similar characteristics to reference streams, but colder water temperatures and small stream size will likely limit growth and reproduction of brook trout but they would likely persist at low numbers.
- Reaches upstream of Elk-01 do not have suitable habitat to support a Colorado River cutthroat trout (CRCT) fishery. Using a logistic regression model, there is only a 5% probability of reaches above Elk-01 supporting a high number of brook trout, a 37% probability of supporting a low number of brook trout, and a 58% probability of not supporting brook trout at all.
- Upstream movement of fish above Elk-00 is limited because of the presence of two 4 foot high waterfalls approximately 600 ft upstream from the confluence of Elk and Coal Creeks. This results in limited genetic exchange and therefore long-term persistence of a CRCT or brook trout population is unlikely.

Overall Weight of Evidence Evaluation for Surface Water

Taken together, the weight of evidence supports the conclusion that mining-related releases from Standard Mine are less toxic to fish in Elk Creek than in the past, especially in the lower reaches. Given the proper habitat, fish could survive in the lower reaches of Elk Creek.

For fish in Coal Creek below the confluence with Elk Creek, the weight of evidence indicates that water discharged from Elk Creek into Coal Creek elevates concentrations of metals in Coal Creek but is not likely to be toxic to fish.

Risks from Contaminants in Sediment

HQ Approach Based on Bulk Sediment

HQ values for sediment have not demonstrated a significant downward trend at most Elk Creek stations, although some improvement was detected at the station nearest the mine (Elk-10). This indicates that sediment concentrations are slower to improve in comparison to surface water. HQ values based on bulk sediment remain above a level of concern at all locations in Elk Creek. No significant changes in Coal Creek have been detected. Panels A and B of Table ES-1 contains a summary of the primary COCs based on the HQ evaluation.

HQ Approach Based on Sediment Porewater

Sediment porewater samples are available from 2006, 2008, and 2009. Although three data points are not sufficient to draw firm conclusions, it appears that there is a general tendency toward slightly decreasing porewater concentrations for both cadmium and zinc at all Elk Creek stations located below the mine. However, HQ values remain above 1.0 for both chemicals, indicating that risks to benthic organisms may still be of concern. Panel A of Table ES-1 contains a summary of the primary COCs based on the HQ evaluation.

For sediment porewater from Coal Creek, the data do not show any consistent time trend patterns. Panel B of Table ES-1 contains a summary of the primary COCs based on the HQ evaluation.

Site-Specific Sediment Toxicity Tests

Benthic toxicity tests using sediments from Elk Creek have not revealed any clear time trends toward decreased risk. Statistically significant increases in mortality were seen for all locations tested in all years, with mortality rates ranging from 61%-100%. These findings support the conclusion that sediments in Elk Creek are toxic to benthic organisms and that improvement is slow.

Similarly, toxicity test results for sediments from Coal Creek do not show any clear time trends. Values are similar to background locations and do not reveal any statistically significant differences in toxicity.

Site-Specific Benthic Community Surveys

Benthic population data are available for 2006, 2007, 2008, and 2009. The data at any one station are quite variable over time, making detection of time trends difficult. Spatial patterns indicate that benthic communities at stations in Elk Creek closest to the mine are most impacted, and the status of the benthic community tends to improve at stations further from the mine. The

available data suggest there has been a time trend toward improved sediment conditions, which is most apparent in the middle reaches of Elk Creek (Elk-06 and Elk-08).

For Coal Creek, spatial patterns are not as clear as in Elk Creek. In general, no clear differences are detected between Coal Creek just below the confluence with Elk Creek and a reference station on Coal Creek above Elk Creek, suggesting that discharge from Elk Creek is having no substantial effect on benthic organisms in Coal Creek. Changes in benthic community further downstream may be related to changes in habitat and/or to sources other than Standard Mine.

Biological Condition Score and Habitat Quality

When comparing benthic community metrices between stations, it is important to recognize that differences may result from differences in habitat as well as differences in chemical contamination level. The EPA has developed a standardized approach for performing this habitat adjustment. In this approach, a number of alternative metrices of benthic community status are combined to yield the Biological Condition Score, and a number of metrices of community status are combined to derive the Habitat Quality Score. Both the Biological Condition Score and the Habitat Quality Score are then expressed as a percentage of corresponding scores from a suitable reference station.

Habitat Quality Scores and Biological Condition Scores are available for multiple stations on Elk Creek and Coal Creek for 2006, 2007, 2008, and 2009. The data are variable, but biological condition scores appear to be improving at some Elk Creek stations. In general, both Biological Condition and Habitat Quality scores are lower for the upper reaches of Elk Creek than for the lower reaches, or for Coal Creek.

Overall Weight of Evidence Evaluation for Sediment

Four different lines of evidence are available to support an evaluation of risks to benthic organisms in Elk Creek and Coal Creek:

1. HQ values based on bulk sediment
2. HQ values based on porewater measurements
3. sediment toxicity tests
4. benthic community surveys.

Taken together, the weight of evidence supports the conclusion that sediments in Elk Creek are slowly improving, but are likely to remain toxic to benthic organisms residing in the sediment. For Coal Creek, hazards from sediment are lower and not likely to be of significant concern.

UPDATED RISK EVALUATION FOR PLANTS AND SOIL INVERTEBRATES

As noted above, EPA has performed a number of response actions at the site that have decreased the amount of mine waste that is present. These actions have reduced concentrations of mining-related contaminants in the soils of the remediated areas, especially in the main area of the mine (Level 1). However, the distribution of soil concentrations of a number of chemicals remain higher than are observed in a nearby area selected to represent background, and HQ values remain above 1.0 in many locations. For other chemicals, the HQ exceedences in site soil were very similar to that for background soil, suggesting that these chemicals may not be attributable to mining-related releases. Panel C of Table ES-1 contains a summary of the primary COCs based on the HQ evaluation. As discussed in the BERA, these HQ results indicate that risks to plants and soil organisms may be of concern, but additional studies would be needed to determine if significant effects are actually occurring.

UPDATED RISK EVALUATION FOR BIRDS AND MAMMALS

Birds and mammals that reside on or near the Standard Mine site may be exposed by three pathways: 1) ingestion of contaminated food items, 2) incidental ingestion of soil or sediment while feeding, and 3) ingestion of on-site surface waters.

Based on the findings of the BERA, in most cases, the majority of exposure and risk is derived from ingestion of soil or from ingestion of food items that have taken up contaminants from soil, and exposure from water is generally minor. Because the site-wide distributions of soil concentrations have changed little since the time of the BERA, HQ-based estimates of exposure and risk to birds and mammals have also changed little. As noted earlier, the BERA found that risks to many receptors were low, although there may be risks to receptors with a high intake of soil (American robin, northern flicker, meadow vole, masked shrew, and deer mouse). These findings are still valid based on an evaluation of current site conditions, however, some risk may be attributable to background conditions because LOAEL-based HQ values for background at are or above onsite. Panel C of Table ES-1 contains a summary of the primary COCs based on the HQ evaluation.

OVERALL CONCLUSIONS

Based on the findings summarized above, the main conclusions of this Risk Addendum are as follows:

- Actions taken by EPA at the Standard Mine Superfund Site have been effective in decreasing risks to fish in Elk Creek. The lower reaches of the stream are presently occupied by fish, but the upper reaches are not. This may be the result of waterfalls that block upstream migration, flow of the stream, and water temperature.

- Sediment quality in Elk Creek appears to be improving only slowly, and risks to benthic macroinvertebrates in Elk Creek remain above a level of concern, especially at upstream stations closest to the site**.**
- Removal actions taken by EPA have decreased the level of mine waste contamination in localized areas, and this has decreased predicted risk to plants and soil invertebrates in these areas. However, the distribution of soil concentrations of a number of chemicals remain higher than background, and HQ values remain above 1.0 in many locations. These HQ results indicate that risks to plants and soil organisms may be of concern, but additional studies would be needed to determine if significant effects are actually occurring.

1.0 INTRODUCTION

1.1 Purpose of This Document

This document is an addendum to the Baseline Ecological Risk Assessment (BERA) for the Standard Mine site, which is located in Gunnison County, CO (USEPA 2008a). The purpose of this document is to utilize new data that have been collected at the site since the time the BERA was completed in order to help evaluate if cleanup activities that EPA has performed at the site have resulted in improved ecological conditions, and to provide an updated evaluation of the potential risks to ecological receptors posed by residual site-related environmental contamination. This information, along with other relevant information, is used by risk managers to decide whether additional remedial actions are needed to protect the environment from site-related releases.

The methods used to evaluate risks in this addendum are in accordance with current United States Environmental Protection Agency (USEPA) guidance for ecological risk assessments (USEPA 1992, 1997, 1998). All receptors, chemicals of potential concern, toxicity values, and methods for estimating exposure and risk are the same as those that were used in the BERA (USEPA 2008a).

1.2 Document Organization

In addition to this introduction, this report is organized into the following main sections.

Section 2 - Summary of the findings and conclusions from the previous BERA.

Section 3 - Summary of the new data that were collected at the site to support an updated evaluation of risks.

Section 4 - Ecological risk characterization for aquatic receptors of concern.

Section 5 - Ecological risk characterization for terrestrial plants and soil organisms.

Section 6 - Ecological risk characterization for birds and mammals.

Section 7 - Citations for all data, methods, studies, and reports utilized in the risk assessment addendum.

2.0 SUMMARY OF PREVIOUS RISK FINDINGS

In 2008, EPA issued a BERA (USEPA 2008a) in order to characterize risks to a variety of ecological receptors from mine-related contaminants. Data from the site were available through 2006. Risks were evaluated for aquatic receptors exposed to mining-related contaminants in surface water and sediment, and risks were evaluated for plants, invertebrates, birds and mammals exposed to mining-related contaminants in on-site soils, surface water, sediment, and food web items. The main findings are summarized below.

2.1 Risk Evaluation for Aquatic Receptors

2.1.1 Evaluation of Risks to Aquatic Receptors from Surface Water

Three lines of evidence were evaluated to assess the potential effects of contaminated surface water on aquatic receptors.

- The HQ approach identified numerous chemicals (cadmium, copper, lead, manganese and zinc) that yielded HQ values in a range of potential concern. Highest values were observed in Elk Creek. For Coal Creek immediately downstream of the confluence with Elk Creek, HQ values were lower than in Elk Creek, but several chemicals continued to be above a level of concern for acute and/or chronic exposures.

- Site specific surface water toxicity tests performed using rainbow trout fry showed high mortality (60-100%) for waters collected from Elk Creek. The highest mortality (100%) was observed at the upstream stations closest to the mine, and there was tendency for a slight reduction in mortality with increasing distance from Standard Mine. Fish exposed to water from Coal Creek immediately downstream of the confluence with Elk Creek showed low mortality, and this level of mortality was not different than observed in Coal Creek just upstream of Elk Creek. This suggests that waters from Elk Creek are sufficiently diluted by Coal Creek that site-related contaminants have only a minimal impact the survival of fish in Coal Creek.

- Fish surveys performed along Elk Creek indicate that some fish are present at the mouth of the creek (likely immigrants from Coal Creek), but that there are no fish present at stations above the mouth. This observation supports the conclusion that water in Elk Creek is toxic to fish. Fish density, biomass, and size (length, weight, and condition) appear to be generally similar in Coal Creek above and below the confluence with Elk Creek. This suggests that fish in Coal Creek are not strongly impacted by releases from Elk Creek.

Based on these three lines of evidence, the weight of evidence conclusions regarding risks to aquatic receptors from contaminants in surface water are as follows:

- Mining-related releases from Standard Mine into surface water are substantially toxic to fish in Elk Creek.

- Water discharged from Elk Creek into Coal Creek elevates concentrations of metals in Coal Creek but this appears to have only minimal to moderate toxicity on fish.

2.1.2 Evaluation of Risks to Aquatic Receptors from Sediment

Four lines of evidence were evaluated to assess the potential effects of contaminated sediments on benthic macroinvertebrates.

- An HQ approach based on measurements of metals in bulk sediment in Elk Creek identified a number of chemicals with HQ values in a range of concern, including cadmium, copper, lead, silver and zinc. For Coal Creek immediately downstream of the confluence with Elk Creek, HQ values were lower than in Elk Creek, but a number of chemicals had HQ values that remained in a range of concern.

- An HQ approach based on measurements of metals in sediment pore water in Elk Creek identified a number of chemicals with HQ values in a range of concern, especially cadmium and zinc. In Coal Creek just downstream of the confluence with Elk Creek, porewater-based HQ values remained elevated for most chemicals, but the magnitude of the exceedences was generally low.

- Site-specific sediment toxicity tests using a small freshwater crustacean (*Hyalella azteca)* revealed very high (98-100%) mortality for all Elk Creek locations tested. Toxicity test results for Coal Creek immediately downstream of the confluence with Elk Creek showed low mortality that was similar to that seen in Coal Creek upstream of Elk Creek, suggesting that sediments from Elk Creek are not having a clear effect on benthic invertebrates in Coal Creek.

- Benthic macroinvertebrates surveys performed by EPA in 2005 and 2006 reveal decreased density and diversity of organisms in Elk Creek compared to a reference station, especially in the upper reaches of Elk Creek just below the mine. When the benthic community data are adjusted for habitat factors, observations in Elk Creek below the mine indicate that the benthic communities are of lower quality than expected based on habitat factors alone, indicating a probable effect of water and/or sediment contamination from Standard Mine. For Coal Creek, the results suggest a slight impairment to the benthic community, but less than in Elk Creek.

Based on these multiple lines of evidence, it is concluded that sediments in Elk Creek are likely to have significant adverse effects on benthic organisms residing in the sediment, but that hazards are lower and of lesser concern in Coal Creek.

2.2 Risk Evaluation for Plants and Soil Invertebrates

EPA collected an extensive set of soil samples from the Standard Mine site, and these samples were used to assess risks to plants and soil invertebrates using the HQ approach. Site-specific toxicity tests and community surveys are not available.

Based on the HQ approach, every metal measured in soil except silver yielded at least one HQ value above 1 for plants and/or soil invertebrates, with an exceedence frequency above 10% for aluminum, antimony, arsenic, chromium, copper, lead, manganese, mercury, selenium, vanadium, and zinc. Some of these chemicals may not be higher than background, but the data on background levels are too limited to support any firm conclusions.

These predictions of risk to plants and soil invertebrates must be interpreted with caution, for two reasons. First, data on the concentrations of metals in soil that cause toxicity to plants and soil invertebrates are usually based on laboratory studies in which soluble forms of test metals are added to test soils. Thus, these values do not account for occurrence of metals in mineral forms that are largely insoluble and do not contribute as much toxicity as soluble forms. Second, because only one line of evidence is available, other lines of evidence (site-specific toxicity tests and/or community surveys) would be needed to further clarify the actual risks from site-related contaminants to plants and soil invertebrates.

2.3 Risk Evaluation for Wildlife Receptors

Risk to birds and mammals that reside on or near the Standard Mine site was evaluated based on exposure from three pathways: 1) ingestion of contaminated food items, 2) incidental ingestion of soil or sediment while feeding, and 3) ingestion of on-site surface waters. Only one line of evidence (the HQ approach) was available for assessment of risks to birds and mammals from these pathways. This approach was used to assess risks to a number of different receptors, each selected to represent a feeding guild that might occur at the site. This included:

Feeding Guild	Representative Avian Species	Representative Mammalian Species
Aerial and/or Terrestrial Insectivores	Cliff Swallow Northern Flicker	Big Brown Bat Masked Shrew
Aquatic Insectivores	American Dipper	--
Herbivores	Greater-Sage Grouse	Mule Deer Meadow Vole
Omnivores	American Robin	Deer Mouse
Piscivores	Belted Kingfisher	--
Carnivores	Red-tailed Hawk	Red Fox Lynx

As noted above, EPA collected an extensive data set for on-site soils and surface water, and also collected and analyzed a number of samples of plants, benthic invertebrates and fish for use in estimating dietary exposure of various receptors. Data on contaminant levels in tissues were not collected for soil invertebrates or small mammals, so tissue concentrations for these food categories were estimated using mathematical models.

In this case, two different types of HQ values were calculated. The first type is based on the No-Observed-Adverse-Effect-Level (NOAEL), which is an estimate of the highest daily dose of a chemical that may be ingested without any unacceptable adverse effect occurring. The second type is based on the Lowest-Observed-Adverse-Effect-Level (LOAEL), which is an estimate of the lowest ingested daily dose that is likely to result in an observable adverse effect.

Many receptors (cliff swallow, dipper, sage grouse, kingfisher, red-tailed hawk, mule deer, fox, lynx, and bat) had no significant HQ exceedences based on either the NOAEL- or LOAEL-based TRV. This indicated that risk to these receptors from site-related contaminants was likely to be minimal. There are five receptors (American robin, northern flicker, meadow vole, masked shrew, and deer mouse) that had NOAEL-based HQ values above 1 for multiple chemicals (aluminum, antimony, arsenic, barium, cadmium, chromium, copper, lead, manganese, nickel, selenium, and/or zinc). These elevated HQ values were attributed to intake of contaminants in soil and/or diet, with no significant contribution from surface water. In most cases (arsenic, barium, cadmium, chromium, copper, manganese, nickel, and selenium), LOAEL-based HQ values did not exceed 1. These results indicate that the magnitude and/or severity of any adverse effects from these chemicals was likely to be low to moderate. However, risks from aluminum, antimony, lead and possibly zinc were possibly significant for one or more of these five receptors.

These conclusions regarding risks to birds and mammals should be interpreted with caution, since calculations of exposure require a number of assumptions and approximations, and toxicity data were limited for many of the receptor types included in the assessment. In particular, HQ values could have been overestimated for receptors with a high intake of soil and/or a high dietary intake of terrestrial invertebrates (e.g., robin, flicker, shrew, and mouse), since conservative assumptions were employed in estimating intake and absorption from these pathways. In addition, because only one line of evidence was available, other lines of evidence (site-specific toxicity tests and/or community surveys) would be needed to further clarify the actual risks from site-related contaminants to birds and mammals.

3.0 RESPONSE ACTIONS AND DATA COLLECTION SINCE THE BERA

3.1 Response Actions

EPA has been working at the site to reduce the impact of mine waste on the environment. The following response actions have been completed since the time of the BERA:

- dewatering the on-site tailings pond
- channelization of influent surface water to pass around on-site wastes
- removal of 50,000 cubic yards of tailings and waste rock
- removal of railroad trestle
- removal of ore bins
- construction of pilot scale passive treatment bioreactor for adit water
- installation of sediment controls along Elk Creek
- restoration and realignment of Elk Creek
- re-vegetation of areas impacted by cleanup activities

3.2 Supplemental Data Collection

EPA has also continued to collect data at the site to help evaluate whether the response actions have been effective in reducing environmental impacts of the site and to provide an improved basis for evaluating ecological risks under current site conditions. Table 3-1 summarizes new data that have been collected by EPA since the time of the BERA. As indicated, the new data span 3 additional years (2007, 2008 and 2009), and include new data of three main types:

- Concentrations of site-related contaminants in abiotic media (soil, surface water, sediment, and porewater)
- Fish and benthic organism population survey data
- Surface water and sediment toxicity tests

Figure 3-1 identifies the typical sampling locations for aquatic samples, and Figure 3-2 shows sampling locations for site and background soil samples.

All of the new data, along with previously collected data utilized in this addendum, are presented in Appendix A.

4.0 RISK EVALUATION FOR AQUATIC RECEPTORS

As discussed in Section 3, the BERA found that site-related contaminants may be of concern to aquatic receptors (fish and benthic macroinvertebrates) in Elk Creek and in Coal Creek downstream of the confluence with Elk Creek. Aquatic receptors living in Elk and Coal Creeks may be exposed to site-related contaminants through several potential pathways. The following exposure pathways were selected for additional quantitative evaluation in this addendum.

- Direct contact with chemicals in surface water. This pathway is applicable to fish and to benthic organisms that reside in the uppermost portion of the sediment substrate or the water column.

- Direct contact with chemicals in sediment. This pathway is most applicable to benthic invertebrate species that live within the sediment substrate.

4.1 Evaluations of Risks to Aquatic Receptors from Surface Water

4.1.1 HQ Approach

Chemicals of Potential Concern

The chemicals of potential concern for exposure of aquatic receptors (fish, benthic invertebrates) to surface water as evaluated in the BERA are aluminum, cadmium, calcium, copper, lead, manganese, nickel, silver, and zinc.

Data

Raw data for surface water samples are provided in Appendix A. Concentration values of metals in surface water may be expressed either as total recoverable or as "dissolved" (that which passes through a 0.45µm filter). There is general consensus that toxicity to aquatic receptors is dominated by the level of dissolved chemicals (Prothro 1993), since chemicals that are adsorbed onto particulate matter may be less toxic than the dissolved forms. Therefore, exposures of aquatic receptors to inorganic contaminants in surface water were evaluated using dissolved concentrations.

Toxicity Assessment

Toxicity benchmark values for the protection of aquatic life from direct contact with chemicals in surface water are available from several sources, including the State of Colorado Table Value Standards, National Ambient Water Quality Criteria (AWQC), Great Lakes Water Quality Initiatives (GRWQI), and USEPA Region IV. Each of the sources evaluated in deriving surface water toxicity benchmarks is described in Appendix B. This appendix also describes the

hierarchy used to identify the most relevant and reliable toxicity benchmark value when more than one value was available. For chemicals where the acute and chronic benchmarks were hardness-dependent, toxicity benchmarks were calculated for each sample based on the hardness of that sample. The acute and chronic toxicity benchmark values selected for use in this assessment are shown in Table 4-1. For convenience, Table 4-2 shows the concentrations of several metals that correspond to HQ values of 1.0 at varying harnesses.

Exposure Assessment

For aquatic receptors (fish and benthic invertebrates), each sample of water or sediment may be viewed as representing an environmental exposure location in which one or more organisms may be exposed. Thus, HQ values were calculated for all available samples. In accord with USEPA guidance, non-detects were evaluated at one-half the detection limit.

Time Trends in HQ

Because toxicity depends on both concentration and hardness, and because both concentration and hardness have been tending to change over time, time trends in risk to aquatic receptors are best evaluated in terms of the time trend in HQ values, since this incorporates the effects of both changes.

Detailed calculations are presented in Appendix D. Results for two of the primary risk drivers (cadmium and zinc) are shown in Figure 4-1 for Elk Creek, and results for Coal Creek are shown in Figure 4-2. Statistical significance (p values) for time trends in HQ values is shown below:

Elk Creek

Chemical	Elk-29	Elk-10	Elk-08	Elk-06	Elk-05	Elk-00
Cadmium	0.16	0.0020	0.010	0.055	0.062	0.0060
Zinc	0.11	0.0030	0.011	0.040	0.048	0.0050

Coal Creek

Chemical	Coal-15	Coal-12	Coal-opp1	Coal-10	Coal-06	Coal-05	Coal-02	Coal-01	Coal-00
Cadmium	0.400	0.015	0.13	0.44	0.27	0.47	0.17	0.33	0.30
Zinc	0.46	0.058	0.12	0.35	0.21	0.45	0.25	0.32	0.31

As seen, for Elk Creek stations below Standard Mine (Elk-10 to Elk-00), there are statistically significant ($p < 0.05$) downward trends in HQ values for both cadmium and zinc at most stations. For Coal Creek stations downstream of Elk Creek, most trends are not statistically significant. This is consistent with previous findings (USEPA 2008a) which indicated that contaminant in Elk Creek generally had only a minor impact on waters in Coal Creek.

Risk Characterization

Based on the most recent surface water data (2009), HQ values remain above 1.0 and greater than reference locations for several chemicals detected in Elk Creek, including cadmium, copper, lead, and zinc. Based on the magnitude and frequency of HQs greater than 1.0, cadmium, lead, and zinc are the main contaminants of concern (COC) for surface water. COCs are contaminants that have a high frequency and/or magnitude of HQ values above 1.0. In Coal Creek downstream of Elk Creek (but upstream of Keystone Mine), HQ values remain above 1.0 and greater than reference locations for cadmium and zinc. These chemicals are considered to be the COCs for Coal Creek for surface water.

4.1.2 Site-Specific Surface Water Toxicity Testing

EPA has performed surface water toxicity tests each year for the past four years using water samples collected from five locations along Elk Creek as well as two locations along Coal Creek (Coal-15 and Coal-20) and two reference locations (Splains-00 and Splains-01). All tests used rainbow trout (*Oncorhynchus mykiss*) fry as the test organisms. The toxicity test results for mortality (the average and standard deviation seen in four replicate tests) are summarized in Figure 4-3.

As seen, in 2006 and 2007, mortality in all Elk Creek stations was significantly higher than reference and control. Mortality tended to decrease in 2008 and further in 2009 in stations closest to the confluence with Coal Creek. In 2009, stations as high upstream as Elk-08 had statistically similar mortality to the reference location. However, as discussed below (see Section 4.1.2.1), the mortality data for 2009 may tend to be biased somewhat low, so these data should be interpreted cautiously. Taken together, these findings support the conclusion that surface water in Elk Creek was highly toxic to fish in previous years, but current surface water conditions at Elk-08 and below are improving and supportive of life.

Toxicity test results for fish exposed to water from Coal Creek immediately downstream of the confluence with Elk Creek (Coal-15) show low mortality, and this level of mortality is not different from that observed in Coal Creek just upstream of Elk Creek (Coal-20). This suggests that waters from Elk Creek are sufficiently diluted by Coal Creek that site-related contaminants have no impact on the survival of fish in Coal Creek.

4.1.2.1 Use of Zinc as a Marker Chemical

Elk Creek is impacted by a number of different metals from the mine site, and each of these metals may contribute to adverse effects in exposed organisms. Of the various COCs that were evaluated, zinc and cadmium contribute the highest HQs based on detected measurements. Based on surface water samples from Elk Creek below Standard Mine from 2005 to 2009, these two chemicals tend to vary in concert (correlation coefficient ≥ 0.92). Because of this, it is convenient to select just one of the contaminants to serve as an indicator of the potential risks

from all of the chemicals combined. Because zinc (but not cadmium) has been used as a positive control (by spiking laboratory water spiking with zinc) as part of the on-going Standard Mine investigations, it is most convenient to use zinc as the indicator chemical.

Figure 4-4 presents percent mortality in rainbow trout fry plotted as a function of HQ value for water collected from Elk Creek (Panel A) and the zinc laboratory water spiking studies (Panel B). Note that the x-axis (HQ, calculated using the hardness dependent-equation recommended by Colorado) (see table 4-1) is plotted on a log scale. The exposure-response curve for both the site water and spiking studies may be characterized by a log-probit curve of the following form:

$$\text{Response (\% mortality)} = \text{Bkg} + (1-\text{Bkg}) \cdot \Phi[a + b \cdot \ln(\text{HQ})]$$

where:

Bkg = Average response in control organisms
Φ = Standard normal cumulative distribution function[1]

In both panels, it is noted that the mortality dose-response curves for data collected from 2009 tend to be somewhat right shifted compared to that collected previously (2006-2008). This is most apparent in three data sets collected in 2009: a) site waters (Panel A, red squares), b) adit water diluted with water from Elk-29 (Panel A, red diamonds), and c) laboratory water spiked with zinc (Panel B, red squares). A smaller but qualitatively consistent right shift is also indicated for adit water diluted with laboratory water (Panel A, blue circles). The reason for the apparent difference between data collected in 2009 and in earlier years is unknown. One potential factor may be related to between-year differences in the size of the test organisms. Figure 4-5 presents the hardness adjusted LC50 for studies conducted by USEPA Region 8 laboratory in recent years. As seen, the data suggest that mortality tends to decrease as size (weight) of the organisms decrease, and studies in 2009 were performed using fish at the low end of the weight range. If so, this could explain the relatively small right shift in the curves for adit water diluted with laboratory water (Panel A, blue circles) and laboratory spiked with zinc (Panel B, red squares). The large right shift in 2009 site waters (Panel A, red squares) as well as the right shift in adit water diluted with Elk-29 water (Panel A, red diamonds) compared to adit water diluted with laboratory water (Panel A, blue circles) suggests that water in Elk Creek may have a higher level of some protective agent in 2009 than in previous years. Figure 4-6 presents the water quality parameters measured at Elk-29 as a function of year. Inspection of this figure does not reveal any clear changes in water quality over time that would be expected to substantially impact mortality.

[1] The value of $\Phi(z)$ ranges from 0 to 1 as the value of z ranges from $-\infty$ to $+\infty$. Values may be determined from tables provided in most statistical text books, or may be computed using a built-in function available in most modern spreadsheets.

Regardless of cause, because of the apparent shift in the sensitivity of rainbow trout fry to zinc in 2009, these data have not been used to characterize toxicity in this risk assessment. Rather, risks from zinc in both laboratory water and site water appear to be reasonably well characterized by the hardness-dependent TRV equation recommended by the State of Colorado (see Table 4-1).

4.1.3 Site-Specific Surveys of Fish Populations

The Colorado Department of Wildlife (CDOW) conducted fish population surveys each fall in 2006 through 2009. Surveys were conducted at three locations on Elk Creek (Elk-00, Elk-01, and Elk-08) and various locations along Coal Creek both above (Coal-25E) and below (Coal-15, Coal-10, Coal-05, and Coal-02) Elk Creek, and at two background locations on Splain's Gulch (SP-00, SP-01). Raw data, station information, and sampling methods are provided in Appendix E. Brook trout constituted 74% of all fish that were captured, with brown trout comprising 22%. Therefore, results presented below are not stratified by species.

Figure 4-7 presents the data on fish density (Panel A) and biomass (Panel B). Inspection of these data yields the following main conclusions:

- At any one station where data are available for more than one year, values vary substantially. For example, the data from the reference stations vary by a factor of 3-4 across the time period of interest. This is expected because fish populations may be influenced by a wide range of factors that can vary substantially from year to year, including water temperature, flow, etc. Thus, the data are not considered to be sufficient to draw conclusions with regard to time trends in fish population statistics, and comparisons between different years must be interpreted with caution.

- For Elk Creek, fish are present at the mouth of the creek (Elk-00). The reach at Elk-00 is very close to Coal Creek, and it is considered likely that fish at this location are immigrants from Coal Creek. Measurements of density and biomass are similar to some Coal Creek and reference stations. These data support the view that water in Elk Creek supports fish at the mouth. No fish have been observed in Elk Creek at stations above Elk-00 (either Elk-01 or Elk-08).

- Fish density and biomass in Coal Creek appear to be slightly greater below the confluence with Elk Creek as compared to upstream of Elk Creek. This suggests that fish in Coal Creek are not impacted by releases from Elk Creek.

- There is an apparent decrease in density and biomass in Coal Creek at stations downstream of Keystone Mine (Coal-10, Coal-05 Coal-02), although the data are too limited to draw firm conclusions about the significance or the cause of this apparent decrease.

Figure 4-8 presents data on fish size, including length, width and coefficient of condition. Because of the lack of clear time trends in density or biomass, these data are not stratified by time. The coefficient of condition is a function of the weight and length of a fish, with increasing coefficients indicating increased relative robustness or well-being of the fish (Williams 2000). Inspection of Figure 4-8 indicates the following main conclusions:

- The distributions of length and weight at reference stations and most Coal Creek stations are relatively wide, indicating the probable existence of a number of different age classes of fish, which is consistent with a naturally reproducing population. In contrast, the length and weight distribution for fish observed in the mouth of Elk Creek (Station Elk-00) is very narrow. This is consistent with the hypothesis that fish in the mouth of Elk Creek are not a reproducing population of mixed age classes, but more likely represent immigrants of a narrow age class from Coal Creek. This hypothesis is supported by Figure 4-9, which shows length distributions of fish from several alternative stations. As seen, the distribution for Elk-00 is similar to that for nearby Coal Creek stations, but not with Splain's Gulch. This is consistent with the idea that fish in Elk Creek are mainly immigrants from Coal Creek.

- In Coal Creek, the distributions of lengths, weights, and condition scores are generally similar upstream of Elk Creek (at stations Coal-25 and Coal-25E) to those in Coal Creek just downstream of Elk Creek (Coal-15 and Coal-10). This observation suggests that water from Elk Creek that enters Coal Creek does not have a substantial adverse effect on the fish in Coal Creek.

4.1.4 Elk Creek Fish Habitat Evaluation

In the fall of 2009, an extensive evaluation of Elk Creek habitat was performed to assess the quantity and quality of aquatic habitat on Elk Creek in order to determine how suitable the stream is to support a trout population (USEPA 2009a). The main findings of this evaluation include the following:

- The first 200-300 feet of Elk Creek currently supports a brook trout fishery.
- The lower reaches of Elk Creek (downstream of ~Elk-06) have similar characteristics to reference streams, but colder water temperatures and small stream size will likely limit growth and reproduction of brook trout but they would likely persist at low numbers.
- Reaches upstream of Elk-01 do not have suitable habitat to support a Colorado River cutthroat trout (CRCT) fishery. Using a "best fit" logistic regression model (Harig and Fausch, 2002), there is only a 5% probability of reaches above Elk-01 supporting a high number of CRCT, a 37% probability of supporting a low number of CRCT, and a 58% probability of not supporting CRCT at all.
- Upstream movement of fish above Elk-00 is limited because of the presence of two 4 foot high waterfalls approximately 600 ft upstream from the confluence of Elk and Coal

Creeks. This results in limited genetic exchange and therefore long-term persistence of a CRCT or brook trout population is unlikely.

4.1.5 Weight of Evidence Evaluation for Surface Water

Elk Creek

For Elk Creek, the HQ approach and site-specific surface water toxicity testing agree that water in Elk Creek was substantially toxic to fish in the past, but conditions have improved in recent years. Based on the site-specific toxicity tests performed in 2006 through 2008 (and excluding 2009), it is expected that fish could survive at upstream locations as high as Elk-06. Data from fish population studies are too variable to allow an evaluation of time trends, but the findings indicate that fish are present in Elk Creek at the mouth in similar density and biomass to some Coal Creek and reference stations. The absence of fish above this station may be related to a steep section that serves as a natural barrier to fish movement upstream and favorable habitat conditions.

> *Taken together, the weight of evidence supports the conclusion that mining-related releases from Standard Mine are less toxic to fish in Elk Creek than in the past. Given the proper habitat, fish could survive in Elk Creek.*

Coal Creek

For fish in Coal Creek below the confluence with Elk Creek, HQ values are above 1 for several chemicals, and are clearly higher than background. However, fish toxicity studies and fish surveys suggest that water in Coal Creek below the confluence with Elk Creek indicate that waters in Coal Creek below Elk Creek are not substantially toxic and are not clearly different from Coal Creek upstream of Elk Creek.

> *Taken together, the weight of evidence indicates that water discharged from Elk Creek into Coal Creek elevates concentrations of metals in Coal Creek but is likely to have only minimal, if any toxicity on fish.*

4.2 Evaluations of Risks to Aquatic Receptors from Sediment

4.2.1 HQ Approach Based on Bulk Sediment

Chemicals of Potential Concern

The chemicals of potential concern for exposure of benthic invertebrates to bulk sediment evaluated in the BERA are aluminum, arsenic, cadmium, copper, lead, manganese, silver, and zinc.

Data

Raw data for sediment samples are provided in Appendix A.

Exposure Assessment

Although concentrations of chemicals in sediment are usually not as time-variable as concentrations in surface water, concentrations do fluctuate as contaminated material is added or removed by surface water flow. In addition, there may be significant small scale variability in sediment concentrations at any specific sampling station. Therefore, exposure to sediments is usually best characterized as a distribution of individual values at a specific location. In accord with USEPA guidance, non-detects were evaluated at one-half the detection limit.

Toxicity Assessment

Toxicity benchmark values for the protection of benthic invertebrates from direct contact with sediment are available from several sources. Each of the sources evaluated in deriving sediment toxicity benchmarks is described briefly in Appendix B-2. This appendix also describes the hierarchy used to identify the most relevant and reliable toxicity benchmark value when more than one value was available. For each chemical, a threshold effect concentration (TEC) and a probable effect concentration (PEC) were identified. Sediment toxicity should be observed only rarely below the TEC and should be frequently observed above the PEC. The toxicity benchmark values selected for evaluation of risks from direct contact with sediment are shown in Table 4-3.

Time Trends in Bulk Sediment Concentration

Detailed presentations of concentration values are provided in Appendix F for all chemicals of potential concern evaluated in the BERA. Results for two of the primary risk drivers (cadmium and zinc) are shown in Figure 4-10 for Elk Creek, while results for Coal Creek are shown in Figure 4-11. For risk characterization purposes, the Probable Effect Concentration (PEC) and the Threshold Effect Concentration (TEC) values have also been included in the figures in Appendix F. The consensus-based TEC was calculated as the geometric mean of all applicable threshold effect values from the literature. The consensus-based TEC is a concentration in sediment below which toxicity is expected to occur only rarely. The consensus-based PEC was calculated as the geometric mean of all applicable probable effect values from the literature. The consensus-based PEC is a concentration in sediment above which toxicity is likely to occur in at least some benthic species. A more detailed description of the types of sediment effect metrics included in the consensus-based TEC and PEC calculations is provided in MacDonald et al. (2000). Tests of statistical significance of the time trend (p values) are presented below:

Elk Creek

Chemical	Elk-29	Elk-10	Elk-08	Elk-06	Elk-05	Elk-00
Cadmium	0.26	0.090	0.12	0.45	0.28	0.16
Zinc	0.45	0.044	0.19	0.33	0.15	0.17

Coal Creek

Chemical	Coal-15	Coal-Opp1	Coal-10
Cadmium	0.025	0.38	0.43
Zinc	0.056	0.34	0.41

As seen, the only statistically significant decrease ($p < 0.05$) in sediment concentration over time was seen in Elk Creek at Elk-10 and Coal Creek at Coal-15. This indicates that some improvement in sediment quality may be occurring close to the mine, but that sediments are slower to improve in comparison to surface water.

Risk Characterization Based on Bulk Sediment HQs

Based on the most recent sediment data (2009), concentration values remain above a level of concern based on both the PEC (blue line) and the TEC (green line) and greater than reference locations for arsenic, cadmium, copper, lead, manganese and zinc at most locations in Elk Creek. Therefore, these chemicals are considered to be the COCs for Elk Creek sediment. In Coal Creek downstream of Elk Creek but upstream of Keystone Mine, cadmium, manganese, and zinc remain above a level of concern based on both the PEC (blue line) and the TEC (green line) in most cases and greater than reference locations. Therefore, these chemicals are considered to be the COCs for Coal Creek sediment.

4.2.2 HQ Approach Based on Sediment Porewater

Adverse effects on benthic organisms from exposure to sediment are likely to be mediated primarily by chemicals that have dissolved into sediment porewater from the bulk sediment. Thus, another approach for evaluating toxicity from chemicals in sediment is to measure the concentrations in the sediment porewater and compare those concentrations to water-based toxicity values.

Chemicals of Potential Concern

Chemicals evaluated in sediment porewater are the same as evaluated in sediment (aluminum, arsenic, cadmium, calcium, copper, lead, manganese, silver, and zinc).

Data

Porewater samples were collected by EPA in 2006, 2008, and 2009 from multiple locations along Coal Creek and Elk Creek with background samples collected from Copley Lake and Splain's Gulch. Details of the sampling and analysis procedures are provided in USEPA (2006b, 2008b, 2009b). In brief, porewater samples were collected *in situ* using a push point sampling device and were analyzed for dissolved and total metals by Inductively Coupled Plasma – Mass Spectrometry (ICPMS) and Inductively Coupled Plasma – Optical Emission (ICPOE) respectively. The procedures for pore water collection using a push point sampler are included in Appendix B of USEPA (2006b, 2008b, and 2009b). Raw data for sediment porewater samples are provided in Appendix A.

Exposure Assessment

Since there may be both spatial and temporal variability in sediment porewater concentrations at any specific sampling station, exposure to benthic macroinvertebrates is usually best characterized as a distribution of concentration values at a specific location. As noted above, because toxicity to aquatic receptors from water exposure is dominated by the level of dissolved chemicals, exposures to inorganics in sediment porewater were evaluated using dissolved concentrations.

Toxicity Assessment

Toxicity benchmarks specifically for the protection of benthic invertebrates from contaminants in porewater are not generally available, so benchmarks for the protection of aquatic communities (including fish, benthic invertebrates, aquatic plants, etc.) from direct contact with chemicals in surface water were used. These are the same values presented earlier for the evaluation of risks to aquatic receptors from surface water (see Table 4-1).

Risk Characterization Based on Sediment Porewater HQs

Detailed calculations of HQ values based on exposure to sediment pore water are provided in Appendix G.

Figures 4-12 presents chronic HQ values for cadmium and zinc in sediment porewater for Elk Creek stations. Although only three data points are available, based on these data it appears that there is a general tendency toward decreasing porewater concentrations for both cadmium and zinc at all Elk Creek stations located below the mine except Elk-10. However, HQ values remain above 1.0 in 2009 for both chemicals, indicating that risks to benthic organisms may still be of concern. Based on this, cadmium and zinc are considered to be COCs for sediment in Elk Creek.

Figure 4-13 presents porewater data for cadmium and zinc at a number of stations along Coal Creek. As shown, the data do not appear to be consistent, showing an apparent downward trend at two stations and an upward trend at one station. However, HQ values remain above 1.0 in 2009 for both chemicals at one station, indicating that risks to benthic organisms may still be of concern. Because of this, cadmium and zinc are considered to be COCs for sediment in Coal Creek.

4.2.3 Site-Specific Sediment Toxicity Tests

EPA has performed a series of benthic macroinvertebrate sediment toxicity tests to determine the toxicity of sediments collected from drainages associated with the Standard Mine. The test sediments were collected in 2006 through 2009. All tests were 10-day flow-through studies, conducted as detailed in USEPA (2006c, 2008b, 2008c, 2009b). In brief, for each sediment sampling location for each time point, 4-8 replicate tests were performed using the amphipod *Hyalella azteca* (*H. azteca*), depending on the year the test was performed. The water used during testing was moderately hard reconstituted water (MHRW). Measurement endpoints assessed in the study were growth and mortality.

The toxicity test results (mean and standard deviation across replicates within a year) are summarized in Figure 4-14. Panel A presents the results for mortality, while Panel B presents results based on weight gain by surviving organisms.

For Elk Creek, increases in mortality compared to control were seen for all locations tested in all years, with mortality rates ranging from 61%-100%. No clear time-trend patterns are apparent. In general, organisms exposed to Elk Creek sediments did not gain weight, except for Elk-00. These findings support the conclusion that sediment in Elk Creek is likely to be causing significant adverse effects on survival of benthic invertebrates in these locations.

Toxicity test results for Coal Creek immediately downstream of the confluence with Elk Creek (Coal-15) show mortality (8%-27%) that is similar to that seen in Coal Creek upstream of Elk Creek (Coal-20), suggesting that sediments from Elk Creek are not having a clear effect on benthic invertebrates in Coal Creek. A comparison of the toxicity observed in Coal Creek to background locations (Splain's Gulch) does not reveal any statistically significant differences. Results based on weight gain by surviving organisms do not reveal any clear effects in Coal Creek compared to reference or control organisms.

4.2.4 Site-Specific Benthic Community Surveys

Benthic macroinvertebrates were collected from the multiple sampling locations in Elk Creek, Coal Creek, and Splain's Gulch in September 2005, July 2006, September 2006, September, 2007, September 2008, and September 2009. The raw data are presented in Appendix H, and Figures 4-15 and 4-16 summarize the results for six selected metrics of community status:

- Panel A shows the total number of different taxa that were observed (an indicator of community diversity)

- Panel B shows the total number of organisms observed (an indicator of community abundance and density). Note that the total number or organisms should be interpreted only semi-quantitatively.

- Panel C shows the fraction of all individuals observed that are from the order Ephemeroptera (mayflies). Mayflies are often adversely impacted by mining-related contamination.

- Panel D shows the EPT index, which is the percent of all organisms that are from the Orders Ephemeroptera (mayflies), Plecoptera (stoneflies), or Trichoptera (caddis flies). As above, insects in these orders are often adversely impacted by mining contamination.

- Panel E shows the fraction of the total taxa observed that are considered to be tolerant to mining pollution. A high fraction of tolerant taxa is an indication that sensitive species have been impacted.

- Panel F shows the fraction of the total individuals that are contributed by the dominant (most abundant) taxon. A high fraction for the dominant taxon is an indication of reduced diversity.

Inspection of these data indicates that, at any one station where data are available for more than one year, values of each metric may vary substantially between observations. This is expected because benthic invertebrate populations may be influenced by a wide range of factors (e.g., water temperature, water flow) that can vary substantially from year to year. Thus, detection of time trends is difficult, and comparisons of metrices between stations, especially between different years, must be done with caution. However, based on the data that are available, there appear to be some signs of improvement, as discussed below.

For Elk Creek (Figure 4-15), evaluation of spatial patterns in community metrices reveals the following:

- Taxa richness (Panel A) is lowest at Elk-10 (immediately downstream of the mine), tending to increase somewhat as distance downstream from the mine increases. At the mouth of Elk Creek (Elk-00), taxa richness is similar to (but slightly less than) that in the reference location (Splain's Gulch). Taxa richness at Elk-06 and Elk-08 show a general improvement over time.

- Abundance of benthic organisms (Panel B) is very low immediately downstream of the mine (Elk-10), with a tendency to increase somewhat as distance from the mine increases. However, the total number of benthic organisms at the mouth of Elk Creek (Elk-00) is lower than in Splain's Gulch. Abundance of benthic organisms at Elk-05, Elk-06, and Elk-08 appear to show a general improvement over time.

- The fraction of organisms that are Ephemeroptera (Panel C) or EPT (Panel D) tend to be lowest immediately downstream of the mine (Elk-10), with a tendency to increase as a function of distance downstream from the mine. This trend is not seen for the two stations in Splain's Gulch (SP-00 and SP-01), suggesting the trend is more likely to be related to chemical toxicity than to altitude.

- The percent tolerant taxa (Panel E) do not display any clear or consistent spatial pattern. However, Elk Creek Stations appear to be slightly lower than Splain's Gulch.

- The percent dominant taxon (Panel F) in Elk Creek is slightly higher than in Splain's Gulch with an increase seen as distance from the mine decreases.

For Coal Creek (Figure 4-16), spatial patterns are not as clear as in Elk Creek. In general, comparison of Coal-15 (downstream of Elk Creek) to Coal-20 (upstream of Elk Creek) does not reveal any clear and consistent difference, suggesting that discharge from Elk Creek is having no substantial effect on benthic organisms in Coal Creek. Panel B suggests there may be a trend toward declining benthic macroinvertebrate abundance at stations further below Coal-15. If so, the trend is most likely attributable to sources of contaminant release along Coal Creek (e.g., the iron fen, Keystone mine) and/or trends in habitat (see below).

4.2.5 Biological Condition Score and Habitat Quality

When comparing benthic community metrices between stations, it is important to recognize that differences may result from differences in habitat as well as differences in chemical contamination level. The EPA has developed a standardized approach for performing this habitat adjustment, referred to as the Rapid Bioassessment Protocol (RBP), as summarized in Figure 4-17 (USEPA 1989b, 1999). In this approach, a number of alternative metrices of benthic community status are combined to yield the Biological Condition Score, and a number of alternative measures of habitat quality are combined to yield the Habitat Quality Score. Raw data on habitat parameters are detailed in Appendix I, along with the calculation of the Habitat Quality Score for each station. Both the Biological Condition Score and the Habitat Quality Score are then expressed as a percentage of corresponding scores from a suitable reference station.

Figure 4-18 presents the time trends in habitat quality and biological condition score for Elk Creek. For habitat quality (Panel A), the data are too variable to draw strong conclusions, but it appears that habitat quality is largely unchanged at stations below the mine, although there may

be a trend toward improved quality at Elk-08. Biological Condition Scores (Panel B) are also variable over time, but an upward trend may be occurring at some stations. In general, both habitat quality and biological condition score tend to increase as a function of distance from the mine.

Figure 4-19 presents the time trends in habitat quality and biological condition score for Coal Creek. No clear time trends are apparent for either sediment quality (Panel A) or Biological Condition Scores (Panel B).

4.2.6 Weight of Evidence Evaluation for Sediment

Four different lines of evidence are available to support an evaluation of risks to benthic organisms in Elk Creek and Coal Creek:

1. HQ values based on bulk sediment
2. HQ values based on porewater measurements
3. Sediment toxicity tests
4. Benthic community surveys.

Both HQ-based approaches indicate that risks from sediments in Elk Creek are tending to decrease over time, but that risks still remain relatively high. HQ values are lower in Coal Creek below Elk Creek, and no clear time trends are apparent. Sediment toxicity testing supports the view that sediment toxicity is generally high in Elk Creek, but low in Coal Creek. Benthic population studies provide several indications of adverse effects on benthic organisms in Elk Creek, especially in the upper reaches just below the mine, with relatively little evidence for an effect in Coal Creek immediately below Elk Creek.

> *Taken together, the weight of evidence supports the conclusion that sediments in Elk Creek are tending to improve slowly, but are likely to remain toxic to benthic organisms residing in the sediment for some time. For Coal Creek, hazards from sediment are lower and less likely to be of significant concern.*

4.3 Uncertainty

As summarized in the BERA, there are a number of sources of uncertainty that remain in the evaluation of risks to aquatic receptors from mining-related releases from the Standard Mine site. Nevertheless, the available data for both fish and benthic macroinvertebrates are generally consistent with the conclusions based on the HQ approach and the toxicity testing approach, and add to the strength of the weight of evidence conclusions.

5.0 RISK EVALUATION FOR PLANTS AND SOIL ORGANISMS

This section provides an updated evaluation of risks for terrestrial plant and soil organisms living in soils which are potentially impacted by remaining contaminants from the Standard Mine site based on current soil conditions.

Only one line of evidence (the HQ approach) is available for assessment of these two classes of receptors. The available data and the assessment findings based on this line of evidence are presented below. As noted in section 3, this evaluation will be an expansion of the BERA in that a background dataset is now available and an additional site samples are will provide a revised onsite dataset.

5.1 Chemicals of Potential Concern

Chemicals of potential concern to plants and soil invertebrates that were evaluated in the BERA are summarized below:

Plants		Soil Invertebrates	
Aluminum	Lead	Arsenic	Lead
Antimony	Manganese	Barium	Manganese
Arsenic	Mercury	Chromium	Mercury
Barium	Selenium	Copper	Zinc
Cadmium	Silver		
Chromium	Thallium		
Cobalt	Vanadium		
Copper	Zinc		

5.2 Exposure Assessment

Because plants are sessile and most soil invertebrates are not highly mobile, exposures were calculated on a sample-by-sample basis, rather than on average concentrations over some larger area. In accord with USEPA guidance, non-detects were evaluated at one-half the detection limit.

As noted above, EPA has performed a number of cleanup actions at the site in order to reduce the amount of mine waste present at the site. In July, 2009, EPA collected 58 new soil samples from Levels 1, 2, and 3 of the Standard Mine site to help characterize the post-cleanup soil conditions. The locations of these samples are shown by the yellow circles in Figure 3-2. In addition, 20 soil samples were collected from several locations with the upper Elk Basin that are uphill of any mining influences and which are intended to characterize local background conditions (Figure 3-2, blue circles).

For the purposes of evaluating exposure of plants and soil invertebrates at the site, the new data collected in 2009 were combined with data points from 2006, if the data point was not altered by any of EPA's response actions. These remaining (unaltered) data points from 2006 are shown by green circles in Figure 3-2.

5.3 Toxicity Assessment

Toxicity benchmarks for the protection of terrestrial receptors (plants and soil organisms) from chemicals in surface soils are available from several sources. Each of the sources evaluated in deriving soil toxicity benchmarks is described briefly in Appendix B-3, along with a hierarchy for identifying the most relevant and reliable benchmark value when more than one value is available. The toxicity benchmarks for all chemicals of potential concern (COPCs) in soil are shown in Table B-3 of Appendix B, and the values are summarized in Table 5-1.

5.4 Time Trends

Figure 5-1 compares the site-wide soil data sets used in the BERA to the site-wide data sets used in this addendum for three example chemicals in soil (cadmium, lead, and zinc). Appendix J contains a similar comparison for other COPCs. Inspection of Figure 5-1 indicates that EPA cleanup actions have clearly reduced the high end of the soil distribution for all three of these chemicals in Level 1 of the site (where most of the response actions occurred). Effects for Levels 2 and 3 are less clear.

5.5 Risk Characterization

The detailed calculations of HQ values are presented in Appendix K (plants) and in Appendix L (soil organisms). The results are presented graphically as scatter plots of the calculated HQ values for soils at the mine site. As was done in the BERA, the distribution of HQ values represents the entire site (including areas outside of the visibly disturbed areas), without stratification by level of remediation status.

Plants

Table 5-2 presents a summary of the frequency and magnitude of HQ values exceeding 1 for plants growing in on-site soils as well as for background soil samples. Figure 5-2 provides examples of the distribution of HQ values for cadmium and zinc. These data are interpreted semi-quantitatively. Based on this approach, inspection of Table 5-2 and the figures in Appendix K indicate the following main conclusions for risks to plants:

- A number of chemicals, including aluminum, arsenic, chromium, copper, lead, manganese, selenium, thallium, vanadium, and zinc have a high frequency and/or magnitude of HQ exceedences in on-site soils. In some cases (e.g., aluminum, vanadium)

the HQ exceedences in site soil were very similar to that for background soil, suggesting that these chemicals may not be attributable to mining-related releases. For several other chemicals (e.g., chromium, manganese, selenium, zinc), there was a similar frequency of HQ values above 1 for background soils as for site soils, but the magnitude of the HQ exceedences in background soil tended to be lower. This suggests that some of the predicted toxicity of metals in soil can be attributed to background, but that risks have increased due to mining-related releases. Therefore, based on a HQ evaluation, the main COCs in soil for plants are arsenic, chromium, copper, lead, manganese, selenium, thallium, and zinc.

- Antimony, barium, cadmium, cobalt, and mercury all have a relatively low frequency and magnitude of HQ exceedences, suggesting that these chemicals are likely to be minor sources of toxicity to plants, at least compared to the other COPCs evaluated. None of these chemicals had HQs greater than 1 in background samples.

Soil Invertebrates

Table 5-3 presents a summary of the frequency and magnitude of HQ values exceeding 1 for soil invertebrates living in on-site soils, as well as for the background soil samples. Figure 5-3 provides examples of the distribution of HQ values for lead and zinc. Inspection of Table 5-3 and the figures in Appendix L indicate the following main conclusions for risks to soil invertebrates:

- Chemicals with a high frequency and/or magnitude of HQ exceedences in on-site soils include arsenic, chromium, copper, lead, manganese, selenium and zinc. HQ exceedences in background samples also occurred in a high magnitude and/or frequency for chromium, manganese, and zinc. This suggests that some of the toxicity can be attributed to background conditions. Therefore, based on a HQ evaluation, the main COCs for invertebrates in soil are arsenic, chromium, copper, lead, manganese, mercury, selenium, and zinc.

- Barium has only a low frequency and/or magnitude of HQ exceedences, suggesting that it is likely to be minor sources of toxicity to plants, at least compared to the other COPCs evaluated. Barium did not have any HQ exceedences in background samples.

5.5 Uncertainties

The BERA identified two main sources of uncertainty in the evaluation of risks to plants and soil invertebrates. The first was the lack of a representative background soil dataset for comparison to onsite soils. This uncertainty no longer exists because of the new background soil data set collected by EPA in 2009. It provides a well-planned systematic representation of the site as well as background, and the number of samples collected is sufficient to characterize the

distribution concentration values with good certainty.

The second source of uncertainty was the lack of reliability of soil benchmarks. For reasons discussed in the BERA, this remains a source of uncertainty. As a result, confidence in the soil benchmark values and hence in the HQ values remains low.

6.0 RISK EVALUATION FOR BIRDS AND MAMMALS

This section presents an evaluation of the risks to avian and mammalian wildlife populations that reside within the vicinity of the Standard Mine site. Only one line of evidence (the HQ approach) is available for assessment of these two classes of receptors. The available data and the assessment findings based on this line of evidence are presented below.

6.1 Selection of Representative Indicator Species

Wildlife receptors that may be exposed at the site include a wide variety of mammals and birds that include a number of different feeding guilds. However, it is neither feasible nor necessary to evaluate exposures and risks for each avian and mammalian species potentially present at the site. Rather, specific wildlife species may serve as surrogates (representative species) for the purpose of estimating exposure and risk to a group of species with similar behavior, dietary preferences, and feeding habits. Selection criteria for wildlife surrogate species included trophic level, feeding habits, and the availability of life history information. The species identified as surrogate species at this site include:

Feeding Guild	Avian Surrogate	Mammalian Surrogate
Aerial and/or Terrestrial Insectivores	Cliff Swallow Northern Flicker	Big Brown Bat Masked Shrew
Aquatic Insectivores	American Dipper	--
Herbivores	Greater-Sage Grouse	Mule Deer Meadow Vole
Omnivores	American Robin	Deer Mouse
Piscivores	Belted Kingfisher	--
Carnivores	Red-tailed Hawk	Red Fox Lynx

6.2 Chemicals of Potential Concern

Chemicals of potential concern to birds and wildlife that were identified in the BERA have been re-evaluated using data collected in 2009 when available. The COPCs are summarized below:

COPCs for Birds and Mammals	
Aluminum	Lead
Antimony	Manganese
Arsenic	Mercury
Barium	Nickel
Beryllium	Selenium
Cadmium	Thallium
Chromium	Vanadium
Cobalt	Zinc
Copper	

6.3 HQ Equation

The basic equation used for calculation of an HQ value for exposure of a wildlife receptor to a chemical by ingestion of an environmental medium (soil, dietary prey item) is:

$$HQ_{i,j,r} = \frac{C_{i,j} \times (IR_{j,r} / BW_r) \times DF_{j,r}}{oTRV_{i,r} / RBA_{i,j,r}} \cdot AUF_r$$

where:

$HQ_{i,j,r}$	=	HQ for exposure of receptor "r" to chemical "i" in medium "j"
$C_{i,j}$	=	Concentration of chemical "i" in medium "j" (e.g., mg/kg)
$IR_{j,r}$	=	Intake rate of medium "j" by receptor "r" (e.g., kg/day)
BW_r	=	Body weight of receptor "r" (kg)
$DF_{j,r}$	=	Dietary fraction of medium "j" by receptor "r"
$RBA_{i,j,r}$	=	Relative bioavailability of chemical "i" in medium "j" by receptor "r"
$oTRV_{i,r}$	=	Oral toxicity reference value for chemical "i" in receptor "r" (mg/kg-d)
AUF_r	=	Area use factor for receptor "r"

Because all receptors are exposed to more than one environmental medium, the total hazard quotient (total HQ) to a receptor from a specific chemical is calculated as the sum of HQs across all media.

6.4 Exposure Factors

Exposure parameters and dietary intake factors for each surrogate wildlife receptor were derived from the Wildlife Exposure Factors Handbook (USEPA, 1993), as well as a variety of other sources. The exposure parameter data evaluated for each wildlife receptor are detailed in Appendix M, and the values selected are summarized in Table 6-1. Wildlife exposure factors were selected to represent average year-round adult exposures. In some cases, no quantitative

data could be located, so professional judgment was used in selecting exposure parameters.

For receptors with home range sizes larger than the area of the site (33 Ha), the AUF was calculated as the ratio of the area of the site divided by the home range area of the receptor. For receptors with home range sizes smaller than the area of the site, the AUF was assumed to be 1.0. The relative bioavailability (RBA) for all chemicals in all media (including soil) was assumed to be 100%. This assumption is likely to be conservative for the soil exposure pathway, since metals in soils at mining sites often exist in poorly absorbable forms, which tends to decrease the amount of chemical absorbed into the body from an ingested dose of soil.

6.5 Exposure Point Concentrations for Soil

When exposure occurs over a geographic area, risk from a chemical is related to the arithmetic mean concentration averaged over the entire exposure area. Since the true arithmetic mean concentration cannot be calculated with certainty from a limited number of measurements, the USEPA recommends that the upper 95th percentile confidence limit (UCL) of the arithmetic mean of the chemical concentrations be used as the Exposure Point Concentration (EPC) (USEPA, 1992). If the 95% UCL exceeded the highest detected concentration, then the highest detected concentration is used as the EPC (USEPA 1989a). The approach for computing the 95% UCL of a data set depends on a number of factors, including the number of data points available, the shape of the distribution of the concentrations, and the degree of censoring (USEPA 2002). In accord with current USEPA guidance (USEPA 2002), UCL values were derived using ProUCL v4.0, a software system developed by the USEPA Technical Support Center. This software calculates UCL values for a data set using several different strategies and recommends which UCL is considered preferable based on the properties of the data set. When calculating the UCL, concentrations reported as non-detects (U-qualified by the laboratory) were evaluated by assuming a concentration value equal to one-half the detection limit (USEPA 1989a). Rejected (R-qualified) data were not used when calculating an EPC.

The data set for soil was described previous in Section 5.2. In brief, 195 data points are available from a systematic investigation of the site and 20 data points are available for comparison to background. Table 6-2 provides a summary of the EPCs for soil used for wildlife.

6.6 Estimating Dietary Tissue Concentrations

Table 6-2 provides a summary of the EPCs for the concentration of COPCs in the tissues of various types of biotic food items at the site and at reference locations. The derivation of these values is discussed below.

<u>Plants</u>

Two composite samples of plant tissue were collected from on-site locations (Elk-29 and SM-

00), and two from a reference location (SP-01) in 2006, in accord with the methods described in USEPA (2006b). Plants were selected based on food sources identified for the blue grouse. Composite samples typically included aspen leaves, dandelions, clover, and vetch at SM-00; and vetch, strawberries, aspen leaves, dandelions, clover, and elderberries from SP-01. The raw data are presented in Appendix A. In accord with ProUCL guidance, because there were fewer than four samples in each category, no attempt was made to compute a UCL, and the EPC was taken to be the maximum detected concentration.

Benthic Invertebrates and Fish

No samples of benthic invertebrates or fish have been collected from Elk Creek within the boundaries of the Standard Mine site. For this reason, samples from Elk Creek below the mine are used to estimate concentrations that might occur in organisms collected from on-site locations. For benthic invertebrates, two samples are available from 2006 (collected at Elk-00 and Elk-05). For fish, three samples are available, all collected from Elk-00 in 2006. Use of these samples to estimate concentrations in on-site aquatic prey items may tend to underestimate true concentrations, but use of measured data is considered to be preferable to use of values derived using default mathematical uptake models.

Samples are also available from reference locations. For benthic invertebrates, this includes three samples from COP-01, SP-00 and SP-01 from 2006, and for fish, this includes three samples all from SP-01 from 2006.

The raw data are presented in Appendix A. As above, because there were fewer than four samples in each category, no attempt was made to compute a UCL, and the EPC was taken to be the maximum detected concentration.

Soil Invertebrates and Small Mammals

Tissue samples from soil invertebrates and small mammals are not available at this site. Therefore, tissue concentrations for these organisms were estimated using soil-to-tissue bioaccumulation models located in the literature, as described in Appendix C. In cases where no uptake model could be located for a chemical, it was conservatively assumed that the uptake of that chemical was equal to the highest available uptake factor for other chemicals for that food item.

6.7 Toxicity Assessment

Two types of oral toxicity values are used in this assessment. The first type is based on the No-Observed-Adverse-Effect-Level (NOAEL), which is an estimate of the highest daily dose of a chemical that may be ingested without any unacceptable adverse effect occurring. The second type is based on the Lowest-Observed-Adverse-Effect-Level (LOAEL), which is an estimate of

the lowest ingested daily dose that is likely to result in an observable adverse effect. If an HQ is below 1 based on the NOAEL TRV, it is believed that risks are minimal. If the HQ is above 1 based on the LOAEL TRV, it is considered likely that some adverse effects will occur. If the HQ is above 1 based on the NOAEL and below 1 based on the LOAEL, it is considered that adverse effects are possible, but they are likely to be minor in extent and/or severity.

The basis for the NOAEL-based and LOAEL-based TRVs selected for use in this assessment are presented in Appendix B, and the results are summarized in Table 6-3.

6.8 Risk Characterization

Appendix N provides the detailed HQ calculations for each wildlife receptor for each chemical of potential concern from each exposure medium. Table 6-4 summarizes the results. If both NOAEL-based and LOAEL-based TRVs are available for a chemical, Table 6-4 shows the range between the two. If only one type of TRV is available, only that HQ is shown. Inspection of this table reveals the following main observations:

- For a number of receptors (cliff swallow, American dipper, greater sage grouse, belted king fisher, red-tailed hawk, mule deer, red fox, Canada lynx, and big brown bat), on-site risks appear to be below a level of concern based on both NOAEL- and LOAEL-based TRVs. These results suggest that risks to these receptors are very unlikely to be of significant ecological concern.

- There are five receptors (American robin, northern flicker, meadow vole, masked shrew, and deer mouse) that have NOAEL-based HQ values above 1 for multiple chemicals (aluminum, antimony, arsenic, cadmium, chromium, copper, lead, manganese, nickel, and/or zinc). These elevated HQ values are attributable to intake of contaminants in soil and/or diet, with no significant contribution from surface water (see Appendix N). Only aluminum and lead have LOAEL-based HQ values that exceed 1. In addition, LOAEL-based HQ values for background are at or above onsite. These results indicate that the magnitude and/or severity of any adverse effects from these chemicals is likely to be low to moderate due to site contamination. However, risks from aluminum, antimony, cadmium, lead and possibly zinc may be significant for one or more of these five receptors.

These results suggest that intake of some metals from soil or the diet may be of concern to several species. However, it should be remembered that risks from ingestion of contaminants in soil are likely to be overestimated because of the assumption of RBA values of 1.0, and that risks from ingestion of soil invertebrates is likely to be overestimated because the concentration of contaminants in the tissues of these organisms is estimated by mathematical uptake models rather than actual measurement. Thus, HQ values for these five receptors should be recognized as uncertain, and are more likely to be high than low.

6.9 Uncertainties

The BERA identified several sources of uncertainty in estimating the risk to wildlife receptors. As above, one of the important uncertainties was the lack of a representative background soil dataset for comparison to onsite soils. This uncertainty has been diminished because of the background soil data collected by EPA in 2009. The remaining sources of uncertainty described in the BERA still exist. These include exposure from the diet, uptake from ingested soil, and reliability of wildlife TRVs.

7.0 REFERENCES

Aughey, E, L Grant, BL Furman, WF Dryden. 1977. The Effects of Oral Zinc Supplementation in a Mouse. Journal of Comparative Pathology. 87:1-14.

Brown, MM, BC Rhyne, and RA Goyer. 1976. Intercellular Effects of Chronic Arsenic Administration on Renal Proximal Tubule Cells. Journal of Toxicology and Environmental Health. 1: 153-157.

Cain, BW and EA Pafford. 1981. Effects of Dietary Nickel on Survival and Growth of Mallard Ducklings. Archives of Environmental Contamination Toxicology. 10:737-745.

Cain, BW, L Sileo, JC Franson, and J Moore. 1983. Effects of Dietary Cadmium on Mallard Ducklings. Environmental Research. 32:286-297.

CDPHE. 2007. Colorado Department of Health and Environment, Water Quality Control Commission Regulations. Regulation No. 31. The Basic Standards and Methodologies for Surface Water (5 CCR 1002-31). http://www.cdphe.state.co.us/regulations/wqccregs/
Colburn T. 1982. Measurements of low levels of molybdenum in the environment using aquatic insects. Bull. Environ. Contam. Toxicol. 29:422-428.

Colburn T. 1986. The use of the stonefly *Pteronarcys californica* Newport as a measure of biologically active cadmium in a high altitude river system, Colorado, USA. Water Quality Bulletin 11:141-147.

Colorado Division of Wildlife (CDOW). 2006. Email communication from Nicole Vieira to Dan Wall on 5/17/06.

Domingo, JL, JL Paternain, JM Llobet and others. 1985. Effects of Cobalt on Postnatal Development and Late Gestation in Rats Upon Oral Administration. Rev. Esp. Fisiol. 41:293-298.

Downs WL, Scott JK, Steadman LT, Maynard EA. 1960. Acute and sub-acute toxicity studies of thallium compounds. American Industrial Hygiene Association Journal. 21:399-406.

Edens, FW and JD Garlich. 1983. Lead-Induced Egg Production Decrease in Leghorn and Japanese Quail Hens. Poultry Science. 62: 1757-1763.

Edens, FW, E Benton, SJ Bursian, and GW Morgan. 1976. Effect of Dietary Lead on Reproductive Performance in Japanese Quail, Coturnix japonica. Toxicology and Applied Pharmacology. 38:370-314.

Efroymson, R.A., M.E. Will, G.W. Suter II, and A.C. Wooten. 1997a. *Toxicological Benchmarks for Screening Contaminants of Potential Concern for Effects on Terrestrial Plants:*

1997 Revision. Prepared for the U.S. Department of Energy, Office of Environmental Management by Lockheed Martin Energy Systems, Inc. managing the Oak Ridge National Laboratory (ORNL). ORNL publication. ES/ER/TM-85/R3, November 1997.

Efroymson, R.A., M.E. Will and G.W. Suter II. 1997b. *Toxicological Benchmarks for Contaminants of Potential Concern for Effects on Soil and Litter Invertebrates and Heterotrophic Process:* 1997 Revision. Prepared for the U.S. Department of Energy, Office of Environmental Management by Lockheed Martin Energy Systems, Inc. managing the Oak Ridge National Laboratory (ORNL). ORNL publication. ES/ER/TM-126/R2, November 1997.

Engineering Field Activity West. 1998. Development of Toxicity Reference Values for Conducting Ecological Risk Assessment at Naval Facilities in California, Interim Final. EFA West, Naval Facilities Engineering Command. United States Navy. San Bruno, CA. September 1998.

Fuyuta M, T Fujimoto, S Hirata. 1978. Embryotoxic Effects of Methylmercuric Chloride Administered to Mice and Rats During Organogenesis. Teratology. 18:353-366.

Gasaway, WC and IO Buss. 1972. Zinc Toxicity in the Mallard Duck. Journal of Wildlife Management. 36(4)1107-1117.

Gray, LE Jr. and JW Laskey. 1980. Multivariate Analysis of the Effects of Manganese on the Reproductive Physiology and Behavior of the Male House Mouse. Journal of Toxicology and Environmental Health. 6:861-867.

Harig, A.L. and K.D. Fausch, 2002. Ecological Applications. Volume 12, No. 2.pp. 535-551.

Harr, JR, JF Bone, IJ Tinsley, PH Weswig, and RS Yamamoto. 1966. Selenium Toxicity in Rats. Symposium: Selenium in Biomedicine, 1st International Symposium. Oregon State University.

Hebert, CD, MR Elwell, GS Travlos, CJ Fitz, and JR Bucher. 1993. Subchronic Toxicity of Cupric Sulfate Administered in Drinking Water and Feed to Rats and Mice. Fundamental and Applied Toxicology. 21(461-475).

Heinz, GH and LN Locke. 1976. Brain Lesions in Mallard Ducklings from Parents Fed Methylmercury. Avian Diseases. 20:9-17.

Heinz, GH. 1974. Effects of Low Dietary Levels of Methylmercury on Mallard Reproduction. Bulletin of Environmental Contamination and Toxicology. 11: 386-392.

Heinz, GH. 1975. Effects of Methylmercury on Approach and Avoidance Behavior of Mallard Ducklings. Bulletin of Environmental Contamination and Toxicology. 13: 554-564.

Heinz, GH. 1976. Methylmercury: Second-Year Feeding Effects on Mallard Reproduction and Duckling Behavior. Journal of Wildlife Management. 40:82-90.

Heinz, GH. 1979. Methylmercury: Reproductive and Behavioral Effects of Three Generations of Mallard Ducks. Journal of Wildlife Management. 43:394-401.
Heinz, GH, DJ Hoffman, and LG Gold. 1989. Impaired Reproduction of Mallards Fed and Organic Form of Selenium. Journal of Wildlife Management. 53(2):418-428.

Ingersoll, CG, MacDonald, DD, RS Carr, FD Calder, ER Long. 1996. Development and Evaluation of Sediment Quality Guidelines for Florida Coastal Waters. *Ecotoxicology* 5:253-278.

Jensen, DW and DV Maurice. 1978. Effect of Methionine on Copper-Induced Growth Depression and Gizzard Erosion. Poultry Science. 57: 1530-1532.

Khera, KS and SA Tabacova. 1973. Effects of Methylmercuric Chloride on the Progeny of Mice and Rats Treated Before or During Gestation. Food and Cosmetics Toxicology. 11(2):245-254.

Krasovskii, GN and SA Fridyland. 1979. Experimental Data for the Validation of the Maximum Permissible Concentration of Cobalt in Water Bodies. Hyg. Sanit. 36:277-279.

Laskey, JW, GL Rehnberg, JF Hein, SC Laws, and FW Edens. 1985. Assessment of the Male Reproductive System in the Pre-weanling Rat Following Mn3O4 Exposure. Journal of Toxicology and Environmental Health. 15:339-350.

Long, ER and LG Morgan. 1990. *The Potential for Biological Effects of Sediment-Sorbed Contaminants Tested in the National Status and Trends Program*. National Oceanic and Atmospheric Administration Publication. Technical Memorandum NOS OMA 52. March 1990.

MacDonald, DD, CG Ingersoll and TA Berger. 2000. Development and Evaluation of Consensus-Based Sediment Quality Guidelines for Freshwater Ecosystems. *Archives of Environmental Contamination and Toxicology* 39:20-31.

Mollenhauer, HH DE Corrier, DE Clark, MF Hare, and MH Elissaide. 1985. Effects of Dietary Cobalt on Testicular Structure. Virchows. Arch. B. 49:241-248.

Moran RE, Wentz DA. 1974. Effects of metal mine drainage on water quality in selected areas of Colorado. 1972-73. US Geological Survey. Colorado Water Resources Circular No 25.

Neuhauser, EF, ZV Cukic, MR Malecki, RC Loehr, PR. 1995. Bioconcentration and Biokinetics of Heavy Metals in the Earthworm. *Environmental Pollution.* 89(3): 293-301.

Norvell MJ, DA Gable, MC Thomas. 1975. Effects of Feeding High Levels of Various Copper Salts to Broiler Chickens. University of Missouri, Environmental Trace Substance Center and Extension Division. Proceedings of University of Missouri's 9th Annual Conference on Trace Substances in Environmental Health. Memorial Union, University of Missouri-Columbia, Columbia, Missouri. 457-463.

Pocino, M, L Baute and I Malave. 1991. Influence of Oral Administration of Excess Copper on the Immune Response. Fundamental and Applied Toxicology. 16:249-259.

Prothro, M. 1993. Office of Water Policy and Technical Guidance on Interpretation and Implementation of Aquatic Life Metals Criteria. Memorandum to Water Management Division Directors and Environmental Services Directors, USEPA Regions I-X. October 1, 1993.

Richardson ME and MR Spivey Fox. 1974. Dietary Cadmium and Enteropathy in the Japanese Quail. Laboratory Investigation. 31(6):722-731.

Sample, BE, DM Opresko, GW Suter II. 1996. *Toxicological Benchmarks for Wildlife: 1996 Revision.* Oak Ridge National Laboratory. Document Number ES/ER/TM-86/R3. June 1996.

Schlicker S and DH Cox. 1968. Maternal Dietary Zinc, and Development and Zinc, Iron, and Copper Content of the Rat Fetus. Journal of Nutrition. 95:287-294.

Schroeder, HA, M Kanisawa, DV Frost, and M Mitchener. 1968. Germanium, Tin, and Arsenic in Rats: Effects of Growth, Survival, and Pathological Legions and Life Span. Journal of Nutrition. 96:37-45.

Schroeder, HA and M Mitchener. 1971. Toxic Effects of Trace Elements on the Reproduction of Mice and Rats. Archives of Environmental Health. 23:102-106.

Smith, MK, EL George, JA Stober, HA Feng, and GL Kimmel. 1993. Perinatal Toxicity Associated with Nickel Chloride Exposure. Environmental Research. 61:200-211.

Stanley, TR, JW Spann, GJ Smith, and R Rosscoe. 1994. Main and Interactive Effects of Arsenic and Selenium on Mallard Reproduction and Duckling Growth and Survival. Archives of Environmental Contamination and Toxicology. 26:444-451.

United States Environmental Protection Agency (USEPA). 1989a. Risk Assessment Guidance for Superfund (RAGS). Volume I. Human Health Evaluation Manual (Part A).

United States Environmental Protection Agency (USEPA). 1989b. *Rapid Bioassessment Protocols for Use in Streams and Rivers: Benthic macroinvertebrates and Fish*. U.S. Environmental Protection Agency, Office of Water Regulations and Standards, Washington, D.C. EPA 440-4-89-001.

United States Environmental Protection Agency (USEPA). 1992. Framework for Ecological Risk Assessment. Risk Assessment Forum. EPA/630/R-92/001.

United States Environmental Protection Agency (USEPA). 1993. Wildlife Exposure Factors Handbook, Volumes 1 and II. U.S. Environmental Protection Agency. EPA/600/R-93/187a and EPA/600/R-93/187ab.

United States Environmental Protection Agency (USEPA). 1997. Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessments. Interim Final. U.S. Environmental Protection Agency, Environmental Response Team (Edison, NJ). June 5, 1997.

United States Environmental Protection Agency (USEPA). 1998. Guidelines for Ecological Risk Assessment. EPA/630/R-95/002F. April, 1998.

United States Environmental Protection Agency (USEPA). 1999. *Rapid Bioassessment Protocols for Use in Streams and Wadeable Rivers: Periphyton, Benthic Macroinvertebrates and Fish*. 2nd Edition. U.S. Environmental Protection Agency, Office of Wetlands, Oceans and Watersheds. Washington, D.C. EPA 841-99-002.

United States Environmental Protection Agency (USEPA). 2002. Calculating Upper Confidence Limits for Exposure Point Concentrations at Hazardous Waste Sites. U.S. Environmental Protection Agency, Office of Emergency and Remedial Response. OSWER 9285.6-10. December 2002.

United States Environmental Protection Agency (USEPA). 2003. Guidance for Deriving Ecological Soil Screening Levels (Eco-SSLs). Draft. Office of Solid Waste and Emergency Response. February 2003.

United States Environmental Protection Agency (USEPA). 2006a. Screening-Level Ecological Risk Assessment For The Standard Mine Site, Gunnison County, Colorado. Report prepared by USEPA Region 8 with technical support from Syracuse Research Corporation. September 29, 2006.

United States Environmental Protection Agency (USEPA). 2006b. Sampling and Analysis Plan/Quality Assurance Project Plan 2006 Sampling Events, Standard Mine, Gunnison County, Colorado. Prepared For: United States Environmental Protection Agency, Region 8 Ecosystem Protection and Remediation – Program Support by TechLaw, Inc. June 2006.

United States Environmental Protection Agency (USEPA). 2006c. Sediment Toxicity Testing Report – Standard Mine Revision A. Prepared for United States Environmental Protection Agency, Region 8 Ecosystem Protection and Remediation – Program Support Prepared by TechLaw. January 2006.

United States Environmental Protection Agency (USEPA). 2007. Ecological Soil Screening Levels (Eco-SSLs). Website. http://www.epa.gov/ecotox/ecossl/. Accessed 12/20/2007.

United States Environmental Protection Agency (USEPA). 2008a. Baseline Ecological Risk Assessment for the Standard Mine Site, Gunnison County, Colorado. Report prepared by

USEPA Region 8 with technical support from SRC, Inc.. May 19, 2008.

United States Environmental Protection Agency (USEPA). 2008b. Sampling and Analysis Plan/Quality Assurance Project Plan 2008 Sampling Events Standard Mine Site Gunnison County, Colorado. Prepared For: United States Environmental Protection Agency, Region 8, Ecosystem Protection and Remediation – Program Support. Prepared By: United States Environmental Protection Agency, Region 8 Environmental Services Assistance Team TechLaw. August 2008.

United States Environmental Protection Agency (USEPA). 2008c. Sampling and Analysis Plan/Quality Assurance Project Plan 2008 Sampling Events Standard Mine Site Gunnison County, Colorado. Prepared For: United States Environmental Protection Agency, Region 8, Ecosystem Protection and Remediation – Program Support. Prepared By: United States Environmental Protection Agency, Region 8 Environmental Services Assistance Team TechLaw. Jully 2008.

United States Environmental Protection Agency (USEPA). 2009a. Elk Creek Fish Habitat Evaluation. Prepared for: Environmental Protection Agency (EPA). Prepared By: Clay Speas Wildlife, Fish and Rare Plants Program Lead Grand Mesa, Uncompahgre and Gunnison National Forests. December 2009.

United States Environmental Protection Agency (USEPA). 2009b. Sampling and Analysis Plan/Quality Assurance Project Plan 2009 Sampling Events Standard Mine Site Gunnison County, Colorado. Prepared For: United States Environmental Protection Agency, Region 8, Ecosystem Protection and Remediation – Program Support. Prepared By: United States Environmental Protection Agency, Region 8 Environmental Services Assistance Team TechLaw. June 2009.

Webster, WS. 1988. Chronic Cadmium Exposure During Pregnancy in the Mouse: Influence of Exposure Levels on the Fetal and Maternal Uptake. Journal of Toxicology and Environmental Health. 24:183-192.

Williams J.E. 2000. The Coefficient of Condition of Fish. Chapter 13 in Schneider, James C. (ed.) 2000. Manual of Fisheries Survey Methods II: with Periodic Updates. Michigan Department of Natural Resources, Fisheries Special Report 25, Ann Arbor.

Wise, A. 1981. Protective Action of Calcium Phytate Against Acute Lead Toxicity in Mice. Bulletin of Environmental Contamination and Toxicology. 27:630-633.