DRAFT FINAL
EXPANDED ENGINEERING EVALUATION/ COST ANALYSIS (EEE/CA) FOR THE IRON MASK MINE AND MILL SITE

Engineering Services Contract Number: W9128F-04-D-0013
Delivery Order Number: 007

Prepared for:

Department of the Army
Corps of Engineers, Omaha District
1616 Capitol Ave Ste 9000
Omaha NE 68102-9000

U.S. Department of the Interior
Bureau of Land Management, Butte Field Office
106 North Parkmont
Butte, Montana 59701

Prepared by:

Pioneer Technical Services, Inc.
P. O. Box 3445
Butte, Montana 59702

May 2009

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COMMENT RESPONSES TO THE
DRAFT ENGINEERING EVALUATION/COST ANALYSIS
FOR THE IRON MASK MINE AND MILL SITE

Prepared by:
Pioneer Technical Services, Inc. (Pioneer)
May 2009

Comments by:
Bureau of Land Management (BLM)
Butte Field Office
January 2009

GENERAL COMMENTS:

Comment #1 -
Please include a glossary which includes abbreviations used.

Response to Comment #1
A glossary of acronyms has been added.

Comment #2
Please break down materials analyzed in Waste Rock Dump #1, Waste Rock Dump #2, Tailings #1, and Tailings #2 – this will help us make decisions about each piece of the reclamation.

Response to Comment #2
Comment incorporated. Table 6-3 in Section 6.3 now includes target risk reductions for each waste source.

Comment #3
Please explain why the 95% is used and how it was derived, and include the 95% as a summary row in all the data sets.

Response to Comment #3
Comment incorporated in Section 5.1.2, and in Table B-2, Appendix B.

Comment #4
Explain better why are there more tailings samples listed on the map than sampled.

Response to Comment #4
Individual samples for each waste and borrow source were consolidated for laboratory analysis.

Comment #5
Please be more specific with the use of the term "soils"- we understand it is commonly used in these reports, but it loses the significance of the differences in waste rock, tailings, background soil and general soils.

Response to Comment #5
The term "soil", as used in this report, refers to cover soil, borrow soil, and background soil. Tailings and waste rock materials are referred to as "waste material" to differentiate them as such. Exposure to soil contaminated with waste material is identified as a human and ecological exposure route as part of the risk assessment.

Comment #6
Map – what does SW mean.

Response to Comment #6
A legend has been added to the map.

Comment #7
The outline in the vicinity of Tailings 1 is confusing – what does it mean, are various levels of contaminants significant here?

Response to Comment #7
The outline of TA-1 has been redrawn to incorporate the entire tailings area based on laboratory results.

Comment #8
Please include an outline of the two dump areas.

Response to Comment #8
Comment incorporated.

Comment #9
[*Please add a reference to the BLM/MBMG Open-file Report to p. 2-1*]

Response to Comment #9
A reference to the report has been added to Section 2.1, Paragraph 3.

TECHNICAL COMMENTS:

Comment CM1
An abstract, or separate 1 page executive summary could address some of the formatting issues of including information at certain points in the main document, especially the different risk parameters and standards used for comparison.

Response to Comment CM1
Comment incorporated. An Executive Summary has been added to the beginning of the document.

<u>Comment CM2</u>
Identify need for the project and EEE/CA – discovery of site, prelim. assessment, etc.

Response to Comment CM2
Comment incorporated in Section 1.1, Paragraph 3.

<u>Comment CM4</u>
Add brief comment about veg. types – such as some representative species found on site. Add description of tree type and location – goes to review questions by IDT staff.

Response to Comment CM4
Comment incorporated in Section 2.1.1, Paragraph 2.

<u>Comment J5</u>
Joan will check status of SHPO mitigation plan with Carrie.

Response to Comment J5
Section 2.1.2 has been revised to incorporate BLM comments.

<u>Comment J6</u>
Joan will check SHPO status with Carrie.

Response to Comment J6
Section 2.1.2 has been revised to incorporate BLM comments.

<u>Comment CM7</u>
The area is "likely" closed, but not officially so until the travel management plan NEPA is done and ROD signed (I think – need to verify with Pat again), so including the ATV risk criteria is good and closure of roads is an appropriate institutional control alternative. Trailheads are planned, but not established.

Response to Comment CM7
Comment noted.

<u>Comment CM8</u>
Insert a BLM comment regarding travel planning and potential use of the area.

Response to Comment CM8
Comment incorporated in Section 2.1.3, Paragraph 1.

<u>Comment CM9</u>
It is frigid bordering cryic soil temperature regime with an ustic soil moisture regime. Small points, but go to expectations and criteria for veg. establishment in reclamation design options.

Response to Comment CM9
Comment incorporated in Section 2.1.4, Paragraph 1.

<u>Comment CM10</u>
Add comment about depth of soil in the area and briefly characterize – sets the stage for reclamation limitations and opportunities – also provides setting for background soil samples. Can include here or in the veg. section. If shallow to bedrock, it may be more appropriate in geology section.

Response to Comment CM10
Comment incorporated in Section 2.1.5.2, Paragraph 3.

<u>Comment J12</u>
Include that the stream begins within the Iron Mask adit as a seep and is hydraulically disconnected from downstream waters (Infiltrates in ~X feet downstream).

Response to Comment J12
Comment incorporated in Section 2.1.6, Paragraph 1. It should be noted that flow was fully infiltrating at the low to moderate flows encountered during the field investigation. However, it is possible that the stream is hydraulically connected to downstream waters during high-flow runoff events.

<u>Comment J14</u>
Add methodology section – here or somewhere – including explaining 95%tile, and what SPLP results mean.

Response to Comment J14
Comment incorporated. A sentence stating that positive SPLP results indicate a potential for leaching has been added to the results summaries for each of the waste sources in Section 3.0, and to the waste descriptions in Section 7.0.

A brief explanation for the use of the upper 95th percentile has been added to Section 5.1.2, Paragraph 4.

<u>Comment J15</u>
Explain the term waste rock and tailings?

Response to Comment J15
Comment incorporated in Section 3.0, Paragraph 3.

<u>Comment J16</u>

What is repository soil - tailings?

Response to Comment J16
Comment incorporated in Section 3.0, Paragraph 2. The term "Repository Soil" has been replaced with "Borrow Area Soil".

Comment J18
Why use different terms for environmental media and sample types?

Response to Comment J18
Section 3.0 has been revised to clarify the environmental media sampled during the investigations.

Comment CM19
Agree – explain better rep. soil, tailings and waste rock.

Response to Comment CM19
See comment responses for J15, J16 and J18.

Comment CM23
Do we need to explain difference between SPLP and TCLP and why SPLP is used here? Appears inconsistent with previous investigation TCLP data.

Response to Comment CM23
Comment incorporated in Section 3.0, Paragraphs 7-9.

Comment J25
Better describe Waste Rock 1 and 2 (maybe move some of section 7.0 here). The overburden is country rock andesite from the cross cut and Waste Rock 2 is mineralized vein material (include %sulfide estimates).

Response to Comment J25
Brief descriptions have been added in Section 3.2.2, Paragraph 2 (also see response to comment J15). All three waste rock dumps exhibit some level of mineralization exceeding 3X background soil values. WR1 and WR3 bear similar metals contents, while WR2 exhibits higher metals content. Results of ABA Total Lime Requirement have been added to each waste rock sample summary in order to provide a comparison of the acid generating potential of each waste rock source.

Results are included in Table B-4 (ABA) which present % Sulfur in various amounts depending on extraction procedure utilized during analysis. Total Sulfur % has been added to the ABA/SMP summary paragraph for each waste source section.

Comment CM26
Perhaps Pioneer could explain this better in an introductory paragraph at the beginning of the section. Actually, an introductory paragraph at the beginning of each section would be good to explain what the section is about?

Response to Comment CM26
Comment incorporated. Introductory paragraphs have been added to each section.

Comment CM27
Why is agronomic testing done? What is the standard-that is recommended rates to establish?? On site after reclamation?

Response to Comment CM27
Comment incorporated in Section 3.0, Paragraphs 10-11.

Comment CM29
Present in micromohls/cm to be consistent with data later in the document.

Response to Comment CM29
Conductivity for soils (Electrical Conductivity) was reported in milliSiemens per centimeter (mS/cm), while surface water conductivity (Specific Conductance) was reported in micromhos per centimeter (µmhos/cm). The units associated with each are reported as such by the laboratories.

Comment CM30
Specify size (i.e. 2mm-75mm if using USDA classification standards).

Response to Comment CM30
Comment incorporated. Grain size distributions for gravel are per ASTM standards (4.75-75mm).

Comment J31
Describe rock material as stated above.

Response to Comment J31
Comment incorporated. See response to Comment J25.

Comment J32
Does this mean it will leach?

Response to Comment J32
Yes, the presence of metals in leachate when material is subjected to the Synthetic Precipitation Leaching Procedure indicates the potential to leach.

Comment J33
Describe rock – as I recall this material was more altered/mineralized than the host andesite.

Response to Comment J33
See response to Comment J25. Also note that the metals results are briefly described in the third paragraph of each source section and included in comprehensive form in the data tables located in Appendix B, where the reader may compare waste sources relative to each other and to 3X average background soil values.

Comment CM34
Explain what this means – probably in an introductory section.

Response to Comment CM34
Comment incorporated. See also responses to Comments J32 and J14.

Comment J35
Describe material – processed rock, size, %sulfides…

Response to Comment J35
Brief descriptions have been added to Section 3.2.3, Paragraph 2.

Results are included in Table B-4 (ABA) which present % Sulfur in various amounts depending on extraction procedure utilized during analysis. Total Sulfur % has been added to the ABA/SMP summary paragraph for each waste source section.

Comment J36
Might want to be clear that these are the tailings transported into the flat.

Response to Comment J36
Comment incorporated. See response to Comment J35.

Comment J37
It would be nice to include a photo of the soils profile X-section you showed us in the field – 3" tails on top of soil.

Response to Comment J37
Comment noted, unfortunately we do not have a photo to include.

Comment J38
Explain.

Response to Comment J38
See responses to Comments CM34, J32 and J14.

Comment CM40
What is hardness?

Response to Comment CM40

Hardness is the measurement of calcium carbonate in milligrams per Liter found in the surface water samples. Section 3.2.4.1, Paragraph 2 has been revised to note this.

Comment CM41

Add narrative description, describing rationale for these analyses. In tabular format (appendix) add one line descriptions of hazards associated with these (i.e. nitrate – causes algae blooms in surface water and when present in ground water can cause ***Methemoglobinemia, a condition that robs the bloodstream of oxygen****.*

Response to Comment CM41

Section 3.0, Paragraph 4 has been revised to state that surface water analysis is performed to determine the presence of contaminants of concern, and whether they meet the DEQ-7 standards.

Descriptions of drinking water testing and potential effects of ingestion are provided in Appendix E from the Montana Department of Health and Human Services. These summaries are now referenced in Section 3.2.4.1 and Section 5.1.3.

Comment CM44

Either indicate how much these are elevated or include a general statement if the degree of elevation is addressed in risk criteria, but agree that as a person reads through the document, the expectation is for this data is needed.. Could expectations for this be laid out in an intro to the section? May relate to stand alone table of criteria which should be included in this document.

Response to Comment CM44

Because of the large amount of data, tables are provided in Appendix B to present the laboratory results and applicable comparison criteria for each sample. The criteria for each sample media is presented in conjunction with the laboratory results to allow for ease of comparison. For instance, *National Sediment Quality Survey* criteria are included directly beneath the stream sediment sample results in Table B-2 as a reference for comparison when reviewing the data. It would be extremely impractical to narrate the results of each analyte for each sample within the text. And presenting comparison criteria in tabular form within Section 3.0 is not particularly useful when the reader must refer to Appendix B for the individual sample results.

Table B-11 has been added to Appendix B to summarize all comparison criteria. All of the criteria are also tabulated separately in Section 5.0 as part of the risk assessments, where the degree of elevation and associated risk is determined.

Comment CM45

I think the methodology/process could be laid out better in an intro paragraph – i.e. Step 1, compare to background to accomplish X; Step 2, compare to criteria Y to accomplish X; Step 3, risk assessment per…., etc.

Response to Comment CM45
Comment incorporated. Section 3.0 has been revised to include basic methodology in conducting the sampling investigations at the site.

Comment CM46
Prefer to use units (%) since other parameters use units.

Response to Comment CM46
The reference to organic matter in this paragraph was intended to provide a visual description of the soil profile as encountered in the field. This reference has been deleted in favor of the organic matter (%) content reported from sampling results in Paragraph 5 of the same section. This edit was also applied to Section 3.2.5.2 (BA-2).

Comment CM47
3" is using USDA criteria.

Response to Comment CM47
Rock content as described within the text was estimated visually in the field. Sizes listed were based on the most prevalent range(s) observed in the test pits, and are intended to provide a basic idea of the amount and size of rock encountered. The fact that these estimations were made in the field has been emphasized in the paragraphs describing rock content.

Comment CM48
Is this a generic descriptor, or trying to convey cobble and stone content vs. gravel?

Response to Comment CM48
See response to Comment CM47.

Comment CM49
For BA-1 – this comment applies to the other similarly formatted paragraphs too.

Response to Comment CM49
Sentence deleted. See also response to Comment CM47.

Comment J64
Explain/reiterate that the residential scenario will most likely never happen – lands acquired by BLM for elk habitat….Also please add BLM criteria – Residential, camper, ATV.

Response to Comment J64
Comment incorporated in Section 5.1.2, Paragraph 2. Ford Camper criteria have been substituted for the previously presented Tetra Tech Recreational criteria.

Comment J65
Please explain why the routes of cont. are combined.

Response to Comment J65
The EPA combines all routes of exposure in development of Regional Screening Levels (RSLs). This is extraneous information in the context of this document and has been deleted.

Comment CM66
Assumed what? Please describe rationale for this method (i.e. removing outliers, etc)? Is this an EPA method or is it a manner to search for the most limiting condition given outliers?

Response to Comment CM66
Comment incorporated in Section 5.1.2, Paragraph 4. The term 'assumed' has been replaced with 'utilized', and an explanation for the use of the upper 95th percentile concentration has been added in Paragraph 5.

Comment J67
Explain why – is this standard EPA practice?

Response to Comment J67
See response to comment CM66.

Comment J68
Do not combine waste rock and tails – they are different materials and different areas.

Response to Comment J68
The EPA Regional Screening Levels (RSLs) and Ford Recreational criteria do not differentiate between types of waste materials. The criteria are applied wholly to all waste sources present on site, regardless of material type, in order to evaluate site-wide risk and determine the primary contaminants of concern (CoCs). Waste sources are further evaluated separately in Section 6.0 to determine the level of risk reduction required for each source, which can then be used to identify and evaluate different cleanup options.

Comment CM69
General table formatting comment: please format in a manner so that Characterization Data appears distinct in the title. The reason is that it is not apparent at first glance that some tables are criteria, HQ, or data.

Response to Comment CM69
Comment incorporated. Table headings, and the order by which the tables appear in the document, have been revised in attempt to make it easier for the reader to follow.

Comment J70
It is ok to combine wastes for the residential scenario, but please be very specific that the samples are combined because this is such an unlikely scenario. Also please be very specific what "solid Media" is – that includes waste rock and tailings.

Response to Comment J70
See response to Comment J68.

<u>Comment CM74</u>
Concur. Note what standards and why (how criteria reflect current and reasonably foreseeable possible rec. use of the area).

Response to Comment CM74
Comment incorporated in Section 5.1.2, Paragraph 3.

<u>Comment J76</u>
Please separate into Waste Rock 1, Waste Rock 2, Tailings 1, and tailings 2 as stated above recommended separating out into geographic areas – so we know how to address each area.

Response to Comment J76
See response to Comment J68.

<u>Comment J77</u>
It is confusing to use different comparison standards for waste rock and tails (e.g. like comparing apples and oranges, the comparison methods be either both in 95th or maximum #s? Or provide a detailed explanation why this difference is used and justify the small sample basis. Also it would be nice to have a column for BLM standards in this table.

Response to Comment J77
See response to Comment CM66. Note that BLM criteria have been substituted for the previously presented Tetra Tech criteria (see Table 5-2), and no longer differentiates between waste rock and tailings.

<u>Comment J78</u>
Break out wastes individually.

Response to Comment J78
See response to Comment J68.

<u>Comment CM80</u>
BLM criteria should be described here. Tetra Tech rec scenario assessment criteria can also be described. This describes in more detail the argument presented in 5.1.2.

Response to Comment CM80
An additional reference to the toxicity data cited in the Ford report has been added in Section 5.1.3, as toxicity effects due to exposures above the risk management criteria are simply referred to as "adverse health effects" by Ford. Individual ATSDR summaries published by the EPA for the nine CoCs have also been added to Appendix E.

Comment J81
Need to be clear exactly what the source of these numbers is.

Response to Comment J81
Comment incorporated.

Comment CM82
Please describe why the CoCs are a concern if they are not carcinogenic. If this requires a lot of description, a table of effects by CoC could be included in the appendix.

Response to Comment CM82
See response to Comment CM80.

Comment J83
Same comment as above – what is the exactly source of these numbers, and describe their basis, if they are federal standards describe in MUCH MORE detail where they are from and why they are used. Did you average the sources? The way this if formatted it is unclear if PRGs are a reference or if it is the contents of the table – clarify title.

Response to Comment J83
Comment incorporated. Table headings have been revised, and the locations of the tables in the document have been changed so they appear in a more direct relationship with their descriptive text.

Comment J85
Why just use Tetra Tech numbers here what happened to EPA, can we add BLM #s to this table?

Response to Comment J85
Recreational Scenario criteria are presented in Table 5-2 (formerly Table 5-4). EPA does not provide recreational criteria. Note that BLM criteria have been substituted for the previously presented Tetra Tech criteria.

Comment J88
Break out individual wastes, tailings.

Response to Comment J88
See response to Comment J68.

Comment J89
Interesting that these CoCs generally agree with the BLM standards – we should write that good comparison in somewhere.

Response to Comment J89
Comment noted. In actuality, the BLM criteria are much stricter and result in HQ values that are nearly an order of magnitude higher for many CoCs than those previously presented using Tetra Tech criteria. Note that the Tetra Tech criteria are no longer referenced within the document.

Comment CM90
Explain a little more. Excess makes it sound like the BLM is OK with the public getting some cancer from the site. What is this standard based on?

Response to Comment CM90
Comment incorporated. The standard is based on EPA criteria as explained in Section 5.1.4, Paragraph 3. The terms 'cancer' and 'excess' have been removed, and the text has been revised to emphasize these values are for residential occupation, and that the anticipated land use does not include residential occupation.

Comment J91
But should reiterate that people do not and will not live at this site, that this value was calculated for a maximum risk evaluation.

Response to Comment J91
See response to Comment CM90. It could be argued that the BLM cannot guarantee non-residential use in perpetuity, thus the reason for including the residential scenario in risk assessment.

Comment CM92
Agree. I want to see a subsection at the end of section 5 that summarizes all of the risk assessments (human, ecological, etc).

Response to Comment CM92
Comment incorporated in Section 5.3, Summary of Risk Analysis.

Comment CM93
Add BLM Big horn Sheep (Cu criteria is more limiting than for deer). Also add cattle to discussion and possibly table (note deer is more stringent, etc). Ranchers and range staff will be concerned about this.

Response to Comment CM93
Comment incorporated. Bighorn Sheep have been added to the group of receptors, and the lowest concentrations of the receptors is included in Table 5-8. Cattle have been added to the terrestrial mammal discussion in Section 5.2.3, Paragraph 4.

Comment J94
Break out by waste type, WR1, WR2, T1, T2.

Response to Comment J94

See response to Comment J68. As with the human health risk assessment, the ecological risk assessment determines risk at the site as a whole, not by individual waste source. Risk reduction requirements for individual waste sources are presented in Section 6.0.

Comment J95
Be specific about which have no ecological toxicity data.

Response to Comment J95
Comment incorporated.

Comment J96
Check…No fish present in stream – it flows only from adit to where it infiltrates in meadow below.

Response to Comment J96
See response to Comment J12. Although no fish were specifically observed during the 2008 investigation, the stream could be hydraulically connected as a tributary to downstream fisheries during high flow events.

Comment J99
Either add row with WQB-7 standards or reference Table 5-9 – although that table is benchmark concentrations not standards…

Response to Comment J99
DEQ-7 criteria are specified in Table 5-8 (formerly Table 5-9). This is a comprehensive table of criteria used for comparison to the site characterization data listed in Tables 5-6 and 5-7.

Comment J100
Separate waste rock and tailings in this review.

Response to Comment J100
See response to Comment J94.

Comment CM101
Briefly describe—do CoCs kill the animals, shorten their lives, induce cancer, pass along contaminants to hunters, or in the case of cattle, pass along contaminants to the beef consuming public?

Response to Comment CM101
General ecological toxicity information published by the EPA has been added in Appendix E. Section 5.2.3 has also been revised to direct the reader to the references for toxicity data cited within the Ford report. No specific toxicity profiles detailing the effects on species at exposure levels above the risk management criteria were included in his report; rather he simply characterized them as “adverse toxic effects”.

Comment J102
Are the criteria, standards and benchmark concentrations the same thing? If not, what does "These" refer to? Explain Benchmark Concentrations a bit more.

Response to Comment J102
Comment incorporated. For consistency, the term "benchmark" has been removed in lieu of using "criteria" to describe comparison criteria. The term "standards" applies to the DEQ-7 water quality standards established as an ARAR. Table 5-8 (formerly Table 5-9) has been re-titled as "Ecological Criteria for Contaminants of Concern", and the individual criteria are referenced within the table. Descriptions for each criteria are provided in the paragraphs directly following the table.

Comment J103
Explain the difference in WQB-7 and these values – is it hardness, if so specifically explain how you reached these values.

Response to Comment J103
The values listed in Table 5-8 are DEQ values. Several of the standards are calculated as a function of hardness. Section 5.2.3, Paragraph 2 has been clarified to state that the hardness calculation utilizes DEQ methodology.

Comment J104
Add source for each of these criteria.

Response to Comment J104
Comment incorporated.

Comment J106
Same question as above.

Response to Comment J106
See response to Comment J102.

Comment J107
Explain T50 and why it was used.

Response to Comment J107
Comment incorporated in Section 5.2.3, Paragraph 3.

Comment CM108
Add sheep and cattle.

Response to Comment CM108
Comment incorporated. See response to Comment CM93.

Comment CM109
Add a summary paragraph or two.

Response to Comment CM109
Comment incorporated in Section 5.3, Summary of Risk Analysis.

Comment CM111
Are these more stringent than BLM standards?

Response to Comment CM111
A comparison of the BLM-Camper criteria from Table 5-2 to the DEQ standards from Table 6-1 shows that the DEQ HHS-SW are more stringent. Ford refers to the EPA ambient water quality standards for use as BLM-Ecological criteria, which closely resemble the DEQ AALS when corrected for hardness.

Comment J113
Break out wastes to individual components.

Response to Comment J113
Table 6-2 lists proposed clean up goals to meet residential, recreational, and ecologic criteria for solid media. These goals (which are the same criteria used in Sections 5.1 and 5.2) apply to all solid media, and do not differentiate between waste sources.

Comment J114
Break out wastes to individual components.

Response to Comment J114
Comment incorporated. Table 6-3 lists target risk reductions necessary for each waste source to meet the clean up criteria. As shown by the table, Ecological risk reduction goals for Zinc are identical for all waste sources, and Recreational risk reduction goals for Arsenic are nearly identical, with a variance of only 6%.

Comment CM115
Yes—and by location?

Response to Comment CM115
Comment incorporated. See response to comment J114.

Comment CM116
Briefly recap problems to be solved.

Response to Comment CM116
Comment incorporated in Section 7.0, Paragraph 2.

Comment CM117
Maybe move/copy some of this into the Background section?

Response to Comment CM117
Comment incorporated in Section 3.0, Paragraph 3. See also response to Comment J25.

<u>Comment J118</u>
Would be useful to estimate a %.

Response to Comment J118
See response to Comment J25.

<u>Comment J119</u>
Leachable?

Response to Comment J119
Yes, "*which indicates a potential to leach if left untreated*" has been added to the last sentence in Section 7.0, Paragraph 5.

<u>Comment J120</u>
Explain tailings are the processed ore. They are generally uniform in size and sulfide content is ~X%, metal content…etc.…This way folks can understand the difference in waste and tails.

Response to Comment J120
See responses to Comments J25 and J15. Characterization data is described in Section 3.0.

<u>Comment J122</u>
Leachable?

Response to Comment J122
Yes, "*which indicates a potential to leach if left untreated*" has been added to the last sentence in Section 7.0, Paragraph 6.

<u>Comment J123</u>
Isn't it also based on the fact that As is so low in the water – and what could be done about that low level contaminant?

Response to Comment J123
In the case of the Iron Mask site, no reductions in surface water contamination are necessary as all contaminant concentrations are currently below criteria for acute aquatic life and recreational use. However, even if contaminants exceeded the criteria, the presumption would continue to be made that reclamation of the waste sources would effectively reduce the surface water contamination.

<u>Comment CM124</u>
Add travel restrictions specifically?

Response to Comment CM124
Comment incorporated in Section 7.1.2, Paragraph 1.

<u>Comment J125</u>
5C – tilling…

Response to Comment J125
Tilling was removed from consideration as an alternative due to the administrative difficulties involved with proving its effectiveness, and the fact it would require non-standard construction equipment be utilized at the site which would offset much of the potential cost savings.

EXECUTIVE SUMMARY

This Iron Mask Mine and Mill Site Expanded Engineering Evaluation/Cost Analysis (EEE/CA) was prepared for the U.S. Army Corps of Engineers (USACE)-Omaha District and the U.S. Department of Interior/Bureau of Land Management (BLM) by Pioneer Technical Services, Inc. (Pioneer). The primary purpose of this EEE/CA is to present analyses of reclamation alternatives for the Iron Mask Mine and Mill Site in accordance with the National Oil and Hazardous Substances Pollution Contingency Plan (NCP) and Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) responses on Public Lands (40 Code of Federal Regulations [CFR] § 300.410 b).

Waste sources, including several waste rock dumps, tailings deposits and a free-draining adit, were identified at the site during a preliminary investigation and subsequent Phase I Environmental Site Assessment conducted by BLM in 2005. Pioneer conducted a supplemental field investigation in 2008 to evaluate the mine and mill wastes at the site, and generate a database that meets the requirements necessary to complete a baseline risk assessment and detailed analysis of reclamation alternatives.

In order to assess the risks to human health and the environment, laboratory results for samples obtained during the 2008 supplemental investigation were compared to criteria published primarily by the U.S. Environmental Protection Agency (EPA) and BLM, and to water quality standards published by the Montana Department of Environmental Quality (DEQ). The human health risk assessment found that arsenic concentrations in soil are more than 40 times higher at the site than considered "safe" for recreational activities. The ecologic risk evaluation found that several contaminants evaluated at the site are likely adversely affecting ecologic receptors through exposures to soil and stream sediment.

Eight reclamation alternatives were considered, ranging from taking no further action at the site, to complete removal and consolidation of wastes into a lined on-site repository. Those alternatives were then subjected to preliminary screening with regards to effectiveness in meeting the reclamation objectives and goals. Seven of the alternatives (including the No Action Alternative) were then selected for a detailed evaluation (Section 8.0) of the following NCP criteria:

- Overall Protection of Human Health and the Environment;
- Compliance with ARARs;
- Long-Term Effectiveness and Performance;
- Reduction of Toxicity, Mobility, or Volume through Treatment;
- Short-Term Effectiveness;
- Implementability; and
- Cost.

Based on the conclusions of the comparative analysis of alternatives, Alternative 4b – Consolidation of All Waste in On-Site Repository with Cover Soil Cap is a cost effective solution that is expected to provide a high degree of protection to human health and the environment, and provide a stable location for waste materials at the Iron Mask Mine and Mill Site.

TABLE OF CONTENTS

Page

1.0 INTRODUCTION 1-1
1.1 PURPOSE AND OBJECTIVES 1-1
1.2 REPORT ORGANIZATION 1-1

2.0 BACKGROUND 2-1
2.1 CURRENT SITE SETTING 2-1
2.1.1 Vegetation/Wildlife 2-1
2.1.2 Historic or Archaeologically Significant Features 2-2
2.1.3 Land Use and Population 2-3
2.1.4 Climate 2-3
2.1.5 Geology 2-4
2.1.5.1 Regional Setting 2-4
2.1.5.2 Local Geologic Setting 2-4
2.1.6 Hydrology and Hydrogeology 2-4
2.2 MINING HISTORY 2-4

3.0 IRON MASK MINE AND MILL SITE DATA COLLECTION 3-1
3.1 PREVIOUS INVESTIGATIONS 3-3
3.2 SUPPLEMENTAL FIELD INVESTIGATION 3-3
3.2.1 Background Samples 3-4
3.2.2 Waste Rock Dumps 3-5
3.2.2.1 Iron Mask-WR1 3-5
3.2.2.2 Iron Mask-WR2 3-6
3.2.2.3 Iron Mask-WR3 3-7
3.2.3 Tailings Areas 3-7
3.2.3.1 Iron Mask-TA1 3-8
3.2.3.2 Iron Mask-TA2 3-8
3.2.4 Stream Sediment and Surface Water Sampling Results 3-9
3.2.4.1 Surface Water 3-9
3.2.4.2 Stream Sediments 3-10
3.2.5 Repository/Borrow Investigation 3-10
3.2.5.1 Iron Mask BA1 3-10
3.2.5.2 Iron Mask BA2 3-11

4.0 SUMMARY OF APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS (ARARS) 4-1

5.0 BASELINE HUMAN HEALTH AND ECOLOGICAL RISK ASSESSMENTS 5-1
5.1 HUMAN HEALTH RISK ASSESSMENTS 5-1
5.1.1 Hazard Identification 5-1
5.1.2 Exposure Scenarios 5-1
5.1.3 Toxicity Assessment 5-4
5.1.4 Risk Characterization 5-5
5.1.4.1 Residential Scenario 5-5

5.1.4.2 Recreational Scenario 5-6
5.1.5 Human Health Risk Assessment Summary 5-7
5.2 ECOLOGICAL RISK EVALUATION 5-8
5.2.1 Contaminants and Receptors of Concern 5-8
5.2.2 Exposure Assessment 5-9
5.2.2.1 Surface Water/Sediment - Aquatic Life Scenario 5-9
5.2.2.2 Terrestrial Mammals Scenario 5-9
5.2.2.3 Plant - Phytotoxicity Scenario 5-10
5.2.3 Ecological Effects Assessment 5-10
5.2.3.1 Surface Water/Sediment - Aquatic Life Scenario 5-11
5.2.3.2 Terrestrial Mammal Scenario 5-11
5.2.3.3 Plant - Phytotoxicity Scenario 5-12
5.2.4 Risk Characterization 5-12
5.3 SUMMARY OF RISK ANALYSIS 5-13

6.0 RECLAMATION OBJECTIVES AND GOALS 6-1
6.1 ARAR-BASED RECLAMATION GOALS 6-1
6.1.1 Surface Water 6-1
6.1.2 Groundwater 6-2
6.1.3 Soil 6-2
6.2 RISK-BASED CLEAN UP GOALS 6-2

7.0 DEVELOPMENT AND SCREENING OF RECLAMATION ALTERNATIVES 7-1
7.1 IDENTIFICATION OF RECLAMATION TECHNOLOGIES AND PROCESS OPTIONS 7-1
7.1.1 No Action 7-2
7.1.2 Institutional Controls 7-2
7.1.3 Engineering Controls 7-5
7.1.3.1 Containment 7-5
7.1.3.2 Surface Controls 7-5
7.1.3.3 On-Site Disposal 7-6
7.1.3.4 Off-Site Disposal 7-6
7.1.4 Excavation and Treatment 7-6
7.1.4.1 Fixation/Stabilization 7-7
7.1.4.2 Reprocessing 7-7
7.1.4.3 Physical/Chemical Treatment 7-7
7.1.4.4 Thermal Treatment 7-8
7.1.5 *In-Situ* Treatments 7-8
7.1.5.1 Physical/Chemical Treatment 7-9
7.1.5.2 Thermal Treatment 7-9
7.2 IDENTIFICATION OF RECLAMATION ALTERNATIVES 7-9
7.3 PRELIMINARY EVALUATION AND SCREENING OF ALTERNATIVES 7-11
7.3.1 Alternative 1: No Action 7-12
7.3.2 Alternative 2: Institutional Controls 7-12
7.3.3 Alternative 3a: Consolidate Waste Rock On-Site With Cover Soil Cap 7-13
7.3.4 Alternative 3b: Consolidate Waste Rock and Tailings On-Site with Cover Soil Cap 7-15

7.3.5 Alternative 4a: Consolidate WR2, WR3 and Tailings in On-Site Repository with Cover Soil Cap 7-17
7.3.6 Alternative 4b: Consolidate All Waste in On-Site Repository with Cover Soil Cap 7-19
7.3.7 Alternative 5a: Consolidate All Waste in On-Site Repository with Multi-Layered Cap 7-21
7.3.8 Alternative 5b: Consolidate All Wastes in On-Site Modified RCRA Repository 7-22
7.4 ALTERNATIVES SCREENING SUMMARY 7-24

8.0 DETAILED ANALYSIS OF ALTERNATIVES 8-1
8.1 QUANTITATIVE EVALUATION OF THRESHOLD CRITERIA 8-3
8.2 ALTERNATIVE 1: NO ACTION 8-5
8.2.1 Overall Protection of Human Health and the Environment 8-5
8.2.2 Compliance with ARARs 8-6
8.2.3 Long-Term Effectiveness and Permanence 8-6
8.2.4 Reduction of Toxicity, Mobility, or Volume Through Treatment 8-7
8.2.5 Short-Term Effectiveness 8-7
8.2.6 Implementability 8-7
8.2.7 Costs 8-7
8.3 ALTERNATIVE 3A: CONSOLIDATE WASTE ROCK ON-SITE WITH COVER SOIL CAP 8-7
8.3.1 Overall Protection of Human Health and the Environment 8-7
8.3.2 Compliance with ARARs 8-8
8.3.3 Long-Term Effectiveness and Permanence 8-8
8.3.4 Reduction of Toxicity, Mobility, or Volume Through Treatment 8-9
8.3.5 Short-Term Effectiveness 8-9
8.3.6 Implementability 8-10
8.3.7 Costs 8-10
8.4 ALTERNATIVE 3B: CONSOLIDATE WASTE ROCK AND TAILINGS ON-SITE WITH COVER SOIL CAP 8-10
8.4.1 Overall Protection of Human Health and the Environment 8-11
8.4.2 Compliance with ARARs 8-12
8.4.3 Long-Term Effectiveness and Permanence 8-12
8.4.4 Reduction of Toxicity, Mobility, or Volume Through Treatment 8-12
8.4.5 Short-Term Effectiveness 8-13
8.4.6 Implementability 8-13
8.4.7 Costs 8-14
8.5 ALTERNATIVE 4A: CONSOLIDATE WR2, WR 3 AND TAILINGS IN ON-SITE REPOSITORY WITH COVER SOIL CAP 8-14
8.5.1 Overall Protection of Human Health and the Environment 8-14
8.5.2 Compliance with ARARs 8-15
8.5.3 Long-Term Effectiveness and Permanence 8-15
8.5.4 Reduction of Toxicity, Mobility, or Volume Through Treatment 8-16
8.5.5 Short-Term Effectiveness 8-16
8.5.6 Implementability 8-16
8.5.7 Costs 8-17

8.6 ALTERNATIVE 4B: CONSOLIDATE ALL WASTE IN ON-SITE REPOSITORY WITH COVER SOIL CAP 8-17
8.6.1 Overall Protection of Human Health and the Environment 8-17
8.6.2 Compliance with ARARs 8-18
8.6.3 Long-Term Effectiveness and Permanence 8-18
8.6.4 Reduction of Toxicity, Mobility, or Volume Through Treatment 8-19
8.6.5 Short-Term Effectiveness 8-19
8.6.6 Implementability 8-19
8.6.7 Costs 8-20
8.7 ALTERNATIVES 5A AND 5B: CONSOLIDATE ALL WASTE IN ON-SITE REPOSITORY WITH MULTI-LAYERED CAP OR MODIFIED RCRA REPOSITORY 8-20
8.7.1 Overall Protection of Human Health and the Environment 8-20
8.7.2 Compliance with ARARs 8-21
8.7.3 Long-Term Effectiveness and Permanence 8-21
8.7.4 Reduction of Toxicity, Mobility, of Volume Through Treatment 8-22
8.7.5 Short-Term Effectiveness 8-22
8.7.6 Implementability 8-23
8.7.7 Costs 8-23

9.0 COMPARATIVE ANALYSIS OF ALTERNATIVES 9-1

10.0 PREFERRED ALTERNATIVE` 10-1

11.0 REFERENCES 11-1

LIST OF FIGURES

Figure 1-1 General Vicinity Map
Figure 3-1 Iron Mask Mine and Mill Site Sample Locations
Figure 7-1 Iron Mask Mine and Mill site alternatives 3a, 3b, 4a, and 4b Typical Cover Soil Cap
Figure 7-2 Iron Mask Mine and Mill Site Alternative 5a Typical Multi-Cap Liner
Figure 7-3 Iron Mask Mine and Mill Site Alternative 5b Typical Modified RCRA Repository

LIST OF TABLES

Page

Table 4-1 Summary of Preliminary Federal Applicable or Relevant and Appropriate Requirements 4-3
Table 4-2 Summary of Preliminary State Applicable or Relevant and Appropriate Requirements 4-9
Table 5-1 Residential Scenario Regional Screening Levels for Contaminants of Concern. 5-2
Table 5-2 Recreational Scenario Human Risk Management Criteria for Contaminants of Concern 5-3
Table 5-3 Characterization Data for the Iron Mask Mine and Mill Site 5-4
Table 5-4 Summary of Hazard Quotients for the Residential Scenario at the Iron Mask Mine and Mill Site 5-6
Table 5-5 Summary of Hazard Quotients for the Recreational Scenario at the Iron Mask Mine and Mill Site 5-7
Table 5-6 Maximum Downstream Contaminant Concentrations in Surface Water and Stream Sediments at the Iron Mask Mine and Mill Site 5-9
Table 5-7 Solid Media Concentrations at the Iron Mask Mine and Mill Site 5-10
Table 5-8 Ecological Criteria for Contaminants of Concern 5-11
Table 5-9 Summary of Ecologic Impact Quotient (EQs) Values for the Iron Mask Mine and Mill Site 5-13
Table 5-10 Summary of Human Health Hazard Quotient and Ecologic Impact Quotient (EQs) Values for the Iron Mask Mine and Mill Site 5-14
Table 6-1 ARAR-Based Reclamation Goals for Surface Water 6-1
Table 6-2 Proposed Solid Media Clean Up Goals for the Iron Mask Mine and Mill Site ... 6-2
Table 6-3 Target Risk Reduction to Attain Human Health and Ecologic Clean Up Goals for the Iron Mask Mine and Mill Site 6-3
Table 7-1 General Response Actions, Technology Types, and Process Options for Waste Materials at the Iron Mask Mine and Mill Site 7-3
Table 7-2 Reclamation Alternatives for Waste Materials at the Iron Mask Mine and Mill Site 7-10
Table 7-3 Iron Mask Mine and Mill Site Reclamation Alternatives Screening Summary 7-43
Table 8-1 Risk Reduction Achievement Matrix for Alternative 1 8-7
Table 8-2 Risk Reduction Achievement Matrix for Alternative 3a 8-9
Table 8-3 Risk Reduction Achievement Matrix for Alternative 3b 8-12
Table 8-4 Risk Reduction Achievement Matrix for Alternative 4a 8-15
Table 8-5 Risk Reduction Achievement Matrix for Alternatives 4b 8-18
Table 8-6 Risk Reduction Achievement Matrix for Alternatives 5a and 5b 8-21
Table 9-1 Comparative Analysis of Alternatives 9-3
Table 9-2 Alternative Cost-Effectiveness Comparison Summary 9-4

LIST OF APPENDICES

Appendix A	Iron Mask Mine and Mill Site, Threatened and Endangered Species Letters
Appendix B	Iron Mask Mine and Mill Site, Laboratory Data
Appendix C	Iron Mask Mine and Mill Site, Montana Department of Health and Human Services Drinking Water Testing Types, ATSDR Toxicity Profile Summaries for the Contaminants of Concern, Ecological Toxicity Information
Appendix D	Iron Mask Mine and Mill Site, Applicable or Relevant and Appropriate Requirements (ARARs)
Appendix E	Iron Mask Mine and Mill Site Cost Estimates

ACRONYMS

AALS	Freshwater Acute Aquatic Life Standard
ABA	Acid Base Accounting
Ag	Silver
amsl	above mean sea level
ARAR	Applicable or Relevant and Appropriate Requirement
As	Arsenic
ASTM	American Society for Testing and Materials
ATSDR	Agency for Toxic Substances and Disease Registry
ATV	All Terrain Vehicle
bgs	below ground surface
BLM	Bureau of Land Management
BMP	Best Management Practice
CEC	Cation Exchange Capacity
Cd	Cadmium
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
CoCs	Contaminants of Concern
Cu	Copper
cy	cubic yards
DEQ/MWCB	Montana Department of Environmental Quality/Mine Waste Cleanup Bureau
DEQ/WQB	Montana Department of Environmental Quality/Water Quality Bureau
DO	Dissolved Oxygen
EEE/CA	Expanded Engineering Evaluation/Cost Analysis
EPA	U. S. Environmental Protection Agency
EQs	Ecological Impact Quotients
^{o}F	degrees Fahrenheit
Fe	Iron
GCL	Geosynthetic Clay Liner
gpm	gallons per minute
HEAST	Health Effects Assessment Summary Table
Hg	Mercury
HHS	Human Health Standard
HQ	Hazard Quotients
IRIS	Integrated Risk Information System
K_2O	Potash
MBMG	Montana Bureau of Mines and Geology
MCL	Maximum Contaminant Levels
MCLG	Maximum Contaminant Level Goal
meq/100g	milliequivilence per 100 grams
mg/kg	milligram per kilogram
mg/L	milligrams per liter
MHP	Montana Heritage Program
mm	millimeters
Mn	Manganese

mS/cm	milliSiemens per centimeter
N	Nitrogen
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
NEPA	National Environmental Policy Act
Ni	Nickel
NTU	Nephelometric Turbidity Unit
P_2O_5	Phosphate
Pb	Lead
Pioneer	Pioneer Technical Services, Inc.
PRG	Preliminary Remediation Goal
PVC	Polyvinyl Chloride
QA/QC	Quality Assurance/Quality Control
RA	Remedial Action
RBC	Risk Based Concentration
RCRA	Resource Conservation and Recovery Act
RI	Remedial Investigation
RI/FS	Remedial Investigation/Feasibility Study
RMC	Risk Management Criteria
RME	Reasonable Maximum Exposure
ROD	Record of Decision
RTI	Renewable Technologies, Inc.
RSLs	Regional Screening Levels
Sb	Antimony
SHPO	State Historic Preservation Office
SMP	Shoemaker-McLean-Pratt
s.u.	standard units (pH)
SPLP	Synthetic Precipitation Leaching Procedure
SW	Surface Water
T50	Modeled Effect Response of 50%
TA	Tailings Area
TCLP	Toxicity Characteristic Leachate Procedure
TDS	Total Dissolved Solids
TSD	Treatment, Storage, and Disposal
UCL	Upper Confidence Limit
USACE	United States Army Corps of Engineers
USDA	United States Department of Agriculture
WR	Waste Rock
WRCC	Western Regional Climate Center
XRF	X-ray Fluorescence
Zn	Zinc
µg/L	micrograms per liter
µmhos/cm	micromhos per centimeter

1.0 INTRODUCTION

1.1 PURPOSE AND OBJECTIVES

This Draft Final EEE/CA for the Iron Mask Mine and Mill Site has been prepared for the USACE-Omaha District and the BLM by Pioneer, under Engineering Services Contract Number W9128F-04-0013, Delivery Order Number 007, and Task Modification #1 G6CT3ECB071614.

The Iron Mask Mine and Mill Site is located approximately seven miles northwest of Townsend, Montana, in Broadwater County (Figure 1-1). The mine is located in the northern Elkhorn Mountains and is positioned at the head of Whipcracker Gulch.

The need for an EEE/CA was identified during a preliminary investigation and subsequent Phase I Environmental Site Assessment conducted by the BLM in 2005.

The NCP requires the BLM, as the lead agency, to complete removal site evaluations for releases or threatened releases identified for possible CERCLA responses on Public Lands (40 CFR §300.410 b). The BLM is also responsible, under the guidance of the National Environmental Policy Act (NEPA), for making decisions that are based on the understanding of environmental consequences, and taking actions that protect, restore, and enhance the environment (40 CFR, §1500).

The primary purpose of this report is to present the detailed analysis of reclamation alternatives for the Iron Mask Mine and Mill Site in accordance with the NCP. Additionally, the site background, waste characteristics, applicable or relevant and appropriate requirements (ARARs), risk assessment, and preliminary development and screening of reclamation alternatives are presented herein. The purpose of providing this supplemental information with the detailed analysis of alternatives is to give the reviewers and risk managers a comprehensive "stand-alone" decision making tool.

1.2 REPORT ORGANIZATION

This EEE/CA is organized into 11 sections. The contents of Sections 2.0 through 11.0 are briefly described in the following paragraphs:

SECTION 2.0 BACKGROUND—presents a background description of the Iron Mask Mine and Mill Site. Significant site features described in this section include: a detailed history of past mining and milling activities, geologic, hydrologic, and climatic characteristics of the site; the biological setting, such as the wildlife and fisheries resources and the vegetation indigenous to the area; and threatened and endangered species concerns, as well as the cultural setting issues, such as present and future land uses.

SECTION 3.0 IRON MASK MINE AND MILL SITE DATA COLLECTION—describes the characteristics of the wastes present at the upper and lower sites and along the creek, including waste types, volume estimates, and contaminant concentrations, as well as an evaluation of existing data derived from previous response actions or investigations. A description of the characteristics of the proposed borrow site and repositories is included.

SECTION 4.0 SUMMARY OF THE APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS—presents the Montana State and Federal government requirements which are considered ARARs for the reclamation effort. Requirements discussed in this section are chemical-, location-, and action-specific in nature.

SECTION 5.0 BASELINE HUMAN HEALTH AND ECOLOGICAL RISK ASSESSMENTS—presents a summary of the human health and ecological risk assessments performed for the site. Contaminant sources, routes of exposure, and receptors are evaluated to determine the relative threats posed by each source within the project boundary and each exposure pathway.

SECTION 6.0 RECLAMATION OBJECTIVES AND GOALS—presents the reclamation objectives and applicable cleanup standards.

SECTION 7.0 DEVELOPMENT AND SCREENING OF RECLAMATION ALTERNATIVES—preliminarily identifies and screens potentially applicable reclamation alternatives. Reclamation alternatives are evaluated based on effectiveness, implementability, and cost.

SECTION 8.0 DETAILED ANALYSIS OF RECLAMATION ALTERNATIVES—presents the detailed analysis of reclamation alternatives pertaining to seven of the nine NCP evaluation criteria.

SECTION 9.0 COMPARATIVE ANALYSIS OF RECLAMATION ALTERNATIVES—presents a comparative analysis of the reclamation alternatives consistent with the NCP.

SECTION 10.0 PREFERRED ALTERNATIVE—presents the preferred alternative and summarizes the reasoning behind selecting this alternative.

SECTION 11.0 REFERENCES—lists the references cited in this text.

2.0 BACKGROUND

Significant site features include and are described in this section: a detailed history of past mining and milling activities, geologic, hydrologic, and climatic characteristics of the site; the biological setting, such as the wildlife and fisheries resources and the vegetation indigenous to the area; and threatened and endangered species concerns, as well as the cultural setting issues, such as present and future land uses.

2.1 CURRENT SITE SETTING

The Iron Mask Mine and Mill Site is located in Broadwater County approximately seven miles northwest of Townsend, Montana. The mine is located in the northern Elkhorn Mountains and is positioned at the head of Whipcracker Gulch. Elevation at the site is approximately 6,000 feet above mean sea level (amsl). The terrain is generally mountainous with moderately steep slopes.

The Iron Mask Mine and Mill Site is accessed by traveling on U.S. Highway 287 approximately 1.3 miles northwest of Townsend, Montana, then traveling west on Indian Creek Road for approximately 4 miles, and then traveling northwest along an unmaintained dirt/gravel road for approximately 3 miles. The legal description for the Iron Mask Mine and Mill Site is Northwest ¼ of the Northwest ¼, Section 30, Township 07 North, Range 01 East (see Figure 1-1).

This site was not inventoried as part of the 1995 Montana Department of Environmental Quality/Mine Waste Cleanup Bureau (DEQ/MWCB) Abandoned Hardrock Mine Priority Sites report. The site was documented in the *Open-file Report – Abandoned/Inactive Mines of Montana* published by the Montana Bureau of Mines and Geology and BLM (MBMG/BLM 1997).

Mining-related features associated with the Iron Mask Mine and Mill Site include a discharging adit and three waste rock dumps, a mill and scattered tailings, two shop buildings, several apparent outhouses, boarding/rooming houses, a root cellar and remnants of a flume. Almost all structures are in poor condition, with building superstructures collapsed and/or completely gone.

The site can be divided into two principal areas of concern as follows:

- Waste rock dumps located directly below and south of the adit opening. Water discharging from the adit runs adjacent to the toe of the northern most waste rock dump. Based on the site inventory conducted by Pioneer, approximately 11,500 cubic yards (cy) of waste rock are contained within the waste rock dumps.

- An apparent tailings impoundment area is located downgradient of the mill site, and scattered surficial tailings deposited throughout the lower end of the site. Based on the site inventory conducted by Pioneer, approximately 1,900 cy of tailings are present within the site.

2.1.1 Vegetation/Wildlife

The Iron Mask Mine and Mill Site is located on a moderately timbered easterly-facing slope. The surrounding topography is generally steep mountainous terrain consisting of moderately forested lands and open grasslands that are important habitat for a variety of big game animals, furbearers, and birds. With the exception of the waste rock dumps, the Iron Mask Mine and Mill

Site is moderately to well vegetated with native and non-native grass and forb species. The waste rock dumps are barren of vegetation.

Vegetation primarily consists of cool season range grasses, sage brush and juniper dominant on southern-facing slopes. Alder and aged cottonwoods are prevalent along Whipcracker Gulch.

There are no wetlands or riparian areas located within the Iron Mask Mine and Mill Site project area. The Whipcracker Gulch drainage located directly downgradient of the project area is a riparian zone with small wetland areas scattered along the drainage.

A survey of the Montana Heritage Program (MHP) web site has recorded two species of concern within the general vicinity of the Iron Mask Mine and Mill Site, the Olive-sided Flycatcher (*Contopus cooperi*) and Canada Lynx (*Lynx Canadensis*) (see Appendix A). No threatened or endangered terrestrial species were noted; however, the surrounding area is known to provide important habitat for the Grey Wolf (*Canis lupus*), Grizzly Bear (*Ursus arctos horribilis*), Black Bear, (*Ursus americanus*) and Wolverine (*Gulo gulo luscus*). The surrounding area is also considered critical summer and winter range for elk, deer and bighorn sheep.

As part of determining if threatened or endangered or sensitive terrestrial species are present, Pioneer sent letters to the following agencies (see Appendix A):

- Ms. Sarah LeMarr, Butte BLM Field Office;
- Mr. Tom Carlson, Montana Department of Fish Wildlife and Parks;
- Ms. Shawna Campbell, U.S. Forest Service; and
- Ms. Katrina Dixon, U.S. Fish and Wildlife Service.

Mr. R. Mark Wilson with the U.S. Fish and Wildlife Service provided the only response. Mr. Wilson stated that, *"Considering the location of the project, the service does not anticipate effects to the federally listed threatened, endangered, candidate or proposed species"*.

2.1.2 Historic or Archaeologically Significant Features

A Class III cultural resource inventory has been performed in the project area, and consultation with the Montana State Historic Preservation Office (SHPO) is proceeding. In the event that SHPO agrees with BLM's findings, this project will have "no effect" on historic properties in the project area. If SHPO does not concur with BLM's findings, a Memorandum of Understanding (MOU) will be developed to resolve the issues. The MOU will be sent to the Advisory Council on Historic Preservation for resolution of the effects of the undertaking on historic properties.

In 2007, Renewable Technologies, Inc. (RTI) conducted intensive reconnaissance-level cultural resources inventories in the vicinity of the Iron Mask Tunnel and Mill Site and at the nearby Light Bulb Adit located approximately 2 miles northeast of the project area (see Figure 1-1). RTI concluded through file searches and field investigations that eight historic sites or districts and one isolate find is located within the project area. Two sites are prehistoric artifact scatters located at the far north end of the reconnaissance area. Four of the sites were recorded by others several years ago and were not evaluated for their National Register eligibility. The four

previously recorded sites are historic and are mining-related, and include the Park-Indian Creek Historic Mine District, a historic road apparently built to serve mines along Indian Creek, the Light Bulb Adit itself, and another small mine site that historically was likely associated with the Light Bulb Adit. None of these four are eligible for listing in the National Register of Historic Places. The two newly-recorded sites are the Iron Mask Mine Tunnel and Mill Site and the Lookout Mine. The Iron Mask Mine Tunnel and Mill Site is a complex of 13 industrial and residential structures and building ruins dating between 1919 and 1949. It lacks both the significance and integrity to be considered National Register eligible. The Lookout Mine is located at the far southwest corner of the reconnaissance area, straddling the line between private and public property. It includes just three mine openings and a small depression, dating between the late nineteenth and mid-twentieth centuries. It too has neither the significance nor integrity required to be considered National Register eligible (RTI, 2007). BLM agrees with RTI's findings of eligibility.

2.1.3 Land Use and Population

Existing land use in the vicinity of the mine site consists primarily of cattle grazing and recreation including hunting, camping, hiking and 4-wheeling. Future land use for the site is anticipated to include continued grazing, and implementation of a travel management plan which may impose motorized travel restrictions to provide additional elk habitat.

Townsend has a population of 1,867 (2000 U.S. Bureau of Census) and is the nearest community located approximately 7 miles to the southeast (see Figure 1-1). The Greymont Western U.S. (Greymont) Indian Creek limestone mine and processing plant are located approximately four miles southeast of the site.

2.1.4 Climate

The Iron Mask Mill and Mine Site area is subject to a cool and dry, continental-dominated climate (WRCC, 2008). It is a frigid (bordering cryic) soil temperature regime with an ustic soil moisture regime.

This region's temperature is generally low and marked by wide seasonal and daily variations. During winter months, the average temperature is in the range of 10 degrees Fahrenheit (^{o}F) to 30° F. The summers are usually warm and arid with night temperatures rather cool. The frost-free period (32° F or greater) is approximately 150 days, from mid-April to late September.

Precipitation at the site is affected by the "rain shadow" effect of the Elkhorn Mountains, and is not abundant in the region (averaging between 6 and 10 inches annually). Stormy weather usually brings the first snows during September; however, they are generally followed by several weeks of fair weather. The area is subject to a distinct spring/summer rainy season with May and June usually being the wettest months of the year. On average, May and June receive 36% of the precipitation.

2.1.5 Geology

2.1.5.1 Regional Setting

The Iron Mask Mine and Mill Site is located in the central Limestone Hills in the northern Elkhorn Mountains, which are underlain by Tertiary andesites. Veins in the area are thin and sparsely distributed. Alteration is isolated to zones around the veins; otherwise the country rock is relatively fresh.

2.1.5.2 Local Geologic Setting

The Iron Mask vein is a mineralized fracture filling and replacement in andesite. It strikes North 15° West and dips 75° to 85° Northeast. The vein ranges from 1.5 feet to greater than 4 feet wide. Ore shoots are described as 1 to 4.5 feet wide discontinuous lenses striking along the trend of the main system. Ore consists of silicified andesite with galena, sphalerite, and limonite. Chalcopyrite and tetrahedrite were documented in some ore shoots (Reed, 1951).

Two additional veins are also described in the area. One subparallel vein 15 feet west of the main vein was assumed to be low grade because it is highly oxidized. The third vein averaging 1 to 5 feet wide was mined for 350 feet. The strike of this vein varies from North 10° East to North 10° West and dips average 77° East (Reed, 1951).

Surficial soils in the vicinity of the site consist of silty sands with abundant gravels and cobbles. Bedrock is relatively close to the surface and is typically encountered at depths shallower than 10 feet, often exposed as outcrops.

2.1.6 Hydrology and Hydrogeology

The topography above the mine area is the headwaters of Whipcraker Gulch and encompasses approximately 100 acres. The Iron Mask adit typically discharges approximately 5-20 gallons per minute (gpm). This is likely due to the mine workings intersecting water-bearing faults. Discharge from the adit flows through Whipcracker Gulch and fully infiltrates within 1,500 feet during low to moderate flows.

A review of standard hydrogeologic literature sources found that no published information specific to this area has been assembled. Therefore, the interpretations of hydrogeologic conditions presented here are based on accepted hydrogeologic principles, local observations, and available geologic information. The mountainous terrain and lack of other groundwater seepage or springs in the general area indicates that the groundwater table is approximately 100 feet below ground surface (bgs).

2.2 MINING HISTORY

The Iron Mask Mine and Mill Site is located within the Park (Indian Creek) Historic Mining District. The Park Mining District is a very large area, covering thousands of acres in and around the Indian Creek drainage along the east side of the Elkhorn Mountains.

In November 1887, local prospectors J.N. Thompson and George Kerwin discovered and claimed the Iron Mask lode on top of a high ridge between Indian Creek to the west and the Missouri River to the east. Over the next few years, no more than a few hundred tons of rich silver-lead ore was extracted from the mine.

After lying idle for a while, reports of mining activity and ore production began to appear in the mining press in early 1895 and continued on an intermittent basis for the next three years. Mining through the Iron Mask shaft continued sporadically in the early 20th century, with activity in 1906 and again beginning in 1917. This resulted in excavation of the Iron Mask Tunnel and, much later, construction of the nearby mill.

By 1918, the Bamar Copper Company was at work at the Iron Mask under bond and lease. By the end of the year, Bamar Copper had sent several shipments of Iron Mask ore outside of the district for treatment.

By October 1927, Bamar Copper convinced another speculator in Butte, William Creden, to assume its holdings at the Iron Mask Mine. By 1929, Creden Mines has mined and shipped a few carloads of lead-zinc ore. The company abandoned work at the Iron Mask after this time.

Over the next couple of years various people tried their luck at the mine. In the spring and summer of 1942, a modest 50-ton flotation mill was built at Iron Mask under the ownership of the Broadwater Zinc and Lead Company. By late 1943, the company had run 1,200 tons or zinc-lead ore through its mill and shipped another 1,612 tons of ore directly to a smelter. In 1949, the Broadwater Zinc and Lead Company treated 1,400 tons of zinc-lead ore before it ceased work for good in early June (RTI, 2007).

Bureau of Land Management records show the site has no active claimant(s) and the mine and mill is abandoned.

3.0 IRON MASK MINE AND MILL SITE DATA COLLECTION

The following sections describe the characteristics of the wastes present at the Iron Mask Mine and Mill Site, including waste types, volume estimates, and contaminant concentrations, as well as an evaluation of existing data derived from previous response actions or investigations. A description of the characteristics of the proposed borrow site and repositories is included. Environmental media sampled as part of the field investigations include background soil, borrow area soil, tailings, waste rock, stream sediment and surface water.

Background soil consists of native, undisturbed soil that surrounds the site, and is sampled to obtain baseline data representative of natural soil conditions. Borrow area soil is uncontaminated soil obtained from a suitable location that is used to backfill and provide growth media for areas excavated during reclamation.

Tailings are generally uniform and finely ground rock particles from which most of the commercial minerals have been extracted, usually disposed along stream channels or within impoundments. Waste rock consists of non-mineralized and low-grade mineralized rock which has been removed from areas adjacent to the ore and stockpiled near the mine opening. Sample results for tailings and waste rock are compared to background soil results to determine if contamination is present. Contamination is considered to be elevated when results exceed three times the average concentration of background soil.

Stream sediment consists of fine soil particles deposited in the stream bed as a result of erosion, and are carried by surface water to the point of disposition. Stream sediments and surface water are sampled to determine if contaminants are present in amounts which exceed applicable comparison criteria.

Each environmental medium is discussed individually and includes available sample locations, descriptions, and summaries of analytical results. Figure 3-1 illustrates locations of samples that were collected during field activities associated with previous investigations and the investigations conducted in 2008 for this EEE/CA. Laboratory results and applicable comparison criteria are presented in Appendix B, and are tabulated as follows:

- Table B-1 Source Sampling Summary;
- Table B-2 Total Metals – Solid Media;
- Table B-3 Total Metals – XRF Data (BLM, 2005) and Pioneer's 2008 Site Investigation;
- Table B-4 Acid-Base Accounting (ABA) and Shoemaker, McLean, Pratt buffer (SMP);
- Table B-5 Synthetic Precipitation Leach Procedure (SPLP);
- Table B-6 Agronomic Properties;
- Table B-7 Physical Properties;
- Table B-8 Total Metals – Surface Water;

- Table B-9 Dissolved Metals – Surface Water;
- Table B-10 Wet Chemistry – Surface Water; and
- Table B-11 Contaminant of Concern (COC) Comparison Criteria.

Results which indicate metals concentrations are elevated are identified as COCs and are further analyzed in Section 5.0, where they are compared to selected criteria for solid media and surface water to determine the human health and ecological risks present at the site.

The SPLP and the Toxicity Characteristic Leaching Procedure (TCLP) tests are used to determine the leach ability of waste materials through the use of low pH solution. The TCLP test is used to characterize an industrial waste stream or other waste materials as defined by Resource Conservation and Recovery Act (RCRA). The TCLP defines if a waste is hazardous and therefore must be disposed in a hazardous waste facility or can be placed in a typical municipal landfill. The TCLP test uses either a sodium acetate solution at pH 4.93 standard units (s.u.) or a dilute acetic acid solution with a pH of 2.8 s.u. depending on the pH of the wastes being tested. The sample is then tumbled in the appropriate extraction fluid for 18 hours and then analyzed.

The SPLP test was developed by the U. S. Environmental Protection Agency (EPA) to simulate acid rain effects on soil waste materials. This test simulates the actual environmental precipitation that the soil will be exposed to and the concentration of contaminant that will leach from soil under these conditions. The extraction fluid pH used in the SPLP is a function of the region where the sample site is located. For samples located east of the Mississippi River the extraction fluid is pH 4.2 s.u., for samples west of the Mississippi River the extraction fluid is pH 5.0 s.u. As with the TCLP test, the sample is then tumbled in the appropriate extraction fluid for 18 hours and then analyzed.

For abandoned mine site investigations, such as that completed at the Iron Mask Mine and Mill Site in 2008, the use of the SPLP is more realistic in terms of what the waste rock and tailings materials are exposed to at the site (i.e., rain and snow fall) and what may leach from these materials under this condition. The results of the SPLP are then used as part of the risk assessment for the site. Additionally, the extraction and beneficiation of ore materials are excluded under Subtitle C of RCRA from regulation as hazardous waste under the Bevill exclusion amendment.

Agronomic testing is completed on all potential borrow area locations to determine the suitability of the soil for use as a vegetative growth media. Agronomic testing is also completed on the exposed waste sources to determine if the limited vegetation at the site is from agronomic and/or physical parameters or chemical factors. The amendment recommendations are based on the establishment of dry-land pasture.

There is currently no vegetative success standard for reclaimed abandoned mine sites. Typically a site is considered "successful" when the reclaimed area vegetative cover percentage, density and production are equal or better than the surrounding non-impacted areas surrounding the site.

3.1 PREVIOUS INVESTIGATIONS

Previous data collection efforts at the site include the *Phase I Environmental Site Assessment Report Proposed Real Property Acquisition Iron Mask Property* (BLM, 2005). This report was completed by the BLM Butte Field Office prior to the acquisition of this property from the Rocky Mountain Elk Foundation.

As part of the Phase I assessment, soil tests were conducted using x-ray fluorescence (XRF) analysis to determine metal concentrations (see Table B-3 in Appendix B). Composite samples were collected from the waste rock dump near the adit, waste rock dump near the mill site and downstream tailings, and compared to background sample concentrations from near each area. Results from this investigation depict the following elements as being significantly elevated above background (>3X background):

- North waste rock dump - Pb, Mn, Hg, Ni, and Zn;
- Mill site – Pb and Mn; and
- Tailings area – As, Fe, Mn, Pb, and Zn.

Additionally, composite samples from each area were submitted to Energy Laboratories in Helena, Montana, for TCLP analysis to determine if the materials would be considered a RCRA characteristic hazardous waste (see Table B-5 Appendix B for sample results). The TCLP test results indicate that only the mill site sample exceeded the regulatory limit concentrations for cadmium (Cd) and Pb for hazardous waste classification. Consequently, this material satisfies the criteria to be considered a RCRA characteristic hazardous waste (EPA hazardous waste numbers D006, and D008, respectively); however, the Bevill Amendment excludes this waste from RCRA regulations because the waste was derived from the extraction, beneficiation, and/or processing of ores or minerals. The TCLP data for the samples collected from the north waste rock dump and tailings area are below the regulatory limits for hazardous waste classification.

One water sample was collected on May 16, 2001 from the mine portal. The results indicate that the water flowing from the mine adit is good quality and did not exceed the Maximum Contaminant Levels (MCLs) for metals. Only copper (Cu) at 4 micrograms per liter (µg/L) and Zn at 2.4 µg/L were above the laboratory detection limit. Field conductivity was measured at 220 micromhos per centimeter (µmhos/cm) at a pH of 8.0 s.u.

3.2 SUPPLEMENTAL FIELD INVESTIGATION

On June 16-18, 2008, Pioneer personnel conducted a supplemental field investigation in accordance with the *Draft Sampling and Analysis Plan for the Iron Mask Mine and Mill Site* (Pioneer-USACE/BLM, 2007). The objective of the 2008 Iron Mask Mine and Mill Site Investigation was to evaluate the mine and mill wastes at the site while generating a database that meets the requirements necessary to complete a baseline risk assessment and detailed analysis of reclamation alternatives.

Additional data required to support this EEE/CA included the following:

- Characterization of heavy metal concentrations in the waste rock dumps and mill tailings at the site;
- Evaluation of the physical and chemical properties of the source material that may affect contaminant migration including the following: leaching properties, pH, buffering capacity, organic carbon content, and particle size distribution;
- Contaminant concentration variations and leaching characteristics of the wastes at the site (porosity, hydraulic conductivity, and SPLP data);
- Physical and construction characteristics of the wastes;
- Generate estimates of volume and surface area of the wastes;
- Detailed topographic and location mapping of the site; and
- Revegetation parameters for waste rock and mill tailings including: soil texture and grain size, percent organic matter, liming requirements, native vegetation determination, and fertilizer recommendation analyses.

The supplemental sampling included investigating three waste rock dumps, mill tailings, stream sediment and surface water from Whipcracker Gulch that originates from the mine adit, and background soils.

Energy Laboratories of Helena, Montana, completed the chemical analysis. Pioneer's Materials Testing Laboratory in Helena analyzed physical properties and Midwest Laboratories of Omaha, Nebraska, conducted the agronomic analysis. In addition to the samples submitted for laboratory analysis, Pioneer utilized XRF analysis in the field for reconnaissance purposes.

The following sections discuss each individual investigation area sampled by Pioneer in 2008.

3.2.1 Background Samples

Five background soil samples were collected from the area surrounding the Iron Mask Mine and Mill Site (see Figure 3-1) to evaluate natural soil concentrations for comparison to samples obtained within areas containing waste materials.

Samples Iron Mask-BG-1 through BG-3 were obtained from the undisturbed hillsides surrounding the adit, to the south, west and north, respectively. Iron Mask-BG-04 was sampled from the area across Whipcracker Gulch directly north of the lower east end of the site. Iron Mask-BG-05 was obtained from the hillside south of the iron pipe gate located at the mine site entrance.

Results of the background sampling are relatively consistent, with no concentration exceeding 3 times the lowest value for each analyte.

Background sample results were averaged across the five samples for each analyte, and then multiplied by 3 to obtain values for direct comparison to concentrations of waste material samples.

3.2.2 Waste Rock Dumps

Nine samples were collected from the three waste rock dumps during the supplemental investigation (see Figure 3-1). Samples for Iron Mask-WR1 were collected from the largest waste rock dump located directly in front of the mine adit. Samples for Iron Mask-WR2 were collected from a smaller waste rock dump located around and above the mill site. Samples for Iron Mask-WR3 were collected from the smallest waste rock dump located along the main access road to the mine site, near the iron pipe entrance gate approximately 850 feet southeast of the adit.

Waste Rock Dump 1 and WR3 consist of mineralized rock, presumably low grade overburden material removed while tunneling toward the higher grade ore. Waste Rock Dump 2 is composed of rock with a higher mineral content than that of the other two waste dumps, and may be ore material which was overcast from the bin at the upper end of the mill.

3.2.2.1 Iron Mask-WR1

WR1 encompasses an area of approximately 0.7 acres directly in front of the adit, and contains an estimated 10,000 cy of material. Three test pits were excavated into WR1 in order to obtain samples representative of the material encountered throughout the upper surface of the dump. Two composite samples and two discrete samples were collected from the test pits and submitted for laboratory analysis.

Composite sample Iron Mask-WR1-A represented waste material collected from the 0 to 6-inch interval in each of the 3 test pits; composite sample Iron Mask-WR1-B represented material collected from the 6-inch interval to the bottom of the excavations, which varied from 6 to 12 feet. Iron Mask-WR1-C was a discrete sample collected from WR1-TP-03 within the 6 to 50-inch interval and Iron Mask-WR1-D was a discrete sample collected from WR1-TP-03 within the 50 to 108-inch interval.

Results of Total Metals analysis show that concentrations of As, Cd, Cu, Pb, Mn, and Zn are significantly elevated (>3 times) in all four samples collected from WR1, when compared to average background concentrations of soils surrounding the site. Concentrations of silver (Ag) are also significantly elevated in samples WR1-B and WR1-C.

The ABA/SMP buffering capacity results for sample WR1-B indicate that WR1 is not considered a potential acid producer, and would not require lime treatment. Total Sulfur for WR1-B is 2.5%. The SPLP data shows all metal concentrations below laboratory detection limits, which indicates no leaching potential.

Agronomic analysis results for sample WR1-B indicate recommended fertilizer application rates of 100 pounds of nitrogen (N), 60 pounds of phosphate (P_2O_5) and 65 pounds of potash (K_2O) are required per acre. Organic matter content of the sample material is reported as 3.3%; the pH is neutral at 7.2 s.u.; the Cation Exchange Capacity (CEC) is 23.8 milliequivilence per 100 grams (meq/100g), which indicates a moderate potential for attenuating heavy metals. Conductivity of the sample is reported as 2.74 milliSiemens per centimeter (mS/cm).

Physical property analysis for sample WR1-B depicts this sample as sandy loam based on U.S. Department of Agriculture (USDA) soil classification for particle sizes <2mm. The gradation distribution shows a gravel content of 60% based on the American Society for Testing and Materials (ASTM) for particle sizes 4.75 to 75mm. Rock content was visually estimated in the field at 40 to 80% rock by volume of 8-inch minus diameter material.

3.2.2.2 Iron Mask-WR2

Waste Rock Dump 2 encompasses an area of approximately 0.5 acres surrounding the mill site, and contains an estimated 1,000 cy of material. Three test pits were excavated into WR2 in order to obtain samples representative of the material encountered above and around the mill site. Two composite samples and one discrete sample were collected from the test pits and submitted for laboratory analysis.

Composite sample Iron Mask-WR2-A represented waste material collected from the 0 to 6-inch interval in each of the 3 test pits; and composite sample Iron Mask-WR2-B represented material collected from the 6-inch interval to the bottom of the excavations, which varied from 15 to 32 inches. Iron Mask-WR2-2-B was a discrete sample collected from WR2-TP-02 within the 6 to 18-inch interval.

Results of Total Metals analysis show that concentrations of As, Cd, Cu, Pb, Mn, Ag and Zn in samples WR2-A and WR2-B are significantly elevated (>3 times) above average background concentrations of soils surrounding the site. The concentration of antimony (Sb) was also elevated in sample WR2-B. Concentrations of As, Cd, Pb, Ag and Zn are significantly elevated in sample WR2-2B.

The ABA/SMP buffering capacity results for samples WR2-B and WR2-2B indicate that WR2 is considered a potential acid producer, with a liming requirement of 85 tons/1,000 tons. Total Sulfur for WR2-B is 3.2%. The SPLP data show the presence of Cd, Mn, and Zn, which indicates a potential for leaching; however, concentrations found in laboratory leachate are below Montana Numeric Water Quality Standards (DEQ/WQB, 2008) Human Health Standards (HHS) for groundwater.

Agronomic analysis results for sample WR2-B indicate recommended fertilizer application rates of 100 pounds N, 70 pounds of P_2O_5 and 80 pounds of K_2O are required per acre. Organic matter content of the sample material is reported as 3.1%; the pH is slightly acidic at 6.0 s.u., and the CEC is 50.4 meq/100g, indicating a moderate potential for attenuating heavy metals. Conductivity of the sample is reported as 3.57 mS/cm.

Physical property analysis for sample WR2-B depicts this sample as sandy loam based on USDA soil classification for particle sizes <2mm. The gradation distribution shows a gravel content of 55% based on the ASTM for particle sizes 4.75 to 75mm. Rock content was visually estimated in the field at 50 to 90% rock by volume of 8-inch minus diameter material.

3.2.2.3 Iron Mask-WR3

Waste Rock Dump 3 is a relatively small waste rock dump near the iron pipe entrance gate to the site, encompassing an area of approximately 0.1 acres and containing an estimated 500 cy of material. One test pit was excavated into WR3, and 2 samples were collected and submitted for laboratory analysis.

Sample Iron Mask-WR3-A represented waste material collected from the 0 to 6-inch interval and Iron Mask-WR3-B represented material collected from the 6-inch interval to the bottom of the excavation at 7 feet.

Results of Total Metals analysis show that concentrations of As, Cd, Cu, Pb, Hg, Ag and Zn in both samples are significantly elevated (>3 times) when compared to average background concentrations of soils surrounding the site. The concentration of Mn is also significantly elevated in sample WR3-B.

The ABA/SMP buffering capacity results for sample WR3-B indicate that WR3 is considered a potential acid producer, with a liming requirement of 41 tons/1,000 tons. Total Sulfur for WR3-B is 0.9%. The SPLP data show the presence of Cd, Mn, and Zn, which indicates a potential for leaching; however, concentrations found in laboratory leachate are below Montana Numeric Water Quality Standards (DEQ/WQB, 2008) HHS for groundwater.

Agronomic analysis results for sample WR3-B indicate recommended fertilizer application rates of 100 pounds N, 65 pounds of P_2O_5 and 65 pounds of K_2O are required per acre. Organic matter content of the sample material is reported as 1.4%; the pH is acidic at 5.0 s.u., and the CEC is 26.6 meq/100g, indicating a moderate potential for attenuating heavy metals. Conductivity of the sample is reported as 4.03 mS/cm.

Physical property analysis for sample WR3-B depicts this sample as loamy sand based on USDA soil classification for particle sizes <2mm. The gradation distribution shows a gravel content of 73% based on the ASTM for particle sizes 4.75 to 75mm. Rock content was visually estimated in the field at 60 to 80% rock by volume of 8-inch minus diameter material.

3.2.3 Tailings Areas

Five samples were collected from two tailings impacted areas during the supplemental investigation (see Figure 3-1). Samples for Iron Mask-TA1 were collected from an area containing shallow tailings deposits located near the lower-east end of the site. Samples for Iron Mask-TA2 were collected from a suspected mill tailings impoundment located southeast of the mill site.

Tailings Area 1 is comprised of fine-grained processed material that is presumed to have been transported downgradient from the mill site and deposited over a large area as the result of a high flow storm event or impoundment failure. Tailings Area 2 consists of similar material that is contained behind a small earthen embankment directly below the mill site. In general, the TA1 material contains a higher concentration of metals than TA2.

3.2.3.1 Iron Mask-TA1

Tailings Area 1 is comprised of an area approximately 2.0 acres in size. Approximately 1,600 cy of waste material is estimated to be contained within this area; however estimation is extremely difficult due to the scattered nature of the shallow waste deposits which vary from 0 to 3 inches in depth. Seven test pits were excavated in the areas within and surrounding the deposits, and three samples were collected and submitted for laboratory analysis.

Sample Iron Mask-TA1-W was collected from visible surficial waste material located directly west of the lower site road. Sample Iron Mask-TA1-A represented material collected from the 0 to 6-inch interval in each of the 7 test pits, and Iron Mask-TA1-B represented material collected from the 6-inch interval to the bottom of the test pit excavations. Excavation depths ranged from 10 to 14 feet.

Results of Total Metals analysis show that concentrations of Sb, As, Cd, Cu, Pb, Mn, Hg, Ag and Zn in sample TA1-W are significantly elevated (>3 times) when compared to average background concentrations of soils surrounding the site. No analyte concentrations were significantly elevated in sample TA1-B.

The ABA/SMP buffering capacity results for samples TA1-W and TA1-B indicate that TA1 is not considered a potential acid producer. Total Sulfur for TA1-W is 0.7%. The SPLP data for sample TA1-W shows the presence of Fe, Pb, Mn and Zn, which indicates a potential for leaching; however, concentrations found in laboratory leachate are below Montana Numeric Water Quality Standards (DEQ/WQB, 2008) HHS for groundwater.

Agronomic analysis results for sample TA1-A indicate recommended fertilizer application rates of 100 pounds N and 15 pounds of P_2O_5 are required per acre. Organic matter content of the sample material is reported as 2.8%; the pH is neutral at 6.9 s.u., and the CEC is 14.3 meq/100g, indicating a moderate potential for attenuating heavy metals. Conductivity of the sample is reported as 0.70 mS/cm.

Agronomic analysis results for sample TA1-B indicate recommended fertilizer application rates of 100 pounds of N, 60 pounds of P_2O_5 and 65 pounds of K_2O are required per acre. Organic matter content of the sample material is reported as 1.3%; the pH is alkaline at 8.1 s.u., and the CEC is 17.8 meq/100g, indicating a moderate potential for attenuating heavy metals. Conductivity of the sample is reported as 1.02 mS/cm.

Physical property analysis for sample TA1-B depicts this sample as sandy loam based on USDA soil classification for particle sizes <2mm. The gradation distribution shows a gravel content of 22% based on the ASTM for particle sizes 4.75 to 75mm. Rock content was visually estimated in the field at 30 to 60% rock by volume of 6-inch minus diameter material.

3.2.3.2 Iron Mask-TA2

Tailings Area 2 is a relatively small tailings impoundment located in a timbered area, southeast and downgradient of the mill site. The impoundment covers approximately 1,875 square feet

and contains an estimated 300 cy of material. Three test pits were excavated by hand into the impoundment and two samples were submitted for laboratory analysis.

Sample Iron Mask-TA2-A represented material collected from the 0 to 6-inch interval in each of the 3 test pits, and Iron Mask-TA2-B represented material collected from the 6-inch interval to the bottom of the test pit excavations. Excavation depths ranged from 12 to 22 inches.

Results of Total Metals analysis show that concentrations of As, Cd, Cu, Pb, Mn, Ag and Zn in both samples are significantly elevated (>3 times) when compared to average background concentrations of soils surrounding the site.

The ABA/SMP buffering capacity results for samples TA2-A and TA2-B indicate that TA2 is not considered a potential acid producer. Total Sulfur for TA2-A is 2.0%. The SPLP data for sample TA2-B shows all analyte concentrations are below laboratory reporting limits, which indicate no potential for leaching.

Agronomic analysis results for sample TA2-B indicate recommended fertilizer application rates of 100 pounds of N, 60 pounds of P_2O_5 and 65 pounds of K_2O are required per acre. Organic matter content of the sample material is reported as 3.0%; the pH is alkaline at 8.0 s.u., and the CEC is 11.9 meq/100g, indicating a moderate potential for attenuating heavy metals. Conductivity of the sample is reported as 1.06 mS/cm.

Physical property analysis for sample TA2-B depicts this sample as sandy loam based on USDA soil classification for particle sizes <2mm. The gradation distribution shows a gravel content of 0.8% based on the ASTM for particle sizes 4.75 to 75mm. Rock content was visually estimated in the field at <10% rock by volume of 3-inch minus diameter material.

3.2.4 Stream Sediment and Surface Water Sampling Results

Four surface water samples and 5 stream sediment samples were collected along Whipcraker Gulch during the supplemental investigation beginning at the Iron Mask Adit and continuing downstream to a point approximately 600 feet downgradient from the lower site access road (see Figure 3-1).

3.2.4.1 Surface Water

Four surface water samples (Iron Mask-SW-01 through SW-04) were collected along the surface water flow that originates from the Iron Mask Adit and continues intermittently downstream through Whipcracker Gulch. Surface water flows encountered during the investigation varied from an estimated 1.56 to 9.25 gpm, and fully infiltrated immediately downgradient of SW-04.

Laboratory analysis was conducted for Total Metals and Dissolved Metals in addition to wet chemistry parameters (total dissolved solids [TDS], chloride, sulfate, nitrate-nitrite, and calcium carbonate concentration [hardness]). Field parameters (pH, conductivity, alkalinity, and temperature) were also analyzed. Tables B-8, B-9 and B-10 provided in Appendix B present the surface water quality results for the Iron Mask Mine and Mill Site. Explanations of tests

pertaining to drinking water are published by the Montana Department of Health and Human Services and included in Appendix E.

Exceedances for Pb were reported for the 2 downstream surface water samples (SW-03 and SW-04) when compared to Montana Numeric Water Quality Standards (DEQ/WQB, 2008) for human health. Values for pH were slightly alkaline and ranged from 7.8 to 8.4 s.u.

3.2.4.2 Stream Sediments

Five stream sediment samples (Iron Mask-SE-01 through SE-05) were collected from Whipcracker Gulch. Iron Mask-SE-01 through SE-04 were collected in conjunction with the surface water samples. Iron Mask-SE-05 was collected from a dry area of the gulch approximately 600 feet downgradient of the lower access road. Each stream sediment sample was submitted to the laboratory for metals analysis.

Concentrations of As, Pb, Ag and Zn in stream sediment samples SE-03, SE-04 and SE-05 collected downgradient of the waste sources exceeded criteria specified in the *National Sediment Quality Survey* (EPA, 2004). Table B-2 in Appendix B presents the laboratory results for the stream sediment samples.

3.2.5 Repository/Borrow Investigation

Two potential borrow area/repository sites were explored during the supplemental investigation (see Figure 3-1). The first area, referred to as Iron Mask BA1, is located in an area bound by the lower and upper site access roads and directly south of TA1. The second area, Iron Mask BA2, is located north of TA1 across Whipcracker Gulch. The sites were chosen for sampling due to their close proximity to the site and relatively flat topography conducive to repository construction.

3.2.5.1 Iron Mask BA1

A total of 8 test pits were excavated at Iron Mask BA1. The test pit locations were selected at random and ranged in depth from to 5.0 to 10.8 feet bgs. Groundwater was not encountered in any of the test pits.

In general, BA1 consisted of a layer of silty loam topsoil typically 1 foot in depth, containing woody debris, grasses, and root mass. The topsoil layer was underlain by several feet of silty sand, light brown to gray in color with some angular gravels and cobbles increasing in amount with depth.

Rock content was visually estimated in the field. The rock content varied, but generally ranged from 10% to 45% rock < 4 inches in diameter at depths less than 3 feet, and 55% to 95% rock < 8 inches at depths ranging from approximately 3 to 10 feet below ground surface (bgs). The deepest rock was layered to an extent to cause backhoe refusal; however, this material is likely rippable with a bulldozer if excavation in these areas is necessary during repository construction.

Two composite samples were collected and submitted for laboratory analysis. Sample Iron Mask-BA1-A was a composite sample collected from the 0 to 6-inch layer in each of the 8 test pits. Iron Mask-BA1-B was a composite sample representing materials from 6 inches to the bottom of the test pits.

Agronomic analysis results for sample BA1-A indicate recommended fertilizer application rates of 100 pounds of N required per acre. Organic matter content of the sample material is reported as 3.1%; the pH is slightly acidic at 6.5 s.u., and the CEC is 14.7 meq/100g, indicating a moderate potential for attenuating heavy metals. Conductivity of the sample is reported as 0.61 mS/cm.

Agronomic analysis results for sample BA1-B indicate recommended fertilizer application rates of 100 pounds of N, 70 pounds of P_2O_5 and 80 pounds of K_2O are required per acre. Organic matter content of the sample material is reported as 1.3%; the pH is moderately alkaline at 8.1s.u., and the CEC is 15.8 meq/100g, indicating a moderate potential for attenuating heavy metals. Conductivity of the sample is reported as 0.43 mS/cm.

Physical property analysis for sample BA1-B depicts this sample as sandy loam based on USDA soil classification for particle sizes <2mm. The gradation distribution shows a gravel content of 27% based on the ASTM for particle sizes 4.75 to 75mm.

Physical property analysis for sample BA1-B assigned a USDA soil classification of Sandy Loam (for particle sizes <2mm) to the BA1 material. Grain size distribution shows gravel content of 27% (ASTM 4.75-75mm particle size) for the sample.

Although no large volume/bulk gradation analyses were conducted, the visual evaluation of the soil indicated a high percentage of oversize rock (four-inch plus material). Consequently, a four-inch or six-inch grizzly would be desirable to screen the excavated material during construction to eliminate oversize reject rock and create higher quality cover soil. Roughly 75% of the excavated volume would be eliminated as reject oversize rock. In other words, to create the quantity of cover soil needed for the project, approximately 175% of the required cover soil volume would have to be excavated from the BA1. Borrow Area 1 is not considered a practical source of cover soil for the reclamation project.

3.2.5.2 Iron Mask BA2

A total of 16 test pits were excavated at Iron Mask BA2. The test pit locations were selected at random and ranged in depth from to 2.6 to 8.3 feet bgs. Groundwater was not encountered in any of the test pits.

In general, BA2 consisted of a layer of silty loam topsoil typically 0.5 to 3 feet in depth, containing woody debris, grasses, and root mass. The topsoil was underlain by a layer of silty sand, light brown to gray in color with some angular gravels and cobbles increasing in amount with depth.

Higher rock content and shallower depths-to-bedrock were more prevalent at the northwest end of the borrow area. Rock content was visually estimated in the field. The rock content in TP-01, 06, 09, 10, 12 and 13 generally ranged from 85% to 100% rock < 6 inches in diameter at depths ranging from 0.5 to 5.5 feet bgs. Rock content in the remainder of the test pits was much lower,

generally 30% to 60% within the subsoil profile which measured 2 to 5 feet thick. Overall, bedrock ranged in depth from 2.6 to 8.3 feet bgs. The deepest rock was layered to an extent to cause backhoe refusal and is not likely rippable with a bulldozer if excavation in these areas is necessary during repository construction.

Two composite samples were collected and submitted for laboratory analysis. Sample Iron Mask-BA2-A was a composite sample collected from the 0 to 6-inch layer in each of the 8 test pits. Iron Mask-BA2-B was a composite sample representing materials from 6 inches to the bottom of the test pits.

Agronomic analysis results for sample BA2-A indicate recommended fertilizer application rates of 100 pounds of N, 55 pounds of P_2O_5 and 40 pounds of K_2O are required per acre. Organic matter content of the sample material is reported as 2.2%; the pH is neutral at 7.6 s.u., and the CEC is 18.3 meq/100g, indicating a moderate potential for attenuating heavy metals. Conductivity of the sample is reported as 0.67 mS/cm.

Agronomic analysis results for sample BA2-B indicate recommended fertilizer application rates of 100 pounds of N, 60 pounds of P_2O_5 and 80 pounds of K_2O are required per acre. Organic matter content of the sample material is reported as 0.8%; the pH is moderately alkaline at 8.3 s.u., and the CEC is 14.0 meq/100gms, indicating a moderate potential for attenuating heavy metals. Conductivity of the sample is reported as 0.44 mS/cm.

Physical property analysis for sample BA2-B depicts this sample as sandy loam based on USDA soil classification for particle sizes <2mm. The gradation distribution shows a gravel content of 25% based on the ASTM for particle sizes 4.75 to 75mm.

Although no large volume/bulk gradation analyses were conducted, the visual evaluation of the soil indicated a high percentage of oversize rock (four-inch plus material). Consequently, a four-inch or six-inch grizzly would be desirable to screen the excavated material during construction to eliminate oversize reject rock and create higher quality cover soil. Roughly 85% of the excavated volume would be eliminated as reject oversize rock. In other words, to create the quantity of cover soil needed for the project, approximately 185% of the required cover soil volume would have to be excavated from the BA2. Borrow Area 2 is not considered a practical source of cover soil for the reclamation project.

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4.0 SUMMARY OF APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS (ARARs)

This section presents the Montana State and Federal government requirements which are considered ARARs for the reclamation effort. Requirements discussed in this section are chemical-, location-, and action-specific in nature.

Section 121(d)(2) of CERCLA, 42 United States Code (USC) § 9621(d)(2), certain provisions of the current NCP, 40 CFD Part 300 (1990), and guidance policy issued by the EPA require that Remedial Actions (RAs) taken pursuant to CERCLA authority shall require or achieve compliance with substantive provisions of ARARs, criteria, or limitations from the State environmental and facility citing laws, and from Federal environmental laws at the completion of RA, and/or during implementation of the RA, unless a waiver is granted. These requirements are threshold standards that any selected remedy must meet. The EPA calls standards, requirements, criteria, or limitations identified pursuant to Section 121(d) "ARARs."

Two general types of clean up actions are recognized under CERCLA: removal actions and RAs. A removal action is an action to abate, prevent, minimize, stabilize, mitigate, or eliminate a release or threat of release. This action is often temporarily taken to alleviate the most acute threats or to prevent future spread of contamination until more comprehensive action can be taken. A Remedial Investigation (RI) is a thorough investigation, evaluation of alternatives, and determination and implementation of a comprehensive and fully protective remedy for the site.

The ARARs are either applicable or relevant and appropriate. Applicable requirements are those standards, requirements, criteria, or limitations promulgated under Federal or State environmental or facility citing laws that specifically address a hazardous substance, pollutant or contaminant, RA, location, or other circumstances found at a CERCLA site. Relevant and appropriate requirements are those standards, requirements, criteria, or limitations promulgated under Federal environmental or State environmental of facility citing laws that, while not "applicable" to hazardous substances, pollutants, contaminants, RAs, locations, or other circumstances found at a CERCLA site, address problems or situations sufficiently similar to those encountered at the CERCLA site such that their use is well suited to the particular site. Factors that may be considered in making this determination are presented in 40 CFR § 300.400(g)(2). Compliance with both ARARs is mandatory.

Each ARAR or group of related ARARs identified here is followed by a specific statutory or regulatory citation, a classification describing whether the ARAR is applicable or relevant and appropriate and a description that summarizes the requirements, and addresses how and when compliance with the ARAR will be measured. Some ARARs will govern the conduct of the RA, some will define the measure of success of the RA, and some will do both. The descriptions given here are provided to allow the user a reasonable understanding of the requirements without having to refer constantly to the statute of regulation itself. However, in the event of any inconsistency between the law and the summary provided in this document, the ARAR is ultimately the requirement stated in law, rather than any paraphrase of the law provided here. Finally, this list contains a non-exhaustive list of other legal provision or requirements that should be complied with. ARARs are divided into contaminant-specific, location-specific, and action-specific requirements, as described in the NCP and EPA guidance. For contaminant-specific ARARs, ARARs are listed according to appropriate media.

Contaminant-specific ARARs include those laws and regulations governing the release to the environment of materials possessing certain chemical or physical characteristics or containing specific chemical compounds. Contaminant-specific ARARs generally set health or risk based numerical values or methodologies which when applied to site-specific conditions, result in the establishment of numerical values. These values establish the acceptable amount or concentration of a chemical that may be found in, or discharged to, the ambient environment.

Location-specific ARARs are restrictions placed on the concentration of hazardous substances or the conduct of cleanup activities because they are in specific locations. Location-specific ARARs relate to the geographic or physical position of the site, rather than to the nature of the site contaminants. Action-specific ARARs are usually technology or activity based requirements on limitations on actions taken with respect to hazardous substances.

Many requirements here are promulgated as identical or nearly identical requirements in both Federal and State law, usually pursuant to delegated environmental programs administered by EPA and the State, such as the requirements of the Federal Clean Water Act and the Montana Water Quality Act. The preamble to the new NCP states that such a situation results in citation to the state provision as the appropriate standard, but treatment of the provision as a Federal requirement. The ARARs and other laws that are unique to state law are identified separately by the State of Montana.

Appendix D provides detailed descriptions of potential Federal and State ARARs. The description of the Federal and State ARARs that follows includes summaries of legal requirements that in many cases attempt to set out the requirement in a simple fashion useful in evaluating compliance with the requirement. In the event of any inconsistency between the law and the summaries in this section, the ARAR is ultimately the requirement as stated in the law, rather than any paraphrase presented here. Table 4-1 presents quick-reference summaries of preliminary Federal ARARs for the Iron Mask Mine and Mill Site. Table 4-2 presents quick-reference summaries of preliminary State ARARs for the Iron Mask Mine and Mill Site.

Table 4-1. Summary of Preliminary Federal Applicable or Relevant and Appropriate Requirements.

Standard, Requirement Criteria Or Limitation	Citation	Description	ARAR Status
FEDERAL CONTAMINANT-SPECIFIC			
Safe Drinking Water Act	40 USC § 300		Relevant and Appropriate
National Primary Drinking Water Standards	40 CFR Part 141	Establishes health-based standards maximum contaminant levels (MCLs) for public water systems.	Relevant and Appropriate
National Secondary Drinking Water Standards	40 CFR Part 143	Establishes aesthetic-based standards (secondary MCLs) for public water systems.	Relevant and Appropriate
Clean Water Act	33 USC. § 1251-1376		Relevant and Appropriate
Water Quality Standards	40 CFR Part 131 Quality Criteria for Water 1976, 1980, 1986	Sets criteria for water quality based on toxicity to aquatic organisms and human health.	Relevant and Appropriate
National Pollutant Discharge Elimination System (NPDES)	40 CFR Part 122	General permits for discharge from construction.	Relevant and Appropriate
Clean Air Act	42 USC § 7409		
National Primary and Secondary Ambient Air Quality Standards	40 CFR Part 50	Air quality levels that protect public health.	Applicable
Resource Conservation and Recovery Act	42 USC § 6901		
Lists Of Hazardous Waste	40 CFR Part 261, Subpart D	Defines those solid wastes that are subject to regulation as hazardous wastes under 40 CFR Parts 262-265 and Parts 124, 270 and 271.	Applicable

Table 4-1. Summary of Preliminary Federal Applicable or Relevant and Appropriate Requirements (continued)

Standard, Requirement Criteria Or Limitation	Citation	Description	ARAR Status
		FEDERAL LOCATION-SPECIFIC	
National Historic Preservation Act	16 USC § 470; 36 CFR Part 800; 40 CFR 6.310(b)	Requires Federal Agencies to take into account the effect of any Federally-assisted undertaking or licensing on any district, site, building, structure, or object that is included in or eligible for inclusion in the National Register of Historic Places and to minimize harm to any National Historic Landmark adversely or directly effected by an undertaking.	Applicable
Archaeological and Historic Preservation Act	16 USC § 469; 40 CFR § 6.301(c)	Establishes procedures to provide for preservation of historical and archaeological data which might be destroyed through alteration of terrain as a result of a Federal construction project or a Federally licensed activity or program.	Applicable
Protection of Wetlands Order	40 CFR Part 6, Appendix A, Executive Order No. 11,990	Avoid adverse impacts associated with destruction or loss of wetlands and avoid support of new construction in wetlands if a practicable alternative exists.	Applicable
Historic Sites, Buildings and Antiquities Act Appendix A, Executive Order No. 11, 990	16 USC §§ 461-467; 40 CFR § 6.301(a)	Requires Federal agencies to consider the existence and location of landmarks on the National Registry of Natural Landmarks to avoid undesirable impacts on such landmarks.	Applicable
Fish and Wildlife Coordination Act	16 USC §§ 2901-2912; 40 CFR Part 6.302(g)	Requires consultation when Federal department or agency proposes or authorizes any modification of any stream or other water body and adequate provision for protection of fish and wildlife resources.	Applicable
Floodplain Management Order	40 CFR Part 6	Requires Federal agencies to evaluate the potential effects of actions they may take in a floodplain to avoid the adverse impacts associated with direct development of a floodplain.	Applicable

Table 4-1. Summary of Preliminary Federal Applicable or Relevant and Appropriate Requirements (continued)

Standard, Requirement Criteria Or Limitation	Citation	Description	ARAR Status
Endangered Species Act	16 USC §§ 1531-1543; 40 CFR 6.302(h); 50 CFR Part 402	Activities may not jeopardize the continued existence of any threatened or endangered species or destroy or adversely modify a critical habitat.	Applicable
Bald Eagle Protection Act	16 USC §§ 668	Requires consultation with the USFWS during reclamation design and reclamation construction to ensure that any cleanup of the site does not unnecessarily adversely affect the Bald Eagle or Golden Eagle.	Applicable
Migratory Bird Treaty Act	16 USC §§ 703	Establishes a federal responsibility for the protection for the international migratory bird resource and requires consultation with the USFWS during reclamation design and reclamation construction to ensure the cleanup of the site does not unnecessarily impact migratory birds. Specific mitigative measures may be identified for compliance with this requirement.	Applicable

Table 4-1. Summary of Preliminary Federal Applicable or Relevant and Appropriate Requirements (continued)

FEDERAL ACTION-SPECIFIC			
Standard, Requirement Criteria Or Limitation	**Citation**	**Description**	**ARAR Status**
Clean Water Act	33 USC § 1342		Relevant and Appropriate
NPDES	40 CFR Part 122	Requires permits for the discharge of pollutants from any point source into waters of the United States.	Relevant and Appropriate
Surface Mining Control and Reclamation Act	30 USC §§ 1201-1328	Protects the environment from effects of surface mining activities.	Relevant and Appropriate
	30 CFR Part 784	Governs underground mining permit applications and minimum requirements for reclamation and operations plans.	Relevant and Appropriate

Table 4-1. Summary of Preliminary Federal Applicable or Relevant and Appropriate Requirements (continued)

Standard, Requirement Criteria Or Limitation	Citation	Description	ARAR Status
Surface Mining Control and Reclamation Act (continued)	30 CFR Part 816	Outlines permanent program performance standards for surface mining activities.	Relevant and Appropriate
Hazardous Materials Transportation Act	49 USC §§ 1801-1813		Relevant and Appropriate
Standards Applicable to Transporters of Hazardous Waste	40 CFR Part 263	Regulates transportation of hazardous waste.	Relevant and Appropriate
Resource Conservation and Recovery Act			
Land Disposal	40 CFR Part 268	Establishes a timetable for restriction of burial of wastes and other hazardous materials.	Applicable
Criteria for Classification of Solid Waste Disposal Facilities and Practices	40 CFR Part 257	Establishes criteria for use in determining which solid waste disposal facilities and practices pose a reasonable probability of adverse effects on health or the environment and thereby constitute prohibited open dumps.	Applicable
Standards for Transporters of Hazardous Waste	40 CFR Part 263	Establishes standards which apply to persons transporting hazardous waste within the U.S. if the transportation requires a manifest under 40 CFR Part 262.	Applicable
Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities	40 CFR Part 264	Establishes minimum national standards which define the acceptable management of hazardous waste for owners and operators of facilities which treat, store, or dispose of hazardous waste.	Applicable

Table 4-1. Summary of Preliminary Federal Applicable or Relevant and Appropriate Requirements (continued)

Standard, Requirement Criteria Or Limitation	Citation	Description	ARAR Status
Occupational Safety And Health Act	29 USC § 655		
Hazardous Waste Operations And Emergency Response	29 CFR 1910.120	Defines standards for employee protection during initial site characterization and analysis, monitoring activities, materials handling activities, training & ER.	Applicable

Table 4-2. Summary of Preliminary State Applicable or Relevant and Appropriate Requirements

Standard, Requirement Criteria Or Limitation	Citation	Description	ARAR Status
STATE CONTAMINANT-SPECIFIC			
Montana Water Quality Act	75-101 et seq., MCA	Laws to prevent, abate, and control the pollution of state waters.	Applicable
		Provides the water use classification for various streams and imposes specific water quality standards per classification.	
Regulations Establishing Ambient Surface Water Quality Standards	ARM 16.20.604-624		Applicable
Regulations Establishing Ambient Surface Water Quality Nondegradation Standards	ARM 16.20.707-714	Applies nondegradation requirements to any activity which could cause a new or increased source of pollution to State waters and outlines review procedures.	Applicable
Regulations Establishing Waste Treatment Standards	ARM 16.20.631-633	Imposes waste treatment requirements to restore and maintain the quality of surface waters to applicable water use categories. Treatment standards are based on the State's policy of nondegradation, and present and anticipated beneficial uses of the receiving waters.	Applicable
	ARM 16.20.925	Technology-based treatment for MPDES permits.	Applicable
Montana Groundwater Pollution Control System Regulations	ARM 16.20.1002	Classifies groundwater into Classes I through IV based on the present and future most beneficial uses of the groundwater and states groundwater is to be classified to actual quality or actual use, whichever places the groundwater in a higher class.	Applicable
	ARM 16.20.1003	Establishes groundwater quality standards for groundwater classification, and should be consulted.	Applicable

Table 4-2. Summary of Preliminary State Applicable or Relevant and Appropriate Requirements (continued)

Standard, Requirement Criteria Or Limitation	Citation	Description	ARAR Status
Montana Groundwater Pollution Control System Regulations (continued)	ARM 16.20.1011	Requires that any groundwater whose existing quality is higher than the standard for its classification must be maintained at that high quality unless degradation is allowed under the principles established in 75-3-303 MCA, and the nondegradation rules at ARM 16.20.706 et.seq.	Applicable
Public Water Supplies Act	75-6-101, MCA	Establishes public policy of MT to "protect, maintain, and improve the quality and potability of water for public water supplies and domestic uses".	Relevant and Appropriate
Public Water Supply Regulations	ARM 16.20.204	Establishes maximum contaminant levels (MCLs) for inorganic chemicals in community water systems.	Relevant and Appropriate
	ARM 16.20.205	Establishes the maximum turbidity contaminant levels for public water supply systems which use surface water in whole or in part.	Relevant and Appropriate
	ARM 16.20.922	Adopts and incorporates language for toxic pollutant effluent standards found in 40 CFR Part 129.	Relevant and Appropriate
	ARM 16.20.923	Adopts and incorporates language for effluent limitations and standards of performance found in 40 CFR Subpart N (except 40 CFR Part 403).	Relevant and Appropriate

Table 4-2. Summary of Preliminary State Applicable or Relevant and Appropriate Requirements (continued)

Standard, Requirement Criteria Or Limitation	Citation	Description	ARAR Status
Clean Air Act Of Montana	75-2-102, MCA	It's Montana's policy is to achieve and maintain such levels of air quality as will protect human health and safety and, to the greatest degree practicable, prevent injury to plant and animal life and property.	
Air Quality Regulations	ARM 16.8.815	No person shall cause or contribute to concentrations of lead in the ambient air which exceed the following 90-day average: 1.5 micrograms per cubic meter of air.	Applicable
	ARM 16.8.818	No person shall cause or contribute to concentrations of particulate matter in the ambient air such that the mass of settled particulate matter exceeds the following 30-day average: 10 grams per square meter.	Applicable
	ARM 16.8.821	No person may cause or contribute to concentrations of PM-10 in the ambient air which exceed the following standard: 1) 24-hr. avg.: 150 micrograms per cubic meter of air, with no more than one expected exceedance per year; 2) Annual avg.: 50 micrograms per cubic meter of air.	Applicable
	ARM 16.8.1302	Lists certain wastes that may not be disposed of by open burning, including oil or petroleum products, RCRA hazardous wastes, chemicals, and treated lumber and timbers.	Relevant and Appropriate

Table 4-2. Summary of Preliminary State Applicable or Relevant and Appropriate Requirements (continued)

Standard, Requirement Criteria Or Limitation	Citation	Description	ARAR Status
Air Quality Regulations (continued)	ARM 16.8.1401	States "no person shall cause or authorize the production, handling, transportation or storage of any material unless reasonable precautions to control emissions of airborne particulate matter are taken."	Applicable
	ARM 16.8.1404	States no person shall cause opacity of 20% over 6 minutes.	Applicable
	ARM 16.8.1424	Sets forth emission standards for hazardous air pollutants.	Applicable
	ARM 26.4.761	Requires a fugitive dust control program be implemented in reclamation operations.	Relevant and Appropriate
Occupational Health Act of Montana	50-70-101, MCA	The purpose of this act is to achieve and maintain such conditions of the work place as will protect human health and safety.	Applicable
Occupational Air Contaminants Requirements	ARM 16.42.102	Establishes maximum threshold limit values for air contaminants believed that nearly all workers may be repeatedly exposed day after day without adverse health effects.	Applicable
Occupational Noise Regulations	ARM 16.42.101	Addresses occupational noise levels and provides that no worker shall be exposed to noise levels in excess of specified levels.	Applicable

Table 4-2. Summary of Preliminary State Applicable or Relevant and Appropriate Requirements (continued)

Standard, Requirement Criteria Or Limitation	Citation	Description	ARAR Status
		STATE LOCATION-SPECIFIC	
Floodplain and Floodway Management Act	76-5-401, MCA	Limits the uses permissible in a floodway and generally prohibits permanent structures, fill, or permanent storage of materials or equipment.	Applicable
	76-5-402 MCA	Lists the permissible uses within the floodplain but outside of floodway.	Applicable
	76-5-403, MCA	Lists certain uses which are prohibited in a designated floodway, including any change that will cause water to be diverted from the established floodway, cause erosion, obstruct the natural flow of water, or reduce the carrying capacity of the floodway, or the concentration or permanent storage of an object subject to flotation or movement during flood level periods.	Applicable
Floodplain Management Regulations	ARM 36.15.216	The factors to consider in determining whether a permit should be issued to establish or alter an artificial obstruction or nonconforming use in the floodplain or floodway are set forth in this section.	Applicable
	ARM 36.15.601	Open space uses allowed in the floodway without a permit.	Applicable
	ARM 36.15.602	Uses allowed in the floodway, which require a permit.	Applicable

Table 4-2. Summary of Preliminary State Applicable or Relevant and Appropriate Requirements (continued)

Standard, Requirement Criteria Or Limitation	Citation	Description	ARAR Status
Floodplain Management Regulations (continued)	ARM 36.15.603	Proposed diversions or changes in place of diversions must be evaluated by DNRC to determine whether they may significantly affect flood velocities.	Applicable
	ARM 36.15.604	Prohibits new artificial obstructions or nonconforming uses that will significantly increase the upstream elevation of the base flood 0.5 feet or significantly increase flood velocities.	Applicable
	ARM 36.15.605	Identifies artificial obstructions and nonconforming uses that are prohibited within the designated floodway except as allowed by permit and includes "a structure or excavation that will cause water to be diverted from the established floodway, cause erosion, obstruct the natural flow of water, or reduce the carrying capacity of the floodway...". Solid waste disposal and storage of highly toxic, flammable, or explosive materials are also prohibited.	Applicable
	ARM 36.15.606	Identifies flood control works that are allowed with designated floodways pursuant to permit and certain conditions including: flood control levies and flood walls, riprap, channelization projects, and dams.	Applicable
	ARM 36.15.701	Describes allowed uses in the flood fringe.	Applicable

Table 4-2. Summary of Preliminary State Applicable or Relevant and Appropriate Requirements (continued)

Standard, Requirement Criteria Or Limitation	Citation	Description	ARAR Status
Floodplain Management Regulations (continued)	ARM 36.15.703	Prohibited uses within the flood fringe including solid and hazardous waste disposal and storage of toxic, flammable, or explosive materials.	Applicable
	ARM 36.15.801	Allowed uses where the floodway is not designated or where no flood elevations are available.	Applicable
Natural Streambed and Land Preservation Standards	87-5-501, 502, and 504, MCA	Fish and wildlife resources are to be protected and no construction project or hydraulic project shall adversely affect game or fish habitat.	Applicable
	ARM 36.2.404	Proposed projects are to be evaluated by the appropriate conservation district based on criteria : 1) whether the project will pass anticipated sediment loads without creating harmful flooding or erosion problems upstream or downstream; 2) whether the project will minimize the amount of stream channel alteration; 3) whether the project will be as permanent a solution as possible and whether the method used will create a reasonably permanent and stable situation; 4) whether the project will minimize effects of fish and aquatic habitat; 5) whether the project will minimize turbidity or other water pollution problems; and , 6) whether the project will minimize adverse effects on the natural beauty of the area.	Applicable

Table 4-2. Summary of Preliminary State Applicable or Relevant and Appropriate Requirements (continued)

Standard, Requirement Criteria Or Limitation	Citation	Description	ARAR Status
Antiquities Act	22-3-424, MCA	Heritage and paleontological sites are given appropriate consideration.	Relevant and Appropriate
	22-3-433, MCA	Evaluation of environmental impacts include consultation with State Historic Preservation Officer (SHPO).	Relevant and Appropriate
	2-3-435, MCA	A heritage or paleontological site is to be reported to the SHPO.	Relevant and Appropriate
Cultural Resource Regulations	ARM 12.8.503-508	Procedures to ensure adequate consideration of cultural values.	Relevant and Appropriate
STATE ACTION SPECIFIC			
Montana Water Quality Act	75-5-605, MCA	Pursuant to this section, it is unlawful to cause pollution of any state waters, to place any wastes in a location where they are likely to cause pollution of any state waters, to violate any permit provision, to violate any provision of the Montana Water Quality Act, to construct, modify, or operate a system for disposing of waste (including sediment, solid waste and other substances that may pollute state waters) which discharge into any state waters without a permit or discharge waste into any state waters.	Applicable
Montana Surface Water Quality Regulations	ARM 16.20.631	Industrial waste must receive treatment equivalent to the best practicable available control technology.	Applicable
	ARM 16.20.604-624	Provides for classification of state waters.	Applicable

Table 4-2. Summary of Preliminary State Applicable or Relevant and Appropriate Requirements (continued)

Standard, Requirement Criteria Or Limitation	Citation	Description	ARAR Status
Montana Surface Water Quality Regulations (continued)	ARM 16.20.625	Technology-based treatment for MPDES permits.	Applicable
	ARM 16.20.633	Requires that the State's surface waters be free from, among other things, substances that will create concentrations or combinations of materials that are harmful to human, animal, plant, or aquatic life. Moreover, no waste may be discharged and no activities may be conducted that can reasonably be expected to violate any of the standards.	Applicable
Nondegradation of Water Quality	ARM 16.20.708-714	Applies nondegradation requirements to any activity which would cause a new or increased source of pollution to state waters and outlines review procedures.	Applicable
Montana Groundwater Act			
Montana Groundwater Pollution Control System Regulations	ARM 16.20.1011	Requires that any ground water whose existing quality is higher than the standard for its classification must be maintained at that high quality in accordance with 75-5-303, MCA, and ARM 16.2.701 et.seq.	Applicable
	ARM 16.20.1002	Classifies groundwater into Classes I through IV based on the present and future most beneficial uses of the groundwater and states groundwater, and states that groundwater is to be classified to actual quantity or actual use, which ever places the groundwater in a higher class.	Applicable

Table 4-2. Summary of Preliminary State Applicable or Relevant and Appropriate Requirements (continued)

Standard, Requirement Criteria Or Limitation	Citation	Description	ARAR Status
Montana Groundwater Pollution Control System Regulations (continued)	ARM 16.20.1003	Establishes groundwater quality standards for groundwater classification.	Applicable
Clean Air Act Of Montana	75-2-102, MCA	It's Montana's policy is to "achieve and maintain such levels of air quality as will protect human health and safety and, to the greatest degree practicable, prevent injury to plant and animal life and property, foster the comfort and convenience of the people, promote the economic and social development of this state, and facilitate the enjoyment of the natural attractions of this state".	Applicable
Air Quality Requirements	ARM 16.8.815	No person shall cause or contribute to concentrations of lead in the ambient air which exceed the following 90-day average: 1.5 micrograms per cubic meter of air.	Applicable
	ARM 16.8.1302	Lists certain wastes that may not be disposed of by open burning.	Applicable
	ARM 16.8.1401 and 1404	No person shall cause or authorize the production, handling, transportation or storage of any material unless reasonable precautions to control emissions of airborne particulate matter are taken.	Applicable
Montana Solid Waste Management Act	75-10-201 et.seq., MCA	Public policy is to "control solid waste management systems to protect the public health and safety and to conserve natural resources whenever possible".	Applicable

Table 4-2. Summary of Preliminary State Applicable or Relevant and Appropriate Requirements (continued)

Standard, Requirement Criteria Or Limitation	Citation	Description	ARAR Status
Solid Waste Management Regulations	ARM 16.14.505 and 508-509	The standards for solid waste disposal are set forth in this provision and include: preclusion against location of solid waste disposal sites in a 100-year floodplain, a requirement that sites be located only in areas that will prevent the pollution of ground and surface waters and public and private water supplies, a requirement for drainage structures to be installed where necessary to prevent surface runoff from entering disposal areas and a requirement that sites be located to allow for reclamation. The standards also provide the process for applying for a solid waste management system license and operation and maintenance plan requirements.	Applicable
	ARM 16.14.520-521	General operational and maintenance requirements for solid waste management facilities.	Applicable
	ARM 16.14.523	Solid waste must be transported in such a manner as to prevent its discharge, dumping, spilling or leaking from the transport vehicle.	Applicable
Montana Hazardous Waste Act and Underground Storage Tank Act	5-10-402, MCA	It's the policy of the State to "protect the public health and safety, the health of living organisms, and the environment from the effects of the improper, inadequate, or unsound management of hazardous wastes".	Applicable

Table 4-2. Summary of Preliminary State Applicable or Relevant and Appropriate Requirements (continued)

Standard, Requirement Criteria Or Limitation	Citation	Description	ARAR Status
Montana Hazardous Waste Regulations	ARM 17.54.701-705	By reference to federal regulatory requirements, these sections establish standards for all permitted hazardous waste management facilities. 1) 40 CFR 264.11 (incorporated by reference in ARM 17.54.702) establishes that hazardous waste management facilities must be closed in such a manner as to minimize the need for further maintenance and to control, minimize or eliminate, to the extent necessary to protect public health and the environment, post-closure escape of hazardous wastes, hazardous constituents, leachate, contaminated runoff or hazardous waste decomposition products to the ground or surface waters or the atmosphere. 2) 40 CFR 264.228(a) (incorporated by reference by ARM 17.54.702) requires that at closure, free liquids must be removed or solidified, the wastes stabilized and the waste management unit covered. 3) 40 CFR 264.228 and 310 (incorporated by reference by ARM 17.54.702) requires that surface impoundments and landfill caps must: (a) provide long-term minimization of migration of liquids through the unit; (b) function with minimum maintenance; (c) promote drainage and minimize erosion or abrasion of the final cover;	Relevant and Appropriate

Table 4-2. Summary of Preliminary State Applicable or Relevant and Appropriate Requirements (continued)

Standard, Requirement Criteria Or Limitation	Citation	Description	ARAR Status
Montana Hazardous Waste Regulations (continued)	ARM 17.54.701-705 (continued)	d) accommodate settling and subsidence; and (e) have a permeability less than or equal to the permeability of the natural subsoil present. 4) 40 CFR 264.119 (incorporated by reference in ARM 17.54.702) requires that, no later than 60 days after certification of closure of each hazardous waste disposal unit, the owner or operator submit a record of the type, location, and quantity of hazardous waste disposed in each unit. The regulation also gives time limits for recording a deed restriction, in accordance with state law, that will, in perpetuity, notify potential purchasers that the property has been used for waste disposal and that its use is restricted.	
	ARM 17.54.111-119	Establishes permit conditions, duration of permits, schedules of compliance, and requirements for recording and reporting.	
	ARM 17.54.130-131	Establishes contents of permit application.	
Montana Strip and Underground Mine Reclamation Act	82-4-231, MCA	Sets forth objectives that require the operator to reclaim and revegetate the land affected by his operation.	Relevant and Appropriate

Table 4-2. Summary of Preliminary State Applicable or Relevant and Appropriate Requirements (continued)

Standard, Requirement Criteria Or Limitation	Citation	Description	ARAR Status
Montana Strip and Underground Mine Reclamation Act (continued)	82-4-233, MCA	Requires that after the operation has been backfilled, graded, topsoiled and approved, the operator shall establish a vegetative cover on all impacted lands.	Relevant and Appropriate
		Specifications for the vegetative cover and performance are provided.	Relevant and Appropriate
Backfilling and Grading Requirements	ARM 26.4.501	Gives general backfilling and grading requirements.	Relevant and Appropriate
	ARM 26.4.501A	Final grading requirements.	Relevant and Appropriate
	ARM 26.4.504	Provides that permanent impoundments may be retained under certain circumstances.	Relevant and Appropriate
	ARM 26.4.514	Gives contouring requirements.	Relevant and Appropriate
	ARM 26.4.519	The operator may be required to monitor settling of regraded areas.	Relevant and Appropriate
	ARM 26.4.520	Spoil material may be disposed of on-site in accordance with requirements of this section. Contains specific requirements for siting, surface runoff, construction of underdrains and revegetation.	Relevant and Appropriate
Hydrology Requirements	ARM 26.4.631	Reclamation operations must be planned and conducted to minimize disturbance to the prevailing hydrologic balance and to prevent material damage to the prevailing hydrologic balance.	Relevant and Appropriate

Table 4-2. Summary of Preliminary State Applicable or Relevant and Appropriate Requirements (continued)

Standard, Requirement Criteria Or Limitation	Citation	Description	ARAR Status
Hydrology Requirements (continued)	ARM 26.4.633	Specifies that sediment controls must be maintained until the disturbed area has been restored and revegetation established.	Relevant and Appropriate
	ARM 26.4.634	Drainage design shall emphasize channel and floodplain premining configuration that blends with the undisturbed drainage system above and below, and will meander naturally, remain in dynamic equilibrium with the system, improve unstable premining condition, provide for floods, provide for long term stability of landscape, and establish a premining diversity of aquatic habitats and riparian vegetation.	Relevant and Appropriate
	ARM 26.4.635-637	Sets forth requirements for temporary and permanent diversions.	Relevant and Appropriate
	ARM 26.4.638	Sediment control measures shall be designed using the best technology currently available to prevent additional sediment to streamflows, meet the more stringent of federal or state effluent limitation, and minimize erosion.	Relevant and Appropriate
	ARM 26.4.640	Provides that discharge from sedimentation ponds, permanent and temporary impoundments, and diversions shall be controlled by energy dissipaters, riprap channels, and other devices, where necessary, to reduce erosion, prevent deepening or enlargement of stream channels, and to minimize disturbance of the hydrologic balance.	Relevant and Appropriate

Table 4-2. Summary of Preliminary State Applicable or Relevant and Appropriate Requirements (continued)

Standard, Requirement Criteria Or Limitation	Citation	Description	ARAR Status
Hydrology Requirements (continued)	ARM 26.4.641	Sets forth methods for prevention of drainage from acid-and toxic-forming spoils into ground and surface waters.	Relevant and Appropriate
	ARM 26.4.642	Prohibits permanent impoundments with certain exceptions, and sets standards for temporary and permanent impoundments.	Relevant and Appropriate
	ARM 26.4.643-646	Provide for groundwater protection, groundwater recharge protection, and surface and groundwater monitoring.	Relevant and Appropriate
	ARM 26.4.649	Prohibits the discharge, diversion, or infiltration of surface and groundwater into existing underground mine workings.	
	ARM 26.4.650	All permanent sedimentation ponds, diversions, impoundments, and treatment facilities must be renovated postmining, to meet criteria specified in the design plan. All such temporary structures shall be regraded to the approximate original contour.	Relevant and Appropriate Relevant and Appropriate
Top Soiling, Revegetation, and Protection of Wildlife and Air Resource Regulations	ARM 26.4.701-702	Requirements for stockpiling soil.	Relevant and Appropriate
	ARM 26.4.703	Materials other than, or along with, soil for final surfacing of spoils or other disturbances must be capable of supporting the approved vegetation and postmining land use.	Relevant and Appropriate

Table 4-2. Summary of Preliminary State Applicable or Relevant and Appropriate Requirements (continued)

Standard, Requirement Criteria Or Limitation	Citation	Description	ARAR Status
Top Soiling, Revegetation, and Protection of Wildlife and Air Resource Regulations (continued)	ARM 26.4.711	The section requires "a diverse, effective, and permanent vegetative cover of the same seasonal variety native to the area affected and capable of meeting the criteria set forth in 82-4-233 shall be established on all areas of land affected except water areas and surface areas of roads".	Relevant and Appropriate
	ARM 26.4.713	Specifies that seeding and planting of disturbed areas must be conducted during the first appropriate period for favorable planting after final seedbed preparation; but not longer than 90 days after top soil placement.	Relevant and Appropriate
	ARM 26.4.714	According to this section, as soon as practical, a mulch or cover crop must be used on all regraded and resoiled areas to control erosion, to promote germination of seeds, and to increase moisture retention of soil until permanent cover is established.	Relevant and Appropriate
	ARM 26.4.716	Establishes the required method of revegetation and provides that introduced species may be substituted for native species as part of an approved plan.	Relevant and Appropriate
	ARM 26.4. 717	Whenever tree species are necessary, trees adapted for local site conditions and climate shall be used.	Relevant and Appropriate

Table 4-2. Summary of Preliminary State Applicable or Relevant and Appropriate Requirements (continued)

Standard, Requirement Criteria Or Limitation	Citation	Description	ARAR Status
Top Soiling, Revegetation, and Protection of Wildlife and Air Resource Regulations (continued)	ARM 26.4.718	Soil amendments must be used as necessary to aid in the establishment of permanent vegetation. Irrigation, management, fencing, or other measures may also be used after review and approval by the department.	Relevant and Appropriate
	ARM 26.4.719	Livestock grazing on reclaimed land is prohibited until revegetation is established and can sustain managed grazing.	Relevant and Appropriate
	ARM 26.4.720	Sets annual department inspection requirements.	Relevant and Appropriate
	ARM 26.4.721	Section specifies that rills and gullies greater than 9 inches which form on the reclaimed area must be filled, graded or otherwise stabilized and the area reseeded.	Relevant and Appropriate
	ARM 26.4.723	Monitoring of vegetation, soils and wildlife.	Relevant and Appropriate
	ARM 26.4.724	Success of revegetation shall be measured on the basis of unmined reference areas.	Relevant and Appropriate
	ARM 26.4.725	Sets periods of responsibility and evaluation.	Relevant and Appropriate
	ARM 26.4.726	Sets means of measuring productivity.	Relevant and Appropriate
	ARM 26.4.728	Sets requirements for composition of vegetation.	Relevant and Appropriate

Table 4-2. Summary of Preliminary State Applicable or Relevant and Appropriate Requirements (continued)

Standard, Requirement Criteria Or Limitation	Citation	Description	ARAR Status
Top Soiling, Revegetation, and Protection of Wildlife and Air Resource Regulations (continued)	ARM 26.4.730-731	Revegetated area must furnish palatable forage in comparable quantity and quality during the same grazing period as the reference area.	Relevant and Appropriate
	ARM 26.4.733	Sets requirements and measurement standards for trees, shrubs, and half-shrubs.	Relevant and Appropriate
	ARM 26.4.751	Section requires that site activities must be conducted so as to avoid or minimize impacts to important fish and wildlife species, including critical habitat and any threatened and endangered species identified at the site.	Relevant and Appropriate
	ARM 26.4.761	Section requires fugitive dust control measures for site preparation and reclamation operations.	Relevant and Appropriate

5.0 BASELINE HUMAN HEALTH AND ECOLOGICAL RISK ASSESSMENTS

This section presents a summary of the baseline human health and ecological risk assessments performed for the site. Contaminant sources, routes of exposure, and receptors are evaluated to determine the relative threats posed by each source within the project boundary and each exposure pathway.

The baseline human health risk assessment performed for the Iron Mask Mine and Mill Site follows the Federal Remedial Investigation/Feasibility Study (RI/FS) process for CERCLA (Superfund) sites (EPA, 1988 and 1989a). The baseline human health risk assessment examines the effects of taking no further actions at the site. This baseline risk assessment involves two steps: hazard identification and risk characterization. These tasks are accomplished by evaluating available data and selecting COCs, comparing those concentrations to previously derived standards or risk-based benchmarks, and characterizing overall risk by integrating the results of the comparison. This risk assessment is performed to determine whether waste materials at the Iron Mask Mine and Mill Site could adversely impact human health or the environment.

5.1 HUMAN HEALTH RISK ASSESSMENTS

5.1.1 Hazard Identification

The initial task of the risk assessment is to select the COCs at the site to identify those that may pose significant potential human health risks. Standard criteria for this selection include:

1. Those contaminants that are associated with and are present at the site;

2. Contaminants in waste sources with concentrations significantly above background levels; and

3. Contaminants with acceptable Quality Assurance/Quality Control (QA/QC) results applied to the data.

Waste materials at the Iron Mask Mine and Mill Site were analyzed for a list of 13 elements. Nine of these analytes are present at the site at concentrations significantly above background (greater than 3 times the average background concentration): Sb, As, Cd, Cu, Pb, Mn, Hg, Ag, and Zn. These nine COCs are retained for detailed evaluation in the human health risk assessment.

5.1.2 Exposure Scenarios

The following section describes the exposure scenarios assumed for the Iron Mask Mine and Mill Site. The exposure assessment identifies the potentially exposed population(s) and exposure pathways and estimates exposure point concentrations and contaminant intakes. Previously derived risk-based clean up goals were calculated using two exposure scenarios: a recreational use scenario (Ford, 2004) and a residential use scenario (EPA, 2008).

5.1.2.1 Residential Scenario

While the anticipated uses of the Iron Mask Mine and Mill Site include recreational use and elk habitat, the residential occupation scenario is evaluated as a reasonable maximum exposure (RME) based on standard EPA practice. Risk-based concentrations were derived for this worst-case residential exposure scenario by the EPA (updated in 2008) as Regional Screening Levels (RSLs), and are presented in Table 5-1. Ford (2004) also provides criteria for residential occupation; however, the more widely-used EPA criteria were chosen for this scenario.

TABLE 5-1
RESIDENTIAL SCENARIO
REGIONAL SCREENING LEVELS (RSLs)
FOR CONTAMINANTS OF CONCERN (EPA, 2008)

Contaminant of Concern	Residential Soil Concentration (mg/kg)	Residential Water Concentration (µg/L)
Antimony	31	15
Arsenic (carc. @1.0E-06)	0.39	0.045
Cadmium	70	18
Copper	3,100	1,500
Lead	400	15*
Manganese	1,800	880
Mercury	23	11
Silver	390	180
Zinc	23,000	11,000

mg/kg – milligrams per kilogram; µg/L – micrograms per Liter
carc. = Carcinogenic effects concentration.
*Lead in drinking water is EPA Action Level and DEQ-HHS, not from RSL table.

5.1.2.2 Recreational Scenario

The EPA does not provide recreational use criteria; however, the BLM has developed Human Risk Management Criteria for exposures at mining sites in a report titled *Risk Management Criteria for Metals at BLM Mining Sites* (Ford, 2004). These criteria were developed using a risk assessment that assumed two recreational use exposures: campers and ATV drivers. The BLM camper recreational use scenario was used to assess overall recreational risks at the Iron Mask Mine and Mill Site, as this would be the most conservative (highest) recreational exposure and more closely represents the anticipated use of the site. Criteria for the recreational scenario are presented in Table 5-2.

TABLE 5-2
RECREATIONAL SCENARIO
HUMAN RISK MANAGEMENT CRITERIA
FOR CONTAMINANTS OF CONCERN (FORD, 2004)

Contaminant of Concern	Recreational Soil Concentration – Camper (mg/kg)	Recreational Water Ingestion (µg/L)
Antimony	50	124
Arsenic	20	93
Cadmium	70	155
Copper	5,000	11,490
Lead	1,000	50
Manganese	19,000	1,548
Mercury	40	93
Silver	700	1,548
Zinc	40,000	92,909

mg/kg – milligrams per kilogram; µg/L – micrograms per Liter

5.1.2.3 Exposure Routes

The soil exposure route utilized the 95th percentile upper confidence limit (UCL) of the mean concentration of the 13 solid waste samples (waste rock and mill tailings) collected during the 2008 site investigation.

According to the *Supplemental Guidance to Risk Assessment Guidance for Superfund (RAGS): Calculating the Concentration Term* (EPA, 1992), the 95th percentile UCL of a mean is defined as a value that, when calculated repeatedly for randomly drawn subsets of site data, equals or exceeds the true mean 95% of the time. The 95th percentile UCL provides a conservative estimate of the average (or mean) concentration and is typically used in risk assessment as a conservative estimate of source concentrations that an individual may be exposed to at the site, also known as the RME concentration. In cases where a reliable value cannot be calculated for the 95th percentile UCL due to insufficient data points, the maximum concentration would be used.

The drinking water ingestion route was evaluated using the maximum total metals concentrations in surface water samples collected immediately downstream from the site wastes. Characterization data used in the human health risk assessments are presented in Table 5-3.

TABLE 5-3
CHARACTERIZATION DATA
FOR THE IRON MASK MINE AND MILL SITE

Contaminant of Concern	All Site Wastes – 95th % UCL (mg/kg)	Surface Water Water (µg/L)
Antimony	7.53	ND
Arsenic	967	9.0
Cadmium	138	1.0
Copper	524	ND
Lead	7,600	40
Manganese	20,300	60
Mercury	1.34	ND
Silver	37.2	ND
Zinc	18,500	150

mg/kg – milligrams per kilogram
µg/L – micrograms per Liter
ND – not detected

5.1.3 Toxicity Assessment

The toxicity assessment examines the potential for the COCs to cause adverse effects in exposed individuals and provides an estimate of the dose-response relationship between the extent of exposure to a particular contaminant and adverse effects. Adverse effects include both non-carcinogenic and carcinogenic health effects in humans. Sources of toxicity data include the EPA's Integrated Observed Effects Level (IRIS), Agency for Toxic Substances and Disease Registry (ATSDR) Toxicological Profiles, Health Effects Assessment Summary Table (HEAST), EPA criteria documents, and various references cited by Ford (2004). The ATSDR summaries for the nine COCs are included in Appendix E. Effects of ingesting secondary contaminants in drinking water are summarized by the Montana Department of Health and Human Services and are also included in Appendix E.

The risk-based concentration criteria that were used to characterize risks from exposure to the COCs for each scenario are presented in Table 5-1 for the Residential Scenario (EPA, 2008) and Table 5-2 for the Recreational Scenario (Ford, 2004). The concentrations listed correspond to hazard quotients (HQ) equal to 1.0.

Note that the As screening concentrations in Table 5-1 are for the 1.0 E-06 carcinogenic risk level. Using a 1.0 E-05 carcinogenic risk level, the As screening concentrations would be 10 times higher (3.9 mg/kg and 0.45 µg/L). At an even higher carcinogenic risk level of 1.0 E-04, the As screening concentrations would be 100 times higher (39 mg/kg and 4.5 µg/L). This is important because the 0.39 mg/kg soil screening concentration is more than an order of magnitude below both the western U.S. mean soil arsenic concentration of 5.5 mg/kg (Shacklette and Boerngen, 1984) and the Iron Mask Mine and Mill Site specific mean background As concentration of 17.3 mg/kg (2008 investigation). The EPA utilizes a 1.0E-06 cancer risk value as a point of departure in assessing the need for contaminant clean up at a particular site; at Superfund sites, acceptable cancer risk levels are generally between 1.0E-04 and 1.0E-06.

5.1.4 Risk Characterization

5.1.4.1 Residential Scenario

The residential exposure assumptions were utilized to estimate contaminant intakes and were compared to the RSLs from Table 5-1. These data were used to calculate residential human health Hazard Quotients (HQs) for each COC. The COC-specific HQs were generated by dividing the on-site waste concentrations from Table 5-3 by the RSL concentrations. The results of the risk calculations for the residential land use scenario at the Iron Mask Mine and Mill Site are summarized in Table 5-4.

TABLE 5-4
SUMMARY OF HAZARD QUOTIENTS (HQ)
FOR THE RESIDENTIAL SCENARIO
AT THE IRON MASK MINE AND MILL SITE

HQ Summary	Soil - Combined	Water Ingestion	HQ Total
Antimony	0.24	0.00	0.24
Arsenic @1.0E-06 carc. risk	2,479.49	200.00	2,679.49
Arsenic @1.0E-05 carc. risk	247.95	20.00	267.95
Arsenic @1.0E-04 carc. risk	24.79	2.00	26.79
Cadmium	1.97	0.06	2.03
Copper	0.17	0.00	0.17
Lead	19.00	2.67	21.67
Manganese	11.28	0.07	11.35
Mercury	0.06	0.00	0.06
Silver	0.10	0.00	0.10
Zinc	0.80	0.01	0.82

The HQ values exceed 1.0 for the residential scenario for four COCs (As, Cd, Pb, and Mn) via the soil exposure pathway and for As and Pb via the water ingestion pathway. The HQ values greater than 1.0 indicate the potential for harmful effects by a COC via the specified pathway. Soil exposure to As comprises the majority of the potential residential risk at the site (total HQ value of 2,680) using the 1.00E-06 carcinogenic risk level. However, if a higher carcinogenic risk level for As is used, the HQ value is reduced.

The EPA utilizes the 1.0E-06 carcinogenic risk level as a point of departure in assessing the need for contaminant clean up at a particular site; at Superfund sites, acceptable carcinogenic risk levels are generally between 1.0E-04 and 1.0E-06. If the carcinogenic risk level is increased to 1.0E-05, the As HQs are reduced by a factor of 10 (to 247.95 and 20.00, respectively). At 1.0E-04 carcinogenic risk, As HQs are reduced by a factor of 100 (to 24.79 and 2.00, respectively). These are still quite elevated with respect to the "no effect" level of HQ=1.0.

5.1.4.2 Recreational Scenario

The recreational exposure assumptions were utilized to estimate contaminant intakes and were compared to the BLM camper risk management criteria from Table 5-2. These data were used to

calculate recreational human health HQs for each COC. The results of the risk calculations for the recreational scenario at the Iron Mask Mine and Mill Site are summarized in Table 5-5.

TABLE 5-5
SUMMARY OF HAZARD QUOTIENTS (HQ)
FOR THE RECREATIONAL SCENARIO
AT THE IRON MASK MINE AND MILL SITE

HQ Summary	Soil - Combined	Water Ingestion	HQ Total
Antimony	0.15	0.00	0.15
Arsenic	48.35	0.10	44.45
Cadmium	1.97	0.01	1.98
Copper	0.10	0.00	0.10
Lead	7.60	0.80	8.40
Manganese	1.07	0.04	1.11
Mercury	0.03	0.00	0.03
Silver	0.05	0.00	0.05
Zinc	0.46	0.00	0.46

The HQs presented in Table 5-5 yield the following. First, HQ values exceed 1.0 for 4 COCs, (As, Cd, Pb, and Mn) via the soil exposure routes. The HQ values greater than 1.0 indicate the potential for harmful effects by a COC via the specified pathway(s). The As and Pb HQs provide the majority of the potential for adverse human health effects for the recreational scenario.

5.1.5 Human Health Risk Assessment Summary

The residential exposure scenario yields HQ values as high as 2,680 for As (at a carcinogenic risk level of 1.0E-06). This indicates that As concentrations are 2 orders of magnitude higher at this site than considered "safe" for residential occupation (at a carcinogenic risk level of 1.0E-06). At higher carcinogenic risk levels, the HQ values are lower, but still exceed "safe" residential concentrations. These levels may be acceptable considering the anticipated land use for the site does not include residential occupation.

The recreational exposure scenario yields HQ values via soil exposures as high as 48 for As and more than 7 for Pb. This indicates that COC concentrations in soil are more than 40 times higher at this site than considered "safe" for recreational activities.

5.2 ECOLOGICAL RISK EVALUATION

A screening level ecologic risk evaluation was performed for the Iron Mask Mine and Mill Site following Federal RI/FS guidance for CERCLA (Superfund) sites (EPA, 1988). The key guidance documents used were EPA's *Risk Assessment Guidance for Superfund, Volume II, Environmental Evaluation Manual* (EPA, 1989a), and *Ecological Assessment of Hazardous Waste Sites* (EPA, 1989b). Due to the sparse and indirect nature of the ecological risk data available for the site, this evaluation is intended as a screening-level ecological risk analysis and the results are of a qualitative nature.

The ecological risk evaluation estimates the effects of taking no action at the site and involves four steps:

1. Identification of contaminants and ecological receptors of concern;

2. Exposure assessment;

3. Ecological effects assessment; and

4. Risk characterization.

These four tasks are accomplished by evaluating available data and selecting contaminants, species and exposure routes of concern, estimating exposure point concentrations and intakes, assessing ecological toxicity of the COCs, and characterizing overall risk by integrating the results of the toxicity and exposure assessments. This ecological risk evaluation is performed to determine whether concentrations of chemicals in accessible waste materials on-site could adversely impact ecologic receptors.

5.2.1 Contaminants and Receptors of Concern

As in the human health risk assessment, contaminants that are significantly above background concentrations and are associated with the site are retained as COCs. Nine of the 13 elements analyzed are present at the site at concentrations significantly above background levels: Sb, As, Cd, Cu, Pb, Mn, Hg, Ag, and Zn. These nine constituents are selected for evaluation because they are present in significant concentrations in wastes onsite (greater than 3 times the average background concentration). However, some COCs may have no ecological toxicity data with which to evaluate potential effects. In the case of this specific ecological risk evaluation, only Ag in soils for terrestrial mammals had no ecological criteria for comparison.

Three groups of ecological receptors have been identified as potentially affected by site contamination. The first group is associated with Whipcracker Gulch and its receiving stream downstream from the site, and includes fisheries and aquatic life. Although the tributary probably does not support a viable fishery, and the stream fully infiltrated at the flows encountered during the 2008 investigation, it is evaluated as if it is or potentially discharges to a fishery.

The second group includes native terrestrial mammals (mule deer, elk, bighorn sheep, and cotton tailed rabbits) which may use the site. They are of concern because they may be impacted by site wastes due to their small body weight and frequent local habitation. These receptors have the some of the lower criteria concentrations for wildlife, and are assumed to be a more conservative estimate of exposure for transient larger mammals and birds of prey, which were not evaluated separately.

The third group of receptors are native terrestrial plant communities, which are notably sparse on many of the wastes at the site. They are of concern because native vegetation is not well established on the wastes, which would help reduce the potential for release of wastes and reduce exposure to the wastes by human and wildlife receptors.

5.2.2 Exposure Assessment

The three exposure scenarios can be semi-quantitatively assessed. The surface water-aquatic life, terrestrial mammals, and plant-phytotoxicity scenarios can be compared directly to toxicity criteria that apply to the respective environmental media.

5.2.2.1 Surface Water/Sediment - Aquatic Life Scenario

Ecologic exposures via this pathway are threefold: direct exposure of aquatic organisms to surface water concentrations that exceed toxicity thresholds; ingestion of aquatic species (e.g., insects) that have bioaccumulated contaminants to the extent that they are toxic to the predator (e.g., fish); and exposure of aquatic organisms (e.g., fish embryos) to sediment pore water environments that are toxic due to elevated contaminant concentrations in the sediments. Data used for this assessment were collected onsite in Whipcracker Gulch (stream sediment and surface water) during 2008. Selected water quality and stream sediment concentration data are presented in Table 5-6.

TABLE 5-6
MAXIMUM DOWNSTREAM CONTAMINANT CONCENTRATIONS IN SURFACE WATER (µg/L) AND STREAM SEDIMENT (mg/kg) AT THE IRON MASK MINE AND MILL SITE

	As	Cd	Cu	Pb	Hg	Ag	Zn
Surface Water	9	1	ND	40	ND	ND	150
Stream Sediment	726	29	112	3,630	1	12	5,660

ND – not detected

5.2.2.2 Terrestrial Mammals Scenario

This scenario involves the potential exposure of mammals that have high localized activity on the wastes. These receptors have a higher exposure than many other species due to their grazing behavior and low relative body weight. Using the same basis described in the human health

assessment, the soil concentrations utilized are the 95th percentile UCL of the mean concentration of the 13 waste samples (waste rock and mill tailings) collected during the 2008 site investigation. Table 5-7 summarizes concentrations measured in surface waste materials on-site during the 2008 investigation.

TABLE 5-7
SOLID MEDIA CONCENTRATIONS (mg/kg)
AT THE IRON MASK MINE AND MILL SITE

	As	Cd	Cu	Pb	Hg	Ag	Zn
95th % UCL All Site Wastes	967	138	524	7,600	1.34	37.2	18,500

mg/kg – milligrams per kilogram

5.2.2.3 Plant - Phytotoxicity Scenario

This scenario involves the limited ability of various plant species to grow in soils or wastes with high concentrations of site-related contaminants. Table 5-7 (above) summarizes concentrations measured in surface waste materials on-site during the 2008 investigation.

5.2.3 Ecological Effects Assessment

The potential effects of the site COCs are available from several literature sources and are referenced in following sections. Brief ecological toxicity summaries published by the EPA are included in Appendix E. No site-specific toxicity tests were performed to support the ecologic risk assessment, either *in-situ* or at a laboratory. Only existing and proposed toxicity-based criteria were used for this ecological effects assessment. These criteria are presented in Table 5-8 for their respective media and location, and are further described below.

TABLE 5-8
ECOLOGICAL CRITERIA
FOR CONTAMINANTS OF CONCERN

Criteria	As	Cd	Cu	Pb	Hg	Ag	Zn
Surface Water (µg/L) – Acute Criteria @ 168 mg/L hardness (DEQ, 2008)	340	3.6	22.8	158	1.7	9.9	186
Sediment Quality Criteria – T50 (mg/kg) (EPA, 2004)	32.6	2.49	157	161	0.87	2.45	384
Terrestrial Mammals RMC (mg/kg)* (Ford, 2004)	200	3	64	106	6	NA	222
Phytotoxicity - Median LOEL (mg/kg) (L. Martin, 1997)	95	25	100	500	32	2	270

mg/kg – milligrams per kilogram
T50 – Modeled effects response of 50 %
LOEL – Lowest Observed Effects Level
NA – not available
µg/L – micrograms per Liter
RMC – Risk Management Criteria
*The lowest of five terrestrial mammal RMCs

5.2.3.1 Surface Water/Sediment - Aquatic Life Scenario

Freshwater acute (1-hour average) water quality standards have been promulgated by the Montana Department of Environmental Quality/Water Quality Bureau (DEQ/WQB, 2008) for the COCs. Five of these standards (Cd, Cu, Pb, Ag, and Zn) are calculated by DEQ methodology as a function of water hardness, and two are numerical standards (As and Hg). The water quality criteria that apply to surface waters at and downstream from the site are presented above in Table 5-8, both numerical and those that are a function of water hardness.

Presently, the EPA has not finalized sediment quality criteria. The criteria used for this assessment utilized the Freshwater Sediment – T_{50} concentration (median response concentration [EPA, 2004]) which are presented in Table 5-8. The T_{50} concentration represents the median sediment concentration where some effects were observed to some species somewhere due to sediments. Use of these criteria is conservative given that an actual fishery at the site is unlikely, and the species that may be affected by elevated sediment concentrations are unknown.

5.2.3.2 Terrestrial Mammal Scenario

Soil concentrations derived for terrestrial mammal exposures are from Ford (2004). According to Ford, wildlife is not expected to experience adverse toxic effects at soil concentrations below the specified criteria. Several literature sources are cited by Ford that explore the ecotoxicity

effects of contaminants on various species of wild and domestic animals, including bioaccumulation and potential for "secondary poisoning" to consuming species.

This report presents risk management criteria for mule deer, elk, white tailed deer, bighorn sheep, and cottontail rabbits. The lowest of these five criteria is listed in Table 5-8, above. Soil concentrations for cattle are also listed in Ford (2004); however, the soil concentrations for cattle are higher than those listed for terrestrial mammals. The criteria listed above are therefore expected to be protective of cattle grazing use of the site.

5.2.3.3 Plant - Phytotoxicity Scenario

Information is available on phytotoxicity for COCs from Lockheed Martin (1997) and these are listed in Table 5-8, above. The availability of contaminants to plants and the potential for plant toxicity depends on many factors including soil pH, soil texture, nutrients, and plant species.

5.2.4 Risk Characterization

This section combines the ecological exposure estimates and concentrations presented in Section 5.2.2 and the ecological effects data presented in Section 5.2.3 to provide a screening level estimate of potential adverse ecological impacts for the scenarios evaluated. This was accomplished by generating ecological impact quotients (EQs), analogous to the human health HQs calculated for human exposures. The COC-specific EQs were generated by dividing the particular contaminant concentration by available ecological effect concentrations from Table 5-8. As with HQs, if EQs are less than 1.0, adverse ecological impacts are not expected at the Iron Mask Mine and Mill Site.

The calculated EQs can be used to assess whether the ecological receptors evaluated are exposed to potentially harmful concentrations of site-related chemicals via the four ecologic pathways evaluated. The site-specific EQs for the 4 ecologic exposure pathways are presented in Table 5-9, estimating a combined ecological EQ for each pathway and each COC.

TABLE 5-9
SUMMARY OF ECOLOGIC IMPACT QUOTIENT (EQ) VALUES FOR THE IRON MASK MINE AND MILL SITE

COC	Aquatic Life-Surface Water	Aquatic Life-Sediment	Terrestrial Mammals	Plant Toxicity	EQ Total
Arsenic	0.03	22.27	4.84	10.18	37.31
Cadmium	0.28	11.65	46.00	5.52	63.44
Copper	0.00	0.71	8.19	5.24	14.14
Lead	0.25	22.55	71.70	15.20	109.70
Mercury	0.00	1.15	0.22	0.04	1.41
Silver	0.00	4.90	NC	18.60	23.50
Zinc	0.81	14.74	83.33	68.52	167.40
Total EQ	1.37	77.97	214.28	123.30	416.90

NC = Not Calculated because no applicable criteria exists.

The aquatic life scenario results in no EQs greater than 1.0 for surface water, and as high as 22 in stream sediment (As and Pb), downstream from the Iron Mask Mine and Mill Site. The terrestrial mammal scenario results in EQs as high as 83% (Zn). The plant toxicity EQs are as high as 69% (zinc). These EQs demonstrate that COCs evaluated at the site are probably adversely affecting ecologic receptors via the stream sediment, terrestrial mammal and plant toxicity exposure scenarios and justify appropriate clean up. Zinc, Pb, Cd, and As are the primary COCs, and terrestrial mammals and plants are the primary ecologic receptors of concern.

5.3 SUMMARY OF RISK ANALYSIS

The human health risk assessment found that for residential exposures, As concentrations in soil are 2 orders of magnitude higher at this site than considered "safe" for residential occupation (at a carcinogenic risk level of 1.0E-06). At higher carcinogenic risk levels, the HQ values are lower, but still exceed "safe" residential concentrations. For recreational exposures, As concentrations in soil are more than 40 times higher at this site than considered "safe" for recreational activities.

The ecologic risk evaluation found that COCs evaluated at the site are probably adversely affecting ecologic receptors via the stream sediment, terrestrial mammal and plant toxicity exposure scenarios and justify appropriate clean up. Zinc, Pb, Cd, and As are the primary COCs, and terrestrial mammals and plants are the primary ecologic receptors of concern.

Table 5-10 summarizes the previously generated Human Health HQs and Ecologic EQs for the site. Many of the HQs and EQs are greater than 1.0, and demonstrate that RAs to mitigate human health and ecologic risk at the Iron Mask Mine and Mill Site are warranted.

TABLE 5-10
SUMMARY OF HUMAN HEALTH HAZARD QUOTIENT (HQ) AND ECOLOGIC IMPACT QUOTIENT (EQ) VALUES FOR THE IRON MASK MINE AND MILL SITE

Assessment	As	Cd	Cu	Pb	Hg	Ag	Zn
Human Health – Residential	**2,680 @10^{-6}** **268 @10^{-5}** **26.8 @10^{-4}**	**2.03**	0.17	**21.7**	0.06	0.10	0.82
Human Health – Recreational	**48.4**	**1.98**	0.10	**8.40**	0.03	0.05	0.46
Ecologic Total	**37.3**	**63.4**	**14.1**	**110**	**1.4**	**23.5**	**167**

6.0 RECLAMATION OBJECTIVES AND GOALS

This section presents the reclamation objectives and applicable cleanup standards, which include ARAR and Risk-based cleanup goals.

6.1 ARAR-BASED RECLAMATION GOALS

6.1.1 Surface Water

Acute Aquatic Life Standards (AALS) and HHSs are common ARARs for the surface water medium. The more stringent of the two standards is identified as the ARAR-based remediation goal; acute rather than chronic aquatic life standards are appropriate since long-term monitoring data are not available. The surface water is being primarily evaluated for aquatic life use rather than for a current or potential source of drinking water; however, the drinking water ARARs are included for completeness. The COCs at the site are Sb, As, Cd, Cu, Pb, Mn, Hg, Ag, and Zn. Table 6-1 presents the ARAR-based reclamation goals for surface water.

TABLE 6-1
ARAR-BASED RECLAMATION GOALS FOR SURFACE WATER (µg/L)

COC	TYPE	CONCENTRATION
Antimony	HHS-SW	5.6 µg/L
Arsenic	AALS	340 µg/L
Arsenic	HHS-SW	10 µg/L
Cadmium	AALS	3.6 µg/L @ 168 mg/L hardness
Cadmium	HHS-SW	5 µg/L
Copper	AALS	22.8 µg/L @ 168 mg/L hardness
Copper	HHS-SW	1,300 µg/L
Lead	AALS	158 µg/L @ 168 mg/L hardness
Lead	HHS-SW	15 µg/L
Mercury	AALS	1.7 µg/L
Mercury	HHS-SW	0.05 µg/L
Silver	AALS	9.9 µg/L @ 168 mg/L hardness
Silver	HHS-SW	100 µg/L
Zinc	AALS	186 µg/L @ 168 mg/L hardness
Zinc	HHS-SW	2,000 µg/L

Source: AALS - Freshwater Acute Aquatic Life Standards (DEQ/WQB, 2008).
HHS-SW – Human Health Standard for Surface Water (DEQ/WQB, 2008).

6.1.2 Groundwater

The ARAR-based reclamation goals for groundwater are most often the MCLs, non-zero maximum contaminant level goals (MCLGs), or State drinking water standards (HHSs), whichever are more stringent. Groundwater was not sampled at the site.

6.1.3 Soil

Chemical-specific ARARs are not available at this time for the soil medium.

6.2 RISK-BASED CLEAN UP GOALS

Previously calculated risk-based cleanup goals are applied for two land-use scenarios at the Iron Mask Mine and Mill Site, recreational and residential. These concentrations were derived using exposure assumptions contained in other documents (Residential-EPA, 2008; Recreational-Ford, 2004; Ecologic-Ford, 2004 or Lockheed Martin, 1997) and are the same as those presented in Sections 5.1 and 5.2. Both sets of clean up goals attempt to reduce the health HQ or ecologic EQ to less than 1.0 and are presented in Table 6-2.

TABLE 6-2
PROPOSED SOLID MEDIA CLEAN UP GOALS
FOR THE IRON MASK MINE AND MILL SITE

Contaminant of Concern	Recreational Soil – BLM Camper (mg/kg)	Residential Soil – EPA RSL (mg/kg)	Ecologic Soil – Wildlife or Plant* (mg/kg)
Antimony	50	31	NA
Arsenic	20	0.39 (@ 1E-06 carc. risk)	95*
Cadmium	70	70	3
Copper	5,000	3,100	64
Lead	1,000	400	106
Manganese	19,000	1,800	NA
Mercury	40	23	6
Silver	700	390	2*
Zinc	40,000	23,000	222

*From Lockheed Martin, 1997
NA = Not Available - no applicable criteria exists.
mg/kg – milligrams per kilogram

In order to estimate the level of clean up, an estimate of the risk reduction required to attain the human health and ecologic reclamation goals set out by the risk assessment has been derived and is presented in Table 6-3.

It is often useful to analyze individual source areas separately to prioritize clean up of specific areas of a site; however, at the Iron Mask Mine and Mill Site, all sources require nearly identical levels of risk reduction. Risk reduction required at each source to attain human health and ecologic reclamation goals for the most stringent COC (by exposure scenario) is shown on Table 6-3.

TABLE 6-3
TARGET RISK REDUCTIONS TO ATTAIN
HUMAN HEALTH AND ECOLOGIC CLEAN UP GOALS
FOR THE IRON MASK MINE AND MILL SITE

COC: Exposure: Risk Level:	Arsenic Residential 1.0 x 10-6	Arsenic Residential 1.0 x 10-5	Arsenic Residential 4.5 x 10-5(bkgd)	Arsenic Recreational 1.0 x 10-5	Zinc (soil) Ecologic
WR1	100%	98%	93%	92%	99%
WR2	100%	100%	98%	98%	99%
WR3	100%	99%	97%	97%	99%
TA1	100%	100%	99%	99%	99%
TA2	100%	100%	99%	98%	99%
Surface Water	100%	95%	93%	NR	NR

NR = Risk reduction not required.
bkgd = background risk level

7.0 DEVELOPMENT AND SCREENING OF RECLAMATION ALTERNATIVES

This section preliminarily identifies and screens potentially applicable reclamation alternatives. Reclamation alternatives are evaluated based on effectiveness, implementability, and cost.

The contaminated waste sources present at the Iron Mask Mine and Mill Site consist of waste rock dumps and mill tailings deposits, each containing a different type of media. Nine COCs are present within the waste sources at concentrations greater than 3 times the average background concentration of surrounding soils: Sb, As, Cd, Cu, Pb, Mn, Hg, Ag, and Zn. Arsenic is the primary COC for recreational users of the site, and zinc is the primary COC for ecologic receptors. All waste sources present at the site require treatment in attempt to meet the clean up goals presented in Section 6.2.

Treatment of the different media types is dependent on the concentration of metal contaminants in the media, as well as the physical characteristics of the media. The following provides a brief description of each of the primary contaminated media.

Waste Rock Dumps - Consist of overburden and gangue materials that generally do not contain sufficient economic quantities of target metals for recovery. The dumps contain non-mineralized and low-grade mineralized rock removed from areas adjacent to the ore and placed in piles close to the mine opening. The nature and extent of the mineralization, climatic conditions, and buffering capacity of the foundation soil determine the potential of the material to impact water quality.

In general, waste rock dumps contain oxidizing sulfide minerals and are subject to percolation of precipitation and runoff. The sulfide minerals within the dump may react with percolating water in the presence of oxygen to form sulfuric acid. Migration of sulfuric acid through the dump results in the further mobilization of solubilized metal oxides. Three waste rock dumps are located at the Iron Mask Mine and Mill Site. Samples collected from two of the waste rock dumps indicated the presence of metals when subjected to SPLP analysis, which indicates a potential to leach if left untreated; however, concentrations in laboratory leachate were found to be below HHS for groundwater (DEQ/WQB, 2008).

Mill Tailings - Tailings are generally uniform, finely ground rock particles from which most of the commercial ore have been recovered in the beneficiation and extraction process. Dry or alternately wet and dry tailings tend to contain oxidized forms of metals at significantly higher concentrations than those found in waste rock. These oxidized metals are easily mobilized during precipitation (infiltration) or high runoff events. Dry tailings are located in an impoundment below the mill site, and in shallow deposits on the ground surface at the lower end of the site. A sample collected from the surficial tailings indicated the presence of metals when subjected to SPLP analysis, which indicates a potential to leach if left untreated; however, concentrations in laboratory leachate were found to be below HHS for groundwater (DEQ/WQB, 2008).

7.1 IDENTIFICATION OF RECLAMATION TECHNOLOGIES AND PROCESS OPTIONS

The purpose of identifying and screening technology types and process options is to eliminate those technologies that are not feasible, while retaining potentially effective options. General response actions are progressively refined into technology types and process options. The

process options are screened and those retained are used to develop reclamation alternatives. General response actions, technology types, and process options potentially applicable to the waste sources present at the Iron Mask Mine and Mill Site are briefly discussed in this section.

General response actions and process options are evaluated for the solid mine wastes (waste rock and mill tailings). There has been no evaluation conducted for surface water, groundwater, or stream sediments. This decision was based primarily on the presumption that reclamation of the contamination at the source(s) would subsequently reduce/eliminate the problems associated with these other environmental media. General response actions and remedial technologies potentially capable of meeting the reclamation objectives are identified in Table 7-1. Response actions for solid mine wastes include No Action, Institutional Controls, Engineering Controls, Excavation and Treatment, and *In-situ* Treatment. Table 7-1 also contains the screening rationale that was used to eliminate or retain the various remedial process options for potential application at the Iron Mask Mine and Mill Site.

In Section 7.2, feasible technologies are presented as reclamation alternatives and are subjected to an initial/preliminary screening based on effectiveness, implementability, and cost. The purpose of the initial screening of alternatives is to identify those alternatives appropriate for a subsequent, detailed analysis. The initial screening also helps identify technology (process option) specific data needs for detailed site characterization as well as needs for possible treatability studies. Alternatives that pass the initial screening process are evaluated in detail in Section 8.0.

7.1.1 No Action

Under the No Action Alternative, no future remediation or monitoring would occur at the site. The No Action Alternative is a stand-alone response that is used as a baseline against which candidate reclamation alternatives are compared.

7.1.2 Institutional Controls

Potentially applicable Institutional Controls consist of land use and access restrictions, such as travel restrictions and prohibition of development. Limitations may be applicable in the case of No Action, on-site disposal, capping in place, or other reclamation alternatives that would result in leaving contaminated material on-site that could be compromised by future activities (i.e., grazing, recreation, etc.).

Institutional Controls involve implementing access restrictions, such as fencing, and land use control. These restrictions are implemented to preclude the future development of impacted areas or to protect an implemented remedy. This type of action does not, in itself, achieve a specific clean up goal. However, Institutional Controls will be considered as adjacent technologies to accompany other reclamation alternatives. Institutional Controls that are developed as part of an alternative are enforced by the local government. Therefore, the local government must be involved in the development and eventual implementation of an Institutional Control.

TABLE 7-1
GENERAL RESPONSE ACTIONS, TECHNOLOGY TYPES, AND PROCESS OPTIONS - IRON MASK MINE AND MILL SITE

GENERAL RESPONSE ACTIONS	REMEDIAL TECHNOLOGY	PROCESS OPTIONS	DESCRIPTION	SCREENING COMMENT
NO ACTION	None	Not Applicable	No Action	
INSTITUTIONAL CONTROLS	Access Restrictions	Fencing	Security fences installed around contaminated areas to limit access.	Potentially effective in conjunction with other technologies. Readily implementable.
		Land Use Control	Restrictions to control current and future land use.	Potentially effective in conjunction with other process options. Readily implementable.
ENGINEERING CONTROLS	Containment	Soil Cover	Application of soil and establishment of vegetative cover to stabilize surface of contamination source.	Surface infiltration and runoff potential would be reduced, but not prevented. Readily implementable.
		Multilayered Cap	Compacted clay or synthetic membrane covered with soil/vegetation over areas of surface contamination.	Potentially effective for some waste sources in conjunction with regrading. Readily implementable.
		Asphalt/Concrete Cover	Application of layer of asphalt or concrete over areas of surface contamination.	Limited feasibility due to remoteness of area and steep slopes. Would require extensive grading and compaction.
	Surface Controls	Consolidation	Combining similar waste types in a common area.	Potentially effective in conjunction with other process options. Involves removing wastes from particularly sensitive areas (e.g. floodplain). Readily implementable.
		Grading	Level out waste piles to reduce slopes for managing surface water infiltration, runoff, and erosion.	Potentially effective in conjunction with other process options. Readily implementable.
		Revegetation	Adding amendments to waste and seeding with appropriate vegetative species to establish an erosion resistant ground surface.	Potentially effective in arid climates if waste does not contain high concentrations of phytotoxic contaminants. Readily implementable.
		Erosion Protection/Runon Control	Erosion resistant materials/fabrics placed directly on waste sources to reduce surface erosion. Surface water diversion structures constructed to direct runoff away from waste source(s).	Potentially effective at reducing contaminant mobility. Readily implementable.
	On-site Disposal	Engineered Repository	Excavated contaminated soil deposited on-site in an engineered repository.	Potentially effective and readily implementable. Depends on site-specific groundwater characteristics (i.e., depth to groundwater).
	Off-site Disposal	Permitted Landfill	Wastes permanently disposed of in a permitted facility.	Potentially effective and implementable, but generally cost prohibitive due to high disposal costs in conjunction with significant transportation costs.
		Permitted Tailings Disposal Facility	Depositing tailings in a permitted off-site impoundment.	Potentially effective if facility with adequate capacity is willing to accept waste. Potentially implementable, but cost-prohibitive due to liability considerations.

Legend

- Technologies/Process options that are screened out.

TABLE 7-1 (cont.)
GENERAL RESPONSE ACTIONS, TECHNOLOGY TYPES, AND PROCESS OPTIONS - IRON MASK MINE AND MILL SITE

GENERAL RESPONSE ACTIONS	REMEDIAL TECHNOLOGY	PROCESS OPTIONS	DESCRIPTION	SCREENING COMMENT
EXCAVATION AND TREATMENT	Fixation/Stabilization	Pozzolan/Cement Based	Hazardous constituents are incorporated into non-leachable cement or pozzolan solidifying agents.	Extensive treatability testing required. Proper disposal of stabilized product would be required. Potentially implementable, but cost-prohibitive.
	Reprocessing	Milling/Smelter	Shipping wastes to existing milling/smelter facility for economic extraction of metals.	Potentially effective if a facility is located and willing to accept waste. Potentially implementable, but cost-prohibitive due to liability considerations.
	Physical/Chemical Treatment	Soil Washing	Separate hazardous constituents from solid media via dissolution and subsequent precipitation.	Effectiveness is questionable. Potential exists to increase mobility by providing partial dissolution of contaminants. More difficulty encountered with wider range of contaminants.
		Acid Extraction	Mobilize hazardous constituents via acid leaching and recover by subsequent precipitation.	Effectiveness is questionable. Sulfides would be acid soluble only under extreme conditions of temperature and pressure.
		Alkaline Leaching	Use alkaline solution to leach contaminants from solid media in a heap, vat, or agitated vessel.	Effectiveness not well-documented for arsenic.
	Thermal Treatment	Fluidized Bed Reactor/Rotary Kiln/Multi-Hearth Kiln	Concentrate hazardous constituents into a small volume by volatilization of metals and formation of metallic oxides as particulates.	Further treatment is required to treat process by-products. Potentially implementable, but cost-prohibitive.
		Vitrification	Extremely high temperature used to melt and/or volatilize all components of the solid media. The molten material containing contaminants is cooled and, in the process, vitrified into a non-leachable form.	Further treatment is required to treat process by-products. Potentially implementable, but cost-prohibitive.
IN SITU TREATMENT	Physical/Chemical Treatment	Stabilization	Waste constituents stabilized in place when combined with injected stabilizing agents.	Extensive treatability testing required. Potentially implementable, but cost-prohibitive.
		Solidification	Solidifying agents used in conjunction with deep soil mixing techniques to facilitate a physical or chemical change in mobility of the contaminants.	Extensive treatability testing required. Potentially implementable, but cost-prohibitive.
		Soil Flushing	Acid/base reagent or chelating agent injected into solid media to solubilize metals. Solubilized reagents are subsequently extracted using dewatering techniques.	Effectiveness not certain. Innovative process currently in its pilot stage.
	Thermal Treatment	Vitrification	Contaminated solid media subjected to extremely high temperature in-place. During cooling, material is vitrified into non-leachable form.	Expect difficulties to be encountered in establishing adequate process control. Potentially implementable, but cost-prohibitive.

Legend

- Technologies/Process options that are screened out.

7.1.3 Engineering Controls

Engineering Controls are used primarily to reduce the mobility of contaminants by creating a barrier that prevents the transport of wastes from the contaminated source to the surrounding environment. Engineering Controls do not reduce the volume or toxicity of the hazardous material. Engineering Controls typically applied include containment/capping, revegetation, run-on/runoff control, and/or disposal.

7.1.3.1 Containment

Containment technologies are used as source control measures to isolate surface water from the contaminated media, to minimize infiltration (and subsequent formation of leachate) of surface water/precipitation into the underlying contaminated media by increasing evapotranspiration processes, and to reduce the potential health risk that may be associated with exposure (direct contact or airborne releases of particulate) to the contaminated media. The cap or cover design is a function of the degree of hazard posed by the contaminated media and may vary in complexity from a simple vegetated soil cover to a multi-layered RCRA cap. The RCRA cap performance standards are included in 40 CFR 264.310, which addresses RCRA landfill closure requirements. These performance standards may not always be appropriate, particularly in instances where the toxicity of the contaminated media is relatively low, where the cap is intended to be temporary, where there is very low precipitation, or where the waste is not leached by infiltrating rain water. Specific cap construction is partially driven by the desired land use following cap construction. Capping is appropriate whenever contaminated materials are left in place at a site, such as when total excavation and removal or treatment would be cost prohibitive. Capping is considered to be a standard construction practice. Equipment and construction methods associated with capping are readily available, and design methods and requirements are well understood.

7.1.3.2 Surface Controls

Similar to containment, surface control measures are used primarily to reduce contaminant mobility. Surface controls may be appropriate in more remote areas where direct human contact is not a primary concern (human receptors not living or working directly on or near the site). Surface control process options include consolidation, grading, revegetation, and erosion protection. These process options are usually integrated as a single reclamation alternative. Consolidation involves grouping similar waste types in a common area for subsequent management or treatment. Consolidation is especially applicable when multiple waste sources are present at a site and one or more of the sources require removal from particularly sensitive areas (i.e., floodplain, residential area, or heavy traffic area) or when treating one large combined waste source in a particular location rather than several smaller waste sources dispersed throughout an area.

Grading is the general term for techniques used to reshape the ground surface to reduce slopes, manage surface water infiltration and runoff, and to aid in erosion control. The spreading and compaction steps used in grading are routine construction practices. The equipment and methods used in grading are similar for all surfaces but will vary slightly depending on the waste type and

the surrounding terrain (i.e., steepness). Periodic maintenance and regrading may be necessary to eliminate depressions formed as a result of settlement/subsidence or erosion.

Revegetation involves adding soil amendments and/or topsoil to the waste's surface to provide nutrients, organic material, and neutralizing agents and/or to improve the water storage capacity of the contaminated media, as necessary. This action is used to establish native vegetative species to provide an erosion-resistant ground surface that helps protect the ground surface from surface water and wind erosion and reduces net infiltration through the contaminated media by increasing evapotranspiration processes. In general, revegetation includes the following steps: 1) selecting appropriate plant species; 2) preparing the seed bed, which may require deep application (tilling) of soil amendments as necessary; 3) seeding/planting; 4) mulching and/or chemical stabilization; and 5) fertilizing and maintenance.

Erosion protection includes using erosion resistant materials, such as mulch, natural or synthetic fabric mats, riprap, and/or surface water diversion ditches, to reduce the erosion potential at the contaminated media's surface. The erosion resistant materials are placed in areas susceptible to surface water erosion (concentrated flow or overland flow) or wind erosion. Proper erosion protection design requires knowledge of drainage area characteristics, average slopes, soil texture, vegetation types and abundance, and precipitation data.

7.1.3.3 On-Site Disposal

Permanent, on-site disposal is used as a source control measure. On-site disposal involves placing the contaminated media in an engineered containment facility located within the site boundary. On-site disposal options may be applied to pre-treated or untreated contaminated materials, depending upon the chemical characteristics of the material. The design configuration of an on-site containment facility would depend on the toxicity and type of material requiring disposal. The design could range in complexity from a relatively simple, unlined and covered impoundment to a double-lined impoundment equipped with double leachate collection systems and RCRA-type cap. Materials failing to meet the SPLP criteria may require disposal in a repository conforming to the performance standards for a RCRA landfill closure.

7.1.3.4 Off-Site Disposal

Off-site disposal involves placing excavated contaminated material in an engineered containment facility located outside the site boundary. Off-site disposal options may be applied to pre-treated or untreated contaminated materials and would depend on SPLP results. Materials failing to meet the SPLP criteria would require disposal in a RCRA-permitted treatment, storage, and disposal (TSD) facility. Conversely, less toxic materials could possibly be disposed of in an off-site permitted sanitary landfill or tailings disposal facility in compliance with other applicable laws. Off-site disposal is most attractive when dealing with relatively small quantities of wastes located relatively near the disposal facility.

7.1.4 Excavation and Treatment

Excavation and treatment incorporates the removal of contaminated media and subsequent treatment via a specific treatment process that chemically, physically, or thermally results in a

reduction of contaminant toxicity and/or volume. Treatment processes have the primary objective of either: 1) concentrating the metal contaminants for additional treatment or recovery of valuable contaminants; or 2) reducing the toxicity of the hazardous contaminants.

Excavation can be completed using conventional earth moving equipment and accepted hazardous materials handling procedures. Precautionary measures, such as stream diversion or isolation, would be necessary for excavating materials contained in the floodplain of a stream. Containment and/or treatment of water encountered during excavation may also be necessary.

7.1.4.1 Fixation/Stabilization

Fixation/stabilization technologies are used to treat materials by physically encapsulating them in an inert matrix (stabilization) and/or chemically altering them to reduce the mobility and/or toxicity of their contaminants (fixation). These technologies generally involve mixing materials with binding agents under prescribed conditions to form a stable matrix. Fixation/stabilization is an established technology for treating inorganic contaminants. The technology incorporates a reagent or combination of reagents to facilitate a chemical and/or physical reduction of the mobility of contaminants in the solid media. Lime/fly ash-based treatment processes and pozzolan/cement-based treatment processes are potentially applicable fixation/stabilization technologies.

7.1.4.2 Reprocessing

Reprocessing involves excavating and transporting the waste materials to an existing permitted mill or smelter facility for processing and economic recovery of target metals. Applicability of this option depends on the willingness of an existing permitted facility to accept and process the material and dispose of the waste. Although reprocessing at active facilities has been conducted in the past, permit limitations, CERCLA liability, and process constraints all limit the feasibility of this process option. In addition to these limitations, costs associated with this alternative are very high (transportation costs in addition to processing costs). In order for a milling facility or smelter to accept the material, pre-concentration of the target metals would likely be required, and the by-product waste resulting from pre-concentrating would still contain elevated metals concentrations requiring proper disposal.

7.1.4.3 Physical/Chemical Treatment

Physical treatment processes use physical characteristics to concentrate contaminants into a relatively small volume for disposal or further treatment. Chemical treatment processes treat contaminants through adding a chemical reagent that removes or fixes the contaminants. The net result of chemical treatment processes is a reduction of toxicity and/or mobility of contaminants in the solid media. Chemical treatment processes often work in conjunction with physical processes to wash the contaminated media with water, acids, bases, or surfactants. Potentially applicable physical/chemical treatment process options include: soil washing, acid extraction, and alkaline leaching.

Soil washing is an innovative treatment process, which consists of washing the contaminated media (with water) in a heap, vat, or agitated vessel to dissolve water-soluble contaminants. Soil washing requires that contaminants be readily soluble in water and sized sufficiently small so

that dissolution can be achieved in a practical retention time. Dissolved metal contaminants contained in the wash solution are precipitated as insoluble compounds, and the treated solids are dewatered before additional treatment or disposal. The precipitates form a sludge, which would require additional treatment, such as dewatering or stabilization prior to disposal.

Acid extraction applies an acidic solution to the contaminated media in a heap, vat, or agitated vessel. Depending on temperature, pressure, and acid concentration, varying quantities of the metal contaminants present in the contaminated media would be solubilized. A broader range of contaminants can be expected to be acid soluble at ambient conditions using acid extraction versus soil washing; however, sulfide compounds may only be acid soluble under extreme conditions of temperature and pressure. Dissolved contaminants are subsequently precipitated for additional treatment and/or disposal.

Alkaline leaching is similar to acid extraction in which a leaching solution (in this case ammonia, lime, or caustic soda) is applied to the contaminated media in a heap, vat, or agitated vessel. Alkaline leaching is potentially effective for leaching the majority of metals from the contaminated media; however, the removal of arsenic is not well documented.

7.1.4.4 Thermal Treatment

Under thermal treatment technologies, heat is applied to the contaminated media to volatilize and oxidize metals and render them amenable to additional processing and/or to vitrify the contaminated media into a glass-like, non-toxic, non-leachable matrix. Potentially applicable moderate temperature thermal processes that volatilize metals and form metallic oxide particulates include the fluidized bed reactor, the rotary kiln, and the multi-hearth kiln. Potentially applicable high temperature thermal treatment processes include vitrification. All components of the contaminated media are melted and/or volatilized under high temperature vitrification. Volatile contaminants and gaseous oxides of sulfur are driven off as gases in the process, and the non-volatile, molten material containing contaminants is cooled and, in the process, vitrified.

Thermal treatment technologies can be applied to wet or dry contaminated media; however, the effectiveness may vary somewhat with variable moisture content and particle size. Crushing may be necessary as a pre-treatment step, especially for large and/or variable particle sizes, such as in waste rock dumps. Moderate temperature thermal processes should only be considered as pre-treatment for other treatment options. This process concentrates the contaminants into a highly mobile (and potentially more toxic) form. High temperature thermal processes immobilize most metal contaminants into a vitrified slag, which would have to be properly disposed. The volatile metals would be removed and/or concentrated into particulate metal oxides, which would likely require disposal as hazardous waste. Thermal treatment costs are extremely high compared to other potentially applicable remedial technologies.

7.1.5 *In-Situ* Treatments

In-situ treatment involves treating the contaminated media in place. *In-situ* technologies reduce the mobility and toxicity of the contaminated media and may reduce worker exposure to the

contaminated materials; however, *in-situ* technologies allow a lesser degree of control, in general, than *ex-situ* treatment options.

7.1.5.1 Physical/Chemical Treatment

Potentially applicable *in-situ* physical/chemical treatment technologies include stabilization/ solidification, soil flushing, and dewatering.
In-situ stabilization/solidification is similar to conventional stabilization in that a solidifying agent (or combination of agents) is used to create a chemical or physical change in the mobility and/or toxicity of the contaminants. The *in-situ* process uses deep mixing techniques to allow maximum contact of the solidifying agents with the contaminated media.

Soil flushing is an innovative process that injects an acidic or basic reagent or chelating agent into the contaminated media to solubilize metals. The solubilized metals are extracted using established dewatering techniques, and the extracted solution is then treated to recover metals or is disposed as aqueous waste. Low permeability materials may hinder proper circulation, flushing solution reaction, and ultimate recovery of the solution. Currently, soil flushing has only been demonstrated at pilot scale.

Dewatering is a common pre-treatment process used to extract water from contaminated solid media. Common dewatering options include well-field extraction, extraction trenches, surface water diversion, and gravity draining of stockpiled saturated materials. Dewatering is most effective in conjunction with additional remedial technologies that reduce contaminant toxicity, mobility, or volume.

7.1.5.2 Thermal Treatment

In-situ vitrification is an innovative process used to melt contaminated solid media in place to immobilize metals into a glass-like, inert, non-leachable solid matrix. Vitrification requires significant energy to generate sufficient current to force the solid media to act as a continuous electrical conductor. This technology is seriously inhibited by high-moisture content. Gases generated by the process must be collected and treated in an off-gas treatment system. *In-situ* vitrification has only been demonstrated at pilot scale, and treatment costs are extremely high compared to other treatment technologies.

7.2 IDENTIFICATION OF RECLAMATION ALTERNATIVES

In this section, the remedial technology types and associated process options that passed the initial screening are assembled into reclamation alternatives. Table 7-2 presents the preliminary reclamation alternatives that have been identified for the solid mine waste materials at the Iron Mask Mine and Mill Site.

Treatment of the surface water in Whipcracker Gulch is not considered because it is assumed that reclamation of the solid mine waste materials (waste rock and tailings) located upgradient will improve sediment and the surface water quality problems that may exist during high runoff events. In this EEE/CA, only solid media alternatives are developed and evaluated in detail. A preferred solid media alternative will be selected and discussed to determine if the action will be

effective enough to meet reclamation goals for both the solid media and surface water in Whipcracker Gulch. Therefore, this EEE/CA is focused specifically on the development, evaluation, and selection of solid media reclamation alternatives.

TABLE 7-2
RECLAMATION ALTERNATIVES FOR THE WASTE MATERIALS AT THE IRON MASK MINE AND MILL SITE

ALTERNATIVE	ACTION
Alternative 1	No Action
Alternative 2	Institutional Controls
Alternative 3a	Consolidate Waste Rock On-Site with a Cover Soil Cap
Alternative 3b	Consolidate Waste Rock and Tailings On-Site with a Cover Soil Cap
Alternative 4a	Consolidate Waste Rock 2, Waste Rock 3 and Tailings in On-Site Repository with Cover Soil Cap
Alternative 4b	Consolidate All Waste in On-Site Repository with Cover Soil Cap
Alternative 5a	Consolidate All Waste in On-Site Repository with Multi-Layer Cap
Alternative 5b	Consolidate All Waste in On-Site Modified RCRA Repository

Under Alternative 1, no further action would occur at the site to control contaminant migration or to reduce toxicity or volume. The site and associated risks would remain unchanged.

Alternative 2 implements Institutional Controls by erecting fences at the site to restrict access to contaminated sources, and land use restrictions to prevent development on or near the affected areas. Under this alternative, no steps are taken to control contaminant migration or to reduce toxicity or volume.

Alternative 3a involves consolidation and regrading of the existing waste rock sources (WR1, WR2 and WR3) at a single location on site, and placement of a 2-foot vegetated cover soil cap. Under this alternative, the surficial tailings located in TA1 would remain in place. The tailings impoundment at TA2 would be regraded in place to promote surface drainage, covered with surrounding soil and revegetated.

Alternative 3b is similar to 3a with respect to the waste rock sources. However, the surficial tailings from TA1 would be excavated and placed with the consolidated waste rock prior to covering with the vegetated soil cap. The tailings impoundment at TA2 would be regraded in place to promote surface drainage, covered with surrounding soil and revegetated.

Alternative 4a involves consolidating only the most contaminated wastes (WR2, WR3, TA1, and TA2) in an on-site repository located within one mile of the waste sources. The repository would be covered with a 2-foot vegetated soil cap. Waste Rock Dump 1 would be regraded in place and covered with a 2-foot vegetated soil cap.

Under Alternative 4b, all waste sources would be removed from the site and placed in an on-site repository, and covered with a 2-foot vegetated soil cap.

Alternatives 5a and 5b involve total removal of all waste sources from the site, and placement in lined on-site repositories. The repository for Alternative 5a would be covered with a multi-layered lined cap, while Alternative 5b would also include a leachate collection system (Modified RCRA)-type repository.

7.3 PRELIMINARY EVALUATION AND SCREENING OF ALTERNATIVES

The alternatives identified in Section 7.2 are described, developed, and then subjected to a preliminary evaluation and screening in this section. The evaluation and screening at this stage is based on the anticipated effectiveness, implementability, and relative costs of the alternatives. The preliminary screening has been conducted to identify those alternatives that are obviously not as cost effective or implementable as other alternatives that would provide a similar degree of risk reduction, thereby reducing the number of reclamation alternatives requiring detailed evaluation.

The evaluation of ***effectiveness*** includes determining the ability of an alternative to effectively reduce adverse human health or environmental impacts sufficiently to achieve the reclamation goals. The reclamation goals include overall protection of human health and the environment, compliance with ARARs, and short- and long-term effectiveness and/or performance related to reducing toxicity, mobility, and/or volume of contaminants. The effectiveness screening criteria includes consideration of the nature and extent of the contamination, as well as site-specific conditions, such as geology, hydrology, hydrogeology, climate, current land use, and potential future land use.

The ***implementability*** of each alternative is evaluated to consider the technical and administrative feasibility of constructing, operating, and maintaining each reclamation alternative. Technical feasibility considerations include applicability of the alternative to the waste source(s), availability of the required equipment and expertise to execute the alternative, and overall reliability of the alternative. Administrative feasibility considerations include logistical and scheduling constraints. The evaluation of implementability also considers appropriate combinations of alternatives with respect to site-specific conditions.

Cost screening consists of developing relative order-of-magnitude cost estimates for each reclamation alternative based on similar sets of assumptions. Costs have been developed by analyzing data available from implementing reclamation alternatives at similar sites, particularly past abandoned mine reclamation activities conducted by the BLM and DEQ/MWCB. Unit and total costs presented in the cost evaluations are conservatively structured to account for contaminated materials handling, adverse site conditions, and contingency.

The cost estimates presented are intended to provide a basis of comparison for preliminary evaluation and screening of the alternatives; actual costs of construction will be dependent on further detailed design and analysis, and subject to fluctuating costs of labor, equipment and materials. However, it is assumed that any cost variations would be applied consistently for each alternative, and would not significantly affect the intended relative cost comparison.

Total costs were derived by applying estimated unit costs to assumed volumes of contaminated solid media. Cost estimates are based on the following volumes of waste material obtained from survey data collected by Pioneer in June 2008:

- Approximately 11,500 cy of waste rock located at WR1, WR2 and WR3; and
- Approximately 1,900 cy of mill tailings located at TA1 and TA2.

As determined by analytical results of samples collected by Pioneer in June 2008, sufficient quantities of on-site soil is not available for use as a vegetative cover. Therefore, each alternative that includes incorporation of a soil cover will also include an assumption that cover soil will be obtained from a borrow source located within approximately 1 mile of the Iron Mask Mine and Mill Site.

A screening summary is presented after evaluating each alternative to identify alternatives retained for further consideration (detailed evaluation/analysis) and to offer rationale for exclusion of those alternatives that will not be considered further.

7.3.1 Alternative 1: No Action

The No Action Alternative means that no actual reclamation activities will occur at the site to control contaminant migration or to reduce toxicity or volume.

Effectiveness - Protection of human health and the environment would not be achieved under the No Action Alternative. Prevention of direct human contact would not be achieved. The contaminant sources present at the Iron Mask Mine and Mill Site would continue to potentially impact surface water via sedimentation from direct exposure to the elements. Toxicity, mobility, and volume of contaminants would not be reduced under the No Action Alternative.

Implementability - Technical and administrative feasibility evaluation criteria do not apply, as there is nothing to implement under this alternative.

Cost Screening - No capital or operating costs would be incurred under this alternative.

Screening Summary - This alternative has been retained as a baseline alternative for further evaluation as suggested by the NCP.

7.3.2 Alternative 2: Institutional Controls

The Institutional Controls Alternative includes erecting fences surrounding the Iron Mask Mine and Mill Site to restrict access to contaminated sources, and implementation of land use restrictions to prevent future land development on or near the affected areas.

Effectiveness - This alternative is not protective of environmental resources. The contaminant sources would continue to potentially impact surface water via sedimentation from direct exposure to the elements. It is not fully protective of human health if implemented as a stand-alone alternative because the waste sources will continue to be exposed and available for potential direct contact. Toxicity, mobility, and volume of the contaminated media would not be reduced under this alternative.

Implementability - Institutional Controls can be implemented based on the criteria of applicability, availability, and reliability. This alternative is considered applicable for reducing the potential for direct contact and restricting future land development. Fencing materials and experienced construction contractors are readily available should this alternative be implemented. Reliability of this alternative for its intended purpose (protection from direct contact) is expected to be fair, requiring strict enforcement and recurring maintenance by the regulatory agencies and landowners. Due to the logistical simplicity of construction and the capability to implement land use restrictions, administrative feasibility is considered good.

Cost Screening - Costs associated with Institutional Controls would be relatively low compared to other reclamation measures; however, a considerable amount of fencing materials would be required to fully enclose the contaminated sources present at the site. Capital costs associated with construction of an access control fence would total approximately $12,650, assuming a fencing requirement of approximately 2,000 linear feet at approximately $5 per linear foot, administration costs of $1,000 (10%) and a contingency cost of $1,650 (15%). Maintenance costs would likely be less than $1,000 per year.

Screening Summary - Institutional Controls will not be considered further as a stand-alone reclamation alternative due to the relatively low effectiveness, but may be used in conjunction with other selected treatment alternatives.

7.3.3 Alternative 3a: Consolidate Waste Rock On-Site With Cover Soil Cap

Alternative 3a involves consolidation of all waste rock sources at the Iron Mask Mine and Mill Site, grading the consolidated waste rock dump, applying cover soil and amendments (organics and lime, if necessary), and establishing vegetation on the surface of the cap materials to provide erosion protection and to decrease net infiltration through the waste by increasing evapotranspiration.

Surface water flow from the Iron Mask Adit and runoff from the surrounding area currently flows along the toe of WR1. Covering the waste material in-place would not fully protect the wastes from possible erosion caused during high flow periods. During construction, waste rock material will be graded away from the existing stream channel to allow reconstruction of a channel capable of conveying the 100-year, 24-hour storm event peak flow. The channel would be armored with grouted riprap to protect against side slope erosion and future stream migration toward waste materials. A temporary surface water diversion (i.e., culvert, pipe, lined ditch, etc.) would be necessary to facilitate construction.

Approximately 50% of the waste materials will require regrading to a maximum slope of 3Horizontal (H):1Vertical (V). After final grading, the waste materials will be revegetated by applying cover soil, incorporating the appropriate amendments into the cover soil, and seeding.

Under this alternative, the existing vegetated tailings located at TA1 would be left in place. The existing tailings impoundment located at TA2 is relatively small (1,875 square feet) and access to the impoundment is limited. Under this alternative the impoundment would be regraded in place to promote positive surface drainage, capped with soils salvaged from the existing earthen embankment and surrounding area, and revegetated.

Conceptual Design and Assumptions

Based on the available data and the above considerations, the conceptual design of Alternative 3a includes:

- Improving and maintaining the existing main access road from Indian Creek Road to the Iron Mask Mine and Mill Site to facilitate safe access by heavy equipment and construction crews.
- Improving and maintaining the existing site access roads to facilitate construction activities.
- Constructing a new surface water diversion to route storm water and adit flow away from waste materials.
- Installing stream protection structures (silt fence and straw bales) to prevent sediment from entering Whipcracker Gulch during construction.
- Excavating a borrow source assumed to be located approximately one mile from the Iron Mask Mine and Mill Site to obtain clean cover material for reclamation work.
- Grading and/or excavating the waste sources away from the existing stream channel and reconstruct/armor the stream channel.
- Consolidate waste materials from WR3 with the existing waste materials at WR1 and WR2. Grade consolidated waste materials to a maximum 3H:1V slope.
- Backfill excavated areas with one foot of amended cover soil, and cap consolidated waste materials with two feet of amended cover soil.
- Regrade TA2 impoundment and cover with surrounding soils.
- Revegetating and mulching all disturbed areas upon completion of construction activities (temporary roads, staging areas, cover soil application areas, etc.).

The current main access road to the Iron Mask Mine and Mill Site is approximately four miles in length and is in fair condition. This unimproved dirt road will require minor upgrading by blading/regrading to facilitate safe access to the site. Existing site access roads are also in fair condition and will require only minor upgrading.

Seeding would likely take place during the fall season. The seed mixture and fertilizer would be applied simultaneously to the prepared seedbeds by approved methods. Mulch or natural fabric mats would be applied to provide temporary protection of highly erodible disturbed surfaces.

Effectiveness – Placing a cover soil cap and establishing vegetation over the waste rock sources would be effective in reducing human and terrestrial biota exposure to the contaminants via direct contact and inhalation of entrained dust. A healthy stand of vegetation also effectively stabilizes the surface against wind and surface water erosion, and minimizes the potential for migration of vadose zone contaminants by increasing evapotranspiration and decreasing water infiltration. Regrading the waste rock material would promote positive surface drainage and improve vegetation establishment by eliminating steep slopes susceptible to erosion. The overall effectiveness of the containment/revegetation program would be enhanced by carefully selecting appropriate plant species that are adapted to site conditions.

Grading waste rock away from the existing surface water flow and construction of an armored stream channel would effectively decrease contaminant mobility to Whipcracker Gulch during high flow events. Regrading the tailings impoundment at TA2 would inhibit ponding of surface water, and placement of cover soil over the waste material would minimize exposure to the contaminants.

The toxicity or volume of the wastes would not be reduced under Alternative 3a since no actual treatment of the contaminants would be conducted. And while currently well vegetated, the surficial tailings scattered within TA1 would continue to be susceptible to direct contact and erosion.

Implementability – Alternative 3a is both technically and administratively feasible; however, the degree of feasibility is dependent on finding a suitable cover soil borrow area. Consolidation and grading of waste sources, incorporation of amended cover soil, establishing vegetation and construction of surface water controls are applicable technologies that utilize standard design methods that have been thoroughly tested. The required construction techniques and the associated equipment are readily available and commonly used.

The reliability of this alternative is expected to be good, but would require periodic monitoring and maintenance to ensure that the integrity of the cap and reconstructed stream channel remains intact.

Cost Screening - The total capital cost for Alternative 3a has been estimated at $248,572 which represents the reclamation of all the waste rock dumps and TA2 at the Iron Mask Mine and Mill Site. Table C-2 (Appendix C) presents the cost details associated with implementing this alternative.

Screening Summary – Alternative 3a has been retained for detailed analysis since consolidation and reclamation of the waste rock sources and reclamation of TA2 may be a feasible and cost-effective remedy for the site.

7.3.4 Alternative 3b: Consolidate Waste Rock and Tailings On-Site with Cover Soil Cap

Alternative 3b is very similar to Alternative 3a in that it involves consolidation of the waste rock sources present at the site. However, Alternative 3b also involves excavating and hauling approximately 1,600 cy of surficial tailings material located at TA1, and placing with the waste rock prior to capping. The excavated area at TA1 would be backfilled with one foot of amended cover soil and revegetated.

As detailed under Alternative 3a, the consolidated waste sources would be graded away from the existing stream channel to accommodate channel reconstruction and armoring with grouted riprap. Waste material slopes would be reduced to a maximum of 3H:1V prior to placement of the amended cover soil cap. The impoundment located at TA2 would be regraded to promote positive surface drainage, covered with surrounding soils and revegetated.

Conceptual Design and Assumptions

The conceptual design for Alternative 3b is similar to that described for Alternative 3a, with the addition of the TA1 waste excavation and consolidation. The conceptual design includes:

- Improving and maintaining the existing main access road from Indian Creek Road to the Iron Mask Mine and Mill Site to facilitate safe access by heavy equipment and construction crews.
- Improving and maintaining the existing site access roads to facilitate construction activities.
- Constructing a new surface water diversion to route storm water and adit flow away from waste materials.
- Installing stream protection structures (silt fence and straw bales) to prevent sediment from entering Whipcracker Gulch during construction.
- Excavating a borrow source assumed to be located approximately one mile from the Iron Mask Mine and Mill Site to obtain clean cover material for reclamation work.
- Grading and/or excavating the waste sources away from the existing stream channel and reconstruct/armor the stream channel.
- Consolidate waste materials from WR3 and TA1with the existing waste materials at WR1 and WR2. Grade consolidated waste materials to a maximum 3H:1V slope.
- Backfill excavated areas with one foot of amended cover soil, and cap consolidated waste materials with two feet of amended cover soil.
- Regrade TA2 impoundment and cover with surrounding soils.
- Revegetating and mulching all disturbed areas upon completion of construction activities (temporary roads, staging areas, cover soil application areas, etc.).

The current main access road to the Iron Mask Mine and Mill Site is approximately four miles in length and is in fair condition. This unimproved dirt road will require minor upgrading by blading/regrading to facilitate safe access to the site. Existing site access roads are also in fair condition and will require only minor upgrading.

Seeding would likely take place during the fall season. The seed mixture and fertilizer would be applied simultaneously to the prepared seedbeds by approved methods. Mulch or natural fabric mats would be applied to provide temporary protection of highly erodible disturbed surfaces.

Effectiveness – Placing a cover soil cap and establishing vegetation over the consolidated waste sources would be effective in reducing human and terrestrial biota exposure to the contaminants via direct contact and inhalation of entrained dust. A healthy stand of vegetation also effectively stabilizes the surface against wind and surface water erosion, and minimizes the potential for migration of vadose zone contaminants by increasing evapotranspiration and decreasing water infiltration. Re-grading the waste rock material would promote positive surface drainage and improve vegetation establishment by eliminating steep slopes susceptible to erosion. The overall effectiveness of the containment/revegetation program would be enhanced by carefully selecting appropriate plant species that are adapted to site conditions.

Grading waste rock away from the existing surface water flow and construction of an armored stream channel would effectively decrease contaminant mobility to Whipcracker Gulch during high flow events. Regrading the tailings impoundment at TA2 would inhibit ponding of surface water, and placement of cover soil over the waste material would minimize exposure to the contaminants. As part of Alternative 3b, the surficial tailings scattered within TA1 would be consolidated with the waste rock material and capped, effectively minimizing exposure.

With the addition of the TA1 waste material consolidation, the overall effectiveness of this alternative is expected to be improved over Alternative 3a; however the toxicity or volume of the wastes would not be further reduced since no actual treatment of the contaminants would be conducted.

Implementability – Alternative 3b is both technically and administratively feasible, however the degree of feasibility is dependent on finding a suitable cover soil borrow area. Consolidation and grading of waste sources, incorporation of amended cover soil, establishing vegetation and construction of surface water controls are applicable technologies that utilize standard design methods that have been thoroughly tested. The required construction techniques and the associated equipment are readily available and commonly used.

The reliability of this alternative is expected to be good, but would require periodic monitoring and maintenance to ensure that the integrity of the cap and armored stream channel remains intact.

Cost Screening - The total capital cost for Alternative 3b has been estimated at $317,768 which represents the reclamation of all the waste rock dumps and tailings materials at the Iron Mask Mine and Mill Site. Table C-3 (Appendix C) presents the cost details associated with implementing this alternative.

Screening Summary – Alternative 3b has been retained for detailed analysis since consolidation and reclamation of the waste rock and tailings sources combined with reclamation of TA2 may be a feasible and cost-effective remedy for the site.

7.3.5 Alternative 4a: Consolidate WR2, WR3 and Tailings in On-Site Repository with Cover Soil Cap

Alternative 4a involves excavation and consolidation of the two highest contaminated waste rock sources, and all tailings materials from the Iron Mask Mine and Mill Site into an unlined on-site repository, applying two feet of amended cover soil, and establishing vegetation on the surface of the repository to provide erosion protection and to decrease net infiltration through the waste by increasing evapotranspiration. All excavated areas would be backfilled with one foot of amended cover soil and revegetated.

Under this alternative, the existing waste rock dump at WR1 would be left in place and graded to a maximum slope of 3H:1V and capped with 2 feet of amended cover soil. Waste material would be graded away from the existing stream channel to accommodate channel reconstruction and armoring with grouted riprap. A temporary surface water diversion (i.e., culvert, pipe, lined ditch, etc.) would be necessary to facilitate construction.

Conceptual Design and Assumptions

Based on the available data and the above considerations, the conceptual design of Alternative 4a includes:

- Improving and maintaining the existing main access road from Indian Creek Road to the Iron Mask Mine and Mill Site to facilitate safe access by heavy equipment and construction crews;
- Improving and maintaining the existing site access roads and repository road to facilitate construction activities;
- Constructing a new surface water diversion to route storm water and adit flow away from waste materials to facilitate construction activities;
- Installing stream protection structures (silt fence and straw bales) to prevent sediment from entering Whipcracker Gulch during construction;
- Excavating a borrow source/repository, assumed to be located approximately one mile from the Iron Mask Mine and Mill Site, to obtain clean cover material for reclamation work and provide containment for excavated waste materials;
- Excavate, haul and place waste materials from WR2, WR3, TA1 and TA2 at the repository;
- Regrade WR1 and cap with 2 feet of amended cover soil;
- Reconstruct stream channel and place armoring materials;
- Backfill excavated areas with one foot of amended cover soil, and cap repository with two feet of amended cover soil; and
- Revegetating and mulching all disturbed areas upon completion of construction activities (temporary roads, staging areas, cover soil application areas, repository cap etc.).

The current main access road to the Iron Mask Mine and Mill Site is approximately four miles in length and is in fair condition. This unimproved dirt road will require minor upgrading by blading/regrading to facilitate safe access to the site. Existing site access roads are also in fair condition and will require only minor upgrading.

Seeding would likely take place during the fall season. The seed mixture and fertilizer would be applied simultaneously to the prepared seedbeds by approved methods. Mulch or natural fabric mats would be applied to provide temporary protection of highly erodible disturbed surfaces.

Effectiveness – Placing the most highly contaminated materials in a secure on-site containment facility would effectively minimize the majority of solid media contaminant mobility and availability for exposure at the site. The waste material would be rendered immobile in an engineered structure located away from steep terrain and protected from erosion problems. Any potential surface water erosion problems of the repository cap would be mitigated through engineered slopes of no steeper than 4H:1V, utilization of storm water control ditches, and establishment of a vegetated cover.

Regrading the waste rock material at WR1 would promote positive surface drainage and improve vegetation establishment by eliminating steep slopes susceptible to erosion. The overall effectiveness of the containment/revegetation program would be enhanced by carefully selecting appropriate plant species that are adapted to site conditions. Grading waste rock away from the existing surface water flow and construction of an armored stream channel would effectively decrease contaminant mobility to Whipcracker Gulch during high flow events.

The toxicity or volume of the wastes would not be reduced under Alternative 4a since no actual treatment of the contaminants would be conducted.

Implementability – Alternative 4a is both technically and administratively feasible; however, the degree of feasibility is dependent on finding a suitable borrow area/repository site. Repository construction and consolidation and grading of waste sources, incorporation of amended cover soil, establishing vegetation and construction of surface water controls are applicable technologies that utilize standard design methods that have been thoroughly tested. The required construction techniques and the associated equipment are readily available and commonly used.

The reliability of this alternative is expected to be better than on-site consolidation alternatives, but would require periodic monitoring and maintenance to ensure that the integrity of the waste rock cap and armored stream channel remains intact. Only minor monitoring and maintenance of the repository cap and storm water controls is anticipated.

Cost Screening - The total capital cost for Alternative 4a has been estimated at $379,880 which represents the reclamation of all the waste sources at the Iron Mask Mine and Mill Site. Table C-4 (Appendix C) presents the cost details associated with implementing this alternative.

Screening Summary – Alternative 4a has been retained for detailed analysis since consolidation of WR2, WR3 and tailings materials to an on-site repository with cover soil cap, and reclamation of WR1 may be a feasible and cost-effective remedy for the site.

7.3.6 Alternative 4b: Consolidate All Waste in On-Site Repository with Cover Soil Cap

Alternative 4b involves excavation and consolidation of all waste sources from the Iron Mask Mine and Mill Site into an unlined on-site repository with a two-foot cover soil cap. The excavated areas would be backfilled with one foot of amended cover soil and revegetated.

Following waste rock removal, the existing stream channel flow would be re-established in a more natural path by construction of a channel capable of conveying the 10-year, 24-hour storm event peak flow. The channel would be rock lined with a suitable substrate material to protect against erosion.

Conceptual Design and Assumptions

The conceptual design for Alternative 4b is similar to that described for Alternative 4a, with the addition of the WR1 material being placed into the repository. The conceptual design includes:

- Improving and maintaining the existing main access road from Indian Creek Road to the Iron Mask Mine and Mill Site to facilitate safe access by heavy equipment and construction crews;
- Improving and maintaining the existing site access roads and repository road to facilitate construction activities;
- Constructing a new surface water diversion to route storm water and adit flow away from waste materials to facilitate construction activities;
- Installing stream protection structures (silt fence and straw bales) to prevent sediment from entering Whipcracker Gulch during construction;

- Excavating a borrow source/repository, assumed to be located approximately one mile from the Iron Mask Mine and Mill Site, to obtain clean cover material for reclamation work and provide containment for excavated waste materials;
- Excavate, haul and place waste materials from WR1, WR2 and WR3 at the repository;
- Excavate, haul and place waste materials from TA1 and TA2 at the repository;
- Reconstruct stream channel and place substrate materials;
- Backfill excavated areas with one foot of amended cover soil, and cap repository with two feet of amended cover soil; and
- Revegetating and mulching all disturbed areas upon completion of construction activities (temporary roads, staging areas, cover soil application areas, repository cap etc.).

The current main access road to the Iron Mask Mine and Mill Site is approximately four miles in length and is in fair condition. This unimproved dirt road will require minor upgrading by blading/regrading to facilitate safe access to the site. Existing site access roads are also in fair condition and will require only minor upgrading.

Seeding would likely take place during the fall season. The seed mixture and fertilizer would be applied simultaneously to the prepared seedbeds by approved methods. Mulch or natural fabric mats would be applied to provide temporary protection of highly erodible disturbed surfaces.

Effectiveness – Placing waste materials in a secure on-site containment facility would effectively minimize the solid media contaminant mobility and availability for exposure at the site. All waste materials would be rendered immobile in an engineered structure located away from steep terrain and protected from erosion problems. Any potential surface water erosion problems of the repository cap would be mitigated through engineered slopes of no steeper than 4H:1V, utilization of storm water control ditches, and establishment of a vegetated cover.

By placing all waste rock material in the repository in addition to the tailings, the overall effectiveness of this alternative is expected to be improved over Alternative 4a; however the toxicity or volume of the wastes would not be further reduced since no actual treatment of the contaminants would be conducted.

Implementability – Alternative 4b is both technically and administratively feasible, however the degree of feasibility is dependent on finding a suitable borrow area/repository site. Repository construction, placement of waste sources, incorporation of amended cover soil, establishing vegetation and construction of surface water controls are applicable technologies that utilize standard design methods that have been thoroughly tested. The required construction techniques and the associated equipment are readily available and commonly used.

The reliability of this alternative is expected to be better than on-site consolidation alternatives, requiring only minor monitoring and maintenance to ensure the integrity of the repository cap and storm water controls.

Cost Screening - The total capital cost for Alternative 4b has been estimated at $635,093 which represents the reclamation of all the waste rock dumps and tailings materials at the Iron Mask

Mine and Mill Site. Table C-5 (Appendix C) presents the cost details associated with implementing this alternative.

Screening Summary – Alternative 4b has been retained for detailed analysis since consolidation of all waste sources to an on-site repository with cover soil cap may be a feasible and cost-effective remedy for the site.

7.3.7 Alternative 5a: Consolidate All Waste in On-Site Repository with Multi-Layered Cap

Alternative 5a consists of excavating and disposing of all solid mine waste materials from the Iron Mask Mine and Mill Site in an on-site repository consisting of a multi-layered cap with no bottom liner.

The considerations are the same as described in Alternative 4b, with the addition of a Geo-synthetic Clay Liner (GCL) and Geocomposite Drainage Layer within the repository cap.

Conceptual Design and Assumptions

Based on the available data and the above considerations, the conceptual design for Alternative 5a includes:

- Improving and maintaining the existing main access road from Indian Creek Road to the Iron Mask Mine and Mill Site to facilitate safe access by heavy equipment and construction crews.
- Improving and maintaining the existing site access roads and repository road to facilitate construction activities.
- Constructing a new surface water diversion to route storm water and adit flow away from waste materials to facilitate construction activities.
- Installing stream protection structures (silt fence and straw bales) to prevent sediment from entering Whipcracker Gulch during construction.
- Excavating a borrow source/repository, assumed to be located approximately 1 mile from the Iron Mask Mine and Mill Site, to obtain clean cover material for reclamation work and provide containment for excavated waste materials.
- Excavate, haul and place waste materials from WR1, WR2 and WR3 at the repository;
- Excavate, haul and place waste materials from TA1 and TA2 at the repository.
- Reconstruct stream channel and place substrate materials.
- Backfill excavated areas with one foot of amended cover soil.
- Constructing a multi-layered cap over the waste materials in the repository. The multi-layered cap consists of a Geotextile Cushion placed directly over the upper most compacted lift of mine wastes in the repository, followed by the GCL, and a Geocomposite Drainage Layer, consisting of a synthetic Geonet drainage material with non-woven Geotextile filter fabric, being placed over the GCL, and a two-foot thick layer of amended cover soil.
- Revegetating and mulching all disturbed areas upon completion of construction activities (temporary roads, staging areas, cover soil application areas, repository cap etc.).

The current main access road to the Iron Mask Mine and Mill Site is approximately four miles in length and is in fair condition. This unimproved dirt road will require minor upgrading by blading/regrading to facilitate safe access to the site. Existing site access roads are also in fair condition and will require only minor upgrading.

Seeding would likely take place during the fall season. The seed mixture and fertilizer would be applied simultaneously to the prepared seedbeds by approved methods. Mulch or natural fabric mats would be applied to provide temporary protection of highly erodible disturbed surfaces.

Effectiveness – Placing waste materials in a secure on-site containment facility would effectively minimize the solid media contaminant mobility and availability for exposure at the site. All waste materials would be rendered immobile in an engineered structure located away from steep terrain and protected from erosion problems. Any potential surface water erosion problems of the repository cap would be mitigated through engineered slopes of no steeper than 4H:1V, utilization of storm water control ditches, and establishment of a vegetated cover.

With the addition of a GCL within the repository cap, the ability of surface water to infiltrate to waste materials is reduced when compared to a conventional cover soil cap. As a result, the overall effectiveness of this alternative is expected to be improved over Alternative 4b; however, the toxicity or volume of the wastes would not be further reduced since no actual treatment of the contaminants would be conducted.

Implementability – Alternative 5a is both technically and administratively feasible; however, the degree of feasibility is dependent on finding a suitable borrow area/repository site. Repository construction, placement of waste sources, incorporation of amended cover soil, establishing vegetation and construction of surface water controls are applicable technologies that utilize standard design methods that have been thoroughly tested. The required construction techniques and the associated equipment are readily available and commonly used. Placement of lining materials is technically more difficult and should only be performed by a contractor with task-specific experience.

When the addition of a GCL is considered, the reliability of this alternative is expected to be improved over that of a conventional cover soil cap as specified in Alternative 4b; however, this alternative would also require minor monitoring and maintenance to ensure the integrity of the repository cap and storm water controls.

Cost Screening - The total capital cost for Alternative 5a has been estimated at $805,868 which represents the reclamation of all the waste rock dumps and tailings materials at the Iron Mask Mine and Mill Site. Table C-6 (Appendix C) presents the cost details associated with implementing this alternative.

Screening Summary – Alternative 5a has been retained for detailed analysis since consolidation of all waste sources to an on-site repository with multi-layered cap may be a feasible and cost-effective remedy for the site.

7.3.8 Alternative 5b: Consolidate All Wastes in On-Site Modified RCRA Repository

Alternative 5b consists of excavating and disposing of all solid mine waste materials from the Iron Mask Mine and Mill Site in an excavated on-site modified RCRA repository consisting of a bottom drainage layer and leachate collection system with a multi-layered cap over the waste materials.

The considerations are the same as described in Alternative 5a, with the addition of the drainage layer and leachate collection system beneath the waste materials in the repository.

Conceptual Design and Assumptions

Based on the available data and the above considerations, the conceptual design for Alternative 5b includes:

- Improving and maintaining the existing main access road from Indian Creek Road to the Iron Mask Mine and Mill Site to facilitate safe access by heavy equipment and construction crews.
- Improving and maintaining the existing site access roads and repository road to facilitate construction activities.
- Constructing a new surface water diversion to route storm water and adit flow away from waste materials to facilitate construction activities.
- Installing stream protection structures (silt fence and straw bales) to prevent sediment from entering Whipcracker Gulch during construction.
- Excavating a borrow source/repository, assumed to be located approximately 1 mile from the Iron Mask Mine and Mill Site, to obtain clean cover material for reclamation work and provide containment for excavated waste materials. The bottom of the repository would consist of a finished graded smooth subgrade with a leachate collection system overlain by a Geocomposite Drainage Layer.
- Construct the leachate collection/removal system consisting of a one-foot thick layer of washed, coarse gravel placed in a collection trench lined with a polyvinyl chloride (PVC) lining. The PVC drain pipes would be installed in conjunction with the coarse gravel layer to facilitate leachate collection/removal. The Geocomposite Drainage Layer would be installed prior to placement of waste materials.
- Excavate, haul and place waste materials from WR1, WR2 and WR3 at the repository.
- Excavate, haul and place waste materials from TA1 and TA2 at the repository.
- Reconstruct stream channel and place substrate materials.
- Backfill excavated areas with 1-foot of amended cover soil.
- Constructing a multi-layered cap over the waste materials in the repository. The multi-layered cap consists of a Geotextile Cushion placed directly over the upper most compacted lift of mine wastes in the repository, followed by the GCL, and a Geocomposite Drainage Layer, consisting of a synthetic Geonet drainage material with non-woven Geotextile filter fabric, being placed over the GCL, and a two-foot thick layer of amended cover soil.
- Revegetating and mulching all disturbed areas upon completion of construction activities (temporary roads, staging areas, cover soil application areas, repository cap etc.).

The current main access road to the Iron Mask Mine and Mill Site is approximately four miles in length and is in fair condition. This unimproved dirt road will require minor upgrading by blading/regrading to facilitate safe access to the site. Existing site access roads are also in fair condition and will require only minor upgrading.

Seeding would likely take place during the fall season. The seed mixture and fertilizer would be applied simultaneously to the prepared seedbeds by approved methods. Mulch or natural fabric mats would be applied to provide temporary protection of highly erodible disturbed surfaces.

Effectiveness – Placing waste materials in a secure on-site containment facility would effectively minimize the solid media contaminant mobility and availability for exposure at the site. All waste materials would be rendered immobile in an engineered structure located away from steep terrain and protected from erosion problems. Any potential surface water erosion problems of the repository cap would be mitigated through engineered slopes of no steeper than 4H:1V, utilization of storm water control ditches, and establishment of a vegetated cover.

With the addition of a leachate collection system and drainage layer below the waste sources, the ability of any potential leachate to infiltrate to subsurface materials and groundwater is reduced, and can be captured for evaporation or treatment as necessary. As a result, the overall effectiveness of this alternative is expected to be improved over Alternative 5a; however, the toxicity or volume of the wastes would not be further reduced since no actual treatment of the contaminants would be conducted.

Implementability – Alternative 5b is both technically and administratively feasible; however, the degree of feasibility is dependent on finding a suitable borrow area/repository site. Repository construction, placement of waste sources, incorporation of amended cover soil, establishing vegetation and construction of surface water controls are applicable technologies that utilize standard design methods that have been thoroughly tested. The required construction techniques and the associated equipment are readily available and commonly used. Placement of lining materials and construction of a leachate collection system are technically more difficult and should only be performed by a contractor with task-specific experience.

When the addition of a leachate collection system and bottom drainage layer is considered, the ultimate reliability of this alternative can be readily monitored and is expected to be improved over that of Alternative 5a; however, this alternative would still require minor monitoring and maintenance to ensure the integrity of the repository cap and storm water controls.

Cost Screening - The total capital cost for Alternative 5b has been estimated at $924,146 which represents the reclamation of all the waste rock dumps and tailings materials at the Iron Mask Mine and Mill Site. Table C-7 (Appendix C) presents the cost details associated with implementing this alternative.

Screening Summary - Alternative 5b has been retained for detailed analysis since complete removal and disposal in a modified RCRA repository may be an effective, feasible, and cost-effective remedy for the site.

7.4 ALTERNATIVES SCREENING SUMMARY

Table 7-3 summarizes the findings of the preliminary evaluation and screening as described in Section 7.3.

TABLE 7-3
IRON MASK MINE AND MILL SITE
RECLAMATION ALTERNATIVES SCREENING SUMMARY

ALTERNATIVE DESCRIPTION	EFFECTIVENESS	IMPLEMENTABLE	ESTIMATED COST	RETAINED FOR DETAILED ANALYSIS
Alt. 1: No Action	NA	NA	$0	Yes
Alt. 2: Institutional Controls	Low	Yes	$12,650	No
Alt. 3a: Consolidate Waste Rock On-Site with Cover Soil Cap	Low-Moderate	Yes	$248,572	Yes
Alt. 3b: Consolidate Waste Rock and Tailings On-Site with Cover Soil Cap	Moderate	Yes	$317,768	Yes
Alt. 4a: Consolidate Waste Rock 2, Waste Rock 3 and Tailings in On-Site Repository with Cover Soil Cap	Moderate-High	Yes	$379,880	Yes
Alt. 4b: Consolidate All Waste in On-Site Repository with Cover Soil Cap	High	Yes	$635,093	Yes
Alt. 5a: Consolidate All Waste in On-Site Repository with Multi-Layer Cap	High	Yes	$805,868	Yes
Alt. 5b: Consolidate All Waste in On-Site Modified RCRA Repository	High	Yes	$924,146	Yes

8.0 DETAILED ANALYSIS OF ALTERNATIVES

This section presents the detailed analysis of reclamation alternatives pertaining to seven of the nine NCP evaluation criteria.

The purpose of the detailed analysis is to evaluate, in detail, reclamation alternatives for their effectiveness, implementability, and associated cost to control and reduce the toxicity, mobility, and/or volume of contaminated solid mine wastes at the Iron Mask Mine and Mill Site. The reclamation alternatives that were retained after the preliminary evaluation and screening (as presented in Section 7.0) are included in this detailed analysis. For clarity, the retained alternative numbers are carried over from Section 7.0. The reclamation alternatives evaluated in detail are applicable to the contaminated solid media waste materials only. The rationale for not directly developing reclamation alternatives for surface water was based primarily on the presumption that reclaiming the solid media waste sources along Whipcracker Gulch will subsequently reduce the potential problems associated with surface water sedimentation at a significantly reduced cost.

As required by the CERCLA and the NCP, reclamation alternatives that were retained after the initial evaluation and screening have been evaluated individually against the following criteria:

- Overall protection of human health and the environment;
- Compliance with ARARs;
- Long-term effectiveness and permanence;
- Reduction of toxicity, mobility, or volume through treatment;
- Short-term effectiveness;
- Implementability; and
- Cost.

Supporting agency acceptance and community acceptance are additional criteria that will be addressed after the BLM and public have reviewed the evaluations presented herein. The analysis criteria have been used to address the CERCLA requirements and considerations with EPA guidance (EPA, 1988), as well as additional technical and policy considerations. These criteria serve as the basis for conducting the detailed analysis and subsequently selecting the preferred reclamation alternative. The criteria listed above are categorized into three groups, each with distinct functions in selecting the preferred alternative. These groups include:

- Threshold Criteria—overall protection of human health and the environment and compliance with ARARs;
- Primary Balancing Criteria—long-term effectiveness and permanence; reduction of toxicity, mobility, or volume through treatment; short-term effectiveness; implementability; and cost; and
- Modifying Criteria—supporting agency and community acceptance.

Overall protection of human health and the environment and compliance with ARARs are threshold criteria that must be satisfied for an alternative to be eligible for selection. Long-term effectiveness and permanence; reduction of toxicity, mobility, or volume; short-term effectiveness; implementability; and cost are the primary balancing factors used to weigh major trade-offs between alternative waste management strategies. Supporting agency and community acceptance are modifying considerations that are formally considered after public comment is

received on the proposed plan (Federal Register, No. 245, 51394-50509, December 1988). Each criterion is briefly described in the following paragraphs.

The overall protection criterion evaluates how the alternative, as a whole, protects and maintains human health and the environment. The overall assessment of protection is based on a combination of factors assessed under other evaluation criteria, especially long-term effectiveness and permanence, short-term effectiveness, and compliance with ARARs.

Compliance with ARARs criterion assesses how each alternative complies with applicable or relevant and appropriate standards, criteria, advisories, or other guidelines. Waivers will be identified, if necessary. The following factors will be addressed for each alternative during the detailed analysis of ARARs:

- Compliance with chemical-specific ARARs;
- Compliance with action-specific ARARs;
- Compliance with location-specific ARARs; and
- Compliance with appropriate criteria, advisories, and guidelines.

Long-term effectiveness and permanence evaluates the alternative's effectiveness in protecting human health and the environment after response objectives have been met. The following components of the criterion will be addressed for each alternative:

- Magnitude of residual risk;
- Adequacy of controls; and
- Reliability of controls.

The reduction of toxicity, mobility, or volume assessment evaluates anticipated performance of the specific treatment technologies. This evaluation focuses on the following specific factors for a particular reclamation alternative:

- The treatment process, the remedies they will employ, and the materials they will treat;
- The amount of hazardous materials that will be destroyed or treated, including how principal threat(s) will be addressed;
- The degree of expected reduction in toxicity, mobility, or volume measured as a percentage of reduction (or order of magnitude);
- Degree to which the treatment will be irreversible; and
- The type and quantity of treatment residuals (i.e., wastewater treatment sludges, spent reagents) that will remain following treatment.

Short-term effectiveness evaluates an alternative's effectiveness in protecting human health and the environment during the construction and implementation period until the response objectives are met. Factors that will be considered under this criterion include:

- Protection of the surrounding community during reclamation actions;
- Protection of on-site workers during reclamation actions;
- Protection from environmental impacts; and
- Time until removal response objectives are achieved.

Implementability evaluates the technical and administrative feasibility of alternatives and the availability of required resources. Analysis of this criterion will include the following factors and sub-factors:

Technical Feasibility

- Construction and operation;
- Reliability of technology;
- Ease of undertaking additional RA; and
- Monitoring considerations.

Administrative Feasibility

- RCRA disposal restrictions;
- Institutional Controls; and
- Permitting requirements.

Availability of Services and Materials

- Adequate off-site treatment, storage capacity, and disposal service;
- Necessary equipment and specialists and provisions to ensure any necessary additional resources;
- Timing of the availability of technologies under consideration; and
- Services and materials.

The cost assessment consists of developing conservative, order-of-magnitude cost estimates based on similar sets of site-specific assumptions. Cost estimates for each alternative will consider the following factors:

Capital Costs

- Construction costs;
- Equipment costs;
- Land and site development costs;
- Disposal costs;
- Legal fees, license, and permit costs;
- Startup and troubleshooting costs; and
- Contingency allowances.

Supporting Agency acceptance will evaluate the technical and administrative issues and concerns the agencies may have regarding each of the alternatives. Acceptance will also focus on legal issues and compliance with state statutes and regulations. ***Community acceptance*** will incorporate public concerns into the analyses of the alternatives.

The final step of this analysis is to conduct a comparative analysis of the alternatives. The analysis will include a discussion of the alternative's relative strengths and weaknesses with respect to each of the criteria and how reasonable key uncertainties could change expectations of their relative performance.

Once completed, this evaluation will be used to select the preferred alternative(s). The selection of the preferred alternative(s) will be documented in a Record of Decision (ROD) by the BLM. A public meeting to present the alternatives will be conducted and relevant oral and written comments will be addressed in writing.

8.1 QUANTITATIVE EVALUATION OF THRESHOLD CRITERIA

In the following detailed evaluations of the threshold criteria, each reclamation alternative contains quantitative estimates of risk reduction as well as estimates regarding whether ARARs

would be attained by implementing the alternative. To quantitatively assess the threshold criteria (overall protection of human health and the environment and attainment of ARARs), the exposure pathways of concern that were identified in the baseline risk assessment (human health and ecologic) were evaluated to determine the risk reduction required to achieve the desired residual risk level (HQ<1.00 and EQ<1.00). Each alternative was then modeled to ascertain the degree of risk reduction achieved, either through reduced contaminant loadings to an exposure pathway or reduced surface area available for certain exposures. The resulting risk reduction estimates are then compared to one another to determine whether the relative risk reduction provided by a specific alternative is greater than another; these risk reductions are also compared to the reduction required to alleviate excess risk via the specific pathway or medium, as determined in the risk assessments. The risk reduction models also estimate resultant contaminant concentrations in the various media, which are then compared to media- and contaminant-specific ARARs.

Modeling estimates and assumptions are used in an attempt to quantify risk reduction and determine whether ARARs would be attained. In the course of performing this quantitative analysis, several assumptions and estimates are necessarily employed. Some of the assumptions are based on standard CERCLA risk assessment guidance, while others are based on site-specific observations and professional judgment. Many of the estimates are based on conservative (worst-case) scenarios, but since alternatives are compared to one another on a relative basis, these assumptions are consistent. Although the NCP states that overall protection of human health and the environment and compliance with ARARs are threshold criteria that must be satisfied for an alternative to be eligible for selection, the evaluation findings should not be considered absolute (i.e., ARARs); instead, the relative risk reduction differences between alternatives are meaningful to risk managers and can be used to evaluate these criteria.

The human health baseline risk assessments determined that the pathways and COCs at the Iron Mask Mine and Mill Site were soil ingestion/dust inhalation of As, Cd, Pb, and Mn. To evaluate the risk reduction for these contaminants via the corresponding pathways, a recreational exposure scenario has been modeled for each reclamation alternative. The resultant risk reductions are compared to the reduction required to achieve the level of protectiveness. Based on the solid media clean up goals presented in Section 6.2, the recreational exposure scenario requires a 98% reduction in surface concentration or area to achieve no toxic effects from As, the primary (most stringent) COC. No reductions are required to attain the recreational water ingestion criteria. While the site is not being evaluated for residential use, the attainment of residential soil criteria and DEQ-HHS for surface water is mentioned for completeness.

The ecologic risk assessment identified three exposure scenarios of concern: aquatic life-sediment, terrestrial mammals and plant phytotoxicity to As, Cd, Pb, Ag and Zn. Based on the solid media clean up goals presented in Section 6.2, the terrestrial mammals and plant phytotoxicity scenarios require 99% and 98% respective reductions in surface concentrations or area to achieve no toxic effects from Zn, the primary (most stringent) COC. No solid media clean up goals were established for stream sediment, as it was assumed that reclamation of the waste sources would improve the sediment environment in Whipcracker Gulch. No reductions are required to meet DEQ-AALS for surface water.

These exposure pathways were modeled to evaluate the relative risk reductions and attainment of ARARs afforded by each alternative. These calculations involved a combination of measured

data collected at the site (waste concentrations), and modeled impacts. A discussion of how the evaluations were performed and the assumptions used follows for each pathway.

The soil/dust and plant phytotoxicity exposure pathways were empirically modeled using reductions in exposed surface area to estimate reduction in human exposures. Assumptions used to evaluate reclamation effectiveness include the following: alternatives that employed soil caps were assigned a 65% long-term effectiveness for preventing exposure to surface wastes; wastes placed in a repository with a soil cap were assigned an 75% long-term effectiveness; wastes placed in a repository with a multi-layered cap were assigned a 85% long-term effectiveness; and sources moved off-site were assumed to have been 100% removed from exposures via this pathway.

The surface water/sediment pathway was also modeled using a simple mathematical model which utilized two components: measured concentrations above and below the site wastes; and an estimate of the relative increases in sediment loading provided by each source, based on relative contaminant concentrations in each source, the area of the source, and the proximity of each source to a surface water conveyance.

Because of the steep terrain at the site, slope stability was also a factor in estimation of long-term effectiveness of each alternative. Alternatives that result in steep slopes as part of reclamation (in-place containment) were assigned a higher long-term risk factor for contaminant exposure and mobility. Lower risk factors were assigned to more stable alternatives (repositories).

Assumptions used to evaluate sediment loadings include the following: alternatives that employed soil caps were assigned a 65% long-term effectiveness for preventing erosion into surface water; wastes placed in a repository with a soil cap were assigned an 75% long-term effectiveness; wastes placed in a repository with a multi-layered cap were assigned a 85% long-term effectiveness; and sources moved off-site were assumed to have been 100% removed from exposures via this pathway.

8.2 ALTERNATIVE 1: NO ACTION

The No Action Alternative is required for analysis by CERCLA and the NCP when evaluating alternatives in detail; the No Action Alternative is used to provide a baseline for comparing other alternatives. Under this alternative, no permanent reclamation activities would be implemented. Consequently, long-term human health and environmental risks associated with the on-site contamination would remain unchanged, with the contaminant sources at the site continuing to pose a threat to human health and environmental resources via dust, soil ingestion and surface water sedimentation.

8.2.1 Overall Protection of Human Health and the Environment

The No Action Alternative provides no control of exposures to contaminated materials and no reduction in risk to human health or the environment. It allows for the continued migration of contaminants and potential degradation of water quality by sediments entering the stream during high runoff events.

Protection of human health would not be achieved under the No Action Alternative. Prevention of human exposure to COCs via the pathways of concern, as identified in the human health risk

assessment, would not occur. Soil ingestion/dust inhalation exposure to As, Cd, Pb, and Mn via contaminated surface soil would not be reduced. None of the risk reduction goals would be met.

Protection of the environment would also not be achieved under the No Action Alternative. Prevention of ecologic exposures, via the scenarios identified in the ecologic risk assessment, would not occur; exposures to arsenic, cadmium, lead, silver and zinc via contaminated surface soil and stream sediment would not be reduced. None of the risk reduction goals would be met.

A risk reduction achievement matrix (Table 8-1) was developed to assess whether the alternative affords sufficient protection to human health and the environment for the pathways and COCs identified in the human health risk assessment (Section 5.1) and the ecological risk assessment (Section 5.2). The conclusions presented in the table are based on worst-case modeling results subject to the limitations and assumptions used in the models (see Section 8.1 for discussion).

TABLE 8-1
RISK REDUCTION ACHIEVEMENT MATRIX FOR ALTERNATIVE 1

Alternative 1	As	Cd	Pb	Mn	Ag	Zn	Overall
Human Health Exposure Pathway:							
Soil Ingestion	No	No	No	No	--	--	No
Ecologic Exposure Pathways:							
Stream Sediment	No	No	No	--	No	No	No
Terrestrial Mammals	No	No	No	--	--	No	No
Plant Phytotoxicity	No	No	No	--	No	No	No

-- = Risk reduction not required for the contaminant for that pathway.
No = Does not achieve required risk reduction for exposure pathway.
Yes = Does achieve required risk reduction for exposure pathway.
Recr.= Achieves recreational risk reduction.
Res.= Achieves residential and recreational risk reduction.

8.2.2 Compliance with ARARs

Federal or State ARARs only apply to water quality. Under the No Action Alternative, no contaminated materials would be treated, removed, or actively managed. Since no water quality ARARs are currently exceeded under the DEQ-AALS, this alternative achieves water quality ARARs for aquatic life acute exposure. Although the recreational water ingestion criteria for humans are not currently exceeded, water quality ARARs would continue to be exceeded for Pb under the more stringent DEQ-HHS.

8.2.3 Long-Term Effectiveness and Permanence

No controls or long-term measures would be placed on the contaminated materials at the site; consequently, all current and future risks would remain the same as described in the baseline risk assessment (Section 5.0). Therefore, the No Action Alternative would not be effective at

minimizing risks from exposure to these materials. The time required until reclamation objectives are reached (by natural contaminant degradation and erosion) would be indefinite and would most likely be measured in terms of geologic time frames.

8.2.4 Reduction of Toxicity, Mobility, or Volume Through Treatment

The No Action Alternative would provide no reduction in toxicity, mobility, or volume of the contaminated materials.

8.2.5 Short-Term Effectiveness

In the short-term, the No Action Alternative would pose no additional threats to the community or the environment because the current site conditions would not be changed. The identical level of risk as identified in the risk assessment (see Section 5.0) would continue to exist in the short and long term.

8.2.6 Implementability

There would be no implementability concerns posed by the No Action Alternative since no action would be taken.

8.2.7 Costs

The cost for implementing this alternative would be zero since no action would be taken.

8.3 ALTERNATIVE 3a: CONSOLIDATE WASTE ROCK ON-SITE WITH COVER SOIL CAP

Alternative 3a involves consolidation of waste rock sources at the Iron Mask Mine and Mill Site, grading the consolidated waste rock dump, applying cover soil and amendments, and establishing vegetation on the surface of the cap materials. Waste rock material would be graded away from Whipcracker Gulch to allow reconstruction of the stream channel. The tailings material located at TA1 would remain in place and the impoundment at TA2 would be regraded in place and covered with surrounding soil. A detailed description of this alternative is presented in Section 7.3.3.

8.3.1 Overall Protection of Human Health and the Environment

This alternative would provide a means of reducing soil ingestion exposure to the COCs and would reduce sediment runoff and plant phytotoxicity at the waste rock sources and TA2, but does nothing to address risks present at TA1. With an overall risk reduction of 20%, protection of human health and the environment is not achieved.

Limited protection of human health would be achieved under this alternative. Reduction of human exposures to COCs via the pathways of concern, as identified in the human health risk assessment, would occur. Soil ingestion exposure to Mn via contaminated surface soil would be

sufficiently reduced below recreational criteria; however, exposure to the primary COC (As) is reduced by only 18%, which is not enough to meet the recreational goal of 98% reduction.

No protection of the environment would be achieved under this alternative. Adequate reduction of ecologic exposures to As, Cd, Pb, Ag and Zn, via the scenarios identified in the ecologic risk assessment, would not occur. Exposure to the primary COC (Zn) under the ecologic risk assessment is also reduced by only 18%, which does not achieve the terrestrial mammal or plant phytotoxicity reduction goals of 99% and 98%.

A risk reduction achievement matrix (Table 8-2) was developed to assess whether the alternative affords sufficient protection to human health and the environment for pathways and COCs identified in the human health risk assessment (Section 5.1) and the ecological risk assessment (Section 5.2). The conclusions presented in the table are based on worst-case modeling results subject to the limitations and assumptions used in the models (see Section 8.1 for discussion).

TABLE 8-2

RISK REDUCTION ACHIEVEMENT MATRIX FOR ALTERNATIVE 3a

Alternative 3a	As	Cd	Pb	Mn	Ag	Zn	Overall
Human Health Exposure Pathway:							
Soil Ingestion	No	No	No	Recr.	--	--	No
Ecologic Exposure Pathways:							
Stream Sediment	No	No	No	--	No	No	No
Terrestrial Mammals	No	No	No	--	--	No	No
Plant Phytotoxicity	No	No	No	--	No	No	No

-- = Risk reduction not required for the contaminant for that pathway.
No = Does not achieve required risk reduction for exposure pathway.
Yes = Does achieve required risk reduction for exposure pathway.
Recr.= Achieves recreational risk reduction.
Res.= Achieves residential and recreational risk reduction.

8.3.2 Compliance with ARARs

There are no ARARs that apply to in-place stabilization/containment of contaminated solid media. Since no water quality ARARs are currently exceeded under the DEQ-AALS, this alternative achieves water quality ARARs for the aquatic life acute exposure. Although the recreational water ingestion criteria for humans are not currently exceeded, water quality ARARs would continue to be exceeded for lead under the more stringent DEQ-HHS.

8.3.3 Long-Term Effectiveness and Permanence

Grading, capping and revegetation of the consolidated waste rock dump and impoundment at TA2 would reduce the risk of direct contact and inhalation of airborne contaminants, provide

protection from surface water and wind erosion, and would reduce net infiltration through the contaminated media by increasing evapotranspiration processes and promoting runoff. However, this alternative does not mitigate risks associated with the contamination present at TA1.

Because of space constraints and the surrounding topography at the site, the steepness of the regraded slopes would likely exceed 3H:1V; soil covers are often subjected to severe surface water erosion problems when placed on slopes steeper than 3H:1V. Compaction may help reduce erosion problems, but may cause revegetation problems. Consequently, erosion control mats may be appropriate for application on the steep slopes of reclaimed waste sources in attempt to improve the long-term effectiveness.

The long-term effectiveness of revegetation would be enhanced by installing proper erosion control materials, applying amendments, and selecting appropriate plant species, as opposed to selecting native species exclusively.

In the long term, water quality and sedimentation in Whipcracker Gulch is expected to be improved through reclamation of the source contamination.

8.3.4 Reduction of Toxicity, Mobility, or Volume Through Treatment

The objective of this alternative is to provide a reduction in contaminant mobility. The volume or toxicity of the contaminants would not be reduced by implementing this alternative.

Reclamation would stabilize the waste rock and TA2 impoundment and reduce contaminant mobility via surface water, wind erosion and infiltration. Removing portions of the waste rock dumps located adjacent to the stream reduces direct contact with the stream and the potential for mobility through surface water erosion. Although the tailings located at TA1 are currently well vegetated, the shallow nature of the deposits leave them susceptible to direct contact and mobility through erosion and infiltration.

Based on modeling results, this alternative is expected to reduce the mobility of the on-site contaminants to an extent that would result in an overall human health and ecological risk reduction (all pathways and all routes of exposure considered) of 20%.

8.3.5 Short-Term Effectiveness

It is anticipated that the construction phase of this alternative would be accomplished in one field season; therefore, impacts associated with construction would be short term. Short-term impacts to the surrounding community are expected to be minimal due to the remote location of the project site and lack of residential occupation in the immediate area. However, short-term air quality impacts to the surrounding environment may occur due to the volumes of wastes requiring excavation and regrading. On-site workers would be adequately protected during the construction phase by utilizing appropriate personal protective equipment and by following proper operating and safety procedures. Control of fugitive dust emissions would be provided by applying water (via water truck) to surfaces receiving heavy vehicular traffic, or in excavation areas, etc.

Under this alternative, some wastes located directly in or near Whipcracker Gulch would be removed and/or regraded. These construction activities would occur directly in or very near the current stream channel and could cause significant short-term adverse impacts to water quality in the stream. For these reasons, the stream would be temporarily diverted away from construction areas as needed to minimize any short-term impacts. Storm water runoff from other general construction activities may also cause short-term adverse impacts to water quality in the stream. Construction Best Management Practices (BMPs) would be employed to address these sources and reduce adverse impacts to surface water from the construction activities.

8.3.6 Implementability

This alternative is both technically and administratively feasible. The road construction, excavation, consolidation, grading, capping, and revegetation steps required are considered conventional construction practices; materials and equipment are readily available. Also, design methods and requirements are well documented and understood. However, the construction steps required to implement this alternative are considered moderately difficult (due, in part, to the steep terrain and the remote location), and should only be performed by experienced contractors utilizing the appropriate equipment.

The caps and associated run-on controls would have to be maintained to ensure that they continue to perform as designed; the caps would continue to be susceptible to possible settlement, erosion, and disruption of cover integrity by vehicles, grazing, deep-rooting vegetation, and burrowing animals. Consequently, frequent long-term monitoring of the remedy, including surface water and sediment monitoring in Whipcracker Gulch, would be required. Required maintenance could be easily determined and implemented through the monitoring and maintenance program.

Integration of institutional controls such as travel restrictions, access controls and livestock management would be beneficial to preserve the integrity of the remedy.

8.3.7 Costs

The total capital cost for Alternative 3a has been estimated at $248,572 which represents the reclamation of all the waste rock dumps and TA2 at the Iron Mask Mine and Mill Site. The total cost does not include costs for monitoring and maintenance or implementation of Institutional Controls. Table C-2 (Appendix C) presents the cost details associated with implementing this alternative. Descriptions of the costs associated with this alternative are presented in Section 7.3.3.

8.4 ALTERNATIVE 3b: CONSOLIDATE WASTE ROCK AND TAILINGS ON-SITE WITH COVER SOIL CAP

Alternative 3b involves consolidation of all waste rock and tailings from TA1 at the Iron Mask Mine and Mill Site, grading the consolidated waste, applying cover soil and amendments, and establishing vegetation on the surface of the cap materials. Waste rock material would be graded away from Whipcracker Gulch to allow reconstruction of the stream channel. The impoundment

at TA2 would be regraded in place and covered with surrounding soil. A detailed description of this alternative is presented in Section 7.3.4.

8.4.1 Overall Protection of Human Health and the Environment

This alternative would provide a means of reducing soil ingestion exposure to the COCs and would reduce sediment runoff and plant phytotoxicity at all waste sources. However, with an overall risk reduction of 81%, protection of human health and the environment is not achieved.

Some protection of human health would be achieved under this alternative. Reduction of human exposures to COCs via the pathways of concern, as identified in the human health risk assessment, would occur. Soil ingestion exposure to Cd and Mn via contaminated surface soil would be reduced below recreational criteria; however, exposure to the primary COC (As) is reduced by 86%, which is not enough to meet the recreational goal of 98% reduction.

Limited protection of the environment would also be achieved under this alternative. Reduction of ecologic exposures to COCs, via the scenarios identified in the ecologic risk assessment, would occur. Terrestrial mammal exposure to arsenic is reduced below the criteria; however reduction of exposure to the primary COC (Zn) is 79%, which does not achieve the terrestrial mammal or plant phytotoxicity reduction goals of 99% and 98%.

A risk reduction achievement matrix (Table 8-3) was developed to assess whether the alternative affords sufficient protection to human health and the environment for pathways and COCs identified in the human health risk assessment (Section 5.1) and the ecological risk assessment (Section 5.2). The conclusions presented in the table are based on worst-case modeling results subject to the limitations and assumptions used in the models (see Section 8.1 for discussion).

TABLE 8-3

RISK REDUCTION ACHIEVEMENT MATRIX FOR ALTERNATIVE 3b

Alternative 3b	As	Cd	Pb	Mn	Ag	Zn	Overall
Human Health Exposure Pathway:							
Soil Ingestion	No	Res.	No	Recr.	--	--	No
Ecologic Exposure Pathways:							
Stream Sediment	No	No	No	--	Yes	No	No
Terrestrial Mammals	Yes	No	No	--	--	No	No
Plant Phytotoxicity	No	No	No	--	No	No	No

-- = Risk reduction not required for the contaminant for that pathway.
No = Does not achieve required risk reduction for exposure pathway.
Yes = Does achieve required risk reduction for exposure pathway.
Recr.= Achieves recreational risk reduction.
Res.= Achieves residential and recreational risk reduction.

8.4.2 Compliance with ARARs

There are no ARARs that apply to in-place stabilization/containment of contaminated solid media. Since no water quality ARARs are currently exceeded under the DEQ-AALS, this alternative achieves water quality ARARs for the aquatic life acute exposure. Although the recreational water ingestion criteria for humans are not currently exceeded, water quality ARARs would continue to be exceeded for lead under the more stringent DEQ-HHS.

8.4.3 Long-Term Effectiveness and Permanence

Grading, capping and revegetation of the consolidated waste (waste rock and TA1) and impoundment at TA2 would reduce the risk of direct contact and inhalation of airborne contaminants, provide protection from surface water and wind erosion, and would reduce net infiltration through the contaminated media by increasing evapotranspiration processes and promoting runoff.

Because of space constraints and the surrounding topography at the site, the steepness of the regraded slopes would likely exceed 3H:1V; soil covers are often subjected to severe surface water erosion problems when placed on slopes steeper than 3H:1V. Compaction may help reduce erosion problems, but may cause revegetation problems. Consequently, erosion control mats may be appropriate for application on the reclaimed waste sources in attempt to improve the long-term effectiveness.

The long-term effectiveness of revegetation would be enhanced by installing proper erosion control materials, applying amendments, and selecting appropriate plant species, as opposed to selecting native species exclusively.

In the long term, water quality and sedimentation in Whipcracker Gulch is expected to be improved through reclamation of the source contamination.

8.4.4 Reduction of Toxicity, Mobility, or Volume Through Treatment

The objective of this alternative is to provide a reduction in contaminant mobility. The volume or toxicity of the contaminants would not be reduced by implementing this alternative. Reclamation would stabilize the waste sources and reduce contaminant mobility via surface water, wind erosion and infiltration. Removing portions of the waste rock dumps located adjacent to the stream reduces direct contact with the stream and the potential for mobility through surface water erosion.

Based on modeling results, this alternative is expected to reduce the mobility of the on-site contaminants to an extent that would result in an overall human health and ecological risk reduction (all pathways and all routes of exposure considered) of 79%. Risk reduction under this alternative is increased over Alternative 3a by inclusion of the tailings material located at TA1 in the remedy.

8.4.5 Short-Term Effectiveness

It is anticipated that the construction phase of this alternative would be accomplished in one field season; therefore, impacts associated with construction would be short term. Short-term impacts to the surrounding community are expected to be minimal due to the remote location of the project site and lack of residential occupation in the immediate area. However, short-term air quality impacts to the surrounding environment may occur due to the volumes of wastes requiring excavation and regrading. On-site workers would be adequately protected during the construction phase by utilizing appropriate personal protective equipment and by following proper operating and safety procedures. Control of fugitive dust emissions would be provided by applying water (via water truck) to surfaces receiving heavy vehicular traffic, or in excavation areas, etc.

Under this alternative, some wastes located directly in or near Whipcracker Gulch would be removed and/or regraded. These construction activities would occur directly in or very near the current stream channel and could cause significant short-term adverse impacts to water quality in the stream. For these reasons, the stream would be temporarily diverted away from construction areas as needed to minimize any short-term impacts. Storm water runoff from other general construction activities may also cause short-term adverse impacts to water quality in the stream. Construction BMPs would be employed to address these sources and reduce adverse impacts to surface water from the construction activities.

8.4.6 Implementability

This alternative is both technically and administratively feasible. The road construction, excavation, consolidation, grading, capping, and revegetation steps required are considered conventional construction practices; materials and equipment are readily available. Also, design methods and requirements are well documented and understood. However, the construction steps required to implement this alternative are considered moderately difficult (due, in part, to the steep terrain and the remote location), and should only be performed by experienced contractors utilizing the appropriate equipment.

The caps and associated run-on controls would have to be maintained to ensure that they continue to perform as designed; the caps would continue to be susceptible to possible settlement, erosion, and disruption of cover integrity by vehicles, grazing, deep-rooting vegetation, and burrowing animals. Consequently, frequent long-term monitoring of the remedy, including surface water and sediment monitoring in Whipcracker Gulch, would be required. Required maintenance could be easily determined and implemented through the monitoring and maintenance program.

Integration of Institutional Controls such as travel restrictions, access controls and livestock management would be beneficial to preserve the integrity of the remedy.

8.4.7 Costs

The total capital cost for Alternative 3b has been estimated at $317,768 which represents the reclamation of all the waste rock dumps and tailings materials at the Iron Mask Mine and Mill Site. The total cost does not include costs for monitoring and maintenance or implementation of Institutional Controls. Table C-3 (Appendix C) presents the cost details associated with implementing this alternative. Descriptions of the costs associated with this alternative are presented in Section 7.3.4.

8.5 ALTERNATIVE 4a: CONSOLIDATE WR2, WR 3 AND TAILINGS IN ON-SITE REPOSITORY WITH COVER SOIL CAP

Alternative 4a involves consolidation of the most highly contaminated waste sources at the Iron Mask Mine and Mill Site into an on-site repository, applying cover soil and amendments, and establishing vegetation on the surface of the cap materials. Waste rock material located at WR1 would be regraded away from Whipcracker Gulch to allow reconstruction of the stream channel, and capped with amended cover soil. A detailed description of this alternative is presented in Section 7.3.5.

8.5.1 Overall Protection of Human Health and the Environment

This alternative would provide a means of reducing soil ingestion exposure to the COCs and would reduce sediment runoff and plant phytotoxicity at all waste sources. However, with an overall risk reduction of 89%, protection of human health and the environment is not achieved.

Considerable protection of human health would be achieved under this alternative. Reduction of human exposures to COCs via the pathways of concern, as identified in the human health risk assessment, would occur. Soil ingestion exposure to Cd, Pb and Mn via contaminated surface soil would be reduced below recreational criteria; exposure to the primary COC (As) is reduced by 93%, but falls short of meeting the recreational goal of 98% reduction.

Some protection of the environment would also be achieved under this alternative. Reduction of ecologic exposures to COCs, via the scenarios identified in the ecologic risk assessment, would occur. Terrestrial mammal exposure to arsenic and plant phytotoxicity due to As and Cd is reduced below the criteria; however, reduction of exposure to the primary COC (Zn) is 88%, which does not achieve the terrestrial mammal or plant phytotoxicity reduction goals of 99% and 98%.

A risk reduction achievement matrix (Table 8-4) was developed to assess whether the alternative affords sufficient protection to human health and the environment for pathways and COCs identified in the human health risk assessment (Section 5.1) and the ecological risk assessment (Section 5.2). The conclusions presented in the table are based on worst-case modeling results subject to the limitations and assumptions used in the models (see Section 8.1 for discussion).

TABLE 8-4

RISK REDUCTION ACHIEVEMENT MATRIX FOR ALTERNATIVE 4a

Alternative 4a	As	Cd	Pb	Mn	Ag	Zn	Overall
Human Health Exposure Pathway:							
Soil Ingestion	No	Res.	Recr.	Recr.	--	--	No
Ecologic Exposure Pathways:							
Stream Sediment	Yes	Yes	Yes	--	Yes	Yes	Yes
Terrestrial Mammals	Yes	No	No	--	--	No	No
Plant Phytotoxicity	Yes	Yes	No	--	No	No	No

-- = Risk reduction not required for the contaminant for that pathway.
No = Does not achieve required risk reduction for exposure pathway.
Yes = Does achieve required risk reduction for exposure pathway.
Recr.= Achieves recreational risk reduction.
Res.= Achieves residential and recreational risk reduction.

8.5.2 Compliance with ARARs

There are no ARARs that apply to in-place stabilization/containment of contaminated solid media. Since no water quality ARARs are currently exceeded under the DEQ-AALS, this alternative achieves water quality ARARs for the aquatic life acute exposure. Although the recreational water ingestion criteria for humans are not currently exceeded, water quality ARARs would continue to be exceeded for lead under the more stringent DEQ-HHS.

8.5.3 Long-Term Effectiveness and Permanence

Grading, capping and revegetating the waste material at WR1 and placing the other waste sources in a secure engineered repository would reduce the risk of direct contact and inhalation of airborne contaminants, provide protection from surface water and wind erosion, and would reduce net infiltration through the contaminated media by increasing evapotranspiration processes and promoting runoff.

Because of space constraints and the surrounding topography at the site, the steepness of the regraded WR1 slopes would likely exceed 3H:1V. Soil covers are often subjected to severe surface water erosion problems when placed on slopes steeper than 3H:1V. Compaction may help reduce erosion problems, but may cause revegetation problems. Consequently, erosion control mats may be appropriate for application on the reclaimed WR1 material. The repository would be located away from steep terrain to allow slopes of 4H:1V or flatter, and would therefore be more effective at protecting waste materials from erosion problems.

The long-term effectiveness of revegetation would be enhanced by installing proper erosion control materials, applying amendments, and selecting appropriate plant species, as opposed to selecting native species exclusively.

In the long term, water quality and sedimentation in Whipcracker Gulch is expected to be resolved through reclamation of the source contamination.

8.5.4 Reduction of Toxicity, Mobility, or Volume Through Treatment

The objective of this alternative is to provide a reduction in contaminant mobility. The volume or toxicity of the contaminants would not be reduced by implementing this alternative. Reclamation would stabilize the waste sources and reduce contaminant mobility via surface water, wind erosion and infiltration. Removing portions of the waste rock dump located adjacent to the stream reduces direct contact with the stream and the potential for mobility through surface water erosion.

Based on modeling results, this alternative is expected to reduce the mobility of the on-site contaminants to an extent that would result in an overall human health and ecological risk reduction (all pathways and all routes of exposure considered) of 89%. Risk reduction under this alternative is increased over Alternative 3b due to the better effectiveness of placing the most highly contaminated waste materials in an engineered repository.

8.5.5 Short-Term Effectiveness

It is anticipated that the construction phase of this alternative would be accomplished in one field season; therefore, impacts associated with construction would be short term. Short-term impacts to the surrounding community are expected to be minimal due to the remote location of the project site and lack of residential occupation in the immediate area. However, short-term air quality impacts to the surrounding environment may occur due to the volumes of wastes requiring excavation and regrading. On-site workers would be adequately protected during the construction phase by utilizing appropriate personal protective equipment and by following proper operating and safety procedures. Control of fugitive dust emissions would be provided by applying water (via water truck) to surfaces receiving heavy vehicular traffic, or in excavation areas, etc.

Under this alternative, some wastes located directly in or near Whipcracker Gulch would be removed and/or regraded. These construction activities would occur directly in or very near the current stream channel and could cause significant short-term adverse impacts to water quality in the stream. For these reasons, the stream would be temporarily diverted away from construction areas as needed to minimize any short-term impacts. Storm water runoff from other general construction activities may also cause short-term adverse impacts to water quality in the stream. Construction BMPs would be employed to address these sources and reduce adverse impacts to surface water from the construction activities.

8.5.6 Implementability

This alternative is both technically and administratively feasible. The road construction, excavation, repository construction, grading, capping, and revegetation steps required are considered conventional construction practices; materials and equipment are readily available. Also, design methods and requirements are well documented and understood. However, the

construction steps required to implement this alternative are considered moderately difficult (due, in part, to the steep terrain and the remote location), and should only be performed by experienced contractors utilizing the appropriate equipment.

The caps and associated run-on controls would have to be maintained to ensure that they continue to perform as designed. The caps would continue to be susceptible to possible settlement, erosion, and disruption of cover integrity by vehicles, grazing, deep-rooting vegetation, and burrowing animals. Consequently, frequent long-term monitoring of the remedy, including surface water and sediment monitoring in Whipcracker Gulch, would be required. Required maintenance could be easily determined and implemented through the monitoring and maintenance program.

Integration of Institutional Controls such as travel restrictions, access controls and livestock management would be beneficial to preserve the integrity of the remedy.

8.5.7 Costs

The total capital cost for Alternative 4a has been estimated at $379,880 which represents the reclamation of all the waste sources at the Iron Mask Mine and Mill Site. The total cost does not include costs for monitoring and maintenance or implementation of Institutional Controls. Table C-4 (Appendix C) presents the cost details associated with implementing this alternative. Descriptions of the costs associated with this alternative are presented in Section 7.3.5.

8.6 ALTERNATIVE 4b: CONSOLIDATE ALL WASTE IN ON-SITE REPOSITORY WITH COVER SOIL CAP

Alternative 4b involves consolidation of all waste sources at the Iron Mask Mine and Mill Site into an on-site repository, applying cover soil and amendments, and establishing vegetation on the surface of the cap materials. A detailed description of this alternative is presented in Section 7.3.6.

8.6.1 Overall Protection of Human Health and the Environment

This alternative would provide a means of reducing soil ingestion exposure to the COCs and would reduce sediment runoff and plant phytotoxicity at all waste sources. An overall risk reduction of 93% is achieved, but is not fully protective of human health and the environment.

Considerable protection of human health would be achieved under this alternative. Reduction of human exposures to COCs via the pathways of concern, as identified in the human health risk assessment, would occur. Soil ingestion exposure to Cd, Pb and Mn via contaminated surface soil would be reduced below recreational criteria. Exposure to the primary COC (As) is reduced by 95%, but falls short of meeting the recreational goal of 98% reduction.

Some protection of the environment would also be achieved under this alternative. Reduction of ecologic exposures to COCs, via the scenarios identified in the ecologic risk assessment, would occur. Terrestrial mammal exposure to As and plant phytotoxicity due to As and Cd is reduced below the criteria; however, reduction of exposure to the primary COC (Zn) is 92%, which does not achieve the terrestrial mammal or plant phytotoxicity reduction goals of 99% and 98%.

A risk reduction achievement matrix (Table 8-5) was developed to assess whether the alternative affords sufficient protection to human health and the environment for the pathways and COCs identified in the human health risk assessment (Section 5.1) and the ecological risk assessment (Section 5.2). The conclusions presented in the table are based on worst-case modeling results subject to the limitations and assumptions used in the models (see Section 8.1 for discussion).

TABLE 8-5
RISK REDUCTION ACHIEVEMENT MATRIX FOR ALTERNATIVE 4b

Alternative 4b	As	Cd	Pb	Mn	Ag	Zn	Overall
Human Health Exposure Pathway:							
Soil Ingestion	No	Res.	Recr.	Res.	--	--	No
Ecologic Exposure Pathways:							
Stream Sediment	Yes	Yes	Yes	--	Yes	Yes	Yes
Terrestrial Mammals	Yes	No	No	--	--	No	No
Plant Phytotoxicity	Yes	Yes	No	--	No	No	No

-- = Risk reduction not required for the contaminant for that pathway.
No = Does not achieve required risk reduction for exposure pathway.
Yes = Does achieve required risk reduction for exposure pathway.
Recr.= Achieves recreational risk reduction.
Res.= Achieves residential and recreational risk reduction.

8.6.2 Compliance with ARARs

There are no ARARs that are required to be met for contaminated solid media. Since no water quality ARARs are currently exceeded under the DEQ-AALS, this alternative achieves water quality ARARs for the aquatic life acute exposure. Although the recreational water ingestion criteria for humans are not currently exceeded, water quality ARARs would continue to be exceeded for lead under the more stringent DEQ-HHS.

8.6.3 Long-Term Effectiveness and Permanence

Placing all waste sources in a secure engineered repository would reduce the risk of direct contact and inhalation of airborne contaminants, provide protection from surface water and wind erosion, and would reduce net infiltration through the contaminated media by increasing evapotranspiration processes and promoting runoff. The repository would be located away from steep terrain to allow slopes of 4H:1V or flatter, and would therefore be more effective at protecting all waste materials from erosion problems. After the removal is completed, the excavated areas would be revegetated; consequently, the current problems associated with the solid media at their existing locations are expected to be permanently corrected.

The long-term effectiveness of revegetation would be enhanced by installing proper erosion control materials, applying amendments, and selecting appropriate plant species, as opposed to selecting native species exclusively.

In the long term, water quality and sedimentation problems in Whipcracker Gulch are expected to be resolved through removal of the source contamination.

8.6.4 Reduction of Toxicity, Mobility, or Volume Through Treatment

The objective of this alternative is to provide a reduction in contaminant mobility. The volume or toxicity of the contaminants would not be reduced by implementing this alternative. A repository would provide the most stable location for all waste sources, and removing the waste rock dump effectively eliminates the potential of contaminant mobility to the stream. Placement of all wastes in an engineered repository further reduces the risk of contaminant mobility by removing the wastes from areas influenced by steep terrain that are subject to increased erosion potential.

Based on modeling results, this alternative is expected to reduce the mobility of the on-site contaminants to an extent that would result in an overall human health and ecological risk reduction (all pathways and all routes of exposure considered) of 93%. Risk reduction under this alternative is increased over Alternative 4a due to the better effectiveness of placing all waste materials in an engineered repository, away from Whipcracker Gulch.

8.6.5 Short-Term Effectiveness

It is anticipated that the construction phase of this alternative would be accomplished in one field season; therefore, impacts associated with construction would be short term. Short-term impacts to the surrounding community are expected to be minimal due to the remote location of the project site and lack of residential occupation in the immediate area. However, short-term air quality impacts to the surrounding environment may occur due to the volumes of wastes requiring excavation. On-site workers would be adequately protected during the construction phase by utilizing appropriate personal protective equipment and by following proper operating and safety procedures. Control of fugitive dust emissions would be provided by applying water (via water truck) to surfaces receiving heavy vehicular traffic, or in excavation areas, etc.

Under this alternative, some wastes located directly in or near Whipcracker Gulch would be removed. These construction activities would occur directly in or very near the current stream channel and could cause significant short-term adverse impacts to water quality in the stream. For these reasons, the stream would be temporarily diverted away from construction areas as needed to minimize any short-term impacts. Storm water runoff from other general construction activities may also cause short-term adverse impacts to water quality in the stream. Construction BMPs would be employed to address these sources and reduce adverse impacts to surface water from the construction activities.

8.6.6 Implementability

This alternative is both technically and administratively feasible. The road construction, excavation, repository construction, capping, and revegetation steps required are considered conventional construction practices; materials and equipment are readily available. Also, design methods and requirements are well documented and understood. However, the construction steps required to implement this alternative are considered moderately difficult (due, in part, to

the steep terrain and the remote location), and should only be performed by experienced contractors utilizing the appropriate equipment.

The repository cap and associated run-on controls would have to be maintained to ensure that they continue to perform as designed; while unlikely to experience settlement or erosion, the cap would continue to be susceptible to possible disruption of cover integrity by vehicles, grazing, deep-rooting vegetation, and burrowing animals. Consequently, long-term monitoring of the repository would be required. Required maintenance could be easily determined and implemented through the monitoring and maintenance program.

Integration of Institutional Controls such as travel restrictions, access controls and livestock management would be beneficial to preserve the integrity of the remedy.

8.6.7 Costs

The total capital cost for Alternative 4b has been estimated at $635,093 which represents the reclamation of all the waste rock dumps and tailings materials at the Iron Mask Mine and Mill Site. The total cost does not include costs for monitoring and maintenance or implementation of institutional controls. Table C-5 (Appendix C) presents the cost details associated with implementing this alternative. Descriptions of the costs associated with this alternative are presented in Section 7.3.6.

8.7 ALTERNATIVES 5a AND 5b: CONSOLIDATE ALL WASTE IN ON-SITE REPOSITORY WITH MULTI-LAYERED CAP OR MODIFIED RCRA REPOSITORY

Alternatives 5a and 5b involve consolidation of all waste sources at the Iron Mask Mine and Mill Site into an on-site lined repository. The Alternative 5a repository consists of a multi-layered cap, and the Alternative 5b modified-RCRA repository includes a multi-layered cap and bottom liner equipped with a leachate collection/removal system. Detailed descriptions of each alternative are included in Sections 7.3.7 and 7.3.8.

8.7.1 Overall Protection of Human Health and the Environment

These alternatives would provide a means of reducing soil ingestion exposure to the COCs and would reduce sediment runoff and plant phytotoxicity at all waste sources. An overall risk reduction of 96% is achieved with either alternative, but neither alternative is completely protective of human health and the environment.

Protection of human health would be substantially achieved under these alternatives. Reduction of human exposures to COCs via the pathways of concern, as identified in the human health risk assessment, would occur. Soil ingestion exposure to Cd, Pb and Mn via contaminated surface soil would be reduced below residential and recreational criteria. Exposure to the primary COC (As) is reduced by 97%, nearly meeting the recreational goal of 98% reduction.

Considerable protection of the environment would also be achieved under this alternative. Reduction of ecologic exposures to COCs, via the scenarios identified in the ecologic risk

assessment, would occur. Terrestrial mammal exposure to As and plant phytotoxicity due to As, Cd, Pb and Ag is reduced below the criteria. Reduction of exposure to the COC (Zn) is 96%, which falls short of the terrestrial mammal and plant phytotoxicity reduction goals of 99% and 98%.

A risk reduction achievement matrix (Table 8-6) was developed to assess whether the alternative affords sufficient protection to human health and the environment for the pathways and COCs identified in the human health risk assessment (Section 5.1) and the ecological risk assessment (Section 5.2). The conclusions presented in the table are based on worst-case modeling results subject to the limitations and assumptions used in the models (see Section 8.1 for discussion).

TABLE 8-6

RISK REDUCTION ACHIEVEMENT MATRIX FOR ALTERNATIVES 5a and 5b

Alternatives 5a and 5b	As	Cd	Pb	Mn	Ag	Zn	Overall
Human Health Exposure Pathway:							
Soil Ingestion	No	Res.	Res.	Res.	--	--	No
Ecologic Exposure Pathways:							
Stream Sediment	Yes	Yes	Yes	--	Yes	Yes	Yes
Terrestrial Mammals	Yes	No	No	--	--	No	No
Plant Phytotoxicity	Yes	Yes	Yes	--	Yes	No	No

-- = Risk reduction not required for the contaminant for that pathway.
No = Does not achieve required risk reduction for exposure pathway.
Yes = Does achieve required risk reduction for exposure pathway.
Recr.= Achieves recreational risk reduction.
Res.= Achieves residential and recreational risk reduction.

8.7.2 Compliance with ARARs

There are no ARARs that are required to be met for contaminated solid media. Since no water quality ARARs are currently exceeded under the DEQ-AALS, this alternative achieves water quality ARARs for the aquatic life acute exposure. Although the recreational water ingestion criteria for humans are not currently exceeded, water quality ARARs would continue to be exceeded for lead under the more stringent DEQ-HHS.

8.7.3 Long-Term Effectiveness and Permanence

Placing all waste sources in a secure engineered repository would reduce the risk of direct contact and inhalation of airborne contaminants, provide protection from surface water and wind erosion, and would reduce net infiltration through the contaminated media by increasing evapotranspiration processes and promoting runoff. By providing an impermeable barrier, the multi-layered cap is expected to offer greater long-term effectiveness and permanence over that

of a soil cap. The repository would be located away from steep terrain to allow slopes of 4H:1V or flatter, and would therefore be most effective at protecting all waste materials from erosion problems. After the removal is completed, the excavated areas would be revegetated; consequently, the current problems associated with the solid media at their existing locations are expected to be permanently corrected.

The long-term effectiveness of revegetation would be enhanced by installing proper erosion control materials, applying amendments, and selecting appropriate plant species, as opposed to selecting native species exclusively.

In the long term, water quality and sedimentation problems in Whipcracker Gulch are expected to be resolved through removal of the source contamination.

8.7.4 Reduction of Toxicity, Mobility, of Volume Through Treatment

The implementation of these alternatives provides the most reduction in contaminant mobility; however, the volume or toxicity of the contaminants would not be reduced. A repository would provide the most stable location for all waste sources, and removing the waste rock dump effectively eliminates the potential of contaminant mobility to the stream. Placement of all wastes in an engineered repository further reduces the risk of contaminant mobility by removing the wastes from areas influenced by steep terrain that are subject to increased erosion potential.

Based on modeling results, both alternatives are expected to reduce the mobility of the on-site contaminants to an extent that would result in an overall human health and ecological risk reduction (all pathways and all routes of exposure considered) of 96%. Risk reduction is increased over Alternative 4b due to the greater long-term effectiveness and permanence of a multi-layered cap.

8.7.5 Short-Term Effectiveness

It is anticipated that the construction phase of either alternative would be accomplished in one field season; therefore, impacts associated with construction would be short term. Short-term impacts to the surrounding community are expected to be minimal due to the remote location of the project site and lack of residential occupation in the immediate area. However, short-term air quality impacts to the surrounding environment may occur due to the volumes of wastes requiring excavation. On-site workers would be adequately protected during the construction phase by utilizing appropriate personal protective equipment and by following proper operating and safety procedures. Control of fugitive dust emissions would be provided by applying water (via water truck) to surfaces receiving heavy vehicular traffic, or in excavation areas, etc.

Under either alternative, some wastes located directly in or near Whipcracker Gulch would be removed. These construction activities would occur directly in or very near the current stream channel and could cause significant short-term adverse impacts to water quality in the stream. For these reasons, the stream would be temporarily diverted away from construction areas as needed to minimize any short-term impacts. Storm water runoff from other general construction activities may also cause short-term adverse impacts to water quality in the stream. Construction

BMPs would be employed to address these sources and reduce adverse impacts to surface water from the construction activities.

8.7.6 Implementability

Alternatives 5a and 5b are both technically and administratively feasible. The road construction, excavation, repository construction, capping, and revegetation steps required are considered conventional construction practices; materials and equipment are readily available. Also, design methods and requirements are well documented and understood. However, the construction steps required to implement this alternative are considered moderately difficult (due, in part, to the steep terrain and the remote location), and should only be performed by experienced contractors utilizing the appropriate equipment. In particular, installation of lining materials should only be performed by experienced personnel with proper oversight.

The repository cap and associated run-on controls would have to be maintained to ensure that they continue to perform as designed. While unlikely to experience settlement or erosion, the cap would continue to be susceptible to possible disruption of cover integrity by vehicles, grazing, deep-rooting vegetation, and burrowing animals. Consequently, long-term monitoring of the repository would be required. The leachate collection system installed with Alternative 5b provides an additional means to monitor the performance of the repository cap. Required maintenance could be easily determined and implemented through the monitoring and maintenance program.

Integration of Institutional Controls such as travel restrictions, access controls and livestock management would be beneficial to preserve the integrity of the remedy.

8.7.7 Costs

The total capital cost has been estimated at $805,868 for Alternative 5a, and $924,146 for Alternative 5b, which represent the reclamation of all the waste rock dumps and tailings materials at the Iron Mask Mine and Mill Site. The total costs do not include costs for monitoring and maintenance or implementation of Institutional Controls. Tables C-6 and C-7 (Appendix C) present the cost details associated with implementing these alternatives. Descriptions of the costs associated with these alternatives are presented in Sections 7.3.7 and 7.3.8.

9.0 COMPARATIVE ANALYSIS OF ALTERNATIVES

This section provides a comparison of the solid media reclamation alternatives retained for the Iron Mask Mine and Mill Site. The comparison focuses mainly on the following criteria: 1) the relative protectiveness of human health and the environment provided by the alternatives; 2) the estimated attainment of ARARs for each alternative; and 3) the long-term effectiveness provided by the alternatives. The primary balancing criteria are also compared although the evaluation of each criterion is very similar due to the technical similarities in the alternatives themselves, with the exception of cost. Table 9-1 presents a summary of the alternatives with respect to the first seven NCP evaluation criteria.

Alternative 1 would not achieve any risk reduction or provide any long-term protection. Alternative 3a does little toward achieving the risk reduction goals. Alternatives 3b and 4a each provide considerable overall risk reduction (between 80 to 90%), while Alternatives 4b, 5a and 5b provide the greatest reductions (greater than 90%).

Although the most protective alternatives fall short of meeting the risk reduction goals for recreational and ecological exposures, it is important to point out that the recreational criterion for As (20 mg/kg) is nearly as low as the average background concentration (17 mg/kg) surrounding the site, and the ecological criterion for Ag (2 mg/kg) is actually below the average background concentration (3 mg/kg). The ecological criteria for Cd, Pb and Zn are nearly equal to or below the 3 times average background level used for screening of potential COCs. Furthermore, the modeling results merely predict the relative performance of each alternative based on a similar set of assumptions. The results should not be taken as absolute, rather they are intended to be used as a risk management tool to assist in selecting an appropriate remedy for the site.

All of the alternatives are expected to comply with the ARARs in regard to DEQ-AALS for acute exposure to aquatic life in surface water. Alternatives 3b through 5b are also expected to comply with the DEQ-HHS for human ingestion of surface water.

The long-term effectiveness of Alternatives 4a, 4b, 5a and 5b is expected to resolve the water quality and sediment environment in Whipcracker Gulch. Erosion concerns and potential future impacts to the stream associated with Alternatives 3a, 3b, and 4a would remain due to steep slope concerns and the proximity of the wastes to the stream. The repository alternatives (4b, 5a and 5b) would provide the most stable reclamation for the waste sources.

The toxicity and volume of the waste sources would not be reduced by implementing any of the alternatives. Mobility would be reduced in proportion to the overall effectiveness of each alternative.

The short-term effectiveness is expected to be similar for each of the action alternatives. The alternatives are all technically similar, and the construction steps required to implement them would be similar as well. All of the action alternatives may have short-term impacts to Whipcracker Gulch, but the impacts can be sufficiently mitigated through the use of BMPs. Any of the action alternatives can be completed in one construction season.

TABLE 9-1
COMPARATIVE ANALYSIS OF ALTERNATIVES

Assessment Criteria	Alternative 1: No Action	Alternative 3a Consolidate Waste Rock On-Site with Cover Soil Cap	Alternative 3b: Consolidate Waste Rock and Tailings On-Site with Cover soil Cap	Alternative 4a: Consolidate Waste Rock 2, Waste Rock 3 and Tailings in On-Site Repository with Cover Soil Cap	Alternative 4b: Consolidate All Waste in On-Site Repository with Cover soil Cap	Alternatives 5a and 5b: Consolidate All Waste in On-Site Repository with Multi-Layer Cap or in Modified RCRA Repository
Overall Protectiveness of Public Health, Safety, and Welfare -	No additional protection offered.	Not Fully protective of Human Health. Exposure to primary CoC (As) is reduced by 18%, goal is 98%.	Not Fully protective of Human Health. Exposure to primary CoC (As) is reduced by 86%, goal is 98%.	Not Fully protective of Human Health. Exposure to primary CoC (As) is reduced by 93%, goal is 98%.	Not Fully protective of Human Health. Exposure to primary CoC (As) is reduced by 95%, goal is 98%.	Most protective of Human Health. Exposure to primary CoC (As) is reduced by 97%, goal is 98%.
Environmental Protectiveness -	No additional protection offered.	Not fully protective of Environment. Exposure to primary CoC (Zn) is reduced by 18%, goal is 98-99%.	Not fully protective of Environment. Exposure to primary CoC (Zn) is reduced by 79%, goal is 98-99%.	Not fully protective of Environment. Exposure to primary CoC (Zn) is reduced by 88%, goal is 98-99%.	Not fully protective of Environment. Exposure to primary CoC (Zn) is reduced by 92%, goal is 98-99%.	Not fully protective of Environment. Exposure to primary CoC (Zn) is reduced by 96%, goal is 98-99%.
Compliance with ARARs -						
Chemical Specific	Surface water quality ARARs are exceeded. (HHS for Pb)	There are no ARARs that apply to stabilization of contaminated solid media. Surface water quality ARARs are exceeded. (HHS for Pb)	There are no ARARs that apply to stabilization/containment of contaminated solid media. No water quality ARARs are exceeded.	There are no ARARs that apply to stabilization/containment of contaminated solid media. No water quality ARARs are exceeded.	There are no ARARs that apply to stabilization/containment of contaminated solid media. No water quality ARARs are exceeded.	There are no ARARs that apply to stabilization/containment of contaminated solid media. No water quality ARARs are exceeded.
Location Specific	None Apply.	All location-specific ARARs would be met.	All location-specific ARARs would be met.	All location-specific ARARs would be met.	All location-specific ARARs would be met.	All location-specific ARARs would be met.
Action Specific	None Apply.	All action-specific ARARs would be met.	All action-specific ARARs would be met.	All action-specific ARARs would be met.	All action-specific ARARs would be met.	All action-specific ARARs would be met.
Long-term Effectiveness and Permanance -						
Magnitude of Residual Risk	No reduction in CoC levels in any environmental media, except by natural degradation/erosion.	Risk reduction goals not achieved.	Risk reduction goals not achieved.	Risk reduction goals not achieved.	Risk reduction goals not achieved.	Risk reduction goals not achieved.
Adequacy and Reliability of Controls	No controls over any on-site contamination, no reliability.	Long term reliability is not achieved.	Long term reliability is not achieved.	Long term reliability is not achieved.	Containment controls are adequate for intended purposes.	Containment controls are adequate for intended purposes.
Reduction of Toxicity, Mobility, and Volume -						
Treatment Process Used and Materials Treated	None	In-place cover/containment and revegetation of waste rock will reduce mobility of CoCs. Future impacts to Whipcracker Gulch possible due to physical location of waste rock, and untreated tailings.	In-place cover/containment and revegetation of wastes will reduce mobility of CoCs. Future impacts to Whipcracker Gulch possible due to physical location of wastes.	Removal and containment of most highly contaminated wastes will reduce mobility of CoCs. Future impacts to Whipcracker Gulch possible due to physical location of Waste Rock 1.	Removal and containment of all wastes will reduce mobility of CoCs.	Removal and containment of all wastes will reduce mobility of CoCs.
Volume of Contaminated Materials Treated/Handled	None	No volume actively treated; approximately 11,500 cy capped/revegetated to reduce exposure to environmental receptors.	No volume actively treated; approximately 13,400 cy capped/revegetated to reduce exposure to environmental receptors.	No volume actively treated; approximately 10,000 cy capped/revegetated and 3,400 cy placed in repository to reduce exposure to environmental receptors.	Total volume of waste material expected to be contained within the repository to effectively isolate from environmental receptors is approximately 13,400 cy.	Total volume of waste material expected to be contained within the repository to effectively isolate from environmental receptors is approximately 13,400 cy.
Expected Degree of Reduction	Minimal, via natural degradation only (potential for future increases in mobility of contaminants).	Volume or toxicity of wastes would not be reduced; however, mobility of CoCs would be reduced by 20%.	Volume or toxicity of wastes would not be reduced; however, mobility of CoCs would be reduced by 81%.	Volume or toxicity of wastes would not be reduced; however, mobility of CoCs would be reduced by 89%.	Volume or toxicity of wastes would not be reduced; however, mobility of CoCs would be reduced by 93%.	Volume or toxicity of wastes would not be reduced; however, mobility of CoCs would be reduced by 96%.
Short-term Effectiveness						
Protection of Surrounding Area During Reclamation Action	Not Applicable.	Fugitive emissions control may be required during construction	Fugitive emissions control may be required during construction	Fugitive emissions control may be required during construction	Fugitive emissions control may be required during construction	Fugitive emissions control may be required during construction
Protection of On-Site Workers During Reclamation Action	Not Applicable.	Expected to be sufficient. Safety hazards likely more prevelant than hazards associated with wastes.	Expected to be sufficient. Safety hazards likely more prevelant than hazards associated with wastes.	Expected to be sufficient. Safety hazards likely more prevelant than hazards associated with wastes.	Expected to be sufficient. Safety hazards likely more prevelant than hazards associated with wastes.	Expected to be sufficient. Safety hazards likely more prevelant than hazards associated with wastes.
Environmental Impacts	Not Applicable.	Short term impacts to Whipcracker Gulch mitigated by use of BMPs.	Short term impacts to Whipcracker Gulch mitigated by use of BMPs.	Short term impacts to Whipcracker Gulch mitigated by use of BMPs.	Short term impacts to Whipcracker Gulch mitigated by use of BMPs.	Short term impacts to Whipcracker Gulch mitigated by use of BMPs.
Time Until Reclamation Action Objectives are Achieved	Not Applicable.	One field season.	One field season.	One field season.	One field season.	One field season.
Implementability						
Ability to Construct and Operate	No construction or operation involved.	Easily implementable, frequent monitoring required.	Easily implementable, frequent monitoring required.	Easily implementable, frequent monitoring required.	Easily implementable, periodic monitoring required.	Easily implementable, periodic monitoring required.
Ease of Implementing more action if necessary.	Not Applicable.	Easily implementable	Easily implementable	Easily implementable	Easily implementable	Easily implementable
Availability of Services and Capacities.	Not Applicable.	Availabile locally and within state.	Availabile locally and within state.	Availabile locally and within state.	Availabile locally and within state.	Availabile locally and within state.
Availability of Equipment and Materials.	Not Applicable.	Availabile locally and within state.	Availabile locally and within state.	Availabile locally and within state.	Availabile locally and within state.	Availabile locally and within state.
Estimated Capital Costs	**$0.00**	**$248,572**	**$317,768**	**$379,880**	**$635,093**	**$805,868 / $924,146**

The implementability of the action alternatives is also expected to be similar. All of the action alternatives would utilize standard construction methods and design practices. Because of their increased stability, Alternatives 4b, 5a and 5b are expected to require the least amount of future monitoring and maintenance.

Table 9-2 compares costs between the alternatives being considered, the amount of overall risk reduction, and the cost per 1% risk reduction. Alternatives 3b and 4a would achieve the most risk reduction per dollar in comparison to the other selected alternatives. However, these alternatives only achieve overall risk reduction in the 80 to 90% range; higher residual risk would remain due to long-term effectiveness concerns, and the potential to incur future maintenance costs is greater. Although Alternatives 4b, 5a and 5b are more expensive than the other alternatives, they offer more reduction in overall risk by providing for more stable containment of waste sources.

TABLE 9-2

ALTERNATIVE COST-EFFECTIVENESS COMPARISON SUMMARY

ALTERNATIVE	OVERALL RISK REDUCTION	TOTAL COST*	COST PER 1% REDUCTION IN RISK	ADDITIONAL COST PER 1% GAIN REDUCTION IN RISK
Alternative 1	0%	$0	$0	$0
Alternative 3a	20%	$248,573	$12,429	$12,429
Alternative 3b	81%	$317,768	$3,923	$1,134
Alternative 4a	89%	$379,880	$4,268	$7,764
Alternative 4b	93%	$635,093	$6,829	$63,803
Alternative 5a	96%	$805,868	$8,394	$56,925
Alternative 5b	96%	$924,146	$9,627	$118,278

*Total cost does not include monitoring and maintenance or implementation of institutional controls.

10.0 PREFERRED ALTERNATIVE`

The total removal of the Iron Mask Mine and Mill Site waste rock dumps and tailings, and disposal of these materials into an on-site repository with cover soil cap, is the preferred alternative (Alternative 4b). This alternative provides a high degree of protection and would effectively isolate the wastes in an engineered facility. This alternative is projected to reduce overall risks to human health and the environment by 93% and is also expected to attain all ARARs for surface water.

The conceptual design for Alternative 4b includes excavating 11,500 cy of waste rock and 1,900 cy of tailings, and disposing of the material into an on-site repository. The repository design consists of a two-foot thick amended soil cap with side slopes of 4H:1V or less. Following removal of the waste sources and underlying contaminated material, the excavation areas would be backfilled with cover soil and amended to establish vegetation. The Whipcracker Gulch stream channel would be reconstructed and stabilized to prevent the stream from cutting or migrating into the reclaimed areas during high flow events.

The decision to select this alternative was based primarily on the stability of the wastes following reclamation. Alternative 3a would not address any of the risk associated with the tailings material at TA1. Alternatives 3a, 3b and 4a would leave some waste sources susceptible to potential erosion and migration due to steep slopes resulting from in-place reclamation at the confined WR1/WR2 location. Alternatives 4b, 5a and 5b each contain all of the waste sources in a more stable repository environment further away from Whipcracker Gulch, and are expected to require a lesser degree of perpetual monitoring and maintenance.

Alternatives 5a and 5b each include the addition of lining materials to the cover soil cap, and in the case of Alternative 5b, a leachate collection system to capture any potential seepage from the waste materials. While the lined cap provides for an additional 3% of risk reduction, the associated cost amounts to an additional $170,775, or $56,925 per additional percent of reduction. Although some of the waste materials exhibit a potential to leach, a leachate collection system does not appear justified by the relatively low contaminant concentrations generated during laboratory testing.

Removal and disposal of all mine wastes into an on-site engineered repository with cover soil cap is expected to provide a high degree of protection to human health and the environment, and provide a stable location for waste materials at the Iron Mask Mine and Mill Site. Therefore, Alternative 4b is the preferred alternative.

11.0 REFERENCES

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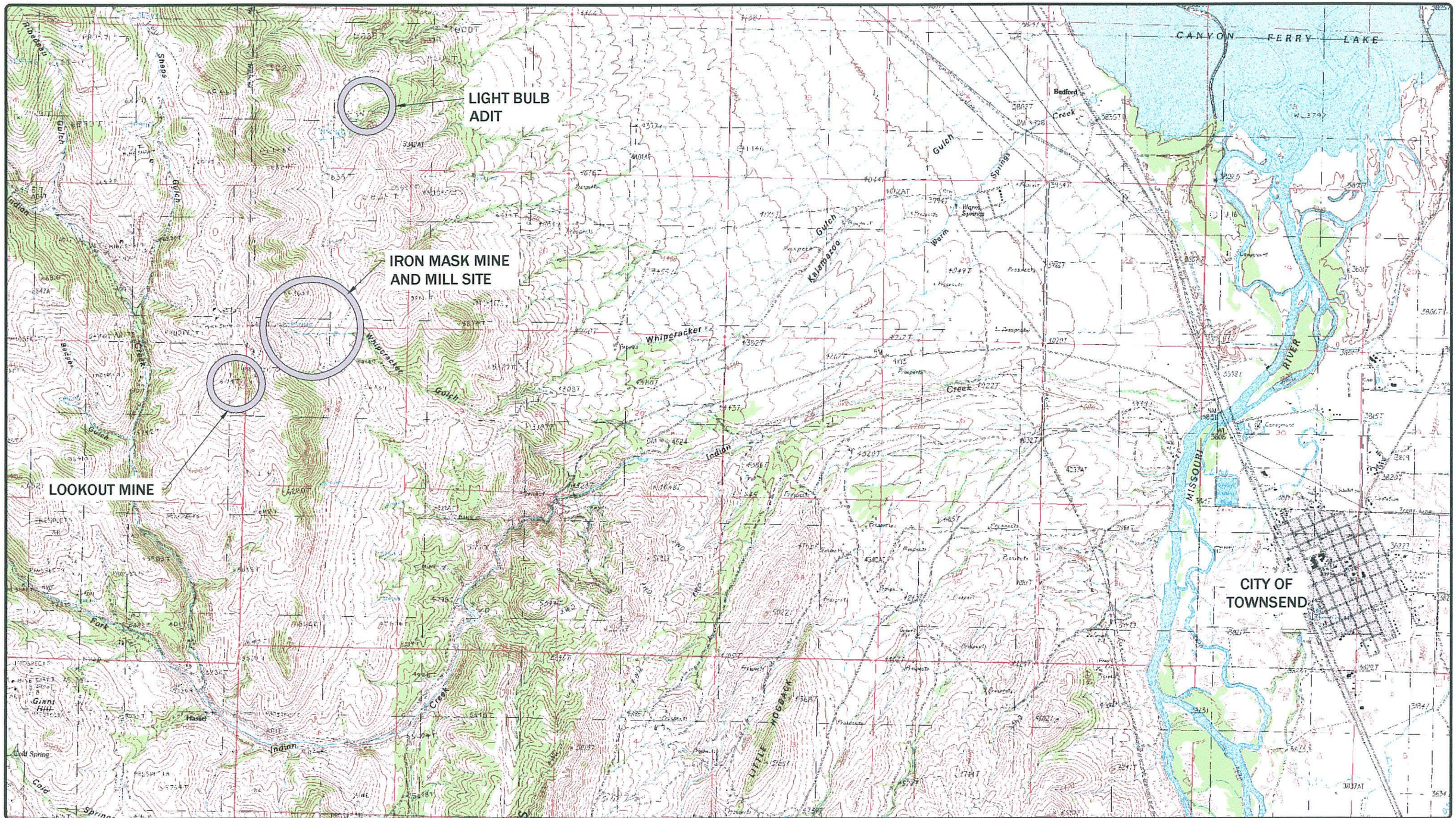
FIGURES



PROJECTION:
ZONE: MSP
DATUM: NAD83
UNITS: FEET
SOURCE: USGS 7.5 MIN QUAD MAPS

SCALE IN FEET
0 1500 3000

FIGURE 1-1 GENERAL VICINITY MAP

PIONEER TECHNICAL SERVICES, INC.
Butte, Helena, Anaconda

DATE: 5/1/09

LEGEND

TP BA-2 TP-09 — TEST PIT

SW/SE-03 — STREAM SAMPLE

BA = BORROW AREA/REPOSITORY AREA
BG = BACKGROUND
WR = WASTE ROCK
TA = TAILINGS
SW = SURFACE WATER
SE = SEDIMENT

INTERMEDIATE FLOW
PERENNIAL FLOW

N

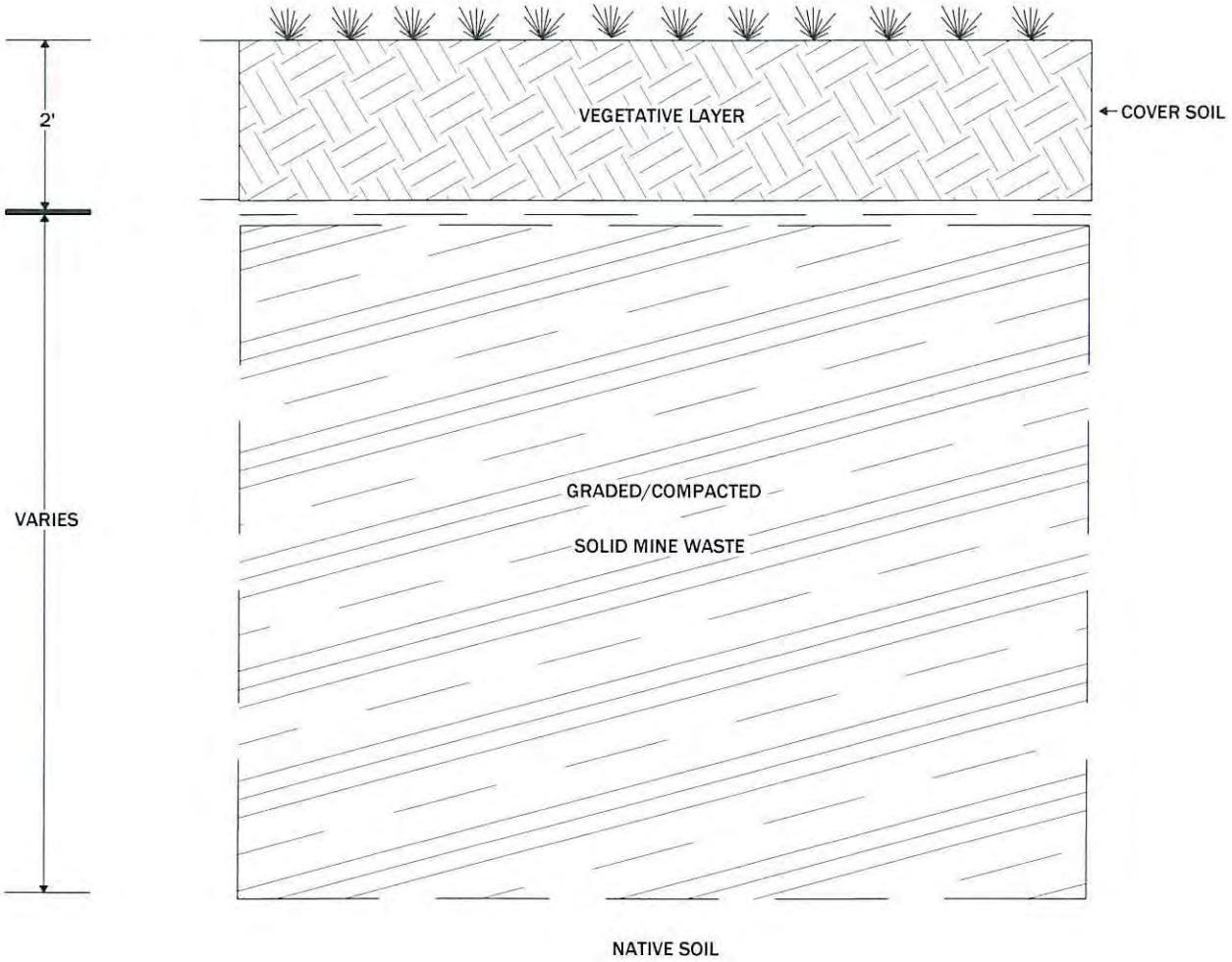
PROJECTION:
ZONE: MSP
DATUM: NAD83
UNITS: FEET
SOURCE: 2005 NAIP PHOTOS

SCALE IN FEET
0 100 200

FIGURE 3-1 IRON MASK MINE & MILL SITE SAMPLE LOCATIONS

PIONEER TECHNICAL SERVICES, INC.
Butte, Helena, Anaconda

DATE 5/1/09



PROJECTION:
ZONE:
DATUM:
UNITS:
SOURCE:

SCALE IN FEET
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FIGURE 7-1 IRON MASK MINE AND MILL SITE ALTERNATIVES 3a, 3b, 4a, AND 4b TYPICAL COVER SOIL CAP

PIONEER TECHNICAL SERVICES, INC.
Butte, Helena, Anaconda

DATE: 5/1/09

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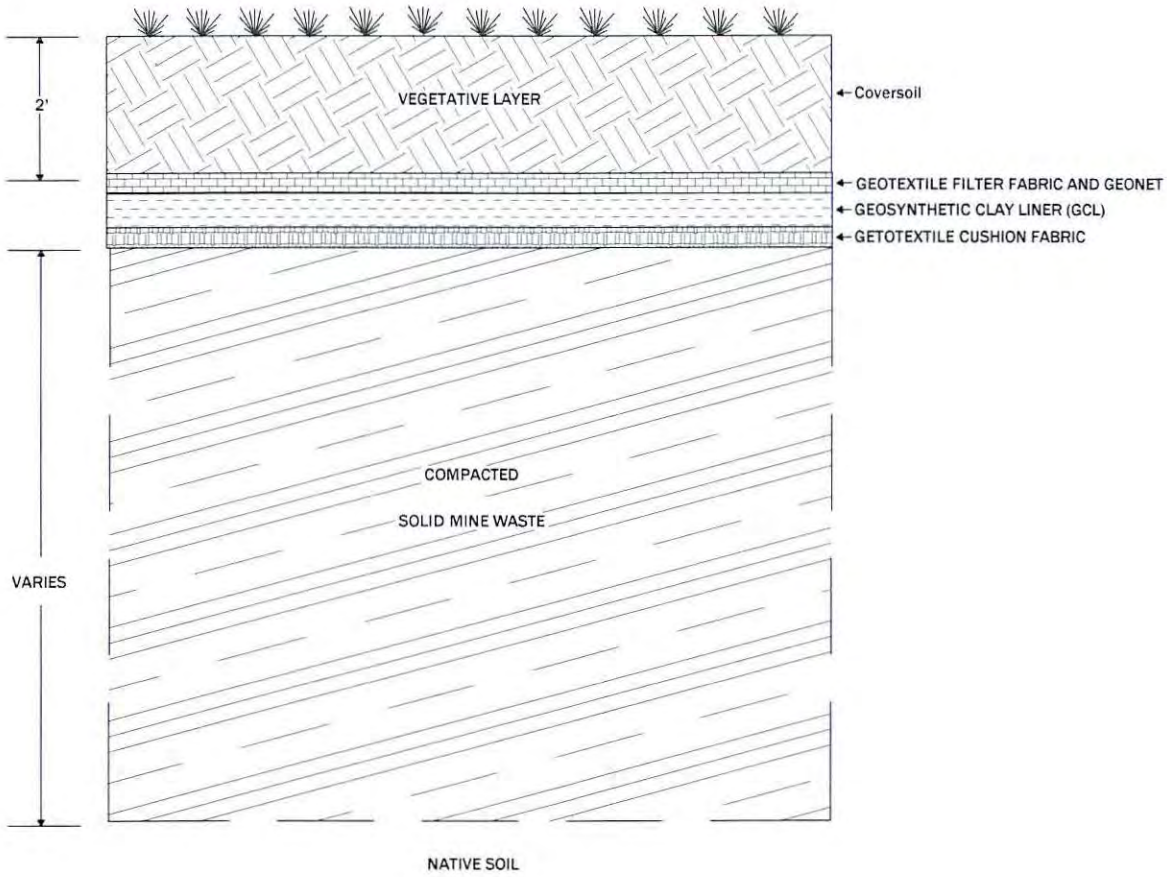

PROJECTION:
ZONE:
DATUM:
UNITS:
SOURCE:

SCALE IN FEET
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FIGURE 7-2 IRON MASK MINE AND MILL SITE ALTERNATIVE 5a TYPICAL MULTI CAP LINER

PIONEER TECHNICAL SERVICES, INC.
Butte, Helena, Anaconda

DATE: 5/1/09

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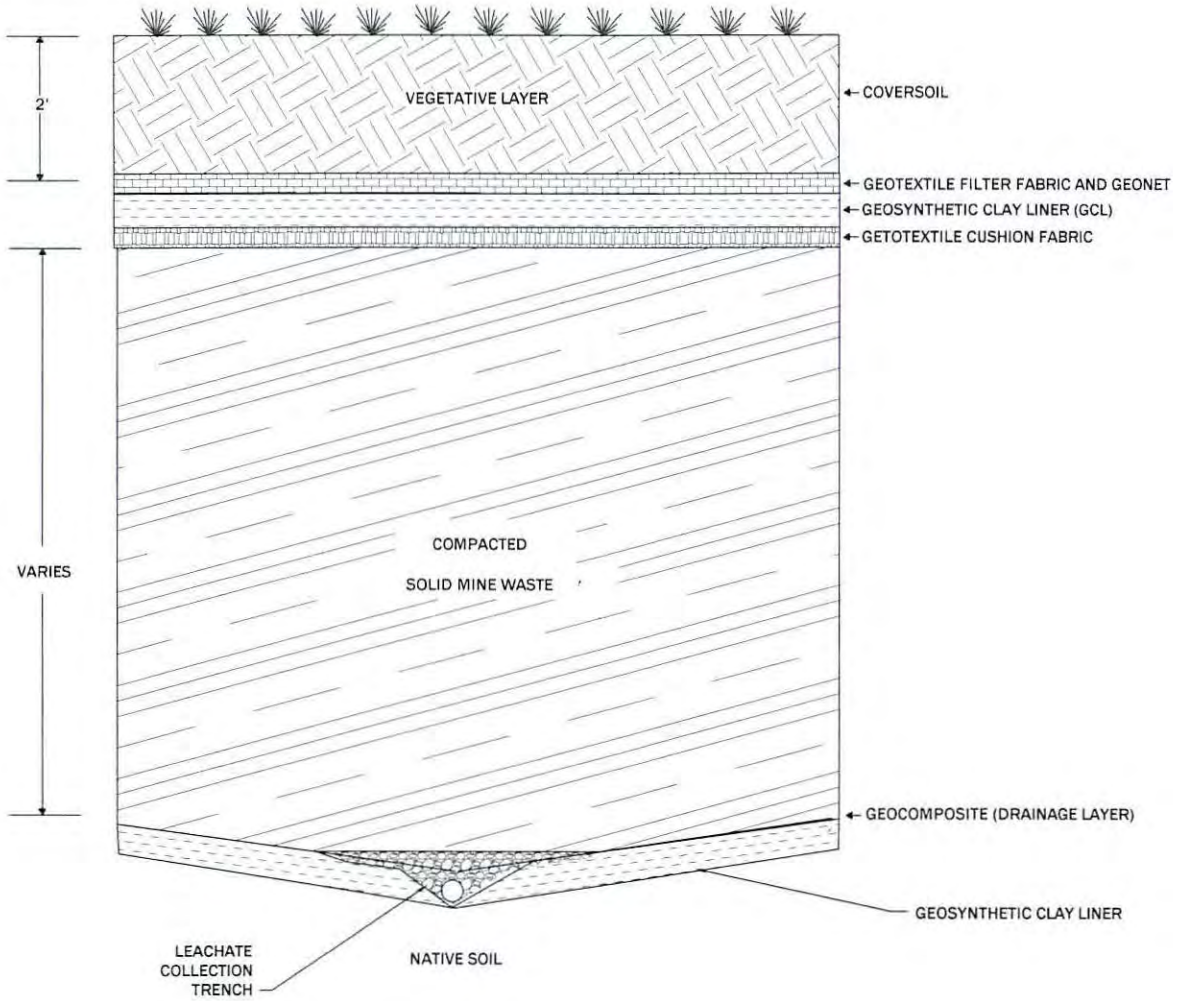

PROJECTION:
ZONE:
DATUM:
UNITS:
SOURCE:

SCALE IN FEET
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FIGURE 7-3 IRON MASK MINE AND MILL SITE ALTERNATIVE 5b TYPICAL MODIFIED RCRA REPOSITORY

PIONEER TECHNICAL SERVICES, INC.
Butte, Helena, Anaconda

DATE: 5/1/09

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APPENDIX A

IRON MASK MINE AND MILL SITE
THREATENED AND ENDANGERED SPECIES LETTERS

United States Department of the Interior

FISH AND WILDLIFE SERVICE

ECOLOGICAL SERVICES
MONTANA FIELD OFFICE
585 SHEPARD WAY
HELENA, MONTANA 59601
PHONE (406) 449-5225, FAX (406) 449-5339

M02 (I)

July 10, 2007

Marty Bennett
Pioneer Technical Services, Inc.
P.O. Box 3445
Butte, Montana 59702

Dear Marty Bennett:

This is in response to your request for information regarding the Iron Mask Mine and Mill Site, situated on Bureau of Land Management land approximately seven miles northwest of Townsend in Broadwater County, Montana. We appreciate the opportunity to review your request and provide comments. These comments have been prepared under the authority of and in accordance with the provisions of the Fish and Wildlife Coordination Act (16 U.S.C. 661 et. seq.), and the Endangered Species Act of 1973, as amended (16 U.S.C. 1531 et. seq.).

Considering the location of the project, the Service does not anticipate effects to federally listed threatened, endangered, candidate or proposed species. There may be state species of concern in the vicinity of the project and we recommend contacting the Montana Department of Fish, Wildlife and Parks at 1420 East Sixth Ave., P.O. Box 200701, Helena, MT 59620-0701, 406-444-2535 or the Montana Natural Heritage Program, 1515 East 6th Avenue, Box 201800, Helena, MT 59620-1800, 406-444-5354.

If wetlands are impacted by this project, Corps of Engineers Section 404 permits may be required. The Service suggests any proposed or future project be designed to avoid and minimize impacts to wetland areas, stream channels and surrounding vegetation to the greatest extent possible. Direct, indirect and cumulative impacts, along with future activities required to maintain these improvements, should be analyzed.

The Service appreciates your efforts to incorporate fish and wildlife resource concerns, including threatened and endangered species, into your project planning. If you have questions or comments related to this issue, please contact Katrina Dixon at 406-449-5225 extension 222.

Sincerely,

R. Mark Wilson

R. Mark Wilson
Field Supervisor

Species of Concern Report

9 Species found with the following criteria:

Township = 7 N Range = 1 E Animals = Mammals, Birds, Reptiles, Amphibians, Fish, Invertebrates
Plants = Vascular Plants, Nonvascular Plants
Report Date: 4/22/2009 10:33:04 AM

▼ Mammals

Name	Family	Nature Serve	GLOBAL Rank	STATE Rank	USFWS	USFS	BLM
Gray Wolf (Canis lupus)	Wolves/Coyotes/Foxes (Canidae)		G4	S3	LE	ENDANGERED	SPECIAL STATUS
	County: Beaverhead, Big Horn, Carbon, Carter, Cascade, Custer, Dawson, Fergus, Flathead, Gallatin, Garfield, Glacier, Granite, Jefferson, Judith Basin, Lake, Lewis and Clark, Lincoln, Madison, Meagher, Mineral, Missoula, Musselshell, Park, Petroleum, Phillips, Powder River, Powell, Ravalli, Roosevelt, Rosebud, Sanders, Silver Bow, Stillwater, Sweet Grass, Teton, Toole, Valley, Yellowstone						
Wolverine (Gulo gulo)	Weasels (Mustelidae)		G4	S3		SENSITIVE	SENSITIVE
	County: Beaverhead, Blaine, Broadwater, Carbon, Cascade, Dawson, Deer Lodge, Flathead, Gallatin, Glacier, Granite, Hill, Jefferson, Judith Basin, Lake, Lewis and Clark, Lincoln, Madison, Meagher, Mineral, Missoula, Park, Pondera, Powell, Ravalli, Sanders, Sheridan, Silver Bow, Teton, Wheatland						
Canada Lynx (Lynx canadensis)	Cats (Felidae)		G5	S3	LT	THREATENED	SPECIAL STATUS
	County: Beaverhead, Big Horn, Blaine, Broadwater, Carbon, Cascade, Chouteau, Daniels, Dawson, Deer Lodge, Fergus, Flathead, Gallatin, Glacier, Granite, Jefferson, Judith Basin, Lake, Lewis and Clark, Liberty, Lincoln, Madison, Meagher, Mineral, Missoula, Musselshell, Park, Phillips, Pondera, Powell, Ravalli, Roosevelt, Rosebud, Sanders, Silver Bow, Stillwater, Sweet Grass, Teton, Toole, Wheatland, Yellowstone						

▼ Birds

Name	Family	Nature Serve	GLOBAL Rank	STATE Rank	USFWS	USFS	BLM
Lark Bunting (Calamospiza melanocorys)	Sparrows (Emberizidae)		G5	S3B			
	County: Beaverhead, Big Horn, Blaine, Broadwater, Carbon, Carter, Cascade, Chouteau, Custer, Daniels, Dawson, Deer Lodge, Fallon, Fergus, Flathead, Gallatin, Garfield, Glacier, Golden Valley, Granite, Hill, Jefferson, Judith Basin, Lewis and Clark, Liberty, Lincoln, Madison, McCone, Meagher, Musselshell, Park, Petroleum, Phillips, Powder River, Powell, Prairie, Ravalli, Richland, Roosevelt, Rosebud, Sanders, Sheridan, Stillwater, Sweet Grass, Teton, Toole, Treasure, Valley, Wheatland, Wibaux, Yellowstone						
McCown's Longspur (Calcarius mccownii)	Sparrows (Emberizidae)		G4	S2B			SENSITIVE
	County: Beaverhead, Blaine, Broadwater, Cascade, Chouteau, Custer, Daniels, Dawson, Fergus, Flathead, Garfield, Glacier, Golden Valley, Hill, Lewis and Clark, Liberty, Madison, McCone, Meagher, Musselshell, Park, Petroleum, Phillips, Pondera, Prairie, Roosevelt, Rosebud, Sheridan, Stillwater, Sweet Grass, Teton, Toole, Valley, Wheatland, Yellowstone						
	Hawks/Eagles		G5	S3	DM	THREATENED	SPECIAL

	(Accipitridae)							STATUS
Bald Eagle (Haliaeetus leucocephalus)	County: Beaverhead, Big Horn, Blaine, Broadwater, Carbon, Carter, Cascade, Chouteau, Custer, Dawson, Deer Lodge, Fallon, Fergus, Flathead, Gallatin, Garfield, Glacier, Golden Valley, Granite, Hill, Jefferson, Judith Basin, Lake, Lewis and Clark, Liberty, Lincoln, Madison, McCone, Meagher, Mineral, Missoula, Musselshell, Park, Petroleum, Phillips, Pondera, Powder River, Powell, Prairie, Ravalli, Richland, Roosevelt, Rosebud, Sanders, Sheridan, Silver Bow, Stillwater, Sweet Grass, Teton, Toole, Treasure, Valley, Wheatland, Wibaux, Yellowstone							
Long-billed Curlew (Numenius americanus)	Sandpipers (Scolopacidae)		G5	S2B				SENSITIVE
	County: Beaverhead, Big Horn, Blaine, Broadwater, Carbon, Carter, Cascade, Chouteau, Custer, Daniels, Dawson, Deer Lodge, Fallon, Fergus, Flathead, Gallatin, Garfield, Glacier, Golden Valley, Granite, Hill, Jefferson, Judith Basin, Lake, Lewis and Clark, Liberty, Lincoln, Madison, McCone, Meagher, Missoula, Musselshell, Park, Petroleum, Phillips, Pondera, Powder River, Powell, Prairie, Ravalli, Richland, Roosevelt, Rosebud, Sanders, Sheridan, Stillwater, Sweet Grass, Teton, Toole, Valley, Wheatland, Wibaux, Yellowstone							
▼ Invertebrates								
Name	Family	Nature Serve	GLOBAL Rank	STATE Rank	USFWS	USFS		BLM
A Spring Snail (Pyrgulopsis bedfordensis)	Amnicolas/Duskysnails (Hydrobiidae)		G1	S1				
	County: Broadwater							
▼ Vascular Plants								
Name	Family	Nature Serve	GLOBAL Rank	STATE Rank	USFWS	USFS		BLM
Sword Townsend-daisy (Townsendia spathulata)	Aster/Sunflowers (Asteraceae)		G3	S3				
	County: Beaverhead, Broadwater, Carbon, Silver Bow							

June 20, 2007

Ms. Sarah LeMarr
BLM Field Office
106 N. Parkmont
Butte, MT 59701

RE: Iron Mask Mine and Mill Site Threatened, Endangered or Sensitive Species Search

Dear Ms. LeMarr

Under contract with the U.S. Army Corps of Engineers (USACE) and the U.S. Department of Interior/Bureau of Land Management (BLM), Pioneer Technical Services, Inc. (Pioneer) is completing an Expanded Engineering Evaluation/Cost Analysis (EEE/CA) for reclamation of the Iron Mask Mine and Mill Site, located in Broadwater County approximately 7 miles northwest of Townsend, Montana. The site is accessed by traveling west from U.S. Highway 12/287, then along Indian Creek Road for approximately 4 miles, then traveling northwest for approximately 3 miles along a 2-track road.

A portion of the information in the analysis incorporates assessing whether unique, endangered, fragile, or limited environmental resources including endangered species (i.e., plants and wildlife) exist at the site or within its immediate proximity.

This site is situated on BLM administered land. Thus far, this project only includes completing the EEE/CA, although there is a possibility that future reclamation work may by performed at the site.

The site encompasses the entire Iron Mask Mine and Mill Site, which is approximately six acres. Please review the described location for any listed or proposed endangered, threatened, sensitive animal or plant species or critical habitat that are known or suspected to occur in the proposed project vicinity (see attached Figure 1 and Figure 2). The legal description for the site is listed below.

Iron Mask Mine and Mill Site, Broadwater County:

Township 7 North, Range 1 East, NW ¼, NW ¼ of Section 30.

If you have any questions or recommendations of additional persons or agencies to contact concerning the matter, please feel free to contact me at (406) 782-5177.

Thank you for your time and assistance.

Sincerely,

Marty Bennett, E.I.
Project Engineer

June 20, 2007

Mr. Tom Carlson
Montana Department of Fish Wildlife and Parks
Townsend District
415 South Front
Townsend, MT 59644

RE: Iron Mask Mine and Mill Site Threatened, Endangered or Sensitive Species Search

Dear Mr. Carlson:

Under contract with the U.S. Army Corps of Engineers (USACE) and the U.S. Department of Interior/Bureau of Land Management (BLM), Pioneer Technical Services, Inc. (Pioneer) is completing an Expanded Engineering Evaluation/Cost Analysis (EEE/CA) for reclamation of the Iron Mask Mine and Mill Site, located in Broadwater County approximately 7 miles northwest of Townsend, Montana. The site is accessed by traveling west from U.S. Highway 12/287, then along Indian Creek Road for approximately 4 miles, then traveling northwest for approximately 3 miles along a 2-track road.

A portion of the information in the analysis incorporates assessing whether unique, endangered, fragile, or limited environmental resources including endangered species (i.e., plants and wildlife) exist at the site or within its immediate proximity.

This site is situated on BLM administered land. Thus far, this project only includes completing the EEE/CA, although there is a possibility that future reclamation work may by performed at the site.

The site encompasses the entire Iron Mask Mine and Mill Site, which is approximately six acres. Please review the described location for any listed or proposed endangered, threatened, sensitive animal or plant species or critical habitat that are known or suspected to occur in the proposed project vicinity (see attached Figure 1 and Figure 2). The legal description for the site is listed below.

Iron Mask Mine and Mill Site, Broadwater County:

Township 7 North, Range 1 East, NW ¼, NW ¼ of Section 30.

If you have any questions or recommendations of additional persons or agencies to contact concerning the matter, please feel free to contact me at (406) 782-5177.

Thank you for your time and assistance.

Sincerely,

Marty Bennett, E.I.
Project Engineer

June 20, 2007

Ms. Shawna Campbell
U.S. Forest Service
Townsend Ranger District
415 South Front
Townsend, MT 59644

RE: Iron Mask Mine and Mill Site Threatened, Endangered or Sensitive Species Search

Dear Ms. Campbell:

Under contract with the U.S. Army Corps of Engineers (USACE) and the U.S. Department of Interior/Bureau of Land Management (BLM), Pioneer Technical Services, Inc. (Pioneer) is completing an Expanded Engineering Evaluation/Cost Analysis (EEE/CA) for reclamation of the Iron Mask Mine and Mill Site, located in Broadwater County approximately 7 miles northwest of Townsend, Montana. The site is accessed by traveling west from U.S. Highway 12/287, then along Indian Creek Road for approximately 4 miles, then traveling northwest for approximately 3 miles along a 2-track road.

A portion of the information in the analysis incorporates assessing whether unique, endangered, fragile, or limited environmental resources including endangered species (i.e., plants and wildlife) exist at the site or within its immediate proximity.

This site is situated on BLM administered land. Thus far, this project only includes completing the EEE/CA, although there is a possibility that future reclamation work may by performed at the site. The site encompasses the entire Iron Mask Mine and Mill Site, which is approximately six acres. Please review the described location for any listed or proposed endangered, threatened, sensitive animal or plant species or critical habitat that are known or suspected to occur in the proposed project vicinity (see attached Figure 1 and Figure 2). The legal description for the site is listed below.

Iron Mask Mine and Mill Site, Broadwater County:

Township 7 North, Range 1 East, NW ¼, NW ¼ of Section 30.

If you have any questions or recommendations of additional persons or agencies to contact concerning the matter, please feel free to contact me at (406) 782-5177.

Thank you for your time and assistance.

Sincerely,

Marty Bennett, E.I.
Project Engineer

June 20, 2007

Ms. Katrina Dixon
U.S. Fish and Wildlife Service
100 N. Park, Suite 320
Helena, MT 59601

RE: Iron Mask Mine and Mill Site Threatened, Endangered or Sensitive Species Search

Dear Ms. Dixon:

Under contract with the U.S. Army Corps of Engineers (USACE) and the U.S. Department of Interior/Bureau of Land Management (BLM), Pioneer Technical Services, Inc. (Pioneer) is completing an Expanded Engineering Evaluation/Cost Analysis (EEE/CA) for reclamation of the Iron Mask Mine and Mill Site, located in Broadwater County approximately 7 miles northwest of Townsend, Montana. The site is accessed by traveling west from U.S. Highway 12/287, then along Indian Creek Road for approximately 4 miles, then traveling northwest for approximately 3 miles along a 2-track road.

A portion of the information in the analysis incorporates assessing whether unique, endangered, fragile, or limited environmental resources including endangered species (i.e., plants and wildlife) exist at the site or within its immediate proximity.

This site is situated on BLM administered land. Thus far, this project only includes completing the EEE/CA, although there is a possibility that future reclamation work may by performed at the site.

The site encompasses the entire Iron Mask Mine and Mill Site, which is approximately six acres. Please review the described location for any listed or proposed endangered, threatened, sensitive animal or plant species or critical habitat that are known or suspected to occur in the proposed project vicinity (see attached Figure 1 and Figure 2). The legal description for the site is listed below.

Iron Mask Mine and Mill Site, Broadwater County:

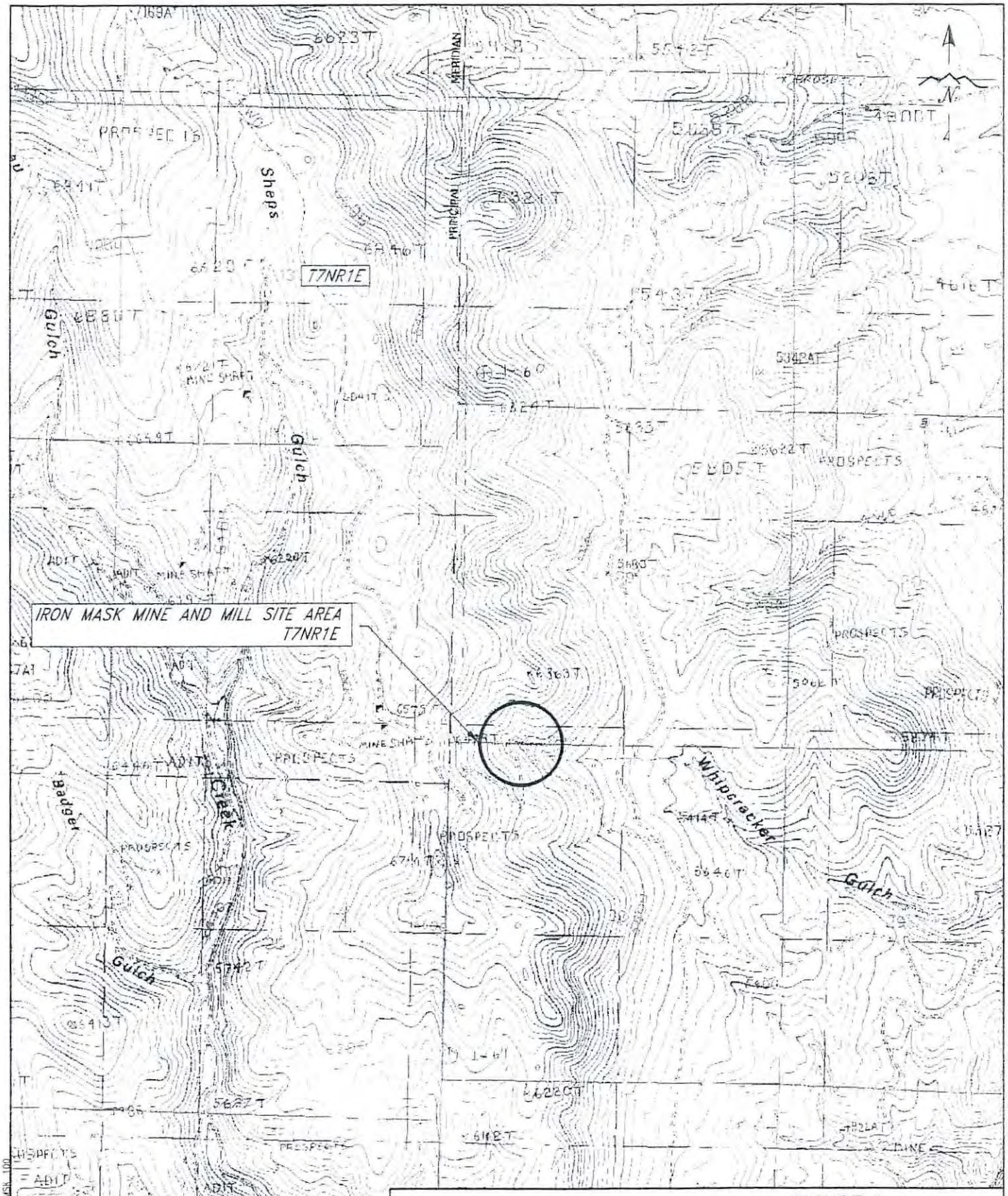
Township 7 North, Range 1 East, NW ¼, NW ¼ of Section 30.

If you have any questions or recommendations of additional persons or agencies to contact concerning the matter, please feel free to contact me at (406) 782-5177.

Thank you for your time and assistance.

Sincerely,

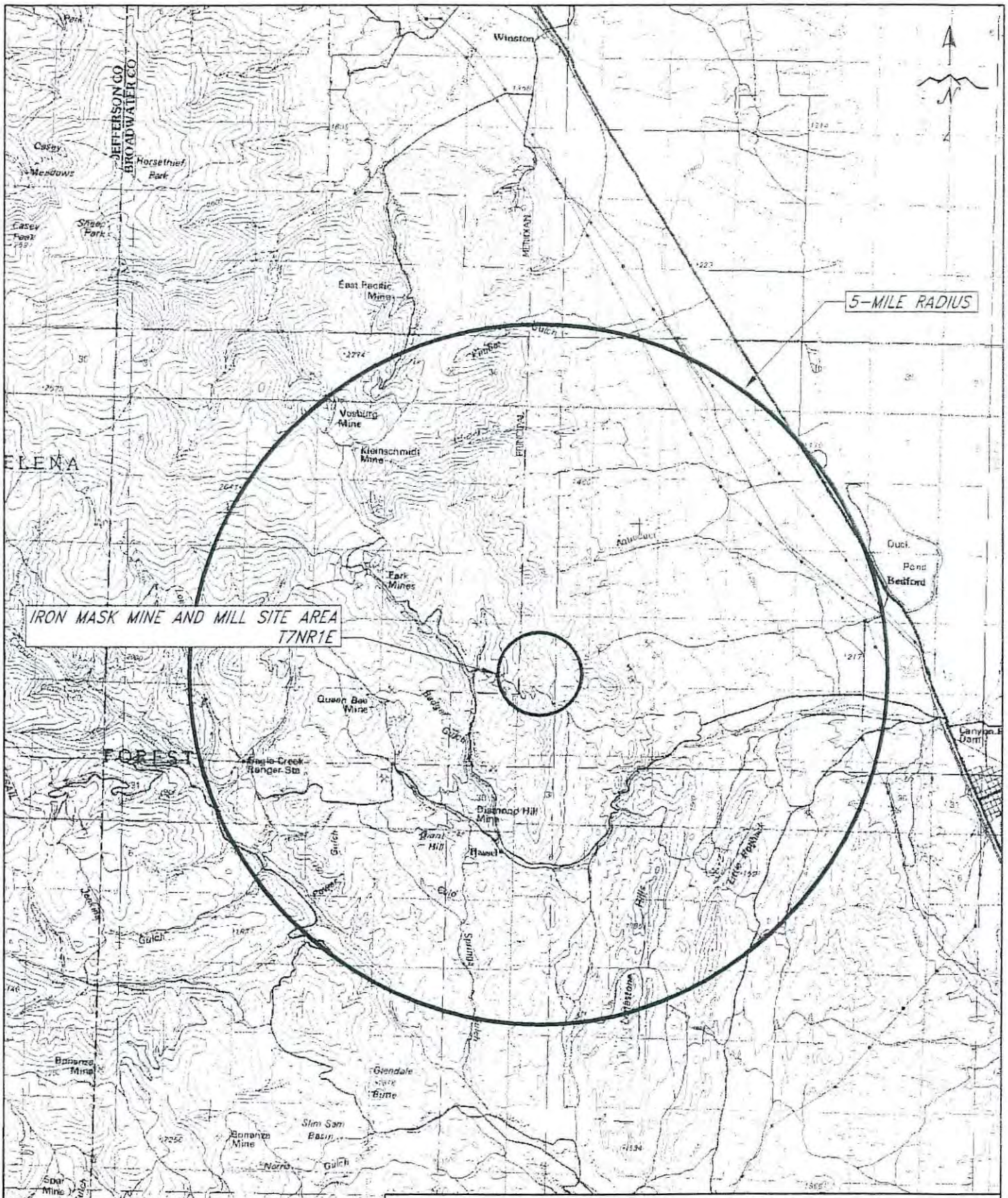
Marty Bennett, E.I.
Project Engineer



PIONEER TECHNICAL SERVICES, INC.

FIGURE 1
IRON MASK
MINE AND MILL SITE
LOCATION MAP

SCALE: 1"=2000'
DATE: 6/15/07



PIONEER TECHNICAL SERVICES, INC.

FIGURE 2
IRON MASK
MINE AND MILL SITE
LOCATION MAP

SCALE: 1"=10000'
DATE: 6/15/07

APPENDIX B

IRON MASK MINE AND MILL SITE
LABORATORY DATA

TABLE B-1
IRON MASK MINE AND MILL SITE
SOURCE SAMPLING SUMMARY
JUNE 2008

Source	Test Pit ID	Depth Interval (feet)	Description	TAL	ABA/SMP	SPLP	Agronomic	Physical
Background								
	IM-BG-1	0.0-0.6	Dark brown loam with moss and small grass, lots of rock					
	IM-BG-2	0.0-0.6	Med. Brown silty loam, not a lot of rock mostly pebbles					
	IM-BG-3	0.0-0.6	Med. Brown loamy silt - 40-50% vegetated					
	IM-BG-4	0.0-0.6	Dark brown silty loam, not a lot of rocks - 50-60% vegetation					
	IM-BG-5	0.0-0.6	Dark brown sandy loam, few rocks - lots of roots 70-80% vegetated					
Composite Samples								
	Iron Mask-BG-1		**Composite Sample - collected from 0.0-0.6 feet. Tested for total metals**	**Table B-2**	**NR**	**NR**	**NR**	**NR**
	Iron Mask-BG-2		**Composite Sample - collected from 0.0-0.6 feet. Tested for total metals**	**Table B-2**	**NR**	**NR**	**NR**	**NR**
	Iron Mask-BG-3		**Composite Sample - collected from 0.0-0.6 feet. Tested for total metals**	**Table B-2**	**NR**	**NR**	**NR**	**NR**
	Iron Mask-BG-4		**Composite Sample - collected from 0.0-0.6 feet. Tested for total metals**	**Table B-2**	**NR**	**NR**	**NR**	**NR**
	Iron Mask-BG-5		**Composite Sample - collected from 0.0-0.6 feet. Tested for total metals**	**Table B-2**	**NR**	**NR**	**NR**	**NR**
Borrow Area 1								
	BA-1 TP-01	0-1.0	A Horizon - Dark brown silty loam with lots of rock					
		1.0-3.17	Light brown silty sand - 35% rock >2"					
		3.17-5.0	Gray rock fracture <8", some soil					
		5.0	Total depth of test pit - backhoe refusal					
	BA-1 TP-02	0-1.0	A Horizon - Dark brown clayey silt with roots and organic matter					
		1.0-4.5	Light brown sandy clay - <10% rock <1"					
		4.5-10.0	Light brown/gray silty sand. Rock content increasing with depth, 70% rock <3" w/ an occasional 6-10" rock					
		10.0	Total depth of test pit - bedrock, backhoe refusal					
	BA-1 TP-03	0-1.0	A Horizon - Dark brown loam					
		1.0-3.75	Light brown soil - <15% rock <2"					
		3.75-10.83	Light gray sandy silt - 55% rock <6", blocky angular not hard to dig					
		10.83	Total depth of test pit - backhoe refusal					
	BA-1 TP-04	0-1.0	A Horizon - Dark brown silty loam					
		1.0-3.25	Light brown sandy silt with 45% gravel sized rock <1 $^{1}/_{2}$					
		3.25-9.0	Tan/gray silty sand with 95% rock <4", angular talus type rock $^{3}/_{4}$" thick up to 6" in diameter/width					
		9.0	Total depth of test pit - backhoe refusal					
	BA-1 TP-05	0-0.25	A Horizon - Dark brown silty loam					
		0.25-4.25	Sandy silt with 20% rock <1"					
		4.25-6.0	Tan/orange sand layer					
		6.0-10.67	Sand layer with 90-95% angular rock 2-3" with an occasional 6" angular rock. Material was damp but no seeps or water was observed					
		10.67	Total depth of test pit - backhoe refusal					
	BA-1 TP-06	0-0.75	A Horizon - Dark brown silty loam					
		0.75-2.42	Light brown silty sand w/ 60% round angular rock <4"					
		2.42-7.0	Layered fractured angular rock, very little soil					
		7.0	Total depth of test pit - backhoe refusal, very hard digging					
	BA-1 TP-07	0-2.0	A Horizon - Dark brown silty loam					
		2.0-9.0	Light brown sandy silt - 65-75% rock <3". Rock content and size increased with depth, 90-95% rock <6"					
		9.0	Total depth of test pit - backhoe refusal, very hard digging					
	BA-1 TP-08	0-1.0	Dark brown loam					
		1.0-2.5	Light brown silty sand w/ gravels <3/4"					
		2.5-4.5	Light gray silty sand w/ broken rock <2"					
		4.5-9.5	Some sand w/ angular rock <6"					
		9.5	Total depth of test pit - backhoe refusal					
Composite Samples								
	Iron Mask-BA1-A		**Composite sample - collected from 0 TO 0.5 feet from eight test pits in Borrow Area 1**	**Table B-2**	**NR**	**NR**	**Table B-6**	**NR**
	Iron Mask-BA1-B		**Composite sample - collected from 0.5 feet to the bottom of eight test pits in Borrow Area 1**	**Table B-2**	**Table B-4**	**NR**	**Table B-6**	**Table B-7**

TABLE B-1
IRON MASK MINE AND MILL SITE
SOURCE SAMPLING SUMMARY
JUNE 2008

Source	Test Pit ID	Depth Interval (feet)	Description	TAL	ABA/SMP	SPLP	Agronomic	Physical
Borrow Area 2								
	BA-2 TP-1	0-1.67	A Horizon - Dark brown silty loam with abundant roots					
		1.67-3.5	Gray shale rock slaby, fractured horizontally. Very little soil, 85% rock mostly 3-6" w/ an occasional 8" rock.					
		3.5	Total depth of test pit - backhoe refusal					
	BA-2 TP-02	0-2.67	A Horizon - Dark brown silty loam with roots, 10% rock <1"					
		2.67-5.16	Light brown silty sand - rock content increases in size and percent with depth. About 60% rock <4" w/ an occasional 8" boulder, all angular					
		5.16	Total depth of test pit - backhoe refusal					
	BA-2 TP-03	0-3.33	A Horizon - Dark brown silty loam					
		3.33-5.67	Light brown silty sand - occasional rock 3 to 6 inches					
		5.67-7.0	Gray ledge rock, fractured, rippable					
		7.0-8.3	Light brown silty sand - increasing rock content with depth. About 30% rock 3-6"					
		8.3	Total depth of test pit - bedrock, backhoe refusal					
	BA-2 TP-04	0-3.16	A Horizon - Dark brown silty loam w/ abundant roots and organic matter, very little rock					
		3.16-7.0	Light brown sandy silty loam - 40% rock 8" and <10% rock <8"					
		7.0	Total depth of test pit - bedrock, backhoe refusal					
	BA-2 TP-05	0-2.58	A Horizon - Dark brown loam w/ roots and organic matter					
		2.58-6.16	Light brown sandy silt - 20% rock 3-6". Gray fracture breaks in small flat pieces.					
		6.16	Total depth of test pit - bedrock, backhoe refusal					
	BA-2 TP-06	0-3.0	A Horizon - Dark brown silty loam w/ roots and organic matter					
		3.0-3.5	Gray shale rock fractures, breaks into small pieces <2" - no soil, solid rock					
		3.6	Total depth of test pit - backhoe refusal					
	BA-2 TP-07	0-0.67	A Horizon - Dark brown silty loam					
		0.67-2.67	Brown silty sandy loam - 30% rock <3"					
		2.67	Total depth of test pit - backhoe refusal, brown/black bedrock mostly round angular not very rippable					
	BA-2 TP-08	0-0.58	A Horizon - Dark brown silty loam					
		1.58-3.42	Light brown sandy silt - 20% gravel <3/4"					
		3.42-6.58	Light brown soil - rock content increases with depth. Round Angular rock hard to dig, breaks up into <2", very little soil					
		6.58-8.25	Hard round angular rock >4" - very little soil					
		8.25	Total depth of test pit - backhoe refusal					
	BA-2 TP-09	0-0.5	A Horizon - Dark brown silty loam					
		0.5-3.25	Gray shale rock, rippable - no soil					
		3.25	Total depth of test pit - backhoe refusal					
	BA-2 TP-10	0-0.67	A Horizon - Dark brown clayey loam - <10% rocks <1"					
		0.67-5.5	Yellow and gray angular rock - 25% rock <6", very little soil					
		5.5	Total depth of test pit - backhoe refusal					
	BA-2 TP-11	0-1.08	A Horizon - Dark brown clayey loam w/ roots and organic					
		1.08-4.0	Gray silt - 35% rock <4"					
		4.0-4.67	Grey fractured rock >6" - very little soil					
		4.67	Total depth of test pit - backhoe refusal					
	BA-2 TP-12	0-0.33	A Horizon - Dark brown silty clay loam					
		0.33-1.42	Light brown clayey silt - 20% rock <2"					
		1.42-2.58	Gray fractured rock, rippable - 95% rock 1-8", no soil					
		2.58	Total depth of test pit - backhoe refusal					
	BA-2 TP-13	0-0.25	A Horizon - Brown silty loam					
		0.25-2.0	Gray/light brown silt - 35% rock <4"					
		2.0-4.0	Gray fractured rock - 95% rock <6", very little soil					
		4.0	Total depth of test pit - backhoe refusal					
	BA-2 TP-14	0-0.67	A Horizon - Brown silty loam					
		0.67-3.92	Light brown silt - no rock					
		3.92-5.33	Gray fractured rock, rippable - 95% rock <3", very little soil					
		5.33	Total depth of test pit - backhoe refusal					
	BA-2 TP-15	0-0.67	A Horizon - Dark brown silty loam w/ some surface rocks					
		0.67-3.0	Light brown silty sand with a few small rocks					
		3.0-4.67	90% rocks <8" - some soil					
		4.67	Total depth of test pit - backhoe refusal					
	BA-2 TP-16	0-0.75	A Horizon - Dark brown silty loam					
		0.75-2.67	Light brown silty sand w/ few rocks					
		2.67-4.67	Large boulders - 75% rock<12"					
		4.67	Total depth of test pit - bedrock, backhoe refusal					
Composite Samples								
	Iron Mask-BA2-A		**Composite sample - collected from 0 to 0.5 feet from the sixteen test pits in Borrow Area 2**	**Table B-2**	**NR**	**NR**	**Table B-6**	**NR**
	Iron Mask-BA2-B		**Composite sample - collected from 0.5 feet to the bottom of the sixteen test pits in Borrow Area 2**	**Table B-2**	**Table B-4**	**NR**	**Table B-6**	**Table B-7**

TABLE B-1
IRON MASK MINE AND MILL SITE
SOURCE SAMPLING SUMMARY
JUNE 2008

Source	Test Pit ID	Depth Interval (feet)	Description	TAL	ABA/SMP	SPLP	Agronomic	Physical
Tailings Area 1								
	TA-1 TP-01	0-0.67	Dark brown loam					
		0.67-2.5	Light brown sandy loam with gravels <1"					
		2.5-10.0	Light brown silty sand w/ 30% angular rock <2" and 10% cobbles <8"					
		10.0-14.0	80-90% broken rock and shale					
		14.0	Total depth of test pit - backhoe refusal					
	TA-1 TP-02	0-1.0	Dark brown loam					
		1.0-12.0	Medium brown silty sand w/ 30% angular gravels <2" and 10% angular cobbles <8"					
		12.0-14.0	Broken rock (shale)					
		14.0	Total depth of test pit - backhoe refusal, hard rock					
	TA-1 TP-03	0-0.25	Light brown/orange silty sand					
		0.25-1.0	Dark brown loam w/ few gravels <¼"					
		1.0-2.5	Medium brown silty sand w/ 20-30% angular rock <3"					
		2.5-4.0	Gray silty sand with 60% angular rock <6"					
		4.0-12.0	Medium brown silty sand w/ 30-40% angular rock <3" and 10% angular cobbles <8"					
		12.0-14.0	Broken rock (shale)					
		14.0	Total depth of test pit - backhoe refusal					
	TA-1 TP-04	0-0.67	Dark brown loam					
		0.67-3.0	Medium brown silty sand w/ 20% gravels <1"					
		3.0-8.0	Light brown silty sand w/ 30% angular rock <3" and 10% angular cobbles <6"					
		8.0-10.0	Broken rock (shale)					
		10.0	Total depth of test pit - backhoe refusal					
	TA-1 TP-05	0-0.67	Dark brown loam					
		0.67-2.0	Medium brown silty sand w/ 30% angular gravels <1"					
		2.0-10.0	Light brown silty sand w/ 30% angular gravels <2" and 10% angular cobbles <8"					
		10.0-10.5	Broken rock					
		10.5	Total depth of test pit - backhoe refusal					
	TA-1 TP-06	0-0.67	Dark brown loam					
		0.67-6.0	Medium to Light brown silty sand w/ 40% gravels <2" and 10% angular cobbles <6"					
		6.0-11.0	Broken rock (shale)					
		11.0	Total depth of test pit - backhoe refusal, hard rock sloped bottom					
Composite Samples								
	Iron Mask-TA1-A		**Composite sample - collected from 0 to 0.5 feet from the six test pits located in the Tailings Area 1**	**NR**	**NR**	**NR**	**Table B-6**	**NR**
	Iron Mask-TA1-B		**Composite sample - collected from 0.5 feet to the bottom of the six test pits located in the Tailings Area 1**	**Table B-2**	**Table B-4**	**NR**	**Table B-6**	**Table B-7**
	Iron Mask-TA1-W		**Composite Sample - collected from 0 to 0.25 feet from just above the lower road in visible tailings**	**Table B-2**	**Table B-4**	**Table B-5**	**NR**	**NR**
Tailings Area 2								
	TA-2 TP-01	0-0.83	Medium brown slightly clayey sandy silt, well vegetated with some roots - no rocks					
		0.83-1.83	1/2 of hole yellow silty clay hard packed damp w/ no rocks and no roots - other 1/2 of hole med brown clayey silt, dry, no rocks and no roots					
		1.83	Total depth					
	TA-2 TP-02	0-0.67	Medium brown silty med grained sand, damp, no rocks and few roots - mostly unvegetated					
		0.67-1.25	Tan med grained sand, damp					
		1.25-1.58	Medium brown med grained sand, damp					
		1.58	Total depth					
	TA-2 TP-03	0-1.0	Medium brown med grained damp sand, few roots and mostly unvegetated around test pit					
		1	Total depth					
Composite Samples								
	Iron Mask-TA2-A		**Composite Sample - collected from 0 to 0.5 feet of waste material from three test pits located in the Tailings Area 2**	**Table B-2**	**Table B-4**	**NR**	**NR**	**NR**
	Iron Mask-TA2-B		**Composite Sample - collected from 0.5 feet to bottom of the three test pits located in the Tailings Area 2**	**Table B-2**	**Table B-4**	**Table B-5**	**Table B-6**	**Table B-7**

TABLE B-1
IRON MASK MINE AND MILL SITE
SOURCE SAMPLING SUMMARY
JUNE 2008

Source	Test Pit ID	Depth Interval (feet)	Description	TM	ABA/SMP	SPLP	Agronomic	Physical
Waste Rock 1								
	WR-1 TP-01 (east-west extension)	0-2.0	Medium brown silty loam w/ grass and some cobbles and pebbles - well vegetated					
		2.0	Abrupt boundary w/ orange colored med grained sand, slightly damp at about 2'6" turns med brown					
		2.0-8.5	Med brown sand, damp, no rock					
		8.5-10.0	Fairly clayey sand with cobbles < 6" - wet					
		10.0-12.0	Dark borwn silty clay - wet					
		12.0	Starting to see cobbles					
	WR-1 TP-01 (north-south extension)	0-3.5	Silty sand w/ yellow staining and cobbles (Andesite) - 60-70% rock <18", no vegetation					
		3.5-6.0	Med brown, dmap slightly clayey sand w/ Mn and Fe staining - 70-80% rock <12" (Andesite and some altered Andesite)					
		6.0	Total depth					
	WR-1 TP-02	0-0.25	Medium brown sitly sand w/ gravel - road fill					
		0.25-1.33	Dark borwn silty sand w/ gravel and cobbles - 60-70% rocks <8"					
		1.33-6.0	Dark borwn silty sand w/ gravel and cobbles, orange/yellow staining - 70-80% rocks <36"					
		6.0	Total depth					
	WR-1 TP-03	0-0.5	Dry, hard packed, red/gray sandy silt w/ gravel and cobbles - 40-50% rock <4"					
		0.5-2.67	Pink brown clayey sand w/ 60% gravel and 20-30% cobbles <12" - moist					
		2.67-4.16	Yellow brown clayey sand w/ gravel and cobbles - some areas 100% cobbles <12", generally 40-50% w/ lots of gravels					
		4.16-6.16	Dark gray w/ cobbles and gravel, looks moist - 50-60% cobbles with less gravel					
		6.16-9.0	Brown clayey sand mostly gravel w/ cobbles <14" 40-50% - some wood debris, moist to wet at bottom					
		9.0	Total depth					
Composite Samples								
	Iron Mask-WR1-A		**Composite sample - collected from 0to 0.5 feet from Test Pits WR1-TP-01, WR1-TP-02, and WR1-TP-03**	**Table B-2**	**NR**	**NR**	**NR**	**NR**
	Iron Mask-WR1-B		**Composite sample - collected from 0.5 feet to the bottom of the test pit, from Test pits WR1-TP-01, WR1-TP-02, and WR1-TP-03**	**Table B-2**	**Table B-4**	**Table B-5**	**Table B-6**	**Table B-7**
	Iron Mask-WR1-C		**Composite sample - collected from 0.5 to 4.1 feet from Test Pit WR1-TP-03**	**Table B-2**	**Table B-4**	**NR**	**NR**	**NR**
	Iron Mask-WR1-D		**Composite sample - collected from 4.1 to 9 feet from Test Pit WR1-TP-03 spoils pile**	**Table B-2**	**Table B-4**	**NR**	**NR**	**NR**
Waste Rock 2								
	WR-2 TP-01	0-0.33	Very dry silty sand w/ rocks and cobbles - ants living in pile					
		0.33-2.67	Orange and black silty sand, some areas have bleaching and yellow staining w/ more clay - 70-80% rock <24" (Andesite), debris in pile					
		2.67	Total depth					
	WR-2 TP-02	0-1.5	Entire test pit is yellow and orange silty sand w/ some areas silty clay - 80-90% rock, all rocks have orange or Mn coating					
		1.5	Total depth					
	WR-2 TP-03	0-0.5	Very dry, med brown silty sand - lots of wood pieces, upper part of hole gravel and pebbles <3"					
		0.5-1.25	Damp med brown silty sand - 50% rock <12" and 50% wood - some rock appears to have salts on them - lots of lumber and debris around holes					
		1.25	Total depth					
Composite Samples								
	Iron Mask-WR2-A		**Composite sample - collected from 0to 0.5 feet from Test Pits WR2-TP-01, WR2-TP-02, and WR2-TP-03**	**Table B-2**	**NR**	**NR**	**NR**	**NR**
	Iron Mask-WR2-2-B		**Composite sample - collected from 0.5 to 2.6 feet from Test Pits WR2-TP-01, WR2-TP-02, and WR2-TP-03**	**Table B-2**	**Table B-4**	**Table B-5**	**NR**	**NR**
	Iron Mask-WR2-B		**Composite sample - collected from 0.5 to 2.6 feet from Test Pits WR2-TP-01, WR2-TP-02, and WR2-TP-03**	**Table B-2**	**Table B-4**	**Table B-5**	**Table B-6**	**Table B-7**
Waste Rock 3								
	WR-3 TP-01	0-0-0.25	Dark brown silty sand w/ cobbles - road fill					
		0.25-0.5	Silty sand w/ pebbles and cobbles, hard packed - 70-80% rock <12"					
		0.5-7.0	Orange w/ yellow staining slightly clayey coarse sand, red stained breecia, andesite - Mn coated rock					
		7.0	Natural ground - dark brown silty loam, damp					
Composite Samples								
	Iron Mask-WR3-A		**Composite sample - collected from 0 to 0.5 feet from WR3-TP-01**	**Table B-2**	**NR**	**NR**	**NR**	**NR**
	Iron Mask-WR3-B		**Composite sample - collected from 0.5 to 7 feet from WR3-TP-01**	**Table B-2**	**Table B-4**	**Table B-5**	**Table B-6**	**Table B-7**

TABLE B-2
IRON MASK MINE AND MILL SITE
SOLID MEDIA DATA

SAMPLE ID	SAMPLE DATE	SAMPLE DESCRIPTION	Sb mg/kg	As mg/kg	Ba mg/kg	Cd mg/kg	Cr mg/kg	Cu mg/kg	Fe mg/kg	Pb mg/kg	Mn mg/kg	Hg mg/kg	Ni mg/kg	Ag mg/kg	Zn mg/kg
Background Samples															
Iron Mask-BG-1	06/16/08	Dark brown loam with moss and small grass, lots of rock - collected from 0-6"	< 5	20.9	180	1.4	23.0	45.6	33,700	27.0	963	< 0.50	14.7	< 5	76.0
Iron Mask-BG-2	06/16/08	Med. Brown silty loam, not a lot of rock mostly pebbles - collected from 0-6"	< 5	19.2	191	1.7	19.3	23.6	33,300	42.2	1,160	< 0.50	12.3	< 5	101
Iron Mask-BG-3	06/16/08	Med. Brown loamy silt - 40-50% vegetated - collected from 0-6"	< 5	18.8	135	1.5	31.0	16.7	32,900	29.4	946	< 0.50	21.2	< 5	91.5
Iron Mask-BG-4	06/16/08	Dark brown silty loam, not a lot of rocks - 50-60% vegetation - collected from 0-6"	< 5	9.6	179	1.1	12.1	17.9	31,900	18.9	839	< 0.50	8.7	< 5	74.9
Iron Mask-BG-5	06/17/08	Dark brown sandy loam, few rocks - lots of roots 70-80% vegetated - collected from 0-6"	< 5	18.2	176	1.6	18.6	16.2	29,200	37.6	957	< 0.50	11.5	< 5	121
		Average Concentration (1):	3.0	17.3	172	1.5	20.8	24.0	32,200	31.0	973	0.3	13.7	3.0	92.9
		3X Average Concentration:	**9.0**	**52.0**	**517**	**4.4**	**62.4**	**72.0**	**96,600**	**93.1**	**2,919**	**0.9**	**41.0**	**9.0**	**279**
Tailings Areas															
Iron Mask-TA1-B	06/17/08	Composite sample - collected from 6" to the bottom of the seven test pits located in the Tailings Area 1 (TA-1-TP-01 through TA-1-TP-07)	< 5	7.4	152	< 1	32.5	30.0	37,500	28.3	1,070	NR	20.5	< 5	128
Iron Mask-TA1-W	06/18/08	Composite Sample - collected from 0-3" from just above the lower road in visible tailings	**15.4**	**1,890**	119	**321**	9.8	**167**	77,700	**12,300**	**33,500**	**3.3**	7.8	**50.7**	**41,600**
Iron Mask-TA2-A	06/18/08	Composite Sample - collected from 0-6" of waste material from TA2-TP-01, TA2-TP-02 and TA2-TP-03	< 5	**1,260**	47.9	**82.5**	11.2	**153**	86,800	**5,220**	**35,100**	0.50	12.7	**23.1**	**12,700**
Iron Mask-TA2-B	06/18/08	Composite Sample - collected from 6" to bottom of the three test pits TA2-TP-01, TA2-TP-02 and TA2-TP-03	< 5	**1,210**	50.8	**77.1**	12.6	**163**	73,800	**4,500**	**34,100**	0.56	12.0	**19.4**	**10,300**
Waste Rock Areas															
Iron Mask-WR1-A	06/18/08	Composite sample collected from WR1 - collected from 0-6" from WR1-TP-01, WR1-TP-02, and WR1-TP-03	< 5	**165**	111	**19.7**	8.8	**119**	51,100	**1,490**	**6,060**	0.65	10.4	5.5	**2,950**
Iron Mask-WR1-B	06/18/08	Composite sample collected from WR1 - collected from 6"to the bottom of the test pit, from WR1-TP-01, WR1-TP-02, and WR1-TP-03	< 5	**240**	104	**114**	7.7	**693**	60,700	**5,110**	**10,400**	< 0.50	10.0	**23.1**	**16,100**
Iron Mask-WR1-C	06/18/08	Discrete sample - collected from 6"-50" from waste material in WR1-TP-03	< 5	**263**	119	**19.6**	14.5	**956**	58,500	**931**	**10,200**	< 0.50	18.4	**16.9**	**2,940**
Iron Mask-WR1-D	06/18/08	Discrete sample - collected from 50"-9' from test pit WR1-TP-03 spoils pile	< 5	**44.3**	239	**9.5**	13.7	**669**	38,000	**588**	2,240	< 0.50	18.0	< 5	**1,190**
Iron Mask-WR2-A	06/17/08	Composite sample collected from WR2 - collected from 0-6" from WR2-TP-01, WR2-TP-02, and WR2-TP-03	5.8	**651**	88.0	**76.7**	< 5	**489**	48,700	**8,590**	**8,560**	< 0.50	21.2	**39.6**	**14,700**
Iron Mask-WR2-2-B	06/18/08	Discrete sample collected from WR2-TP-02 - collected from 6"-18"	< 5	**349**	25.2	**4.4**	< 5	13.6	47,600	**1,550**	700	< 0.50	< 5	**10.4**	**1,040**
Iron Mask-WR2-B	06/17/08	Composite sample collected from WR2 - collected from 6" to the bottom of the test pit from WR2-TP-01, WR2-TP-02, and WR2-TP-03	**11.1**	**1,020**	87.9	**139**	< 5	**635**	53,100	**14,200**	**13,000**	0.59	23.5	**77.7**	**21,100**
Iron Mask-WR3-A	06/17/08	Composite sample collected from WR3 - collected from 0-6" from WR3-TP-01	< 5	**446**	77.3	**21.4**	11.9	**211**	43,300	**3,310**	1,980	**1.4**	8.0	**20.9**	**3,340**
Iron Mask-WR3-B	06/17/08	Composite sample collected from WR3 - collected from 6"-7' from WR3-TP-01	7.5	**593**	77.5	**182**	7.0	**72.3**	47,100	**5,900**	**4,870**	**1.7**	< 5	**24.7**	**19,700**
		95% Upper Confidence Limit (UCL) of the mean concentration- waste rock and tailings:	**7.5**	**967**	**132**	**138**	**15.3**	**524**	**64,959**	**7,602**	**20,303**	**1.3**	**17.1**	**37.2**	**18,470**

TABLE B-2

IRON MASK MINE AND MILL SITE

SOLID MEDIA DATA

SAMPLE ID	SAMPLE DATE	SAMPLE DESCRIPTION	Sb mg/kg	As mg/kg	Ba mg/kg	Cd mg/kg	Cr mg/kg	Cu mg/kg	Fe mg/kg	Pb mg/kg	Mn mg/kg	Hg mg/kg	Ni mg/kg	Ag mg/kg	Zn mg/kg
Borrow Areas															
Iron Mask-BA1-A	06/16/08	Composite sample - collected from 0-6" from the eight test pits in Borrow Area 1	< 5	9.2	163	< 1	19.6	137	28,200	25.7	743	< 0.50	14.7	< 5	295
Iron Mask-BA1-B	06/16/08	Composite sample - collected from 6" to the bottom of the eight test pits in Borrow Area 1	< 5	6.4	177	< 1	12.0	119	24,400	22.1	608	< 0.50	13.6	< 5	150
Iron Mask-BA2-A	06/16/08	Composite sample - collected from 0-6" from the sixteen test pits in Borrow Area 2	< 5	8.7	155	< 1	14.5	601	28,900	32.7	694	< 0.50	12.3	< 5	801
Iron Mask-BA2-B	06/16/08	Composite sample - collected from 6" to the bottom of the sixteen test pits in Borrow Area 2	< 5	< 5	134	< 1	71.0	17.7	31,400	12.2	755	< 0.50	38.5	< 5	67.4
Sediment Samples															
Iron Mask-SE-01	06/16/08	Sample collected 10' from collapsed portal in active flow	< 5	< 5	59	< 1	32	29	27,600	65	469	< 0.50	15	< 5	245
Iron Mask-SE-02	06/16/08	Sample collected at the base of the gray waste rock dump just before it disappears underground	< 5	20	71	2	17	26	28,100	**221**	1,020	< 0.50	9	< 5	**1,190**
Iron Mask-SE-03	06/16/08	Sample collected near bottom of barren runoff area from the red waste rock dump but above bermed area that may have been tailings pond of runoff control	< 5	**361**	57	21	9	112	38,100	**3,630**	8,420	0.50	8	**12**	**5,320**
Iron Mask-SE-04	06/16/08	Sample collected below living quarters and 10-15 ft above where water disappears	< 5	**227**	38	9	14	45	32,000	**1,590**	4,950	< 0.50	8	< 5	**3,360**
Iron Mask-SE-05	06/16/08	Sample collected in drainage in an area where water would flow - drainage is well veg. W/ no indication that water has flowed recently	< 5	**726**	72	29	12	57	38,300	**3,140**	10,700	0.62	8	**10**	**5,660**
		National Sediment Quality Survey (NSQS) (EPA, 2004) T50 Effect Concentration	**NA**	**32.6**	**NA**	**NA**	**NA**	**157**	**NA**	**161**	**NA**	**0.87**	**NA**	**2.45**	**384**

mg/Kg - milligrams per Kilogram

Concentrations in **BOLD** indicate values that exceed 3 times the average background concentration.

NA=Not Available.

(1) For Non Detected samples, 60% of the reporting limit was used for the purposes of calculating average.

Sb - Antimony, Fe - Iron, Zn - Zinc

As - Arsenic, Pb - Lead

Ba - Barium, Mn - Manganese

Be - Beryllium, Hg - Mercury

Cd - Cadmium, Ni - Nickel

Cr - Chromium, Se - Selenium

Cu - Copper, Ag - Silver

TABLE B-3
IRON MASK MINE AND MILL SITE
XRF DATA (BLM)

Sample Number	Date	As mg/kg	Cu mg/kg	Fe mg/kg	Pb mg/kg	Mn mg/kg	Zn mg/kg	Notes
Site 1	08/08/05	< LOD	< LOD	26,777	39.7	927.0	< LOD	North dump top near tracks. Grey - purple andesitic waste rock, clay rich layer.
Site 2	08/08/05	< LOD	657.6	52,582	1,969.6	10,195.2	814.4	North dump top. Andesite withquartz and limonite veins, local strong limonite.
Site 3T	08/08/05	< LOD	< LOD	18,099	351.2	1,760.0	1,229.6	North dump top, North lobe. Grey andesite with weak limonite.
Site 3M	08/08/05	93.8	< LOD	28,598	624.0	3,827.2	2,268.8	North dump middle, North lobe. Gravel to sand sized andesite, some brown clay.
Site 3B	08/08/05	< LOD	< LOD	28,083	734.4	2,779.2	2,400.0	North dump bottom, North lobe. Grey andesite with local limonite, rare hematite.
Site 4T	08/08/05	< LOD	< LOD	26,880	307.4	1,360.0	1,049.6	North dump, middle lobe. Grey and purple andesite, rare carbonate veins.
Site 4M	08/08/05	< LOD	< LOD	19,596	95.1	1,280.0	192.2	North dump, middle lobe. Grey and purple andesite, gravel to sand size.
Site 4B	08/08/05	< LOD	< LOD	25,497	996.0	3,139.2	2,609.6	North dump, middle lobe. Grey andesite, weak limonite.
Combined North Dump (1 - 4)	**08/08/05**	**< LOD**	**< LOD**	**26,291**	**628.4**	**2,800.0**	**1,360**	**Combination of Waste Rock samples (1 - 4).**
5T	08/08/05	163.9	< LOD	< LOD	1,050	2,508.8	964.0	Mill dump, top, Mn coated andesite, probable calcite veinlets.
5M	08/08/05	377.6	< LOD	3,099	1,739	1,819.2	473.6	Mill dump, middle, andesite,Mn coatings and sulfides (py/cpy) on fractures.
5B	08/08/05	996	1,160	< LOD	19,597	8,044.8	8,755.2	Below and south of mill, mix of native soil and milled andesite.
6	08/08/05	< LOD	< LOD	< LOD	23,692	33,075.2	239,820.0	Under mill building, fine milled andesite with white coating of salts.
Combined Mill Area (5 - 6	**08/08/05**	**< LOD**	**< LOD**	**54,067.0**	**9,299.2**	**54,067.2**	**35,788.8**	**Combination of material near mill samples (5 - 6).**
Tails #1	08/08/05	1,160.0	< LOD	71,475.2	3,708.8	71,475.2	17,689.6	Chocolate colored fine silt overlying dark silt, native rock fragments 4 inches deep.
Tails #2	08/08/05	1,360.0	< LOD	72,755.2	4,099.2	72,755.2	12,396.8	Light brown fine silt sand 3 inches deep.
Tails #3	08/08/05	3,849.6	< LOD	140,902.4	18,496.0	140,902.4	2,428.8	Iron rich sandy horizon 1 to 4 inches thick on streambank.
Tails #4	08/08/05	668.8	< LOD	59,852.8	5,440.0	59,852.8	9,504.0	Brown silt (10YR53) overlyingMN coated platty clay structure.
Combined Tails	08/08/05	1,680.0	< LOD	83,968.0	7,468.8	83,968.0	9,024.0	Combination of mill materials (1 - 4).
BKGR #1	08/08/05	< LOD	< LOD	22,988.8	47.7	< LOD	115.0	Background material near mill site.
BKGR #2	08/08/05	< LOD	< LOD	20,390.4	30.6	< LOD	115.1	Background material near tailings area.
Standards	08/08/05							
Blank	08/08/05	< LOD	< LOD	235.6	< LOD	< LOD	< LOD	Standard
NIST 2709	08/08/05	< LOD	< LOD	23,692.8	< LOD	1,080.0	< LOD	Standard
NIST 2711	08/08/05	< LOD	< LOD	19,289.6	1,029.6	< LOD	402.4	Standard
NIST 2710	08/08/05	650.4	3,440	32,998	5,228	10,797	6,829	Standard

XRF - X-Ray Fluorescence Spectroscopy
LOD - Limit of Detection
mg/kg - milligram er kilogram
As - Arsenic
Cu - Copper
Fe - Iron
Pb - Lead
Mn - Manganese
Zn - Zinc
NIST-2709, NIST-2710, and NIST-2711 - XRF standards

TABLE B-3 (continued)
IRON MASK MINE AND MILL SITE
XRF DATA (Pioneer)

Sample Number	Date	Time	XRF Number	As mg/kg	STD As		Cu mg/kg	STD Cu		Fe mg/kg	STD Fe		Pb mg/kg	STD Pb		Mn mg/kg	STD Mn		Zn mg/kg	STD Zn	
NIST-2709	06/17/08	7:24	277	16.70	8.88	-	< LOD	98.16	-	26,898.51	453.33	H	20.96	10.18	-	512.11	120.30	H	132.62	54.19	-
NIST-2710	06/17/08	7:29	278	688.91	82.85	H	3,143.48	138.14	H	34,946.33	602.65	H	5,706.26	105.51	H	10,392.37	419.32	H	7,273.70	157.77	H
NIST-2711	06/17/08	7:33	279	73.69	33.36	-	132.76	70.44	-	22,116.84	421.39	H	1,202.87	43.71	H	588.02	124.13	H	334.29	59.97	H
IM-BLANK	06/17/08	7:36	280	< LOD	7.85	-	< LOD	73.56	-	< LOD	115.46	-	< LOD	10.04	-	< LOD	75.29	-	< LOD	59.40	-
IM-BG1	06/17/08	7:46	281	23.28	9.35	-	< LOD	96.57	-	28,114.20	464.50	H	25.74	10.40	-	1,031.06	144.56	H	128.29	54.07	-
IM-BG4	06/17/08	7:50	282	< LOD	12.76	-	< LOD	95.96	-	25,736.68	442.25	H	19.66	9.92	-	692.98	127.47	H	113.45	53.18	-
IM-BG2	06/17/08	7:55	283	21.07	10.96	-	< LOD	105.25	-	30,516.59	501.23	H	56.60	12.73	H	997.21	149.63	H	150.59	58.53	-
IM-BG3	06/17/08	7:58	284	24.67	10.26	-	< LOD	108.27	-	35,425.90	541.48	H	31.81	11.44	-	1,050.50	156.02	H	100.75	58.29	-
IM-TP-1-A	06/17/08	9:51	285	< LOD	12.57	-	< LOD	82.37	-	16,215.39	327.61	H	49.28	10.42	H	600.53	106.00	H	140.58	46.27	H
IM-TP-1-B	06/17/08	9:55	286	< LOD	13.62	-	< LOD	107.82	-	22,646.26	438.42	H	19.08	10.40	-	508.01	123.76	H	135.80	59.10	-
IM-TP-3-A	06/17/08	10:47	287	649.34	69.20	H	< LOD	151.35	-	57,391.32	843.86	H	3,043.32	84.43	H	26,482.24	713.64	H	14,719.36	232.56	H
IM-TP-3-B	06/17/08	10:53	288	109.13	25.80	H	< LOD	116.39	-	32,150.73	538.54	H	531.32	31.55	H	3,826.21	252.86	H	2,131.30	93.70	H
IM-TP-3-C	06/17/08	11:13	289	23.83	10.20	-	< LOD	103.75	-	27,729.96	477.86	H	35.32	11.60	H	840.24	140.59	H	130.49	57.80	-
IM-TP-3-D	06/17/08	11:17	290	< LOD	14.04	-	< LOD	106.79	-	32,172.95	515.97	H	30.13	11.55	-	870.42	146.08	H	< LOD	86.31	-
TP-OL-1-A	06/17/08	11:31	291	1,529.81	129.42	H	< LOD	201.55	-	99,298.30	1,253.67	H	8,689.69	160.55	H	49,524.41	1,101.38	H	40,498.98	422.64	H
TP-OL-1-B	06/17/08	11:36	292	< LOD	17.49	-	< LOD	115.92	-	29,654.74	519.37	H	60.88	14.35	H	750.97	147.71	H	3,114.95	106.48	H
IM-TP-4-A	06/17/08	11:39	293	46.52	13.38	H	< LOD	86.33	-	17,800.12	347.75	H	155.41	15.93	H	1,229.68	134.55	H	479.02	53.67	H
IM-TP-4-B	06/17/08	11:42	294	< LOD	13.95	-	< LOD	110.96	-	26,041.79	471.43	H	28.01	11.10	-	766.58	139.38	H	92.32	58.96	-
TP-OL-1-C	06/17/08	11:51	295	< LOD	16.48	-	< LOD	111.39	-	27,475.65	492.03	H	51.42	12.99	H	612.18	135.72	H	148.18	61.91	-
IM-TP-5-A	06/17/08	11:59	296	88.14	23.33	H	< LOD	85.76	-	20,780.73	375.65	H	633.45	29.42	H	2,599.17	180.96	H	2,178.80	77.09	H
IM-TP-5-B	06/17/08	12:02	297	< LOD	13.36	-	< LOD	107.27	-	30,529.08	502.57	H	17.27	10.44	-	691.65	136.08	H	< LOD	86.26	-
IM-BLANK-02	06/17/08	12:12	298	< LOD	8.17	-	< LOD	75.63	-	< LOD	119.52	-	< LOD	10.10	-	< LOD	76.07	-	< LOD	59.23	-
IM-TP-6-A	06/17/08	12:26	299	771.50	79.08	H	< LOD	146.48	-	55,318.40	795.76	H	4,489.53	98.29	H	24,397.25	660.37	H	16,394.80	233.93	H
IM-TP-6-AD	06/17/08	12:28	300	881.85	83.69	H	< LOD	153.83	-	58,519.83	840.09	H	4,707.55	103.28	H	25,975.97	698.63	H	17,569.11	248.26	H
IM-TP-6-B	06/17/08	12:32	301	16.62	8.98	-	< LOD	93.72	-	25,062.02	429.46	H	31.12	10.28	H	669.86	123.27	H	161.65	52.69	H
IM-TP-5-C	06/17/08	12:35	302	< LOD	13.76	-	< LOD	110.76	-	29,505.03	508.65	H	< LOD	16.02	-	759.38	143.24	H	106.75	60.85	-
IM-TP-6-C	06/17/08	12:43	303	< LOD	11.91	-	< LOD	94.42	-	26,261.65	438.30	H	13.83	9.18	-	541.49	117.74	H	< LOD	76.09	-
IM-TP-7-A	06/17/08	13:14	304	1,060.07	96.40	H	< LOD	167.77	-	78,437.38	1,018.01	H	5,756.44	119.16	H	42,848.11	931.54	H	34,172.50	353.34	H
IM-TP-7-B	06/17/08	13:18	305	< LOD	13.69	-	< LOD	101.02	-	25,579.93	452.66	H	30.74	10.85	-	655.67	128.56	H	177.96	56.98	H
IM-TP-7-C	06/17/08	13:22	306	< LOD	12.65	-	< LOD	99.00	-	26,662.02	459.78	H	21.04	10.10	-	508.38	122.57	H	< LOD	81.36	-
TP-OL-2-A	06/17/08	13:42	307	77.07	19.65	H	< LOD	98.37	-	20,843.01	401.59	H	350.92	23.88	H	2,147.45	180.02	H	1,224.37	71.49	H
IM-BG-05	06/17/08	15:06	308	17.47	9.44	-	< LOD	96.07	-	19,946.86	387.91	H	39.33	11.06	H	790.28	126.30	H	122.23	52.47	-
IM-WR3-A	06/17/08	15:11	309	270.23	50.60	H	< LOD	136.24	-	44,035.81	674.29	H	1,995.93	63.92	H	1,929.73	218.23	H	1,330.01	93.05	H
IM-WR3-B	06/17/08	15:14	310	517.27	65.17	H	< LOD	135.82	-	56,336.14	762.55	H	3,246.45	81.46	H	2,408.85	241.24	H	3,423.75	121.35	H
IM-WR1-A	06/17/08	15:55	311	< LOD	18.03	-	< LOD	117.68	-	39,144.43	590.74	H	75.36	15.15	H	556.28	141.87	H	160.30	63.96	-
IM-WR1-B	06/17/08	15:58	312	< LOD	14.64	-	< LOD	113.07	-	39,551.72	582.15	H	34.58	11.98	-	567.83	139.82	H	222.60	62.86	H
WR1-1N-B	06/17/08	16:29	313	178.51	31.49	H	< LOD	127.79	-	43,657.90	656.20	H	701.83	37.73	H	4,824.41	296.30	H	2,556.84	106.00	H
IM-WR1-A	06/17/08	16:38	314	174.36	40.47	H	< LOD	116.69	-	46,813.23	654.79	H	1,445.63	51.46	H	4,218.02	271.98	H	2,205.99	96.68	H
IM-WR2-B	06/17/08	16:41	315	528.15	69.94	H	< LOD	143.29	-	60,058.18	823.22	H	3,500.45	87.79	H	10,500.20	451.37	H	146.94	146.94	-
NIST-2710	06/18/08	7:02	316	590.41	80.38	H	2,907.69	132.41	H	33,714.38	583.85	H	5,608.00	103.16	H	10,228.20	409.86	H	7,132.11	153.88	H
NIST-2711	06/18/08	7:06	317	78.10	33.10	-	< LOD	104.62	-	22,699.35	426.64	H	1,176.17	43.23	H	495.05	120.08	H	376.79	60.76	H
NIST-2709	06/18/08	7:09	318	15.65	9.16	-	< LOD	98.01	-	26,706.40	454.11	H	27.37	10.71	-	387.68	115.87	H	133.18	54.65	-
IM-BLANK-3	06/18/08	7:12	319	< LOD	7.55	-	< LOD	73.04	-	< LOD	114.76	-	< LOD	9.29	-	< LOD	80.42	-	< LOD	59.87	-
IM-WR1-TP2-A	06/18/08	9:46	320	229.58	44.86	H	< LOD	129.53	-	51,025.36	714.74	H	1,613.54	56.44	H	9,648.67	406.03	H	2,448.25	105.50	H
IM-WR1-TP2-B	06/18/08	9:50	321	223.11	75.89	-	306.92	123.11	-	60,275.24	903.12	H	3,757.71	99.48	H	8,518.16	453.81	H	30,929.46	347.99	H
IM-WR1-TP3-C	06/18/08	10:18	322	76.34	28.55	-	192.80	83.72	-	40,513.50	614.37	H	688.23	36.35	H	3,338.21	248.14	H	2,134.89	96.82	H
IM-WR1-TP3-D	06/18/08	10:21	323	46.80	22.25	-	< LOD	128.28	-	35,040.76	584.28	H	368.88	28.11	H	2,244.80	217.05	H	1,119.34	85.02	H
WR2-2-B	06/18/08	13:16	324	130.00	41.44	H	< LOD	115.58	-	31,143.93	528.19	H	1,627.72	53.77	H	387.29	129.20	-	978.32	77.69	H
WR2-2-A	06/18/08	13:18	325	303.33	38.81	H	< LOD	126.18	-	42,537.40	640.62	H	1,080.91	46.08	H	1,180.73	179.87	H	492.37	74.94	H
WR2-3-A	06/18/08	13:23	326	1,837.52	240.12	H	1,451.81	209.98	H	107,844.72	1,508.91	H	24,523.40	312.78	H	34,957.43	1,092.21	H	68,704.21	636.50	H
WR2-3-B	06/18/08	13:27	327	2,633.39	246.43	H	1,315.83	194.35	H	108,190.09	1,461.32	H	27,257.06	317.58	H	44,560.41	1,178.63	H	62,873.13	586.85	H
NIST-2710	06/18/08	13:13	328	5,703.24	81.82	H	2,859.86	132.78	H	33,897.71	588.81	H	5,703.24	104.53	H	10,375.07	414.70	H	6,964.70	153.42	H
NIST-2711	06/18/08	13:19	329	83.79	33.05	-	135.63	70.90	-	22,436.67	425.39	H	1,158.02	43.05	H	527.72	121.49	H	289.53	59.47	H
NIST-2709	06/18/08	13:21	330	< LOD	13.38	-	< LOD	99.98	-	27,898.76	465.40	H	23.74	10.49	-	533.17	122.58	H	99.17	54.36	-
BLANK-4	06/18/08	13:25	331	< LOD	8.15	-	< LOD	74.07	-	< LOD	116.18	-	< LOD	9.25	-	< LOD	80.01	-	< LOD	59.01	-
IM-TA1-A	06/18/08	14:15	332	1,055.00	124.39	H	< LOD	205.91	-	87,797.73	1,177.62	H	8,383.22	157.93	H	36,778.58	954.99	H	37,235.77	407.11	H
IM-TA2-B	06/18/08	14:21	333	3,373.60	75.03	H	< LOD	164.20	-	70,621.23	960.31	H	3,373.60	90.88	H	39,587.92	887.83	H	9,056.90	194.41	H

XRF - X-Ray Fluorescence Spectroscopy
STD - Standard Deviation
LOD - Limit of Detection
mg/kg - milligram er kilogram
H - XRF results are 3 times greater than the STD
NIST-2709, NIST-2710, and NIST-2711 - XRF standards

As - Arsenic
Cu - Copper
Fe - Iron
Pb - Lead
Mn - Manganese
Zn - Zinc

TABLE B-4
IRON MASK MINE AND MILL SITE
ACID/BASE ACCOUNTING and SMP RESULTS

Sample No.	Sample Date	Sample Description	Total Sulfur %	Sulfur HCl Extract %	Sulfur HNO_3 Extract %	Sulfur Residual %	Sulfur H_2O Extract %	Acid Potential tons/1,000	Acid/Base Potential tons/1,000	Neut. Potential tons/1,000	SMP Lime Requirement tons/1,000	ABA Lime Requirement tons/1,000	Total Lime Requirement tons/1,000	SMP Buffer pH su
Iron Mask-WR1-B	06/18/08	Composite sample collected from WR1 - collected from 6"to the bottom of the test pit, from WR1-TP-01, WR1-TP-02, and WR1-TP 03	2.5	0	1.4	0.62	0.45	56	25	81	0	77.19	0	7.4
Iron Mask-WR1-C	06/18/08	Composite sample - collected from 6"-50" from waste material in WR1-TP-03	0.47	0	0.44	0.01	0	15	49	64	0	14.06	0	7.6
Iron Mask-WR1-D	06/18/08	Composite sample - collected from 50"-9' from test pit WR1-TP-03 spoils pile	2.5	0	2.1	0.33	0.11	84	14	98	0	79.38	0	7.3
Iron Mask-WR2-B	06/17/08	Composite sample collected from WR2 - collected from 6-32" from WR2-TP-01, WR2-TP-02, and WR2-TP-03	3.2	0.07	1.8	0.4	0.94	56	-14	42	2	99.77	74.71	6.7
Iron Mask-WR2-2-B	06/18/08	Composite sample collected from WR2 - located on a red/black area on the west side of WR2 dump slope, lots of wood debris	2.0	0.37	0.67	0.02	0.92	21	-18	3	12	58.99	84.98	5.3
Iron Mask-WR3-B	06/17/08	Composite sample collected from WR2 - collected from 6"-7' from WR2-TP-01	0.93	0.09	0.55	0.08	0.22	17	-14	4	8	28.67	40.84	5.8
Iron Mask-TA1-B	06/17/08	Composite sample - collected from 6" to the bottom of the seven test pits located in the Tailings Area 1	0	0	0	0	0	0.01	25	25	1	0.00	0	6.8
Iron Mask-TA1-W	06/18/08	Composite Sample - collected from 0-3" from just above the lower road in visible tailings	0.69	0	0.61	0.05	0.03	24	35	59	0	21.56	0	7.1
Iron Mask-TA2-A	06/18/08	Composite Sample - collected from 0-6" of waste material from three test pits located in the Tailings Area 2	2.0	0	1.8	0.1	0.01	74	32	110	0	59.69	0	7.3
Iron Mask-TA2-B	06/18/08	Composite Sample - collected from 6" to bottom of the three test pits located in the Tailings Area 2	1.9	0	1.8	0.08	0	82	26	110	0	58.75	0	7.3
Iron Mask-BA1-B	06/16/08	Composite sample - collected from 6" to the bottom of the eight test pits in Borrow Area 1	0	0	0	0	0	0.04	62	62	0	0.00	0	7.4
Iron Mask-BA2-B	06/16/08	Composite sample - collected from 6" to the bottom of the sixteen test pits in Borrow Area 2	0	0	0	0	0	0.04	88	88	0	0.00	0	7.4

su - Standard units
HCl - Hydrochloric Acid
HNO_3 - Nitric Acid
H_2O - Water
SMP - Shoemaker, McLean, Pratt buffer
t/1,000t = Tons of $CaCO_3$ equilivant per 1000 tons of material
Neut. Pot. = Neutralization Potential is used to assess the acid buffering capacity of the waste or soil.

A low concentration of basic species in the soil (NP) and a high concentration of Sulfur, this number will be negative indicating that the soil has a high acid generation potential and little buffering capacity.
NA = Not Available or Requested
The Acid Base Potential was calculated from non-sulfate sulfur.

TABLE B-5
IRON MASK MINE AND MILL SITE
SYNTHETIC PRECIPITATION LEACH PROCEDURE (SPLP)
METAL RESULTS (Pioneer 2008)

SAMPLE ID	SAMPLE DATE	SAMPLE DESCRIPTION	Sb µg/L	As µg/L	Ba µg/L	Cd µg/L	Cr µg/L	Cu µg/L	Fe µg/L	Pb µg/L	Mn µg/L	Hg µg/L	Ni µg/L	Ag µg/L	Zn µg/L
Iron Mask-WR1-B	06/18/08	Composite sample collected from WR1 - collected from 6"to the bottom of the test pit, from WR1-TP-01, WR1-TP-02, and WR1-TP-03	< 0.5	< 0.5	< 10	< 0.1	< 0.5	< 0.5	< 1	< 0.5	< 0.5	< 0.02	< 0.5	< 0.5	< 1
Iron Mask-WR2-B	06/17/08	Composite sample collected from WR2 - collected from 6-32" from WR2-TP-01, WR2-TP-02, and WR2-TP-03	< 0.5	< 0.5	< 10	0.3	< 0.5	< 0.5	< 1	< 0.5	6.5	< 0.02	< 0.5	< 0.5	21
Iron Mask-WR2-2-B	06/17/08	Composite sample collected from WR2 - collected from 6-32" from WR2-TP-01, WR2-TP-02, and WR2-TP-03	< 0.5	< 0.5	< 10	0.1	< 0.5	< 0.5	< 1	< 0.5	15	< 0.02	< 0.5	< 0.5	16
Iron Mask-WR3-B	06/17/08	Composite sample collected from WR2 - collected from 6"-7' from WR2-TP-01	< 0.5	< 0.5	< 10	0.2	< 0.5	< 0.5	< 1	< 0.5	8.5	< 0.02	< 0.5	< 0.5	31
Iron Mask-TA1-W	06/18/08	Composite Sample - collected from 0-3" from just above the lower road in visible tailings	< 0.5	< 0.5	< 10	< 0.1	< 0.5	< 0.5	4	1.1	1.3	< 0.02	< 0.5	< 0.5	4
Iron Mask-TA2-B	06/18/08	Composite Sample - collected from 6" to bottom of the three test pits located in the Tailings Area 2	< 0.5	< 0.5	< 10	< 0.1	< 0.5	< 0.5	< 1	< 0.5	< 0.5	< 0.02	< 0.5	< 0.5	< 1
MONTANA NUMERIC WATER QUALITY STANDARDS (DEQ-7) (February 2008) Human Health Standard (Groundwater)			6	10	2000	5	100	1300	300 [C]	15	50 [C]	2	100	100	2000

µg/L = micrograms per Liter

[C] = Secondary Aesthetic HHS

Sb - Antimony
As - Arsenic
Ba - Barium
Be - Beryllium
Cd - Cadmium
Cr - Chromium
Cu - Copper
Zn - Zinc
Fe - Iron
Pb - Lead
Mn - Manganese
Hg - Mercury
Ni - Nickel
Se - Selenium
Ag - Silver

IRON MASK MINE AND MILL SITE
TOXICITY CHARACTERISTIC LEACHING PROCEDURE (TCLP)
METAL RESULTS (BLM - 2005)

SAMPLE ID	SAMPLE DATE	SAMPLE DESCRIPTION	As mg/L	Ba mg/L	Cd mg/L	Cr mg/L	Pb mg/L	Hg mg/L	Se mg/L	Ag mg/L
Combined Mill Area	08/04/05	Combination of material near mill samples (5 - 6).	< 0.5	< 10	15.1	< 0.5	18.2	< 0.02	< 0.1	< 0.5
Combined N. Dump	08/04/05	Combination of Waste Rock samples (1 - 4).	< 0.5	< 10	< 0.1	< 0.5	< 0.5	< 0.02	< 0.1	< 0.5

mg/L = milligrams per Liter

As - Arsenic
Ba - Barium
Cd - Cadmium
Cr - Chromium
Pb - Lead
Hg - Mercury
Se - Selenium
Ag - Silver

TABLE B-6
IRON MASK MINE AND MILL SITE
SUPPLEMENTAL SAMPLING AGRONOMIC PROPERTIES

SAMPLE ID	SAMPLE DATE	SAMPLE DESCRIPTION	Organic Matter (%)	RECOMMENDED FERTILIZER APPLICATION RATE			Bicarbonate P ppm	Soil pH	Cation Exchange Capacity (meq / 100g)	Sodium Adsoption Ratio (unitless)	Saturation Percentage (%)	Conductivity (mS/cm)	Field Capacity (1/3 Bar)	Wilting Point (15 Bar %)
				Nitrogen (lbs / ac)	Phosphate (P_2O_5) (lbs / ac)	Potash (K_2O) (lbs / ac)								
Iron Mask-BA1-A	06/16/08	Composite sample - collected from 0-6" from the eight test pits in Borrow Area 1	3.1	100	NR	NR	NR	6.5	14.7	0.4	50.2	0.61	10.42	6.06
Iron Mask-BA2-A	06/16/08	Composite sample - collected from 0-6" from the sixteen test pits in Borrow Area 2	2.2	100	55	40	NR	7.6	18.3	0.3	30.4	0.67	14.15	8.51
Iron Mask-BA1-B	06/16/08	Composite sample - collected from 6" to the bottom of the eight test pits in Borrow Area 1	1.3	100	70	80	1	8.1	15.8	0.7	25.1	0.43	11.57	4.63
Iron Mask-BA2-B	06/16/08	Composite sample - collected from 6" to the bottom of the sixteen test pits in Borrow Area 2	0.8	100	60	80	2	8.3	14.0	0.7	21.1	0.44	9.8	4.32
Iron Mask-WR1-B	06/18/08	Composite sample collected from WR1 - collected from 6"to the bottom of the test pit, from WR1-TP-01, WR1-TP-02, and WR1-TP-03	3.3	100	60	65	6	7.2	23.8	0.2	50.0	2.74	8.21	3.76
Iron Mask-WR2-B	06/17/08	Composite sample collected from WR2 - collected from 6-32" from WR2-TP-01, WR2-TP-02, and WR2-TP-03	3.1	100	70	80	NR	6.0	50.4	0.2	50.9	3.57	13.01	4.9
Iron Mask-WR3-B	06/17/08	Composite sample collected from WR2 - collected from 6"-7' from WR2-TP-01	1.4	100	65	65	NR	5.0	26.6	0.2	39.1	4.03	13.04	5.65
Iron Mask-TA1-A	06/17/08	Composite sample - collected from 0-6" from the seven test pits located in the Tailings Area 1	2.8	100	15	NR	NR	6.9	14.3	0.3	53.1	0.70	11.97	6.84
Iron Mask-TA1-B	06/17/08	Composite sample - collected from 6" to the bottom of the seven test pits located in the Tailings Area 1	1.3	100	60	65	4	8.1	17.8	1.4	19.6	1.02	8.47	4.19
Iron Mask-TA2-B	06/18/08	Composite Sample - collected from 6" to bottom of the three test pits located in the Tailings Area 2	3.0	100	60	65	5	8.0	11.9	0.0	38.5	1.06	15.38	6.4

bar - barometric pressure
lbs/ac - pounds per acre
mS/cm - milliSiemens per centimeter
meq/100g - milliequivalence per 100 grams
NR = Not Requested

TABLE B-7
IRON MASK MINE AND MILL SITE
SUPPLEMENTAL SOIL SAMPLING PHYSICAL PROPERTIES

SAMPLE ID	SAMPLE DATE	SAMPLE DESCRIPTION	USDA Texture	Rapid Hydrometer Percent Sand, Silt, Clay			Available Moisture (%)	Specific Gravity Unitless	Maximum Dry Density psf	Optimum Moisture %
				Sand %	Silt %	Clay %				
Iron Mask-WR1-B	06/18/08	Composite sample collected from WR1 - collected from 6" to the bottom of the test pit, from WR1-TP-01, WR1-TP-02, and WR1-TP-03	Sandy Loam	70.8	20.1	9.1	4.45	2.9	140.5	7.8
Iron Mask-WR2-B	06/17/08	Composite sample collected from WR2 - collected from 6-32" from WR2-TP-01, WR2-TP-02, and WR2-TP-03	Sandy Loam	69.7	20.7	9.6	8.11	2.5	135.9	9.6
Iron Mask-WR3-B	06/17/08	Composite sample collected from WR2 - collected from 6" 7' from WR2-TP-01	Loamy Sand	74.7	22.8	2.5	7.39	2.8	NR	NR
Iron Mask-TA2-B	06/18/08	Composite Sample - collected from 6" to bottom of the three test pits located in the Tailings Area 2	Sandy Loam	53.4	34.2	12.4	8.98	2.9	108.2	19.7
Iron Mask-TA1-B	06/17/08	Composite sample - collected from 6" to the bottom of the seven test pits located in the Tailings Area 1	Sandy Loam	62.6	25.7	11.7	4.28	2.8	NR	NR
Iron Mask-BA1-B	06/16/08	Composite sample - collected from 6" to the bottom of the eight test pits in Borrow Area 1	Sandy Loam	65.2	24.1	10.7	6.94	2.5	NR	NR
Iron Mask-BA2-B	06/16/08	Composite sample - collected from 6" to the bottom of the sixteen test pits in Borrow Area 2	Sandy Loam	56.3	31.6	12.1	5.48	2.8	NR	NR

psf - Pounds per Square Foot
Not Requested

TABLE B-8
IRON MASK MINE AND MILL SITE
TOTAL METALS SURFACE WATER DATA

Sample ID	Sample Date	Time Sampled	Sample Description	Sb ug/L	As ug/L	Ba ug/L	Cd ug/L	Cr ug/L	Cu ug/L	Fe ug/L	Pb ug/L	Mn ug/L	Hg ug/L	Ni ug/L	Ag ug/L	Zn ug/L	Hardness mg $CaCO_3$/L
Iron Mask-SW-01	06/16/08	15:20	Sample collected 10' from collapsed portal	< 5	< 5	< 100	< 1	< 10	< 10	< 30	< 10	< 10	< 1	< 10	< 5	40	159
Iron Mask-SW-02	06/16/08	14:10	Sample collected at the base of the gray waste rock dump just before it disappears underground	< 5	< 5	< 100	< 1	< 10	< 10	320	10	40	< 1	< 10	< 5	80	156
Iron Mask-SW-03	06/16/08	13:15	Sample collected near bottom of barren runoff area from the red waste rock dump but above bermed area that may have been tailings pond of runoff control	< 5	6	< 100	1	< 10	< 10	350	40	60	< 1	< 10	< 5	150	168
Iron Mask-SW-04	06/16/08	11:40	Sample collected below living quarters and 10-15 ft above where water disappears	< 5	9	< 100	< 1	< 10	< 10	140	30	30	< 1	< 10	< 5	90	180
MONTANA NUMERIC WATER QUALITY STANDARDS (DEQ-7) (February 2008)																	
			Aquatic Life Standard (Acute) corrected for hardness.	NA	NA	NA	3.61	NA	22.8	NA	158	NA	NA	8.00	9.91	186	**168**
MONTANA NUMERIC WATER QUALITY STANDARDS (DEQ-7) (February 2008)																	
			Aquatic Life Standard (Acute)	--	340	--	-- A	--	-- A	-- b	-- A	-- C	1.7	-- A	A	-- A	
			Human Health Standard (Surface Water)	5.6	10	2,000	5	100	1,300	300 b	15	50 C	0.05	100	100	2,000	

Sb-Antimony, As-Arsenic, Ba-Barium, Cd-Cadmium, Cr-Chromium, Cu-Copper, Fe-Iron
Pb-Lead, Mg-Magnesium, Mn-Manganese, Hg-Mercury, Ni-Nickel, Ag-Silver, Zn-Zinc
NA - Not Available
ug/L - micrograms per Liter
$CaCO_3$/L = Calcium Carbonate per Liter
A - Concentration value based on hardness. No sample shall exceed these concentrations after corrected for hardness.
b - The concentration of iron must not reach values that interfere with the uses specified in the surface and groundwater standards (17.30.601 et seq and 17.30.1001 et seq.)
The Secondary Maximum Contaminant Level of 300 micrograms per Liter which is based on aesthetic properties such as taste, odor, and staining may be considered as guidance to determine the levels that will interfere with the specified uses.
C- The concentration of manganese must not reach values that interfere with the uses specified in the surface and groundwater standards (17.30.601 et seq and 17.30.1001 et seq.).
The Secondary Maximum Contaminant Level of 50 micrograms per Liter which is based on aesthetic properties such as taste, odor, and staining may be considered as guidance to determine the levels that will interfere with the specified uses.

TABLE B-9
IRON MASK MINE AND MILL SITE
DISSOLVED METALS SURFACE WATER DATA

SAMPLE ID	SAMPLE DATE	SAMPLE TIME	SAMPLE DESCRIPTION	Al µg/L	Sb µg/L	As µg/L	Ba µg/L	Cd µg/L	Ca µg/L	Cr µg/L	Cu µg/L	Fe µg/L	Pb µg/L	Mg µg/L	Mn µg/L	Hg µg/L	Ni µg/L	Ag µg/L	Zn µg/L	Hardness mg $CaCO_3$/L
010521P001	5/16/2001	16:00	Sample collected from portal	< 19	< 3	< 1	26	0.1	47800	< 8	4	< 7	< 1	11000	< 1	0.2	< 11	< 2	24	Not Reported
			2008 Site Investigation																	
Iron Mask-SW-01	06/16/08	15:20	Sample collected 10' from collapsed portal	NR	< 5	< 5	< 100	< 1	47000	< 10	< 10	< 30	< 10	10000	< 10	< 1	< 10	< 5	30	159
Iron Mask-SW-02	06/16/08	14:10	Sample collected at the base of the gray waste rock dump just before it disappears underground	NR	< 5	< 5	< 100	< 1	47000	< 10	< 10	< 30	< 10	9000	< 10	< 1	< 10	< 5	20	156
Iron Mask-SW-03	06/16/08	13:15	Sample collected near bottom of barren runoff area from the red waste rock dump but above bermed area that may have been tailings pond of runoff control	NR	< 5	< 5	< 100	< 1	51000	< 10	< 10	< 30	< 10	10000	< 10	< 1	< 10	< 5	70	168
Iron Mask-SW-04	06/16/08	11:40	Sample collected below living quarters and 10-15 ft above where water disappears	NR	< 5	8	< 100	< 1	55000	< 10	< 10	< 30	< 10	10000	< 10	< 1	< 10	< 5	60	180

µg/L - micrograms per Liter
CaCO3/L = Calcium Carbonate per Liter
NR = Analysis not requested

Al - Aluminum
Sb - Antimony
As - Arsenic
Ba - Barium
Be - Beryllium
Cd - Cadmium
Cr - Chromium
Cu - Copper
Fe - Iron
Pb - Lead
Mn - Manganese
Hg - Mercury
Ni - Nickel
Se - Selenium
Ag - Silver
Zn - Zinc

TABLE B-10
IRON MASK MINE AND MILL SITE
WET CHEMISTRY RESULTS & FIELD MEASUREMENTS

SAMPLE ID	SAMPLE DATE	SAMPLE TIME	SAMPLE DESCRIPTION	pH SU	TDS mg/L	Chloride mg/L	Sulfate mg/L	NO_3/NO_2 - N mg/L	Conductivity umhos/cm	DO mg/L	Alkalinity mg/L $CaCO_3$	Field Redox mV	Hardness mg $CaCO_3$/L	Temp °C	Turbidity NTU	Flow Est. gpm
010521P001	05/16/01	16:00	Sample collected from portal	8.0	NR	<5	60.4	0.71	375	NR	NR	NR	NR	NR	NR	NR
2008 Site Investigation																
Iron Mask-SW-01	06/16/08	15:20	Sample collected 10' from collapsed portal	7.9	243	3	57	0.63	388	9.13	149	-201.6	159	8.1	0.1	6.28
Iron Mask-SW-02	06/16/08	14:10	Sample collected at the base of the gray waste rock dump just before it disappears underground	8.4	239	2	57	0.36	382	7.36	140.5	212.7	156	19.4	2.2	5.71
Iron Mask-SW-03	06/16/08	13:15	Sample collected near bottom of barren runoff area from the red waste rock dump but above bermed area that may have been tailings pond or runoff control	8.2	255	3	68	0.36	402	7.72	132.5	269.7	168	14.3	12.5	9.25
Iron Mask-SW-04	06/16/08	11:40	Sample collected below living quarters and 10-15 ft above where water disappears	7.8	274	2	79	0.24	420	6.94	135	214.5	180	15.9	1.05	1.56

SU - standard units
mg/L - milligrams per Liter
NR - Not Reported
NO_3/NO_2-N - Nitrate/Nitrite-N
mV - milli-Volts
mg/L $CaCO_3$ - milligrams per Liter calcium carbonate
umhos/cm - micromhos per centimeter
°C - Celsius
DO - Dissolved Oxygen
TDS - Total Dissolved Solids
NTU - Nephelometric Turbidity Unit
gpm - gallons per minute

TABLE B-11
IRON MASK MINE AND MILL SITE
CoC COMPARISON CRITERIA

CRITERIA	Unit	Sb	As	Cd	Cu	Pb	Mn	Hg	Ag	Zn
Solid Media										
EPA Residential Soil [1]	mg/kg	31	22	70	3,100	400	1,800	23	390	23,000
BLM Residential Soil [2]	mg/kg	3	1	3	250	400	960	2	35	2,000
BLM Recreational Soil - Camper [2]	mg/kg	50	20	70	5,000	1,000	19,000	40	700	40,000
BLM Terrestrial Mammals [3]	mg/kg	N/A	200	3	64	106	N/A	6	N/A	222
Lockheed Plant Phytoxicity [4]	mg/kg	N/A	95	25	100	500	N/A	32	2	270
EPA Stream Sediment [5]	mg/kg	N/A	32.6	2.49	157	161	N/A	0.87	2.45	384
Water										
EPA Residential Water [1]	ug/L	15	11	18	1,500	15*	880	11	180	11,000
BLM Residential Surface Water [2]	ug/L	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
BLM Recreational Surface Water - Camper [2]	ug/L	124.0	93.0	155.0	11,490	50	1,548	93.0	1,548	92,909
ARARs										
DEQ-7 Acute Aquatic Life Standard (AALS) @ 168 hardness [6]	ug/L	N/A	340	3.6	22.8	158	N/A	1.7	9.9	186
DEQ-7 Human Health Standard (HHS) for Surface Water [6]	ug/L	5.6	10	5	1,300	15	50 [C]	0.05	100	2,000

* = DEQ-7 HHS for Lead
[C] = Secondary Aesthetic HHS
N/A = Not Available
(1) Regional Screening Levels (EPA, 2008).
(2) Risk Management Criteria (Ford, 2004).
(3) Risk Management Criteria (Ford, 2004), the lowest of five mammals: mule deer, bighorn sheep, white-tailed deer, elk and cotton tail rabbit.
(4) Median Lowest Observed Effects Level (Lockheed Martin, 1997).
(5) T_{50} - Modeled effects response of 50% (EPA, 2004).
(6) Montana Numeric Water Quality Standards (DEQ/WQB, 2008)

APPENDIX C

IRON MASK MINE AND MILL SITE, MONTANA DEPARTMENT OF HEALTH AND HUMAN SERVICES DRINKING WATER TESTING TYPES, ATSDR TOXICITY PROFILE SUMMARIES FOR THE CONTAMINANTS OF CONCERN, ECOLOGICAL TOXICITY INFORMATION

WATER QUALITY FOR PRIVATE WELL OWNERS

Taken from the Montana Department of Health and Human Services, 2009
http://www.dphhs.mt.gov/PHSD/Lab/Environmental/doc/PrivateWellTesting.DOC

GROUNDWATER

A large percentage of people living in Montana depend on groundwater as the primary source of drinking water. Rain or snow that falls to earth is initially called surface water. Surface water that seeps down into the soil becomes groundwater. The water often enters an aquifer, an underground water storage reservoir of rock, gravel and sand. Aquifers can be shallow or very deep, and several aquifers can exist independently in a given area. That groundwater is normally accessed through wells. A well drilled at one location might tap into a shallow aquifer, while a well drilled 500 feet away may tap a deep aquifer. Often, many wells are drilled into a single aquifer.

Public Drinking Water supplies, such as those in towns and cities, are governed by state and federal regulations designed to insure safe, clean water for consumers. Unlike those of us whose water quality is governed by the EPA's Safe Drinking Water Act, rural residents must insure that their own water supplies are clean and safe. No regulations exist to govern the levels of contaminants allowable in private wells, nor are there requirements for testing to be done on a regular basis.

SOURCES OF CONTAMINATION

A number of factors influence a well's susceptibility to contamination. Well location and construction are of maximum importance. The well should be located away from potential sources of contamination, such as septic systems; livestock yards or barns; landfills or dumps; above-ground or underground fuel storage tanks which might possibly leak; areas where pesticides, herbicides or fertilizers are mixed; and low-lying areas which may be subject to flooding during times of runoff.

Shallow wells, which may be more subject to the influence of surface water, are generally more at risk for contamination than are deep wells. A poorly sealed well can have space between the casing and the surrounding soil, providing a direct channel for surface water to enter the groundwater which serves the well. Improperly capped wells allow insects, small rodents or runoff to directly enter the well. Old wells constructed with thin casings can crack, allowing contaminated surface water to enter the well. To ensure proper construction of a new well, or for maintenance on an existing well, contact a licensed well driller in your area. Your county sanitarian or county extension agent may be able to provide you with a list of licensed drillers.

Groundwater itself may become contaminated in a number of ways. The most common way for this to happen is through the influence of contaminated surface water. Shallow aquifers can come under the influence of surface water if a stream, river, pond or lake is near. Flooding from spring runoff, or runoff from fields which have been fertilized or have had pesticides or herbicides sprayed can also threaten groundwater. Spilled organic compounds, such as fuels, solvents, pesticides and herbicides can be carried by surface water as it percolates through the soil to an aquifer. Aquifers may be contaminated by surface water which leaches heavy metals from mines, nitrate and bacteria from septic systems or livestock yards, and various kinds of organic compounds from landfills. Abandoned but unsealed wells provide easy access for contamination carried by rodents, flood or runoff water, or from improper disposal of waste or refuse in the well. An entire aquifer can be contaminated because of one open abandoned well.

TYPES OF CONTAMINATION

Contaminants may be natural or man-made. Naturally-occurring contaminants include calcium and magnesium (which together form hardness), iron, sodium, sulfate, nitrate, arsenic, lead and fluoride. Generally, these minerals are found in the environment only in small amounts that do not pose a health threat. High concentrations of certain minerals in water often lead to unpleasant taste, odor, color, or hardness. Several of these minerals are described in "Types of Testing " below.

Human activity often causes naturally-occurring minerals to be released into the environment in large amounts. Heavy metals such as lead, arsenic and cadmium are leached from mine tailings as surface water passes over and through them. The use of fertilizers on croplands and lawns can increase the amounts of nitrate and phosphorus which enter the water supply. Septic systems and livestock yards contribute to increased levels of nitrate.

Microorganisms are another type of natural contaminant. Bacteria found naturally in the soil may be responsible for much of the odor, color and taste problems in well water. Non-disease producing iron, sulfur and manganese bacteria, considered "nuisance" bacteria, metabolize iron, sulfur and manganese, respectively, leaving behind

"rotten egg" or "musty" odors, slime and dark color. Total coliform bacteria form a large group of microorganisms which are not disease producing, but which act as indicator organisms that disease-producing bacteria may also be present. Total coliforms are discussed below.

Man-made contaminants include such things as pesticides and herbicides, known as Synthetic Organic Compounds, and petroleum products or byproducts, fuels and solvents, known as Volatile Organic Compounds. Many of these compounds are suspected carcinogens, while others can cause neurological damage or injury to specific organs in the body.

TYPES OF TESTING

The following types of tests will aid private well owners in determining the quality of their drinking water. Other tests are available as well.

Total Coliform Bacteria - **Total Coliforms** are a large group of usually harmless bacteria that are naturally present in soil and vegetation, and also in the intestinal tract of warm-blooded animals. Although total coliforms normally do not produce illness, their presence in drinking water is used as an indicator that other, potentially harmful bacteria may be present. Since total coliforms and fecal coliforms often coexist, the presence of total coliform in drinking water is a warning to check for possible sources of contamination.

E. Coli is a coliform bacterium of fecal origin whose presence indicates that the water may be contaminated with human or animal wastes. These wastes come from septic systems, sewage plants, feedlots and pastures, or from wildlife, domesticated animals and pets. Microbes in these wastes can cause short-term effects, such as diarrhea, cramps, nausea, headaches, or other symptoms. They may pose an increased health risk for infants, young children, and people with severely compromised immune systems.

Specific Conductance - Specific Conductivity, measured in micro mhos per centimeter (umho/cm), is a measure of the ability of water to conduct an electrical current; it is also referred to as the salinity, salt content, the total mineral content or □alkali" content. It is dependent on the amount of dissolved minerals (such as salt) in the water. Generally, the more dissolved material in the water, the more electrical current that can be transmitted. A large amount of dissolved material in water may adversely affect its quality. Some typical dissolved materials are sodium, magnesium, calcium, iron, chloride, nitrate, sulfate and phosphate. Dissolved minerals may come from rocks and soil as water runs through and across it. Acid mine drainage, which increases the amount of dissolved metals in the water, agricultural runoff of fertilizers or from livestock feedlots, and runoff from roads where automobile fluids and salts from chemicals used for ice removal have collected may all contribute to the amount of dissolved solids (minerals) in the water. Due to the many different constituents that make up the total mineral content, it is difficult to set a standard for human consumption. Drinking waters up to 400 umhos/cm are considered excellent, while water with conductivity above 8500 umhos/cm may have an objectionable taste.

Nitrate (Nitrate + Nitrite) - Nitrate is present naturally in the environment. It is a constituent of plant material, where it is found in varying levels dependent on the type of plant. Elevated levels of nitrate in drinking water (above 10 milligrams per liter) may cause a condition called methemoglobinemia, or "blue baby syndrome", in infants under 6 months of age. Nitrate is converted to nitrite in the digestive system of infants; nitrite then interferes with the oxygen-carrying ability of the blood, causing lack of oxygen to the brain and other organs. Infants suffering from "blue baby syndrome" need immediate medical care. Adults are normally not affected by nitrate at this level. Nitrate contamination may come from erosion of natural deposits, from dead and decaying plant material, runoff from fertilizer use, leaching from septic tanks or sewage systems and from runoff of animal wastes from feedlots, corrals and barns. EPA has set a limit for nitrate in public drinking water systems at 10 mg/L.

Fluoride – Fluoride is found in combined form in numerous rock types in nature. Fluoride enters drinking water through erosion of natural deposits, as a water additive which promotes strong teeth, and through discharge from fertilizer and aluminum factories. A fluoride concentration between 0.7 to 1.5 mg/L is effective in the prevention of dental caries. Fluoride concentrations greater than 2.0 mg/L can produce fluorosis (mottling of the teeth) in children under the age of nine. Drinking levels of fluoride in excess of the EPA's drinking water limit may lead to fluorosis and bone damage, including pain and tenderness of the bones. EPA has set a drinking water limit for fluoride at 4 mg/L.

pH - The pH of a sample is an indication of how acidic or basic the water is. On a scale of 1 to 14, with 1 being highly acidic and 14 being highly basic, lemon juice may have a pH of around 2, while household bleach may have a pH of 12.5. A pH of 7 units is considered neutral. Highly acidic water can promote the leaching of metals from plumbing pipes. Generally, the US EPA recommends drinking water have a pH between 6.5 to 8.5 units.

Chloride - Chloride salts in excess of 100 mg/L may give a salty taste to water. Chloride may increase the corrosive activity of water when combined with calcium and magnesium. EPA recommends that the chloride content of drinking water should not exceed 250 mg/L.

Sulfate - Sulfate is a substance that occurs naturally in drinking water. Sulfate in water containing calcium forms hard scale in steam boilers. High concentrations of sulfate in combination with other constituents give a bitter taste to water. Concentrations above 250 mg/L can have a laxative effect for those not used to drinking the water, but 500 mg/L is considered safe for human consumption. Domestic water in Montana containing as much as 1,000 mg/L sulfate is used for drinking in the absence of a less mineralized water supply. EPA recommends sulfate in drinking water be below 250 mg/L, based on aesthetic effects (i.e., taste and odor).

Hardness - In most water nearly all of the hardness is due to calcium and magnesium. Calcium and magnesium, which are naturally occurring in rock and soil, react with soap to form precipitates which increase soap consumption, and react with certain constituents to form scale. As a general rule, a value of below 60 mg/L is considered soft; from 60 to 120 mg/L is considered moderately hard; from 120 to 180 mg/L is considered hard; and values above 180 mg/L are considered very hard.

Sodium – Sodium is a naturally occurring element usually found in the environment that combines with other compounds (such as chloride or bicarbonate) to form salts. Sodium is an essential nutrient in human physiology, and is normally supplied by food. Sodium content may be of interest to persons on sodium restricted diets. Sodium restricted diets are essential in treating congestive cardiac failure, hypertension, renal disease, cirrhosis of the liver, toxemias of pregnancy, and Meniere's disease. If you feel this may be applicable to you or members of your household, it is recommended that your physicians be informed of the sodium content. EPA has set no drinking water limit for sodium.

Iron - More than about 0.3 mg/L of iron can stain laundry and utensils reddish brown. Larger quantities cause unpleasant taste and odor, and may encourage growth of iron bacteria, which may produce a musty or "rotten egg" sulfur odor. Excessive iron may also interfere with the efficient operation of exchange-silicate water softeners. EPA recommends iron levels in drinking water be below 0.3 mg/L, for aesthetic purposes.

Arsenic – Arsenic occurs naturally in rock and soil. Arsenic in water is frequently found near mining areas and hot springs. Normal weathering or exposure to acid mine drainage can cause arsenic to be deposited in water. Arsenic is also used in manufacturing, refineries, wood preservatives, animal feed additives and herbicides. Some people who drink water containing arsenic in excess of the recommended limit over many years could experience skin damage or problems with their circulatory system, and may have an increased risk of getting cancer. The EPA has set a limit of 0.050 mg/L in public drinking water supplies, but is reviewing the drinking water standard for arsenic because of special concerns that it may not be stringent enough.

Lead – Lead is a naturally occurring element that is found is small amounts in the earth's crust. Most contamination from lead is caused by human activities. Lead can be released into the environment through discharges from factories or smelters, or leaching by acid mine drainage. Drinking water may leach lead from soldered joints or old lead pipes. Infants and young children are typically more vulnerable to lead in drinking water than the general population. Lead in drinking water is rarely the sole cause of lead poisoning, but it can add to a person's total lead exposure. Infants and children who drink water containing lead in excess of the Action Level* could experience delays in their physical or mental development. Children could show slight deficits in attention span and learning abilities. Adults who drink this water over many years could develop kidney problems or high blood pressure. It is always a good idea to let a faucet run for a minute or two before drawing water for drinking or cooking. The EPA has set an action level* of 0.015 mg/L lead in public drinking water supplies.

Copper - Copper is a metal found in natural ore deposits. It is an essential nutrient, required by the body in very small amounts. It is widely used in household plumbing materials. Corrosion of household plumbing systems, erosion of natural deposits, and leaching from wood preservatives are ways copper may enter drinking water. The EPA has found that copper may cause stomach and intestinal distress in sensitive individuals when they are exposed to levels above the Action Level* (1.3 mg/L) for relatively short periods of time. Some who drink water containing copper in excess of the action level over many years could suffer liver or kidney damage. People with Wilson's Disease should consult their personal doctor. It is always a good idea to let a faucet run for a minute or two before drawing water for drinking or cooking. EPA's action level* for copper in drinking water is 1.3 mg/L.

Manganese - Manganese is a naturally occurring substance found in rocks, soil, and food. It is an essential nutrient usually supplied by foods. Manganese is often found in drinking water, where it may be considered an undesirable impurity in high levels due to its tendency to form black oxide stains. The EPA has not set a specific drinking water limit, but the recommended limit is 0.05 mg/L to prevent staining of clothes or plumbing fixtures.

Synthetic Organic Compounds (SOCs) - SOCs encompass a wide range of organic compounds, including pesticides and herbicides used for crops and lawns, wood preservatives, PCBs from electrical transformers, and

byproducts from PVC and other plastics. SOCs may be released during manufacturing processes, runoff from fields where herbicides or pesticides have been used, and disposal of industrial wastes. Some SOCs affect the central nervous system, while others affect organs such as the liver and kidneys. Certain of these compounds are suspected carcinogens. The EPA has set maximum contaminant limits in drinking water at different levels for each compound. EPA has banned the use of some of these compounds, but because they tend to stay in the environment, testing is required or recommended.

Volatile Organic Compounds (VOCs) - VOCs are petroleum byproducts, including fuels such as gasoline and diesel, fuel additives, solvents, cleaning compounds such as dry cleaning solution, degreasers, refrigerants and adhesives. Some are suspected carcinogens, others affect the central nervous system, while others attack specific organs in the body. The EPA has set drinking water maximum contaminant limits at different levels for each compound.

*Action Level - the concentration of a contaminant which, if exceeded, triggers treatment or other requirements which a Public Drinking Water Supply system must follow. Private wells are not affected by this regulation.

TESTING LABORATORIES

Montana is fortunate to have a number of certified laboratories available to test drinking water. Laboratories which test Public Drinking Water Supplies are certified by the Montana Department of Public Health and Human Services (DPHHS) Environmental Laboratory, and must meet rigorous federal and state standards in order to retain their certification. Some of these laboratories offer testing packages which contain a number of the above listed tests. Most laboratories will provide explanations of test results upon request. Private well owners are encouraged to contact one of these certified laboratories to find out more information about testing and prices. Contact the DPHHS Environmental Laboratory at (406) 444-2642 for a list of certified laboratories in the state, or for more information about testing for private wells. For more information about water quality in your area, contact your county sanitarian or county extension agent.

FOR MORE INFORMATION

For more information about water quality in your area, contact your county sanitarian or county extension agent. The Environmental Protection Agency maintains a toll-free telephone line to call for more information about drinking water and water quality. The number for the Safe Drinking Water Hotline is 800-426-4791.

ATSDR
AGENCY FOR TOXIC SUBSTANCES
AND DISEASE REGISTRY

ANTIMONY
CAS # 7440-36-0

Agency for Toxic Substances and Disease Registry ToxFAQs September 1995

This fact sheet answers the most frequently asked health questions (FAQs) about antimony. For more information, call the ATSDR Information Center at 1-888-422-8737. This fact sheet is one in a series of summaries about hazardous substances and their health effects. This information is important because this substance may harm you. The effects of exposure to any hazardous substance depend on the dose, the duration, how you are exposed, personal traits and habits, and whether other chemicals are present.

SUMMARY: Exposure to antimony occurs in the workplace or from skin contact with soil at hazardous waste sites. Breathing high levels of antimony for a long time can irritate the eyes and lungs, and can cause problems with the lungs, heart, and stomach. This chemical has been found in at least 403 of 1,416 National Priorities List sites identified by the Environmental Protection Agency.

What is antimony?

(Pronounced ăn′tə-mō′nē)

Antimony is a silvery-white metal that is found in the earth's crust. Antimony ores are mined and then mixed with other metals to form antimony alloys or combined with oxygen to form antimony oxide.

Little antimony is currently mined in the United States. It is brought into this country from other countries for processing. However, there are companies in the United States that produce antimony as a by-product of smelting lead and other metals.

Antimony isn't used alone because it breaks easily, but when mixed into alloys, it is used in lead storage batteries, solder, sheet and pipe metal, bearings, castings, and pewter. Antimony oxide is added to textiles and plastics to prevent them from catching fire. It is also used in paints, ceramics, and fireworks, and as enamels for plastics, metal, and glass.

What happens to antimony when it enters the environment?

- Antimony is released to the environment from natural sources and from industry.
- In the air, antimony is attached to very small particles that may stay in the air for many days.
- Most antimony ends up in soil, where it attaches strongly to particles that contain iron, manganese, or aluminum.
- Antimony is found at low levels in some rivers, lakes, and streams.

How might I be exposed to antimony?

- Because antimony is found naturally in the environment, the general population is exposed to low levels of it every day, primarily in food, drinking water, and air.
- It may be found in air near industries that process or release it, such as smelters, coal-fired plants, and refuse incinerators.
- In polluted areas containing high levels of antimony, it may be found in the air, water, and soil.
- Workers in industries that process it or use antimony ore may be exposed to higher levels.

How can antimony affect my health?

Exposure to antimony at high levels can result in a variety of adverse health effects.

Breathing high levels for a long time can irritate your eyes and lungs and can cause heart and lung problems, stomach pain, diarrhea, vomiting, and stomach ulcers.

In short-term studies, animals that breathed very high levels of antimony died. Animals that breathed high levels

had lung, heart, liver, and kidney damage. In long-term studies, animals that breathed very low levels of antimony had eye irritation, hair loss, lung damage, and heart problems. Problems with fertility were also noted. In animal studies, problems with fertility have been seen when rats breathed very high levels of antimony for a few months.

Ingesting large doses of antimony can cause vomiting. We don't know what other effects may be caused by ingesting it. Long-term animal studies have reported liver damage and blood changes when animals ingested antimony. Antimony can irritate the skin if it is left on it.

Antimony can have beneficial effects when used for medical reasons. It has been used as a medicine to treat people infected with parasites.

How likely is antimony to cause cancer?

The Department of Health and Human Services, the International Agency for Research on Cancer, and the Environmental Protection Agency (EPA) have not classified antimony as to its human carcinogenicity.

Lung cancer has been observed in some studies of rats that breathed high levels of antimony. No human studies are available. We don't know whether antimony will cause cancer in people.

Is there a medical test to show whether I've been exposed to antimony?

Tests are available to measure antimony levels in the body. Antimony can be measured in the urine, feces, and blood for several days after exposure. However, these tests cannot tell you how much antimony you have been exposed to or whether you will experience any health effects. Some tests are not usually performed in most doctors' offices and may require special equipment to conduct them.

Has the federal government made recommendations to protect human health?

The EPA allows 0.006 parts of antimony per million parts of drinking water (0.006 ppm). The EPA requires that discharges or spills into the environment of 5,000 pounds or more of antimony be reported.

The Occupational Safety and Health Administration (OSHA) has set an occupational exposure limit of 0.5 milligrams of antimony per cubic meter of air (0.5 mg/m^3) for an 8-hour workday, 40-hour workweek.

The American Conference of Governmental Industrial Hygienists (ACGIH) and the National Institute for Occupational Safety and Health (NIOSH) currently recommend the same guidelines for the workplace as OSHA.

Glossary

Carcinogenicity: Ability to cause cancer.
CAS: Chemical Abstracts Service.
Ingestion: Taking food or drink into your body.
Long-term: Lasting one year or more.
Milligram (mg): One thousandth of a gram.
Parasite: An organism living in or on another organism.
ppm: Parts per million.
Short-term: Lasting 14 days or less.

References

Agency for Toxic Substances and Disease Registry (ATSDR). 1992. Toxicological profile for antimony. Atlanta, GA: U.S. Department of Health and Human Services, Public Health Service.

Where can I get more information? For more information, contact the Agency for Toxic Substances and Disease Registry, Division of Toxicology, 1600 Clifton Road NE, Mailstop F-32, Atlanta, GA 30333. Phone: 1-888-422-8737, FAX: 770-488-4178. ToxFAQs Internet address via WWW is http://www.atsdr.cdc.gov/toxfaq.html ATSDR can tell you where to find occupational and environmental health clinics. Their specialists can recognize, evaluate, and treat illnesses resulting from exposure to hazardous substances. You can also contact your community or state health or environmental quality department if you have any more questions or concerns.

ATSDR
AGENCY FOR TOXIC SUBSTANCES AND DISEASE REGISTRY

ARSENIC

CAS # 7440-38-2

Division of Toxicology and Environmental Medicine ToxFAQs™ August 2007

This fact sheet answers the most frequently asked health questions (FAQs) about arsenic. For more information, call the ATSDR Information Center at 1-800-232-4636. This fact sheet is one in a series of summaries about hazardous substances and their health effects. It is important you understand this information because this substance may harm you. The effects of exposure to any hazardous substance depend on the dose, the duration, how you are exposed, personal traits and habits, and whether other chemicals are present.

HIGHLIGHTS: Exposure to higher than average levels of arsenic occur mostly in the workplace, near hazardous waste sites, or in areas with high natural levels. At high levels, inorganic arsenic can cause death. Exposure to lower levels for a long time can cause a discoloration of the skin and the appearance of small corns or warts. Arsenic has been found in at least 1,149 of the 1,684 National Priority List sites identified by the Environmental Protection Agency (EPA).

What is arsenic?

Arsenic is a naturally occurring element widely distributed in the earth's crust. In the environment, arsenic is combined with oxygen, chlorine, and sulfur to form inorganic arsenic compounds. Arsenic in animals and plants combines with carbon and hydrogen to form organic arsenic compounds.

Inorganic arsenic compounds are mainly used to preserve wood. Copper chromated arsenate (CCA) is used to make "pressure-treated" lumber. CCA is no longer used in the U.S. for residential uses; it is still used in industrial applications. Organic arsenic compounds are used as pesticides, primarily on cotton fields and orchards.

What happens to arsenic when it enters the environment?

- Arsenic occurs naturally in soil and minerals and may enter the air, water, and land from wind-blown dust and may get into water from runoff and leaching.
- Arsenic cannot be destroyed in the environment. It can only change its form.
- Rain and snow remove arsenic dust particles from the air.
- Many common arsenic compounds can dissolve in water. Most of the arsenic in water will ultimately end up in soil or sediment.
- Fish and shellfish can accumulate arsenic; most of this arsenic is in an organic form called arsenobetaine that is much less harmful.

How might I be exposed to arsenic?

- Ingesting small amounts present in your food and water or breathing air containing arsenic.
- Breathing sawdust or burning smoke from wood treated with arsenic.
- Living in areas with unusually high natural levels of arsenic in rock.
- Working in a job that involves arsenic production or use, such as copper or lead smelting, wood treating, or pesticide application.

How can arsenic affect my health?

Breathing high levels of inorganic arsenic can give you a sore throat or irritated lungs.

Ingesting very high levels of arsenic can result in death. Exposure to lower levels can cause nausea and vomiting, decreased production of red and white blood cells, abnormal heart rhythm, damage to blood vessels, and a sensation of "pins and needles" in hands and feet.

Ingesting or breathing low levels of inorganic arsenic for a long time can cause a darkening of the skin and the appearance of small "corns" or "warts" on the palms, soles, and torso.

Skin contact with inorganic arsenic may cause redness and swelling.

Almost nothing is known regarding health effects of organic arsenic compounds in humans. Studies in animals show that some simple organic arsenic compounds are less toxic than inorganic forms. Ingestion of methyl and dimethyl compounds can cause diarrhea and damage to the kidneys

How likely is arsenic to cause cancer?

Several studies have shown that ingestion of inorganic arsenic can increase the risk of skin cancer and cancer in the liver, bladder, and lungs. Inhalation of inorganic arsenic can cause increased risk of lung cancer. The Department of Health and Human Services (DHHS) and the EPA have determined that inorganic arsenic is a known human carcinogen. The International Agency for Research on Cancer (IARC) has determined that inorganic arsenic is carcinogenic to humans.

How can arsenic affect children?

There is some evidence that long-term exposure to arsenic in children may result in lower IQ scores. There is also some evidence that exposure to arsenic in the womb and early childhood may increase mortality in young adults.

There is some evidence that inhaled or ingested arsenic can injure pregnant women or their unborn babies, although the studies are not definitive. Studies in animals show that large doses of arsenic that cause illness in pregnant females, can also cause low birth weight, fetal malformations, and even fetal death. Arsenic can cross the placenta and has been found in fetal tissues. Arsenic is found at low levels in breast milk.

How can families reduce the risks of exposure to arsenic?

❑ If you use arsenic-treated wood in home projects, you should wear dust masks, gloves, and protective clothing to decrease exposure to sawdust.

❑ If you live in an area with high levels of arsenic in water or soil, you should use cleaner sources of water and limit contact with soil.

❑ If you work in a job that may expose you to arsenic, be aware that you may carry arsenic home on your clothing, skin, hair, or tools. Be sure to shower and change clothes before going home.

Is there a medical test to determine whether I've been exposed to arsenic?

There are tests available to measure arsenic in your blood, urine, hair, and fingernails. The urine test is the most reliable test for arsenic exposure within the last few days. Tests on hair and fingernails can measure exposure to high levels of arsenic over the past 6-12 months. These tests can determine if you have been exposed to above-average levels of arsenic. They cannot predict whether the arsenic levels in your body will affect your health.

Has the federal government made recommendations to protect human health?

The EPA has set limits on the amount of arsenic that industrial sources can release to the environment and has restricted or cancelled many of the uses of arsenic in pesticides. EPA has set a limit of 0.01 parts per million (ppm) for arsenic in drinking water.

The Occupational Safety and Health Administration (OSHA) has set a permissible exposure limit (PEL) of 10 micrograms of arsenic per cubic meter of workplace air (10 $\mu g/m^3$) for 8 hour shifts and 40 hour work weeks.

References

Agency for Toxic Substances and Disease Registry (ATSDR). 2007. Toxicological Profile for Arsenic (Update). Atlanta, GA: U.S. Department of Public Health and Human Services, Public Health Service.

Where can I get more information? For more information, contact the Agency for Toxic Substances and Disease Registry, Division of Toxicology and Environmental Medicine, 1600 Clifton Road NE, Mailstop F-32, Atlanta, GA 30333. Phone: 1-800-232-4636, FAX: 770-488-4178. ToxFAQs Internet address via WWW is http://www.atsdr.cdc.gov/toxfaq.html. ATSDR can tell you where to find occupational and environmental health clinics. Their specialists can recognize, evaluate, and treat illnesses resulting from exposure to hazardous substances. You can also contact your community or state health or environmental quality department if you have any more questions or concerns.

ATSDR
AGENCY FOR TOXIC SUBSTANCES AND DISEASE REGISTRY

CADMIUM

CAS # 7440-43-9

Division of Toxicology and Environmental Medicine ToxFAQs™ September 2008

This fact sheet answers the most frequently asked health questions (FAQs) about cadmium. For more information, call the ATSDR Information Center at 1-800-232-4636. This fact sheet is one in a series of summaries about hazardous substances and their health effects. It is important you understand this information because this substance may harm you. The effects of exposure to any hazardous substance depend on the dose, the duration, how you are exposed, personal traits and habits, and whether other chemicals are present.

HIGHLIGHTS: Exposure to cadmium happens mostly in the workplace where cadmium products are made. The general population is exposed from breathing cigarette smoke or eating cadmium contaminated foods. Cadmium damages the kidneys, lungs, and bones. Cadmium has been found in at least 1,014 of the 1,669 National Priorities List sites identified by the Environmental Protection Agency (EPA).

What is cadmium?

Cadmium is a natural element in the earth's crust. It is usually found as a mineral combined with other elements such as oxygen (cadmium oxide), chlorine (cadmium chloride), or sulfur (cadmium sulfate, cadmium sulfide).

All soils and rocks, including coal and mineral fertilizers, contain some cadmium. Most cadmium used in the United States is extracted during the production of other metals like zinc, lead, and copper. Cadmium does not corrode easily and has many uses, including batteries, pigments, metal coatings, and plastics.

What happens to cadmium when it enters the environment?

- ❑ Cadmium enters soil, water, and air from mining, industry, and burning coal and household wastes.
- ❑ Cadmium does not break down in the environment, but can change forms.
- ❑ Cadmium particles in air can travel long distances before falling to the ground or water.
- ❑ Some forms of cadmium dissolve in water.
- ❑ Cadmium binds strongly to soil particles.
- ❑ Fish, plants, and animals take up cadmium from the environment.

How might I be exposed to cadmium?

- ❑ Eating foods containing cadmium; low levels are found in all foods (highest levels are found in shellfish, liver, and kidney meats).
- ❑ Smoking cigarettes or breathing cigarette smoke.
- ❑ Breathing contaminated workplace air.
- ❑ Drinking contaminated water.
- ❑ Living near industrial facilities which release cadmium into the air.

How can cadmium affect my health?

Breathing high levels of cadmium can severely damage the lungs. Eating food or drinking water with very high levels severely irritates the stomach, leading to vomiting and diarrhea.

Long-term exposure to lower levels of cadmium in air, food, or water leads to a buildup of cadmium in the kidneys and possible kidney disease. Other long-term effects are lung damage and fragile bones.

How likely is cadmium to cause cancer?

The Department of Health and Human Services (DHHS) has determined that cadmium and cadmium compounds are known human carcinogens.

How can cadmium affect children?

The health effects in children are expected to be similar to the effects seen in adults (kidney, lung, and bone damage depending on the route of exposure).

A few studies in animals indicate that younger animals absorb more cadmium than adults. Animal studies also indicate that the young are more susceptible than adults to a loss of bone and decreased bone strength from exposure to cadmium.

We don't know if cadmium causes birth defects in people. The babies of animals exposed to high levels of cadmium during pregnancy had changes in behavior and learning ability. There is also some information from animal studies that high enough exposures to cadmium before birth can reduce body weights and affect the skeleton in the developing young.

How can families reduce the risks of exposure to cadmium?

❑ In the home, store substances that contain cadmium safely, and keep nickel-cadmium batteries out of reach of young children.
❑ Cadmium is a component of tobacco smoke. Avoid smoking in enclosed spaces like inside the home or car in order to limit exposure to children and other family members.
❑ If you work with cadmium, use all safety precautions to avoid carrying cadmium-containing dust home from work on your clothing, skin, hair, or tools.
❑ A balanced diet can reduce the amount of cadmium taken into the body from food and drink.

Is there a medical test to determine whether I've been exposed to cadmium?

Cadmium can be measured in blood, urine, hair, or nails. Urinary cadmium has been shown to accurately reflect the amount of cadmium in the body.

The amount of cadmium in your blood shows your recent exposure to cadmium. The amount of cadmium in your urine shows both your recent and your past exposure.

Has the federal government made recommendations to protect human health?

The EPA has determined that exposure to cadmium in drinking water at concentrations of 0.04 ppm for up to 10 days is not expected to cause any adverse effects in a child.

The EPA has determined that lifetime exposure to 0.005 ppm cadmium is not expected to cause any adverse effects.

The FDA has determined that the cadmium concentration in bottled drinking water should not exceed 0.005 ppm.

The Occupational Health and Safety Administration (OSHA) has limited workers' exposure to an average of 5 $\mu g/m^3$ for an 8-hour workday, 40-hour workweek.

References

Agency for Toxic Substances and Disease Registry (ATSDR). 2008. Toxicological Profile for Cadmium (Draft for Public Comment). Atlanta, GA: U.S. Department of Public Health and Human Services, Public Health Service.

Where can I get more information? For more information, contact the Agency for Toxic Substances and Disease Registry, Division of Toxicology and Environmental Medicine, 1600 Clifton Road NE, Mailstop F-32, Atlanta, GA 30333. Phone: 1-800-232-4636, FAX: 770-488-4178. ToxFAQs Internet address via WWW is http://www.atsdr.cdc.gov/toxfaq.html. ATSDR can tell you where to find occupational and environmental health clinics. Their specialists can recognize, evaluate, and treat illnesses resulting from exposure to hazardous substances. You can also contact your community or state health or environmental quality department if you have any more questions or concerns.

ATSDR
AGENCY FOR TOXIC SUBSTANCES AND DISEASE REGISTRY

COPPER

CAS # 7440-50-8

Division of Toxicology ToxFAQs™ September 2004

This fact sheet answers the most frequently asked health questions (FAQs) about copper. For more information, call the ATSDR Information Center at 1-888-422-8737. This fact sheet is one in a series of summaries about hazardous substances and their health effects. It is important you understand this information because this substance may harm you. The effects of exposure to any hazardous substance depend on the dose, the duration, how you are exposed, personal traits and habits, and whether other chemicals are present.

HIGHLIGHTS: Copper is a metal that occurs naturally in the environment, and also in plants and animals. Low levels of copper are essential for maintaining good health. High levels can cause harmful effects such as irritation of the nose, mouth and eyes, vomiting, diarrhea, stomach cramps, nausea, and even death. Copper has been found in at least 906 of the 1,647 National Priority Sites identified by the Environmental Protection Agency (EPA).

What is copper?

Copper is a metal that occurs naturally throughout the environment, in rocks, soil, water, and air. Copper is an essential element in plants and animals (including humans), which means it is necessary for us to live. Therefore, plants and animals must absorb some copper from eating, drinking, and breathing.

Copper is used to make many different kinds of products like wire, plumbing pipes, and sheet metal. U.S. pennies made before 1982 are made of copper, while those made after 1982 are only coated with copper. Copper is also combined with other metals to make brass and bronze pipes and faucets.

Copper compounds are commonly used in agriculture to treat plant diseases like mildew, for water treatment and, as preservatives for wood, leather, and fabrics.

What happens to copper when it enters the environment?

❑ Copper is released into the environment by mining, farming, and manufacturing operations and through waste water releases into rivers and lakes. Copper is also released from natural sources, like volcanoes, windblown dusts, decaying vegetation, and forest fires.

❑ Copper released into the environment usually attaches to particles made of organic matter, clay, soil, or sand.

❑ Copper does not break down in the environment. Copper compounds can break down and release free copper into the air, water, and foods.

How might I be exposed to copper?

❑ You may be exposed to copper from breathing air, drinking water, eating foods, or having skin contact with copper, particulates attached to copper, or copper-containing compounds.

❑ Drinking water may have high levels of copper if your house has copper pipes and acidic water.

❑ Lakes and rivers that have been treated with copper compounds to control algae, or that receive cooling water from power plants, can have high levels of copper. Soils can also contain high levels of copper, especially if they are near copper smelting plants.

❑ You may be exposed to copper by ingesting copper-containing fungicides, or if you live near a copper mine or where copper is processed into bronze or brass.

❑ You may be exposed to copper if you work in copper mines or if you grind metals containing copper.

How can copper affect my health?

Everyone must absorb small amounts of copper every day because copper is essential for good health. High levels of copper can be harmful. Breathing high levels of copper can cause irritation of your nose and throat. Ingesting high levels of copper can cause nausea, vomiting, and diarrhea. Very-high doses of copper can cause damage to your liver and kidneys, and can even cause death.

How likely is copper to cause cancer?

We do not know whether copper can cause cancer in humans. The EPA has determined that copper is not classifiable as to human carcinogenicity.

How can copper affect children?

Exposure to high levels of copper will result in the same type of effects in children and adults. We do not know if these effects would occur at the same dose level in children and adults. Studies in animals suggest that the young children may have more severe effects than adults, but we don't know if this would also be true in humans. There is a very small percentage of infants and children who are unusually sensitive to copper.

We do not know if copper can cause birth defects or other developmental effects in humans. Studies in animals suggest that high levels of copper may cause a decrease in fetal growth.

How can families reduce the risk of exposure to copper?

The most likely place to be exposed to copper is through drinking water, especially if your water is corrosive and you have copper pipes in your house. The best way to lower the level of copper in your drinking water is to let the water run for at least 15 seconds first thing in the morning before drinking or using it. This reduces the levels of copper in tap water dramatically.

If you work with copper, wear the necessary protective clothing and equipment, and always follow safety procedures. Shower and change your clothes before going home each day.

Is there a medical test to show whether I've been exposed to copper?

Copper is found throughout the body; in hair, nails, blood, urine, and other tissues. High levels of copper in these samples can show that you have been exposed to higher-than normal levels of copper. These tests cannot tell whether you will experience harmful effects. Tests to measure copper levels in the body are not usually available at a doctor's office because they require special equipment, but the doctor can send samples to a specialty laboratory.

Has the federal government made recommendations to protect human health?

The EPA requires that levels of copper in drinking water be less than 1.3 mg of copper per one liter of drinking water (1.3 mg/L).

The U.S. Department of Agriculture has set the recommended daily allowance for copper at 900 micrograms of copper per day (μg/day) for people older than eight years old.

The Occupational Safety and Health Administration (OSHA) requires that levels of copper in the air in workplaces not exceed 0.1 mg of copper fumes per cubic meter of air (0.1 mg/m^3) and 1.0 mg/m^3 for copper dusts.

Reference

Agency for Toxic Substances and Disease Registry (ATSDR). 2004. Toxicological Profile for Copper. Atlanta, GA: U.S. Department of Health and Human Services, Public Health Service.

Where can I get more information? For more information, contact the Agency for Toxic Substances and Disease Registry, Division of Toxicology, 1600 Clifton Road NE, Mailstop F-32, Atlanta, GA 30333. Phone: 1-888-422-8737, FAX: 770-488-4178. ToxFAQs Internet address via WWW is http://www.atsdr.cdc.gov/toxfaq.html. ATSDR can tell you where to find occupational and environmental health clinics. Their specialists can recognize, evaluate, and treat illnesses resulting from exposure to hazardous substances. You can also contact your community or state health or environmental quality department if you have any more questions or concerns.

ATSDR
AGENCY FOR TOXIC SUBSTANCES AND DISEASE REGISTRY

LEAD

CAS # 7439-92-1

Division of Toxicology and Environmental Medicine ToxFAQs™ August 2007

This fact sheet answers the most frequently asked health questions (FAQs) about lead. For more information, call the ATSDR Information Center at 1-800-232-4636. This fact sheet is one in a series of summaries about hazardous substances and their health effects. It is important you understand this information because this substance may harm you. The effects of exposure to any hazardous substance depend on the dose, the duration, how you are exposed, personal traits and habits, and whether other chemicals are present.

HIGHLIGHTS: Exposure to lead can happen from breathing workplace air or dust, eating contaminated foods, or drinking contaminated water. Children can be exposed from eating lead-based paint chips or playing in contaminated soil. Lead can damage the nervous system, kidneys, and reproductive system. Lead has been found in at least 1,272 of the 1,684 National Priority List sites identified by the Environmental Protection Agency (EPA).

What is lead?

Lead is a naturally occurring bluish-gray metal found in small amounts in the earth's crust. Lead can be found in all parts of our environment. Much of it comes from human activities including burning fossil fuels, mining, and manufacturing.

Lead has many different uses. It is used in the production of batteries, ammunition, metal products (solder and pipes), and devices to shield X-rays. Because of health concerns, lead from paints and ceramic products, caulking, and pipe solder has been dramatically reduced in recent years. The use of lead as an additive to gasoline was banned in 1996 in the United States.

What happens to lead when it enters the environment?

- Lead itself does not break down, but lead compounds are changed by sunlight, air, and water.
- When lead is released to the air, it may travel long distances before settling to the ground.
- Once lead falls onto soil, it usually sticks to soil particles.
- Movement of lead from soil into groundwater will depend on the type of lead compound and the characteristics of the soil.

How might I be exposed to lead?

- Eating food or drinking water that contains lead. Water pipes in some older homes may contain lead solder. Lead can leach out into the water.
- Spending time in areas where lead-based paints have been used and are deteriorating. Deteriorating lead paint can contribute to lead dust.
- Working in a job where lead is used or engaging in certain hobbies in which lead is used, such as making stained glass.
- Using health-care products or folk remedies that contain lead.

How can lead affect my health?

The effects of lead are the same whether it enters the body through breathing or swallowing. Lead can affect almost every organ and system in your body. The main target for lead toxicity is the nervous system, both in adults and children. Long-term exposure of adults can result in decreased performance in some tests that measure functions of the nervous system. It may also cause weakness in fingers, wrists, or ankles. Lead exposure also causes small increases in blood pressure, particularly in middle-aged and older people and can cause anemia. Exposure to high lead levels can severely damage the brain and kidneys in adults or children and ultimately cause death. In pregnant women, high levels of exposure to lead may cause miscarriage. High-level exposure in men can damage the organs responsible for sperm production.

How likely is lead to cause cancer?

We have no conclusive proof that lead causes cancer in humans. Kidney tumors have developed in rats and mice that had been given large doses of some kind of lead compounds. The Department of Health and Human Services

(DHHS) has determined that lead and lead compounds are reasonably anticipated to be human carcinogens and the EPA has determined that lead is a probable human carcinogen. The International Agency for Research on Cancer (IARC) has determined that inorganic lead is probably carcinogenic to humans and that there is insufficient information to determine whether organic lead compounds will cause cancer in humans.

How can lead affect children?

Small children can be exposed by eating lead-based paint chips, chewing on objects painted with lead-based paint, or swallowing house dust or soil that contains lead.

Children are more vulnerable to lead poisoning than adults. A child who swallows large amounts of lead may develop blood anemia, severe stomachache, muscle weakness, and brain damage. If a child swallows smaller amounts of lead, much less severe effects on blood and brain function may occur. Even at much lower levels of exposure, lead can affect a child's mental and physical growth.

Exposure to lead is more dangerous for young and unborn children. Unborn children can be exposed to lead through their mothers. Harmful effects include premature births, smaller babies, decreased mental ability in the infant, learning difficulties, and reduced growth in young children. These effects are more common if the mother or baby was exposed to high levels of lead. Some of these effects may persist beyond childhood.

How can families reduce the risks of exposure to lead?

- ❑ Avoid exposure to sources of lead.
- ❑ Do not allow children to chew or mouth surfaces that may have been painted with lead-based paint.
- ❑ If you have a water lead problem, run or flush water that has been standing overnight before drinking or cooking with it.
- ❑ Some types of paints and pigments that are used as make-up or hair coloring contain lead. Keep these kinds of products away from children
- ❑ If your home contains lead-based paint or you live in an area contaminated with lead, wash children's hands and faces often to remove lead dusts and soil, and regularly clean the house of dust and tracked in soil.

Is there a medical test to determine whether I've been exposed to lead?

A blood test is available to measure the amount of lead in your blood and to estimate the amount of your recent exposure to lead. Blood tests are commonly used to screen children for lead poisoning. Lead in teeth or bones can be measured by X-ray techniques, but these methods are not widely available. Exposure to lead also can be evaluated by measuring erythrocyte protoporphyrin (EP) in blood samples. EP is a part of red blood cells known to increase when the amount of lead in the blood is high. However, the EP level is not sensitive enough to identify children with elevated blood lead levels below about 25 micrograms per deciliter (μg/dL). These tests usually require special analytical equipment that is not available in a doctor's office. However, your doctor can draw blood samples and send them to appropriate laboratories for analysis.

Has the federal government made recommendations to protect human health?

The Centers for Disease Control and Prevention (CDC) recommends that states test children at ages 1 and 2 years. Children should be tested at ages 3–6 years if they have never been tested for lead, if they receive services from public assistance programs for the poor such as Medicaid or the Supplemental Food Program for Women, Infants, and Children, if they live in a building or frequently visit a house built before 1950; if they visit a home (house or apartment) built before 1978 that has been recently remodeled; and/or if they have a brother, sister, or playmate who has had lead poisoning. CDC considers a blood lead level of 10 μg/dL to be a level of concern for children.

EPA limits lead in drinking water to 15 μg per liter.

References

Agency for Toxic Substances and Disease Registry (ATSDR). 2007. Toxicological Profile for lead (Update). Atlanta, GA: U.S. Department of Public Health and Human Services, Public Health Service.

Where can I get more information? For more information, contact the Agency for Toxic Substances and Disease Registry, Division of Toxicology and Environmental Medicine, 1600 Clifton Road NE, Mailstop F-32, Atlanta, GA 30333. Phone: 1-800-232-4636, FAX: 770-488-4178. ToxFAQs Internet address via WWW is http://www.atsdr.cdc.gov/toxfaq.html. ATSDR can tell you where to find occupational and environmental health clinics. Their specialists can recognize, evaluate, and treat illnesses resulting from exposure to hazardous substances. You can also contact your community or state health or environmental quality department if you have any more questions or concerns.

ATSDR
AGENCY FOR TOXIC SUBSTANCES AND DISEASE REGISTRY

MANGANESE

CAS # 7439-96-5

Division of Toxicology and Environmental Medicine ToxFAQs™ September 2008

This fact sheet answers the most frequently asked health questions (FAQs) about manganese. For more information, call the ATSDR Information Center at 1-800-232-4636. This fact sheet is one in a series of summaries about hazardous substances and their health effects. It is important you understand this information because this substance may harm you. The effects of exposure to any hazardous substance depend on the dose, the duration, how you are exposed, personal traits and habits, and whether other chemicals are present.

HIGHLIGHTS: Manganese is a trace element and eating a small amount from food or water is needed to stay healthy. Exposure to excess levels of manganese may occur from breathing air, particularly where manganese is used in manufacturing, and from drinking water and eating food. At high levels, it can cause damage to the brain. Manganese has been found in at least 869 of the 1,669 National Priorities List sites identified by the Environmental Protection Agency (EPA).

What is manganese?

Manganese is a naturally occurring metal that is found in many types of rocks. Pure manganese is silver-colored, but does not occur naturally. It combines with other substances such as oxygen, sulfur, or chlorine. Manganese occurs naturally in most foods and may be added to some foods.

Manganese is used principally in steel production to improve hardness, stiffness, and strength. It may also be used as an additive in gasoline to improve the octane rating of the gas.

What happens to manganese when it enters the environment?

❑ Manganese can be released to the air, soil, and water from the manufacture, use, and disposal of manganese-based products.

❑ Manganese cannot break down in the environment. It can only change its form or become attached to or separated from particles.

❑ In water, manganese tends to attach to particles in the water or settle into the sediment.

❑ The chemical state of manganese and the type of soil determine how fast it moves through the soil and how much is retained in the soil.

❑ The manganese-containing gasoline additive may degrade in the environment quickly when exposed to sunlight, releasing manganese.

How might I be exposed to manganese?

❑ The primary way you can be exposed to manganese is by eating food or manganese-containing nutritional supplements. Vegetarians who consume foods rich in manganese such as grains, beans and nuts, as well as heavy tea drinkers, may have a higher intake of manganese than the average person.

❑ Certain occupations like welding or working in a factory where steel is made may increase your chances of being exposed to high levels of manganese.

❑ Manganese is routinely contained in groundwater, drinking water, and soil at low levels. Drinking water containing manganese or swimming or bathing in water containing manganese may expose you to low levels of this chemical.

How can manganese affect my health?

Manganese is an essential nutrient, and eating a small amount of it each day is important to stay healthy.

The most common health problems in workers exposed to high levels of manganese involve the nervous system. These health effects include behavioral changes and other nervous system effects, which include movements that may become slow and clumsy. This combination of symptoms when sufficiently severe is referred to as "manganism". Other less severe nervous system effects such as slowed hand movements have been observed in

some workers exposed to lower concentrations in the work place.

Nervous system and reproductive effects have been observed in animals after high oral doses of manganese.

How likely is manganese to cause cancer?

The EPA concluded that existing scientific information cannot determine whether or not excess manganese can cause cancer.

How can manganese affect children?

Studies in children have suggested that extremely high levels of manganese exposure may produce undesirable effects on brain development, including changes in behavior and decreases in the ability to learn and remember. We do not know for certain that these changes were caused by manganese alone. We do not know if these changes are temporary or permanent. We do not know whether children are more sensitive than adults to the effects of manganese, but there is some indication from experiments in laboratory animals that they may be.

Studies of manganese workers have not found increases in birth defects or low birth weight in their offspring. No birth defects were observed in animals exposed to manganese.

How can families reduce the risks of exposure to manganese?

❑ Children are not likely to be exposed to harmful amounts of manganese in the diet. However, higher-than-usual amounts of manganese may be absorbed if their diet is low in iron. It is important to provide your child with a well-balanced diet.

❑ Workers exposed to high levels of airborne manganese in certain occupational settings may accumulate manganese dust on their work clothes. Manganese-contaminated work clothing should be removed before getting into your car or entering your home to help reduce the exposure hazard for yourself and your family.

Is there a medical test to determine whether I've been exposed to manganese?

Several tests are available to measure manganese in blood, urine, hair, or feces. Because manganese is normally present in our body, some is always found in tissues or fluids.

Because excess manganese is usually removed from the body within a few days, past exposures are difficult to measure with common laboratory tests.

Has the federal government made recommendations to protect human health?

The EPA has determined that exposure to manganese in drinking water at concentrations of 1 mg/L for up to 10 days is not expected to cause any adverse effects in a child.

The EPA has established that lifetime exposure to 0.3 mg/L manganese is not expected to cause any adverse effects.

The FDA has determined that the manganese concentration in bottled drinking water should not exceed 0.05 mg/L.

The Occupational Health and Safety Administration (OSHA) has established a ceiling limit (concentration that should not be exceeded at any time during exposure) of 5 mg/m^3 for manganese in workplace air.

References

Agency for Toxic Substances and Disease Registry (ATSDR). 2008. Toxicological Profile for Manganese (Draft for Public Comment). Atlanta, GA: U.S. Department of Public Health and Human Services, Public Health Service.

Where can I get more information? For more information, contact the Agency for Toxic Substances and Disease Registry, Division of Toxicology and Environmental Medicine, 1600 Clifton Road NE, Mailstop F-32, Atlanta, GA 30333. Phone: 1-800-232-4636, FAX: 770-488-4178. ToxFAQs Internet address via WWW is http://www.atsdr.cdc.gov/toxfaq.html. ATSDR can tell you where to find occupational and environmental health clinics. Their specialists can recognize, evaluate, and treat illnesses resulting from exposure to hazardous substances. You can also contact your community or state health or environmental quality department if you have any more questions or concerns.

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MERCURY
CAS # 7439-97-6

Agency for Toxic Substances and Disease Registry ToxFAQs April 1999

This fact sheet answers the most frequently asked health questions (FAQs) about mercury. For more information, call the ATSDR Information Center at 1-888-422-8737. This fact sheet is one in a series of summaries about hazardous substances and their health effects. It's important you understand this information because this substance may harm you. The effects of exposure to any hazardous substance depend on the dose, the duration, how you are exposed, personal traits and habits, and whether other chemicals are present.

HIGHLIGHTS: Exposure to mercury occurs from breathing contaminated air, ingesting contaminated water and food, and having dental and medical treatments. Mercury, at high levels, may damage the brain, kidneys, and developing fetus. This chemical has been found in at least 714 of 1,467 National Priorities List sites identified by the Environmental Protection Agency.

What is mercury?

(Pronounced mŭr′kyə-rē)

Mercury is a naturally occurring metal which has several forms. The metallic mercury is a shiny, silver-white, odorless liquid. If heated, it is a colorless, odorless gas.

Mercury combines with other elements, such as chlorine, sulfur, or oxygen, to form inorganic mercury compounds or "salts," which are usually white powders or crystals. Mercury also combines with carbon to make organic mercury compounds. The most common one, methylmercury, is produced mainly by microscopic organisms in the water and soil. More mercury in the environment can increase the amounts of methylmercury that these small organisms make.

Metallic mercury is used to produce chlorine gas and caustic soda, and is also used in thermometers, dental fillings, and batteries. Mercury salts are sometimes used in skin lightening creams and as antiseptic creams and ointments.

What happens to mercury when it enters the environment?

- ❑ Inorganic mercury (metallic mercury and inorganic mercury compounds) enters the air from mining ore deposits, burning coal and waste, and from manufacturing plants.
- ❑ It enters the water or soil from natural deposits, disposal of wastes, and volcanic activity.
- ❑ Methylmercury may be formed in water and soil by small organisms called bacteria.
- ❑ Methylmercury builds up in the tissues of fish. Larger and older fish tend to have the highest levels of mercury.

How might I be exposed to mercury?

- ❑ Eating fish or shellfish contaminated with methylmercury.
- ❑ Breathing vapors in air from spills, incinerators, and industries that burn mercury-containing fuels.
- ❑ Release of mercury from dental work and medical treatments.
- ❑ Breathing contaminated workplace air or skin contact during use in the workplace (dental, health services, chemical, and other industries that use mercury).
- ❑ Practicing rituals that include mercury.

How can mercury affect my health?

The nervous system is very sensitive to all forms of mercury. Methylmercury and metallic mercury vapors are more harmful than other forms, because more mercury in these forms reaches the brain. Exposure to high levels of metallic, inorganic, or organic mercury can permanently damage the brain, kidneys, and developing fetus. Effects on brain functioning may result in irritability, shyness, tremors, changes in vision or hearing, and memory problems.

Short-term exposure to high levels of metallic mercury vapors may cause effects including lung damage, nausea,

vomiting, diarrhea, increases in blood pressure or heart rate, skin rashes, and eye irritation.

How likely is mercury to cause cancer?

There are inadequate human cancer data available for all forms of mercury. Mercuric chloride has caused increases in several types of tumors in rats and mice, and methylmercury has caused kidney tumors in male mice. The EPA has determined that mercuric chloride and methylmercury are possible human carcinogens.

How can mercury affect children?

Very young children are more sensitive to mercury than adults. Mercury in the mother's body passes to the fetus and may accumulate there. It can also can pass to a nursing infant through breast milk. However, the benefits of breast feeding may be greater than the possible adverse effects of mercury in breast milk.

Mercury's harmful effects that may be passed from the mother to the fetus include brain damage, mental retardation, incoordination, blindness, seizures, and inability to speak. Children poisoned by mercury may develop problems of their nervous and digestive systems, and kidney damage.

How can families reduce the risk of exposure to mercury?

Carefully handle and dispose of products that contain mercury, such as thermometers or fluorescent light bulbs. Do not vacuum up spilled mercury, because it will vaporize and increase exposure. If a large amount of mercury has been spilled, contact your health department. Teach children not to play with shiny, silver liquids.

Properly dispose of older medicines that contain mercury. Keep all mercury-containing medicines away from children.

Pregnant women and children should keep away from rooms where liquid mercury has been used.

Learn about wildlife and fish advisories in your area from your public health or natural resources department.

Is there a medical test to show whether I've been exposed to mercury?

Tests are available to measure mercury levels in the body. Blood or urine samples are used to test for exposure to metallic mercury and to inorganic forms of mercury. Mercury in whole blood or in scalp hair is measured to determine exposure to methylmercury. Your doctor can take samples and send them to a testing laboratory.

Has the federal government made recommendations to protect human health?

The EPA has set a limit of 2 parts of mercury per billion parts of drinking water (2 ppb).

The Food and Drug Administration (FDA) has set a maximum permissible level of 1 part of methylmercury in a million parts of seafood (1 ppm).

The Occupational Safety and Health Administration (OSHA) has set limits of 0.1 milligram of organic mercury per cubic meter of workplace air (0.1 mg/m^3) and 0.05 mg/m^3 of metallic mercury vapor for 8-hour shifts and 40-hour work weeks.

References

Agency for Toxic Substances and Disease Registry (ATSDR). 1999. Toxicological profile for mercury. Atlanta, GA: U.S. Department of Health and Human Services, Public Health Service.

Where can I get more information? For more information, contact the Agency for Toxic Substances and Disease Registry, Division of Toxicology, 1600 Clifton Road NE, Mailstop F-32, Atlanta, GA 30333. Phone: 1-888-422-8737, FAX: 770-488-4178. ToxFAQs Internet address via WWW is http://www.atsdr.cdc.gov/toxfaq.html ATSDR can tell you where to find occupational and environmental health clinics. Their specialists can recognize, evaluate, and treat illnesses resulting from exposure to hazardous substances. You can also contact your community or state health or environmental quality department if you have any more questions or concerns.

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SILVER
CAS # 7440-22-4

Agency for Toxic Substances and Disease Registry ToxFAQs July 1999

This fact sheet answers the most frequently asked health questions (FAQs) about silver. For more information, call the ATSDR Information Center at 1-888-422-8737. This fact sheet is one in a series of summaries about hazardous substances and their health effects. It's important you understand this information because this substance may harm you. The effects of exposure to any hazardous substance depend on the dose, the duration, how you are exposed, personal traits and habits, and whether other chemicals are present.

HIGHLIGHTS: Silver is an element found naturally in the environment. At very high levels, it may cause argyria, a blue-gray discoloration of the skin and other organs. This chemical has been found in at least 27 of the 1,177 National Priorities List sites identified by the Environmental Protection Agency (EPA).

What is silver?

(Pronounced sĭl′vər)

Silver is a naturally occurring element. It is found in the environment combined with other elements such as sulfide, chloride, and nitrate. Pure silver is "silver" colored, but silver nitrate and silver chloride are powdery white and silver sulfide and silver oxide are dark-gray to black. Silver is often found as a by-product during the retrieval of copper, lead, zinc, and gold ores.

Silver is used to make jewelry, silverware, electronic equipment, and dental fillings. It is also used to make photographs, in brazing alloys and solders, to disinfect drinking water and water in swimming pools, and as an antibacterial agent. Silver has also been used in lozenges and chewing gum to help people stop smoking.

What happens to silver when is enters the environment?

- ❑ Silver may be released into the air and water through natural processes such as the weathering of rocks.
- ❑ Human activities such as the processing of ores, cement manufacture, and the burning of fossil fuel may release silver into the air.
- ❑ It may be released into water from photographic processing.
- ❑ Rain may wash silver out of soil into the groundwater.
- ❑ Silver does not appear to concentrate to a significant extent in aquatic animals.

How might I be exposed to silver?

- ❑ Breathing low levels in air.
- ❑ Swallowing it in food or drinking water.
- ❑ Carrying out activities such as jewelry-making, soldering, and photography.
- ❑ Using anti-smoking lozenges or other medicines containing it.

How can silver affect my health?

Exposure to high levels of silver for a long period of time may result in a condition called arygria, a blue-gray discoloration of the skin and other body tissues. Lower-level exposures to silver may also cause silver to be deposited in the skin and other parts of the body; however, this is not known to be harmful. Argyria is a permanent effect, but it appears to be a cosmetic problem that may not be otherwise harmful to health.

Exposure to high levels of silver in the air has resulted in breathing problems, lung and throat irritation, and stomach pains. Skin contact with silver can cause mild allergic reactions such as rash, swelling, and inflammation in some people.

Animal studies have shown that swallowing silver results in the deposit of silver in the skin. One study in mice found that the animals exposed to silver in drinking water were less active than unexposed animals.

No studies are available on whether silver affects reproduction or causes developmental problems in people.

How likely is silver to cause cancer?

No studies are available on whether silver may cause cancer in people. The only available animal studies showed both positive and negative results when silver was implanted under the skin.

The EPA has determined that silver is not classifiable as to human carcinogenicity.

Is there a medical test to show whether I've been exposed to silver?

Silver can be measured in the blood, urine, feces, and body tissues of exposed people. Silver builds up in the body, and the best way to learn if past exposure has occurred is to look for silver in samples of skin. Tests for silver are not commonly done at a doctor's office because they require special equipment. Although doctors can find out if a person has been exposed to silver by doing these tests, they cannot tell whether any health effects will occur.

Has the federal government made recommendations to protect human health?

The EPA recommends that the concentration of silver in drinking water not exceed 0.10 milligrams per liter of water (0.10 mg/L) because of the skin discoloration that may occur.

The EPA requires that spills or accidental releases of 1,000 pounds or more of silver be reported to the EPA.

The Occupational Safety and Health Administration (OSHA) limits silver in workplace air to 0.01 milligrams per cubic meter (0.01 mg/m^3) for an 8-hour workday, 40-hour workweek. The National Institute of Occupational Safety and Health (NIOSH) also recommends that workplace air contain no more that 0.01 mg/m^3 silver.

The American Conference of Governmental Industrial Hygienists (ACGIH) recommends that workplace air contain no more than 0.1 mg/m^3 silver metal and 0.01 mg/m^3 soluble silver compounds.

The federal recommendations have been updated as of July 1999.

Glossary

Carcinogenicity: Ability to cause cancer.

CAS: Chemcial Abstracts Service.

Milligram (mg): One thousandth of a gram.

National Priorities List: A list of the nation's worst hazardous waste sites.

Soluble: Capable of being dissolved in water.

References

Agency for Toxic Substances and Disease Registry (ATSDR). 1990. Toxicological profile for silver. Atlanta, GA: U.S. Department of Health and Human Services, Public Health Service.

Where can I get more information? For more information, contact the Agency for Toxic Substances and Disease Registry, Division of Toxicology, 1600 Clifton Road NE, Mailstop F-32, Atlanta, GA 30333. Phone:1-888-422-8737, FAX: 770-488-4178. ToxFAQs Internet address via WWW is http://www.atsdr.cdc.gov/toxfaq.html ATSDR can tell you where to find occupational and environmental health clinics. Their specialists can recognize, evaluate, and treat illnesses resulting from exposure to hazardous substances. You can also contact your community or state health or environmental quality department if you have any more questions or concerns.

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ZINC

CAS # 7440-66-6

Division of Toxicology ToxFAQs™ August 2005

This fact sheet answers the most frequently asked health questions (FAQs) about zinc. For more information, call the ATSDR Information Center at 1-888-422-8737. This fact sheet is one in a series of summaries about hazardous substances and their health effects. It is important you understand this information because this substance may harm you. The effects of exposure to any hazardous substance depend on the dose, the duration, how you are exposed, personal traits and habits, and whether other chemicals are present.

HIGHLIGHTS: Zinc is a naturally occurring element. Exposure to high levels of zinc occurs mostly from eating food, drinking water, or breathing workplace air that is contaminated. Low levels of zinc are essential for maintaining good health. Exposure to large amounts of zinc can be harmful. It can cause stomach cramps, anemia, and changes in cholesterol levels. Zinc has been found in at least 985 of the 1,662 National Priority List sites identified by the Environmental Protection Agency (EPA).

What is zinc?

Zinc is one of the most common elements in the earth's crust. It is found in air, soil, and water, and is present in all foods. Pure zinc is a bluish-white shiny metal.

Zinc has many commercial uses as coatings to prevent rust, in dry cell batteries, and mixed with other metals to make alloys like brass, and bronze. A zinc and copper alloy is used to make pennies in the United States.

Zinc combines with other elements to form zinc compounds. Common zinc compounds found at hazardous waste sites include zinc chloride, zinc oxide, zinc sulfate, and zinc sulfide. Zinc compounds are widely used in industry to make paint, rubber, dyes, wood preservatives, and ointments.

What happens to zinc when it enters the environment?

- Some is released into the environment by natural processes, but most comes from human activities like mining, steel production, coal burning, and burning of waste.
- It attaches to soil, sediments, and dust particles in the air.
- Rain and snow remove zinc dust particles from the air.
- Depending on the type of soil, some zinc compounds can move into the groundwater and into lakes, streams, and rivers.
- Most of the zinc in soil stays bound to soil particles and does not dissolve in water.
- It builds up in fish and other organisms, but it does not build up in plants.

How might I be exposed to zinc?

- Ingesting small amounts present in your food and water.
- Drinking contaminated water or a beverage that has been stored in metal containers or flows through pipes that have been coated with zinc to resist rust.
- Eating too many dietary supplements that contain zinc.
- Working on any of the following jobs: construction, painting, automobile mechanics, mining, smelting, and welding; manufacture of brass, bronze, or other zinc-containing alloys; manufacture of galvanized metals; and manufacture of machine parts, rubber, paint, linoleum, oilcloths, batteries, some kind of glass, ceramics, and dyes.

How can zinc affect my health?

Zinc is an essential element in our diet. Too little zinc can cause problems, but too much zinc is also harmful.

Harmful effects generally begin at levels 10-15 times higher than the amount needed for good health. Large doses taken by mouth even for a short time can cause stomach cramps, nausea, and vomiting. Taken longer, it can cause anemia and decrease the levels of your good cholesterol. We do not know if high levels of zinc affect reproduction in humans. Rats that were fed large amounts of zinc became infertile.

Inhaling large amounts of zinc (as dusts or fumes) can cause a specific short-term disease called metal fume fever. We do not know the long-term effects of breathing high levels of zinc.

Putting low levels of zinc acetate and zinc chloride on the skin of rabbits, guinea pigs, and mice caused skin irritation. Skin irritation will probably occur in people.

How likely is zinc to cause cancer?

The Department of Health and Human Services (DHHS) and the International Agency for Research on Cancer (IARC) have not classified zinc for carcinogenicity. Based on incomplete information from human and animal studies, the EPA has determined that zinc is not classifiable as to its human carcinogenicity.

How can zinc affect children?

Zinc is essential for proper growth and development of young children. It is likely that children exposed to very high levels of zinc will have similar effects as adults. We do not know whether children are more susceptible to the effects of excessive intake of zinc than the adults.

We do not know if excess zinc can cause developmental effects in humans. Animal studies have found decreased weight in the offspring of animals that ingested very high amounts of zinc.

How can families reduce the risks of exposure to zinc?

❑ Children living near waste sites that contain zinc may be exposed to higher levels of zinc through breathing contaminated air, drinking contaminated drinking water, touching or eating contaminated soil.

❑ Discourage your children from eating soil or putting their hands in their mouths and teach them to wash their hands frequently and before eating.

❑ If you use medicines or vitamin supplements containing zinc, make sure you use them appropriately and keep them out of the reach of children.

Is there a medical test to determine whether I've been exposed to zinc?

There are tests available to measure zinc in your blood, urine, hair, saliva, and feces. These tests are not usually done in the doctor's office because they require special equipment. High levels of zinc in the feces can mean high recent zinc exposure. High levels of zinc in the blood can mean high zinc consumption and/or high exposure. Tests to measure zinc in hair may provide information on long-term zinc exposure; however, the relationship between levels in your hair and the amount of zinc you were exposed to is not clear.

Has the federal government made recommendations to protect human health?

The EPA recommends that drinking water should contain no more than 5 milligrams per liter of water (5 mg/L) because of taste. The EPA requires that any release of 1,000 pounds (or in some cases 5,000 pounds) into the environment be reported to the agency.

To protect workers, the Occupational Safety and Health Administration (OSHA) has set an average limit of 1 mg/m^3 for zinc chloride fumes and 5 mg/m^3 for zinc oxide (dusts and fumes) in workplace air during an 8-hour workday, 40-hour workweek.

Similarly, the National Institute for Occupational Safety and Health (NIOSH) has set the same standards for up to a 10-hour workday over a 40-hour workweek.

References

Agency for Toxic Substances and Disease Registry (ATSDR). 2005. Toxicological Profile for Zinc (Update). Atlanta, GA: U.S. Department of Public Health and Human Services, Public Health Service.

Where can I get more information? For more information, contact the Agency for Toxic Substances and Disease Registry, Division of Toxicology, 1600 Clifton Road NE, Mailstop F-32, Atlanta, GA 30333. Phone: 1-888-422-8737, FAX: 770-488-4178. ToxFAQs Internet address via WWW is http://www.atsdr.cdc.gov/toxfaq.html. ATSDR can tell you where to find occupational and environmental health clinics. Their specialists can recognize, evaluate, and treat illnesses resulting from exposure to hazardous substances. You can also contact your community or state health or environmental quality department if you have any more questions or concerns.

Ecological Toxicity Information

U.S. Environmental Protection Agency (EPA)

Region 5 Superfund - Ecological Risk Assessment Information (2008)

http://www.epa.gov/R5Super/ecology/html/toxprofiles.htm

Toxicity Profiles:

Presented below is a brief discussion of the general fate and transport processes associated with selected Contaminants of Potential Ecological Concern (COPECs).

Aluminum

Toxicity information about aluminum is generally lacking. It has been determined that fish tend to be more sensitive to aluminum toxicity than aquatic invertebrates (Sparling et al. 1997). Aluminum can cause pulmonary and developmental problems. Aluminum toxicity has been linked to soil pH--the amount of soluble aluminum, rather than the total aluminum concentration in the soil. Soils at a site with a pH greater than 5.5 can generally be considered non-toxic in terms of aluminum.

Arsenic

In plants, arsenic has been shown to cause wilting, chlorosis, browning, dehydration, mortality, and inhibition of light activation (Eisler 1988a). Arsenic is a carcinogen (cancer-causing), teratogen, and possible mutagen (causing mutations in genes/DNA) in mammals (ATSDR 1993). Chronic exposure can result in fatigue, gastrointestinal distress, anemia, neuropathy, and skin lesions that can develop into skin cancer in mammals. It can cause death in soil microbiota and earthworms. Cancer-causing and genetic mutation-causing effects occur in aquatic organisms, with those effects including behavioral impairments, growth reduction, appetite loss, and metabolic failure. Aquatic bottom feeders are more susceptible to arsenic. In birds tolerance to arsenic varies among species, but effects include destruction of gut blood vessels, blood-cell damage, muscular incoordination, debility, slowness, jerkiness, falling, hyperactivity, fluffed feathers, drooped eyelids, immobility, seizures, and systemic, growth, behavioral, and reproductive problems (Stanley et al. 1994; Whitworth et al. 1991; Camardese et al. 1990).

Barium

Elevated levels of barium can induce a wide range of effects in mammals including gastrointestinal distress, muscular paralysis, and cardiovascular effects. Barium is does not bioaccumulate, and concentrations in higher species rarely exceed 10 mg/kg (Moore 1991).

Cadmium

Cadmium is highly toxic to wildlife; it is cancer-causing and teratogenic and potentially mutation-causing, with severe sublethal

and lethal effects at low environmental concentrations (Eisler 1985a). It is associated with increased mortality, and it effects respiratory functions, enzyme levels, muscle contractions, growth reduction, and reproduction. It bioaccumulates at all trophic levels, accumulating in the livers and kidneys of fish (Sindayigaya, et al. 1994; Sadiq 1992). Crustaceans appear to be more sensitive to cadmium than fish and mollusks (Sadiq 1992). Cadmium can be toxic to plants at lower soil concentrations than other heavy metals and is more readily taken up than other metals (EPA 1981). On the other hand, some insects can accumulate high levels of cadmium without adverse effects (Jamil and Hussain 1992).

Chromium

There is no significant biomagnification of chromium in aquatic food webs (ATSDR, 1993). However, there are a wide range of adverse effects in aquatic organisms. In benthic invertebrates there has been observed reduced fecundity and survival, growth inhibition, and abnormal movement patterns (U.S. EPA 1980b). Fish experienced reduced growth, chromosomal aberrations, reduced disease resistance, and morphological changes.

The toxic effects of chromium are primarily found at the lower trophic levels. The main potential ecological impacts result from direct exposure of algae, benthic invertebrates, and embryos and fingerlings of freshwater fish and amphibians to chromium. Chromium may bioaccumulate in algae, other aquatic vegetation, and invertebrates, but it does not biomagnify. Chromium inhibits growth in duckweed and algae, reduces fecundity and survival of benthic invertebrates, and reduces growth of freshwater fingerlings. It is cancer-causing, mutation-causing, and teratogenic. Chromium exists in two oxidation states in the environment: trivalent (+3) and hexavalent (+6), the latter of which is more toxic. Chromium+6 is readily converted to chromium+3 in animals, which appears to protect higher organisms from the effects of low level exposures (Eisler 1986).

Copper

Copper is a micronutrient and toxin. It strongly adsorbs to organic matter, carbonates and clay, which reduces its bioavailability. Copper is highly toxic in aquatic environments and has effects in fish, invertebrates, and amphibians, with all three groups equally sensitive to chronic toxicity (U.S. EPA 1993; Horne and Dunson 1995). Copper is highly toxic to amphibians (including mortality and sodium loss), with adverse effects in tadpoles and embryos (Horne and Dunson 1995; Owen 1981). Copper will bioconcentrate in many different organs in fish and mollusks (Owen 1981). There is low potential for bioconcentration in fish, but high potential in mollusks. Copper sulfate and other copper compounds are effective algaecides (free copper ions are the lethal agent). Single-cell and filamentous algae and cyanobacteria are particularly susceptible to the acute effects, which include reductions in photosynthesis and growth, loss of photosynthetic pigments, disruption of potassium regulation, and mortality. Sensitive algae may be affected by free copper at low (parts per billion) ppb concentrations in freshwater.

There is a moderate potential for bioaccumulation in plants and no biomagnification.Toxic effects in birds include reduced growth rates,

lowered egg production, and developmental abnormalities. While mammals are not as sensitive to copper toxicity as aquatic organisms, toxicity in mammals includes a wide range of animals and effects such as liver cirrhosis, necrosis in kidneys and the brain, gastrointestinal distress, lesions, low blood pressure, and fetal mortality. (ATSDR 1990c; Kabata-Pendias and Pendias 1992; Ware 1983; Vymazal 1995).

Cyanide

Cyanide toxicity is caused by the free cyanides (HCN and CN-) that inhibit cytochrome oxidase and thereby suppress aerobic respiration. Fish are the most susceptible organisms - sensitive species exhibit chronic and lethal effects at as low as 5 to 7 grams/liter (chronic) and 20 to 76 grams/liter (lethal), respectively. The toxicity of complex cyanides is usually, but not always, low, but the degradation products often include free cyanides which are toxic. Free cyanides readily degrade in the open environment but persist in groundwater. They do not bioaccumulate. Sublethal effects in fish include reduced reproductive capacity (decreased egg number and viability, and reduced embryo and larval survival), impaired swimming ability, altered growth, and hepatic necrosis. Free cyanides are phytotoxic at higher concentrations than those associated with adverse effects in fish. Mammals are less sensitive than fish, and are relatively tolerant of intermittent sublethal exposures (Eisler 1991).

Lead

Lead is cancer-causing, and adversely effects reproduction, liver and thyroid function, and disease resistance (Eisler 1988b). The main potential ecological impacts of wetland contaminants result from direct exposure of algae, benthic invertebrates, and embryos and fingerlings of freshwater fish and amphibians to lead. It can be bioconcentrated from water, but does not bioaccumulate and tends to decrease with increasing trophic levels in freshwater habitats (Wong et al. 1978; Eisler 1988b). Lead adversely affects algae, invertebrates, and fish. There are also limited adverse effects in amphibians, including loss of sodium, reduced learning capability, and developmental problems (Horne and Dunson 1995; Freda 1991). Fish exposed to high levels of lead exhibit a wide-range of effects including muscular and neurological degeneration and destruction, growth inhibition, mortality, reproductive problems, and paralysis (Eisler 1988b; EPA 1976). Lead adversely affects invertebrate reproduction; algal growth is affected. Lead partitions primarily to sediments, but becomes more bioavailable under low pH, hardness and organic matter content (among other factors). Lead bioaccumulates in algae, macrophytes and benthic organisms, but the inorganic forms of lead do not biomagnify.

At elevated levels in plants, lead can cause reduced growth, photosynthesis, mitosis, and water absorption (Eisler 1988b). Birds and mammals suffer effects from lead poisoning such as damage to the nervous system, kidneys, liver, sterility, growth inhibition, developmental retardation, and detrimental effects in blood (Eisler 1988b; Amdur et al. 1991).
Lead poisoning in higher organisms has been associated with lead shot and organolead compounds, but not with food chain exposure to inorganic lead (other than lead shot, sinkers or paint) (Eisler 1988b).

There are complex interactions with other contaminants and diet. Lead poisoning in higher organisms primarily affects hematologic and neurologic processes.

Manganese

Elevated levels of manganese in birds have been shown to cause the following effects: decreased hemoglobin, anemia, reduced growth; in mammals, effects include alterations of brain chemicals, gastric irritation, delayed testicular development, low birth weights, behavioral changes, and muscular weakness (ATSDR 1991).

Mercury

Mercury is a mutagen (mutation-causing), teratogen, and carcinogen (cancer-causing), with toxicity and environmental effects varying with the form of mercury, dose, and route of ingestion, and with the exposed organism's species, sex, age, and general condition (Eisler, 1987a, Fimreite 1979). There is a high potential for bioaccumulation and biomagnification with mercury, with biomagnified concentrations reported in fish up to 100,000 times the ambient water concentrations (Eisler 1987a, Callahan et al. 1979). Methylmercury is the most toxic form. Inorganic mercury is methylated primarily by bacteria in both anaerobic and aerobic environments. The organic mercury compounds are more readily absorbed and poorly excreted in comparison with inorganic forms. The primary targets of acute exposures are the central nervous system and kidneys in fish, birds and mammals.

In invertebrates, effects range from non-observable to chromosomal abnormalities in some flies and reduced segment regeneration in worms (Eisler 1987a). Mercury can inhibit frog metamorphosis and has many effects in fish. In water, at concentrations at or well below even 1 ppb (part-per-billion), mercury can cause effects including: loss of appetite, brain lesions, cataracts, abnormal motor coordination, and behavioral changes (MacDonald 1993). There are also effects on reproduction, growth, behavior, metabolism, blood chemistry, osmoregulation, and oxygen exchange at relatively low concentrations of mercury (Eisler 1987a). Juveniles are commonly more susceptible than adults.

Upper trophic level fish, birds and mammals are particularly vulnerable because of the pronounced biomagnification of organomercury (Eisler 1987a). There are numerous effects in birds, including delayed testicular development, altered mating behavior, reduced fertility, reduced survivability and growth in young, and gonadal atresia. In mammals, it has been shown that mercury can cause ataxia, aphagia, tremors, and diminished movement coordination (ATSDR 1994). There are varied neurological and reproductive effects as well (Cagiano et al. 1990; Khera et al. 1973).

Nickel

Nickel is cancer-causing (carcinogen) and mutation-causing (mutagen). Some observed effects of nickel in aquatic environments include tissue damage, genotoxicity, and growth reduction

(Environment Canada 1994a). Mollusks and crustaceans are more sensitive than other organisms.

Selenium

Selenium undergoes bioconcentration, bioaccumulation, and biomagnification as trophic levels increase (Taylor et al., 1992). It can enter the food web through both sediments and surface water. Elevated levels cause growth reduction in green algae (Eisler 1985b). In other aquatic organisms, the following adverse effects have been observed: loss of equilibrium and other neurological disorders, liver damage, reproductive failure, reduced growth, reduced movement rate, chromosomal aberrations, reduced hemoglobin and increased white blood cell count, and necrosis of the ovaries.

Silver

Silver may biomagnify in some aquatic invertebrates (Adriano 1986). However, it is highly toxic to aquatic organisms (EPA 1992). Elevated concentrations can cause larval mortality, developmental abnormalities, and reduced larval growth in fish (Klein-MacPhee et al. 1984); growth reduction in juvenile mussels (Calabrese et al. 1984); and adverse effects on reproduction in gastropods (Nelson et al. 1983). There are some indications of toxicity in plants. However, there are other reports suggesting that silver is not highly phytotoxic. Silver is toxic to soil microbes, thus inhibiting biotransformation (ATSDR 1990b). Effects on mammals include pulmonary edema, congestion, and mortality.

Thallium

Low rates of bioconcentration may occur in aquatic systems and thallium may be as toxic as copper on a weight basis (Zitko et al. 1975). Thallium can cause reductions in larval fish growth and percent embryo hatchability and mortality (LeBlanc and Dean 1984).

Zinc

In many types of aquatic plants and animals, growth, survival, and reproduction can all be adversely affected by elevated zinc levels (Eisler 1993). Zinc in aquatic systems tends to be partitioned into sediment and less frequently dissolved as hydrated zinc ions and organic and inorganic complexes (MacDonald 1993). Zinc is toxic to plants at elevated levels, causing adverse effects on growth, survival, and reproduction (Eisler 1993). Terrestrial invertebrates show sensitivity to elevated zinc levels, with reduced survival, growth, and reproduction. Elevated zinc levels can cause mortality, pancreatic degradation, reduced growth, and decreased weight gain in birds (Eisler 1993; NAS 1980); and elevated zinc can cause a wide range of problems in mammals including: cardiovascular, developmental, immunological, liver and kidney problems, neurological, hematological (blood problems), pancreatic, and reproductive (Eisler 1993; Domingo 1994).

APPENDIX D

IRON MASK MINE AND MILL SITE
APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS
(ARARs)

INTRODUCTION

Section 121(d) of CERCLA, 42 U.S.C. § 9621(d), certain provisions of the current National Contingency Plan (the NCP), 40 CFR Part 300 (1990), and guidance and policy issued by the Environmental Protection Agency (EPA) require that remedial actions taken pursuant to CERCLA authority shall require or achieve compliance with substantive provisions of applicable or relevant and appropriate standards, requirements, criteria, or limitations from state environmental and facility siting laws, and from federal environmental laws at the completion of the remedial action, and/or during the implementation of the remedial action, unless a waiver is granted. These requirements are threshold standards that any selected remedy must meet. See Section 122(d)(4) of CERCLA, 42 U.S.C. § 9621(d)(4); 40 CFR § 300.430(f)(1). EPA calls standards, requirements, criteria, or limitations identified pursuant to section 121(d) "ARARs," or applicable or relevant and appropriate requirements.

ARARs are either applicable or relevant and appropriate. Applicable requirements are those standards, requirements, criteria, or limitations promulgated under federal or state environmental or facility siting laws that specifically address a hazardous substance, pollutant, or contaminant, remedial action, location, or other circumstance found at a CERCLA site. Relevant and appropriate requirements are those standards, requirements, criteria, or limitations promulgated under federal environmental or state environmental or facility siting laws that, while not "applicable" to hazardous substances, pollutants, contaminants, remedial actions, locations, or other circumstances found at a CERCLA site, address problems or situations sufficiently similar to those encountered at the CERCLA site such that their use is well suited to the particular site. Factors which may be considered in making this determination are presented in CFR § 300.400(g)(2). Compliance with both applicable and relevant and appropriate requirements is mandatory.

Each ARAR or group of related ARARs identified here is followed by a specific statutory or regulatory citation, a classification describing whether the ARAR is applicable or relevant and appropriate, and a description which summarizes the requirements, and addresses how and when compliance with the ARAR will be measured (some ARARs will govern the conduct of the remedial action, some will define the measure of success of the remedial action, and some will do both). The descriptions given here are provided to allow the user a reasonable understanding of the requirements without having to refer constantly to the statute or regulation itself. However, in the event of any inconsistency between the law and the summary provided in this document, the applicable or relevant and appropriate requirement is ultimately the requirement as set out in the law, rather than any paraphrase of the law provided here.

Finally, this list contains a non-exhaustive list of other legal provisions or requirements which should be complied with. ARARs are divided into contaminant specific, location specific, and action specific requirements, as described in the NCP and EPA guidance. For contaminant specific ARARs, ARARs are listed according to the appropriate media.

Contaminant specific ARARs include those laws and regulations governing the release to the environment of materials possessing certain chemical or physical characteristics or containing specific chemical compounds. Contaminant specific ARARs generally set health or risk based

numerical values or methodologies which, when applied to site-specific conditions, result in the establishment of numerical values. These values establish the acceptable amount of concentration of a chemical that may be found in, or discharged to, the ambient environment.

Location specific ARARS are restrictions placed on the concentration of hazardous substances or the conduct of cleanup activities because they are in specific locations. Location specific ARARs relate to the geographic or physical position of the site, rather than to the nature of the site contaminants.

Action specific ARARs are usually technology or activity based requirements or limitations on actions taken with respect to hazardous substances.

Many requirements listed here are promulgated as identical or nearly identical requirements in both federal and state law, usually pursuant to delegated environmental programs administered by EPA and the states, such as the requirements of the federal Clean Water Act and the Montana Water Quality Act. The preamble to the new NCP states that such a situation results in citation to the State provision as the appropriate standard, but treatment of the provision as a federal requirement. ARARs and other laws which are unique to state law are identified separately by the State of Montana.

FEDERAL ARARS

1. FEDERAL CONTAMINANT SPECIFIC REQUIREMENTS

a. Groundwater Standards – Safe Drinking Water Act (Relevant and Appropriate)[1]

The national primary drinking water standards (40 CFR part 141), better known as maximum contaminant levels and maximum contaminant level goals (MCLs and MCLGs), are applicable to the Iron Mask Mine and Mill Site area because the aquifer underlying the area is a current public water system, as defined in the Safe Drinking Water Act, 42 U.S.C. § 300f(4). Groundwater use through private wells occurs approximately five miles down gradient from the area.

Standards such as the MCL and MCLG standards are promulgated pursuant to both federal and state law. Under the Safe Drinking Water Act, EPA has granted the State of Montana primacy in implementation and enforcement of the Safe Drinking Water Act. Nevertheless, both federal and state promulgated standards are potential ARARs for the Iron Mask Mine and Mill Site. Here, for ease of reference, for the primary contaminants of concern the more stringent of federal or state standards are listed, unless identical, in which case both standards are identified. Thus, the numerical standards identified by the State, which are applicable standards, are duplicated here where equivalent or more stringent.

Chemical	MCLG	MCL
Antimony	0.006 mg/l[2]	0.006/l[3]
Arsenic	N.A.[4]	0.05 milligrams per liter (mg/l)[5]
Cadmium	0.005 mg/l[6]	0.005 mg/l[7]
Copper	1.3 mg/l[8]	1.3 mg/l[9]
Lead	N.A. [10]	0.015 mg/l[11]
Mercury	0.002 mg/l[12]	0.002 mg/l[13]

These standards incorporate applicable Resource Conversation and Recovery Act (RCRA) standards for groundwater found at 40 CFR Part 264, Subpart F, which is incorporated pursuant to state law at ARM 17.54.702. The RCRA standards are the same or less stringent than the MCLs or MCLGs identified above.

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1 42 U.S.C. Sections 300f et seq.
2 40 CFR § 141.51.
3 40 CFR § 141.62.
4 An MCLG and a revised MCL for arsenic may be promulgated by EPA in the near future. If promulgated prior to issuance of a decision document for the Iron Mask Mine and Mill Site, these standards will be incorporated.
5 40 CFR § 141.11.
6 40 CFR § 141.51.
7 40 CFR § 141.62.
8 40 CFR § 141.51.
9 40 CFR § 141.80(c). The requirement is an action level rather than a simple numerical standard.
10 The MCLG for lead is zero, which is not consedered appropriate for Superfund site cleanups.
11 40 CFR § 141.80(c), which establishes an action level rather than a pure numerical standard.
12 40 CFR § 141.51.
13 40 CFR § 141.62.

b. Air Standards – Clean Air Act (Applicable)

Limitations on air emissions resulting from cleanup activities or emissions resulting from wind erosion of exposed hazardous substances are set forth in the action specific requirements, below.

2. FEDERAL LOCATION SPECIFIC REQUIREMENTS

a. Fish and Wildlife Coordination Act (Applicable)

These standards are found at 16 U.S.C. §§ 1531 – 1566 and 40 CFR § 6.302(g). They require that federally funded or authorized projects ensure that any modification of any stream or other water body affected by a funded or authorized action provide for adequate protection of fish and wildlife resources. Compliance with this ARAR necessitates consultation with the U.S. Fish and Wildlife Service (USFWS) and the State of Montana Department of Fish, Wildlife, and Parks. Further consultation with these agencies will occur during cleanup selection and implementation, and specific mitigative or other measures may be identified to achieve compliance with this ARAR.

b. Floodplain Management Order (Applicable)

This Requirement (40 CFR Part 6, Appendix A, Executive Order No. 11,988) mandated that federally funded or authorized actions within the 100 year flood plain avoid, to the maximum extent possible, adverse impacts associated with development of a floodplain. Compliance with this requirement in detailed in EPA's August 6, 1985 "Policy on Floodplains and Wetlands Assessments for CERCLA Actions." Specific measures to minimize adverse impacts may be identified following consultation with the appropriate agencies.

If the removal action selected for the Iron Mask Mine and Mill Site is found to potentially affect the floodplain, the following information will be produced: a Statement of Findings which will set forth the reasons why the proposed action must be located in or affect the floodplain; a description of significant facts considered in making the decisions to locate in or affect the floodplain or wetlands including alternative sites or actions; a statement indicating whether the selected action conforms to applicable state or local floodplain protection standards; a description of the steps to be taken to design or modify the proposed action to minimize the potential harm to or within the floodplain; and a statement indicating how the proposed action affects the natural or beneficial values of the floodplain.

c. Protection of Wetland Order (Relevant and Appropriate)

This requirement (40 CFR Part 6, Appendix A, Executive Order No. 11, 990) mandates that federal agencies and potentially responsible parties (PRPs) avoid, to the extent possible, the adverse impacts associated with the destruction or loss of wetlands and to avoid support of new construction in wetlands if a practicable alternative exists. Section 404(b)(1), 33 U.S.C. § 1344(b)(1), also prohibits the discharge of dredged or fill material into waters of the United States. Together, these requirements create a "no net loss" of wetlands standard. If wetlands are

found to be potentially affected by the Iron Mask Mine and Mill Site reclamation, this ARAR would be applicable.

d. The Endangered Species Act (Applicable)

This statute and implementing regulations (16 U.S.C. §§ 1531 – 1543, 50CFR Part 402, and 40 CFR § 6.302(h)) require that any federal activity or federally authorized activity may not jeopardize the continued existence of any threatened or endangered species or destroy or adversely modify a critical habitat. The area around the Iron Mask Mine and Mill Site is not known to harbor endangered and threatened species.

Compliance with this requirement involves consultation with USFWS, and a determination of whether there are listed or proposed species or critical habitats present at the site, and, if so, whether any proposed activities will impact such wildlife or habitat.

e. The National Historic Preservation Act (Applicable)

This statute and implementing regulations (16 U.S.C. § 470, 40 CFR § 6.310(b), 36 CFR Part 800) require federal agencies or federal projects to take into account the effect of any federally assisted undertaking or licensing on any district, site building, structure, or object that is included in, or eligible for, the Register of Historic Places. If effects cannot be avoided reasonably, measures should be implemented to minimize or mitigate the potential effect. In order to comply with this ARAR, the BLM may consult with the State Historic Preservation Officer (SHPO), who can assist in identifying listed or eligible resources, and in assessing whether proposed cleanup actions will impact the resources and any appropriate mitigative measures.

f. Archaeological and Historic Preservation Act (Applicable)

The statute and implementing regulations (16 U.S.C. § 469, 40 CFR § 6.301(c)) establish requirements for evaluation and preservation of historical and archaeological data, which may be destroyed through alteration of terrain as a result of federal construction projects or a federally licensed activity or program. If eligible scientific, prehistoric, or archaeological artifacts are discovered during site activities, they must be preserved in accordance with these requirements.

g. Historic Sites, Buildings, and Antiquities Act (Applicable)

This requirement states that "in conducting an environmental review of a proposed action, the responsible official shall consider the existence and location of natural landmarks using information provided by the National Park Service pursuant to 36 CFR § 62.6(d) to avoid undesirable impacts upon such landmarks. The Programmatic Agreement activities described above should aid all parties in compliance with this ARAR.

h. Migratory Bird Treaty Act (Applicable)

This requirement (16 U.S.C. §§ 703 et seq.) establishes a federal responsibility for the protection of the international migratory bird resource and requires continued consultation with the USFWS

during remedial design and remedial construction to ensure that the cleanup of the site does not unnecessarily impact migratory birds. Specific mitigative measures may be identified for compliance with this requirement.

i. Bald Eagle Protection Act (Applicable)

This requirement (16 U.S.C. §§ 668 et seq.) establishes a federal responsibility for protection of bald and golden eagles, and requires continued consultation with the USFWS during remedial design and remedial construction to ensure that any cleanup of the site does not unnecessarily adversely affect the bald and golden eagle. Specific mitigative measures may be identified for compliance with this requirement. Although, the Bald Eagle has not been spotted in the area, they could frequent the area.

j. Resource Conservation and Recovery Act (Relevant and Appropriate)

Any discrete waste units created or retained by the Iron Mask Mine and Mill Site cleanup must comply with the siting restrictions and conditions found at 40 CFR § 264.18(a) and (b). These sections require that waste repositories must not be located in seismic impact zones or in a 100 year flood plain. The repository planned for the Site is not indicated as being in a 100 year floodplain.

3. FEDERAL ACTION SPECIFIC REQUIREMENTS

a. Solid Waste (Applicable), Surface Mining Control and Reclamation (Applicable), and RCRA (Relevant and Appropriate) Requirements.

The contamination at the Iron Mask Mine and Mill Site is primarily mining waste form various man-made sources. This waste may not be RCRA hazardous waste, although EPA reserves its rights to make a more formal determination in this regard at a later date. For any management (i.e., treatment, storage, or disposal) or removal or retention of that contamination, the following requirements are ARARs.

1. Requirements described at 40 CFR §§ 257.3-1(a), 257.3-3, and257.3-4, governing waste handling, storage, and disposal, including retention of the waste, in general.[14]

2. For any discrete waste units which are addressed by the Iron Mask Mine and Mill Site cleanup, reclamation and closure regulations found at 30 CFR Parts 816 and 784, governing coal and to a lesser extent, non-coal mining, are applicable requirements.[15]

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[14] Solid Waste regulations are promulgated pursuant to the federal Solid Waste Disposal Act, as amended by the Resource Conversation and Recovery Act, 42 U.S.C. 6901 et seq. They are applicable regulations, although the State of Montana has the lead role in regulating solid waste disposal in the State of Montana. These regulations are also applicable to the hazardous waste described in the section above.

[15] The Surface Mining Control and Reclamation Act is promulgated at 30 U.S.C. Sections 1201 – 1326.

b. Air Standards – Clean Air Act (Applicable)

These Standards, promulgated pursuant to section 109 of the Clean Air Act,[16] are applicable to releases into the air from any Iron Mask Mine and Mill Site cleanup activities.

i. Lead: No person shall cause or contribute to concentrations of lead in the ambient air which exceed 1.5 micrograms per cubic meter ($\mu g/m^3$) of air, measured over a 90-day average.

These standards are promulgated at ARM 16.8.815 as part of a federally approved State Implementation Plan (SIP), pursuant to the Clean Air Act of Montana, §§ 75-2-101 et seq., MCA. Corresponding federal regulations are found at 40 CFR § 50.12.

ii. Particulate matter that is 10 microns in diameter or smaller (PM-10): No person shall cause of contribute to concentrations of PM-10 in the ambient air which exceed;

- 150 $\mu g/m^3$ 24 hour average, no more than one expected exdeedance per calendar year;

- 50 $\mu g/m^3$ or air, annual average.

These regulations are promulgated at ARM 17.8.223 as part of a federally approved SIP, pursuant to the Clean Air Act of Montana, §§ 75-5-101 et seq., MCA. Corresponding federal regulations are found at 40 CFR § 50.6.

Ambient air standards under section 109 of the Clean Air Act are also promulgated for carbon monoxide, hydrogen sulfide, nitrogen dioxide, sulfur dioxide, and ozone. If emissions of these compounds were to occur at the site on connection with any cleanup action, these standards would also be applicable. See ARM 17.8.212 and 40 CFR Part 50.

c. Dredge and Fill Requirements (Applicable)

Regulations found at 40 CFR Part 230 address conditions or prohibitions against depositing dredge and fill material into water of the United States. If remediation activities would result in an activity subject to these regulations, they would be applicable.

d. Transportation of Hazardous or Contaminated Waste (Relevant and Appropriate)

40 CFR Part 263 establishes regulations for the transportation of hazardous waste. These regulations would govern any on-site transportation of material. Any off-site transportation would be subject to applicable regulations.

[16] 42 U.S.C. §§ 7401 et. seq.

STATE OF MONTANA ARARS

4. MONTANA CONTAMINANT SPECIFIC REQUIREMENT

a. Water Quality

i. Surface Water Quality Standards (Applicable)

Under the state Water Quality Act, §§ 75-5-101 et seq., MCA, the state has promulgated regulations to protect, maintain, and improve the quality of surface waters in the state. The requirements listed below are applicable water quality standards with which any remedial action must comply. No perennial surface water is present at the Iron Mask Mine and Mill Site; therefore, surface water quality standards are not applicable.

According to ARM 17.30.1310(3), MPDES permits are not necessary for any discharge that complies with the instructions of an on-scene coordinator pursuant to the MCP (40 CFR Part #)) et. Seq.). This exemption is identical to the federal exemption for NPDES permits. See 40 CFR section 122.3(d). The on-scene coordinator is the government official designated by the lead agency to coordinate and direct removal actions under the National Contingency Plan (NCP), subpart E. 40 CFR section 300.5. Removal actions include containment of hazardous substances form water and shorelines and taking other actions necessary to minimize or mitigate damage to public health or welfare or the environment. 40 CFR section 300.5. Removal also means cleaning up or removing hazardous substance releases from the environment, monitoring, assessing and evaluating releases or threats thereof, disposal of removed material, or other actions necessary to minimize or mitigate damage to public health or welfare or the environment. Id. Corey Meier is the BLM Project Officer of this site and is overseeing the reclamation work. As the government official of the lead agency of a federally approved Abandoned Mine Program directing and coordinating this removal action, Corey Meier is the on-scene coordinator. These activities are conducted pursuant to the NCP. Since this removal action will be conducted with the imprimatur of Corey Meier, the on-scene coordinator, and be executed pursuant to his instructions, the expected discharges of water from the planned tailings impoundment will not require an MPDES permit.

For the primary contaminants of concern, the WQB-7 levels are listed below. WQB-7 (applicable) provides that "whenever both Aquatic Life Standards and Human Health Standards exist for the same analyte, the more restrictive of these values will be used as the numeric Surface Water Quality Standard."

Chemical	WQB-7 Standard (Surface Water)
Antimony	6 μg/l
Arsenic	18 μg/l
Cadmium	5 μg/l
Copper	1,300 μg/l

Lead	15 μg/l
Manganese	50 μg/l
Mercury	0.05 μg/l
Zinc	2,000 μg/l

Additional restrictions on any discharge to surface waters are included in:

ARM 17.30.637 (Applicable), which prohibits discharges containing substances that will:

(a) Settle to form objectionable sludge deposits or emulsions beneath the surface of the water upon adjoining shorelines;

(b) Create floating debris, scum, a visible oil film (or be present in concentrations at or in excess of 10 milligrams per liter) or globules of grease or other floating materials;

(c) Produce odors, colors or other conditions which create a nuisance or render undesirable tastes to fish flesh or make fish inedible;

(d) Create concentrations or combinations of materials which are toxic or harmful to human, animal, plant or aquatic life;

(e) Create conditions which produce undesirable aquatic life.

ii <u>Groundwater Pollution Control System (Applicable)</u>

In addition to the standards set forth below, relevant and appropriate MCLs and MCLGs are included in the federal ARARs identified above.

ARM 17.30.1002 (Applicable) classifies groundwater into Classes I through IV based on the present and future most beneficial uses of the groundwater, and states that groundwater is to be classified according to actual quality or actual use, whichever places the groundwater in a higher class. Class I is the highest quality class; class IV the lowest.

ARM 17.30.1003 (Applicable) establishes the groundwater quality standards applicable with respect to each groundwater classification. Concentrations of dissolved substances in Class I or II groundwater (or Class III groundwater which is used as a drinking water source) may not exceed the human health standards listed in department Circular WQB-7. For the primary contaminants of concern these levels are listed above.

Concentrations of other dissolved or suspended substances must not exceed levels that render the waters harmful, detrimental or injurious to public health. Maximum allowable concentration of these substances also must not exceed acute or chronic problem levels that would adversely affect existing or designated beneficial uses of groundwater of that classification. ARM 17.30.1003 specifies certain references that may be used as a guide in determining problem levels unless local conditions make these values inappropriate.
An additional concern with respect to ARARs for groundwater is the impact of groundwater upon the surface water. If significant loadings of contaminants form groundwater sources to surface water contribute to the inability of the stream to meet the classification standards, then alternatives to alleviate such groundwater loading must be evaluated and, if appropriate, implemented.

b. Air Quality

In addition to the standards identified in the federal action specific ARARs above, the State of Montana has identified certain air quality standards in the action-specific section of the State ARARs below.

5. MONTANA LOCATION SPECIFIC REQUIREMENTS

a. Solid Waste Management Regulations (Applicable)

Regulations promulgated under the Solid Waste Management Act, §§ 75-10-201 et seq., MCA, specify requirements that apply to the location of any solid waste management facility. Under ARM 17.50.505 (Applicable, a facility for the treatment, storage or disposal of solid wastes:

(a) must be located where a sufficient acreage of suitable land is available for solid waste management;
(b) may not be located in a 100-year floodplain;
(c) may be located only in areas which will prevent the pollution of ground and surface waters and public and private water supply systems;
(d) must be located to allow for reclamation and reuse of the land;
(e) drainage structures must be installed where necessary to prevent surface runoff from entering waste management areas; and
(f) where underlying geological formations contain rock fractures or fissures which may lead to pollution of the ground water or areas in which springs exist that are hydraulically connected to a proposed disposal facility, only Class III disposal facilities may be approved.

Even Class III landfills may not be located on the banks of or in a live or intermittent stream or water saturated areas, such as marshes or deep gravel pits which contain exposed ground water. ARM17.50.505(2)(j).

In addition, § 75-10-212 (Applicable) prohibits dumping or leaving any debris or refuse upon or within 200 yards of any highway, road, street, or alley of the State or other public property, or on privately owned property where hunting, fishing, or other recreation is permitted. However, the restriction relating to privately owned property does not apply to the owner, his agents, or those disposing of debris or refuse with the owner's consent.

b. Natural streambed and Land Preservation Standards (Applicable)

Sections 87-5-502 and 504, MCA, (Applicable—substantive provisions only) provide that a state agency or subdivision shall not construct, modify, operate, maintain or fail to maintain any construction project or hydraulic project which may or will obstruct, damage, diminish, destroy, change, modify, or vary the natural existing shape and form of any stream or its banks or tributaries I a manner that will adversely affect any fish or game habitat. The requirement that any such project must eliminate or diminish any adverse effect on fish or game habitat is applicable to the state in approving remedial actions to be conducted.

ARM 36.2.404 (Applicable) establishes minimum standards which would be applicable if a remedial action alters or affects a streambed, including any channel change, new diversion, riprap or other streambank protection project, jetty, new dam or reservoir or other commercial, industrial or residential development. No such project may be approved unless reasonable efforts will be made consistent with the purpose of the project to minimize the amount of stream channel alteration, insure that the project will be as permanent a solution as possible and will create a reasonably permanent and stable situation, insure that the project will pass anticipated water flows without creating harmful erosion upstream or downstream, minimize turbidity, effects on fish and aquatic habitat, and adverse effects on the natural beauty of the area and insure that streambed gravels will not be used in the project unless there is no reasonable alternative. Soils erosion and sedimentation must be kept to a minimum. Such projects must also protect the use of water for any useful or beneficial purpose. See § 75-7-102, MCA.

6. MONTANA ACTION SPECIFIC REQUIREMENTS

a. Air Quality

i. Air Quality Regulations (Applicable) Excavation/earth-moving transportation)

Dust suppression and control of certain substances likely to be released into the air as a result of earth moving, transportation and similar actions may be necessary to meet air quality requirements. Certain ambient air standards for specific contaminants and particulates are set forth in the federal action specific section above. Additional air quality regulations under the state Clean Air Act, §§ 75-2-101 et seq., MCA, are discussed below.

ARM 17.8.308 (1) and (2) and 17.8.304 (Applicable) provides that no person shall cause or authorize the production, handling, transportation or storage of any material; or cause or authorize the use of any street, road, or parking lot; or operate a construction site or demolition project, unless reasonable precautions to control emissions of airborne particulate matter are taken. Emissions of airborne articulate matter must be controlled so that they do not "exhibit an opacity of twenty percent (20%) or greater averaged over six consecutive minutes."

In addition, state law provides an ambient air quality standard for settled particulate matter. Particulate matter concentrations in the ambient air shall not exceed the following 30-day average: 10 grams per square meter. ARM 17.8.220 (Applicable).

ARM 17.8.308(4) (Applicable) requires that any new source of airborne particulate matter that has the potential to emit less than 100 tons per year of particulates shall apply best available control technology (BACT); any new source of airborne particulate matter that has the potential to emit more than 100 tons per year of particulates shall apply lowest achievable emission rate (LAER). The BACT and LAER standards are defined in ARM 17.0.301.

ARM 26.4.761 (Applicable) specifies a range of measures for controlling fugitive dust emissions during mining and reclamation activities. Some of these measures could be considered relevant

and appropriate to control fugitive dust emissions in connection with excavation, earth moving and transportation activities conducted as part of the remedy at the site. Such measures include, for example, paving, watering, chemically stabilizing, or frequently compacting and scraping roads, promptly removing rock, soil or other dust-forming debris from roads, restricting vehicle speeds, revegetating, mulching, or otherwise stabilizing the surface of areas adjoining roads, restricting unauthorized vehicle travel, minimizing the area of disturbed land, and promptly revegetating regraded lands.

b. Solid Waste Regulations

Solid Waste Management Regulations are applicable to the management of the waste rock and similar wastes within this Site. Certain of these regulations are identified in the state Location Specific ARARs above. Other applicable requirements are discussed here.

ARM 17.50.505(2) (Applicable) specifies standards for solid waste management facilities, including the requirements that:

1. if there is the potential for leachate migration, it must be demonstrated that leachate will only migrate to underlying formations which have no hydraulic continuity with any state waters;
2. adequate separation of such wastes from underlying or adjacent water must be provided considering terrain, type of underlying soil formations, and facility design; and
3. no new disposal units or lateral expansions may be located in wetlands.

ARM 17.50.523 (Applicable) requires that such waste must be transported in such a manner as to prevent its discharge, dumping, spilling, or leaking from the transport vehicle.

Section 75-10-206, MCA, (Applicable) allows variances to be granted from solid waste regulations if failure to comply with the rules does not result in a danger to public health or safety or compliance with specific rules would produce hardship without producing benefits to the health and safety of the public that outweigh the hardship. In light of the nature if the wastes at issue and the likelihood that any repository would contain only a single type of waste, i.e. tailings and related materials, many of the Solid Waste Regulations regarding design of landfills, ARM 17.50.510-511, and landfill closure requirements and post-closure care, ARM 17.50.530-531, may appropriately be subject to variance in selecting and implementing a remedy at this Site.

c. Reclamation Requirements

i. Reclamation Activities – Hydrology Regulations (Applicable)
(Excavation, earth moving, altering drainage patterns)

The hydrology regulations promulgated under the Strip and Underground Mine Reclamation Act, §§ 82-4-201 et seq., MCA, provide detailed guidelines for addressing the hydrologic impacts of mine reclamation activities and earth moving projects and are applicable for addressing these impacts in the Iron Mask Mine and Mill Site.

ARM 26.4.631 (Applicable) provides that long-term adverse changes in the hydrologic balance from mining and reclamation activities, such as changes in water quality and quantity, and location of surface water drainage channels shall be minimized. Water pollution must be minimized and, where necessary, treatment methods utilized. Diversions of drainages to avoid contamination must be used in preference to the use of water treatment facilities. Other pollution minimization devices must be used if appropriate, including stabilizing disturbed areas through land shaping, diverting runoff, planting quickly germinating and growing stands of temporary vegetation, regulating channel velocity of water, lining drainage channels with rock or vegetation, mulching, and control of acid-forming, and toxic-forming waste materials.

ARM 26.4.633 (Applicable) states that all surface drainage from a disturbed area must be treated by the best technology currently available (BTCA). Treatment must continue until the area is stabilized.

ARM 26.4.634 (Applicable) provides that, in reclamation of drainages, drainage design must emphasize channel and floodplain dimensions that approximate the pre-mining configuration and that will blend with the undisturbed drainage above and below the area to be reclaimed. The average stream gradient must be maintained with a concave longitudinal profile. This regulation provides specific requirements for designing the reclaimed drainage to:

1. meander naturally;
2. remain in dynamic equilibrium with the system;
3. improve unstable pre-mining conditions;
4. provide for floods; and
5. establish a pre-mining diversity of aquatic habitats and riparian vegetation.

ARM 26.4.635 through 26.4.637 (Applicable) set forth requirements for temporary and permanent diversions.

ARM 26.4.640 (Applicable) provides that discharge from sedimentation ponds, permanent and temporary impoundments, and diversions shall be controlled by energy dissipaters, riprap channels, and other devices, where necessary, to reduce erosion, prevent deepening or enlargement of stream channels, and to minimize disturbance of the hydrologic balance.

ii. <u>Reclamation and Revegetation Requirements (Applicable)</u> (Excavation)

ARM 26.4.501 and 501A (Applicable) give general back-filling and final grading requirements.

ARM 26.4.504 (Applicable) provides that permanent impoundments that meet the requirements of ARM 26.4.642 may be retained in mined and reclaimed sites, provided that all highwalls are eliminated by grading to appropriate contours and the post-mining land use and protection of hydrologic balance provisions are satisfied. No impoundments may be constructed on top of areas in which excess materials are deposited.

ARM 26.4.514 (Applicable) sets out contouring requirements.

ARM 26.4.519 (Applicable) provides that an operator may be required to monitor settling of regraded areas.

ARM 26.4.520 (Applicable) provides that spoil material may be placed in a controlled (engineered) manner in a disposal area other than the mine workings or excavations. Also provides various other relevant requirements, including, but not limited to, those for water protection i.e., that leachate and surface runoff from the fill must not degrade surface or ground waters or exceed effluent limitations.

ARM 26.4.638 (Applicable) specifies sediment control measures to be implemented during operations.

ARM 26.4.641 (Applicable) provides that drainage from acid-and toxic-forming spoil ground and surface water must be avoided by several enumerated means, all of which are relevant.

ARM 26.4.642 (Applicable) prohibits permanent impoundments except under certain circumstances. Also provides other construction requirements for embankments, dams and diversion ditches.

ARM 26.4.643-646 (Applicable) provides for protection of groundwater and groundwater recharge, and provides requirements for monitoring surface and groundwater.

ARM 26.4.650 (Applicable) provides for post-mining rehabilitation of sedimentation ponds, diversion, impoundments and treatment facilities before abandonment of the permit area.

ARM 26.4.702 (Applicable) requires that during the redistributing and stockpiling of soil (for reclamation):

1. regraded areas must be deep-tilled, sub-soiled, or otherwise treated to eliminate any possible slippage potential, to relieve compaction, and to promote root penetration and permeability of the underlying layer; this preparation must be done on the contour whenever possible and to a minimum depth of 12 inches;
2. redistribution must be done in a manner that achieves approximate uniform thicknesses consistent with soil resource availability and appropriate for the post-mining vegetation, land uses, contours, and surface water drainage systems; and
3. redistributed soil mist be reconditioned by sub-soiling or other appropriate methods.

ARM 26.4.703 (Applicable) When using materials other than, or along with, soil for final surfacing in reclamation, the operator must demonstrate that the material (1) is at least as capable as the soil of supporting the approved vegetation and subsequent land use, and (2) the medium must be the best available in the area to support vegetation. Such substitutes mist be used in a manner consistent with the requirements for redistribution of soil in arm 26.4.701 and 702.
Are 26.4.711 (Applicable) requires that a diverse, effective, and permanent vegetative cover of the same seasonal variety native to the area of land to be affected shall be established except on road surfaces and below the low-water line of permanent impoundments. Vegetative cover is considered of the same seasonal variety if it consists of a mixture of species of equal or superior utility when compared with the natural (or pre-existing) vegetation during each season of the

year. (See also ARM 26.4.716 below regarding substitution of introduced species for native species.)

ARM 26.4.713 (Applicable) provides that seeding and planting of disturbed areas must be conducted during the first appropriate period for favorable planting after final seedbed preparation but may not be more than 90 days after soil has been replaced.

ARM 26.4.714 (Applicable) requires use of a mulch or cover crop or both until an adequate permanent cover can be established. Use of mulching and temporary cover may be suspended under certain conditions.

ARM 26.4.716 (Applicable) establishes the required method of revegetation, and provides that introduced species may be substituted for native species as part of an approved plan.

ARM 26.4.718 (Applicable) requires the use of soil amendments and other means such as irrigation, management, fencing, or other measures, if necessary to establish a diverse and permanent vegetative cover.

ARM 26.4.720 (Applicable) requires annual state inspection of seeded areas.

ARM 26.4.721 (Applicable) requires rills and gullies forming in areas that have been regraded or resoiled must be filled, graded or otherwise stabilized and the area reseeded or replanted under certain circumstances.

ARM 26.4.723 (Applicable) requires periodic monitoring and data review of vegetation, soils, wildlife and other items at the site by the operator as prescribed or approved by the state.

ARM 26.4.724 (Applicable) provides revegetation comparison standards.

ARM 26.4.725 (Applicable) establishes commencement of the minimum period of responsibility for reestablishing vegetation.

ARM 26.4.726 (Applicable) establishes vegetation production, cover, diversity, density and utility requirements for revegetation and reclamation success.

ARM 26.4.728 (Applicable) sets forth requirements for the composition of vegetation on reclaimed areas.

ARM 26.4.730-731 (Applicable) requires season of use standards and analysis of toxicity if such toxicity is suspected due to the effects of disturbance caused by the reclamation technique.

7. OTHER LAWS (NON-EXCLUSIVE LIST)

CERCLA defines as ARARs only federal environmental and state environmental and siting laws. Remedial design, implementation, and operation and maintenance must nevertheless comply

with all other applicable laws, both state and federal, if the remediation work is done by parties other than the federal government or its contractors.

The following "other laws" are included here to provide a reminder of other legally applicable requirements for actions being conducted at the Iron Mask Mine and Mill Site. They do not purport to be an exhaustive list of such legal requirements, but are included because they set out related concerns that must be addressed and, in some cases, may require some advance planning. They are not included as ARARs because they are not "environmental or facility siting laws." As applicable laws other than ARARs, they are not subject to ARARs waiver provisions.

Section 121(e) of CERCLA exempts removal or remedial actions conducted entirely on-site from federal, state, or local permits. This exemption is not limited to environmental or facility siting laws, but applies to other permit requirements as well.

a. Other Federal Laws

i. Occupational Safety and Health Regulations

The federal Occupational Safety and Health Act regulations found at 29 CFR § 1910 are applicable to worker protection during conduct of RI/FS or remedial activities.

b. Other Montana Laws

i. Water Rights

Section 85-2-101, MCA, declares that all waters within the state are the state's property, and may be appropriated for beneficial uses. The wise use of water resources is encouraged for the maximum benefit to the people and with minimum degradation of natural aquatic ecosystems.

Parts 3 and 4 of Title 85, MCA, set out requirements for obtaining water rights and appropriating and utilizing water. All requirements of these parts are laws, which must be complied with in any action using or affecting waters of the state. Some of the specific requirements are set forth below.

Section 85-2-302, MCA, specifies that a person may not appropriate water or commence construction of diversion, impoundment, withdrawal or distribution works therefore except by applying for and receiving a permit from the Montana Department of Natural Resources and Conservation. While the permit itself may not be required under federal law, appropriate notification and submission of an application should be performed and a permit should be applied for in order to establish a priority date in the prior appropriation system. A 1991 amendment imposes a fee of $1.00 per acre foot for appropriations of ground water, effective until July 1, 1993.

ii. Occupational Health Act, §§ 50-70-101 et seq., MCA.

ARM 17.74.101 addresses occupational noise. In accordance with this section, no worker shall be exposed to noise levels in excess of the levels specified in this regulation. This regulation is

applicable only to limited categories of workers and for most workers the similar federal standard in 29 CFR § 1910.95 applies.

ARM 17.74.102 addressed occupational air contaminants. The purpose of this rule is to establish maximum threshold limit values for air contaminants under which it is believed that nearly all workers may be repeatedly exposed day after day without adverse health effects. In accordance with this rule, no worker shall be exposed to air contaminant levels in excess of the threshold limit values listed in the regulation. This regulation is applicable only to limited categories of workers and for most workers the similar federal standard in 29 CFR § 1910.1000 applies.

iii. Montana Safety Act

Sections 50-71-201,202 and 203, MCA, state that every employer must provide and maintain a safe place of employment, provide and require use of safety devices and safeguards, and ensure that operations and processes are reasonably adequate to render the place of employment safe. The employer must also do every other thing reasonably necessary to protect the life and safety of its employees. Employees are prohibited from refusing to use or interfering with the use of safety devices.

iv. Employee and Community Hazardous Chemical Information Act

Sections 50-78-201, 202, and 204, MCA, state that each employer must post notice of employee rights, maintain at the work place a list of chemical names of each chemical in the work place, and indicate the work area where the chemical is stored or used. Employees must be informed of the chemicals at the work place and trained in the proper handling of the chemicals.

APPENDIX E

IRON MASK MINE AND MILL SITE
COST ESTIMATES

Table E-1

Alternative 2 - Institutional Controls						
Item	**Description**	**Quantity**	**Unit**	**Unit Price**		**Total Price**
1	**Administration**					
1.1	**Mobilization, Bonding, Insurance (10%)**	**1**	**LS**	**$ 1,000.00**	**$**	**1,000.00**
2	**Institutional Controls**					
2.1	**Access Control**	**1**	**LS**	**$ 10,000.00**	**$**	**10,000.00**
	Install Fence and Access Gate	*2000*	*LF*	*$ 5.00*	*$*	*10,000.00*
	SUBTOTAL:				$	11,000.00
	Contingency (15%):				$	1,650.00
	TOTAL CAPITAL COSTS:				**$**	**12,650.00**

Table E-2							
Alternative 3a - Consolidate Waste Rock On-Site with Cover Soil Cap							
Item	**Description**	**Quantity**	**Unit**	**Unit Price**		**Total Price**	
1	**Administration**						
	1.1 Mobilization, Bonding, Insurance (10%)	**1**	**LS**	**$**	**19,650.00**	**$**	**19,650.00**
2	**Site Preparation**						
	2.1 Road Improvements						
	Main Access Road	*4.0*	*MI*	*$*	*1,000.00*	*$*	*4,000.00*
	Construction Access Roads	*1.0*	*MI*	*$*	*1,000.00*	*$*	*1,000.00*
						$	**5,000.00**
3	**Reclamation**						
	3.1 Borrow Area						
	Strip, Stockpile and Replace Borrow Area Topsoil	*2,000*	*CY*	*$*	*5.00*	*$*	*10,000.00*
	Excavate/Stockpile Borrow Area Cover Soil	*4,200*	*CY*	*$*	*5.00*	*$*	*21,000.00*
						$	**31,000.00**
	3.2 Consolidate Waste Material On-Site						
	Regrade WR-1	*5,000*	*CY*	*$*	*3.00*	*$*	*15,000.00*
	Regrade WR-2	*500*	*CY*	*$*	*3.00*	*$*	*1,500.00*
	Excavate, Haul and Place WR-3	*500*	*CY*	*$*	*6.00*	*$*	*3,000.00*
						$	**19,500.00**
	3.3 Cover Soil						
	Haul, and Place Amended Cover Soil Cap	*4,000*	*CY*	*$*	*12.00*	*$*	*48,000.00*
	Backfill Excavated Areas	*200*	*CY*	*$*	*8.00*	*$*	*1,600.00*
						$	**49,600.00**
	3.4 Reclaim TA-2						
	Regrade and Cover TA-2	*300*	*CY*	*$*	*3.00*	*$*	*900.00*
						$	**900.00**
	3.5 Revegetation						
	Organic Amendment	*200*	*Dry Ton*	*$*	*250.00*	*$*	*50,000.00*
	Fertilize and Seed	*4*	*AC*	*$*	*1,000.00*	*$*	*4,000.00*
	Mulch	*4*	*AC*	*$*	*2,000.00*	*$*	*8,000.00*
						$	**62,000.00**
4	**Drainage Reconstruction**						
	4.1 Construct New Stream Channel						
	Excavation	*500*	*LF*	*$*	*12.00*	*$*	*6,000.00*
	Grouted Riprap	*150*	*CY*	*$*	*150.00*	*$*	*22,500.00*
						$	**28,500.00**
	SUBTOTAL:					$	216,150.00
	Contingency (15%):					$	32,422.50
	TOTAL CAPITAL COSTS:					**$**	**248,572.50**

Table E-3							
Alternative 3b - Consolidate Waste Rock and Tailings On-Site with Cover Soil Cap							
Item	**Description**	**Quantity**	**Unit**	**Unit Price**		**Total Price**	
1	**Administration**						
	1.1 Mobilization, Bonding, Insurance (10%)	**1**	**LS**	**$**	**25,120.00**	**$**	**25,120.00**
2	**Site Preparation**						
	2.1 Road Improvements						
	Main Access Road	*4.0*	*MI*	*$*	*1,000.00*	*$*	*4,000.00*
	Construction Access Roads	*1.0*	*MI*	*$*	*1,000.00*	*$*	*1,000.00*
						$	**5,000.00**
3	**Reclamation**						
	3.1 Borrow Area						
	Strip, Stockpile and Replace Borrow Area Topsoil	*2,000*	*CY*	*$*	*5.00*	*$*	*10,000.00*
	Excavate/Stockpile Borrow Area Cover Soil	*6,000*	*CY*	*$*	*5.00*	*$*	*30,000.00*
						$	**40,000.00**
	3.2 Consolidate Waste Material On-Site						
	Regrade WR-1	*5,000*	*CY*	*$*	*3.00*	*$*	*15,000.00*
	Regrade WR-2	*500*	*CY*	*$*	*3.00*	*$*	*1,500.00*
	Excavate, Haul and Place WR-3	*500*	*CY*	*$*	*6.00*	*$*	*3,000.00*
	Excavate, Haul and Place TA-1	*1,600*	*CY*	*$*	*8.00*	*$*	*12,800.00*
						$	**32,300.00**
	3.3 Cover Soil						
	Haul, and Place Amended Cover Soil Cap	*4,000*	*CY*	*$*	*12.00*	*$*	*48,000.00*
	Backfill Excavated Areas	*2,000*	*CY*	*$*	*8.00*	*$*	*16,000.00*
						$	**64,000.00**
	3.4 Reclaim TA-2						
	Regrade and Cover TA-2	*300*	*CY*	*$*	*3.00*	*$*	*900.00*
						$	**900.00**
	3.5 Revegetation						
	Organic Amendment	*250*	*Dry Ton*	*$*	*250.00*	*$*	*62,500.00*
	Fertilize and Seed	*6*	*AC*	*$*	*1,000.00*	*$*	*6,000.00*
	Mulch	*6*	*AC*	*$*	*2,000.00*	*$*	*12,000.00*
						$	**80,500.00**
4	**Drainage Reconstruction**						
	4.1 Construct New Stream Channel						
	Excavation	*500*	*LF*	*$*	*12.00*	*$*	*6,000.00*
	Grouted Riprap	*150*	*CY*	*$*	*150.00*	*$*	*22,500.00*
						$	**28,500.00**
	SUBTOTAL:					$	276,320.00
	Contingency (15%):					$	41,448.00
	TOTAL CAPITAL COSTS:					**$**	**317,768.00**

Table E-4							
Alternative 4a - Consolidate Waste Rock 2, Waste Rock 3 and Tailings in On-Site Repository with Cover Soil Cap							
Item	**Description**	**Quantity**	**Unit**	**Unit Price**		**Total Price**	
1	**Administration**						
	1.1 Mobilization, Bonding, Insurance (10%)	**1**	**LS**	**$**	**30,030.00**	**$**	**30,030.00**
2	**Site Preparation**						
	2.1 Road Improvements						
	Main Access Road	*4.0*	*MI*	*$*	*1,000.00*	*$*	*4,000.00*
	Construction Access Roads	*1.0*	*MI*	*$*	*1,000.00*	*$*	*1,000.00*
	Repository Access Road	*1.0*	*MI*	*$*	*1,000.00*	*$*	*1,000.00*
						$	**6,000.00**
3	**Reclamation**						
	3.1 Borrow Area						
	Strip, Stockpile and Replace Borrow Area Topsoil	*2,000*	*CY*	*$*	*5.00*	*$*	*10,000.00*
	Excavate/Stockpile Borrow Area Cover Soil	*7,000*	*CY*	*$*	*5.00*	*$*	*35,000.00*
						$	**45,000.00**
	3.2 Reclaim WR-1						
	Regrade WR-1	*5,000*	*CY*	*$*	*3.00*	*$*	*15,000.00*
						$	**15,000.00**
	3.3 Consolidate Waste Material in Repository						
	Excavate, Haul and Place WR-2	*1,000*	*CY*	*$*	*12.00*	*$*	*12,000.00*
	Excavate, Haul and Place WR-3	*500*	*CY*	*$*	*12.00*	*$*	*6,000.00*
	Excavate, Haul and Place TA-1	*1,600*	*CY*	*$*	*12.00*	*$*	*19,200.00*
	Excavate, Haul and Place TA-2	*300*	*CY*	*$*	*12.00*	*$*	*3,600.00*
						$	**40,800.00**
	3.4 Cover Soil						
	Haul, and Place Amended Cover Soil Cap	*4,000*	*CY*	*$*	*12.00*	*$*	*48,000.00*
	Backfill Excavated Areas	*3,000*	*CY*	*$*	*8.00*	*$*	*24,000.00*
						$	**72,000.00**
	3.5 Revegetation						
	Organic Amendment	*300*	*Dry Ton*	*$*	*250.00*	*$*	*75,000.00*
	Fertilize and Seed	*6*	*AC*	*$*	*1,000.00*	*$*	*6,000.00*
	Mulch	*6*	*AC*	*$*	*2,000.00*	*$*	*12,000.00*
						$	**93,000.00**
4	**Drainage Reconstruction**						
	4.1 Construct New Stream Channel						
	Excavation	*500*	*LF*	*$*	*12.00*	*$*	*6,000.00*
	Stream Bed Material	*150*	*CY*	*$*	*150.00*	*$*	*22,500.00*
						$	**28,500.00**
	SUBTOTAL:					$	330,330.00
	Contingency (15%):					$	49,549.50
	TOTAL CAPITAL COSTS:					**$**	**379,879.50**

Table E-5							
Alternative 4b - Consolidate All Waste in On-Site Repository with Cover Soil Cap							
Item	**Description**	**Quantity**	**Unit**	**Unit Price**		**Total Price**	
1	**Administration**						
	1.1 Mobilization, Bonding, Insurance (10%)	**1**	**LS**	**$**	**50,205.00**	**$**	**50,205.00**
2	**Site Preparation**						
	2.1 Road Improvements						
	Main Access Road	*4.0*	*MI*	*$*	*1,000.00*	*$*	*4,000.00*
	Construction Access Roads	*1.0*	*MI*	*$*	*1,000.00*	*$*	*1,000.00*
	Repository Access Road	*1.0*	*MI*	*$*	*1,000.00*	*$*	*1,000.00*
						$	**6,000.00**
3	**Reclamation**						
	3.1 Borrow Area						
	Strip, Stockpile and Replace Borrow Area Topsoil	*2,000*	*CY*	*$*	*5.00*	*$*	*10,000.00*
	Excavate/Stockpile Borrow Area Cover Soil	*11,000*	*CY*	*$*	*5.00*	*$*	*55,000.00*
						$	**65,000.00**
	3.2 Consolidate Waste Material in Repository						
	Excavate, Haul and Place WR-1	*10,000*	*CY*	*$*	*12.00*	*$*	*120,000.00*
	Excavate, Haul and Place WR-2	*1,000*	*CY*	*$*	*12.00*	*$*	*12,000.00*
	Excavate, Haul and Place WR-3	*500*	*CY*	*$*	*12.00*	*$*	*6,000.00*
	Excavate, Haul and Place TA-1	*1,600*	*CY*	*$*	*12.00*	*$*	*19,200.00*
	Excavate, Haul and Place TA-2	*300*	*CY*	*$*	*12.00*	*$*	*3,600.00*
						$	**160,800.00**
	3.3 Cover Soil						
	Haul, and Place Amended Cover Soil Cap	*7,000*	*CY*	*$*	*12.00*	*$*	*84,000.00*
	Backfill Excavated Areas	*4,000*	*CY*	*$*	*8.00*	*$*	*32,000.00*
						$	**116,000.00**
	3.4 Revegetation						
	Organic Amendment	*500*	*Dry Ton*	*$*	*250.00*	*$*	*125,000.00*
	Fertilize and Seed	*6*	*AC*	*$*	*1,000.00*	*$*	*6,000.00*
	Mulch	*6*	*AC*	*$*	*2,000.00*	*$*	*12,000.00*
						$	**143,000.00**
4	**Drainage Reconstruction**						
	4.1 Construct New Stream Channel						
	Excavation	*500*	*LF*	*$*	*12.00*	*$*	*6,000.00*
	Stream Bed Material	*150*	*CY*	*$*	*35.00*	*$*	*5,250.00*
						$	**11,250.00**
	SUBTOTAL:					$	552,255.00
	Contingency (15%):					$	82,838.25
	TOTAL CAPITAL COSTS:					**$**	**635,093.25**

Table E-6							
Alternative 5a - Consolidate All Waste in On-Site Repository with Multi-Layer Cap							
Item	**Description**	**Quantity**	**Unit**	**Unit Price**		**Total Price**	
1	**Administration**						
	1.1 Mobilization, Bonding, Insurance (10%)	**1**	**LS**	**$**	**63,705.00**	**$**	**63,705.00**
2	**Site Preparation**						
	2.1 Road Improvements						
	Main Access Road	*4.0*	*MI*	*$*	*1,000.00*	*$*	*4,000.00*
	Construction Access Roads	*1.0*	*MI*	*$*	*1,000.00*	*$*	*1,000.00*
	Repository Access Road	*1.0*	*MI*	*$*	*1,000.00*	*$*	*1,000.00*
						$	**6,000.00**
3	**Reclamation**						
	3.1 Borrow Area						
	Strip, Stockpile and Replace Borrow Area Topsoil	*2,000*	*CY*	*$*	*5.00*	*$*	*10,000.00*
	Excavate/Stockpile Borrow Area Cover Soil	*11,000*	*CY*	*$*	*5.00*	*$*	*55,000.00*
						$	**65,000.00**
	3.2 Consolidate Waste Material in Repository						
	Excavate, Haul and Place WR-1	*10,000*	*CY*	*$*	*12.00*	*$*	*120,000.00*
	Excavate, Haul and Place WR-2	*1,000*	*CY*	*$*	*12.00*	*$*	*12,000.00*
	Excavate, Haul and Place WR-3	*500*	*CY*	*$*	*12.00*	*$*	*6,000.00*
	Excavate, Haul and Place TA-1	*1,600*	*CY*	*$*	*12.00*	*$*	*19,200.00*
	Excavate, Haul and Place TA-2	*300*	*CY*	*$*	*12.00*	*$*	*3,600.00*
						$	**160,800.00**
	3.3 Repository Cap and Cover Soil						
	Geotextile Cushion	*10,000*	*SY*	*$*	*2.50*	*$*	*25,000.00*
	Geosynthetic Clay Liner	*10,000*	*SY*	*$*	*5.50*	*$*	*55,000.00*
	Geocomposite Drainage Layer	*10,000*	*SY*	*$*	*5.50*	*$*	*55,000.00*
	Haul, and Place Amended Cover Soil Cap	*7,000*	*CY*	*$*	*12.00*	*$*	*84,000.00*
	Backfill Excavated Areas	*4,000*	*CY*	*$*	*8.00*	*$*	*32,000.00*
						$	**251,000.00**
	3.4 Revegetation						
	Organic Amendment	*500*	*Dry Ton*	*$*	*250.00*	*$*	*125,000.00*
	Fertilize and Seed	*6*	*AC*	*$*	*1,000.00*	*$*	*6,000.00*
	Mulch	*6*	*AC*	*$*	*2,000.00*	*$*	*12,000.00*
						$	**143,000.00**
4	**Drainage Reconstruction**						
	4.1 Construct New Stream Channel						
	Excavation	*500*	*LF*	*$*	*12.00*	*$*	*6,000.00*
	Stream Bed Material	*150*	*CY*	*$*	*35.00*	*$*	*5,250.00*
						$	**11,250.00**
	SUBTOTAL:					$	700,755.00
	Contingency (15%):					$	105,113.25
	TOTAL CAPITAL COSTS:					**$**	**805,868.25**

Table E-7						
Alternative 5b - Consolidate All Waste in On-Site Modified RCRA Repository						
Item	**Description**	**Quantity**	**Unit**	**Unit Price**		**Total Price**
1	**Administration**					
	1.1 Mobilization, Bonding, Insurance (10%)	**1**	**LS**	**$ 73,055.00**	**$**	**73,055.00**
2	**Site Preparation**					
	2.1 Road Improvements					
	Main Access Road	*4.0*	*MI*	*$ 1,000.00*	*$*	*4,000.00*
	Construction Access Roads	*1.0*	*MI*	*$ 1,000.00*	*$*	*1,000.00*
	Repository Access Road	*1.0*	*MI*	*$ 1,000.00*	*$*	*1,000.00*
					$	**6,000.00**
3	**Reclamation**					
	3.1 Borrow Area					
	Strip, Stockpile and Replace Borrow Area Topsoil	*2,000*	*CY*	*$ 5.00*	*$*	*10,000.00*
	Excavate/Stockpile Borrow Area Cover Soil	*11,000*	*CY*	*$ 5.00*	*$*	*55,000.00*
					$	**65,000.00**
	3.2 Consolidate Waste Material in Repository					
	Excavate, Haul and Place WR-1	*10,000*	*CY*	*$ 12.00*	*$*	*120,000.00*
	Excavate, Haul and Place WR-2	*1,000*	*CY*	*$ 12.00*	*$*	*12,000.00*
	Excavate, Haul and Place WR-3	*500*	*CY*	*$ 12.00*	*$*	*6,000.00*
	Excavate, Haul and Place TA-1	*1,600*	*CY*	*$ 12.00*	*$*	*19,200.00*
	Excavate, Haul and Place TA-2	*300*	*CY*	*$ 12.00*	*$*	*3,600.00*
					$	**160,800.00**
	3.3 Leachate Collection/Removal System					
	Grade and Compact Subgrade	*10000*	*SY*	*$ 1.65*	*$*	*16,500.00*
	Leachate Collection/Removal System	*1*	*LS*	*$ 22,000.00*	*$*	*22,000.00*
	Geocomposite Drainage Layer	*10000*	*SY*	*$ 5.50*	*$*	*55,000.00*
					$	**93,500.00**
	3.4 Repository Cap and Cover Soil					
	Geotextile Cushion	*10,000*	*SY*	*$ 2.50*	*$*	*25,000.00*
	Geosynthetic Clay Liner	*10,000*	*SY*	*$ 5.50*	*$*	*55,000.00*
	Geonet Drainage Layer	*10,000*	*SY*	*$ 5.50*	*$*	*55,000.00*
	Haul, and Place Amended Cover Soil Cap	*7,000*	*CY*	*$ 12.00*	*$*	*84,000.00*
	Backfill Excavated Areas	*4,000*	*CY*	*$ 8.00*	*$*	*32,000.00*
					$	**251,000.00**
	3.5 Revegetation					
	Organic Amendment	*500*	*Dry Ton*	*$ 250.00*	*$*	*125,000.00*
	Fertilize and Seed	*6*	*AC*	*$ 1,000.00*	*$*	*6,000.00*
	Mulch	*6*	*AC*	*$ 2,000.00*	*$*	*12,000.00*
					$	**143,000.00**
4	**Drainage Reconstruction**					
	4.1 Construct New Stream Channel					
	Excavation	*500*	*LF*	*$ 12.00*	*$*	*6,000.00*
	Stream Bed Material	*150*	*CY*	*$ 35.00*	*$*	*5,250.00*
					$	**11,250.00**
	SUBTOTAL:				$	803,605.00
	Contingency (15%):				$	120,540.75
	TOTAL CAPITAL COSTS:				**$**	**924,145.75**