Minerals & Geology - ANTIMONY QUEEN

- 2002-02-26_CERCLA_ICIM--sowa
- 2002-07_APA_antimony_queen--boles
- 2003-12_SI_report_antimony_queen--CES
- 2004-03-05_baseline_prp_report_antimony_queen--lentz
- 2006-04--EECA_report_antimony_queen-CES
- Acronyms

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ANTIMONY QUEEN MINE
INITIATION OF CERCLA INVESTIGATION
MEMORANDUM

I. PURPOSE

The purpose of this Memorandum is to document, pursuant to the Guidelines of the National Oil and Hazardous Substance Contingency Plan (NCP), 40 CFR 300, et seq., the decision to initiate a CERCLA investigation, and such further CERCLA actions as may be subsequently determined appropriate, as authorized by Section 104 (42 USC 9604) of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA; 42 USC 9601 et seq.), and Executive Order 12580, 52 Federal Register 2923-26 (January 23, 1987).

A release, or threat of a release, of hazardous substances, pollutants or contaminants that potentially pose a threat to public health or welfare or the environment, has occurred or may occur at the Antimony Queen Mine (Site) on and/or from lands under the jurisdiction, custody, or control of the USDA Forest Service, Okanogan and Wenatchee National Forests (National Forest System or NFS lands).

II. SITE CONDITIONS AND BACKGROUND

A. Site Location and Historical Activities

The Antimony Queen Mine is located approximately 9 mi (aerial distance) southwest of the town of Carlton, in Okanogan County, Washington. Mine workings occupy the lower to middle slopes of the steep, valley walls of Gold Creek drainage and are included within the Methow Mining District. The site is included on the Hungry Mountain USGS 7.5-minute topographic map (1968). The location and legal description for the site is:

- Latitude 48° 06’ 22”N
- Longitude 120° 02’ 21”W
- Section 11, Township 31 North, Range 21 East, Willamette Meridian

The following is a brief summary of the history of the Site:

- 1906 through 1919 –Four lode claims comprising the original Antimony Queen group were staked by L. W. Barton; Dixie Queen, Minnie, Blue Bell and Lucky Ike. All of these claims were maintained through 1919 by assessment work, Proofs of Labor and Notices of Intents to Hold. Various individuals and two different companies incorporated in Okanogan County (Antimony Queen Mining Co. and Gold Creek Antimony Mines and Smelter Co.) owned the mine during this period. The claims were abandoned after 1919.

    - 1916 – Purdy (1951) reports that 1000 tons of antimony ore and several hundred tons of antimony oxide were shipped from the mine about this time. The oxide product was reportedly manufactured in a small plant near the mine.

- 1937 through 1953– The property was relocated as the Silver Seal # 1-3 and Jumbo lodes beginning in 1937. H. Johnsten, W. B. Smith, V. LaMotte and G. Gibson shared ownership of the group until 1951, when the claims were quitclaimed to G. O. P. Antimony, Inc. The claims were abandoned after 1953.

    - 1941 -- Purdy (1951) reports 2/3rds of a car or ore were shipped in 1941 from the mine. Huntting (1956) reported production of 20 tons that year.

    - 1952 – A Proof of Labor filed by G. O. P. Antimony listed the following development work: 110 feet of drift, a 20 foot bridge and 1000 feet of road.

- 1970 through 1972 – Mine workings were relocated as the Antimony Queen lode by F. J. Reeves. Lessee (?) Cheryl Lee Mines, Inc. partially rebuilt the access bridge, reopened the workings and mined 4 tons of ore. The claims were abandoned after 1972.

- 1977 through 1978 – R. Holmes, K. Hoeft and F. Bissile relocated the Antimony Queen lode and mine workings. No appreciable work was accomplished and the claims were abandoned thereafter.

- 1981 through 1982 – E. Norquest relocated the Antimony Queen lode and mine workings. No appreciable work was accomplished and the claims were abandoned thereafter.

- 1983 through 1988 – D. Flannegan relocated the Antimony Queen lode and mine workings. No appreciable work was accomplished and the claims were abandoned thereafter.

- 1989 through 1993 – The Site was included in two large lode claim groups during this period. Successive owners were Canevex Resources, Inc. and Cameco US. Inc. Exploration work conducted by these parties was outside the Antimony Queen Mine area. No appreciable work was accomplished at the mine site and the claims were abandoned thereafter.

Site Characteristics

The Antimony Queen mine is located in North Fork Gold Creek, an east-flowing drainage off the Sawtooth Ridge Mountain Range, North Cascade Mountains geomorphic province. The Site occupies the southern portion of a major northwest trending structural low known as the Methow-Pasayten graben. This structure preserves Mesozoic-aged sedimentary and volcanic rocks of terrestrial and marine origin in a block extending from below Carlton northwestward into British Columbia. Mineral deposits at Antimony Queen occur in an eastward-striking quartz-calcite-sulfide vein system hosted by argillite and greywacke of the Cretaceous-Jurassic Newby Group (Barksdale, 1975). Genesis of the vein system is complex, involving several stages of development, fracturing and brecciation. Veins are reported up to 2 feet wide and ore shoots up to 2 feet wide and 40 feet long (Purdy, 1951). Minerals described in the vein system include pyrite,

arsenopyrite, sphalerite, galena, jamesonite, stibnite, quartz, and calcite. One to three ounces of gold per ton is reported in some of the pyrite and arsenopyrite crystals (Purdy, 1951). Commodities present at the Site include mainly antimony, with minor amounts of gold, lead, zinc, tungsten and arsenic.

Mine workings include five adits; four being mostly caved and one open. The lower two adits, at elevations of 1,940 and 1,970 feet above mean sea level (amsl) respectively, are the most extensive. Combined development totals up to 780 lineal feet of drifts and crosscuts in these adits, with an additional 200 lineal feet in the other workings. Total waste rock disposed at all adit portals is less than 2000 cubic yards (CES, 2004). Total production from the Antimony Queen Mine has been relatively small, probably less than 1200 tons.

B. Release or Threatened Release into the Environment of a Hazardous Substance, Pollutant, or Contaminant

A Site Inspection completed at the Site (CES, 2004) has determined that a release has occurred and that an Engineering Evaluation/Cost Analysis (EE/CA) is warranted.

C. Actions Taken on the Site

Recent actions taken at the Site include:

1. *Abbreviated Preliminary Assessment, USFS 7/02*
2. *Site Inspection, CES Engineering 01/04*

III. PROPOSED ACTIONS AND ESTIMATED COSTS

The proposed action for the Site is to initiate CERCLA. In compliance with the NCP, an EE/CA will be performed to evaluate removal alternatives.

The anticipated costs for the various aspects of the project are uncertain at this time as valuable data is missing. However, costs for work completed and an estimate of future work would be:

1. APA - $4000
2. SI - $78,000
3. EE/CA - $50,000
4. PRP Search - $10,000
5. Removal Action - $300,000
6. Three year monitoring - $78,000
7. Total Anticipated Cost - $520,000

IV. ADMINISTRATIVE RECORD AND COMMUNITY RELATIONS

Pursuant to 40 CFR 300.415(m), I designate Dennis Boles of the Fremont/Winema National Forest as the On-Scene Coordinator and Rod Lentz/Deb Kelly Okanogan-Wenatchee National Forests, as Spokespersons for the project.

A Community Relations Plan will be developed for this project. The Administrative Record for any response action selected will be compiled and made available during regular business hours at the office of the Okanogan and Wenatchee National Forests, Okanogan Valley Office, Okanogan, Washington. A Notice of Availability of the Administrative Record will be published in local newspapers.

V. DECISION

By this Memorandum, I am initiating CERCLA activities at the Antimony Queen Mine as appropriate.

By copy of this Memorandum, we are formally notifying the State of Washington and EPA of our finding of the appropriateness of initiating CERCLA activities at the Site.

VI. REFERENCES

CES, 2004 Site inspection, Antimony Queen Mine: Unpublished USFS report, Contract #10181-1-D007, 20 p. plus tables, figures and appendices.

Huntting, M. T., 1956, Inventory of Washington Minerals, Part II: Washington Div. of Mines and Geology, Bull. 37, 428 p.

Purdy, C. P., 1951, Antimony occurrences of Washington: Washington Div. of Mines and Geology, Bull. 39, 186 p.

S/ Richard Sowa
Richard Sowa Date: 02/26/04
Director of Engineering
Pacific Northwest Region

cc:
Ecology
EPA

ABBREVIATED PRELIMINARY ASSESMENT

ANTIMONY QUEEN

Okanogan National Forest
Okanogan County, Washington

July 2002

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EXECUTIVE SUMMARY

The Forest Service performed an Abbreviated Site Assessment for the Antimony Queen mine (Site) to determine the need for further site characterization. The Site waste piles are placed on steep side slopes and a portion are located within the Gold Creek floodplain. A Niton XRF unit was used for In Situ field screening of the waste piles for any potential contaminants. Water and sediment samples were not collected.

Three elements exceeded EPA Region IX Preliminary Remediation Goals (PRG) as to acceptable industrial levels in soil. The elements were arsenic, antimony and nickel. It is apparent material is moving into Gold Creek from erosion forces.

Based on the proximity of the Site to Gold Creek and to residential areas approximately one mile downstream from the Site, it is recommended a Site Inspection be performed.

ABBREVIATED PRELIMINARY ASSESSMENT
ANTIMONY QUEEN

1.0 INTRODUCTION

An Abbreviated Preliminary Assessment (APA) was performed by the US Forest Service in accordance with the EPA "Guidance for Performing Preliminary Assessments Under CERCLA", EPA "Improving Site Assessment: Abbreviated Preliminary Assessments" of 1999, the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) of 1980, the Superfund Amendments and Reauthorization Act (SARA) of 1986, and the National Contingency Plan as outlined in 40 CFR Parts 300.410(c)(1)(i-v).

The purpose of this investigation was to determine whether or not there is a potential for a release of contaminants to the environment and/or to human health. The purpose of an APA is to determine whether further site characterization is warranted. A Niton XRF 700 Series was utilized to help in the preliminary screening of this site.

2.0 SITE DESCRIPTION, OPERATIONAL HISTORY, AND WASTE CHARACTERISTICS

The Antimony Queen (Site) is located approximately 5 miles southwest of Carlton, WA, on Forest Service Road 4340. The legal description for the site is; Latitude: 48°06'22", Longitude: 120°02'21", Sec 11, T 31 N, R 21 E, USGS Quadrangle Map - Hungry Mountain. The site is situated on steep hillsides adjacent to Gold Creek. The Site is located in the mining district of Methow Squaw Creek.

The Site consists of four adits (Inventory of Washington Minerals: Part II, Metallic Minerals, 1956. Washington Division of Mines and Geology Bulletin 37) of which only the two lowest were located. The lower of these two adits is open and water is draining from its portal. Flow is very low, less than a gallon per minute. The higher adit is caved. The largest waste pile sits at the portals of and directly below these adits. The toe of a smaller waste pile, apparently originating from another working higher on the hillside, lies upstream from the main waste pile. Both occupy steep side slopes and lie partially in the flood zone of Gold Creek. There are no structures, other than the adits, in the area. Accessing the site requires crossing Gold Creek on foot as there are no bridges or roads on the Site. Approximately two acres are disturbed on the Site.

"A small amount of ore was extracted and may have been shipped in 1906. About 10 years later, 1000 tons of stibnite ore and several hundred tons of antimony oxide, which had been manufactured in a small plant near the mine, were shipped. About 2/3 of a carload of ore was shipped in 1941. Development includes three main adits and about 1000 feet of workings." (ibid., p. 18)

The waste piles are from hardrock mining and contain coloration indicative of high iron content. The host rock is argillite and graywacke. The ore minerals included of stibnite, jamesonite, arsenopyrite, pyrite, galena, sphalerite, and scheelite. Gangue minerals included calcite, pyrite, and pyrrhotite. Commodities for the Site consisted of antimony, gold, lead, zinc, tungsten and arsenic.

Currently, the site is inactive.

3.0 SITE SAMPLING AND TEST RESULTS

A Niton XRF, XL-722S was used to assess the waste piles for potential contamination. In Situ testing was performed on the Site per EPA Method 6200. Surface soils were removed to approximately 4 to 6 inches below grade in order to get below highly oxidized surface layers. Rocks, debris and other deleterious materials were removed. The soil was worked to gain a flat surface area on which to set the Niton.

No surface water, sediment, or adit discharge samples were collected and analyzed.

The following constituents exceeded EPA Region IX PRG industrial levels.

Location	Constituent	Result (mg/kg)	PRG (mg/kg)
Side Slope of Large Waste Pile	Arsenic	7200	2.7
	Antimony	3920	820
Upper Level of Large Waste Pile	Arsenic	7468	2.7
	Antimony	10,899	820
	Nickel	56,883	41,000
Toe of Small Waste Pile	Arsenic	6816	2.7
	Antimony	1989	820
	Nickel	74,598	41,000

It is apparent that material is entering Gold Creek. The ramification from this material entering an aquatic environment is unknown at this time.

4.0 SUMMARY

A portion of the Antimony Queen waste piles lay within the flood plan of Gold Creek. It was apparent erosion forces are contributing some material to Gold Creek. The site lies approximately one mile upstream from residential areas. It is suspected these residences have domestic water wells.

The constituents of concern that exceeded EPA Region IX industrial levels in soil were arsenic, antimony and nickel. At this time, it is unclear as to any impacts to the aquatic environment.

5.0 RECOMMENDATION

Based on the In Situ screening of the waste piles with the Niton XRF unit, the proximity of the waste piles to Gold Creek, the proximity of residences to the Site and EPA's APA Checklist (Appendix A), it is recommended that a Site Investigation (SI) be completed. As part of this investigation, water samples from pore spaces of the stream gravels should be collected as well as sampling of the benthic organisms. In addition to testing water samples from the pore spaces of

the gravels for the presence of metallic elements, water parameters such as pH, conductivity, turbidity, dissolved oxygen, temperature, total dissolved solids, and oxygen reduction potential are required. The waste piles should be sampled at depth and a determination of volumes should be calculated. The water from the lower adit should be sampled and tested for the field parameters as outlined above as well as for elemental contaminants. Acid base accounting (ABA) is required. Sediment samples are to be collected from the center of the stream and preferably at depth and analyzed. Surface water samples are also required.

Appendix A

ABBREVIATED PRELIMINARY ASSESSMENT CHECKLIST

ABBREVIATED PRELIMINARY ASSESSMENT CHECKLIST

This checklist can be used to help the site investigator determine if an Abbreviated Preliminary Assessment (APA) is warranted. This checklist should document the rationale for the decision on whether further steps in the site investigation process are required under CERCLA. Use additional sheets, if necessary.

Checklist Preparer: Dennis Boles, Environmental Engineer (Name/Title) — July 29, 2002 (Date)

Winema NF, 2819 Dahlia St, Klamath Falls, OR 97601 (Address) — 541-219-1201 (Phone)

djboles@fs.fed.us (E-Mail Address)

Site Name: Antimony Queen

Previous Names (if any): New Deal, Dixie Queen, Reedy, Silver Seal

Site Location: The site is located approximately 5 miles southwest of Carlton on FS Road 4340.

The site is located on the riparian area of Gold Creek.

Legal Description: Latitude: 48°06'22" Longitude: 120°02'21"

Describe the release (or potential release) and its probable nature: Gold Creek runs at the toe of the waste pile. The following elements exceed industrial levels of the PRGs and the results and relevant PRG industrial levels are listed in parentheses:

Side Slope of Waste Pile: Arsenic – 7200 mg/kg (2.7 mg/kg), Antimony – 3920 (820)

Upper Level of Waste Pile: Arsenic – 7468, Antimony – 10,899, Nickel – 56,883 (41,000)

Site Adjacent to the Main Waste Pile: Arsenic – 6816, Antimony – 1989, Nickel – 74,598

Part 1 - Superfund Eligibility Evaluation

If All answers are "no" go on to Part 2, otherwise proceed to Part 3	**YES**	**NO**
1. Is the site currently in CERCLIS or an "alias" of another site?		**X**
2. Is the site being addressed by some other remedial program (Federal, State, or Tribal)?		**X**
3. Are the hazardous substances potentially released at the site regulated under a statutory exclusion (i.e., petroleum, natural gas, natural gas liquids, synthetic gas usable for fuel, normal application of fertilizer, release located in a workplace, naturally occurring, or regulated by the NRC, UMTRCA, or OSHA)?		**X**
4. Are the hazardous substances potentially released at the site excluded by policy considerations (i.e., deferred to RCRA corrective action)?		**X**
5. Is there sufficient documentation to demonstrate that no potential for a release that could cause adverse environmental or human health impacts exist (i.e., comprehensive remedial investigation equivalent data showing no release above ARAR's, completed removal action, documentation showing that no hazardous substance release have occurred, or an EPA approved risk assessment completed)?		**X**

Please explain all "yes" answer(s). _____

_____

_____

_____

Part 2 - Initial Site Evaluation

For Part 2, if information is not available to make a "yes" or "no" response, further investigation may be needed. In these cases, determine whether an APA is appropriate. Exhibit 1 parallels the questions in Part 2. Use Exhibit 1 to make decisions in Part 3.

If the answer is "no" to any questions 1, 2, or 3, proceed directly to Part 3.	**YES**	**NO**
1. Does the site have a release or a potential to release?	X	
2. Does the site have uncontained sources containing CERCLA eligible substances?	X	
3. Does the site have documented on-site, adjacent, or nearby targets?	X	

If the answers to questions 1, 2, and 3 above were all "yes" then answer the questions below before proceeding to Part 3.	**YES**	**NO**
4. Does documentation indicate that a target (i.e., drinking water wells, drinking surface water intakes, etc.) has been exposed to a hazardous substance released from the site?		X
5. Is there an apparent release at the site with no documentation of exposed targets, but there are targets on site or immediately adjacent to the site?	X	
6. Is there an apparent release and no documented on-site targets or targets immediately adjacent to the site, but there are nearby targets (i.e., targets within 1 mile)?	X	
7. Is there no indication of a hazardous substance release, and there are uncontained sources containing CERCLA hazardous substances, but there is a potential to release with targets present on site or in proximity to the site?	X	

Notes:

EXHIBIT 1

SITE ASSESSMENT DECISION GUIDELINES FOR A SITE

Exhibit 1 identifies different types of site information and provides some possible recommendations for further site assessment activities based on that information. You will use Exhibit 1 in determining the need for further action at the site, based on the answers to the questions in Part 2. Please use your professional judgment when evaluating a site. Your judgment may be different from the general recommendations for a site given below.

Suspected/Documented Site Conditions		**APA**	**FULL PA**	**PA/SI**	**SI**
1. There are no releases or potential to release.		Yes	No	No	No
2. No uncontained sources with CERCLA-eligible substances are present on site.		Yes	No	No	No
3. There are no on-site, adjacent, or nearby targets		Yes	No	No	No
4. There is documentation indicating that a target (i.e., drinking water wells, drinking surface water intakes, etc.) has been exposed to a hazardous substance released from the site.	Option 1: APA SI	Yes	No	No	Yes
	Option 2: PA/SI	No	No	Yes	No
5. There is an apparent release at the site with no documentation of exposed targets, but there are targets on site or immediately adjacent to the site.	Option 1: APA SI	Yes	No	No	Yes
	Option 2: PA/SI	No	No	Yes	N/A
6. There is an apparent release and no documented on-site targets and no documented immediately adjacent to the site, but there are nearby targets. Nearby targets are those targets that are located within 1 mile of the site and have a relatively high likelihood of exposure to a hazardous substance migrating from the site.		No	Yes	No	No
7. There is no indication of a hazardous substance release, and there are uncontained sources containing CERCLA hazardous substances, but there is a potential to release with targets present on site or in proximity to the site.		No	Yes	No	No

<u>Part 3 - EPA Site Assessment Decision</u>

When completing Part 3, use Part 2 and Exhibit 1 to select the appropriate decision. For example, if the answer to question 1 in Part 2 was “no,” then an APA may be performed and the “NFRAP” box below should be checked. Additionally, if the answer to question 4 in Part 2 is “yes,” then you have two options (as indicated in Exhibit 1): Option 1 -- conduct an APA and check the “Lower Priority SI” or “Higher Priority SI” box below; or Option 2 -- proceed with a combined PA/SI assessment.

Check the box that applies based on the conclusions of the APA:

( ) NFRAP
(X) Higher Priority SI
( ) Lower Priority SI
( ) Defer to RCRA Subtitle C
( ) Defer to NRC
( ) Refer to Removal Program – further site assessment needed
( ) Refer to Removal Program – NFRAP
( ) Site is being addressed as part of another CERCLIS site
( ) Other: _____

Regional EPA Reviewer: _____ _____
Print Name/Signature Date

PLEASE EXPLAIN THE RATIONALE FOR YOUR DECISION:

The toe of the waste pile at Antimony Queen is on the floodplain of Gold Creek. It is obvious that material is transported to Gold Creek during rain and snow melt situations. Considering there are residential users within one (1) mile downstream of the site, an SI is warranted for this site. Also, water samples from the pore spaces of the gravels of Gold Creek should be collected both up and down stream from the site and analyzed for impacts to benthic organisms. Arsenic, antimony, and nickel all exceed the EPA Region IX PRGs for industrial levels. ABA should be performed at the site.

NOTES:

The site sits on steep side slopes and getting equipment on the waste piles is impossible. Based on this, hand tools will be required in order to collect soil samples for laboratory evaluation and to determine the volume of material on-site as well as any impact to groundwater in the area.

Minerals & Geology - ANTIMONY QUEEN

Site Inspection Report

- Report (text, tables, and figures (PDF (download size 3.5MB)
- Appendix A. Sampling and Analysis Plan (SAP) change
- Appendix B. Photographs
- Appendix C. General Information Form (PDF download size 89kb)
- Appendix D. Mine Maps and Miscellaneous
- Appendix E. Well Logs and Water Rights
- Appendix F. Ecological Survey
- Appendix G. Laboratory Analytical Reports
- Appendix H. Quality Assurance/Quality Control (PDF download size 13kb)

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509.996.2208 Fax

Naches Ranger District
10237 Highway 12
Naches, WA 98937

509.653.1401 Voice/TTY
509.653.2638 Fax

North Cascade Smokejumper Base
23 Intercity Airport Road
Winthrop, WA 98862

509.997.9750 Voice
509.997.2077 Fax

Tonasket Ranger District
1 West Winesap
Tonasket, WA 98855 (509) 486-2186 Voice

509.486.1922 Fax
509.486.5144 TTY

Wenatchee River Ranger District
600 Sherbourne
Leavenworth, WA 98826

509. 548-2550 or 548.2551 Voice
509.548.5817 Fax

Forestry Sciences Laboratory
1133 N. Western
Wenatchee, WA 98801

509.662-4315 Voice
509.664.2742 Fax

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SITE INSPECTION
Antimony Queen Mine
Okanogan National Forest

January 2004

SITE INSPECTION
Antimony Queen Mine
Okanogan National Forest

Principal Author and Investigator: *MaryAnn Amann, RG, Staff II Geologist*
Dustin G. Wasley, PE, Managing Engineer

Reviewed By: *John D. Martin, RG, Principal Geologist*

Prepared for: USDA Forest Service
Okanogan National Forest

Site Location: Antimony Queen Mine
Okanogan National Forest
Okanogan County, Washington

Prepared by: Cascade Earth Sciences
P.O. Box 14725
Spokane, Washington 99214
(509) 921-0290

PN: 2323008/January 2004

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EXECUTIVE SUMMARY

A Site Inspection (SI) was performed at the Antimony Queen Mine (Site), located in the Okanogan National Forest, near Carlton, Washington. The SI was conducted to assess if the Site poses an immediate and potential threat to human health and the environment, and to collect sufficient information to support a decision regarding the need for further action.

In general, the Site consists of five adits (four are collapsed and one is open) and two waste rock piles. The Site is situated adjacent to the main stem of Gold Creek, a tributary of the Methow River in central Washington. Evidence of mining waste was observed in Gold Creek in pool areas near the Site. Mining waste appears to have been introduced into the surface water by historic disposal practices, and by erosion of fine-grained waste rock during high rainfall events and during spring snowmelt.

The SI consisted of the following tasks 1) background information research and file review, 2) onsite and offsite site reconnaissance and ecological assessment, and 3) collection of soil, waste rock, plant tissue, surface water, pore water, sediment, and benthic macroinvertebrate samples. Based on the information gathered during these tasks, the results indicate the following:

- Hazardous substances (primarily arsenic) have been released from the Site to surface water and appear to have impacted stream sediments, pore-water, and possibly benthic macroinvertebrate populations. In addition, Gold Creek is a potential habitat for several federal and state threatened and endangered fish (Chinook salmon, steelhead and the bull trout) and other non-listed fish species (i.e., rainbow and cutthroat trout), which are possibly being affected by the release from the Site. Therefore, the surface water pathway is complete and further assessment is warranted.

- Groundwater is used for drinking water and other uses within the vicinity of the Site (< 1 mile) and a release from the Site could potentially affect local groundwater or impact wells downstream of the Site. Therefore, the groundwater pathway appears to be complete and further assessment is warranted.

- The soil exposure pathway is complete for both human and ecological receptors, and a release of hazardous substances has been documented in this SI. Waste rock samples exceeded the Environmental Protection Agency Industrial Preliminary Remediation Goals for both arsenic and antimony. In addition, onsite vegetation appears to be impacted by activities associated with the Site. Arsenic concentrations in plant tissue samples collected from waste piles ranged up to ten times higher than the concentrations measured in tissue samples collected from background locations.

- The most likely air exposure pathway is inhalation of dust or particulate matter. However, most of the particulate matter in the air originates from the waste piles currently at the Site. Therefore, remediation of the Site should address any air pathway concerns. Given this, and the remote location and limited use of the Mine, no further assessment into site-specific levels of compounds in the air is recommended.

Based on the information gathered as part of the SI and presented in this report, CES recommends performing an Engineering Evaluation / Cost Analysis (EECA) at the Site. As part of the EECA, a risk assessment should be performed to assess the human and ecological impacts, establish removal cleanup standards, and assess removal action alternatives. Physical dangers (i.e. opened adits, steep waste piles, etc.) should also be included as part of the EECA.

1.0 INTRODUCTION AND OBJECTIVES

The United States Forest Service (USFS) retained Cascade Earth Sciences (CES) to perform a Site Inspection (SI) at the Antimony Queen Mine (Site). The SI was performed in accordance to the U.S. Environmental Protection Agency (EPA) publication, *Guidance for Performing Site Inspections Under CERCLA* (EPA, 1992). The purpose of the SI is to determine the potential threat to human health and the environment from issues identified during the Abbreviated Preliminary Assessment (APA) conducted by the USFS at the Site (USFS, 2002). The work was performed under our existing 5-year USFS Contract (#10181-1-D007) and in accordance with the Purchase Order # 43-05GG-3-0035 dated March 12, 2003.

In general, the objectives of the SI were to (1) assess the immediate or potential threat that (mining) wastes pose to human health and/or the environment, and (2) collect sufficient information to support a decision regarding the need for further action. The information was collected in general accordance with CERCLA protocols and documentation requirements for assessments involving hazardous substances. Specifically, as outlined in the EPA CERCLA guidance document (EPA, 1992), "the sampling locations are strategically planned to identify the substances present, determine whether hazardous substances are being released to the environment, and determine whether hazardous substances have impacted specific targets."

The SI field activities included sampling and analysis of soil, waste rock, plant tissue, surface water, pore-water, and sediment samples from the Site and vicinity. This SI was performed following the Field Operation Plan (FOP) developed by CES, and approved by the USFS on June 1, 2003 (CES, 2003). The FOP was developed based on the APA completed by the USFS in 2002 and the Statement of Work (SOW) provided by the USFS in the request for proposals dated February 25, 2003. During field activities, CES made several modifications to the sampling locations and analyses after discussions and concurrence with the USFS Contracting Officers Representative (COR) and On-Scene Coordinator (OSC). These changes were documented in a letter from CES to the USFS on July 21, 2003; a copy of the letter is attached in Appendix A.

2.0 SITE DESCRIPTION, OPERATIONAL HISTORY AND WASTE CHARACTERISTICS

The following sections give a specific description of the Site location and an operational history of the Site. Photographs of the Site and sampling locations are included in Appendix B. No regulatory removal actions have been undertaken at the Site. In addition, no permits, violations, and/or regulatory inspections have been document at the Site. The General Information Form is included in Appendix C historical maps, sketches and miscellaneous information are included in Appendix D.

2.1 Description and Location

The Site is located in the Okanogan National Forest (ONF) in Okanogan County, approximately 9 miles southwest of Carlton, WA, (Plate 1). According to the USGS 7 ½ Minute Quadrangle Map - Hungry Mountain, the Site location is described as:

- Section 11, Township 31 North, Range 21 East of the Willamette Meridian;
- Latitude – 48° 06' 22"
- Longitude – 120° 02' 21"
- Elevation – 2,050 to 2,550 feet above mean sea level (amsl).

The Site is accessed by traveling from State Route 153 and turning west onto Gold Creek Loop Road. Continue on Gold Creek Loop Road and turn west on Forest Service Road (FR) 4340 (Gold Creek Road) and travel approximately 4 miles west. At the Okanogan National Forest sign, turn south on an unnamed access road, which dead ends into Gold Creek. Accessing the Site requires crossing Gold Creek on foot, as there are no bridges or roads to the Site. The Site is situated on steep slopes adjacent to Gold Creek. Approximately two acres are disturbed and the Site is inactive. Commodities for the Site consisted mainly of antimony, with minor amounts of gold, lead, zinc, tungsten and arsenic.

Figure 1 provides a general layout of the Site, including 2-foot contours and pertinent features. The following were identified as major and key features at the Site.

- Five adits exist at the Site, four are collapsed or partially collapsed (Adits 1, 3, 4 and 5) and one is open (Adit 2).
  - The lower most adit (Adit 1) is located at an elevation of 1940 feet amsl and reportedly consisted of 220-230 lineal feet of underground workings.
  - The main adit (Adit 2) is located approximately 50 feet west and upslope of Adit 1 at an elevation of approximately 1970 feet amsl, and has between 500 to 550 lineal feet of underground workings.
  - Adit 3 is located upslope and approximately 80 feet south of Adit 2 at an elevation of approximately 2050 feet amsl. No ore was extracted from this adit, as it reportedly only extended 30 to 35 lineal feet into the hillside.
  - Adit 4 is located approximately 2100 feet southwest and upslope of Adit 3 at an elevation of approximately 2160 feet amsl. No ore was extracted, as the adit reportedly only extended 40 lineal feet into the hillside.
  - The upper most adit (Adit 5) is located 70 feet southwest and upslope of Adit 4 at an elevation of approximately 2200 feet amsl. This adit reportedly has between 160 to 175 lineal feet of underground workings, which includes a stope that daylights 50 feet upgradient of the portal. Little is known about the production from this adit. However, judging from the waste rock pile (WR Pile 2) and scree field located downgradient from the adit, a limited amount of ore was probably extracted from this adit for further processing offsite.
- With the exception of what appeared to be a small empty "powder house" located 100 feet east of Adit 1, no structures were present at the Site.
- Two waste rock piles were observed during the SI field activities. Waste rock from both piles was observed in Gold Creek.
  - Waste Rock Pile 1 (WR1) is associated with Adit 2. Most of the ore that was extracted from the mine came from this adit. Based on the topographic survey and field observations, the volume of WR1 is estimated at 925 cubic yards (CY).
  - Waste Rock Pile 2 (WR2) is associated with Adit 5 and is situated along the steep slope above WR1. Waste rock from WR2 is scattered, at an average depth of 1.5 to 2 feet, for approximately 400 feet down to Gold Creek. Based on this, CES estimates the volume of WR2 at 650 CY.
- Gold Creek, a tributary to the Methow River, flows adjacent to WR1 and the base of WR2.

2.1.1 Operational History and Waste Characteristics

Little information is available regarding the operational history of the Antimony Queen Mine. However, the following information was gleaned from *Inventory of Washington Minerals – Part II Metallic Minerals* (Huntting, 1956), *Metal Mines of Washington Preliminary Report* (Derkey, et. al, 1990), and *USFS Report of Mineral Examination of the Antimony Queen Mine* (Garrett, 1970). The Site was also

known as the New Deal, Dixie Queen, Reedy, Silver Seal, and Jumbo Mines; and consists of four unpatented claims (Jumbo and Silver Seal No. 1, 2 and 3). All workings and production at the Site has been done on the Silver Seal No. 1 claim. The following information is a chronological summary of the operational history and production of the Site.

- 1906 – Site owned by Antimony Queen Mining Company, small amount of ore was extracted and shipped for smelting.
- 1916 – The Gold Creek Antimony Mine and Smelting Co. reportedly shipped 1000 tons of stibnite ore and several hundred tons of antimony oxide, which had been milled and concentrated in a small plant near the Site, for offsite smelting.
- 1940 – Owned by H.B. Johnston, Vernon LaMotte, George Gibson, and C.E. Baker.
- 1941 – Site leased by William Oldfield. Oldfield reported that about one ton of ore was being hand sorted per day during that time.
- 1949 – H.B. Johnston retained ownership of the Site.
- 1951 to 52 - Site leased to G.O.P. Antimony, Inc., by H.B. Johnston.
- 1970 – Francis Reeves began redevelopment of the Site; activities included partial construction of a bridge over Gold Creek near Adit 1, leveling of the mill site on the north side of Gold Creek, and excavation of exploratory pits to access ore body. Due to the decline in antimony prices, Francis never completed the redevelopment of the Site.

2.1.2 Climate

The information presented in this section was compiled from the Western Regional Climate Center website (WRCC, 2003). Climate in Okanogan County varies depending on elevation and distance from the Cascade summit. Precipitation decreases as elevation decreases in an easterly direction from the summit of the Cascade Range. The Site lies along the east slope of the Cascade Range at an elevation of between 2,000 to 2,300 feet amsl. The following data were compiled from the Stockdill Ranch Monitoring Station, located approximately 13 miles north of the Site at an elevation of 2,201 feet amsl.

- Total average precipitation is approximately 19 inches per year.
- Total average snowfall is approximately 109 inches per year.
- The average minimum temperature of approximately 6° F occurs in January.
- The average maximum temperature of approximately 85° F occurs in July.
- Temperature extremes range from approximately 104° F in summer to -32° F in winter months.

3.0 PATHWAYS AND ENVIRONMENTAL HAZARD ASSESSMENT

3.1 Groundwater Exposure Pathway

3.1.1 Geologic Setting

Regional geologic information presented in this section was obtained from the Washington State Natural Resource Department Division of Geology and Earth Resources (2003) and Orr and Orr (2002). Site-specific geology was compiled from Derkey (1990) and Bunning (1990), as well as site-specific reconnaissance performed by a CES Registered Geologist registered in the State of Washington.

3.1.1.1 Regional Geology

The Antimony Queen Mine is located in the Methow Terrane in the northeastern Cascade Range geologic province. The North Cascades consist of jagged mountains with numerous glaciers and are composed predominantly of Mesozoic crystalline and metamorphic rocks. The structural fabric is extremely complex because of the unrelated terranes that have been brought in contact with each other by strike-slip and thrust faults. The eastern boundary of the North Cascades province is the Chewack-Pasayten fault zone, located approximately 12 miles to the east of the Site. The Site lies within the Methow Basin, which is bounded on the west by the Ross Lake Fault and on the east by the Chewack-Pasayten Fault. The terrane is approximately 160 miles long and 20 miles wide tapering to the north.

The Methow Basin was a shallow marine inlet separated from the open ocean by a chain of volcanic islands (Orr et. al., 2002). Sediments filled the basin in Late Jurassic and were folded by compression and uplift in Late Cretaceous. A network of north-south trending faults separated and shifted the basin in the Early Tertiary to where it is today.

Geology in the vicinity of the Antimony Queen Mine consists of sedimentary rocks of the undivided Newby Group of Cretaceous-Jurassic age (Bunning, 1990). These rocks consist of irregularly interbedded, fine- to coarse-grained feldspathic volcanic lithic sandstones (graywacke), conglomerate, siltstones and silty black shales (argillite). Quartz, plagioclase and opaque minerals are found in sandstones and as matrix material. In places clasts and matrix have been altered to calcite, sericite, pyrite, hematite and other opaque minerals. In some areas such as the Gold Creek shear zones (in the South Fork Gold Creek area), the rocks have been dynamothermally metamorphosed under greenschist-facies and deformed in the ductile and/or brittle-ductile-transitional regimes. Quartz and calcite occur in both composite and monomineralic veins (Bunning, 1990).

Numerous folds and faults are mapped in the area around the Site. A buried axis of an anticline is mapped directly through the Site. During the SI field event, near the upper adit, the attitude of an exposed bed was measured at N 50 ^{o} W and dips 85° north. This correlates well with published fault data in the area.

3.1.1.2 Site Specific Mining Geology

Commodities at the Site included antimony, gold, silver and tungsten. Minerals include stibnite, pyrite, scheelite, pyrrhotite, galena, jamesonite, sphalerite, arsenopyrite and chalcopyrite. The gangue is calcite. The ore deposits are found in quartz veins and breccia zones in limey argillite. Ore veins are reportedly up to 2 feet wide and 40 feet long. One vein reportedly contained from 10 to 90% stibnite and was 2 to 12 inch wide.

The following site-specific geology is summarized from a detailed report by Purdy (1951). The reader is directed to the full report for more details.

- The Newby Formation in the vicinity of the Site has a general strike of N 30-40° W with dips varying from 50-80 ^{o} W.
- The mine workings trend along the eastward-striking vein system and extend from Gold Creek to elevations of about 383 feet above Gold Creek.
- No correlation could be made between rock types and quantity of sulfides.
- Fault displacement could not be determined.

- A quartz vein in Level No. 1 (Adit 1) reportedly contained pyrite, arsenopyrite, sphalerite, galena, jamesonite, stibnite, quartz and calcite. A spectrographic analysis of some of the pyrite and arsenopyrite crystals showed a content of 1 to 3 ounces of gold per ton. Prominent jointing was observed to contain scheelite (tungsten ore).
- The principle workings of the property are contained in Level No. 2 (Adit 2), 30 feet above Level No. 1. The best stibnite ore at the Site was reportedly located at the intersection of the Level No. 2 adit with the drift on Vein C (see underground workings map in Appendix D).
- Level No. 3 (Adit 3) was driven along a thin fault seam in a zone of crushed limonitized greywacke or argillilte about 2 feet thick.
- Level No. 4 (Adit 4) was a composite adit driven in badly crumpled and shattered greywacke or argillite stained with limonite.
- An assay collected from Level No. 5 (Adit 5) showed gold at 0.16 ounce/ton and silver at 0.46 ounce/ton, and arsenic at a concentration of 5.8%. Stibnite was present in a quartz vein varying from 2 inches to 1 foot thick with concentrations ranging up to 10% stibnite.

3.1.2 Hydrogeology

The Site is located within the Gold Creek watershed. A review of the State of Washington Water Resources Department (WRD) database for water wells Site shows over 28 wells located within a 4-mile radius of the Site. However, many of the wells are outside the Gold Creek drainage system (i.e. adjacent to the Methow River or along the Middle or South Fork). Therefore, only well logs from wells located directly along the North Fork and Main Stem of Gold Creek were reviewed in order to gain understanding about the shallow aquifer in the area. Two wells are upstream from the Mine and six are downstream. The approximate location of the wells are represented as circles and shown on Plate 1 and Figure 2. Generally these wells are shallow, less than 100 feet deep. They are cased 18 to 55 feet below ground surface (BGS). There is a cemented or hardpan zone above the water bearing zone listed on some of the well logs, which may act to semi-confine the lower aquifer. Static water levels are noted from 18 to 21 feet BGS on the drillers logs. Copies of the state well logs reviewed are included in Appendix E. None of the wells were sampled during the SI field activities.

The shallow geology of the Gold Creek drainage can be summarized as interbeds of sand and gravel and clay to a depth of approximately 60 feet BGS. These unconsolidated sediments are likely a result of Holocene glaciation, which deposited glacial drift along the stream channels. Weathered bedrock (stated as granite on the logs) is encountered below the unconsolidated sediments. The depth of first water is not noted on the well logs, one can only assume that shallow groundwater would be found in the sand and gravel lenses. However, the shallow water table may not be laterally extensive as clay and boulders are usually deposited contemporaneously in a glacial environment and may truncate water bearing lenses.

None of the five adits associated with the Site had flowing seeps during the SI field activities; however, only Adit 1 had evidence that seeps may occur during high flows times of the year.

3.1.3 Targets

Targets are defined as receptors that are located within the target distance for a particular pathway. For the groundwater pathway, the target distance has been defined as 4-miles and example targets are drinking water wells, wellhead protection areas, etc (See Plate 1). There are no wellhead protection areas located within a 4-mile radius of the Site. There are however numerous homes within a 4-mile radius of the Site. The homes outside the Gold Creek Drainage system are not discussed further. Several homes (approximately 8) are within the Gold Creek drainage system, downstream from the Site and have wells as a source of their domestic water supply. As mentioned in the previous section (Section 3.1.2), these wells are generally

shallow, less than 100 feet deep, and are cased 18 to 55 feet BGS with static water levels between 18 and 21 feet BGS.

3.1.4 Groundwater Exposure Pathway Summary

Groundwater is used for drinking water and other uses within the vicinity of the Site (< 1 mile) and it is likely that groundwater provides base flow to Gold Creek during certain times of the year. Based on this, a release from the Site could potentially affect local groundwater or impact wells downstream of the Site. Therefore, the groundwater pathway appears to be complete and further assessment is warranted.

3.2 Surface Water Exposure Pathway

3.2.1 Hydrologic Setting

The Antimony Queen Mine is bordered on the northeast by the Gold Creek (Plate 1 and Figure 2). According to the USGS 7½ minute quadrangle maps (USGS, 1990) of the area, the Gold Creek watershed above the Antimony Queen Mine is approximately 29,000 acres or 45 square miles (Plate 1). Various springs and unnamed tributaries flow into Gold Creek upgradient of the Site, the largest is Foggy Dew Creek, located approximately 1 mile upstream. During wet times of the year it appears that a seep emanates from Adit 1, which eventually discharges into Gold Creek, just downstream of WR1. However, during the field activities, no water was flowing from the adit, but based on field observations the flow appears to be relatively low (i.e., < 10 gallons per minute). Overland flow (i.e. sheet flow) down the slope and across both waste rock piles at the Antimony Queen Mine flows north into Gold Creek.

Approximately 1 mile below the Site the Middle Fork of Gold Creek discharges to the main stem of Gold Creek; and another mile downstream, the South Fork of Gold Creek enters. Gold Creek eventually flows into the Methow River approximately 5.5 miles below the Site. The Methow River flows south and east, for approximately 20 miles, before the confluence with the Columbia River at Lake Pateros. Plate 1 also shows the 1- and 4-mile radius circles from the Site and the confluence of Gold Creek and the Methow River.

The flow rates in Gold Creek were measured on two different dates. On July 8, 2003, the flow rate in Gold Creek, approximately 300 feet upstream of the Site, was measured at approximately 92 cubic feet per second (cfs). Additional flow rate measurements were collected on July 20, 2003 (Table 1) at each Station, flow rates ranged from approximately 77 cfs at Station GC-01 (located upstream of the Site) to 95 cfs at Station GC-04 (located downstream of the Site). For comparison, the flow rates of the Methow River measured at USGS Station 12449760 in Carlton were 3,020 cfs on July 8, 2003, and 1,650 cfs on July 20, 2003, (USGS, 2003). In addition, USGS Station 12449795 is located on Gold Creek, approximately 0.5 miles upstream of the confluence with the Methow River. However, the Station has only been used once, on September 21, 2001, to collect water quality parameters (i.e. flow rates, major cation and anions, temperature, etc.). The flow rate on September 21, 2001, was measured at 4 cfs, which indicates that the flows in Gold Creek fluctuate dramatically throughout the year. The bedload of Gold Creek consists of mainly boulders, cobbles, gravels, and sands, with minor amounts of silt and clay, see Appendix B for photographs.

3.2.2 Targets

For the surface water pathway, the target distance has been defined as 15-miles, and example targets are surface water intakes supplying drinking water, sensitive environments (i.e., wetlands), and aquatic organisms. As the Gold Creek empties into the Methow River, only points above the confluence are considered targets because of the high flow rate and dilution of the Methow River when compared to Gold Creek.

3.2.2.1 Local Surface Water Use

Plate 1 shows the 1 and 4-mile radius from the Antimony Queen Mine. There are several residences (approximately 8 year-round and 4 seasonal) along Gold Creek before the confluence with the Methow River. Surface water rights were examined and are shown as an inverted triangle on Plate 1 and Figure 2. Based on a review of the Washington Department of Ecology Water Rights Tracking System, there are reportedly17 surface water rights along Gold Creek between the Site and the Methow River, with some of the rights from the early 1900's. The rights are located by Township, Range and Section, and therefore the exact location of the point of diversion cannot be accurately determined. The quantity of the water rights varies from 0.02 cubic feet per second (cfs) to 2.11 cfs. A log of the water rights is included in Appendix E. Several water rights indicate that the surface water use is for domestic activities, as well as irrigation or water for livestock. Surface water uses were not field verified as part of the SI and since Gold Creek flows through the National Forest, public access is not restricted. Surface water use may also be used for swimming, camping (washing dishes, cooking), and fishing.

3.2.2.2 Wetlands

Maps outlining designated wetland areas were prepared by the National Wetlands Inventory (NWI), a division of the U.S. Fish and Wildlife Service. The document was prepared primarily by analysis of high altitude aerial photographs. Wetlands were identified based on vegetation, visible hydrology, and geography in accordance with Classification of Wetlands and Deepwater Habitats of the United States (USF&W, 1979). The following are considered "listed" on the NWI map (USF&W, 1995):

- Adjacent to the Site is designated as Palustrine, Forested, Temporarily Flooded (PFOA);
- Downstream of the Site is designated as PFOA and Riverine, Upper Perennial, Unconsolidated Shore, Temporarily Flooded (R3USA); and
- Approximately one mile downstream from the Site and continuing to the confluence with the Methow River, Palustrine scrub shrub seasonally flooded areas (PSSC) is present.

3.2.2.3 Aquatic Ecological Survey

Aquatic surveys were conducted to assess the potential impacts of the Site on the instream habitat, benthic macroinvertebrate community, and presence of fish species because each may be affected by site-related physical impacts or chemical contamination. Refer to Appendix F for complete Ecological Survey. Four stream reaches, approximately 300 feet in length, were established. One reach was established upstream of the Site and three downstream of the Site. An attempt was made to include both riffle and pool habitat within each reach. Habitat ratings were completed for each reach using USEPA Rapid Bioassessment Protocol - Habitat Assessment Field Data Sheets (Barbour 1999). Additional instream characterization was conducting with the Physical Characterization Field Data Sheet (Barbour 1999). The following habitat conditions were noted:

- Based on the assessment, the instream Gold Creek habitat is undisturbed and of relatively high quality.
- Habitat scores (172 to 184) indicated optimal physical habitat conditions for the upstream reach (at Station GC-01), the reach immediately downstream of the Site (at Station GC-02), and the farthest downstream reach (at Station GC-04).
- The reach at Station GC-03, located approximately 0.75 miles downstream from the Site, had a suboptimal habitat score (163), primarily due to the lack of streambank vegetation.
- All reaches had only one or two of four possible velocity/depth regimes, with fast/deep and slow/deep being absent from each reach.

- The reach at Station GC-04 had the highest habitat score (184). However, when substrate size, diversity, and composition (physical characterization) are also considered, the reach at Station GC-02 had the highest overall physical habitat quality. The diversity in substrate size at Station GC-02 may be related to waste-pile gravel being deposited in this area.

Sampling of benthic macroinvertebrates was conducted in pool and riffle habitat at each of the stream reaches. At Station GC-01, GC-02, and GC-03, only off-channel pools were present. Because no off-channel pool habitats were available in the vicinity of Station GC-04, the pool sample was collected from a small depositional area along the shoreline of a relatively deep "run" habitat. Laboratory enumeration was completed for up to 300 individuals in each sample. Abundance, diversity, metals tolerance, and temperature preference were examined for the invertebrates present in each pool and riffle sample, and were qualitatively compared between Stations. Pool data were only compared to other pool data and riffle data were only compared to other riffle data. The results of the benthic invertebrate investigation in pool habitats show that:

- The abundance of all invertebrates was dominated by the Order Chironomidae, Family Diptera (midges, mosquitoes, gnats, and flies) and the abundance decreased consecutively from Station GC-01 to Station GC-03, then rebounded at Station GC-04. In addition, the abundance of nematodes (which includes species frequently considered tolerant of poor instream conditions) increased between Stations GC-01, GC-02, and GC-03, then decreased at Station GC-04.
- The diversity of functional feeding groups and species diversity in pool samples decreased consecutively between Stations GC-01, GC-02, and GC-03, and rebounded at Station GC-04. The number of species of gatherers and predators far outnumbered other functional feeding groups.
- The metals tolerance index increased slightly and was inversely correlated with the temperature preference metric for pool samples at Stations GC-02 and GC-03. The Shannon-Weaver species diversity index for these two Stations was also inversely correlated with the metals tolerance index.
- These results suggest a potential impact to benthic invertebrate populations in pool habitats at Stations GC-02 and GC-03. The apparent rebound in diversity at Station GC-04 may be an artifact of the "pool" substation location being within the channel rather than off-channel pool habitat comparable to the other Stations.

The results of the benthic invertebrate investigation in riffle habitats suggest that:

- The abundance of all invertebrates and the pollution/habitat-sensitive EPT species (i.e., taxonomic Orders Ephemeroptera [mayflies], Plecoptera [stoneflies], and Trichoptera [caddisflies]) both increased at Station GC-02 then decreased consecutively at Stations GC-03 and GC-04 down to levels similar to Station GC-01 upstream of the Site.
- The diversity of functional feeding groups and species diversity in riffle samples varied, but remained similar for all Stations.
- The metals tolerance index decreased slightly and was inversely correlated with the temperature preference metric for riffle samples at Stations GC-02 and GC-04. The Shannon-Weaver species diversity index was essentially unchanged across all Stations.
- These results suggest minimal or no noticeable impacts to benthic invertebrate populations inhabiting riffle habitats downstream of the Site.

The presence of fish was documented by visual observation during the ecological survey. Only two fish (what appeared to be rainbow/steelhead trout) were noted, in an off-channel pool immediately

downstream of the Site at Station GC-02. No fish barriers were observed during the survey. A USFS fish biologist (Molesworth, 2003) and the Washington Department of Fish and Wildlife Priority Habitat and Species listing both acknowledge the presence of federally endangered anadromous Chinook salmon and steelhead trout, federally threatened Dolly Varden/bull trout, and resident rainbow trout, cutthroat trout, and sculpin. Although habitat scores ranked high, a relatively low abundance and/or lack of species diversity within the fish community is typical in cold headwater streams such as Gold Creek. Fish may be exposed to site-related contamination in surface water or sediment, and sculpins may be the most highly exposed fish due to their limited home range and bottom-dwelling/foraging habits.

3.2.3 Site Inspection Analytical Results

This section presents the surface water, pore water, and stream sediment analytical results for SI conducted at the Antimony Queen Mine. Sample locations are shown on Figure 2, analytical results are tabulated in Tables 1, 2 and 3, and the laboratory reports are located in Appendix G. Photographs of selected sampling locations are included in Appendix B. Changes to the sampling program were made during the field event after discussion and concurrence with the USFS representative. A complete report of the quality assurance / quality control (QA/QC) is included in Appendix H. Field activities were conducted from July 8 to 10, 2003; the reader is referred to the FOP (CES, 2003) for sampling procedure and protocols.

A total of eight water samples (four surface water and four pore-water) and four sediment samples were collected from pool substations in Gold Creek during the SI field activities; one upstream from the Site (Station GC-01), one adjacent to the Site (Station GC-02), and two downstream from the Site (Stations GC-03 and GC-04). Pore water and sediment samples could not be collected at the riffle substations due to the lack of sand, silt and clay substrate, and the presence of gravels, cobbles and boulders. Laboratory analysis includes the following for each of the media sampled:

- Surface Water – Total recoverable metals for the 23 Target Analyte List (TAL); arsenic speciation (III and V); chromium speciation (III and VI); total and weak acid dissociable (WAD) cyanide; pH; conductivity; hardness as calcium carbonate ($CaCO_3$); total dissolved solids (TDS); total suspended solids (TSS, organic and inorganic); total organic carbon (TOC); and sulfate.
- Pore Water – Dissolved metals for the 23 TAL; dissolved arsenic speciation (III and V); dissolved chromium speciation (III and VI); dissolved and WAD cyanide; pH; conductivity; hardness as $CaCO_3$; TDS; organic and inorganic TSS; and sulfate.
- Sediment – Total metals for the 23 TAL; acid volatile sulfides (AVS); simultaneously extracted metals (SEM) for cadmium, copper, lead, nickel, and zinc; grain size; and clay-sized particle mineral composition.

The following field parameters were collected at both the pool and riffle substations at each Station: pH, temperature, conductivity, dissolved oxygen (DO), oxygen reduction potential (Eh), turbidity, and TDS.

Surface water laboratory and field analytical results collected in Gold Creek are summarized in the following:

- Of the analyzed metals, only total arsenic and barium exceeded any of the applicable comparison criteria or standard.
- Total arsenic concentrations ranged from 0.322 micrograms per kilogram (μg/L) upstream of the Site at Station GC-1 to 0.489 μg/L at Station GC-3, which is located approximately 0.75 miles downstream of the Site. In all samples, total arsenic exceeded the State of Washington

and EPA Ambient Water Quality Criteria (AWQC) for Protection of Human Health of 0.018 μg/L. However, no forms of arsenic (total, III and V) exceeded any of the identified aquatic and ecological standards.

- Barium concentrations ranged from 10 μg/L at Station GC-3 to 11 μg/L at Station GC-1, 2, and 4. All samples exhibited barium concentrations above the ORNL surface water preliminary remediation goal (PRG) and the EPA Tier II secondary chronic value (SCV) of 4 μg/L. The State of Washington does not have human or ecological standards for barium in surface water.
- Total and WAD cyanide was not detected above the method detection limit (MDL) of 10 μg/L.
- Wet chemistry results are summarized as follows: pH ranged from 7.2 to 7.3 standard units (su); conductivity ranged from 64 to 74 microsiemans (uS); hardness as $CaCO_3$ ranged from 29 to 30 milligrams per liter (mg/L); TDS ranged from 40 to 50 mg/L; and sulfate was not detected above the method detection limit (MDL) of 10 mg/L.
- Field parameters measured, and their respective ranges, included: temperature (9.9 to 11.3 ^{o}C); pH (7.4 to 7.9 su); conductivity (50 to 52 uS); DO (14.4 to 18 mg/L); turbidity (92 to 145 NTUs); and Eh (61 to 272 millivolts [mv]).

Pore water laboratory and field analytical results collected in Gold Creek are summarized in the following:

- Of the metals analyzed, only arsenic V, barium, iron, manganese and silver exceeded any of the applicable ecological comparison standards.
- Dissolved arsenic V concentrations ranged from 0.36 μg/L at Station GC-1 to 7.30 μg/L at Station GC-2, which is located adjacent to the Site. Two samples, collected at Stations GC-2 and GC-3, exceeded the ORNL surface water PRG and the Tier II SCV of 3.1 μg/L. The State of Washington does not have ecological standards for arsenic V in pore water.
- Two samples, collected at Stations GC-2 and GC-3 (16 and 15 μg/L, respectively), exceeded the ORNL pore water PRG of 4 μg/L for barium. The State of Washington does not have human or ecological standards for barium in pore water.
- Only one sample, collected at Station GC-2 (294 μg/L), exceeded the ORNL pore water PRG of 120 μg/L for manganese.
- The Washington Ambient Acute Water Quality Criteria for Protection of Aquatic Life and the ORNL PRG (0.44 and 0.36 μg/L, respectively) for silver was only exceeded in one sample, collected at Station GC-3 (1.3 μg/L).
- Total and WAD cyanide was not detected above the method detection limit (MDL) of 10 μg/L.
- Wet chemistry results are summarized as follows: pH ranged from 6.6 to 7.1 su; conductivity ranged from 66 to 74 uS; hardness as $CaCO_3$ ranged from 29 to 34 mg/L; TDS ranged from 40 to 50 mg/L; and sulfate was not detected above the MDL of 10 mg/L.
- Field parameters measured, and their respective ranges, included: temperature (12.24 to 14.03 ^{o}C), pH (7.7 to 7.8 su), conductivity (51 to 62 uS), DO (9.4 to 15.2 mg/L), turbidity (91 to 351 NTUs), and Eh (18 to 265 mv).

Sediment laboratory analytical results collected in Gold Creek are summarized in the following:

- Arsenic (both total and inorganic) was the only metal that exceeded any comparison standard. However, no sediment comparison standards have been established for the various forms of arsenic.

- Total arsenic concentrations ranged from 4.7 milligrams per kilogram (mg/kg) at Station GC-1 to 16.3 mg/kg at Station GC-4, of which three samples exceeded the EPA Freshwater Threshold Effects Level (TEL) and Washington's lowest proposed Sediment Quality Value (SQV), both at 5.9 mg/kg.
- Inorganic arsenic concentrations ranged from 1.688 mg/kg at Station GC-01 to 7.612 mg/kg at Station GC-02, of which only two samples (GC-02 and GC-03) exceeded the EPA Freshwater TEL and the lowest Washington proposed SQV of 5.9 mg/kg.
- The sediment grain size was between 97.5% and 100% sand and gravel, with minor amounts of silt and clay in all samples.
- The mineral composition of clay-sized particle was very similar for all samples. Generally, the clay fraction percentages (by weight) were, plagioclase feldspar at 48 to 50%, quartz at 32 to 34%, k-feldspar at 9 to 11%, and mica/illite, chlorite, and clinoamphibole at <5%.

3.2.4 Surface Water Exposure Pathway Summary

Based on the information presented in this section, metals (primarily arsenic) have been released into Gold Creek from the Site. In addition, the benthic macroinvertebrate populations in pool habitats appear to be impacted by stream sediments and pore-water because of the lack of species diversity when compared to downstream Stations. However, increased instream temperature due to a lack of bank vegetation may also be related to the changes is species diversity. Arsenic and barium exceeded the lowest comparison standard in surface water at all Stations. Arsenic V, barium, iron, manganese, and silver exceeded the lowest comparison standard in pore-water at Stations GC-02 and GC-03; and only arsenic exceeded the lowest comparison standard in sediments at Stations GC-02, GC-03, and GC-04.

In addition, Gold Creek is a potential habitat for several federal and state threatened and endangered fish (Chinook salmon, steelhead and the bull trout) and other non-listed fish species (i.e. rainbow and cutthroat trout), which are possibly being affected by the release from the Site. Therefore, the surface water pathway does appear to be complete and further assessment is warranted.

3.3 Soil Exposure Pathway

3.3.1 Targets

3.3.1.1 Local Use

There are no onsite workers or persons living within 200 feet of the Site; however, there are occupied structures and/or people who live within a 4-mile radius of the Site. Public use of the Site and vicinity is most likely minimal, though public access records are not maintained**.** Access is currently not restricted by fencing, nor were any "No Trespassing" signs noted during the SI. In general, land uses in this area are limited to timber harvesting, firewood cutting, recreation (hiking, fishing, camping, hunting, etc.) and some minerals prospecting.

The closest residence to the Site is located approximately 0.4 miles downstream of the Site along Gold Creek; it is unclear whether this is a permanent or seasonal residence. Additional residences (approximately seven) are located farther downstream along Gold Creek, and no residences were observed upstream of the Site. The Foggy Dew campground, located approximately 0.6 miles upstream of the Site, offers overnight camping at over ten campsites.

3.3.1.2 Terrestrial Ecological Survey

Terrestrial habitats and animals that are present, or likely to be present, at and surrounding the Site were documented during the ecological survey and via discussions with regional biologists. Lists of endangered, threatened, or sensitive plants and animals known to be present in the vicinity of the Site were obtained from the WADFW Priority Habitats and Species (PHS) program and Department of Natural Resources Natural Heritage Program (WANHP). Refer to Appendix F for complete Ecological Survey.

The following five distinct plant communities were observed on and adjacent to the Site.

- Coniferous forest over a majority of the onsite and offsite area;
- Meadow community at the east central border of the Site;
- Riparian forest along undisturbed banks of Gold Creek;
- Disturbed riparian along the creek bank below the lower and upper adits; and
- Disturbed upland vegetation on the waste piles located downslope from these same adits.

The dominant plant community can be characterized as a Douglas fir (*Pseudotsuga mensiezii*) - false box (*Pachistima myrsintes*) - bluebunch wheatgrass (*Agropyron spicata*) association that occurred throughout the study area. The disturbed riparian area is the result of past mining activities and ongoing waste pile erosion. Overall, the waste piles and areas downslope of them are essentially devoid of vegetation, but high quality habitat is available in close proximity to, and surrounding the Site.

The WADNR NHP has no documentation of rare plants or high quality native ecosystems occurring in the vicinity of Antimony Queen Mine. The USFS has identified 71 plant species as occurring in the Okanogan National Forest that are listed as threatened or sensitive by WDFW and/or the U.S. Fish and Wildlife Service (USFWS). In addition, the USFS lists 19 “survey & manage” plant species that, although they are not listed as threatened or sensitive, the agency manages and protects from ground-disturbing activities. None of the plant species listed as threatened, endangered, or under USFS management were observed during the site visit. However, if a removal action is necessary at this Site, field surveys for early blooming USFS survey and manage species may be needed prior to conducting any ground disturbance activity.

Ants, beetles, butterflies, a rattlesnake, a spotted frog, red-breasted nuthatches, western tanagers, a warbler, American robins, Swainson’s thrushes, sparrows, ruffed grouse, squirrels, and chipmunks were the primary invertebrate and wildlife species identified at or in the vicinity of the Site. Game trails were present on the Site suggesting larger mammals (i.e., mule deer) pass through the Site. Furthermore, many other species are possibly found at and in the vicinity of the Site.

The following outlines the federal and state threatened and endangered species that were observed during the survey or are listed as having potential habitat in the vicinity of the Site:

- Federal and state threatened bald eagle (*Haliaeetus leucocephalus*) and lynx (*Lynx Canadensis*); however none were observed during the survey.
- State threatened western gray squirrel (*Sciurus griseus);* two western gray squirrels were observed in the riparian area across Gold Creek north of the Site.
- State endangered spotted frog (*Rana pretiosa),* which was observed in the vicinity of the Site during the survey.

Overall, relatively few invertebrate and wildlife species were documented at the Site. This is not unusual given the limited extent of the ecological surveys. However, the varied habitat and foraging preferences represented by the documented species shows that the species inhabiting the area surrounding the Site are diverse and suggest that other species are likely to be present. Of the invertebrates and wildlife documented or likely to inhabit the Site, ants are likely to be the species most highly exposed to Site-related contamination. Insectivorous species that may forage frequently on invertebrates within the waste piles and frogs inhabiting the creek and its shoreline in the vicinity of the Site may also be exposed to Site-related contamination.

3.3.2 Previous Investigations

In July of 2002, the USFS performed an APA, which consisted of collecting several samples from waste rock piles at the Site. The purpose of this investigation was to determine whether or not there is a potential for a release of contaminants to the environment and/or to human health, and whether further site characterization is warranted. A Niton XRF 700 Series, using *in situ* field screening methods, was utilized to help in the preliminary screening of the Site. Antimony, arsenic and nickel were detected at concentrations exceeding the EPA Region IX Industrial PRGs (USFS, 2002).

3.3.3 Site Inspection Analytical Results

The following sections present the background soil, waste rock, and vegetation tissue analytical results for the Antimony Queen Mine. Sample locations for soils, waste rock and tissue samples are shown on Figure 1. Analytical results for background soils are tabulated in Table 4 and for waste piles in Table 5. Vegetation tissue results are tabulated in Table 6. The laboratory reports are located in Appendix G. A discussion of QA/QC procedures is included in Appendix H.

A total of three background soil samples, fourteen waste rock samples, and six vegetation samples (three co-located with background soil samples and three co-located with waste rock samples) were collected around the Site. Laboratory analysis includes the following for each of the media sampled:

- Background Soil - Total metals for the 23 TAL, arsenic III and V, and pH.
- Waste Rock - Total metals for the 23 TAL, arsenic III and V, total sulfur, acid based accounting (ABAs), synthetic precipitation leaching procedure (SPLP), and pH.
- Plant Tissue - Total metals for the 23 TAL, and total cyanide.

3.3.3.1 Background Soil Analytical Results

Background soil samples were collected from three areas around the Antimony Queen Mine to provide representative chemistry of undisturbed areas around the Site. Two were collected from the steep slope above Adit 2 (AQ-S-1 and AQ-S-3) and one along Gold Creek upstream from the Site (AQ-S-2). Sample locations are shown on Figure 1 as S-1, S-2, and S-3 (i.e., without the AQ identifier). Laboratory results are summarized in Table 4, with the mean concentrations for selected metals listed in the following table:

Mean Concentrations of Selected Metals in Background Soils (Results in mg/kg)

Ag	As III	As V	As	Cd	Cr	Cu	Ni	Pb	Sb	Zn
0.9	1.9	858	1,040	2.4	10	88	17	45.5	82	192

Background soil laboratory analytical results are summarized in the following:

- Background soil pH ranged from 5.8 to 6.7su, with a mean concentration of 6.3 su, indicating slightly acidic soils.
- Background soils exhibit high levels of arsenic (all forms) exceeding the ORNL PRG for soil of 9.9 mg/kg and EPA Region IX Industrial PRG of 1.6 mg/kg (cancer endpoint) and 260 mg/kg (non-cancer endpoint).
- The concentration of cadmium exceeds the Washington - Method A Industrial Soil Cleanup Levels for Human Receptors of 2.0 mg/kg. In addition, concentrations of antimony, barium, chromium, cobalt, copper, lead and vanadium exceed the ORNL PRGs for soil ecological receptors.

3.3.3.2 Waste Rock Analytical Results

A total of 14 waste rock samples, three from the upper pile (WR2) and 11 from the lower pile (WR1), were collected and submitted for laboratory analysis during the SI field activities. In addition, one soil sample was collected from adjacent to the suspected Powderhouse for nitrate and sulfate analysis to assess the potential for explosive residues in the soil. As outlined in the SOW, the USFS requested that samples be collected at various depths at each sampling location, including from native soil beneath the piles. However, because the Site is located on the south side of Gold Creek, heavy equipment (i.e., drill rig or backhoe) could not be used. Therefore, CES attempted to penetrate the piles using a stainless steel hand auger and/or shovel, but due to the density and size of the waste rock, CES was only able to penetrate the waste rock piles at depths of 2 feet BGS or less. Based on a review of the laboratory results and field observations, the chemical and physical characteristics of WP1 and WP2 are very similar. Therefore, the results will be presented in one section and will not be discussed separately. Sample locations are shown on Figure 1 as WR1-1, WR1-2, etc. and laboratory results are summarized in Table 4.

Based on the laboratory analytical results and field observations, the following is summarized regarding the waste rock at the Site:

- Of the 23 metals analyzed, only three metals (antimony, arsenic, and cadmium) exceeded the EPA Region IX Industrial PRGs in waste rock samples.
  - Total antimony concentrations range from 330 mg/kg in AQ-WR1-10 to 14,500 mg/kg in AQ-WR1-8, and nine of the ten samples analyzed exceeded the EPA PRG of 410 mg/kg.
  - Total arsenic concentrations range from 2,300 mg/kg at AQ-WR1-10 to 11,800 mg/kg at AQ-WR1-5, and all samples exceeded the EPA PRGs of 1.6 mg/kg for cancer endpoints and 260 mg/kg for non-cancer endpoints.
  - Only one sample (AQ-WR1-4 at 9.49 mg/kg) exceeded the EPA PRG of 7.4 mg/kg for cadmium.
- Only arsenic and cadmium were at concentrations that exceed the Washington Method A Industrial Cleanup Level of 20 mg/kg and 2 mg/kg, respectively; however, these levels only exist for five metals (arsenic, cadmium, chromium, lead, and mercury).
- Aluminum, antimony, arsenic III and V, barium, cadmium, cobalt, copper, lead, manganese, nickel, selenium, silver, vanadium, and zinc were at concentrations that exceeded the lowest Washington Ecological Indicator Soil Concentrations, which exist for plants, soil biota, and wildlife receptors.
- Antimony, arsenic, chromium, copper, and zinc concentrations exceeded the lowest EPA Ecological Soil Screening Levels, which were developed for plants, invertebrates, birds, and mammals for only seven of the 23 metals.

- ORNL Soil PRGs were exceeded for the following metals: antimony, arsenic, cadmium, chromium, cobalt, copper, lead, mercury, nickel, selenium, silver, vanadium, and zinc.
- ABAs were analyzed on ten waste rock samples, acid base potential (ABP) ranged from –28 to +505 t $CaCO_3$/Kt (ABP units are presented as tons of calcium carbonate needed to neutralize a kiloton of waste). ABP is the result of the acid neutralizing potential (ANP) minus the acid generating potential (AGP). A negative ABP indicates that the acid generating potential is greater than the acid neutralization potential, and thus the material has the potential to produce acid rock drainage (ARD). With the exception of AQ-WR1-6, the waste rock at the Site does not have the potential to produce ARD. AQ-WR1-6 also exhibited the highest total sulfur content at 1.09%, while the rest of the samples had less than 0.2% total sulfur.
- The soil sample collected adjacent to the suspected Powderhouse exhibited a nitrate concentration of <0.5 mg/kg and sulfate of 17 mg/kg. These concentrations do not suggest that explosive residues are present in the soil adjacent to the suspected Powderhouse building.
- With the exception of AQ-WR1-6 (4.9 su), the pH of the waste rock samples ranged from 6.5 to 7.8 su, indicating a slightly acidic to neutral pH.
- None of the samples exceeded any of the SPLP comparable standards.
- The volume of waste rock piles was estimated by measuring the base of the pile, height and slopes of sides and with the use of AutoCAD. Based on these calculations WR1 is estimated at 925 CY and WR2 is estimated at 650 CY.

The following table presents the mean concentrations of selected metals in waste rock and the enrichment value relative to mean concentrations in background soils. As the table shows, antimony and arsenic are the metals that are most enriched when compared to background soils, this is also consistent with the information presented above.

Mean Concentrations of Selected Metals in Waste Rock Samples as Compared to Background Soil Concentrations (Results in mg/kg)

	Ag	As III	As V	As	Cd	Cr	Cu	Ni	Pb	Sb	Zn
Mean Conc. Waste Rock	2.7	20.2	6,762	8,670	4.1	8.1	146	24	87	5,873	278
Mean Conc. Background	0.9	1.9	858	1,040	2.4	10	88	17	45.5	82	192
Enrichment Value*	*0.34x*	***10.8x***	***7.9x***	***8.3x***	***1.7x***	*0.8x*	***1.7x***	***1.4x***	***1.9x***	***72x***	***1.5x***

* - The enrichment value is equal to the number of times ("x") the site soils are greater or less than the background soils (i.e. the mean concentration of antimony in waste rock is 72 times greater than background soils). Values greater than 1 times the background are bolded.

3.3.3.3 Plant Tissue Analytical Results

Six vegetation samples, co-located with background soil and waste rock samples, were collected around the Site. Laboratory results are presented in Table 6 and shown on Figure 1 as V-1, V-2, etc. As the waste piles are not well vegetated, a reconnaissance was first performed to determine which species of plant was abundant and widespread enough for the sampling program, and one that would likely be foraged on by ecological receptors. Based on the reconnaissance, serviceberry (*Amelanchier alnifolia)* was sampled; however, at one location (AQ-V-6) only common snowberry (*Symphoricarpos alba)* was present and was therefore sampled. Samples AQ-V-1, V-3, and V-4 were collected to represent background plant tissue concentrations at the same location as background soil sample locations (S-1, S-3, and S-2, respectively). Samples AQ-V-2, V-5, and V-6 were collected to represent waste rock plant tissue concentrations and were co-located with waste rock samples WR2-1, WR1-4, and WR1-10, respectively.

Comparison standards do not exist for plant tissue concentrations; however, they do exist for soil concentrations that are used to assess impacts to plant growth and the subsequent exposure to wildlife receptors that forage on plants. These standards are included under the waste rock discussion. Results indicate that antimony, arsenic, iron, and potassium plant tissue concentrations were generally higher in vegetation growing on waste piles when compared to background. All other metals in plant tissue growing on waste rock were similar or lower than the plant tissue samples collected from background locations.

3.3.4 Soil Exposure Pathway Summary

Metal concentrations in background soils are elevated; eleven metals are present at concentrations exceeding one or more comparison standard. Antimony and arsenic concentrations detected above several comparison standards have been identified in both background soils and waste rock at the Site. All samples collected from the waste rock exceeded the EPA Industrial PRG for arsenic, and nine out of ten samples exceed the EPA Industrial PRG for antimony. The following metals were detected in waste rock at concentrations exceeding both the mean background soil value and one or more comparison standard: antimony, arsenic (all forms), barium, cadmium, copper, lead, manganese, mercury, nickel, silver, and zinc. The soil exposure pathway is considered complete for both human and ecological receptors, and a release of hazardous substances has been documented in this SI. However, there are currently no residents or workers occupying the Site and the EPA Industrial PRGs are based on a daily exposure of 8 hours per day for 5 days per week. Because of this, the risk of long-term exposure to contaminants by human receptors is low.

On-site vegetation appears to be impacted by activities associated with the Site. Arsenic concentrations in plant tissue samples collected from waste piles ranged up to ten times higher than the concentrations measured in tissue samples collected from background locations. Several federal and state threatened and endangered species were observed during the survey or are listed as having potential habitat in the vicinity of the Site, they include the bald eagle, lynx, western gray squirrel, and spotted frog. Because of the elevated concentrations of arsenic in plant tissue, and the fact that ecological receptors may feed on vegetation at the Site, the potential exists that ecological receptors could be impacted.

3.4 Air Exposure Pathway

3.4.1 Targets

The target distance for the air pathway has been defined as 1 and 4 miles from the Site. As outlined in Section 3.3.1.1, approximately 8 homes were identified during the SI, the closest of which is 0.4 miles from the Site. Sensitive environments, including wetlands, which are located within 4 miles from the Site, are outlined in Section 3.2.2.

3.4.2 Air Exposure Pathway Summary

Air samples were not collected as part of the field activities. Arsenic and other metals were likely released to the air during the processing as dust and particulate matter. Currently, the most likely air pathway is due to inhalation of particulate matter. As with soil exposure, this pathway is considered complete because arsenic impacted soil and waste material is concentrated at the surface where human and ecological receptors could be exposed to particulate matter. Because the air pathway is linked to the soil exposure pathway, addressing and/or eliminating the soil exposure pathway will likely render the air exposure pathway incomplete. Therefore, further assessment of the air pathway is not recommended.

4.0 CONCLUSIONS AND RECOMMENDATIONS

Relevant conclusions and recommendations are presented below.

- Evidence suggests that hazardous substances from the Antimony Queen Mine have been released to surface water. Based on the information, metals (primarily arsenic) have been released into Gold Creek, and appear to have impacted stream sediments, pore-water, and possibly benthic macroinvertebrate populations in pool habitats. Erosion of fine-grained waste rock into Gold Creek was observed at the Site, this is most likely occurring during high rainfall events and during spring snowmelt.

- Gold Creek is a potential habitat for several federal and state threatened and endangered fish (Chinook salmon, steelhead and the bull trout) and other non-listed fish species (i.e., rainbow and cutthroat trout), which are possibly being affected by the release from the Site.

- Results suggest a potential impact to benthic macroinvertebrate populations in pool habitats at Stations GC-02 and GC-03 due to a lack in diversity of species. However, increased instream temperature due to a lack of bank vegetation may also be related to the changes is species diversity. No noticeable impacts to benthic macroinvertebrate populations inhabiting riffle habitats downstream of the Site were observed.

- Groundwater is used for drinking water and other uses within the vicinity of the Site (< 1 mile) and a release from the Site could potentially affect local groundwater or impact wells downstream of the Site. Therefore, the groundwater pathway appears to be complete and further assessment is warranted.

- Onsite vegetation appears to be impacted by activities associated with the Site. The concentrations of arsenic in plant tissue samples collected from waste piles range from two to over ten times higher than the concentrations measured in tissue samples collected from background locations. Because of this, and the fact that ecological receptors may feed on vegetation at the Site, the potential exists, albeit low, that ecological receptors could be impacted.

- The waste piles are extremely high in metals concentrations, particularly antimony and arsenic. All samples collected from the waste rock exceed the EPA industrial PRG for arsenic. Nine out of ten exceed the EPA industrial PRG for antimony. Although background soil samples also exceeded comparison standards for several metals, the following metals in waste rock were detected at concentrations exceeding one or more comparison standard and greater than the mean background soil concentrations: antimony, arsenic (all forms), barium, cadmium, copper, lead, manganese, mercury, nickel, silver, and zinc. The soil exposure pathway is considered complete for both human and ecological receptors, and a release of hazardous substances has been documented in this SI.

- Several federal and state threatened and endangered species were observed during the survey or are listed as having potential habitat in the vicinity of the Site, they include the bald eagle, Canada lynx, western gray squirrel, and spotted frog. However, only the western gray squirrel and spotted frog were observed during the SI.

- The most likely air exposure pathway is inhalation of dust or particulate matter. However, most of the particulate matter in the air originates from the waste piles currently at the Site. Therefore, remediation of the Site should address any air pathway concerns. Given this, and the remote location

and limited use of the Mine, no further assessment into site-specific levels of compounds in the air is recommended.

Based on the information gathered as part of the SI and presented in this report, CES recommends performing an Engineering Evaluation / Cost Analysis (EECA) at the Antimony Queen Mine. As part of the EECA, a risk assessment should be performed to assess the human and ecological impacts, establish removal cleanup standards, and assess removal action alternatives. Physical dangers (i.e. opened adits, steep waste piles, etc.) should also be included as part of the EECA.

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TABLES

Table 1. **Surface Water Analytical Results**
Table 2. **Pore Water Analytical Results**
Table 3. **Sediment Analytical Results**
Table 4. **Background Soil Analytical Results**
Table 5. **Waste Rock Analytical Results**
Table 6. **Plant Tissue Analytical Results**

Table 1. Surface Water Analytical Results
Antimony Queen Mine Site Inspection, Okanogan National Forest, Okanogan County, Washington

Sample I.D. / Station No.	Sample Date	Pool (P) or Riffle (R)	Aluminum, TR	Antimony, TR	Arsenic III, Total	Arsenic V, Total	Arsenic, Total	Barium, TR	Beryllium, TR	Cadmium, TR	Calcium, TR	Chromium III, Total	Chromium VI, Total	Chromium, TR	Cobalt, TR	Copper, TR	Iron, TR	Lead, TR	Magnesium, TR	Manganese, TR	Mercury, Total	Nickel, TR	Potassium, TR	Selenium, TR	Silver, TR	Sodium, TR	Thallium, TR	Vanadium, TR	Zinc, TR
			Results in ug/L																										
GC-SW-1	7/10/2003	P	70B	<0.2	0.065	0.257	**0.322**	**11**	*<2*	<0.1	8,900	<5	*<5*	<10	<10	*<10*	<10	<0.1	1,800	<5	0.000732	<10	900B	*<2*	<0.05	1,600	<0.05	<5	20B
GC-SW-2	7/10/2003	P	<30	<0.2	0.063	0.323	**0.386**	**11**	*<2*	<0.1	9,000	<5	*<5*	<10	<10	*<10*	<10	<0.1	1,900	<5	0.000829	<10	700B	*<2*	<0.05	1,700	<0.05	<5	20B
GC-SW-3	7/9/2003	P	<30	<0.2	0.041	0.448	**0.489**	**10**	*<2*	<0.1	8,700	<5	*<5*	<10	<10	*<10*	<10	<0.1	1,800	<5	0.000716	<10	800B	*<2*	<0.05	1,700	<0.05	<5	10B
GC-SW-4	7/9/2003	P	<30	<0.2	0.084	0.333	**0.417**	**11**	*<2*	<0.1	8,800	<5	*<5*	<10	<10	*<10*	<10	<0.1	1,800	<5	0.000731	<10	800B	*<2*	<0.05	1,700	<0.05	<5	10B
Standards, corrected for hardness where applicable (used 30 mg/L as hardness average for Gold Creek samples)																													
Washington - Human Health [1]			NS	14	NS	NS	0.018	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	0.14	610	NS	170	NS	NS	1.7	NS	NS
Washington - Aquatic Life [2]			NS	NS	NS	NS	190	NS	NS	0.42	NS	66	10	NS	NS	4.1	NS	0.66	NS	NS	0.012	56.8	NS	5	NS	NS	NS	NS	38
EPA - Aquatic Life [3]			87	NS	NS	NS	150	4	0.66	0.11	NS	27.6	11	NS	23	3.2	1000	0.66	NS	120	0.77	18.8	NS	5	0.36	NS	12.00	20	42.6
EPA - Human Health [4]			NS	5.6	NS	NS	0.018	1000	4	5	NS	NS	NS	100	NS	1,300	300	15	NS	50	50	610	NS	170	NS	NS	1.7	NS	7,400
ORNL - Aquatic Life [5]			87	30	190	3.1	NS	4	0.66	0.15	116,000	44	2	NS	23	0.23	158	0.66	82,000	120	0.23	160	53,000	0.39	0.36	680,000	9	20	30

Sample I.D. / Station No.	Sample Date	Pool (P) or Riffle (R)	Flow Rate (7/20/03) in cubic feet per second	Cyanide, Total	Cyanide WAD	Temperature (Field)	pH (Lab)	pH (Field)	Conductivity @ 25C (Lab)	Conductivity (Field)	Dissolved Oxygen (Field)	Turbidity (Field)	Oxygen Reduction Potential (Field)	Hardness as CaCO3	Total Dissolved Solids (Field)	Residue, Filterable (TDS) @180	Residue, Non- Filterable (TSS) @105 C	Residue, Volatile (Filterable) @ 550 C	Total Organic Carbon	Sulfate
			cfs	mg/L	mg/L	°C	su	su	uS	uS	mg/L	NTU	mV	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
GC-SW-1	7/10/2003	P	NM	<0.01	<0.01	11.21	7.3	7.84	66	52	18.05	145	232	30	30	40	<5	<10	4B	<10
GC-SW-1	7/10/2003	R	77	NC	NC	11.22	NC	7.63	NC	52	16.8	153	256	NC	30	NC	NC	NC	NC	NC
GC-SW-2	7/10/2003	P	NM	<0.01	<0.01	10.82	7.3	7.38	74	52	14.5	93	61	30	30	50	<5	10B	3B	<10
GC-SW-2	7/10/2003	R	78	NC	NC	10/69	NC	7.42	NC	52	16.6	159	94	NC	30	NC	NC	NC	NC	NC
GC-SW-3	7/9/2003	P	NM	<0.01	<0.01	11.3	7.3	7.92	69	50	15.2	102	272	29	30	40	<5	10B	3B	<10
GC-SW-3	7/9/2003	R	89	NC	NC	11.26	NC	7.60	NC	50	13.8	145	275	NC	30	NC	NC	NC	NC	NC
GC-SW-4	7/9/2003	P	NM	<0.01	<0.01	9.91	7.2	7.80	64	51	14.36	92	234	29	30	40	<5	8B	3B	<10
GC-SW-4	7/9/2003	R	95	NC	NC	9.92	NC	8.00	NC	52	14.76	120	240	NC	30	NC	NC	NC	NC	NC

NOTES:
Analysis was conducted by ACZ Laboratories, Inc. in Steamboat Springs, CO.
TR = Total Recoverable Metals, Chromium III was calculated by subtracting Chromium VI from Total Chromium
mg/L = milligrams per liter
ug/L = micrograms per liter
su = standard units
uS = micro siemans
< value = analyte not detected above method detection limit (MDL)
B = analyte detected between method detection limit (MDL) and practical quantification limit (PQL)
NS = No Standard
Bolded values indicate that the value exceeds one or more standard
Italic values indicate that the MDL exceeds the lowest standard
NM - Not Measured
NC - Not Collected

STANDARD NOTES:
1 - State of Washington ambient water quality criteria for protection of human health (DOE, 2001)
2 - State of Washington chronic ambient water quality criteria for protection of aquatic life (DOE, 2001)
3 - EPA recommended chronic ambient water quality criteria for freshwater aquatic life used (EPA, 2002).
If none existed, used Tier II secondary chronic values (ORNL, 1996)
4 - EPA recommended ambient water quality criteria for protection of human consumption of water and fish (EPA, 2002)
5 - ORNL ecological screening level values for freshwater, lowest chronic value used (ORNL, 1996).

Table 2. Pore Water Analytical Results
Antimony Queen Mine Site Inspection, Okanogan National Forest, Washington

Sample I.D. / Station No.	Sample Date	Pool (P) or Riffle (R)	Aluminum, Diss.	Antimony, Diss.	Arsenic III, Diss.	Arsenic V, Diss.	Arsenic Diss.	Barium, Diss.	Beryllium, Diss.	Cadmium, Diss.	Calcium, Diss.	Chromium III, Diss.	Chromium VI, Diss.	Chromium, Diss.	Cobalt, Diss.	Copper, Diss.	Iron, Diss.	Lead, Diss.	Magnesium, Diss.	Manganese, Diss.	Mercury, Diss.	Nickel, Diss.	Potassium, Diss.	Selenium, Diss.	Silver, Diss.	Sodium, Diss.	Thallium, Diss.	Vanadium, Diss.	Zinc, Diss.
			Results in ug/L																										
GC-PW-1	7/10/2003	P	<30	<0.2	0.022	0.36	0.38	**9B**	*<2*	<0.1	9,400	<5	*<5*	<10	<10	*<10*	10B	<0.1	1,800	<5	0.00106	<10	1,000	*<2*	<0.05	1,800	0.18B	<5	10B
GC-PW-2	7/10/2003	P	<30	0.4B	10.6	**7.30**	17.9	**16**	*<2*	<0.1	10,600	<5	*<5*	<10	<10	*<10*	**800**	0.2B	1,700	**294**	0.00822	<10	900B	*<2*	<0.05	1,700	0.08	<5	10B
GC-PW-3	7/9/2003	P	<30	0.8B	4.87	**4.04**	8.91	**15**	*<2*	<0.1	8,800	<5	*<5*	<10	<10	*<10*	120	<0.1	1,700	59	0.00153	<10	1,000	*<2*	**1.3**	1,600	0.13	<5	10B
GC-PW-4	7/9/2003	P	<30	<0.2	0.019	0.46	0.477	**9B**	*<2*	<0.1	8,600	<5	*<5*	<10	<10	*<10*	<10	<0.1	1,800	<5	0.000813	<10	800B	*<2*	<0.05	1,700	0.10B	<5	10B
Standards, corrected for hardness where applicable (used 30 mg/L as hardness average for Gold Creek samples)																													
Washington - Aquatic Life [1]			NS	NS	NS	NS	190	NS	NS	0.42	NS	66	10	NS	NS	4.1	NS	0.66	NS	NS	0.012	511	NS	5	NS	NS	NS	NS	38
EPA - Aquatic Life [2]			87	NS	NS	3.1	150	4	0.66	0.11	NS	27.6	11	NS	23	3.2	1000	0.66	NS	120	0.77	18.8	NS	5	0.36	NS	12	20	42.6
ORNL - Aquatic Life [3]			87	30	190	3.1	NS	4	0.66	0.15	1.2E5	44	2	NS	23	0.23	158	0.66	82,000	120	0.23	160	53,000	5	0.36	6.8E5	12	20	30

Sample I.D. / Station No.	Sample Date	Pool (P) or Riffle (R)	Cyanide, Total	Cyanide WAD	Temperature (Field)	pH (Lab)	pH (Field)	Conductivity @ 25C (Lab)	Conductivity (Field)	Dissolved Oxygen (Field)	Turbidity (Field)	Oxygen Reduction Potential (Field)	Hardness as CaCO3	Total Dissolved Solids (Field)	Residue, Filterable (TDS) @180	Residue, Non- Filterable (TSS) @105 C	Residue, Volatile (Filterable) @ 550 C	Sulfate
			mg/L	mg/L	°C	su	su	uS	uS	mg/L	NTU	mV	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
GC-PW-1	7/10/2003	P	<0.01	<0.01	13.2	7.0	7.68	68	52	15.15	351	233	31	30	40	6B	6B	<10
GC-PW-2	7/10/2003	P	<0.01	<0.01	14.03	6.6	7.74	74	62	9.34	201	18	34	30	50	<5	8B	<10
GC-PW-3	7/9/2003	P	<0.01	<0.01	NC	6.6	NC	67	NC	NC	NC	NC	29	30	40	<5	8B	<10
GC-PW-4	7/9/2003	P	NA	NA	12.24	7.1	7.84	66	51	14.6	91	265	29	30	40	54	26	<10

NOTES: Analysis was conducted by ACZ Laboratories, Inc. in Steamboat Springs, CO.
Diss. = Dissolved Metals, Chromium III was calculated by subtracting Chromium VI from Total Chromium
mg/L = milligrams per liter
ug/L = micrograms per liter
su = standard units
uS = micro siemans
< value = analyte not detected above method detection limit (MDL)
B = analyte detected between method detection limit (MDL) and practical quantification limit (PQL)
NS = No Standard
NA = Not Analyzed
NC = Not Collected
Bolded values indicate that the value exceeds one or more standard
Italic values indicate that the MDL exceeds the lowest standard

STANDARD NOTES:
1 - State of Washington chronic ambient water quality criteria for protection of aquatic life (DOE, 2001)
2 - EPA recommended chronic ambient water quality criteria for freshwater aquatic life used (EPA, 2002).
If none existed, used Tier II secondary chronic values (ORNL, 1996)
3 - ORNL ecological screening level values for freshwater, lowest chronic value used (ORNL, 1996).

Table 3. Sediment Analytical Results
Antimony Queen Mine Site, Okanogan National Forest, Okanogan County, Washington

Sample ID	Sample Date	Aluminum, Total	Antimony, Total	Arsenic III, Inorganic	Arsenic V, Inorganic	Arsenic, Inorganic	Arsenic, Total	Barium, Total	Beryllium, Total	Cadmium, Total	Calcium, Total	Chromium, Total	Cobalt, Total	Copper, Total	Iron, Total	Lead, Total	Magnesium, Total	Manganese, Total	Mercury, Total	Nickel, Total	Potassium, Total	Selenium, Total	Silver, Total	Sodium, Total	Thallium, Total	Vanadium, Total	Zinc, Total
		mg/kg																									
GC-SS-1	7/10/2003	4,550	<0.2	0.011	1.677	1.688	4.7	30.6	<0.2	0.1B	1,650	14	4	6.0	8,900	1.3	2950	127	<0.05	7.9	890	<2	<0.05	70 B	0.17	17.3	25
GC-SS-2	7/10/2003	4,660	0.3B	0.025	7.587	**7.612**	**6.9**	32.9	<0.2	<0.1	1,600	14	4	6.0	8,960	1.3	3040	122	<0.04	7.2	870	<2	<0.05	70 B	0.09 B	17.3	24
GC-SS-3	7/9/2003	4270	0.3B	0.037	6.129	**6.166**	**12.6**	27.2	<0.2	0.1B	1460	10	3	6.3	9310	1.3	2570	123	<0.04	6.1	590	<2	<0.05	70 B	0.09 B	16.5	21
GC-SS-4	7/9/2003	6360	0.6B	0.026	4.749	4.775	**16.3**	33.2	<0.2	0.2B	1740	20	4 B	9.6	13800	1.6	4040	227	<0.04	9.6	660	<2	<0.05	50 B	0.07 B	23.0	29
Standards																											
WA - Freshwater (under development) [1]		NS	35	NS	NS	5.9	5.9	NS	NS	0.6	NS	26	NS	16	NS	31	NS	NS	0.17	16	NS	NS	3.9	NS	NS	NS	110
WA - Marine [2]		NS	NS	NS	NS	57	57	NS	NS	5.1	NS	260	NS	390	NS	450	NS	NS	0.41	NS	NS	NS	6.1	NS	NS	NS	410
EPA - Freshwater TEL [3]		NS	NS	NS	NS	5.9	5.9	NS	NS	0.596	NS	37.3	NS	35.7	NS	35	NS	NS	0.174	18	NS	NS	NS	NS	NS	NS	123
EPA - Freshwater PEL [4]		NS	NS	NS	NS	17	17	NS	NS	3.53	NS	90	NS	197	NS	91.3	NS	NS	0.486	35.9	NS	NS	NS	NS	NS	NS	315
ORNL - Freshwater [5]		NS	NS	NS	NS	42	42	NS	NS	4.2	NS	159	NS	77.7	NS	110	NS	NS	0.7	38.5	NS	NS	1.8	NS	NS	NS	270

Sample ID	Sample Date	Acid Volatile Sulfide	Simultaneously Extracted Metals					Texture by Hydrometer			Solids	Clay Mineralization						
			Cadmium	Copper	Lead	Nickel	Zinc	Clay	Sand	silt		Quartz	Plagioclase Feldspar	K-Feldspar	Mica/Illite	Chlorite	Clinoamphibole	Unidentified
		umol/g	mg/L					%										
GC-SS-1	7/10/2003	<0.02	<0.2	1.1B	<1	0.7B	14.5	1.3	97.5	1.3 B	81.2	32	49	9	<5	<5	<3	<5
GC-SS-2	7/10/2003	<0.02	<0.2	1.7B	1B	0.9B	17.2	<0.1	97.5	5	72.3	33	48	9	<5	<5	<3	<5
GC-SS-3	7/9/2003	<0.02	<0.2	2.2	<1	0.5B	3.7	<0.1	100	1.3 B	83.1	33	50	11	NA	<5	<3	<5
GC-SS-4	7/9/2003	<0.01	0.1B	1.4	<1	0.5B	3.5	<0.1	97.5	2.5 B	87.4	34	48	9	<5	<5	<3	<5

NOTES:
Analysis was conducted by ACZ Laboratories, Inc. in Steamboat Springs, CO and Brooks Rand in Portland, OR
mg/kg = milligrams per kilogram
mg/L = milligrams per liter
umol/g = micromole per gram
< value = analyte not detected above MDL
B = analyte detected between method detection limit (MDL) and practical quantification limit (PQL)
NS = No Standard

STANDARD NOTES:
1 - State of Washington, Development of Freshwater Sediment Quality Values (DOE, Sept 2002)
2 - State of Washington, Marine Sediment Management Standards (DOE, 1995)
3 - EPA Threshold Effects Level (NOAA, 1999)
4 - EPA Probable Effects Level (NOAA, 1999)
5 - ORNL ecological screening level values for freshwater, lowest chronic value used (ORNL, 1996)

Table 4. Background Soil Analytical Results
Antimony Queen Mine Site, Okanogan National Forest, Okanogan County, Washington

Sample ID	Sample Date	Sample Depth (feet)	pH (lab)	Aluminum, Total	Antimony, Total	Arsenic III, Inorganic	Arsenic V, Inorganic	Arsenic, Inorganic	Arsenic, Total	Barium, Total	Beryllium, Total	Cadmium, Total	Calcium, Total	Chromium, Total	Cobalt, Total	Copper, Total	Iron, Total	Lead, Total	Magnesium, Total	Manganese, Total	Mercury, Total	Nickel, Total	Potassium, Total	Selenium, Total	Silver, Total	Sodium, Total	Thallium, Total	Vanadium, Total	Zinc, Total
			su	mg/kg																									
AQ-S-1	7/8/2003	0.5	5.8	**23,000**	**161**	**2.628**	**748**	**750**	**1,120**	**145**	0.6 B	**2.31**	3,800	**10**	18	**77**	35,700	**74.8**	3,350	2,170	<0.05	16	1,430	<0.6	0.8	390	0.18	41.7	195
AQ-S-2	7/8/2003	0.5	6.7	**17,200**	**56**	**1.708**	**1,315**	**1,317**	**1,020**	**130**	0.4 B	**2.03**	7,820	**11**	19	**93**	36,500	38.5	4,630	2,360	<0.05	17	2,760	<0.6	1.01	330	0.14	44.6	190
AQ-S-3	7/8/2003	0.5	6.3	**18,600**	**28**	1.269	**511**	**512**	**982**	**159**	0.5 B	**2.86**	3,960	**9**	**25**	**93**	48,000	23.1	3,250	3,410	0.04 B	19	1,820	<0.6	0.88	270	0.15	51	190
Mean			6.3	19,600	82	1.868	858	860	1,040	145	0.5	2.4	5,193	10	21	88	40,067	45.5	3,743	2,647	0.04	17	2,003	NC	0.9	330	0.16	45.8	192
Standards																													
WA - Method A Indust. Soil Cleanup Levels - Human Receptors				NS	NS	NS	NS	NS	20	NS	NS	2.0	NS	19	NS	NS	NS	1,000	NS	NS	2	NS	NS	NS	NS	NS	NS	NS	NS
WA - Ecological Receptors (p=plant, b=soil biota, w=wildlife)				50p	5p	7w	10p	NS	NS	102w	10p	4p	NS	42p,b	20p	50b	NS	50p	NS	1,100p	0.1b	30p	NS	0.3w	2p	NS	1p	2p	86p
EPA Indust. PRGs - Human Receptors				100,000	410	NS	NS	260 / 1.6	260 / 1.6	67,000	1,900	7.4	NS	64	1,900	41,000	100,000	750	NS	19,000	310	20,000	NS	5,100	5,100	NS	67	7,200	100,000
EPA - Ecological Receptors (m=mammal, b=bird, i = invertebrate, p=plant)				NS	21m	NS	NS	37p	37p	NS	NS	29p	NS	5p	32b	61i	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	120i
ORNL - Ecological Receptors				NS	5	NS	NS	9.9	9.9	283	10	4	NS	0.4	20	60	NS	40.5	NS	NS	0.00051	30	NS	0.21	2	NS	1	2	8.5

NOTES: Analysis was conducted by ACZ Laboratories, Inc. in Steamboat Springs, CO, per EPA Method 6010/7000 series
mg/kg = milligrams per kilogram
su = standard units
< value = analyte not detected above MDL
B = analyte detected between method detection limit (MDL) and practical quantification limit (PQL)
NC = Not Calculated
EPA Industrial PRGs = Preliminary Remediation Goals - USEPA Region 9 (2002).
ORNL = Oak Ridge National Laboratory Preliminary Remediation Goals for Ecological Endpoints (1997)
WA = Washington State Department of Ecology, MTCA (2001)

Table 5. Waste Rock Analytical Results
Antimony Queen Mine Site, Okanogan National Forest, Okanogan County, Washington

Sample ID	Sample Date	Sample Depth (feet)	pH	Aluminum, Total	Antimony, Total	Arsenic III, Inorganic	Arsenic V, Inorganic	Arsenic, Inorganic	Arsenic, Total	Barium, Total	Beryllium, Total	Cadmium, Total	Calcium, Total	Chromium, Total	Cobalt, Total	Copper, Total	Iron, Total	Lead, Total	Magnesium, Total	Manganese, Total	Mercury, Total	Nickel, Total	Potassium, Total	Selenium, Total	Silver, Total	Sodium, Total	Thallium, Total	Vanadium, Total	Zinc, Total	Total Sulfur	ABAs: Acid Generation Potential	ABAs: Acid Neutralization Potential	ABAs: Acid-Base Potential
			su	mg/kg																										%	t CaCO3/Kt		
AQ-WR1-1	7/9/2003	1.0	7.8	2,520	7,500	23.0	9,934	9,957	11,400	179	0.4 B	5.05	15,900	4	21	125	60,000	70.1	620	2,050	0.65	21	1,100	<0.6	1.56	50	0.49	11.4	297	0.03	1	506	505
AQ-WR1-2	7/9/2003	2.0	NA	NA	NA	40.6	8,904	8,945	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
AQ-WR1-3	7/9/2003	1.5	7.5	2,670	6,500	24.6	9,388	9,413	11,800	189	0.5	2.92	9,800	5	22	141	69,700	54	1,260	1,890	0.80	24	1,110	<0.6	1.68	40	0.31	13.7	253	0.11	3	503	500
AQ-WR1-4	7/9/2003	2.0	7.9	2,170	11,600	14.7	8,399	8,413	10,700	187	0.4	9.49	37,100	19	19	116	51,000	104	410	1,780	0.45	26	1,080	<0.6	2.01	40	0.71	10.4	331	0.03	1	91	90
AQ-WR1-5	7/9/2003	2.0	7.6	2,300	6,200	29.8	9,273	9,303	11,800	216	0.5	4.01	9,570	4	23	151	65,200	60.7	620	2,330	0.62	25	1,180	<0.6	1.76	50	0.37	12.5	293	0.05	2	27	25
AQ-WR1-6	7/9/2003	0.5	4.9	6,270	14,500	11.4	6,699	6,711	7,900	111	0.6	2.69	3,880	8	21	134	66,400	79.8	1,710	1,910	0.63	23	1,010	1.1 B	2.03	70	0.2	22.9	221	1.09	34	6	-28
AQ-WR1-7	7/9/2003	1.5	NA	NA	NA	11.0	5,541	5,552	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
AQ-WR1-8	7/9/2003	2.0	6.6	14,900	900	4.9	4,163	4,168	4,500	134	0.6	4.43	4,490	12	29	193	74,000	227	4,370	4,010	0.15	32	1,340	0.6 B	7.09	170	0.28	42	314	0.04	1	13	12
AQ-WR1-9	7/9/2003	1.0	NA	NA	NA	4.2	2,065	2,069	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
AQ-WR1-10	7/9/2003	1.0	6.5	12,900	330	2.4	1,831	1,833	2,300	117	0.6 B	2.85	6,440	10	28	173	66,800	56.2	3,460	3,750	0.13	36	1,700	<0.6	1.27	210	0.15	40.6	236	0.03	1	14	13
AQ-WR1-11	7/9/2003	1.5	6.7	8,620	3,360	16.4	3,936	3,953	5,700	145	0.5	2.19	8,170	8	25	135	57,100	49	3,280	3,050	0.66	28	1,460	<0.6	1.38	160	0.16	29.1	206	0.21	7	19	12
AQ-WR2-1	7/8/2003	1.0	6.7	6,650	4,530	20.7	8,183	8,204	10,300	165	0.6 B	4.41	5,340	6	19	159	74,300	74.9	1,360	2,590	0.39	11	1,280	<0.6	4.6	80	0.32	22.8	374	0.02	1	14	13
AQ-WR2-2	7/9/2003	2.0	NA	NA	NA	45.5	6,251	6,296	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
AQ-WR2-3	7/9/2003	1.0	7.2	7,050	3,310	33.7	10,102	10,135	10,300	159	0.6 B	3.04	7,950	5	25	137	66,800	97.5	2,260	2,390	0.54	15	1,750	<0.6	3.15	130	0.23	24.9	257	0.19	6	18	12
MEAN				6,605	5,873	20.21	6,762	6,782	8,670	160	0.52	4.11	10,864	8.1	23.2	146	65,130	87	1,935	2,575	0.50	24	1,301	NC	2.65	100	0.32	23	278	0.18	NC	NC	NC
Standards																																	
WA - Method A Indust. Soil Cleanup Levels - Human Receptors				NS	NS	NS	NS	NS	20	NS	NS	2	NS	19	NS	NS	NS	1,000	NS	NS	2	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
WA - Ecological Receptors (p=plant, b=soil biota, w=wildlife)				50p	5p	7w	10p	NS	NS	102w	10p	4p	NS	42p,b	20p	50b	NS	50p	NS	1,100p	0.1b	30p	NS	0.3w	2p	NS	1p	2p	86p	NS	NS	NS	NS	NS
EPA Indust. PRGs - Human Receptors				100,000	410	NS	NS	NS	260 / 1.6	67,000	1,900	7.4	NS	64	1,900	41,000	100,000	750	NS	19,000	310	20,000	NS	5,100	5,100	NS	67	7,200	100,000	NS	NS	NS	NS	NS
EPA - Ecological Receptors (m=mammal, b=bird, i = invertebrate, p=plant)				NS	21m	NS	NS	NS	37p	NS	NS	29p	NS	5p	32b	61i	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	120i	NS	NS	NS	NS	NS
ORNL - Ecological Receptors				NS	5	NS	NS	9.9	9.9	283	10	4	NS	0.4	20	60	NS	40.5	NS	NS	0.00051	30	NS	0.21	2	NS	1	2	8.5	NS	NS	NS	NS	NS

Sample ID	Sample Date	Sample Depth (feet)	Synthetic Precipitation Leaching Procedure: Arsenic	Barium	Cadmium	Chromium	Lead	Mercury	Selenium	Silver
			Results in mg/L							
AQ-WR1-1	7/9/2003	1.0	2.33	<0.003	<0.001	<0.01	<0.001	<0.0002	<0.001	<0.005
AQ-WR1-3	7/9/2003	1.5	1.8	<0.003	<0.001	<0.01	<0.001	<0.0002	<0.001	<0.005
AQ-WR1-4	7/9/2003	2.0	1.8	<0.003	<0.001	<0.01	<0.001	<0.0002	<0.001	<0.005
AQ-WR1-5	7/9/2003	2.0	1.75	0.003B	<0.001	<0.01	<0.001	<0.0002	<0.001	<0.005
AQ-WR1-6	7/9/2003	0.5	0.855	0.008B	<0.0005	<0.01	0.0017B	<0.0002	<0.001	<0.005
AQ-WR1-8	7/9/2003	2.0	0.356	0.005B	<0.0002	<0.01	0.0047	<0.0002	<0.001	<0.005
AQ-WR1-10	7/9/2003	1.0	0.247	0.005B	<0.0002	<0.01	0.0011	<0.0002	<0.001	<0.005
AQ-WR1-11	7/9/2003	1.5	0.461	0.005B	<0.0002	<0.01	0.0011	<0.0002	<0.001	<0.005
AQ-WR2-1	7/8/2003	1.0	2.48	0.005B	<0.001	<0.01	0.002B	<0.0002	<0.001	<0.005
AQ-WR2-3	7/9/2003	1.0	1.74	0.004B	<0.001	<0.01	<0.001	<0.0002	<0.001	<0.005
Applicable Standards										
RCRA TCLP Disposal Limits			5	100	1	5	5	0.2	1	5

NOTES:

Analysis was conducted by ACZ Laboratories, Inc. in Steamboat Springs, CO.
mg/kg = milligrams per kilogram
mg/L = milligrams per liter
t CaCO3/Kt = tons of calcium carbonate needed to neutralize 1000 tons of waste/soil. Negative number indicates lack of $CaCO_3$, positive value indicates excess (no need).
su = standard units
< value = analyte not detected above MDL
B = analyte detected between method detection limit (MDL) and practical quantification limit (PQL)
NA = not analyzed
EPA Industrial PRGs = Preliminary Remediation Goals - USEPA Region 9 (2002).
ORNL = Oak Ridge National Laboratory Preliminary Remediation Goals for Ecological Endpoints (1997)
WA = Washington State Department of Ecology, MTCA (2001)

Table 6. Plant Tissue Analytical Results
Antimony Queen Mine Site, Okanogan National Forest, Okanogan County, Washington

Sample ID	Sample Date	Onsite or Background	Aluminum	Antimony	Arsenic	Barium	Beryllium	Cadmium	Calcium	Chromium	Cobalt	Copper	Iron	Lead	Magnesium	Manganese	Mercury	Nickel	Potassium	Selenium	Silver	Sodium	Thallium	Vanadium	Zinc	Cyanide
			mg/kg																							
AQ-V-1	7/8/2003	Bkg	57	0.3B	2.1	76.6	<0.2	0.07B	13,400	<1	<1	5B	81	0.45	2,350	248	<0.1	<1	16,300	<0.6	0.05 B	<30	<0.03	<0.5	30	3.0
AQ-V-2	7/8/2003	Onsite	40	0.7	2.9	12.1	<0.2	<0.05	16,600	<1	<1	6	77	0.28B	3,140	89.9	<0.1	<1	15,500	<0.6	0.04 B	<30	<0.03	<0.5	32	1.1B
AQ-V-3	7/8/2003	Bkg	37	<0.5	1.8	32.0	<0.2	0.19B	16,000	<1	<1	7	82	0.3B	2,440	409	<0.09	<1	12,000	<0.6	<0.03	<30	0.1B	<0.5	35	12.5
AQ-V-4	7/9/2003	Bkg	18	1.4B	3.5	11.4	<0.2	<0.05	13,200	<1	<1	5	66	0.4B	2,680	160	<0.1	<1	22,700	<0.6	<0.03	<30	<0.1	<0.5	19	<0.5
AQ-V-5	7/9/2003	Onsite	58	18.8	24.0	4.6	<0.2	<0.05	13,200	<1	<1	7	249	1.2	3,160	236	<0.1	1B	24,700	<0.6	0.04B	<30	<0.1	0.6B	30	<0.5
AQ-V-6	7/9/2003	Onsite	39	2.5	5.7	6.2	<0.2	0.10B	13,100	<1	<1	6	104	0.3B	2,480	480	<0.1	<1	31,800	<0.6	<0.03	<30	<0.1	<0.5	30	<0.5

NOTES: Analysis was conducted by ACZ Laboratories, Inc. in Steamboat Springs, CO, per EPA Method 6010/7000 series.
mg/kg = milligrams per kilogram
< value = analyte not detected above MDL
B = analyte detected between method detection limit (MDL) and practical quantification limit (PQL)
The vegetation type for all samples was *amelanchier alnifolia* (serviceberry), except AQ-V-6 which was *symphoricarpos alba* (common snowberry)

FIGURES

Figure 1. **Site Layout, including Waste Rock, Soil and Plant Tissue Sampling Locations**

Figure 2. **Surface Water Stations, including Water Rights, Residences, and Well Information**

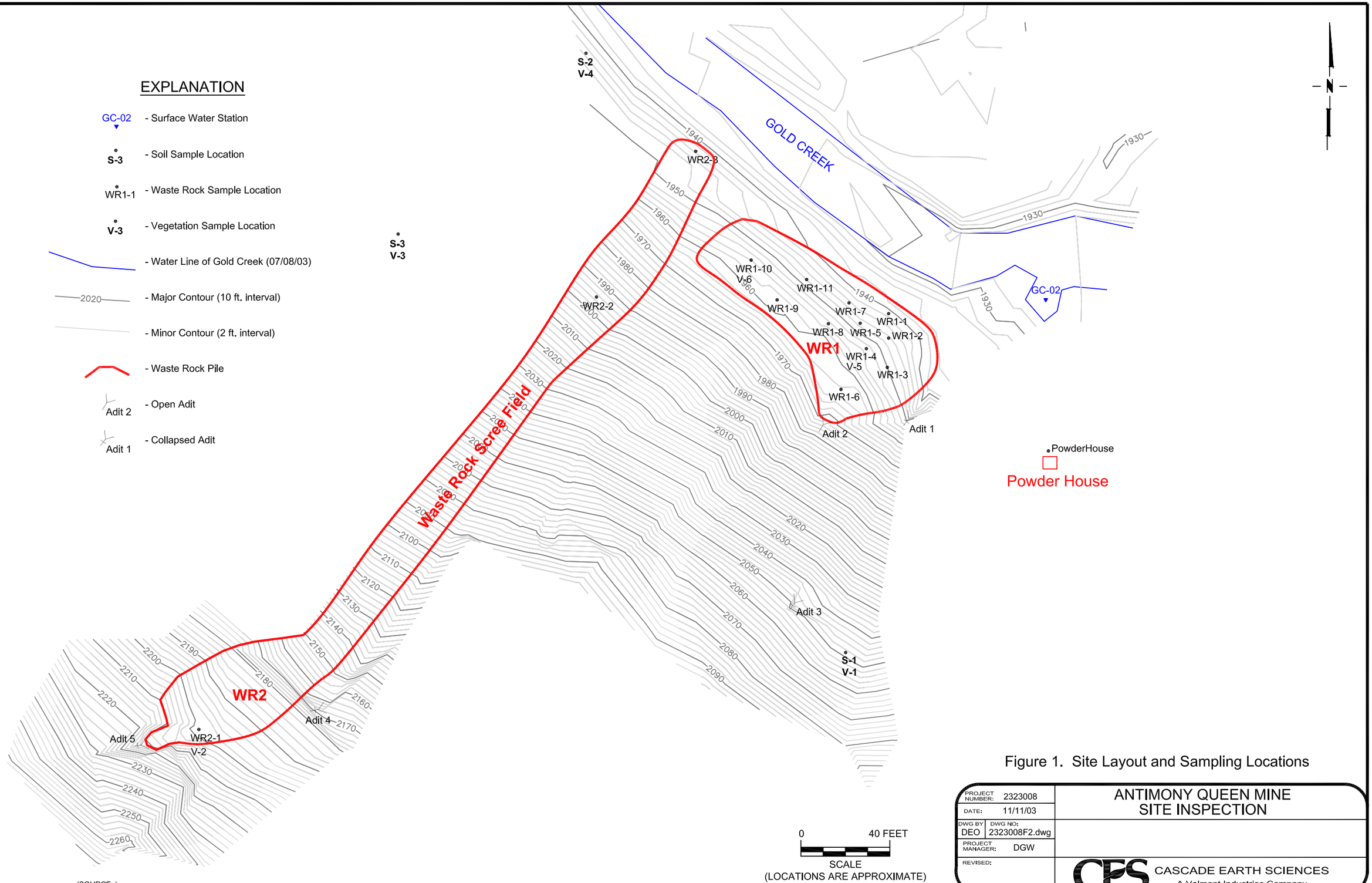
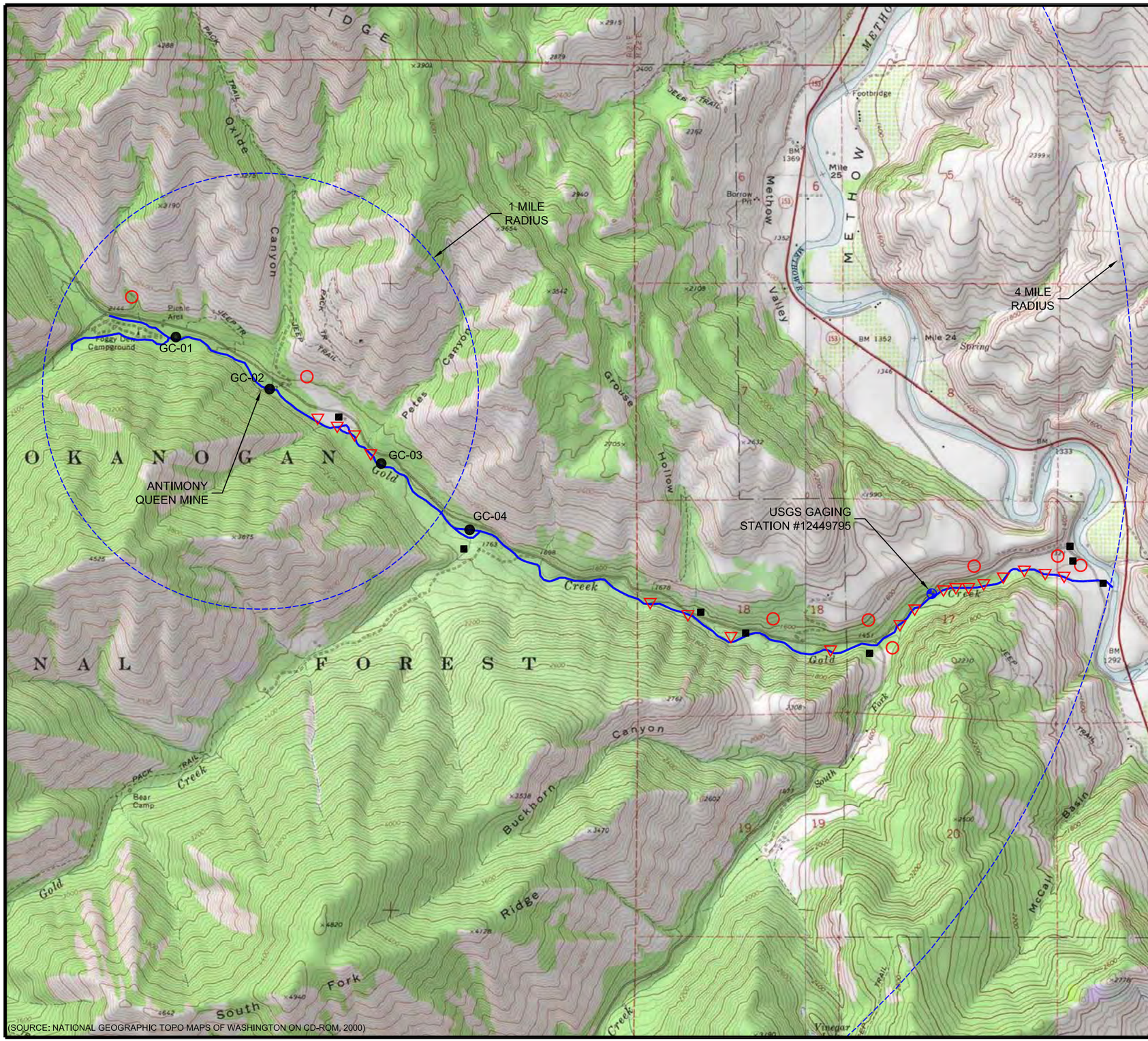


Figure 1. Site Layout and Sampling Locations

PROJECT NUMBER: 2323008	ANTIMONY QUEEN MINE SITE INSPECTION
DATE: 11/11/03	
DWG BY: DEO / DWG NO: 2323008F2.dwg	
PROJECT MANAGER: DGW	
REVISED:	CASCADE EARTH SCIENCES A Valmont Industries Company



EXPLANATION

- Radius Surrounding Mine Site
- Surface Water Rights - Approximate Location
- Water Well - Approximate Location
- USGS Gaging Station
- Surface Water Station
- Occupied Residence - Approximate Location

N

SCALE 1 INCH = 2,000 FEET

1 1/2 0 1 MILE

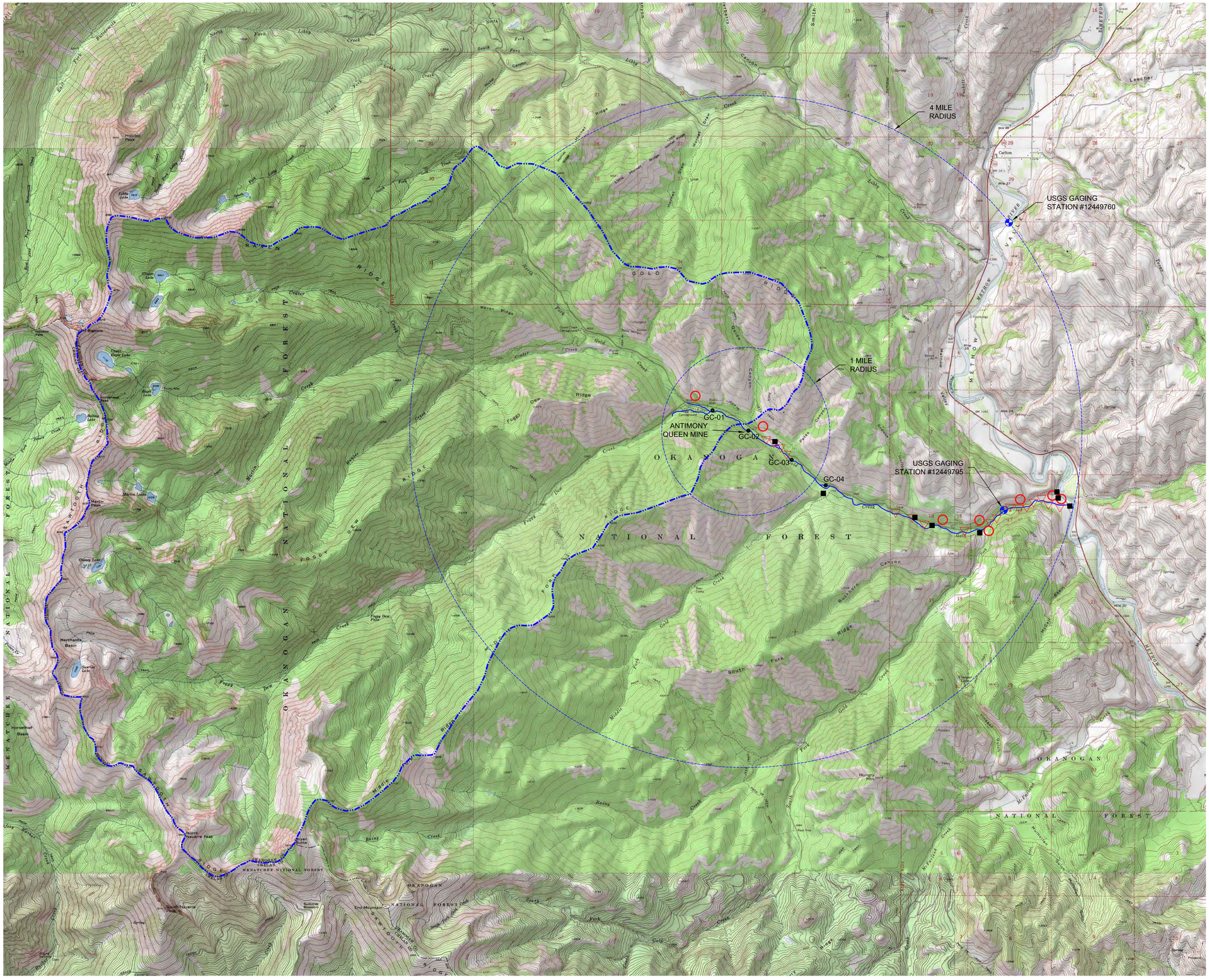
CONTOUR INTERVAL = 40 FEET

Figure 2. Surface Water Stations, including Water Right, Residence & Well Information

PROJECT NUMBER: 2323008	ANTIMONY QUEEN MINE SITE INSPECTION
DATE: 11/21/03	
DWG BY: DW/DO DWG NO: 2323008F2.dwg	
PROJECT MANAGER: DGW	
REVISED:	CASCADE EARTH SCIENCES A Valmont Industries Company

PLATES

Plate 1 **Topographic Map with Estimated Watershed Boundaries and the 1- and 4-mile radii from Site, including Surface Water Stations**



EXPLANATION

- Watershed Boundary
- Radius Surrounding Mine Site
- Surface Water Rights - Approximate Location
- Water Well - Approximate Location
- USGS Gaging Station
- Surface Water Station
- Occupied Residence - Approximate Location

N

SCALE 1 INCH = 3,000 FEET

1 0.5 0 1 MILE

CONTOUR INTERVAL = 40 FT.

Plate 1. Gold Creek Watershed Boundary
With 1 and 4 mile Radius

PROJECT NUMBER: 2323008	ANTIMONY QUEEN MINE SITE INSPECTION
DATE: 11/21/03	
DWG BY: DEO DWG NO: 2323008P1.dwg	
PROJECT MANAGER: DGW	
REVISED:	CASCADE EARTH SCIENCES A Valmont Industries Company

(SOURCE: NATIONAL GEOGRAPHIC TOPO MAPS OF WASHINGTON ON CD-ROM, 2000)

Antimony Sampling and Analysis Plan Changes

Subject: Changes in the Antimony Queen Mine Sampling and Analysis Plan PDF (download size 132kb)

509.996.2208 Fax

Naches Ranger District
10237 Highway 12
Naches, WA 98937

509.653.1401 Voice/TTY
509.653.2638 Fax

North Cascade Smokejumper Base
23 Intercity Airport Road
Winthrop, WA 98862

509.997.9750 Voice
509.997.2077 Fax

Tonasket Ranger District
1 West Winesap
Tonasket, WA 98855 (509) 486-2186 Voice

509.486.1922 Fax
509.486.5144 TTY

Wenatchee River Ranger District
600 Sherbourne
Leavenworth, WA 98826

509. 548-2550 or 548.2551 Voice
509.548.5817 Fax

Forestry Sciences Laboratory
1133 N. Western
Wenatchee, WA 98801

509.662-4315 Voice
509.664.2742 Fax

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July 21, 2003

Mr. Dennis Boles
Winema National Forest
2819 Dahlia
Klamath Falls, Oregon 97601

SUBJECT: CHANGES IN THE ANTIMONY QUEEN MINE SAMPLING AND ANALYSIS PLAN

Dear Dennis:

Cascade Earth Sciences (CES) proposed the following changes to the Sampling and Analysis Plan (SAP) for the Antimony Queen Mine Site Inspection. In addition, several modifications were made in the field; these are also outlined in the following bullets.

- In the original Statement of Work (SOW) and CES' proposal, surface water samples were to be analyzed for both total recoverable (TR) and dissolved metals. Most ecological preliminary remediation goals (PRGs) are based on dissolved metals; however, this would not address the impacts on terrestrial ecological receptors. Furthermore, EPA and Department of Ecology (DOE) surface water PRGs are based on TR, with the exception of a few metals (i.e. chromium and selenium), which are based on dissolved. Based on this, CES feels that analyzing for both TR and dissolved would be a duplicate of results; and CES therefore proposes only to analyze for TR metals in surface water.
- In CES' original proposal, arsenic (As) and chromium (Cr) speciation was to be analyzed at each sediment sampling station. Washington DOE does not have freshwater sediment PRGs; however, they refer to the most recent compilation of national PRGs. The Oregon Department of Environmental (DEQ) ecological sediment screening values are based on national PRGs, including Oak Ridge National Laboratories (ORNL) and others. Oregon DEQ and ORNL sediment PRGs are based on As speciation and total Cr. Because of this, CES proposes that all sediment samples be analyzed for As speciation and total Cr.
- The whole sediment pore-water sampling was removed from the sampling requirements. I*n-situ* sampling provides more accurate and realistic approach to assessing pore-water concentrations and the affect on aquatic receptors. When whole sediment samples are collected and shipped to the lab for pore-water extraction using a centrifuge, they are more likely to be subject to conditions that can change the redox of the sample and thus have an impact on the pore-water results. In addition, based on the field conditions observed, it was not possible to collect whole sediment samples.
- ORNL ecological PRGs for soil are based on As III and total Cr; however, EPA Region 9 PRGs are based on total As and Cr speciation. Based on this and the fact that arsenic is known to be elevated in the area around the mine, As speciation was added to the analysis suite for soil/waste rock samples. However, chromium is not know to exist around the mine; therefore, Cr speciation will only be run if total Cr is greater than the Cr VI PRG.
- Due to substrate size (i.e. boulders and cobbles), pore-water and sediment samples could not be collected at the "riffle" substations. Because of this, pore-water, surface water and sediment samples could only be collected at the "pool" substations.

- A small structure (3 feet x 3 feet) was discovered approximately 100 feet east of the lower adits. Based on evidence in the field, it appears as if this may have been a "powder house", to store explosives and black powder used in the mining process. Because of this, CES collected a sample from the soil immediately adjacent to the structure for nitrate and total sulfur analysis.

Please contact me at (509) 921-0290 if you have any questions.

Regards,
CASCADE EARTH SCIENCES

Dustin G. Wasley, PE
Managing Engineer

Photographs - Photo Album 1

Photograph 1: Looking downstream at Station CG-04 (Download size 135 kb)

Photograph 2: Looking upstream at Station GC-04

Photograph 3: Looking downstream at Station GC-03 (Download size 125 kb)

Photograph 4. Looking upstream at Station GC-03

RELATED LINKS

- Photo Album 1
- Photo Album 2
- Photo Album 3

Photograph 5a. Looking downstream at Station CG-02 (Download size 101 kb)

Photograph 5b. Looking upstream at Station GC-02. Note mine on the left. (Download size 124 kb)

Photograph 6 . Looking downstream at Station GC-01. (Download size 132 kb)

Photograph

7. Looking upstream at Station GC-01 (Download size 120 kb)

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Photographs - Photo Album 2

Photograph 8. Looking south at Adit 1. (Download size 103 kb)

Photograph 9. Looking south at Adit 2. (Download size 105 kb)

Photograph 10. Close-up of Adit 2.(Download size 91 kb

Photograph 11. Looking south at Adit 5. (Download size 126 kb)

RELATED LINKS

- Photo Album 1
- Photo Album 2
- Photo Album 3

Photograph 12. Close-up of Adit 5. (Download size 92 kb)

Photograph 13. Looking west at sampling location AQ-S-1 and AQ-V-1 (Download size 119 kb)

Photograph 14. Looking east at the suspected Powerhouse. (Download size 122 kb)

Photograph 15. Looking inside the

Powderhouse.
(Download
size 91 kb)

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Photographs - Photo Album 3

Photograph 16. Looking south at WR1 and Adit 2. (Download size 115 kb)

Photograph 17. Looking south at Adit 2. (Download size 111 kb)

Photograph 18. Looking south at WR1 and sampling locations.(Download size 113 kb)

Photograph 19. Looking southwest at WR1 and sampling locations. (Download size 91 kb)

RELATED LINKS

- Photo Album 1
- Photo Album 2
- **Photo Album 3**

Photograph 20. Looking west at far end of WR1. Sample WR-1-9 shown. (Download size 94 kb)

Photograph 21. Looking north form crest of WR1 at Gold Creek. (Download size 120 kb)

Photograph 22. Looking south at scree field from WR2 (Download size 108 kb)

Photograph 23. Gold Creek at the Antimony Queen

Mine. (Download size 100 kb)

top

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GENERAL INFORMATION FORM

GENERAL

Region/Station: 6 Forest Number: District No:
Congressional District: 4

Project Name: Antimony Queen Mine
Project Type: Site Inspection
Regional Priority: NA
5th Level HUC: Gold Creek is sub watershed of Methow River 4th order HUC = 17020008
Single Site: Yes Multiple Site:
List all site names in multiple sites:

ENVIRONMENT

Watershed Name: Gold Creek
Regional Watershed Priority: NA
Watershed size (acres): 29,100 acres
Size of disturbed area (acres): 2 acres
Nearest surface water source: North Fork Gold Creek, adjacent to mine
Miles of stream impacted by site: 200 feet
303d listed impaired surface water- Yes: No: X
If 303d listed impaired, what are the water quality limited contaminants?

Is the site affecting a Wild and Scenic river - Yes: No: X
Describe potential for a catastrophic failure if not addressed: High levels of arsenic, antimony and barium could be deposited into Gold Creek
Beneficial uses downstream: Fishing, irrigation, stock watering, swimming
Nearest critical sensitive area: Palustrine, Forested, Temporarily Flooded wetland
Distance sensitive area is from site: Adjacent to site
Sensitive species: Tailed and Westernfrog- See SI Tables for complete listing and names
T&E species: Chinook salmon, bull trout/Dolly Varden, summer steelhead, spotted frog, bald eagle, Canada lynx, Western gray squirrel
Is the soil environment conducive to contaminant movement - Yes: X No:
Activities in the watershed that also contribute to environmental damage (logging, roads, dredging, grazing, etc.): logging, roads, grazing
Would a removal action have a noticeable positive impact on or reduce the potential future risk of damaged resources - Yes: X No:
Other critical information relating to the environment: very steep slopes condusive to soils movement into Gold Creek

HUMAN HEALTH AND SAFETY

	Within 200 feet of the Site	Within 4 miles of the Site	Within 15 miles of the Site
Year round population based on residences	0	20, based on 8 residences * 2.5 persons/residence	NA
Seasonal population based on residences	0	30, based on 12 residences * 2.5 persons/residence	NA
Water wells	0	50 total; however, only 8 along Gold Creek	NA
Surface water intakes	0	18 water rights along Gold Creek	NA

Recreational activities within 200 feet of the site: Yes, nothing to restrict access, fishing, swimming, camping, hunting, hiking
Recreational activities that occur within 15 miles of the site: all of the above
Established recreational sites within 200 feet of the site: None
Established recreational sites within 15 miles of the site: Foggy Dew Campground 1 mile upstream

Depth to groundwater (feet): 20
Beneficial uses downstream: domestic use, irrigaton, stock watering, swimming
Physical hazards: steep slopes, scree fields

Physical Hazard	
Dangerous Highwall	Yes, at Adit 2
Subsidence	No
Vertical Opening/Shaft	Yes
Dangerous Impoundment	No
Dangerous Pile and Embankment	Yes, WR1 and WR2
Dangerous Slide	Yes, scree field from Adit 4/5
Hazardous Equipment or Unstable Structures	No
Hazardous Explosive Gases	No
Hazardous Water Body/Ponds	No
Solid Waste	Yes
Horizontal Opening/Adit	Yes, 5 Adits

Other critical information relating to health and safety: Fugitive emissions from waste rock piles, swift current and boulders in Gold Creek

MIXED OWNERSHIP INFORMATION

% of the site on NFS land: 100 %
% of the watershed on NFS land: 100% above the Mine

POTENTIAL CONTAMINATION

	Yes	No
Surface Water Indicators		
High turbidity in surface water		X
Active erosion into surface water	X	
Staining or precipitate/sediments		X
Aquatic kills		X
Visible plume		X
Discharges to surface water sources (ie., adit drainage or leachate)		X, seasonal from Adit 1
Noticeable decline in aquatic population (compared to upstream of the site)		X
Surface water void of life in the area of the mine site		X
Site located in the floodplain/wetland	X	
Failing or Inadequate Design		
Oversteepened slopes	X	
Unlined ponds		X
Inadequate landfill design or dumps		X
Unstable retainment structure		X
Past Practices		
Uncontrolled landfill/dump		X
Improper disposal		X
Chemical/wates were stored on site in drums/tanks, etc.		Unknown
Past practices at site used hazardous materials		Unknown
Other Indicators		
Stressed vegetation		X
Dead vegetation or lack of vegetation	X, on waste piles	
Animal kills		X
Visual contaminants	X	
Heavily stained soils/salts present	X	

Other critical potential contaminant information: _____

_____

ADDITIONAL STUIES

Biological studies that shows a decrease in the number and lower species diversity downstream of the site: Yes: X No: ___

Increased mortality in nesting wildlife: Yes: ___ No: X

Other critical contaminant information: _____

ANALYTICAL/DOCUMENTED CONTAMINATION

Media	Location	Rate of Discharge/Volume (gpm or cy)	Contaminant	Exceedence	Background*
SurfaceWater	SW-1	34,500 gpm	Arsenic Barium	322 ug/L 11 ug/L	0.322 ug/L 11 ug/L
	SW-2	35,000 gpm	Arsenic Barium	0.386 ug/L 11 ug/L	0.322 ug/L 11 ug/L
	SW-3	40,000 gpm	Arsenic Barium	0.489 ug/L 10 ug/L	0.322 ug/L 11 ug/L
	SW-4	42,500 gpm	Arsenic Barium	0.417 ug/L 11 ug/L	0.322 ug/L 11 ug/L
Pore Water	PW-2	Unknown	Arsenic, Total ArsenicV Barium Manganese	17.9 ug/L 7.3 ug/L 16 ug/L 294 ug/L	0.38 ug/L 0.358 ug/L 9 ug/L <5 ug/L
	PW-3	Unknown	Arsenic, Total Arsenic V Barium Silver	8.91 ug/L 4.04 ug/L 16 ug/L 1.3 ug/L	0.38 ug/L 0.358 ug/L 9 ug/L <0.05 ug/L
	PW-4	Unknown	Arsenic, Total	0.477 ug/L	0.38 ug/L
Sediment	SS-2	Unknown	Arsenic, Total	6.9 mg/kg	4.7 mg/kg
	SS-3	Unknown	Arsenic, Total	12.6 mg/kg	4.7 mg/kg
	SS-4	Unknown	Arsenic, Total	16.3 mg/kg	4.7 mg/kg
Waste Rock	AQ-WR1-1	WR1 = 925 CY	Antimony Arsenic, III Arsenic, Total	7,500 mg/kg 23.032 mg/kg 11,400 mg/kg	82 mg/kg 1.868 mg/kg 1,040 mg/kg
	AQ-WR1-2		Arsenic, III	40.609 mg/kg	
	AQ-WR1-3		Antimony Arsenic, Total	6,500 mg/kg 11,800 mg/kg	82 mg/kg 1,040 mg/kg
	AQ-WR1-4		Antimony Arsenic, Total	11,600 mg/kg 10,700 mg/kg	82 mg/kg 1,040 mg/kg
	AQ-WR1-5		Antimony Arsenic, Total	6,200 mg/kg 11,800 mg/kg	82 mg/kg 1,040 mg/kg
	AQ-WR1-6		Antimony Arsenic, Total	14,500 mg/kg 7,900 mg/kg	82 mg/kg 1,040 mg/kg
	AQ-WR1-7		Arsenic, III	11.023 mg/kg	1.868 mg/kg
	AQ-WR1-9		Arsenic, III	4.221 mg/kg	1.868 mg/kg
	AQ-WR1-10		Antimony Arsenic, Total	330 mg/kg 2,300 mg/kg	82 mg/kg 1,040 mg/kg
	AQ-WR1-11		Antimony Arsenic, III Arsenic, Total	3,360 mg/kg 16.421 mg/kg 5,700 mg/kg	82 mg/kg 1.868 mg/kg 1,040 mg/kg
	AQ-WR2-1	WR2 = 650 CY	Antimony Arsenic, Total	4,530 mg/kg 10,300 mg/kg	82 mg/kg 1,040 mg/kg
	AQ-WR2-2		Arsenic, III	45.483 mg/kg	1.868 mg/kg
	AQ-WR2-3		Antimony Arsenic, Total	3,310 mg/kg 10,300 mg/kg	82 mg/kg 1,040 mg/kg

* - Mean Background Concentrations

Minerals & Geology

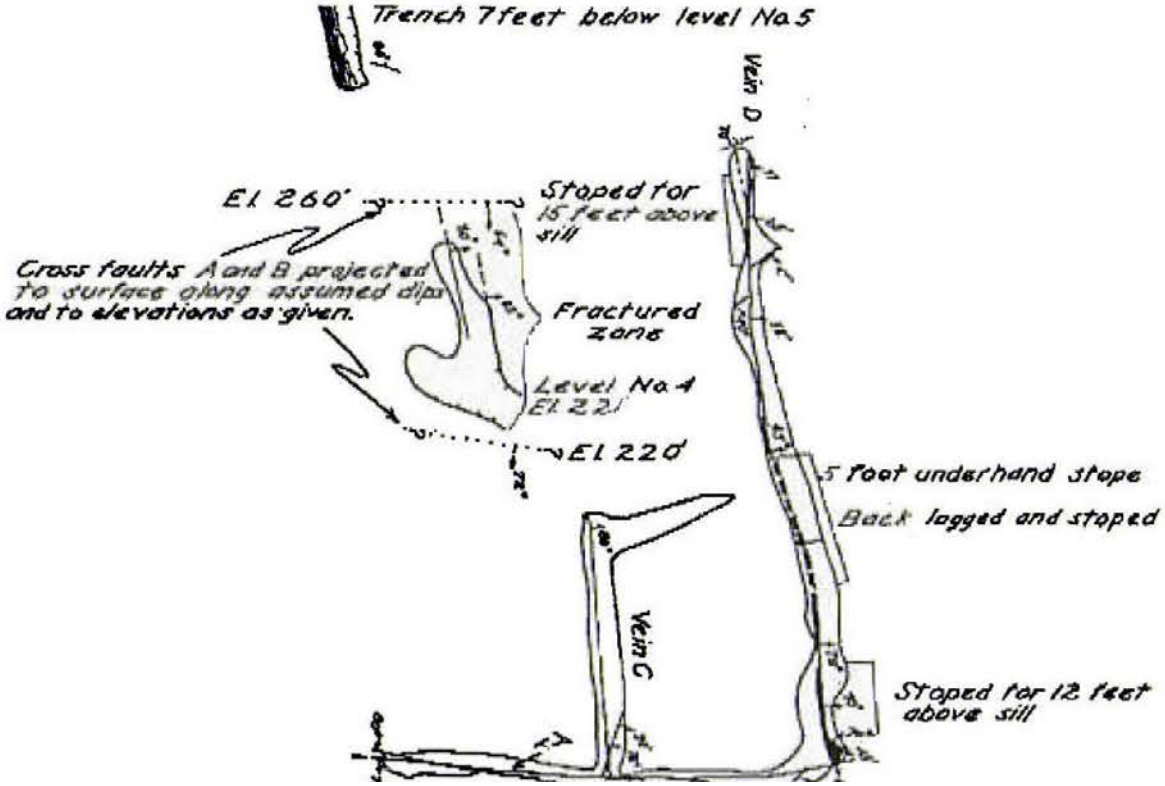
Maps

- Map
- Adit Map

http://www.fs.fed.us/r6/oka/global-websites/images/projects/map1.jpg[11/22/2011 3:07:38 PM]

http://www.fs.fed.us/r6/oka/global-webSites/images/projects/map1.jpg[11/22/2011 3:07:38 PM]

ANTIMONY QUEEN MINE



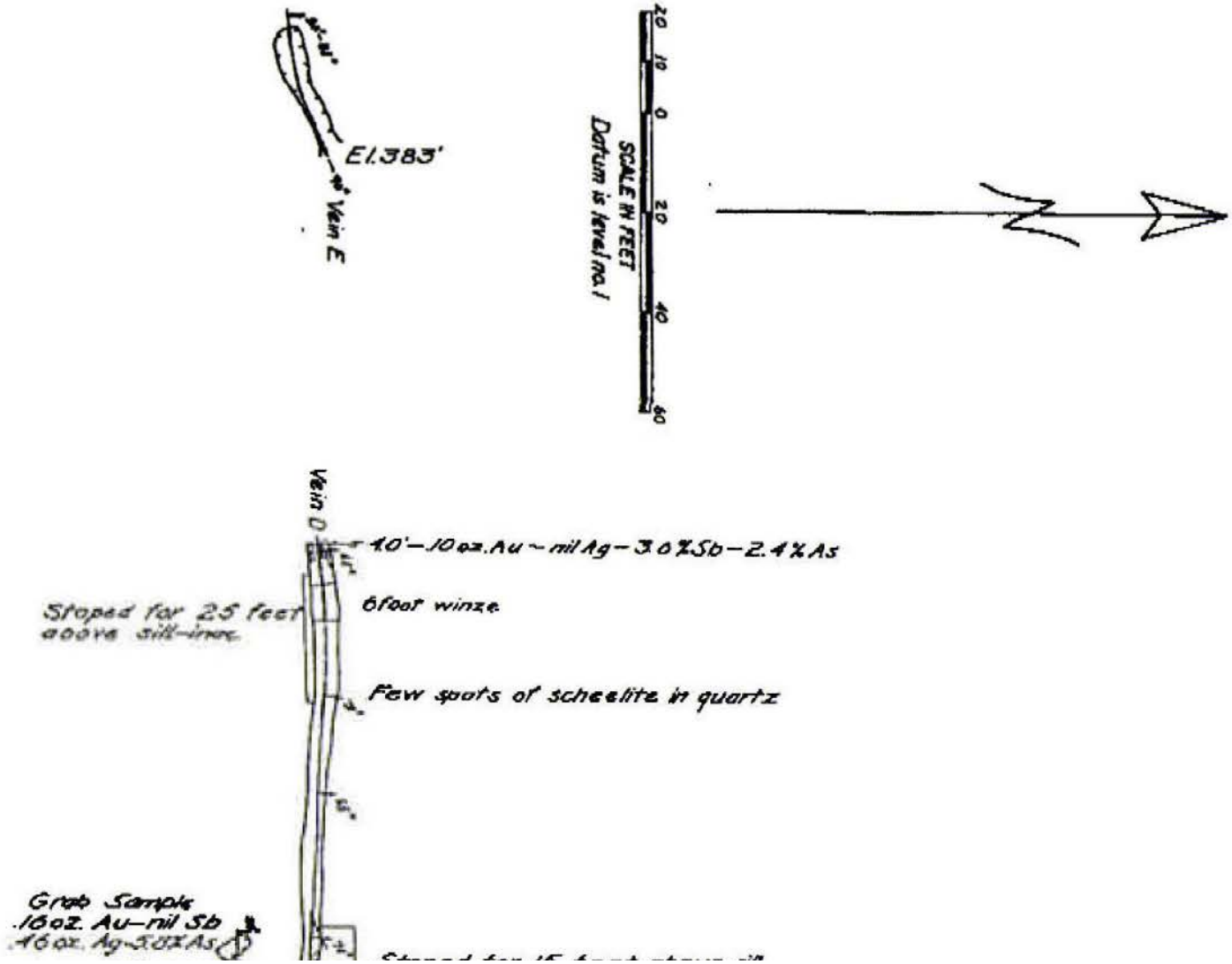


FIGURE 10. GE

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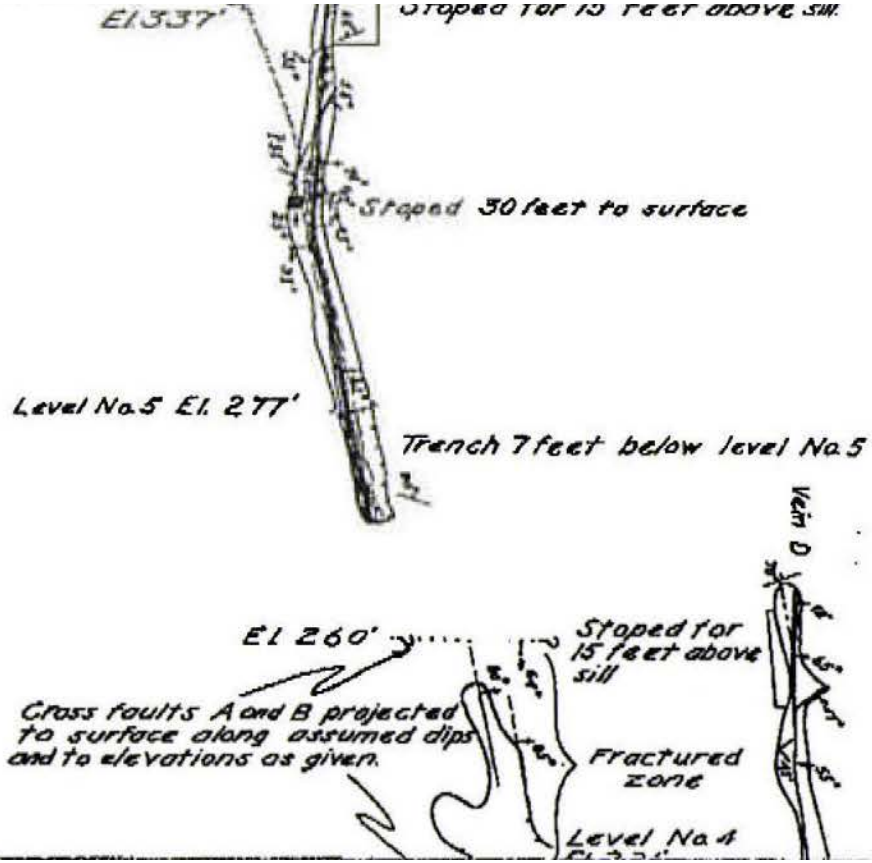

OLOGIC PLAN OF ANTIMONY QUEEN

http://www.fs.fed.us/r6/oka/global-websites/images/projects/adit2.jpg[11/22/2011 3:07:46 PM]

Minerals & Geology

Well Logs and Water Rights

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23 Intercity Airport Road
Winthrop, WA 98862

509.997.9750 Voice
509.997.2077 Fax

Tonasket Ranger District
1 West Winesap
Tonasket, WA 98855 (509) 486-2186 Voice

509.486.1922 Fax
509.486.5144 TTY

Wenatchee River Ranger District
600 Sherbourne
Leavenworth, WA 98826

509. 548-2550 or 548.2551 Voice
509.548.5817 Fax

Forestry Sciences Laboratory
1133 N. Western
Wenatchee, WA 98801

509.662-4315 Voice
509.664.2742 Fax

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File Original and First Copy with Department of Ecology
Second Copy — Owner's Copy
Third Copy — Driller's Copy

WATER WELL REPORT

STATE OF WASHINGTON

Application No. .....

Permit No. .....

(1) OWNER: Name Ray Campbell Address P.O. Box 562 Brewster, Wash.

(2) LOCATION OF WELL: County Okanogan — SW ¼ NE ¼ Sec. 17 T. 31 N., R. 22 W.M. G

Give location and distance from section or subdivision corner

(3) PROPOSED USE: Domestic ☒ Industrial ☐ Municipal ☐ Irrigation ☐ Test Well ☐ Other ☐

(4) TYPE OF WORK: Owner's number of well (if more than one) ....

New well ☒ Deepened ☐ Reconditioned ☐

Method: Dug ☐ Bored ☐ Cable ☒ Driven ☐ Rotary ☐ Jetted ☐

(5) DIMENSIONS: Diameter of well 6 inches.

Drilled 52 ft. Depth of completed well 52 ft.

(6) CONSTRUCTION DETAILS:

Casing installed: 6" Diam. from 0 ft. to 52 ft.

Threaded ☐ ..." Diam. from ... ft. to ... ft.

Welded ☒ ..." Diam. from ... ft. to ... ft.

Perforations: Yes ☐ No ☒

Type of perforator used ....

SIZE of perforations ... in. by ... in.

... perforations from ... ft. to ... ft.

... perforations from ... ft. to ... ft.

... perforations from ... ft. to ... ft.

Screens: Yes ☐ No ☒

Manufacturer's Name ....

Type .... Model No. ....

Diam. .... Slot size .... from .... ft. to .... ft.

Diam. .... Slot size .... from .... ft. to .... ft.

Gravel packed: Yes ☐ No ☒ Size of gravel: ....

Gravel placed from .... ft. to .... ft.

Surface seal: Yes ☒ No ☐ To what depth? 18 ft.

Material used in seal Puddly Clay

Did any strata contain unusable water? Yes ☐ No ☒

Type of water? .... Depth of strata ....

Method of sealing strata off ....

(7) PUMP: Manufacturer's Name ....

Type: .... H.P. ....

(8) WATER LEVELS: Land-surface elevation above mean sea level .... ft.

Static level 34 ft. below top of well Date 12/11/73

Artesian pressure .... lbs. per square inch Date ....

Artesian water is controlled by .... (Cap, valve, etc.)

(9) WELL TESTS: Drawdown is amount water level is lowered below static level

Was a pump test made? Yes ☐ No ☒ If yes, by whom? ....

Yield: gal./min. with ft. drawdown after hrs.

" " " "

" " " "

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level

... of test ....

Bailer test 20 gal./min. with 4 ft. drawdown after 1 hrs.

Artesian flow .... g.p.m. Date ....

Temperature of water .... Was a chemical analysis made? Yes ☐ No ☐

(10) WELL LOG:

Formation: *Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of formation.*

MATERIAL	FROM	TO
boulders	0	20
fine sand	20	50
gravel (med.)	50	52

RECEIVED
JUL 2 1974
DEPARTMENT OF ECOLOGY
CENTRAL REGIONAL OFFICE

JUN 28 1974
DEPARTMENT ...

Work started 11/29, 1973 Completed 12/11, 1973

WELL DRILLER'S STATEMENT:

This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.

NAME Glessner Well Drilling (Person, firm, or corporation) (Type or print)

Address Box 302 Mansfield Wn

[Signed] Wesley Glessner (Well Driller)

License No. 0154 Date 12/14, 1973

(USE ADDITIONAL SHEETS IF NECESSARY)

S. F. No. 7356—OS—(Rev. 4-71).

6/28/74

115829

File Original with
Department of Ecology
Second Copy Owner s Copy
Third Copy Driller s Copy

WATER WELL REPORT

STATE OF WASHINGTON

Notice of Intent W155168

UNIQUE WELL I D # AGM 211

Water Right Permit No

(1) OWNER Name Dethier/Duggins Address 620 University Rd Friday Harbor WA 98250

(2) LOCATION OF WELL County Okanogan NW 1/4 NE 1/4 Sec 10 T 31 N R 21 E WM

(2a) STREET ADDRESS OF WELL (or nearest address)

TAX PARCEL NO B

(3) PROPOSED USE ☒ Domestic ☐ Industrial ☐ Municipal ☐ Irrigation ☐ Test Well ☐ Other ☐ DeWater

(4) TYPE OF WORK Owner s number of well (if more than one)
☒ New Well ☐ Deepened ☐ Reconditioned ☐ Decommission
Method ☐ Dug ☐ Bored ☐ Cable ☐ Driven ☒ Rotary ☐ Jetted

(5) DIMENSIONS Diameter of well 8 + 4 inches
Drilled 192 feet Depth of completed well 192 ft

(6) CONSTRUCTION DETAILS
Casing Installed
☒ Welded 8 steel Diam from +2 ft to 170 ft
☐ Liner installed 4 steel Diam from +2 ft to 192 ft
☐ Threaded Diam from ft to ft

Perforations ☒ Yes ☐ No Torch
Type of perforator used
SIZE of perforations 1/4 in by 3 in
20 perforations from 192 ft to 175 ft

Screens ☐ Yes ☒ No ☐ K Pac Location
Manufacturer s Name
Type Model No
Diam Slot Size from ft to ft
Diam Slot Size from ft to ft

Gravel/Filter packed ☐ Yes ☐ No ☐ Size of gravel/sand
Material placed from ft to ft

Surface seal ☒ Yes ☐ No To what depth? 170 ft
Material used in seal bentonite
Did any strata contain unusable water? ☐ Yes ☐ No
Type of water? Depth of strata
Method of sealing strata off

(7) PUMP Manufacturer s Name
Type H P

(8) WATER LEVELS Land surface elevation above mean sea level ft
Static level 39 ft below top of well Date 5-12-02
Artesian pressure lbs per square inch Date
Artesian water is controlled by
(Cap valve etc)

(9) WELL TESTS Drawdown is amount water level is lowered below static level
Was a pump test made? ☐ Yes ☐ No If yes by whom?
Yield gal /min with ft drawdown after hrs
Yield gal /min with ft drawdown after hrs
Yield gal /min with ft drawdown after hrs
Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level

Date of test
Bailer test 8 gal /min with ft drawdown after hrs
Airtest 8 gal /min with ft drawdown after 3 hrs
Artesian flow g p m Date
Temperature of water Was a chemical analysis made? ☒ Yes ☐ No

(10) WELL LOG or DECOMMISSIONING PROCEDURE DESCRIPTION
Formation Describe by color character size of material and structure and the kind and nature of the material in each stratum penetrated with at least one entry for each change of information Indicate all water encountered

MATERIAL	FROM	TO
Top soil	0	3
sandy gravel	3	12
hard blue clay	12	35
wet grey clay	35	50
clean sand & gravel	50	65
hard pan gravel	65	90
tplus	90	145
decomposed shale	145	170
shale/conglomerate	170	179
broken sandstone/conglom	179	192
esate, water bearing.		
Cased 8" to 170 lined 4" to 192' Sealed with bentonite from 170 to minus 7'		

DEPT OF ECOLOGY Received JUN 10 2002 CENTRAL REGION OFFICE

Work Started 5-6 02 Completed 5-26 02

WELL CONSTRUCTION CERTIFICATION

I constructed and/or accept responsibility for construction of this well and its compliance with all Washington well construction standards Materials used and the information reported above are true to my best knowledge and belief

Type or Print Name Marshall Miller License No 1437
(Licensed Driller/Engineer)

Trainee Name License No

Drilling Company MVM Quality Drilling, LLC

(Signed) MV Miller License No 1437
(Licensed Driller/Engineer)

Address 22905 Riverview Rd., Chelan, WA 98816

Contractor s Registration No MVMQUDL0033MM Date 5-26 02

(USE ADDITIONAL SHEETS IF NECESSARY)

Ecology is an Equal Opportunity and Affirmative Action employer For special accommodation needs contact the Water Resources Program at (360) 407 6600 The TDD number is (360) 407 6006

ECY 050 1 20 (11/98)

File Original and First Copy with Department of Ecology
Second Copy — Owner's Copy
Third Copy — Driller's Copy

WATER WELL REPORT

STATE OF WASHINGTON

Start Card No. W 049652
UNIQUE WELL I.D. # ACA 411
Water Right Permit No. 134796

(1) OWNER: Name Ronald & Karen Foutch Address PO Box 47074 Seattle WA 98146

(2) LOCATION OF WELL: County Okanogan - SW 1/4 SE 1/4 Sec 18 T. 31 N., R. 22 W.M.

(2a) STREET ADDRESS OF WELL (or nearest address) 80 Gold Creek Road Carlton WA

(3) PROPOSED USE: [X] Domestic [ ] Irrigation [ ] DeWater [ ] Industrial [ ] Test Well [ ] Municipal [ ] Other

(4) TYPE OF WORK: Owner's number of well (If more than one) 1
Abandoned [ ] New well [X] Deepened [ ] Reconditioned [ ]
Method: Dug [ ] Cable [ ] Rotary [ ] Bored [ ] Driven [ ] Jetted [ ]

(5) DIMENSIONS: Diameter of well 6 inches.
Drilled 42 feet. Depth of completed well 42 ft.

(6) CONSTRUCTION DETAILS:
Casing installed: 6 " Diam. from +3 ft. to 42 ft.
Welded [X] " Diam. from ft. to ft.
Liner installed [ ] " Diam. from ft. to ft.
Threaded [ ]

Perforations: Yes [ ] No [X]
Type of perforator used
SIZE of perforations in. by in.
perforations from ft. to ft.
perforations from ft. to ft.
perforations from ft. to ft.

Screens: Yes [ ] No [X]
Manufacturer's Name
Type Model No.
Diam. Slot size from ft. to ft.
Diam. Slot size from ft. to ft.

Gravel packed: Yes [ ] No [X] Size of gravel
Gravel placed from ft. to ft.

Surface seal: Yes [X] No [ ] To what depth? 18 ft.
Material used in seal Bentonite
Did any strata contain unusable water? Yes [ ] No [X]
Type of water? Depth of strata
Method of sealing strata off

(7) PUMP: Manufacturer's Name None
Type: H.P.

(8) WATER LEVELS: Land-surface elevation above mean sea level ft.
Static level 19 ft. below top of well Date 6/14
Artesian pressure lbs. per square inch Date
Artesian water is controlled by (Cap, valve, etc.)

(9) WELL TESTS: Drawdown is amount water level is lowered below static level
Was a pump test made? Yes [ ] No [ ] If yes, by whom?
Yield: gal./min. with ft. drawdown after hrs.
" " " "
" " " "

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level

Date of test
Bailer test gal./min. with ft. drawdown after hrs.
Airtest 20 gal./min. with stem set at 38 ft. for 1 hrs.
Artesian flow g.p.m. Date
Temperature of water Was a chemical analysis made? Yes [ ] No [X]

(10) WELL LOG or ABANDONMENT PROCEDURE DESCRIPTION

Formation: Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of information.

MATERIAL	FROM	TO
Sandy loam	0	5
Cemented boulders, hard pan; beige	5	20
Fine sand, tight, orange	20	38
Coarse sand; gravel	38	42

Drilled w/NUMEX under-reaming system
5.5" Drive Shoe @ 43'

WRC #134796

Owner abandoned old well

RECEIVED
AUG - 5 1996
DEPARTMENT OF ECOLOGY
CENTRAL REGION OFFICE

Work Started 6/14/96 19. Completed 6/14/96 19

WELL CONSTRUCTOR CERTIFICATION:

I constructed and/or accept responsibility for construction of this well, and its compliance with all Washington well construction standards. Materials used and the information reported above are true to my best knowledge and belief.

NAME Country Town Drilling (PERSON, FIRM, OR CORPORATION) (TYPE OR PRINT)
Address PO Box 279 Carlton WA 98814
(Signed) (WELL DRILLER) License No. 1492
Contractor's Registration No. ~~COUNTTD131QW~~ Date 6/15 1996

(USE ADDITIONAL SHEETS IF NECESSARY)

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ECY 050-1-20 (9/93)

File Original and First Copy with Department of Ecology
Second Copy — Owner's Copy
Third Copy — Driller's Copy

WATER WELL REPORT

STATE OF WASHINGTON

Start Card No. 37367
UNIQUE WELL I.D. # ABG916
Water Right Permit No. _____

(1) OWNER: Name Gebbers Farms Address Box 7 Brewster WA 98812

(2) LOCATION OF WELL: County Okanogan Lot 2 NW 1/4 SW 1/4 Sec 17 T 31 N., R 22 W.M.

(2a) STREET ADDRESS OF WELL (or nearest address) _____

(3) PROPOSED USE: [X] Domestic [ ] Irrigation [ ] DeWater Industrial [ ] Test Well [ ] Municipal [ ] Other [ ]

(4) TYPE OF WORK: Owner's number of well (if more than one) _____
Abandoned [ ] New well [X] Deepened [ ] Reconditioned [ ]
Method: Dug [ ] Cable [ ] Rotary [X] Bored [ ] Driven [ ] Jetted [ ]

(5) DIMENSIONS: Diameter of well 6" inches.
Drilled 540 feet. Depth of completed well 540 ft.

(6) CONSTRUCTION DETAILS:
Casing installed: 6" Diam. from 0 ft. to 282 ft.
Welded [X] Liner installed [ ] Threaded [ ]
_____" Diam. from _____ ft. to _____ ft.
_____" Diam. from _____ ft. to _____ ft.

Perforations: Yes [ ] No [X]
Type of perforator used _____
SIZE of perforations _____ in. by _____ in.
_____ perforations from _____ ft. to _____ ft.
_____ perforations from _____ ft. to _____ ft.
_____ perforations from _____ ft. to _____ ft.

Screens: Yes [ ] No [X]
Manufacturer's Name _____
Type _____ Model No. _____
Diam. _____ Slot size _____ from _____ ft. to _____ ft.
Diam. _____ Slot size _____ from _____ ft. to _____ ft.

Gravel packed: Yes [ ] No [X] Size of gravel _____
Gravel placed from _____ ft. to _____ ft.

Surface seal: Yes [X] No [ ] To what depth? 20 ft.
Material used in seal Bentenite
Did any strata contain unusable water? Yes [ ] No [X]
Type of water? _____ Depth of strata _____
Method of sealing strata off _____

(7) PUMP: Manufacturer's Name _____
Type: _____ H.P. _____

(8) WATER LEVELS: Land-surface elevation above mean sea level _____ ft.
Static level 138 ft. below top of well Date Aug 94
Artesian pressure _____ lbs. per square inch Date _____
Artesian water is controlled by _____ (Cap, valve, etc.)

(9) WELL TESTS: Drawdown is amount water level is lowered below static level
Was a pump test made? Yes [ ] No [X] If yes, by whom? _____
Yield: _____ gal./min. with _____ ft. drawdown after _____ hrs.
" " " "
" " " "

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level

Date of test _____
Bailer test _____ gal./min. with _____ ft. drawdown after _____ hrs.
Airtest 5 gal./min. with stem set at 538 ft. for 1 hrs.
Artesian flow _____ g.p.m. Date _____
Temperature of water _____ Was a chemical analysis made? Yes [ ] No [X]

(10) WELL LOG or ABANDONMENT PROCEDURE DESCRIPTION

Formation: Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of information.

MATERIAL	FROM	TO
Sand + Gravel	0	31
Clay	31	282
Granite Bed Rock	282	540

Work Started Aug 1994 Completed Aug 1994

WELL CONSTRUCTOR CERTIFICATION:

I constructed and/or accept responsibility for construction of this well, and its compliance with all Washington well construction standards. Materials used and the information reported above are true to my best knowledge and belief.

NAME Tri River Drilling (PERSON, FIRM, OR CORPORATION) (TYPE OR PRINT)
Address Box 7 Brewster WA 98812
(Signed) Albert Glesner (WELL DRILLER) License No. 1372
Contractor's Registration No. FRIRIDL077 RF Date Aug 18 1994

(USE ADDITIONAL SHEETS IF NECESSARY)

ECL 050-1-20 (2/93)

File Original and First Copy with Department of Ecology
Second Copy — Owner's Copy
Third Copy — Driller's Copy

WATER WELL REPORT

STATE OF WASHINGTON

Start Card No. W27077
UNIQUE WELL I.D. # AB6917
Water Right Permit No.

(1) OWNER: Name Gebbers Farms Address Box 7 Brewster Wa 98812

(2) LOCATION OF WELL: County Okanogan Lot 1 NW 1/4 SW 1/4 Sec. 17 T. 31 N., R. 22 W.M.

(2a) STREET ADDRESS OF WELL (or nearest address)

(3) PROPOSED USE: [X] Domestic [ ] Irrigation [ ] DeWater [ ] Industrial [ ] Test Well [ ] Municipal [ ] Other

(4) TYPE OF WORK: Owner's number of well (if more than one)
Abandoned [ ] New well [ ] Deepened [ ] Reconditioned [ ]
Method: Dug [ ] Cable [ ] Rotary [X] Bored [ ] Driven [ ] Jetted [ ]

(5) DIMENSIONS: Diameter of well 6 inches.
Drilled 300 feet. Depth of completed well 300 ft.

(6) CONSTRUCTION DETAILS:
Casing installed: 6" Diam. from 0 ft. to 248 ft.
Welded [X] Liner installed [ ] Threaded [ ]
Diam. from ft. to ft.
Diam. from ft. to ft.

Perforations: Yes [ ] No [X]
Type of perforator used
SIZE of perforations in. by in.
perforations from ft. to ft.
perforations from ft. to ft.
perforations from ft. to ft.

Screens: Yes [ ] No [X]
Manufacturer's Name
Type Model No.
Diam. Slot size from ft. to ft.
Diam. Slot size from ft. to ft.

Gravel packed: Yes [ ] No [X] Size of gravel
Gravel placed from ft. to ft.

Surface seal: Yes [X] No [ ] To what depth? 20 ft.
Material used in seal Bentonite
Did any strata contain unusable water? Yes [ ] No [X]
Type of water? Depth of strata
Method of sealing strata off

(7) PUMP: Manufacturer's Name
Type: H.P.

(8) WATER LEVELS: Land-surface elevation above mean sea level ft.
Static level 150 ft. below top of well Date July 94
Artesian pressure lbs. per square inch Date
Artesian water is controlled by (Cap, valve, etc.)

(9) WELL TESTS: Drawdown is amount water level is lowered below static level
Was a pump test made? Yes [ ] No [X] If yes, by whom?
Yield: gal./min. with ft. drawdown after hrs.

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level

Date of test
Bailer test gal./min. with ft. drawdown after hrs.
Airtest 5 gal./min. with stem set at 298 ft. for 1 hrs.
Artesian flow g.p.m. Date
Temperature of water Was a chemical analysis made? Yes [ ] No [X]

(10) WELL LOG or ABANDONMENT PROCEDURE DESCRIPTION

Formation: Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of information.

MATERIAL	FROM	TO
Sand + Gravel	0	26
Clay	26	248
Granite Rock	248	300
Water in Falt in Rock		

Work Started July 1994 Completed July 1994

WELL CONSTRUCTOR CERTIFICATION:

I constructed and/or accept responsibility for construction of this well, and its compliance with all Washington well construction standards. Materials used and the information reported above are true to my best knowledge and belief.

NAME Tri-River Drilling (PERSON, FIRM, OR CORPORATION) (TYPE OR PRINT)
Address Box 7 Brewster WA 98812
(Signed) Albert Glessner (WELL DRILLER) License No. 1372
Contractor's Registration No. TRIRIDL077RF Date Aug 18 1994

(USE ADDITIONAL SHEETS IF NECESSARY)

ECL 050-1-20 (2/93)

93

File Original and First Copy with Department of Ecology
Second Copy — Owner's Copy
Third Copy — Driller's Copy

WATER WELL REPORT

STATE OF WASHINGTON

Application No. 64 529165

Permit No. E

(1) OWNER: Name RICHARD HERR Address CARLTON WASH

(2) LOCATION OF WELL: County ..... SW ¼ NW ¼ Sec. 16 T. 31 N., R. 22 W.M.

Bearing and distance from section or subdivision corner

(3) PROPOSED USE: Domestic ☒ Industrial ☐ Municipal ☐ Irrigation ☐ Test Well ☐ Other ☐

(4) TYPE OF WORK: Owner's number of well (if more than one) .....

New well ☒ Method: Dug ☐ Bored ☐
Deepened ☐ Cable ☐ Driven ☐
Reconditioned ☐ Rotary ☒ Jetted ☐

(5) DIMENSIONS: Diameter of well 6 inches.
Drilled 50 ft. Depth of completed well 50 ft.

(6) CONSTRUCTION DETAILS:

Casing installed: 6" Diam. from 0 ft. to 50 ft.
Threaded ☐ ..." Diam. from ..... ft. to ..... ft.
Welded ☒ ..." Diam. from ..... ft. to ..... ft.

Perforations: Yes ☐ No ☒
Type of perforator used .....
SIZE of perforations ..... in. by ..... in.
..... perforations from ..... ft. to ..... ft.
..... perforations from ..... ft. to ..... ft.
..... perforations from ..... ft. to ..... ft.

Screens: Yes ☐ No ☒
Manufacturer's Name .....
Type ..... Model No. .....
Diam. ..... Slot size ..... from ..... ft. to ..... ft.
Diam. ..... Slot size ..... from ..... ft. to ..... ft.

Gravel packed: Yes ☐ No ☒ Size of gravel: .....
Gravel placed from ..... ft. to ..... ft.

Surface seal: Yes ☒ No ☐ To what depth? 18 ft.
Material used in seal BENTONITE
Did any strata contain unusable water? Yes ☐ No ☒
Type of water? ..... Depth of strata .....
Method of sealing strata off .....

(7) PUMP: Manufacturer's Name .....
Type: ..... H.P. .....

(8) WATER LEVELS: Land-surface elevation above mean sea level ..... ft.
Static level 26 ft. below top of well Date .....
Artesian pressure ..... lbs. per square inch Date .....
Artesian water is controlled by ..... (Cap, valve, etc.)

(9) WELL TESTS: Drawdown is amount water level is lowered below static level
Was a pump test made? Yes ☐ No ☒ If yes, by whom? .....
Yield: gal./min. with ft. drawdown after hrs.
" " " "
" " " "

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level

Date of test .....
Bailer test ..... gal./min. with ..... ft. drawdown after ..... hrs.
Artesian flow ..... g.p.m. Date .....
Temperature of water ..... Was a chemical analysis made? Yes ☐ No ☐

(10) WELL LOG:

Formation: *Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of formation.*

MATERIAL	FROM	TO
OVERBURDEN	0	2
COURSE SAND & GRAVEL	2	11
BROWN CLAY & GRAVEL	11	31
COURSE SAND & GRAVEL	31	50
Approx 50 Gpm		

RECEIVED
JAN 6 1988
DEPARTMENT OF ECOLOGY
CENTRAL REGION OFFICE

Work started NOV 18, 19 87 Completed NOV 19, 19 87

WELL DRILLER'S STATEMENT:

This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.

NAME METHOW VALLEY DRILLING
(Person, firm, or corporation) (Type or print)

Address BOX 68 TWISP WASH

[Signed] [signature]
(Well Driller)

License No. 0426 Date NOV 22, 19 87

(USE ADDITIONAL SHEETS IF NECESSARY)

ECY 050-1-20

Unrecorded

STATE OF WASHINGTON
DEPARTMENT OF CONSERVATION AND DEVELOPMENT

WELL LOG No...../.....-.....

Date January 7, 19 65

Record by Driller

Source Driller's Record

Location: State of WASHINGTON

County Douglas

Area

Map

SW ¼ NW ¼ sec. 16 T. 31 N., R. 22 E. W.

Diagram of Section

Drilling Co. G. Allen Reed

Address Route 1, Box 154-A1, Brewster, Washington

Method of Drilling..... Date....., 19.....

Owner Andrew N. Nielsen

Address Box 231, Twisp, Washington

Land surface, datum.....ft. above/below

Correlation	Material	Thickness (feet)	Depth (feet)
	Surface to 45' boulder formation		
	gravel and clay binder	45	
	water at 28'		
	45' to 50' coarse sand		
	and gravel	45	50
	Casing: 6" from 0 to 50'		
	Shoe set at 50 feet		
	SWL: 28'		
	Bailed in excess of 20 gpm for ½ hour		
	immediate recovery, August 6, 1964		

(Transcribe driller's terminology literally but paraphrase as necessary, in parentheses. If material water-bearing, so state and record static level if reported. Give depths in feet below land-surface datum unless otherwise indicated. Correlate with stratigraphic column, if feasible. Following log of materials, list all casings, perforations, screens, etc.)

Turn up

Sheet.....of.....sheets

113877

WATER WELL REPORT

ECOLOGY Original & 1st copy Ecology 2nd copy owner 3rd copy driller

Construction/Decommission (x in circle)
- O Construction
- O Decommission *ORIGINAL CONSTRUCTION Notice of Intent Number* _____

CURRENT Notice of Intent No W122688

Unique Ecology Well ID Tag No AGM 700

Water Right Permit No _____

Property Owner Name Bob Newell

Well Street Address 171 Old Cole Rd

City Carlton County ~~Wash~~ Okanogan

Location NW 1/4 1/4 ~~SE~~ 1/4 Sec 18 Twn 31 R 22 EWM or ~~WWM~~ circle one

Lat/Long (s t r still REQUIRED) Lat Deg _____ Lat Min/Sec _____ Long Deg _____ Long Min/Sec _____

Tax Parcel No _____

PROPOSED USE [X] Domestic [ ] Industrial [ ] Municipal [ ] DeWater [ ] Irrigation [ ] Test Well [ ] Other _____

TYPE OF WORK Owner s number of well (if more than one) _____
[X] New Well [ ] Reconditioned *Method* [ ] Dug [ ] Bored [ ] Driven [ ] Deepened [ ] Cable [X] Rotary [ ] Jetted

DIMENSIONS Diameter of well _____ inches drilled _____ ft
Depth of completed well _____ ft

CONSTRUCTION DETAILS
Casing Installed [X] Welded 6 Diam from 0 ft to 55 ft
[ ] Liner installed _____ Diam from _____ ft to _____ ft
[ ] Threaded _____ Diam from _____ ft to _____ ft

Perforations [ ] Yes [X] No
Type of perforator used _____
SIZE of perfs _____ in by _____ in and no of perfs _____ from _____ ft to _____ ft

Screens [ ] Yes [ ] No [ ] K Pac Location _____
Manufacturer's Name _____
Type _____ Model No _____
Diam _____ Slot Size _____ from _____ ft to _____ ft
Diam _____ Slot Size _____ from _____ ft to _____ ft

Gravel/Filter packed [ ] Yes [ ] No [ ] Size of gravel/sand _____
Materials placed from _____ ft to _____ ft

Surface Seal [X] Yes [ ] No To what depth? 55 ft
Materials used in seal cement
Did any strata contain unusable water? [X] Yes [ ] No
Type of water? _____ Depth of strata _____
Method of sealing strata off cement

PUMP Manufacturer s Name _____
Type _____ H P _____

WATER LEVELS Land surface elevation above mean sea level 1 ft
Static level 21 ft below top of well Date 5-7-02
Artesian pressure _____ lbs per square inch Date _____
Artesian water is controlled by _____ (cap valve etc)

WELL TESTS Drawdown is amount water level is lowered below static level
Was a pump test made? [ ] Yes [X] No If yes by whom? _____
Yield _____ gal /min with _____ ft drawdown after _____ hrs
Yield _____ gal /min with _____ ft drawdown after _____ hrs
Yield _____ gal /min with _____ ft drawdown after _____ hrs

Recovery data (time taken as zero when pump turned off)(water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level

Date of test _____
Bailer test _____ gal /min with _____ ft drawdown after _____ hrs
Airtest 20 gal /min with stem set at 90 ft for 2 hrs
Artesian flow _____ g p m Date _____
Temperature of water _____ Was a chemical analysis made? [ ] Yes [X] No

CONSTRUCTION OR DECOMMISSION PROCEDURE
Formation Describe by color character size of material and structure and the kind and nature of the material in each stratum penetrated with at least one entry for each change of information Indicate all water encountered (USE ADDITIONAL SHEETS IF NECESSARY)

MATERIAL	FROM	TO
Sand & gravel	0	14
Brown clay	14	29
gray clay	29	31
gray hard pan	31	34
granite	34	88
fractured granite	88	90

DEPT OF ECOLOGY Received MAY 29 2002 CENTRAL REGION OFFICE

Start Date 5-6-02 Completed Date 5-7-02

WELL CONSTRUCTION CERTIFICATION I constructed and/or accept responsibility for construction of this well and its compliance with all Washington well construction standards Materials used and the information reported above are true to my best knowledge and belief

[X] Driller [ ] Engineer [ ] Trainee Name (Print) Rich Bynum

Driller/Engineer/Trainee Signature [signature]

Driller or Trainee License No 0781

Drilling Company Methow Valley Drilling

Address P.O. Box 68

City State Zip Twisp, Wash 98856

Contractor s Registration No Methovvdrlcl Date 5-7-02

If trainee, licensed driller s Signature and License no _____

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Second Copy - Owner's Copy
Third Copy - Driller's Copy

93180

WATER WELL REPORT

STATE OF WASHINGTON

Notice of Intent W122369

UNIQUE WELL I D # AFY 171

Water Right Permit No _____

(1) OWNER Name Barry & Connie Swanson Address 2113 116th AVE NE Lake Stevens W

(2) LOCATION OF WELL County Okanogan SW 1/4 NE 1/4 Sec 11 T 32 N R 31 WM

(2a) STREET ADDRESS OF WELL (or nearest address) Twisp River

TAX PARCEL NO _____

DEPT. OF ECOLOGY

(3) PROPOSED USE ☒ Domestic ☐ Industrial ☐ Municipal ☐ Irrigation ☐ Test Well ☐ Other ☐ DeWater

(4) TYPE OF WORK. Owner's number of well (if more than one) _____
☒ New Well ☐ Deepened ☐ Reconditioned ☐ Decommission
Method ☐ Dug ☐ Bored ☐ Cable ☐ Driven ☒ Rotary ☐ Jetted

(5) DIMENSIONS Diameter of well 6 inches
Drilled 160 feet Depth of completed well 160 ft

(6) CONSTRUCTION DETAILS
Casing installed
☐ Welded 6" Diam from 0 ft to 100 ft
☐ Liner installed " Diam from ft to ft
☐ Threaded " Diam from ft to ft

Perforations ☐ Yes ☒ No
Type of perforator used _____
SIZE of perforations _____ in by _____ in
_____ perforations from _____ ft to _____ ft

Screens ☐ Yes ☒ No ☐ K-Pac Location _____
Manufacturer's Name _____
Type _____ Model No _____
Diam _____ Slot Size _____ from _____ ft to _____ ft
Diam _____ Slot Size _____ from _____ ft to _____ ft

Gravel/Filter packed ☐ Yes ☒ No ☐ Size of gravel/sand _____
Material placed from _____ ft to _____ ft

Surface seal ☒ Yes ☐ No To what depth? 18 ft
Material used in seal Bentonite
Did any strata contain unusable water? ☐ Yes ☒ No
Type of water? _____ Depth of strata _____
Method of sealing strata off _____

(7) PUMP Manufacturer's Name _____
Type _____ H P _____

(8) WATER LEVELS Land-surface elevation above mean sea level _____ ft
Static level 120 ft below top of well Date _____
Artesian pressure _____ lbs per square inch Date _____
Artesian water is controlled by _____
(Cap, valve, etc)

(9) WELL TESTS Drawdown is amount water level is lowered below static level
Was a pump test made? ☐ Yes ☒ No If yes, by whom? _____
Yield _____ gal./min with _____ ft drawdown after _____ hrs
Yield _____ gal /min with _____ ft drawdown after _____ hrs
Yield _____ gal /min with _____ ft drawdown after _____ hrs
Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level

Date of test _____
Bailer test _____ gal./min with _____ ft drawdown after _____ hrs
Airtest 8 gal./min with _____ ft drawdown after _____ hrs
Artesian flow _____ g p m Date _____
Temperature of water _____ Was a chemical analysis made? ☐ Yes ☒ No

(10) WELL LOG or DECOMMISSIONING PROCEDURE DESCRIPTION
Formation Describe by color, character, size of material and structure, and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of information Indicate all water encountered

MATERIAL	FROM	TO
Overburden	0	5
Clay	5	21
Sand	21	40
Gravel	40	61
Hardpan	61	98
Granite	98	150
Fractured granite	150	160

RECEIVED
SEP 08 2000
DEPARTMENT OF ECOLOGY
WELL DRILLING UNIT

DEPT OF ECOLOGY Received SEP 13 2000 CENTRAL REGIONAL OFFICE

Work Started 6-30 Completed Same

WELL CONSTRUCTION CERTIFICATION

I constructed and/or accept responsibility for construction of this well, and its compliance with all Washington well construction standards Materials used and the information reported above are true to my best knowledge and belief

Type or Print Name R Bynum License No 0781
(Licensed Driller/Engineer)
Trainee Name _____ License No _____
Drilling Company _____
(Signed) R Bynum License No 0781
(Licensed Driller/Engineer)
Address P.O. Box 68 Twisp, Wash
Contractor's Registration No Methoudiack Date 6-30

(USE ADDITIONAL SHEETS IF NECESSARY)

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ECY 050-1-20 (11/98)

Minerals & Geology

Ecological Survey

- Ecological Survey PDF (download size 2MB)

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509.548.5817 Fax

Forestry Sciences Laboratory
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Wenatchee, WA 98801

509.662-4315 Voice
509.664.2742 Fax

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Ecological Survey
Antimony Queen Mine
Carlton, Washington

December 23, 2003

Prepared on Behalf of

Cascade Earth Sciences
12720 East Nora Avenue
Spokane, Washington 99216

For

U.S. Forest Service, Region 6
Okanogan National Forest
Okanogan County, Washington

LANDAU ASSOCIATES
130 2nd Avenue South
Edmonds, WA 98020
(425) 778-0907

EXECUTIVE SUMMARY

A survey was completed to document ecological conditions at the Antimony Queen Mine and within adjacent Gold Creek. The results of this survey were used to provide a preliminary assessment of the potential for mine-related ecological impacts. Overall, the terrestrial ecology of the mine and surrounding area is relatively undisturbed and of high quality. The only apparent impacts to the terrestrial ecology are the waste piles associated with the lower and uppermost adits, which are essentially devoid of vegetation. Because of the steep slope surrounding the adits, the mining wastes have slid from the waste piles into Gold Creek, disturbing the riparian vegetation along an approximately 50 m (meter) length of the southern shoreline.

There was more gravel in Gold Creek immediately downstream of the mine. The gravel is likely to have originated from the waste piles and appears to have a positive effect on physical stream quality because it presents a potential area of spawning habitat for resident and anadromous fishes. The potential chemical effect of this instream mine-related gravel on fish eggs and spawning fish depends on water quality within the gravel, which was not assessed as part of this survey.

The number of aquatic invertebrate species present and species diversity appeared to be lower within instream pool habitats at two sampling stations downstream of the mine. Because particulate-bound mine-related chemicals could be expected to settle in pool habitats, these differences may be the result of mine-related contamination. However, instream temperature, which increased at these two stations, was also qualitatively correlated to the changes in pool species diversity. The high-energy nature and steep gradient of Gold Creek suggests that particulate-bound contamination may have been transported to locations downstream of the current area of investigation and possibly to the Methow River.

The areas of potential mine-related terrestrial impacts make up a very small portion of the overall available terrestrial habitat in the vicinity of the mine. Thus, any potential impacts to terrestrial species would be expected to occur only for those species that are regularly exposed to mine-related chemical contamination (i.e., the waste piles). The contribution of waste-pile gravel to Gold Creek has resulted in better physical instream habitat. However, it should be determined whether this area represents an attractive nuisance due to the presence of mine-related chemical concentrations that are unacceptable for fish eggs and spawning. The areas of potential mine-related impacts within the pool habitats are also areas likely used by threatened and endangered fish species. Thus, the potential for mine-related contamination to present ecological risks within the pool habitats should also be assessed.

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1.0 INTRODUCTION

The Antimony Queen Mine (site) is located within the Okanogan National Forest (ONF) in Okanogan County, approximately 14.5 kilometers (km) southwest of Carlton, Washington, on Forest Service Road (FR) 4340 (Figure 1). According to the U.S. Geological Survey (USGS) Quadrangle Map, Hungry Mountain, the site is located in the southeast quarter of the northwest quarter of Section 11 Township 31 North, Range 21 East, of the Willamette Meridian at Latitude: 48°06'22", Longitude: 120°02'21". The mine is located on the south side of Gold Creek. Antimony, gold, silver and tungsten were mined at the site, which is currently inactive. Detailed site history and a review of previous investigations have been provided earlier (Cascade Earth Sciences [CES] 2003) and are not reiterated herein.

1.1 SITE DESCRIPTION

The site is situated on the steep hillsides of Foggy Dew Ridge along the North Fork of Gold Creek. The mine is bordered on the north by Gold Creek and is surrounded by a steep forested hillside on the other three sides. Gold Creek flows into the Methow River approximately 6 km east of the mine.

The mine includes four adits, only one of which is still open, and an old roadbed that lies below the lower adit and proceeds upstream from the site, along Gold Creek. The open adit is lowest in elevation, located approximately 20 m upslope from, and 10 m higher in elevation than Gold Creek. No water was observed flowing from the lower adit during this ecological survey, however, water was documented as draining from its portal at a rate of less than 0.1 cubic ft per second (cfs) during a July 2002 U.S. Forest Service site visit (USFS 2002). The lower adit has a waste pile extending from its opening down to Gold Creek. The second (upper) adit is located approximately 65 m in elevation above, and slightly west of the lower adit. This adit has collapsed and no water was observed or documented as flowing from it. There is a rubble pile at the opening of the upper adit and a narrow (approximately 5 m wide) waste rock slide that extends downslope from the adit to the old roadbed located just upslope from the creek. The other two adits were between the upper and lower adits, but are caved and currently appear as rubble piles.

1.2 OBJECTIVES

The overall objective of the ecological survey was to document the ecology at the abandoned mine and provide a preliminary assessment of the potential for mine-related ecological effects. The specific objectives were three-fold:

- Characterize terrestrial, riparian, and instream habitats, terrestrial macroinvertebrates, herpetiles (reptiles and amphibians), birds, mammals, fish, and benthic (i.e., sediment dwelling) invertebrates present, or likely to be present at the site, including the presence of threatened and endangered species and their habitat.

- Provide an initial characterization of the potential for exposure of ecological receptors to site-related chemicals and of ecological effects that may occur as a result of this exposure, or as a result of site-related physical disturbance of the environment.

- Summarize the potential for site-related ecological effects, make recommendations regarding the need for further ecological effects assessment at the site, and, as necessary, suggest possible actions to better understand the potential ecological effects.

Section 2.0 of this report provides the methodology and results of the field surveys. Section 3.0 presents the conclusions reached during the survey and recommendations are made regarding the need for, and approach to, further ecological assessment. References for this report are provided in Section 4.0.

2.0 METHODOLOGY AND RESULTS

A review of public information and onsite surveys were performed to achieve the objectives of the ecological survey. State and federal agency biologists familiar with the site and region surrounding the site were also contacted for information on terrestrial and aquatic species known to be, or likely to be present onsite. In addition, a search for rare, threatened, or endangered (RTE) species was requested from the Washington Department of Natural Resources Natural Heritage Program (WDNR NHP; plants and sensitive habitats only) and the Priority Habitat and Species (PHS) program of the Washington Department of Fish and Wildlife (WDFW). The RTE species observed or expected at the site are discussed below in their appropriate sections.

Two biologists conducted the onsite surveys on July 6-8, 2003 to document plant community and stream habitats, and the invertebrates, fish, and wildlife present in these habitats. Similar information was collected in comparable habitats located adjacent to, or upstream of, the site to document undisturbed, (i.e., reference) habitat conditions. Specific methodologies used to collect information and field survey results are described in the following sections and additional information on the methodology can be found in the Field Operations Plan (CES 2003).

Onsite areas were those that were within a rectangular area that encompassed the shoreline of Gold Creek, upslope to an elevation above the highest adit, and extended approximately 30 m on either side of the adits (Figure 2). The site extends approximately 100 m along Gold Creek and 100 m upslope from the creek, for a total area of approximately 0.8 hectare (ha).

2.1 TERRESTRIAL ENVIRONMENT

2.1.1 PLANT COMMUNITIES/HABITAT

Description of the plant communities at, and surrounding, the site allows a comparison of on to offsite plant communities and provides an understanding of the habitat that is present. Knowledge of the habitat also allows an understanding of the species (i.e., ecological receptors) that are likely to be present at and surrounding the site.

2.1.1.1 Methodology

The regional USFS botanist was contacted to obtain plant species lists for the region (Ohlson 2003). The site was walked to determine plant communities present in onsite areas of mine-related disturbance, apparently undisturbed onsite areas, naturally disturbed offsite areas (e.g., landslide areas), and undisturbed offsite areas. The area of each onsite plant community was estimated and compared to

the overall area of the site to determine the percent cover of each plant community. From these observations, the number and locations of onsite survey stations were determined based on the percentage of the site covered by a given plant community as follows:

- <25% of site covered by plant community ..... 1 sample plot
- 25% to <50%, of site covered by plant community ..... 2 sample plots
- 50% to <75% of site covered by plant community ..... 3 sample plots
- 75% to 100% of site covered by plant community ..... 4 sample plots

Offsite plant communities located within 50 m of the mine site boundary that were considered representative of historic onsite communities were also identified. The number of offsite adjacent sample locations for each plant community were determined based on the percentage of offsite adjacent area that was covered by that community, as follows:

- <50%, of adjacent area covered by plant community ..... 1 sample plot
- 50% to 100% of adjacent area covered by plant community ..... 2 sample plots

Based on the reconnaissance observations, the following ten survey stations were established:

- 4 onsite forest stations
- 2 offsite forest stations
- 1 open meadow station (on the site boundary)
- 1 offsite riparian station
- 1 onsite riparian station
- 1 onsite waste pile station.

The locations of vegetation survey stations are shown on Figure 2.

Survey stations were located in an area representative of each targeted plant community. All herbaceous (including weeds), shrub, and tree species were identified, and percent cover was estimated for each species, within a 5-m radius of each survey station,. Plants were identified using *Flora of the Pacific Northwest* (Hitchcock and Cronquist 1990) nomenclature and documented on field forms for each sample plot.

2.1.1.2 Results

The plant species documented onsite and likely to be present in the areas surrounding the mine are listed in Table 1. Five distinct plant communities were observed on, and adjacent to, the mine site. These included:

- Coniferous forest over a majority of the on and offsite area
- A meadow community at the east central border of the site
- Riparian forest along undisturbed banks of Gold Creek
- Disturbed riparian along the creek bank below the lower and upper mine adits
- Disturbed upland vegetation on the waste piles located downslope from these same adits.

The dominant plant community can be characterized as a Douglas fir (*Pseudotsuga mensiezii*), false box (*Pachistima myrsintes*), and bluebunch wheatgrass (*Agropyron spicata*) association that occurred throughout the study area. A dense cover of Douglas fir was the sole tree species observed in this community, with an open understory and a dense ground layer. Shrub species that occurred commonly in the open understory included false box, serviceberry (*Amelanchier alnifolia*) and snowberry (*Symphoricarpos alba*) with locally common patches of Douglas maple (*Acer glabrum*), oceanspray (*Holodiscus discolor*), tall Oregon grape (*Mahonia aquifolium*), and birch-leaved spirea (*Spirea betufolia*). Other shrub species observed that occurred less frequently included shrubby penstemon (*Penstemon myrsintes*), pink mountain heather (*Phyllodoce empetriformis*), squaw currant (*Ribes cereum*), Bebb's willow (*Salix bebbiana*), and Scouler's willow (*S. scouleriana*). The ground layer was dominated by bluebunch wheatgrass with locally common dog pelt lichen (*Peltigra canina*). Other ground layer species that occurred less frequently included arrow-leaved balsamroot (*Balsamorhiza saggitata*); old man's whiskers (*Geum triflorum*); prickly lettuce (*Lactuca serriola*); bracken fern (*Pteridium aquilinum*); yarrow (*Achillea millefolium*); pearly everlasting (*Anaphalis margaritacea*); racemose pussy toes (*Antennaria racemosa*); heart-leafed arnica (*Arnica cordifolia*); Lyall's mariposa lily (*Calochortus opiculatus*), and fragile fern (*Cystopteris fragilis*). Ground layer species that occurred throughout this community, but with low percent cover included parsnip-flowered buckwheat (*Eriogonum heracloides*), Idaho fescue (*Festuca idahoensis*), narrow-leafed hawkweed (*Hieracleum umbellatum*), round-leaved alum root (*Heuchera cylindrica*), and false Solomon seal (*Smilicina racemosa*).

The meadow community can be characterized as a serviceberry-bluebunch wheatgrass association that was observed in only one relatively small area at the east-central boundary of the site. This plant community is comprised of a densely growing ground layer with an open layer of scattered shrubs. Bluebunch wheatgrass dominates the ground layer, with commonly occurring western pasqueflower (*Anemone occidentalis*), parsnip-flowered buckwheat, Idaho fescue, and round-leaved alum root. Other observed ground layer species that occurred infrequently included Lyall's mariposa lily, Alaska rein-orchid (*Piperia unalaschensis*), and false Solomon seal. The shrub species that occurred most frequently

was serviceberry; with oceanspray, false box, and squaw current interspersed throughout the meadow. One Douglas fir sapling was also observed in this community.

The waste piles are characterized by a distinct lack of vegetation over most of the piles, with small areas where weedy and/or pioneer species are growing. One black cottonwood tree was observed in this habitat with a sparse open layer of snowberry. Black cottonwood and Douglas fir saplings were also noted in the understory. The most common groundcover species was the weedy diffuse knapweed (*Centaurea diffusa*), with minor cover of false Solomon seal, pearly everlasting, and nodding brome (*Bromus anomalus*).

The undisturbed riparian community is characterized as a black cottonwood (*Populus trichocarpa*)/mountain alder (*Alnus incana* ssp. *tenuifolia*) – red-stemmed dogwood (*Cornus sericea*) association that was observed immediately upstream and downstream from the mine site (see vegetation data sheet VS-8). This plant community has a dense understory layer growing under the slightly open tree canopy, with a sparse ground layer. Black cottonwood and mountain alder dominate the tree canopy, with scattered Douglas fir. In addition to the dominant shrub, red-stemmed dogwood, other shrubs that occurred frequently were Douglas maple and ocean spray. Less frequently occurring shrubs in this community include serviceberry, false box, mock orange (*Phildelphus lewisii*), snowberry, and oval-leaved blueberry. The sparse ground layer included scouring rush (*Equisetum hyemale*) and false Solomon seal.

The disturbed riparian community is characterized as a black cottonwood-snowberry association that was observed in a narrow band along the Gold Creek bank immediately downslope from the mine waste piles/slides. This plant community has a sparse understory and groundcover layers under an open tree canopy. Black cottonwood was the dominant tree species (although it had only 35 percent cover), with one Douglas fir sapling observed. Red-stemmed dogwood occurred very infrequently in the shrub layer and scouring rush and a Douglas maple seedling occurred very infrequently in the ground layer.

The riparian area on the north side of Gold Creek was not formally surveyed, as it is located on a relatively flat gradient compared to the steep hillsides on the south side of the creek, and appears to be subject to regular flooding events. In the vicinity of the mine, most of the riparian habitat north of the creek is comprised of barren cobble substrate, indicating that this area has been recently, or is frequently, scoured by water overflowing the banks of the creek. Due to this natural disturbance, the predominant vegetation is an open stand of trees with little to no groundcover and scattered shrubs. Immediately north, adjacent and upstream from the mine, the riparian forest consists of mixed-age Ponderosa pine (*Pinus ponderosa*) trees with a few Douglas fir trees also present. The understory layer is non-existent and the ground layer consists of sparsely growing grasses. Downstream from the mine site in an area partially protected from floodwaters, the mixed riparian forest has approximately 80 percent cover dominated by

young, successional black cottonwood and mountain alder, with less frequently occurring Ponderosa pine and willow. There is an open understory with patches of red-twig dogwood, willow saplings, thimbleberry (*Rubus parviflorus*) and Nootka rose (*Rosa nutkana*). The groundlayer is nearly absent with scattered areas of sparsely-growing horsetail (*Equisetum* sp.), sedge (*Carex* sp.), and pinedrops (*Pterospora andromedea*). While the riparian area on the north side of creek appears to be frequently disturbed by human foot traffic and annual flooding, it exhibited greater percent cover, species diversity, and structural diversity than the riparian areas disturbed by past mining activities on the opposite (southern) creek bank.

The WDNR NHP has no documentation of RTE plants or high quality native ecosystems occurring in the vicinity of Antimony Queen mine. However, because they have not conducted field surveys of this area, the lack of recorded information does not preclude the presence of significant plants or ecosystems. The USFS has identified 71 plant species as occurring in the Okanogan National Forest that are listed as threatened or sensitive in Washington State and/or the U.S. Fish and Wildlife Service (USFS) (Table 2). In addition, the USFS lists 19 plant species that, although they are not listed as threatened or sensitive, the agency manages and protects them from ground-disturbing activities (Table 3). None of the species listed as threatened, endangered, or under USFS management were observed during our site visit. However, the field surveys were conducted relatively late in the growing season to accommodate access across Gold Creek, and to allow collection of stream invertebrates from the creek. Therefore, plant species that flower and die early in the year were unlikely to be discovered by these recent plant surveys. If remediation work is necessary at this site, field surveys for early blooming USFS survey and manage species may be needed prior to any ground disturbance activity.

2.1.1.3 Discussion

There was no distinct difference between the on and offsite Douglas fir association. Any variation in frequency and percent cover of individual species appeared to be more dependent on slope aspect (i.e., steepness, direction facing, and elevation) than proximity to past mine activity. The waste piles from the highest and lowest adits had the greatest impact on vegetation. Prior to the mine, the waste pile areas likely supported the same Douglas fir association observed on the steep slopes on and adjacent to the site. Currently, the waste piles do not support mature forest; instead, some colonizer and weedy species such as black cottonwood and diffuse knapweed were observed on the mostly barren waste piles. While the forest habitat exhibits a greater than 100 percent average cover of vegetation (considering each structural layer) the waste piles were mostly devoid of vegetation with greater than 70 percent bare ground. Even the forested survey station that exhibited signs of disturbance due to natural landslides (VS-6) had greater groundcover, a greater variety of species, and fewer weedy species than the waste

piles. The lack of vegetation on the waste piles may be due to a one or a combination of factors, including continued disturbance from human foot travel, compaction, lack of organic material for rooting, ongoing erosion, or elevated concentration of contaminants.

There was a distinct difference between the on and offsite riparian habitats observed on the south side of Gold Creek. The disturbed onsite riparian area located immediately downgradient of the waste piles had a very open canopy with few species represented in all layers (canopy, understory, and ground). In contrast, the undisturbed riparian area upstream of the mine exhibited a very dense vegetation canopy with a wide range of species present in the tree and shrub canopy layers. The difference in vegetative cover and diversity between the disturbed and undisturbed riparian forest could be caused by the same factors as those discussed above for the lack of vegetation on the waste piles.

Riparian areas are often considered a priority habitat by the WDFW and the PHS list documents the Methow Valley riparian corridor (i.e., cottonwood; dogwood; willow; snowberry; mock-orange, and rose community) as important for many species of wildlife. Although not specifically identified in the WDNR NHP list, this riparian habitat is depicted on the PHS map along Gold Creek and its tributaries. Riparian habitat similar to that described for the Methow River is present along the southern shoreline of Gold Creek upstream and downstream of the site, and also immediately downstream of the site along the northern shoreline of the creek. In general, the riparian habitat becomes more dense and wider with increasing distance downstream from the site.

2.1.2 BIRDS

2.1.2.1 Methodology

Prior to the field effort, the regional USFS wildlife biologist was contacted to discuss which species were likely to be present at the site and species lists were obtained for the area surrounding the site (Rohrer 2003). The dominant habitats at the site were determined during an initial site reconnaissance. One bird survey station was established in the forest community and one in the riparian community. The forest bird survey station (BS-03) was established at an elevation above the mine, near the eastern boundary of the site at a location where both on and offsite forest and meadow communities could be observed. The first riparian survey station (BS-01) was placed approximately 50 m north of Gold Creek, aligned with the waste pile slide (i.e., scree field) associated with the upper adit. This station was abandoned after the first morning survey because two gray squirrels continually chattered during the survey, alarming nearby birds and prohibiting auditory bird identification. The second riparian survey station (BS-02) was established approximately 50 m north of Gold Creek, aligned with the western site boundary. The three bird survey stations are shown on Figure 2 and were located at a distance from the

creek in an attempt to reduce noise associated with cascading water within the creek and allow auditory bird identification.

Each bird survey station was visited twice in the evening before sunset and twice in the morning at about sunrise. The first survey at each station included a 15-minute period during which all birds observed or heard were documented on field data sheets. The second bird survey at stations BS-02 and BS-03 (Figure 2) was increased to a 30-minute period in an attempt to better document the presence of birds at and surrounding the site. Birds identified during other field efforts were also documented in field notebooks.

2.1.2.2 Results

During the bird surveys, four bird species were identified in forested habitats and three were identified in riparian habitat. Birds documented in forested habitat included black-chinned hummingbird (*Archilochus alexandri*), red-breasted nuthatch (*Sitta canadensis*), peregrine falcon (*Falco peregrinus*), and western tanager (*Piranga ludoviciana*). Birds documented in the open riparian habitat included American robin (*turdus migratorius*) and Swainson's thrush (*Catharus ustulatus*). An unidentified flycatcher was observed between stations during the morning surveys.

During the vegetation, mammal, and stream surveys additional birds species were identified. These included yellow-rumped warbler (*Dendroica coronata*) and American dipper (*Cinclus mexicanus*) near Gold Creek Station 4 (GC-04 downstream of the site), a Swainson's thrush and a ruffed grouse (*Bonasa umbellus*) near GC-02 (immediately downstream of the site), a western wood pewee (*Contopus sordidulus*) at the lower adit, and a vesper sparrow (*Pooecetes gramineus*) in a grassy upland area near GC-01 (upstream of the site). These and other birds likely to be present in the vicinity of the site are listed in Table 4.

The WDFW PHS program lists the north fork of Gold Creek as a priority breeding habitat for the harlequin duck (*histrionicus histrionicus*). Harlequin ducks are not an RTE species and were not observed during the stream surveys, but suitable breeding and rearing habitat is present. State and federally threatened bald eagles (*Haliaeetus leucocephalus*) were noted in the PHS as being present within the vicinity of the site, but are not documented in close proximity to the site. The RTE bird species potentially found at the site are shown in Table 4.

2.1.2.3 Discussion

Relatively few birds were documented during the formal bird surveys and during other field activities. This was likely related to two primary factors. First, the stream noise associated with Gold

Creek was clearly audible from all bird survey stations, especially at the higher elevation survey station on the slope above the lower adit. The creek noise made it very difficult to hear birdsong anywhere near the site. Second, the habitat was open evergreen forest at both survey stations, which often supports relatively few song and perching birds, compared to the number found in dense broadleaf and deciduous foliage such as that downstream near GC-04. The open habitat also made it difficult for survey personnel to approach the survey station and complete the survey without flushing birds from the survey area. The second survey period was extended from 15 to 30 minutes in an attempt to allow birds to return to the vicinity of the survey station, but this did not increase the number of birds heard or observed during the second set of surveys.

The birds that were observed during site activities represented several distinct foraging strategies in several different habitats, and likely well represented other birds (listed in Table 4) that could be expected to inhabit the area surrounding the site. The warbler, thrush, peewee, robin, and grouse represent species adapted to dense, moist riparian corridors where fruits, seeds, and insects are common on the ground, in the foliage, and in the air. The tanager and nuthatch represent species well-adapted to eating insects on and around evergreen trees. The sparrow was noted in a dry upland grassy area adjacent to the creek. The dipper is an aquatic species dependent on stream invertebrates. Together, the varied habitat and foraging preferences represented by the documented birds shows that the species inhabiting the area surrounding the mine site are diverse and suggest that other species are likely to be present but were not noted during our limited survey.

A western wood peewee was observed plucking insects from the air in front of the lower adit. Chemical impacts to upland bird species would be expected only if the birds were picking bugs or other food items from the soil within the waste piles, or otherwise eating insects or fruit that had been exposed to or were rooted in the waste piles. Because the mining-related disturbed areas at the site were relatively small (especially in relation to the available surrounding undisturbed habitat), physical impacts to upland bird species would be expected only if the disrupted habitat was particularly critical for a species. No such habitats were listed or noted for the site.

Aquatic bird species such as the harlequin or dipper may have the highest potential for exposure of birds to chemicals due to the potential distribution of mine-related materials in Gold Creek, downstream from the site. Any physical impacts due to waste piles entering the creek seem unlikely given that the scouring energy of Gold Creek is high and would carry any fine and smaller diameter particles downstream, leaving the cobbles and boulders, which are the predominant natural instream substrate. Ground feeding insectivorous birds may also be exposed to site-related contamination as they glean buts from the waste pile.

2.1.3 MAMMALS, HERPETILES, AND INVERTEBRATES

2.1.3.1 Methodology

Prior to the field effort, the regional USFS biologist was contacted to discuss which species were likely to be present at the site and species lists were obtained for the area surrounding the site (Rohrer 2003). No list of invertebrates was obtained for the site.

Initial survey planning for mammals, herpetiles, and invertebrates called for four linear transects to be established across the site. These transects were to be placed to intersect as many of the onsite plant communities and terrain types as possible. However, the very steep nature of the site and rough terrain made such an approach infeasible. Given site conditions, a field biologist walked in a zigzag pattern up the slope on one side of the site, passed across the upper portion of the site, and then in a zigzag pattern down the opposite side of the site. During this survey, rocks and logs were overturned and any indications of terrestrial macroinvertebrates, herpetiles, and mammals were documented in a field notebook. Such indications included sitings, trails, tunnels, or tracks. In addition, during the course of the two-day field effort, any on or offsite observations of these species were also documented in field notebooks.

2.1.3.2 Results

The only mammal documented during the field survey included an unidentified chipmunk near bird survey station 3. This was most likely a yellow pine chipmunk (*Eutamias amoenus*). Mule deer (*Odocoileus hemonius*) scat was noted during the survey along game trails that traversed the site. During the bird surveys, two western gray squirrels (*Sciurus griseus*) were noted in the trees near bird survey station 1. Small mammal burrows were noted on and offsite in the open grassy undercover on the slope above the lower adit. No such burrows were noted on the rocky slopes or on waste pile/slide areas. The mammals likely to be present in the vicinity of the site are listed in Table 5.

The WDFW PHS program lists the site as within the range of the state and federally threatened lynx (*Lynx canadensis*) and as a regular concentration area for state threatened western gray squirrel. The site is also listed as a regular concentration area and migration corridor for mule deer and marten (*Martes americana*) and have been noted by WDFW personnel downstream of the site near station GC-04. Neither the mule deer nor the marten are RTE species. The RTE mammal species observed or expected at the site are shown in Table 5.

The only herpetiles noted in the vicinity of the site during the entire field effort were a spotted frog (*Rana pretiosa*) and a western rattlesnake (*crotalus viridis*). The spotted frog is listed by the State of Washington as endangered. No federal sensitive, threatened, or endangered herpetiles were listed for the

onsite or nearby offsite areas, in any of the available databases. The herpetiles likely to be present in the vicinity of the site are listed in Table 6.

Relatively few sitings or indicators of ground-dwelling invertebrates were noted during the survey or field effort. Ants were the most numerous invertebrates noted, especially offsite, north of Gold Creek and on the lower adit waste pile. Most of the ants appeared to be little black ant (*Monomorium minimum*), but what appeared to be red ants (*Formica* spp.) were also noted. Butterflies (and/or moths) were common both on and offsite. While no butterflies or moths were captured for identification, the coloration noted suggests that those present may have been Gray Hairstreak (*Strymon melinus*), Silvery Blue (*Glaucopsyche lygdamus*), brown elfin (*Incisalia augustinus*), and/or woolly bear caterpillar moth (*Isia isabella*). While mostly active at night and not noted during the survey, moths such as yellow woolly bear moth (*Diacrisia virginica*) and lichen moth (*Lycomorpha pholus*) may also be present in the vicinity of the site. Several beetles were also noted onsite, but were not identified. Numerous flies (including mayflies [Order *Ephemeroptera*]), grasshoppers, and crickets were also observed, primarily offsite, but were not identified. No RTE invertebrate species were observed or expected at the site.

2.1.3.3 Discussion

As is generally expected during short-term surveys, relatively few mammals and herpetiles were documented on or offsite. Based on game trails present at the upper elevations of the site and the presence of deer droppings in several areas, mule deer pass through the site. Chipmunks, ground squirrels, and tree squirrels (including the state threatened western gray squirrel are all potentially present onsite, but are unlikely to frequent the nearly barren mine-related waste piles due to the lack of food and cover). Small mammals such as voles, mice, and shrews are also likely to be present in the forest, but also are unlikely to inhabit the waste piles. Bats such as the Townsend's Big-Eared Bat may also use the lower adit as a roost.

While only a spotted frog and a rattlesnake were documented in the vicinity of the site, it is likely that other frogs, salamanders, and snakes are present in the vicinity of the site. Snakes may bask on sun-warmed rocks in the waste pile or scoured riparian areas north of Gold Creek. Salamanders may be found in any of the on or offsite habitats but, along with frogs, are more likely to be associated with the creek or moist riparian habitats. As such, they have the potential to be exposed to site-related contamination in the creek, if present. The frog that was found along the creek adjacent to the site appeared healthy and normal.

Particular invertebrate species were abundant on and offsite, especially ants. The forest litter contained more invertebrate species than did the waste piles where ants were the only invertebrates noted.

The barren, creek scoured substrate in the riparian area north of Gold Creek provides a habitat (cobbles) similar to the waste piles (rock/gravel) and ants were also the only invertebrates documented in this area.

Of the mammals, herpetiles, and invertebrates documented or likely to inhabit the site, ants are likely to be the species exposed to the highest concentrations of site-related contamination. In addition, insectivorous species may be exposed to mine-related contamination as they forage opportunistically on these invertebrates because they are easy to collect on the barren waste piles. Frogs are likely to have the highest potential for exposure to site-related contamination in surface water downstream of the site.

2.2 AQUATIC ENVIRONMENT

2.2.1 HABITAT

2.2.1.1 Methodology

The approach for the stream habitat survey is a modification of the Urban Stream Baseline Assessment Methodology (USBEM) developed during the Tri-County Urban Issues Endangered Species Act study (2000). A Phase I effort was completed to determine whether stream habitats were good, fair, or poor for fish and benthic (sediment-dwelling) invertebrates and included in-office determination and field verification of stream type, riparian vegetation characteristics, stream reach definition, fish distribution, and likely channel alterations. This was completed through initial discussions with a USFS fisheries biologist who was familiar with Gold Creek and the fish species that are likely to be present, an examination of the location of the site within the watershed, a review of aerial photographs of the site vicinity, and confirmation of the stream characteristics during the field effort. Based on the evidence, channel type, riparian vegetation, creek reaches, fish distribution, and channel alteration were determined.

A Phase II field assessment was completed by first establishing stream reaches in the vicinity of previously selected Gold Creek sampling stations. The general locations of sampling stations were selected prior to the field effort to characterize stream habitat and benthic invertebrate populations in areas upstream, adjacent to, and downstream of potential site-related impacts. At each sampling station a reach was defined that contained representative pool and riffle habitat. Then, U.S. Environmental Protection Agency (EPA) habitat assessment field data sheets (Barbour et al. 1999) were completed and fish passage barriers, riparian recruitment potential, pool frequency, channel pattern, and large woody debris (LWD) were documented to characterize instream habitat conditions. Gold Creek width, depth, and gradient (low, medium, high) and the locations of obvious input channels, connected wetlands, areas of runoff from the site to the stream, or apparent site related impacts were also noted.

2.2.1.2 Results

The approximate sample station locations are shown on Figure 3. The section of Gold Creek from station GC-01 to station GC-04 was the only portion of Gold Creek or its tributaries that was investigated.

Phase I Assessment

Based on the EPA Region X system for identifying stream channel types (Paustian et al. 1992), the channel type for the farthest upgradient Gold Creek sampling station is "high gradient contained". This reach is dominated by steep banks, boulder and large cobble substrate, and limited LWD. There were no instream pools and very few off-channel pools. Between stations GC-01 and GC-02, the channel type changed from high to "moderate gradient contained" and remained this channel type through station GC-04. This channel type was similar to the high gradient type found upstream, but in-channel LWD was more frequent and in-channel pools were present, although both were still relatively uncommon. The changes also included an increase in cobble and large gravel as a percentage of the total substrate, and a decreased percentage of boulders. Between GC-02 and GC-04, the gradient appeared similar, with the substrate dominated by cobbles, but included some boulder and gravel areas. Sand and organic material deposits were found in pools at stations GC-01, GC-02, and GC-03. The "pool" area selected at station GC-04 consisted primarily of gravel with some sand, but no organic material as it was located within the main stream channel. Based on channel type (predominantly gradient and substrate), station GC-01 represents a reach within Gold Creek that is different from the remaining sampling stations.

Based on a review of aerial photographs of the site vicinity prior to our survey, the predominant creek-side vegetation is relatively thick forest at stations GC-01 and GC-04, and more open forest at stations GC-02 and GC-03. The flood plain width varied from station to station, but was non-existent at GC-01 and very wide at stations GC-02, and GC-03. Station GC-04 had a flood plain of intermediate width compared to the other stations. The overall vegetation pattern was confirmed during the field effort with primarily coniferous forest present surrounding the creek at stations GC-01, GC-02, and GC-03 and a dense deciduous riparian area adjacent to station GC-04. However, while within a larger open coniferous area, the reach representing station GC-02 had a deciduous forest with a limited understory in the riparian zone immediately adjacent to the channel. Thus, the reach surrounding station GC-01 had no flood plain and a relatively dense coniferous forest with some understory shrubs in the nearshore riparian zone. The reach at station GC-02 had a relatively broad flood plain, deciduous forest adjacent to the channel, and this deciduous forest was surrounded by open coniferous forest. The reach at station GC-03 had very open coniferous forest and the broadest flood plain of any station. The reach at station GC-04 had a dense deciduous riparian area and understory, and an intermediate width flood plain. The open

understory noted for stations GC-02 and GC-03 appeared to be related to frequent flooding and scouring of the flood plain by Gold Creek.

The PHS map and USFS fisheries biologist both suggested that Gold Creek and Foggy Dew Creek are habitats for resident and anadromous salmonid fish species (see Section 2.2.3 for a discussion of fish species present in Gold Creek). Although no fish barriers were observed, given the high gradient and lack of pool, run, or off-channel habitats at station GC-01, unless gravel spawning or lower gradient areas are present upstream of station GC-01 in Foggy Dew or Gold Creeks, it is expected that the majority of salmonid species remain below station GC-01.

Phase II Assessment

Photographs of each reach are provided in Appendix A. The EPA habitat assessment scores ranged from 163 to 184 out of a possible score of 200. Based on this scoring, instream habitats were rated as optimal at stations GC-01, GC-02, and GC-04 and suboptimal at station GC-03. The suboptimal rating was primarily the result of a lack of bank vegetation within the sampling reach. At all stations the habitat assessment scores were lowered by marginal or poor velocity/depth regimes (i.e., slow/deep, slow/shallow, fast/deep, and fast/shallow), with only one or two of four possible regimes present. Pool frequency was also rated poor at all stations because there were greater than 7 channel widths between pools (USBEM 2000). These marginal or poor ratings are indicative of the high gradient, cascading nature of Gold Creek within the area of investigation.

The pools at stations GC-01, GC-02, and GC-03 were all off channel. Station GC-02 was a relatively large pool created by LWD but had flow only during high water. No pool could be located for several hundred meters upstream or downstream of station GC-04, so the “pool” sample was collected from an instream area of slack water where a small amount of sand and gravel had accumulated on the inside corner of a deep “run”. The pool at station GC-03 was similar in size to that at station GC-01, but was deeper and likely retained flow at lower water levels.

No fish passage barriers were noted during the investigation; LWD recruitment potential was high at stations GC-01, GC-02, and GC-04 and medium at station GC-03. Instream LWD was rated as good at all stations. Channel pattern was poor to fair with a sinuous channel but limited velocity/depth regimes.

One parameter that is not well captured on the habitat assessment field data sheet is the substrate components (i.e., bedrock, boulder, cobble, gravel, sand, silt, clay, or organic material). This was estimated during the field investigation and documented on the physical characterization field data sheet. Boulders were most numerous (35 percent of instream habitat) at station GC-01. The percent of substrate that was boulders was similar (20 to 25 percent) at the remaining three stations but generally decreased

proceeding downstream. Cobble was lowest at Station GC-02 where the most gravel was present. Otherwise, cobble increased proceeding downstream, but cobble size became smaller. Gravel was not present at station GC-01, was highest at Station GC-02, then constituted approximately 5 percent or less of the substrate at stations GC-03 and GC-04. Sand and organic materials were found in the off channel pools at Stations GC-01, GC-02, and GC-03 but were marginal components of the gravelly "pool" area selected for Station GC-04.

2.2.1.3 Discussion

Materials from the lower and upper adit waste piles and the mine-related roadway below the adits were sliding into Gold Creek. Given the naturally steep southern bank associated with this portion of the creek and the high energy of water within the creek, debris entering the creek is likely carried downstream and thus, the amount of channel alteration resulting from the waste piles currently is minimal. A higher percentage of gravel was noted immediately downstream of the mine. This gravel was not specifically examined for similarity to waste pile rock, but its presence was an anomaly compared to the rest of the investigated portions of the creek. Given the gradient and energy of Gold Creek, contributions of fine and medium-grained materials contributed to the channel have been rapidly dispersed downstream. These site-related materials introduced to the creek are not expected to represent significant physical impact because their introduction and movement within the stream mirror natural processes already present within the portion of Gold Creek studied during this investigation.

Riparian vegetation was thickest at station GC-04 where deciduous trees and shrubs crowded the stream and provided significant canopy cover. The riparian vegetation was similar in a limited area immediately surrounding the invertebrate sampling reach at station GC-02, but upstream and downstream of this reach, the riparian habitat was open coniferous forest with limited canopy cover over the creek. Regardless of riparian habitat quality, the potential for LWD recruitment is medium to high along the entire investigated length of Gold Creek, and LWD was present at all sampling reaches. The variability in riparian vegetation along the creek also provides for potential variability of instream habitat conditions.

Based on the available data, the instream Gold Creek habitat is undisturbed and of relatively high quality. The general lack of slow velocity water throughout the investigated length of Gold Creek results in a lack of instream gravel, sand, and silt. This leaves boulders and cobbles as the dominant substrate component. This, combined with the lack of 2 or 3, of 4 possible velocity/depth regimes (slow velocity/shallow, slow velocity deep, fast velocity/shallow and fast velocity/deep) decreased the instream habitat diversity and, therefore, the habitat quality.

When including both instream and riparian conditions, the highest quality pool habitat was present at Station GC-02. Pool habitat at Station GC-03 ranks second, at station GC-01 ranks 3rd, and the

lowest quality pool habitat was present at station GC-04. Station GC-02 also had the highest quality riffle habitat. The riffle habitat at Station GC-04 would rank 2nd, at station GC-03 ranks 3rd and at station GC-01 ranks last because both the substrate and velocity/depth regime are limited compared to just the velocity/depth regime limitations at station GC-03. Overall, the highest quality combination of instream (pool and riffle) and riparian habitat is provided at station GC-02.

Site-related physical impacts due to waste pile rock sliding into the creek seem to be limited within the area of investigation because the high gradient nature of Gold Creek rapidly transports most of the naturally occurring and site-related silt, sand, and gravel downstream. The lower portions of Gold Creek would need to be inspected to determine whether these finer-grained materials are likely to settle out within Gold Creek or are being transported to the Methow River. However, the greatest amount of gravel substrate was at immediately downstream from the lower adit. This suggests that the best instream habitat in the investigated length of Gold Creek may be a result of mine-related erosion.

2.2.2 INVERTEBRATES

2.2.2.1 Methodology

After characterizing stream conditions within a reach, one invertebrate sample was collected from pool habitat and one was collected from riffle habitat. Sampling was initiated at the downstream sampling area and proceeded upstream. Samples were collected via "jabs" with a D-ring dipnet (500-micron mesh) using EPA Rapid Bioassessment Protocol methods. Within riffle habitats, each jab consisted of placing the dipnet on the bottom of the creek facing upstream and then disturbing approximately 1 ft of the streambed upstream of the net opening by kicking the creek bottom and churning up the substrate. Any cobbles within the area of disturbance were picked up and washed off by hand in the current upstream of the net opening. In this manner, invertebrates on the stream bottom were dislodged and carried downstream into the net. Within pool habitats each jab consisted of scooping the top 2-4 inches of substrate, then rinsing the substrate within the dipnet to sieve out the finest grained material. To complete each sample, three jabs from the same reach and same habitat were washed into a 5-gal bucket. The majority of water was decanted from the bucket through the dipnet screen. Then a small amount of water was added to the bucket and used to "wash" the remaining substrate by shaking the bucket vigorously and then quickly decanting the water through the dipnet screen. This washing was repeated 3 to 5 times until the decanted water contained no debris. In this manner, the heavier sand, gravel, and cobble remained in the bucket while the lighter weight dislodged invertebrates, organic material, and some sand were caught in the dipnet. Any rocks or large organic matter accidentally transferred to the dipnet were picked clean of invertebrates and removed. The entire contents of the

dipnet were then hand-transferred into a wide-mouth sample jar containing 95 percent ethanol as a preservative. The sample jar was labeled with the sample station, sample number, date and time of collection, and initials of the sampling personnel and placed in a shipping cooler. This process was repeated for each pool and riffle within each of four sampling locations to collect a total of four pool samples and four riffle samples.

The invertebrate samples were shipped to a laboratory for enumeration. For each sample, up to 300 invertebrates were identified to the lowest possible taxonomic classification (i.e., order, family, genus, or species) and the number of individuals within each species was determined. The enumeration was then used to calculate abundance, functional group composition, community composition, dominance, richness, and biotic indices.

2.2.2.2 Results

Pool Samples

Within the four pool samples, the number of invertebrates was 774 at station GC-01, 2093 at station GC-02, and then decreased to 882 at station GC-03 and 250 at station GC-04 (Figure 4). As shown in Figure 4, the number of Ephemeroptera, Plecoptera, and Trichoptera (EPT) increases between station GC-01 and GC-02, decreases slightly at GC-03, and is highest that station GC-04. Figure 5 shows the community composition in pool habitats based on the percent of invertebrates that is represented by the predominant taxa. This figure shows that the invertebrates at pool stations GC-01 and GC-02 are dominated by Diptera and that the percentage of Nematodes increases at each of stations GC-01, GC-02, and GC-03 and are the most abundant taxa at station GC-03, while EPT and Diptera are most abundant at station GC-04. Figure 5 also shows that the Diptera Family is dominated by Chironomid species. Figure 6 shows that the predominant foraging methods of the species present in the pool samples are gathering and predation, with some shredders.

The number of species (i.e., species diversity) at pool stations is presented for all species, EPT, Chironomidae, Oligochaete, and Coleoptera is shown in Figure 7 for each of the four pool stations. Chironomids represent the Diptera, and Nematodes were not identified to species and so could not be included in this figure. Generally, there is a decrease in the number of species across stations GC-01, GC-02, and GC-03 and a rebound in the number at station GC-04. The number of Chironomid species were similar at stations GC-01 and GC-02, but then decreased at each of stations GC-03 and GC-04. The number of Oligochaete species were similar and low across all stations. Coleoptera species were limited across stations GC-01, GC-02, and GC-03, but increased at station GC-04.

Figure 8 shows a summary of biological indices pertinent to the site and pool habitats. The Shannon-Weaver Index is a measure of diversity at the site that takes into account species diversity and

distribution of individuals within each species. This index decreases slightly between stations GC-01 and GC-02, decreases more dramatically between stations GC-02 and GC-03 and rebounds at station GC-04. The metals tolerance index correlates to the number of species that are tolerant of metals contamination. This index increased between stations GC-01, GC-02, and GC-03, and then decreased and was equivalent to GC-01 at station GC-04, opposite of the Shannon-Weaver index of species diversity. The temperature preference index correlates to the number of species present that prefer colder water temperatures. Thus, as the temperature of the water increases, the index decreases. The temperature preference index was a mirror image of the metals tolerance index, with decreasing index values between stations GC-01, GC-02, and GC-03, and a rebound to a value higher than GC-01 at station GC-04.

Riffle Samples

Within the four riffle samples, the number of invertebrates was 400 at station GC-01, increased to 672 at station GC-02, and then decreased to 618 at stations GC-03 and 301 at station GC-04 (Figure 9). Similar to pool samples, the most invertebrates were found at station GC-02. As shown in Figure 9, the number of EPT follows the same pattern as overall invertebrate abundance. Figure 10 shows the community composition based on the percent of all invertebrates that is represented by the predominant taxa. This figure shows that EPT species represent the majority of invertebrates at all stations, EPT are dominated by ephemeroptera, that chironomid and oligochaete species are in relatively consistent number across stations, and that station GC-02 has the most even distribution of species within the predominant taxa. However, the only visible trend in Figure 10 is that the number of EPT species decreases from station GC-01 to GC-03. Figure 11 shows that the predominant foraging methods of the species present in the pool samples are gathering and predation, but the scrapers and shredders are also well represented.

The number of species (i.e., species diversity) is presented for all species, EPT, Diptera, and Oligochaetes in Figure 12 for each of the four riffle stations. EPT species are predominant but Diptera (comprised of approximately 50 percent chironomid species) also represent a significant portion of the species present at the four stations. Nematodes were not identified to species and so could not be included in this figure. Generally, the number of species is consistent across all four stations.

Figure 13 shows a summary of biological indices pertinent to the site and riffle habitats. The Shannon-Weaver Index is a measure of diversity at the site that takes into account species diversity and distribution of individuals within each species. This index is essentially the same across all riffle stations. The metals tolerance index correlates to the number of species present that are tolerant of metals contamination. This index decreased between stations GC-01 and GC-02, increased between stations GC-02, and GC-03, and then decreased to its lowest level at station GC-04. The temperature preference index correlates to the number of species present that are adjusted to colder water temperatures. Thus, as

the temperature of the water increases, the index decreases. Similar to pool habitat results, the temperature preference index essentially was a mirror image of the metals tolerance index with increasing index values between stations GC-01and GC-02, decreasing values between GC-02 and GC-03, and a rebound to a value higher than GC-01 at station GC-04.

2.2.2.3 Discussion

No statistical analyses were conducted on the samples. This discussion is based on the invertebrate counts at each station and trends in invertebrate abundance and diversity between stations.

Similar to Section 2.2.2.2, the following discussion is separated for pool and riffle habitats. Then the potentially important similarities and/or differences between the two habitats are presented. The enumeration results for pool samples are considered more likely to be predictive of potential chemical effects because the pools represent depositional areas where sediment-bound site-related chemicals would settle to the creek bottom and result in the exposure of benthic invertebrates to the chemicals. Whereas, the enumeration results for riffle samples were considered more likely to be predictive of potential physical effects because site-related gravel and cobble sized rock may be deposited in the riffle areas.

Pool Samples

The relatively high total number (i.e., abundance) of invertebrates found in the pool samples reflects the quality of invertebrate habitat (as described in Section 2.2.1.3) found in each pool. However, this correlation was not present for EPT species, primarily due to the fact that EPT species generally prefer instream habitat to off channel pool habitats. Because the "pool" habitat sampled at station GC-04 was not off channel, as were the pools at all other stations, it represented a more preferred habitat for EPT species, and this is reflected in the EPT abundance pattern shown in Figure 4. Excluding station GC-04, the EPT abundance reflects pool habitat rankings discussed in Section 2.2.1.3. The abundance of invertebrates does not suggest a potential site-related impact because both Stations GC-02 and GC-03 are downstream from the site, but have more invertebrates than upstream of the site at Station GC-01.

Generally, good quality and diverse aquatic habitats without chemical or other anthropogenic impacts support invertebrate communities of large numbers where no individual species is present in overwhelming abundance (EPA 1990). Good quality habitat has been documented to be present in Gold Creek. Thus, the dominance of chironomids or nematodes as shown on Figure 5 for stations GC-01, GC-02, and GC-03, suggests that Gold Creek habitat diversity may be limited. As noted earlier, this was the case with limited velocity/depth regimes at all stations. Similarly, the imbalance in representative functional foraging groups, as shown on Figure 6, also suggests limited instream diversity. However, if limited velocity/depth regime were the only influence at all stations, similar species composition and

similar foraging strategies would be expected for similar pool types (i.e., excludes Station GC-04 which had more instream pool character than did the other stations). As shown on Figures 5 and 6 both the pool community composition and dominant pool foraging strategies change at Stations GC-02 and GC-03. In addition, as shown on Figure 7, the pool species diversity also decreases at these two stations. Thus, the changes noted do not seem well explained by instream habitat differences.

The Shannon-Weaver Index presented on Figure 8 shows that diversity within the pools decreases slightly at station GC-02 compared to GC-01, decreases more dramatically at station GC-03 and rebounds at station GC-04. Figure 8 also shows that there are two factors potentially correlated to the change in diversity. First, the proportion of species that are tolerant of metals contamination increases at stations GC-03 and GC-04. Second, the proportion of species preferring cooler temperatures decreases at stations GC-02 and GC-03 and rebounds at station GC-04. Based on percent cover and the relatively shallow stream depth present along the stream from just upstream of station GC-02 and extending downstream of station GC-03, increased temperatures could be expected. In fact, the measured temperatures at these two stations (14.2 and 13.6°C) were similar, and both were higher than those measured GC-01 and GC-04 (both 12.7°C). Given this evidence, changes in pool species diversity and foraging strategies may be related to stream conditions or metals concentrations within the stream water and/or sediment. Comparisons of species diversity to chemical concentrations in sediment and water would provide further evidence regarding the potential for chemical-related impacts to invertebrate populations inhabiting the pools of Gold Creek.

Riffle Samples

The pattern of abundance for EPT species across riffle stations (Figure 9) is very similar to the pattern for all invertebrates. However, this pattern does not correlate with the quantitative habitat quality rankings. Rather, it correlates with the amount of gravel documented within the riffles. The abundance of invertebrates does not suggest a potential site-related impact because stations GC-02 and GC-03, downstream of the mine, have the most invertebrates present.

Generally, good quality riffle habitat was documented as present in Gold Creek. Thus, a variety of species without a single dominant species could be expected. Figure 10 shows that EPT species (primarily Ephemeroptera) were much more common than other species at riffle station GC-01. However, this station had the steepest gradient and the most boulders (i.e., the least variable substrate) and therefore, the dominance of species suited to such habitat is not unusual. At riffle stations GC-02 and GC-03 the percent EPT species decreases compared to GC-01, and increases at GC-04. Regardless of the increases or decrease in the percentage of EPT species present, the change is accompanied by an increase in the percent of one or more other species. Thus, riffle stations GC-02, GC-03, and GC-03 express a

higher diversity than station GC-01, as would be expected given the better substrate habitat present at these downstream stations. The diversity of species present at all riffle stations is also visible on Figures 11 where representatives of five foraging strategies are present at all stations in a relatively balanced proportion compared to those documented at pool stations. The species diversity is very consistent across the riffle stations (Figure 12). The consistency in foraging strategy and taxa composition suggests a lack of site-related impact on invertebrates at riffle stations.

The Shannon-Weaver Index (Figure 13) shows that diversity is very consistent across the riffle stations. Similar to the results for the pool samples (Figure 8), the metals tolerance index and temperature preference index shown on Figure 13 are inversely correlated to each other. Unlike the pool samples, the proportion of species in riffle samples that are tolerant of metals contamination at the three downstream stations is less than or equivalent to the metal tolerance index at station GC-01. Also unlike the pool samples, the temperature preference index does not appear to reflect actual measured temperatures. Given this evidence, there is no obvious evidence of site-related impact to benthic invertebrates.

2.2.3 FISH

2.2.3.1 Methodology

Prior to the field effort, a regional USFS fisheries biologist (Molesworth 2003) was contacted to determine fish species likely to inhabit Gold Creek. The WDFW priority habitat and species list reported several priority fish species inhabit Gold Creek and its tributaries. The presence of fish was also determined visually during the stream habitat and invertebrate investigation, and by several stealthy perpendicular approaches to the stream with careful visual examination for fish movement.

2.2.3.2 Results

The fish species reported or expected to be present in Gold Creek include the federally endangered spring Chinook salmon (*Oncorhynchus tshawytscha*), resident rainbow trout and the federally endangered summer steelhead (*Salmo gairdneri*), resident cutthroat trout (Salmo clarki), resident Dolly Varden (*Salvelinus malma*), and the federally threatened bull trout (*Salvelinus confluentis*). Two salmonids were observed in a pool immediately downstream from the lower adit. One was approximately 6-8 cm inches in length and the other 14-16 cm. The larger of the two fish was identified as rainbow trout/steelhead. One approximately 3.5 cm unidentified sculpin (*Cottus* sp.) was caught in the dip net during the riffle invertebrate sampling. No juvenile fish were observed in the creek.

2.2.3.3 Discussion

A potential area of spawning gravel for resident and possibly anadromous fish exists immediately downstream of the site at invertebrate sampling station GC-02. The anadromous spring Chinook salmon and summer-run steelhead are potential spawning species in this vicinity however larger areas of gravel are likely to be present in the lower portions of Gold Creek, which is expected to provide a majority of spawning habitat for these anadromous fish. Summer-run steelhead were reported in the PHS database upstream in Foggy Dew Creek, as well. Chinook are likely to migrate from the stream soon after emergence, but some steelhead are likely to remain in Gold Creek and its tributaries for a year or more.

Rainbow trout, Dolly Varden, and or bull trout are documented by the USFS (Molesworth 2003) and in the PHS database as resident in Gold Greek, Foggy Dew Creek, and Crater Creek (a tributary to Foggy Dew Creek). These species are likely to move upstream and downstream on a regular basis and are likely to be present in the vicinity of the site all year. Cutthroat trout were only noted from the discussion with the USFS fisheries biologist (Molesworth 2003) and not on any of the PHS or other rare, threatened, or endangered species lists.

3.0 CONCLUSIONS AND RECOMMENDATIONS

3.1 CONCLUSIONS

The Antimony Queen Mine site is within an area that is relatively undisturbed by human activities and good quality terrestrial and instream habitats are present at, and surrounding, the site. Mining activities in the early 1900s involved physical disturbances to the natural environment. Although mining activities halted decades ago, physical disturbances are still obvious, particularly the waste piles emanating from the lower and uppermost adits. Both of these waste piles have limited or no vegetation growing on them, and extend from upland into riparian habitats. The only apparent and likely areas of chemical affect for terrestrial plants, invertebrates, and wildlife are on the waste piles. Given the relatively small area of the waste piles, the potential for terrestrial ecological effects is likely limited to species such as invertebrates, small mammals, and song/perching birds that have small home ranges, may forage on, and are more likely to be regularly exposed to, the waste piles.

Mining wastes were likely introduced to Gold Creek during past mining activities and continue to slide into the creek. This contribution appears to have resulted in an atypical gravel substrate in creek riffles immediately downstream of the lower adit, and has resulted in increased diversity of instream physical habitat. The steep gradient of Gold Creek results in high-energy water flow within the channel and flood plain, and transport of most of the fine-grained particles (smaller gravel, sand, silt, or clay) to depositional areas downstream of the site, and likely downstream of station GC-04. The high-energy flow also results in the rapid transport of any dissolved site-related contaminants, likely to the Methow River.

Based on stream invertebrate enumeration results, the only apparent potential instream effects were noted in pool habitats between the site and station GC-03. In these locations, the species diversity was lower and metals tolerant species were slightly more prevalent. Given the depositional nature of pool habitat, potential effects to invertebrates in pools are more likely related to chemicals attached to fined-grained materials than to site-related physical changes in substrate. However, increased instream temperature due to a lack of bank vegetation may also be related to the changes is species composition. The lack of an off channel pool at station GC-04 may have resulted in a reduced possibility of detecting potential effects in pool habitats downstream of station GC-03.

Federally listed threatened and endangered fish (upper Columbia River steelhead, upper Columbia River chinook salmon, and bull trout) and state listed endangered spotted frogs inhabit Gold Creek. Mine related physical alterations of the creek seem to have increased fish spawning habitat due to the increased gravel noted downstream of the mine. The potential ecological effects of site-related contamination in Gold Creek have not yet been assessed. Overall, further assessment of aquatic

ecological effects represents a higher priority than the assessment of potential terrestrial ecological effects.

3.2 RECOMMENDATIONS

Terrestrial, aquatic, and benthic ecological risk-based screening should be conducted to identify potential risks to ecological receptor types and determine contaminants of potential ecological concern (COPECs). Any identified COPECs should be examined with regard to their potential for bioaccumulation in terrestrial and aquatic food chains. If some COPECs have a significant potential to bioaccumulate, site-specific exposure modeling should be conducted to quantify potential ecological risks to upper trophic level species. The calculated ecological risks for both lower and upper trophic level species can then be used to more clearly define the need for further characterization of the extent of contamination or for ecologically-protective removal action.

4.0 USE OF THIS REPORT

This ecological survey has been prepared for the exclusive use of Cascade Earth Sciences and the U.S. Forest Service for specific application to the Antimony Queen Mine in Carlton, Washington. No other party is entitled to rely on the information, conclusions, and recommendations included in this document without the express written consent of Landau Associates. Further, the reuse of information, conclusions, and recommendations provided herein for extensions of the project or for any other project, without review and authorization by Landau Associates, shall be at the user's sole risk. Landau Associates warrants that within the limitations of scope, schedule, and budget, our services have been provided in a manner consistent with that level of care and skill ordinarily exercised by members of the profession currently practicing in the same locality under similar conditions as this project. We make no other warranty, either express or implied.

This document has been prepared under the supervision and direction of the following key staff.

LANDAU ASSOCIATES, INC.

Rone A. Brewer

Rone A. Brewer
Senior Risk Assessor/Ecologist

RAB/rgm

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TABLE 1
PLANT SPECIES AND PERCENT COVER BY SURVEY STATION
ANTIMONY QUEEN MINE
CARLTON, WASHINGTON

	Location (a):	OS/OF	OS	OF	OS	OS	OF	OS	OF	OS	WA
	Survey Station:	2	1	3	4	5	6	7	8	10	9
	Habitat Type (b):	M	F	F	F	F	F	F	R	R	DF
Scientific Name	**Common Name**										
TREES											
Alnus incana ssp. tenuifolia	Mountain alder	-	-	-	-	-	-	-	30	-	-
Populus trichocarpa	Black cottonwood	-	-	-	-	-	-	-	25	35	35
Pseudotsuga mensiezii	Douglas fir	-	80	50	30	65	80	60	15	15	-
SHRUBS											
Acer glabrum	Douglas maple	-	5	-	-	-	20	-	20	1	-
Amelanchier alnifolia	serviceberry	15	1	3	3	5	1	-	5	-	-
Cornus sericea	Red-stemmed dogwood	-	-	-	-	-	-	-	30	3	-
Holodiscus discolor	Ocean spray	10	10	-	-	-	-	-	25	-	-
Mahonia aquifolium	Tall Oregon grape	-	5	1	-	7	-	5	-	-	-
Pachistima myrsintes	False box	10	2	1	10	2	3	15	10	-	-
Penstemon fruticosus	Shrubby penstemon	-	-	-	-	-	-	5	-	-	-
Philadelphus lewisii	Mock orange	-	-	-	-	-	-	-	5	-	-
Phyllodoce empetriformis	Pink mountain heather	-	10	-	-	-	-	-	-	-	-
Populus trichocarpa	Black cottonwood (sapling)	-	-	-	-	-	-	-	-	-	10
Pseudotsuga mensiezii	Douglas fir (sapling)	3	-	-	-	-	-	-	-	-	2
Pteridium aquilinum	Bracken fern	-	-	-	10	3	-	-	-	-	-
Ribes cereum	Squaw currant	10	-	-	-	2	-	-	-	-	-
Salix bebbiana	Bebb's willow	-	-	2	-	-	-	-	-	-	-
Salix scouleriana	Scouler's willow	-	-	-	25	-	-	-	-	-	-
Spirea betulifolia	Birch-leaved spirea	-	7	2	1	-	-	1	-	-	-
Symphoricarpos alba	Common snowberry	-	-	15	15	4	-	-	15	-	10

TABLE 1
PLANT SPECIES AND PERCENT COVER BY SURVEY STATION
ANTIMONY QUEEN MINE
CARLTON, WASHINGTON

	Location (a):	OS/OF	OS	OF	OS	OS	OF	OS	OF	OS	WA
	Survey Station:	2	1	3	4	5	6	7	8	10	9
	Habitat Type (b):	M	F	F	F	F	F	F	R	R	DF
Scientific Name	**Common Name**										
GROUNDCOVER											
Achillea millefolium	Yarrow	-	1	-	-	-	-	1	-	-	-
Agropyron spicata	Bluebunch wheatgrass	75	25	80	50	5	50	65	-	-	-
Anaphalis margaritacea	Pearly everlasting	-	-	-	-	-	1	-	-	-	1
Anemone occidentalis	Western pasqueflower	30	-	-	-	-	-	-	-	-	-
Antennaria racemosa	Racemose pussy toes	-	-	5	2	-	-	-	-	-	-
Arnica cordifolia	Heat-leafed arnica	-	-	1	-	-	-	-	-	-	-
Arnica parryi	Parry's arnica	-	-	-	-	-	-	10	-	-	-
Balsamorhiza saggitata	Arrow-leaved balsamroot	-	-	-	1	-	-	-	-	-	-
Bromus anomalus	Nodding brome	-	-	-	-	-	-	-	-	-	1
Calochortus opiculatus	Lyall's Mariposa lily	<1	-	1	-	<1	-	-	-	-	-
Centaurea diffusa	Diffuse knapweed	-	-	-	-	-	-	-	-	-	10
Cystopteris fragilis	Fragile fern	-	-	-	-	3	5	2	-	-	-
Equisetum hyemale	Scouring rush	-	-	-	-	-	-	-	5	2	-
Eriogonum heracloides	Parsnip-flower buckwheat	20	-	1	2	-	2	3	-	-	-
Festuca idahoensis	Idaho fescue	20	3	1	2	2	-	5	-	-	-
Geum triflorum	Old man's whiskers	-	-	-	1	-	-	-	-	-	-
Hieracleum umbellatum	Narrow-leafed hawkweed	-	2	3	2	3	1	-	-	-	-
Heuchera cylindrica	Round-leaved alum root	20	-	1	-	1	3	1	-	-	-
Lactuca serriola	Prickly lettuce	-	-	-	1	-	-	1	-	-	-
Peltigera canina	Dog pelt	-	60	35	-	-	-	-	-	-	-
Piperia unalaschensis	Alaska rein-orchid	<1	-	-	-	-	-	-	-	-	-
Smilicina racemosa	False Solomon seal	1	1	1	2	2	1	-	1	-	1

Notes:
(a) OS = Onsite, OF = Offsite, WA = Waste Pile
(b) DF = Disturbed Forest, F = Forest, M = Meadow, R = Riparian

TABLE 2
SENSITIVE PLANT SPECIES LIST, USFS APRIL 1999
ANTIMONY QUEEN MINE
CARLTON, WASHINGTON

Species Name	Common Name	Federal Status (a)	State Status (b)
Agoseris elata	Tall agoseris		S
Agrostis borealis	Northern bentgrass		S
Anemone nuttalliana	Prairie crocus		S
Astragalus microcystis	Least bladdery milkvetch		S
Botrychium ascendens	Upswept moonwort	SoC	S
Botrychium campestre	Prairie dunewort		S
Botrychium crenulatum	Crenulate moonwort	SoC	S
Botrychium hesperium	Western moonwort		S
Botrychium lineare	Lance-leaved moonwort	SoC	S
Botrychium paradoxum	Two-spiked moonwort		S
Botrychium pedunculosum	Hairy pepperwort	SoC	S
Carex atrata var. atrosquama (C. atrosquama in WA)	Blackened sedge	SoC	S
Carex atrata var. erecta (C. heteroneura)	Black-scaled sedge		S
Carex capillaris	Hair-like sedge		S
Carex chordorrhiza	Cordroot sedge		S
Carex comosa	Bearded sedge		S
Carex dioica var. gynocrates (C. dioica in WA)	Yellow bog sedge		S
Carex flava	Yellow sedge		S
Carex hystericina	Porcupine sedge		S
Carex norvegica	Scandanavian sedge		S
Carex rostrata	Beaked sedge		S
Carex saxatilis var. major	Sedge		S
Carex scirpoidea var. scirpoidea	Single-spike sedge		S
Carex stenophylla (C. eleocharis)	Narrow-leaved sedge		S
Carex sychnocephala	Many-headed sedge		S
Carex tenuifolia	Sparse-leaved sedge		S
Carex vallicola	Valley sedge		S
Carex xerantica	Dryland sedge		S
Chrysosplenium tetrandrum	Golden saxifrage		S
Cicuta bulbifera	Bulb-bearing water hemlock		S
Claytonia lanceolata var. pacifica	Lance-leaved spring beauty		S
Collomia mazama	Mt. Mazama collomia	SoC	
Dodecatheon austrofrigidum	Tundra shootingstar	SoC	T
Draba cana	Lance-leaved draba		S
Dryas drummondii	Drummond's anemone		S
Eleocharis atropurpurea	Purple spikerush		X
Erigeron salishii	Star Peak fleabane		S
Eriophorum viridicarinatum	Thinleaf cottonsedge		S
Eritrichium nanum var. elongatum	Alpine forget-me-not		S
Gentiana glauca	Blue-green gentian		S
Gentianella tenella	Dane's dwarf gentian		S
Geum rivale	Water avens		S
Howellia aquatilis	Water howellia	LT	
Iliamna longisepala	Longsepal globemallow		S
Loiseleuria procumbens	Alpine azalea		S
Lycopodium dendroideum	Prickley prince's pine		S
Mimulus evanescens	Ephemeral monkeyflower		C
Mimulus pulsiferae	Pulsifer's monkeyflower		S
Mimulus suksdorfii	Suksdorf's monkeyflower		S
Nicotiana attenuata	Coyote tobacco		S
Oxytropis campestris var. gracilis	Slender locoweed		S
Parnassia kotzebuei	Grass-of-parnassus		S

TABLE 2
SENSITIVE PLANT SPECIES LIST, USFS APRIL 1999
ANTIMONY QUEEN MINE
CARLTON, WASHINGTON

Species Name	Common Name	Federal Status (a)	State Status (b)
Pellaea brachyptera	Baker Sierra cliffbrake		S
Platanthera obtusata	Blunt-leaf orchid		S
Polemonium viscosum	Sky pilot or Alpine skunkbush		S
Potentilla diversifolia var. perdissecta	Diverse-leaved cinquefoil		S
Potentilla nivea	Snow cinquefoil		S
Potentilla quinquefolia	Five-leaved cinquefoil		S
Rubus acaulis	Nagoonberry		S
Salix glauca	Grey-leaved willow		S
Salix pseudomonticola	Ball false mountain willow		S
Sanicula marilandica	Black snakeroot		S
Saxifraga cernua	Nodding saxifrage		S
Sisyrinchium septentrionale	Blue-eyed grass		S
Spiranthes diluvialis	Diluvim ladies' tresses	LT	T
Spiranthes porrifolia	Western ladies' tresses		S
Talinum sediforme	Okanogan fameflower		S
Teucrium canadense ssp. viscidum	Wood sage		S
Thalictrum dasycarpum	Purple meadow rue		S
Trimorpha elata	Tall bitter fleabane		S
Vaccinium myrtilloides	Velvet-leaved blueberry		S

Notes:

Blank status indicates no listing was available for the species.

(a) U.S. Fish and Wildlife Service Federal Status: SoC = Species of Concern, an unofficial status indicating the species appears to be in jeopardy, but there is insufficient data to list. LT = Listed Threated indicating the species is likely to become endangered.

(b) Washington State Status: S = State Sensitive. T = threatened indicating the species is likely to become endangered in Washington. X = Possibly Extinct.

TABLE 3
U.S. FOREST SERVICE PLANT MANAGEMENT LIST, USFS MARCH 2003
ANTIMONY QUEEN MINE
CARLTON, WASHINGTON

Scientific Name	Common Name	Federal Status (a)	State Status (b)
FUNGI			
Bridgeoporus nobilissimus (Oxyporus nobilissimus)	Fuzzy sandozi		
LICHENS			
Hypogymnia duplicata	Rare leafy lichen		
Leptogium cyanescens	Blistered jellyskin		
Lobaria linita	Cabbage lungwort		
Nephroma occultum	Paw		
Niebla cephalota	Niebla		
Pseudocyphellaria rainierensis	Old growth speckleberry		
Ramalina thrausta	Angel hair		
Teloschistes flavicans	Golden-hair lichen		
BRYOPHYTES			
Schistostega pennata	Schistostega		
Tetraphis geniculata	Bent-kneed four-tooth moss		
VASCULAR PLANTS			
Botrychium montanum	Desolation meadow grapefern		
Coptis asplenifolia	Spleenwort-leaved goldthread		
Coptis trifolia	Three-leaf goldthread		
Corydalis aquae-gelidae	Cold water corydalis		
Cypripedium montanum	Mountain lady's slipper		
Eucephalus vialis (syn. Aster vialis)	Bradshaw wayside aster		
Galium kamtschaticum	Boreal bedstraw		
Platanthera orbiculata var. orbiculata	Large round-leaved orchid		

Notes:

Blank status indicates no listing was available for the species.

(a) U.S. Fish and Wildlife Service Federal Status: SoC = Species of Concern, an unofficial status indicating the species appears to be in jeopardy, but there is insufficient data to list. LT = Listed Threated indicating the species is likely to become endangered.

(b) Washington State Status: S = State Sensitive. T = threatened indicating the species is likely to become endangered in Washington. X = Possibly Extinct.

TABLE 4
BIRD SPECIES POTENTIALLY INHHABITING THE VICINITY OF THE SITE
ANTIMONY QUEEN MINE
CARLTON, WASHINGTON

Scientific Name	Common Name	Federal Status	State Status	Observed/ Expected
BIRDS				
Recurvirostra americana	American Avocet		SP	
Botaurus lentiginosus	American Bittern		SP	
Fulica americana	American Coot			
Pluvialis dominica	American Golden Plover		SP	
Carduelis tristis (Spinus tristis)	American Goldfinch		SP	
Falco sparverius	American Kestrel (Sparrow Hawk)		SP	
Setophaga ruticilla	American Redstart		SP	
Anas americana (Mareca americana)	American Wigeon (Widgeon)			
Gavia arctica	Arctic Loon			
Myiarchus cinerascens	Ash-throated Flycatcher		SM	
Calidris bairdii (Erolia bairdii)	Baird's Sandpiper		SP	
Haliaeetus leucocephalus	Bald Eagle	FT	ST	
Columba fasciata	Band-tailed Pigeon			
Riparia riparia	Bank Swallow		SP	E
Tyto alba	Barn Owl		SP	
Hirundo rustica	Barn Swallow		SP	
Strix varia	Barred Owl		SP	E
Bucephala islandica	Barrow's Goldeneye			
Megaceryle alcyon	Belted Kingfisher		SP	E
Thryomanes bewickii	Bewick's Wren		SP	E
Cypseloides niger	Black Swift		SM	
Chlidonias niger	Black Tern	FCo	SM	
Picoides arcticus	Black-backed Woodpecker		SC	E
Pluvialis squatarola (Squatarola squatarola)	Black-bellied Plover		SP	
Pica pica	Black-billed Magpie			E
Parus atricapillus	Black-capped Chickadee		SP	O
Archilochus alexandri	Black-Chinned hummingbird		SP	O
Nycticorax nycticorax	Black-crowned Night Heron		SM	
Pheucticus melanocephalus	Black-headed Grosbeak		SP	E
Himantopus mexicanus	Black-necked Stilt		SM	
Dendroica nigrescens	Black-throated Gray Warbler		SP	E
Dendragapus obscurus	Blue Grouse			E
Cyanocitta cristata	Blue Jay		SP	E
Anas discors	Blue-winged Teal			
Dolichonyx oryzivorus	Bobolink		SM	
Bombycilla garrula	Bohemian Waxwing		SP	
Larus philadelphia	Bonaparte's Gull		SP	
Parus hudsonicus	Boreal Chickadee		SM	E
Aegolius funereus	Boreal Owl		SM	E
Euphagus cyanocephalus	Brewer's Blackbird		SP	E
Spizella breweri	Brewer's Sparrow		SP	E
Certhia familiaris	Brown Creeper		SP	E
Molothrus ater	Brown-headed Cowbird		SP	E
Tryngites subruficollis	Buffbreasted Sandpiper		SP	
Bucephala albeoloa	Bufflehead			
Athene cunicularia (Speotyto cunicularia)	Burrowing Owl	FCo	SC	
Larus californicus	California Gull		SP	
Lophortyx californicus	California Quail			E
Stellula calliope	Calliope Hummingbird		SP	

TABLE 4
BIRD SPECIES POTENTIALLY INHHABITING THE VICINITY OF THE SITE
ANTIMONY QUEEN MINE
CARLTON, WASHINGTON

Scientific Name	Common Name	Federal Status	State Status	Observed/ Expected
BIRDS				
Branta canadensis	Canada Goose			
Aythya valisineria	Canvasback			
Catherpes mexicanus	Canyon Wren		SP	E
Hydroprogne caspia	Caspian Tern		SM	
Carpodacus cassinii	Cassin's Finch		SP	E
Bombycilla cedrorum	Cedar Waxwing		SP	E
Parus rufescens	Chestnut-backed Chickadee		SP	E
Spizella passerina	Chipping Sparrow		SP	E
Alectoris chukar (Alectoris graeca)	Chukar			E
Anas cyanoptera	Cinnamon Teal			
Nucifraga columbiana	Clark's Nutcracker		SP	E
Petrochelidon pyrrhonota	Cliff Swallow		SP	E
Corvus brachyrhynchos	American Crow			E
Casmerodius albus	Common Egret		SP	
Colaptes auratus (Colaptes cafer)	Common Flicker (Red-shafted Flicker)			E
Bucephala clangula	Common Goldeneye			
Gavia immer	Common Loon		SS	
Mergus merganser	Common Merganser			
Chordeiles minor	Common Nighthawk		SP	E
Corvus corax	Common Raven		SP	O
Carduelis flammea (Acanthis flammea)	Common Redpoll		SP	E
Geothlypis trichas	Common Yellowthroat		SP	E
Accipiter cooperii	Cooper's Hawk		SP	E
Junco hyemalis	Dark-eyed Junco (Slate-colored)			E
Cinclus mexicanus	American Dipper		SP	O
Phalacrocorax auritus	Double-crested Cormorant		SP	
Picoides pubescens (Dendrocopos pubescens)	Downy Woodpecker		SP	E
Calidris alpina (Erolia alpina)	Dunlin		SP	
Empidonax oberholseri	Dusky Flycatcher (Wright's Flycatcher)		SP	E
Podiceps nigricollis (Podiceps caspicus)	Eared Grebe		SP	
Tyrannus tyrannus	Eastern Kingbird		SP	E
Anas penelope (Mareca penelope)	European Wigeon (Widgeon)			
Hesperiphona vespertina	Evening Grosbeak		SP	E
Buteo regalis	**Ferruginous Hawk**	**FCo**	**ST**	**E**
Otus Flammeolus	Flammulated Owl		SC	E
Sterna forsteri	Forster's Tern		SM	
Passerella iliaca	Fox Sparrow		SP	E
Larus pipixcan	Franklin's Gull		SP	
Anas strepera	Gadwall			
Larus hyperboreus	Glaucous Gull		SP	
Larus glaucescens	Glaucous-winged Gull		SP	
Aquila chrysaetos	Golden Eagle		SC	
Regulus satrapa	Golden-crowned Kinglet		SP	E
Zonotrichia atricapilla	Golden-crowned Sparrow		SP	E
Accipiter gentilis	Goshawk	FCo	SC	E
Dumetella carolinensis	Gray Catbird		SP	E
Perisoreus canadensis	Gray Jay		SP	E
Perdix perdix	Gray Partridge (Hungarian Partridge)			E
Leucosticte tephrocotis	Gray-crowned Rosy Finch		SP	E
Ardea herodias	Great Blue Heron		SM	E
Strix nebulosa	Great Gray Owl		SM	E
Bubo virginianus	Great Horned Owl		SP	E
Aythya marila	Greater Scaup			
Tringa melanoleucas (totanus melanoleucus)	Greater Yellowlegs		SP	

TABLE 4
BIRD SPECIES POTENTIALLY INHHABITING THE VICINITY OF THE SITE
ANTIMONY QUEEN MINE
CARLTON, WASHINGTON

Scientific Name	Common Name	Federal Status	State Status	Observed/ Expected
BIRDS				
Anas crecca (Anas carolinensis)	Green-winged Teal			
Ammodramus savannarum	Grasshopper Sparrow		SM	E
Falco rusticolus	Gyrfalcon		SM	E
Picoides villosus (Dendrocopos villosus)	Hairy Woodpecker		SP	E
Histrionicus histrionicus	Harlequin Duck	FCo		E
Zonotrichia querula	Harris' Sparrow		SP	E
Surnia ulula	Hawk Owl			E
Catharus guttatus (Hylochichla guttata)	Hermit Thrush		SP	E
Dendroica occidentalis	Hermit Warbler		SP	E
Larus argentatus	Herring Gull		SP	
Carduelis hornemanni (Acanthis hornemanni)	Hoary Redpoll		SP	E
Lophodytes cucullatus	Hooded Merganser			
Podiceps auritus	Horned Grebe		SM	
Eremophila alpestris	Horned Lark		SP	E
Carpodacus mexicanus	House Finch		SP	E
Passer domesticus	House Sparrow			
Troglodytes aedon	House Wren		SP	E
Limosa haemastica	Hudsonian Godwit		SP	
Larus glaucoides	Iceland Gull		SP	
Charadrius vociferus	Killdeer		SP	
Calcarius lapponicus	Lapland Longspur		SP	
Chondestes grammacus	Lark Sparrow		SP	E
Passerina amoena	Lazuli Bunting		SP	E
Empidonax minimus	Least Flycatcher		SP	E
Calidris minutilla (Erolia minutilla)	Least Sandpiper		SP	
Aythya affinis	Lesser Scaup			
Tringa flavipes (Totanus flavipes)	Lesser Yellowlegs		SP	
Melanerpes lewis (Asyndesmus lewis)	Lewis' Woodpecker		SC	E
Melospiza lincolnii	Lincoln's Sparrow		SP	E
Lanius ludovicianus	Loggerhead Shrike	FCo	SC	
Numenius americanus	Long-billed Curlew		SM	
Limnodromus scolopaceus	Long-billed Dowitcher		SP	
Cistothorus palustris (Telmatodytes palustris)	Long-billed Marsh Wren		SP	
Asio otus	Long-eared Owl		SP	E
Stercorarius longicaudus	Long-tailed Jaeger		SP	
Oporornis tolmiei	MacGillivray's Warbler		SP	E
Anas platyrhynchos	Mallard			
Limosa fedoa	Marbled Godwit		SP	
Circus cyaneus	Northern Harrier		SP	E
Falco columbarus	Merlin (Pigeon Hawk)		SC	E
Mimus polyglottos	Mockingbird		SP	
Sialia currucoides	Mountain Bluebird		SP	E
Parus gambeli	Mountain Chickadee		SP	E
Charadrius montanas (Eupoda montana)	Mountain Plover		SP	
Zenaida macroura (Zenaidura macroura)	Mourning Dove			E
Vermivora ruficapilla	Nashville Warbler		SP	E
Icterus galbula (Icterus bullockii)	Northern Oriole (Bullock's Oriole)		SP	E
Lobipes lobatus	Northern Phalarope			
Anas clypeata (Spatula clypeata)	Northern Shoveler			
Lanius excubitor	Northern Shrike		SP	E
Picoides tridactylus	Three-toed Woodpecker		SM	E
Seiurus noveboracensis	Northern Waterthrush		SM	
Clangula hyemalis	Long-Tailed Duck			
Nuttallornis borealis	Olive-sided Flycatcher	FCo	SP	E

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BIRD SPECIES POTENTIALLY INHHABITING THE VICINITY OF THE SITE
ANTIMONY QUEEN MINE
CARLTON, WASHINGTON

Scientific Name	Common Name	Federal Status	State Status	Observed/ Expected
BIRDS				
Vermivora celata	Orange-crowned Warbler		SP	E
Pandion haliaetus	Osprey		SM	E
Calidris melonotos (Erolia melanotos)	Pectoral Sandpiper		SP	
Falco peregrinus	Peregrine Falcon	FCo	SS	O
Podilymbus podiceps	Pied-billed Grebe		SP	
Dryocopus pileatus	Pileated Woodpecker		SC	
Pinicola enucleator	Pine Grosbeak		SP	E
Carduelis pinus (Spinus pinus)	Pine Siskin		SP	E
Anas acuta	Northern Pintail			
Phalaenoptilus nuttallii	Poor-will			
Falco mexicanus	Prairie Falcon		SM	E
Carpodacus purpureus	Purple Finch		SP	E
Progne subis	Purple Martin		SC	
Sitta pygmaea	Pygmy Nuthatch		SP	E
Glaucidium gnoma	Pygmy Owl			E
Loxia curvirostra	Red Crossbill		SP	E
Caldris canutus	Red Knot		SP	
Mergus serrator	Red-breasted Merganser			
Sitta canadensis	Red-breasted Nuthatch		SP	O
Vireo olivaceus	Red-eyed Vireo		SP	E
Aythya americana	Redhead			
Podiceps grisegena	Red-necked Grebe		SM	
Buteo jamaicensis	Red-tailed Hawk		SP	E
Agelaius phoeniceus	Red-winged Blackbird		SP	E
Larus delawarensis	Ring-billed Gull		SP	
Aythya collaris	Ring-necked Duck			
Phasianus colchicus	Ring-necked Pheasant			
Turdus migratorius	Robin		SP	O
Columba livia	Rock Dove			
Salpinctes obsoletus	Rock Wren		SP	E
Chen rossii	Ross' Goose			
Buteo lagopus	Rough-legged Hawk		SP	E
Stelgidopteryx ruficollis	Rough-winged Swallow		SP	E
Regulus calendula	Ruby-crowned Kinglet		SP	E
Oxyura jamaicensis	Ruddy Duck			
Arenaria interpres	Ruddy Turnstone		SP	
Bonasa umbellus	Ruffed Grouse			O
Selasphorus rufus	Rufous Hummingbird		SP	
Pipilo erythrophthalmus	Spotted (Rufous-sided) Towhee		SP	E
Euphagus carolinus	Rusty Blackbird		SP	E
Centrocercus urophasianus	Sage Grouse	FC	ST	
Amphispiza belli	Sage Sparrow		SC	E
Oreoscoptes montanus	Sage Thrasher		SC	E
Calidris alba (Crocethia alba)	Sanderling		SP	
Grus canadensis	Sandhill Crane		SE	
Passerculus sandwichensis	Savannah Sparrow		SP	O
Aegolius acadicus	Saw-whet Owl		SP	E
Sayornis saya	Say's Phoebe		SP	E
Otus asio	Screech Owl		SP	E
Charadrius semipalmatus	Semipalmated Plover		SP	
Calidris pusilla (Ereunetes pusillus)	Semipalmated Sandpiper		SP	
Accipiter striatus	Sharp-shinned Hawk		SP	E
Pedioecetes phasianellus	Sharp-tailed Grouse	FCo	ST	
Limnodromus griseus	Short-billed Dowitcher		SP	

TABLE 4
BIRD SPECIES POTENTIALLY INHHABITING THE VICINITY OF THE SITE
ANTIMONY QUEEN MINE
CARLTON, WASHINGTON

Scientific Name	Common Name	Federal Status	State Status	Observed/ Expected
BIRDS				
Asio flammeus	Short-eared Owl		SP	E
Plectrophenax nivalis	Snow Bunting		SP	
Chen caerulescens (Chen hyperborea)	Snow Goose			
Nyctea scandiaca	Snowy Owl		SM	
Tringa solitaria	Solitary Sandpiper		SP	
Vireo solitarius	Solitary Vireo		SP	E
Melospiza melodia	Song Sparrow		SP	E
Porzana carolina	Sora			
Strix occidentalis	**Spotted Owl**	**FT**	**SE**	
Actitis macularia	Spotted Sandpiper		SP	
Canachites canadensis	Spruce Grouse			E
Sturnus vulgaris	Starling			
Cyanocitta stelleri	Steller's Jay		SP	E
Micropalama himantopus	Stilt Sandpiper		SP	
Melanitta perspicillata	Surf Scoter			
Buteo swainsoni	Swainson's Hawk		SM	E
Catharus ustulata (Hylocichla ustulata)	Swainson's Thrush		SP	O
Vermivora peregrina	Tennessee Warbler		SP	E
Myadestes townsendi	Townsend's Solitaire		SP	E
Dendroica townsendi	Townsend's Warbler		SP	E
Spizella arborea	Tree Sparrow		SP	E
Iridoprocne bicolor	Tree Swallow		SP	E
Olor buccinator	Trumpeter Swan			
Meleagris gallopavo	Turkey			
Cathartes aura	Turkey Vulture		SM	E
Bartramia longicauda	Upland Sandpiper		SE	
Ixoreus naevius	Varied Thrush		SP	E
Chaetura vauxi	Vaux's Swift		SC	
Catharus fuscescens (Hylocichla fuscescens)	Veery		SP	
Pooecetes gramineus	Vesper Sparrow		SP	E
Tachycineta thalassina	Violet-green Swallow		SP	E
Rallus limicola	Viriginia Rail			
Vireo gilvus	Warbling Vireo		SP	E
Anthus spinoletta	Water Pipit			
Sialia mexicana	Western Bluebird		SM	E
Empidonax difficilis	Western Flycatcher		SP	E
Aechmophorus occidentalis	Western Grebe		SC	
Tyrannus verticalis	Western Kingbird		SP	E
Sturnella neglecta	Western Meadowlark		SP	E
Calidris mauri	Western Sandpiper		SP	
Piranga ludoviciana	Western Tanager		SP	E
Contopus sordidulus	Western Wood Pewee		SP	O
Numenius phaeopus	Whimbrel		SP	
Olor columbianus	Tundra Swan			
Pelecanus erythrorhynchose	White Pelican			
Sitta carolinensis	White-breasted Nuthatch		SP	E
Zonotrichia leucophrys	White-crowned Sparrow		SP	E
Plegadis chihi	White-faced Ibis		SP	
Anser albifrons	White-fronted Goose			
Picoides albolarvatus (Dendrocopos albolarvatus)	White-headed Woodpecker		SC	E
Calidris fusciocollis (Erolia fuscicollis)	White-rumped Sandpiper		SP	
Lagopus leucurus	White-tailed Ptarmigan			
Zonotrichia albicollis	White-throated Sparrow		SP	E
Aeronautes saxatalis	White-throated Swift		SP	

TABLE 4
BIRD SPECIES POTENTIALLY INHHABITING THE VICINITY OF THE SITE
ANTIMONY QUEEN MINE
CARLTON, WASHINGTON

Scientific Name	Common Name	Federal Status	State Status	Observed/ Expected
BIRDS				
Loxia leucoptera	White-winged Crossbill		SP	E
Melanitta deglandi	White-winged Scoter			
Catoptrophorus semipalmatus	Willet		SP	
Sphyrapicus thyroideus	Williamson's Sapsucker		SP	E
Empidonax traillii	Willow Flycatcher (Traill's Flycatcher)	FCo	SP	E
Capella gallinago	Common Snipe			
Steganopus tricolor	Wilson's Phalarope		SP	
Wilsonia pusilla	Wilson's Warbler		SP	E
Troglodytes troglodytes	Winter Wren		SP	E
Aix sponsa	Wood Duck			
Dendroica petechia	Yellow Warbler		SP	E
Sphyrapicus varius	Yellow-bellied Sapsucker		SP	E
Coccyzus americanus	Yellow-billed Cuckoo	FC	SC	
Icteria virens	Yellow-breasted Chat		SP	E
Xanthocephalus xanthocephalus	Yellow-headed blackbird		SP	E
Dendroica coronata	Yellow-rumped Warbler		SP	O

Notes:

Bold indicates regulated species observed or expected at the site.
Blank status indicates no listing was available for the species.
E = Expected at or near the site
FC = Federal Candidate Species
FCo = Federal Species of Concern indicating there is not enough data to assess species status.
FE = Federal Endangered Species
FT = Federal Threatened indicating species is likely to become federally endangered.
O = Observed at or near the site
SC = State Candidate
SE= State Endangered
SM = State Monitor
SoC = Species of Concern, an unofficial status indicating species may be in jeopardy, but there is insufficient data to list.
SP = Not listed but considered protected in the state.
SS = State Sensitive indicating species may exhibit declining populations but not enough data to assess species status.
ST = State Threatened indicating the species is likely to become state endangered
SX = Possibly Extinct in the State.

TABLE 5
MAMMALS SPECIES DOCUMENTED OR EXPECTED AT THE SITE
ANTIMONY QUEEN MINE
CARLTON, WASHINGTON

Scientific Name	Common Name	Federal Status	State Status	Observed/ Expected
MAMMALS				
Alces alces	Moose			
Antozous pallidus	Pallid Bat		SM	E
Aplodontia rufa	Aplodontia (Mountain Beaver)			E
Canis latrans	Coyote			E
Canis lupus	Gray Wolf	FT	SE	
Castor canadensis	Beaver			E
Cervus canadensus nelsoni	Rocky Mountain Elk			
Clethrionomys gapperi	Boreal Redback Vole			E
Coryhorhinus townsendii	Townsend's Big-eared Bat	FCo	SC	E
Eptisicus fuscus	Big Brown Bat		SP	E
Erethizon dorsatum	Porcupine			E
Eutamias amoenus	Yellow Pine Chipmunk		SC	O
Eutamias minimus	Least Chipmunk		SP	E
Eutamias townsendi	Townsend's Chipmunk		SP	E
Felis concolor	Hoary Bat		SP	E
Felis concolor	Mountain Lion (Cougar)			E
Glaucomys sabrinus	Northern Flying Squirrel		SP	E
Gulo luscus	Wolverine	FCo	SC	E
Lagurus curtatus	Sagebrush Vole		SM	
Lasionycteris noctivagans	Silver-haired Bat		SP	E
Lasiurus borealis	Red Bat		SM	E
Lepus americanus	Snowshoe Hare			
Lutra canadensis	River Otter			
Lynx canadensis	**Lynx**	**FT**	**ST**	**E**
Lynx rufus	Bobcat			E
Marmota caligata	Hoary Marmot		SP	E
Marmota flaviventris	Yellow-bellied Marmot			E
Martes americana	Marten			E
Martes pennanti	**Fisher**	**FCo**	**SE**	**E**
Mephitis mephitis	Striped Skunk			E
Microsorex hoyi	Pgymy Shrew		SM	E
Microtus longicaudus	Longtail Vole			E
Microtus montanus	Mountain Vole			E
Microtus oregoni	Oregon Vole			E
Microtus pennsylvanicus	Meadow Vole			
Microtus richardsoni	Water Vole			E
Mus musculus	House Mouse			
Mustela erminea	Shorttail Weasel (Ermine)			E
Mustela frenata	Longtail Weasel			E
Mustela vision	Mink			E
Myotis californicus	California Myotis		SP	E
Myotis evotis	Long-eared Myotis	FCo	SM	E
Myotis keeni	Keen's Myotis		SC	E
Myotis leibii	Small-footed Myotis	FCo	SM	E
Myotis lucifugus	Little Brown Bat		SP	E
Myotis thysanodes	Fringed Myotis	FCo	SM	E
Myotis volans	Long-legged Myotis	FCo	SM	E
Myotis yumanensis	Yuma Myotis	FCo	SP	E
Neotoma cinerea	Busytail Woodrat			E
Neuotrichus gibbsi	Shrew-mole			E
Ochotona princeps	Pika		SP	E
Odocoileus hemionus hemionus	Mule Deer			O
Odocoileus virginianus ochrourus	White-tailed Deer			

TABLE 5
MAMMALS SPECIES DOCUMENTED OR EXPECTED AT THE SITE
ANTIMONY QUEEN MINE
CARLTON, WASHINGTON

Scientific Name	Common Name	Federal Status	State Status	Observed/ Expected
MAMMALS				
Ondatra zibethica	Muskrat			
Oreamnos americanus	Mountain Goat			
Ovis canadensis	Bighorn Sheep			
Perognathus parvus	Great Basin Pocket Mouse			E
Peromyscus maniculatus	Deer Mouse			E
Phenacomys intermedius	Heather Vole			E
Pipistrellus hesperus	Western Pipistrel		SM	
Procyon lotor	Raccoon			E
Rattus norvegicus	Norway Rat			
Reithrodontomys megalotis	Western Harvest Mouse			
Scapanus ororius	Coast Mole			
Sciurus griseus	**Western Gray Squirrel**	**FCo**	**ST**	**O**
Sorex cinereus	Masked Shrew			
Sorex merriami	Merriam's Shrew		SC	
Sorex obscurus	Dusky Shrew			E
Sorex palustris	Northern Water Shrew			E
Sorex trowbridgei	Trowbridge's Shrew			E
Sorex vagrans	Vagrant Shrew			
Spermophillus columbianus (Citellus columbianus)	Columbian Ground Squirrel			
Spermophillus sateratus (Citellus sateratus)	Cascade Golden-mantled Ground Squirrel		SP	E
Spermophilus lateralis	Golden-mantled Ground Squirrel		SP	E
Spilogale putorius	Spotted Skunk			
Sylvilagus nuttalli	Nuttal's Cottontail			
Synaptomys borealis	Northern Bog Lemming		SM	
Tamiasciurus douglasi	Douglas Squirrel - Chickaree		SP	O
Tamiasciurus hudsonicus	Red Squirrel		SP	
Taxidea taxus	Badger			
Thomomys talpoides	Northern Pocket Gopher			
Ursus americanus	Black Bear			
Ursus arctos	Grizzly Bear	FT	SE	
Vulpes fulva	Red Fox			
Zapus princeps	Western Jumping Mouse			
Zapus trinotatus	Pacific Jumping Mouse			

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E = Expected at or near the site

FCo = Federal Species of Concern indicating there is not enough data to assess species status.

FT = Federally Threatened indicating species is likely to become federally endangered.

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SC = State Candidate

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SP = Not listed but considered protected in the state.

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ST = State Threatened indicating the species is likely to become state endangered

SX = Possibly Extinct in the State.

TABLE 6
HERPETILES DOCUMENTED OR EXPECTED AT THE SITE
ANTIMONY QUEEN MINE
CARLTON, WASHINGTON

Scientific Name	Common Name	Federal Status	State Status	Observed/ Expected
AMPHIBIANS				
Ambystoma macrodactylum	Long-toed Salamander			E
Ambystoma tigrinum	Tiger Salamander		SM	
Ascaphus Truei	Tailed Frog	FCo		E
Bufo boreas	Western Toad	FCo	SC	
Hyla regilla	Pacific Treefrog			
Rana pretiosa	**Spotted Frog**	**FC**	**SE**	**O**
Scaphiopus intermontanus	Great Basin Spadefoot			
REPTILES				
Charina bottae	Rubber Boa			E
Chrysemys picta	Painted Turtle		SP	
Coluber constrictor	Western Yellow-Bellied Racer			
Crotalus viridis	Western Rattlesnake			E
Eumeces Skiltonianus	Western Skink			E
Gerrhonotus coeruleus	Northern Alligator Lizard			
Hypsiglena torquata	Spotted Night Snake		SM	E
Phrynosoma douglassi	Short-horned Lizard			E
Pituophis melanoleucus	Gopher Snake (Bull Snake)			E
Sceloporus graciosus	Sagebrush Lizard	FCo	SC	
Sceloporus occidentalis	Western Fence Lizard			E
Thamnophis elegans	Western Garter Snake			E
Thamnophis sirtalis	Common Garter Snake			E

Notes:
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FCO = Federal Species of Concern
FC = Federal Candidate Species
O = Observed at or near the site
SC = State Candidate Species
SE = State Endangered Species
SM = State Monitor Species
SP = No State Listing but Considered Protected.

APPENDIX A

Selected Site Photographs

1. Lower adit and waste pile with Gold Creek shoreline in foreground.

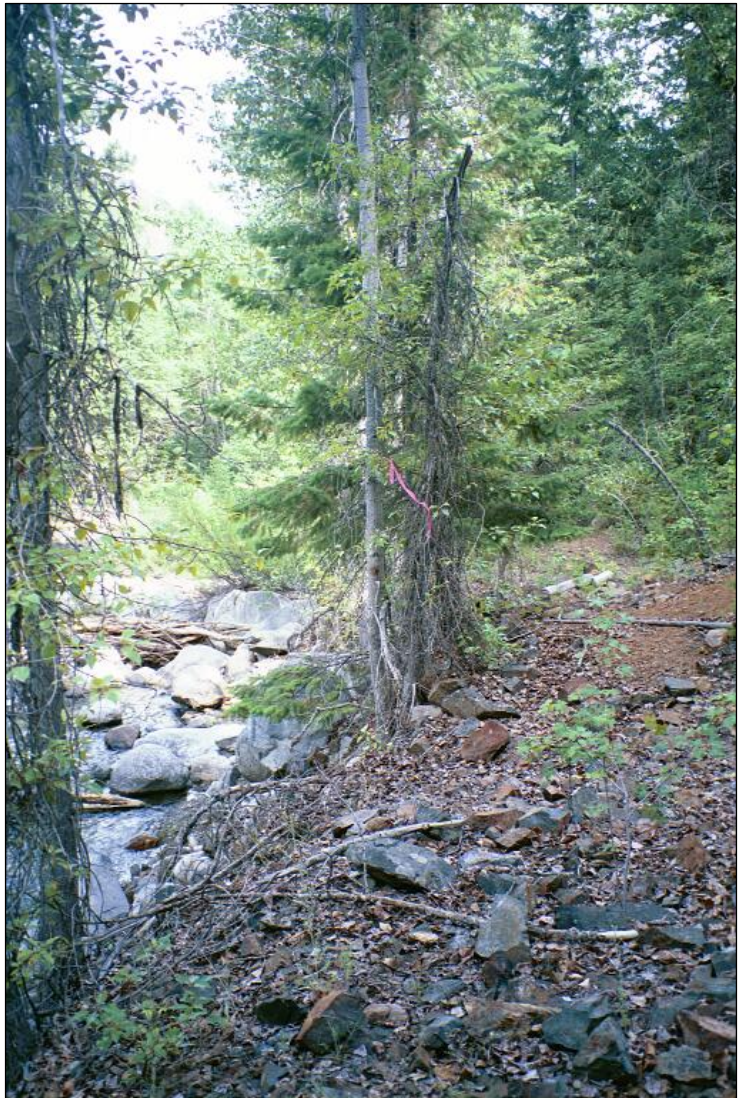
2. View of waste pile slide from uppermost adit looking downhill toward Gold Creek.

LANDAU ASSOCIATES

Antimony Queen Mine
Carlton, Washington

Selected Site Photographs

Figure
A-1



3. Bottom of waste pile slide emanating from uppermost adit and disturbed riparian habitat.

4. Undisturbed riparian habitat along Gold Creek.

LANDAU ASSOCIATES

Antimony Queen Mine
Carlton, Washington

Selected Site Photographs

Figure
A-2

5. Typical forest habitat.

6. Typical meadow habitat within the forest habitat.

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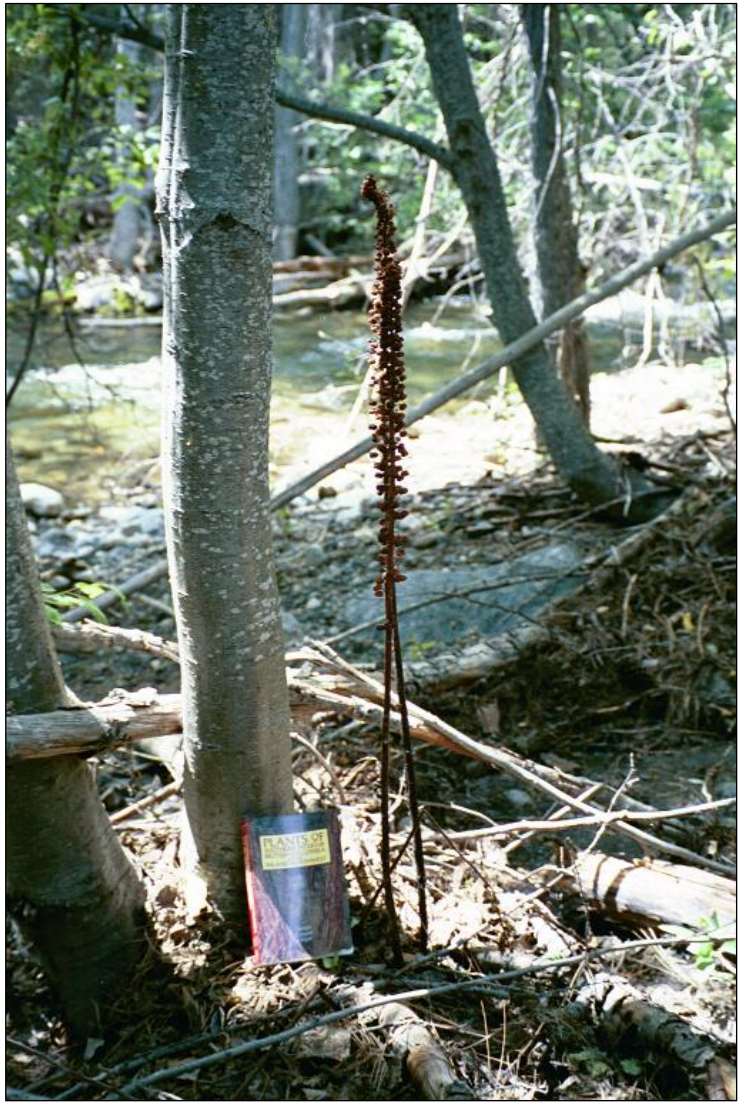
LANDAU ASSOCIATES

Antimony Queen Mine Carlton, Washington	**Selected Site Photographs**	Figure A-3

7. View downslope from near uppermost adit. Note open pine forest on creek floodplain at bottom of slope.



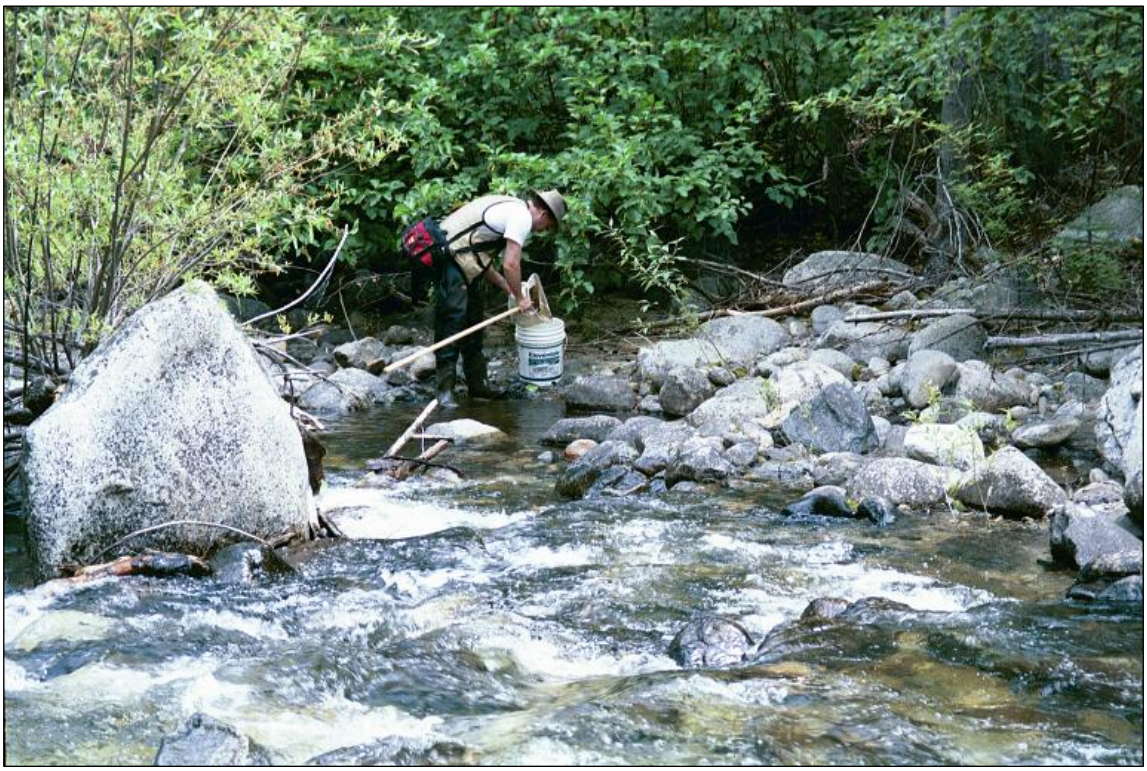
8. Scoured riparian habitat at station GC-02.

LANDAU ASSOCIATES

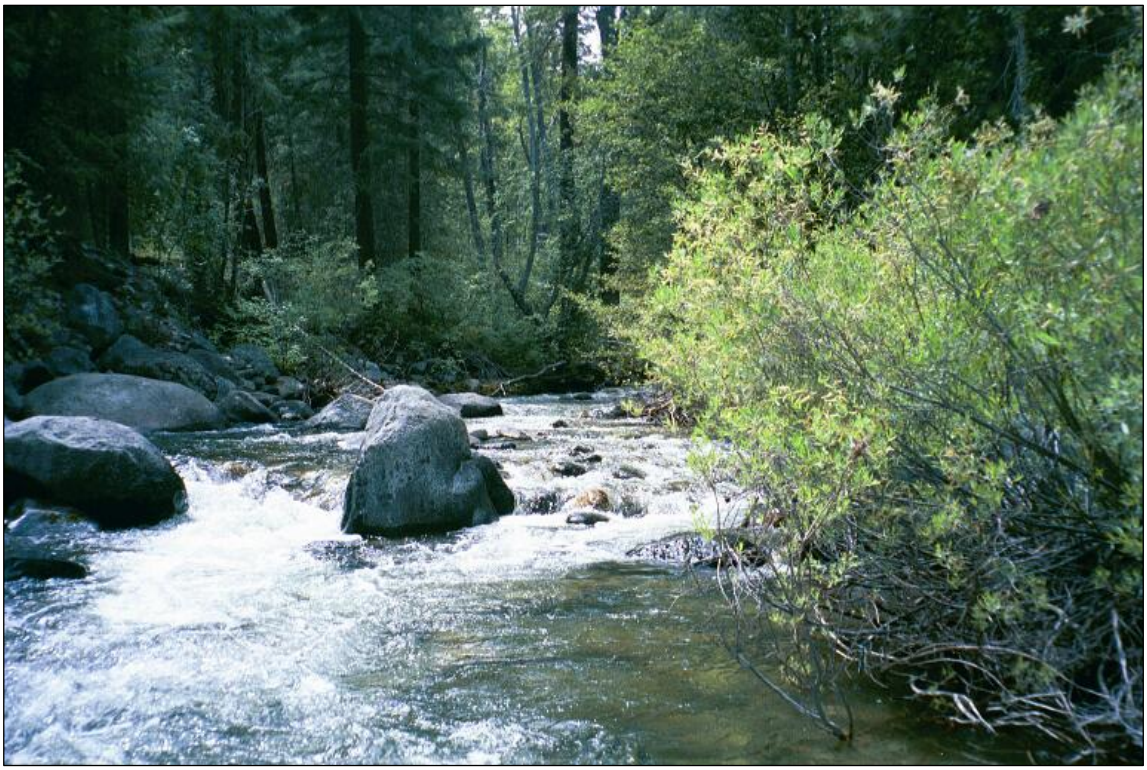
Antimony Queen Mine
Carlton, Washington

Selected Site Photographs

Figure
A-4



9. Off-channel pool and riffle habitat at station GC-01.



10. View upstream from station GC-01.

10/27/03 S:\WPROC\665\001\BA_apb-5.doc

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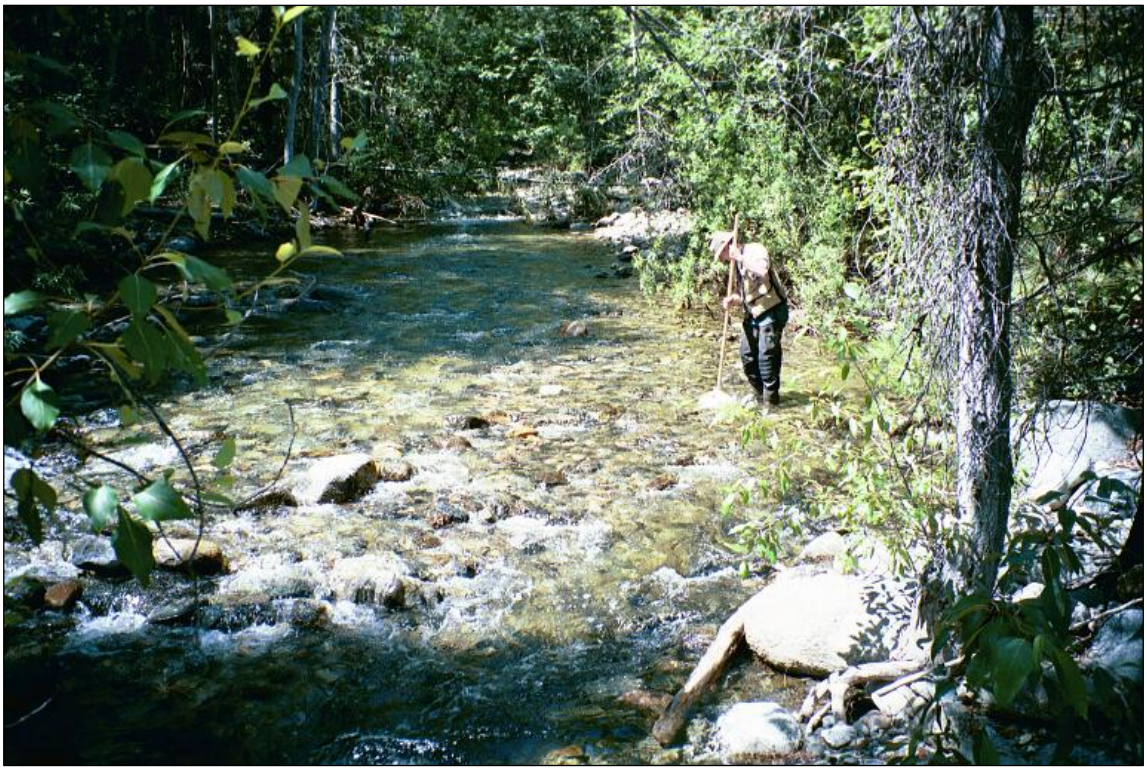
Antimony Queen Mine Carlton, Washington	**Selected Site Photographs**	Figure A-5

11. Off-channel pool habitat at Gold Creek sampling station GC-02.



12. Riffle habitat at Gold Creek sampling station GC-02.

10/27/03 S:\WPROC\665\001\BA_apb-6.doc

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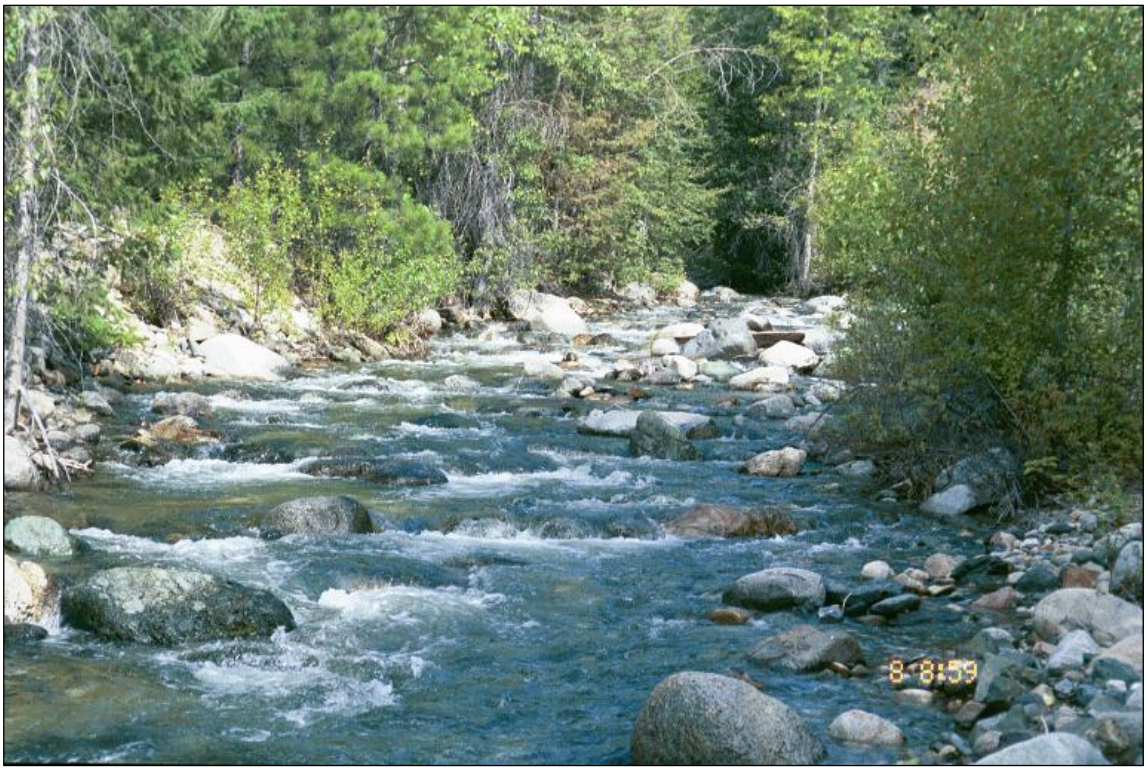
Antimony Queen Mine Carlton, Washington	**Selected Site Photographs**	Figure A-6

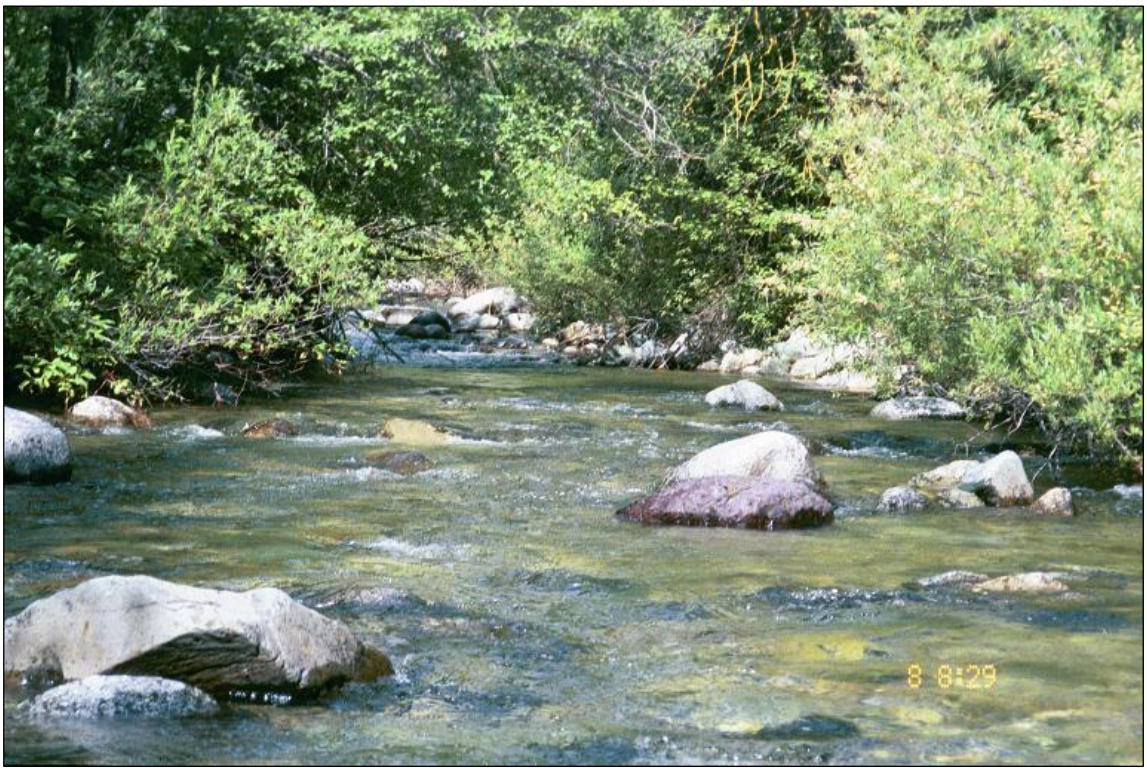
13. Riffle habitat at station GC-03.



14. Gold Creek upstream of station GC-03.

LANDAU ASSOCIATES

Antimony Queen Mine Carlton, Washington	**Selected Site Photographs**	Figure A-7



15. Riffle and pool (background) habitat at station GC-04.

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Antimony Queen Mine Carlton, Washington	**Selected Site Photographs**	Figure A-8

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Laboratory

- Brooks Rand Report - Antimony Queen PDF (download size 2.5 MB)

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23 Intercity Airport Road
Winthrop, WA 98862

509.997.9750 Voice
509.997.2077 Fax

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1 West Winesap
Tonasket, WA 98855 (509) 486-2186 Voice

509.486.1922 Fax
509.486.5144 TTY

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Leavenworth, WA 98826

509. 548-2550 or 548.2551 Voice
509.548.5817 Fax

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Minerals & Geology

Quality Assurance / Quality Control

- Field and Laboratory Quality Assurance/Quality Control PDF (download size 120kb)
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1.0 FIELD AND LABORATORY QUALITY ASSURANCE/QUALITY CONTROL (QA/QC)

Field and laboratory QA/QC objectives and procedures are detailed in the Quality Assurance Project Plan (QAPP), which is located in the Field Operations Plan (CES, 2003). The purpose of the QAPP is to establish guidelines necessary to provide information that is representative of field conditions. The QAPP presents a description of field documentation procedures, sample custody procedures, field instrument calibration procedures, procedures for the collection of field QA/QC samples, and laboratory quality assurance methods. The QAPP also includes data validation methods and data management procedures.

ACZ Laboratories, Inc of Steamboat Springs, Colorado, and Brooks Rand of Seattle, Washington were the primary contract laboratory for this project. In order to meet the Level II data validation objectives for this project, CES received Tier II deliverables. This data package included a transmittal letter, sample analytical results, method blank results, and surrogate recovery results where applicable. The results of matrix spiked samples and either duplicate samples or duplicate matrix spike samples, were also included.

Both laboratories' Quality Assurance Manuals address calibration procedures, internal QC checks, QA performance audits; system audits, preventative maintenance, and procedures used to assess data precision, accuracy and completeness. Corrective action is also addressed in the lab's standard operating procedures (SOP). Laboratory QA/QC manuals are available upon request.

1.1 Data Validation

Field observations and activities, and sample locations were logged in field books compiled by on-site personnel. Daily logs included a description of all persons entering and leaving the Site, daily start and completion times, and any problems that were encountered. Photographs were taken to document sampling activities. Quality assurance was maintained in the field using appropriate field documentation and sample custody procedures.

The laboratories in accordance with their SOPs conducted data validation. Errors detected in the process were identified and evaluated in regards to the overall required accuracy of the method and the objectives of the study. Results of the internal laboratory QA/QC procedures such as lab blank, matrix spike, and surrogate analysis were reported as part of the Level II QA/QC report and are summarized on the Analytical Laboratory Data Validation Check Sheet, included in this Appendix. Problems encountered by the labs with regards to chain-of-custody, sample holding times, sample analysis, laboratory contamination, etc., were documented by the lab. `

A review of laboratory and field documents indicates that proper chain of custody records were maintained for all samples collected for this project. A record of transfer of possession of the samples was maintained including the custodial signature, dates of possession, time of transfer, and the signature of the persons receiving custody of the samples. The chain of custody forms were complete and included the required information such as sample code number, signature of the collector, date and time of collection and the total number of samples transferred.

1.2 Precision

Precision measures the reproducibility of measurements under a given set of conditions. Specifically, it is a quantitative measure of the variability of a group of measurements compared to their average values. A check on laboratory precision was performed as outlined below.

Two field duplicate samples were submitted, one for surface water and one for pore-water. These duplicate samples were submitted as a blind sample. Precision is measured by the relative percent differences (RPDs) between a sample and a duplicate of that sample. Generally, RPD values of 75% or less are considered acceptable for field duplicate QA/QC (Data Quality Objectives for Remedial Response Activities, EPA 540/G-87/004, 1987). Testing laboratories set their own limits for laboratory RPDs. If RPDs fell within laboratory limits, where defined, the precision was considered acceptable.

RPDs were calculated using the following formula:

$$RPD = \frac{(Test1 - Test2)}{((Test1 + Test2)/2)}$$

Where:

Result of Test 1 is the laboratory analytical result of the original sample (e.g., soil or ground water),
Result of Test 2 is the result of the laboratory analysis of the field blind duplicate sample, or the laboratory-derived duplicate of the original sample,
Test1 – Test2 is the Difference,
(Test1 + Test2)/2 is the Average, and
The result is a percentage (times 100) in absolute value.

Precision for metal concentrations in water samples are presented in Table 1 of this appendix. All duplicate samples were within the acceptable precision range outlined above. Based on this, precision for the sample results is acceptable.

1.3 Accuracy

Accuracy is a measure of the closeness of the measured value to the "true value." It is a function of techniques and procedures that minimize sampling and analytical error. Field personnel maintained the accuracy in the field by following the sampling procedures outlined in the Field Operations Plan. Duplicate samples were collected as outlined in the Plan.

Laboratory accuracy is expressed as percent recovery and is calculated from recovery data as determined by sample spiking with surrogate compounds. A summary of sample matrix spike recovery results is presented at the end of this section.

Since the goal of the SI is to determine areas of that may be impacted from historical mining operations, the reported value for a particular location is the value of the official sample. No other problems with accuracy were identified. Corrective actions were not necessary and therefore none were taken.

Matrix spike recovery was within laboratory control limits of 70% to 130%, except for as noted at the end of the section.

Based on a review of laboratory reports and explanations, accuracy for the sample results is deemed acceptable.

1.4 Comparability

Data from this investigation is either directly comparable, or comparable with defined limitations, to literature data or other applicable criteria such as regulatory requirements.

1.5 Completeness

CES followed the SOW in creating a sampling plan to collect all of the designated samples. Changes to the sampling plan were made in the field after discussion and concurrence with the United States Forest Service (USFS) representative. Therefore, all necessary samples were collected in the appropriate areas, shipped under chain of custody, received and analyzed by the laboratory.

Completeness is defined as the total number of samples taken for which valid analytical data are obtained divided by the total number of samples submitted for analyses and multiplied by 100.

Valid results were obtained for all 41 samples (including QA/QC samples). Based upon this data, completeness for this investigation was determined to be 100%.

1.6 Representativeness

Representativeness is a measure of how closely the measured results reflect the actual concentration of distribution of the chemical compounds in the matrix sampled. The sampling plan design, standard operating procedures, sampling techniques, and sample handling protocols (e.g., storage, preservation, and transportation) have been developed to ensure the collection of representative samples. Representativeness of the data from samples collected as part of this investigation was provided by the sampling methods outlined in the Field Operations Plan (CES, 2003).

All specified sampling protocols were diligently followed. As a result, no metals were detected above the practical quantitation limit (PQL) in the rinsate blank samples. Although aluminum and zinc were detected at the method detection limit (MDL), the results are flagged as estimates and likely have minimal affect on the representativeness of the investigation. No problems were encountered in obtaining representative samples during the investigation conducted at the Site. Corrective actions were not necessary and therefore none were taken.

1.7 Laboratory QA/QC

In general, laboratory QA/QC was well documented and adequate for the purposes of this project.

The laboratory followed requirements for analysis and reporting under the EPA Level II protocols (EPA, 1987), including, laboratory blanks, laboratory duplicates, matrix spikes and matrix spike duplicates. All values between the MDL and the PQL were noted on the laboratory analytical reports. Analytical reports were reviewed to determine that all spikes, duplicates and lab blanks were within acceptable limits, with the exception of those listed in the case narrative and extended qualifier reports of the analytical report.

All samples were analyzed within the holding times specified for the individual analytical procedure with the exception of the following:

- ACZ Project # L42043 – Cyanide was distilled within the hold time but analyzed after the 14 day hold time. Even though cyanide was analyzed outside the hold time, the sample was distilled within the hold time and therefore the data is acceptable to the EPA.
- ACZ Project # L42029 – Total volatile solids analysis was completed initially within the hold time of 7 days, but required re-analysis outside of the hold time due to analyst error in the initial analysis. The data is considered valid because the initial analysis was completed within the hold time.
- ACZ Project # L41994 and #L41972 – Hexavalent chromium analysis was not performed within the EPA hold time of 24 hours. Samples were either received after the hold time, or too close to the hold time. The data is considered valid because 1) analysis was performed on all samples within 26 hours of sample collection (only 2 hours after the hold time), 2) total chromium was not detected above the MDL in any water sample, and 3) total chromium concentrations in waste rock samples do not appear to be elevated.

Based on the review of the laboratory QA/QC, the data is considered valid, with the exceptions listed in the analytical reports.

UNITED STATES
DEPARTMENT OF AGRICULTURE
FOREST SERVICE

MINERAL REPORT

BASELINE PRP SEARCH REPORT

ANTIMONY QUEEN MINE

USDA Forest Service
Pacific Northwest Region

Okanogan and Wenatchee National Forests
Methow Valley Ranger District

(Title)

LANDS INVOLVED

Approximately 20 acres located in
Section 11, T31N, R21E;
Willamette Meridian,
Okanogan County, Washington

Prepared by:

RODNEY T. LENTZ
Area Mining Geologist
March 5, 2004

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Appendix E Articles of Incorporation—Cheryl Lee Mines, Inc.
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Appendix G Cameco (US) Inc. Corporate Information

BASELINE PRP SEARCH REPORT

ANTIMONY QUEEN MINE

USDA Forest Service
Pacific Northwest Region

Okanogan and Wenatchee National Forests
Methow Valley Ranger District

Okanogan County, Washington

INTRODUCTION

The Antimony Queen Site is an abandoned mine property located on Forest Service System lands approximately 5 miles southwest of Carlton, WA. Site workings include four adits, three of which are fully or partially caved. The main adit, situated 40 feet above Gold Creek (1,970 feet above mean sea level), remains open and evidence of minor seasonal discharge is present. Approximately 925 cubic yards of mine waste rock at the adit's portal extends to the valley bottom and lies partially in the flood zone of Gold Creek. The toe of a smaller waste pile originating from the highest adit on the hillside (2,212 feet AMSL) also impinges on the valley floor. Except for several prospect pits and cuts and a small powder house no other structures are known in the area. Access is by foot only, the old mine road and Gold-Creek-bridge crossing having been washed out decades ago. Approximately two acres of disturbed surface are distributed across a total site area of about 20 acres.

Historical records indicate that the Antimony Queen mine was discovered in 1906 by L. W. Barton of Methow, Washington. The greater part of property development took place between 1906 and 1919. Purdy (1951, p. 18) reports: "A small amount of ore was extracted and may have been shipped in 1906. About 10 years later, 1,000 tons of stibnite ore and several hundred tons of antimony oxide, which had been manufactured in a small plant near the mine, were shipped. About 2/3 of a carload of ore was shipped in 1941." Huntting reported in 1956 that site "development includes three main adits and about 1000 feet of workings."

The oxidation of pyrite and other sulfides in the waste rock imparts a distinctive rust-red color to the piles. Bedrock hosting the deposit consists of argillite and graywacke. Ore minerals present include stibnite, jamesonite, arsenopyrite, pyrite, galena, sphalerite and scheelite; gangue minerals include calcite, pyrite, and pyrrhotite. Potential commodities are antimony, gold, lead, zinc, tungsten and arsenic. Evidence of the release of arsenic and other heavy metals into Site soils and the waters of Gold Creek is documented in a Site Inspection finalized in January, 2004.

LANDS INVOLVED

The main Antimony workings are included in an area approximately 200 feet wide and 400 feet long on the steep, south wall of the Gold Creek valley, Okanogan County, Washington. Although currently abandoned, the associated mineral occurrence has been the target of a series of unpatented lode mining claims from 1906, intermittently through 1993. The legal description for the site is; Latitude: 48°06'22", Longitude: 120°02'21"; T31N, R21E, W.M., Section 11, NW/4SW/4 (Figures 1 & 2). Site access is from Alternate State Route 153 (East-side Gold Creek access road), 4.5 miles up FS Road 4340.

Gold Creek drains Sawtooth Ridge, a rugged mountain range which divides the Stehekin (Lake Chelan) and Methow Valleys. Elevation at the site varies between 1,950 and 2,200 feet above mean sea level. Climate is semi-arid, offering 19 inches of precipitation annually, mainly in winter and spring.

LAND STATUS AND RECORD DATA

Official land status is described in the Master Title Plat for township T31N, R21E, Willamette Meridian (Figure 3). The Antimony Queen Site lies entirely on Federal lands open to mineral entry under the General Mining Laws. The area was included in the Washington Forest Reserve in 1907 and is presently administered by the Okanogan and Wenatchee National Forests. Both the surface and mineral estates are federally owned. The later has and continues to be open to locatable, leasable and salable mineral entry. Surrounding and including the lands in question is the Buttermilk Sheep and Grazing grazing allotment (Permit No. 1708). No special use permits or cost share agreements encumber the subject tract. Bureau of Land Management (BLM) mining claim records show no active mining claims covering the mine site after 1993 (Appendix B).

Current Forest Plan direction for the subject lands (USDA Forest Service, 1989, as amended) is to provide natural appearing foreground, middle, and background along major scenic travel routes while providing wood products (Management Prescription 33). The lands are classified as matrix under the Northwest Forest Plan (USDA Forest Service, et al., 1994) Management direction does not preclude leasable or salable mineral activities. Land uses in the area include roaded recreation, timber harvest and mineral (stone) production.

DATA COLLECTION AND METHODS

Initial investigation involved the examination of Forest Service and Bureau of Land Management (BLM) land status records. The search for potentially responsible parties began with a review of Okanogan National Forest mining files. While Forest Service Surface Management regulations were not in place until 1974 the Antimony Queen and Silver Seal #4 file was opened in 1970 with the discovery of mine work initiated by Francis Reeves. Okanogan County Quartz Records, Deed Records, Miscellaneous Records and Articles of Incorporation were carefully reviewed for documents involving Site mining claims, individual and corporate owners and operators, as well as title information and conveyances. The published and unpublished mining and geology literature was reviewed. BLM mining claim records were also searched for information applicable to the Antimony Queen Site. Finally some internet research was conducted to ascertain current addresses or other information.

OWNER/OPERATOR HISTORY

Mining Locations and Claimants/Operators

The Antimony Queen mine has a long, complex history of claimants and operators beginning in 1906. Table 1 summarizes the Site mining claim history.

Discovered during the summer of 1906, L. W. Barton made the first locations on the antimony- and arsenic-bearing veins at the Site of the Antimony Queen mine. These included the Dixie Queen, Minnie, Lucky Ike, Blue Bell and IreneV lode claims (the later relocated in 1908 as the Hooter). Proofs of Labor descriptions indicate that most development work for this group, often referred to as the Antimony group or mine, was done on the Dixie Queen claim. The Dixie Queen claim was leased in 1907 to the **Antimony Queen Mining Company** and then conveyed along with the Minnie, Blue Bell, Lucky Ike and Hooter to **Gold Creek Antimony Mines and Smelting Company** (GCAMS) through B. P. Kunkler in 1908. Both companies were incorporated in the state of Washington (Appendices B & C). GCAMS drove tunnel and extracted ore at the

site between 1908 and 1919. Purdy (1951) reports that 1,000 tons of antimony ore and several hundred tons of antimony oxide were shipped from the mine about 1916. The oxide product was reportedly manufactured in a small plant near the mine. The claims were apparently abandoned after 1919.

World War II hostilities created renewed interest in antimony. H. B. (Harry) Johnsten and W. B. (C.) Smith relocated Dixie Queen workings as the Silver Seal #1 lode claim in 1937 (along with associated Silver Seal #2 and #3, and the Jumbo lodes). Johnsten, et al. retained ownership of the claim group from 1937 until their conveyance to G. O. P. Antimony, Inc. in 1951. Partial interest in the claim was conveyed to Vernon LaMotte and A. A. Hunt. Apparently, the claims were briefly leased to William Oldfield in 1941[1], during which time "2/3rd car load of ore was shipped"[2] (Purdy, 1951). The mine was later quitclaimed to Joseph R. Gray and Ernest Oberbillig of **G. O. P. Antimony, Inc.** (GOPA), a Washington corporation (Appendix D), in 1951. An application to the US Department of the Interior Defense Minerals Authority for exploration funds was submitted that same year by GOPA (DMA Docket 979)[3]. GOPA reported significant work on the claim group in 1952; "110' drift, 20' bridge over Gold Creek, and 1000' of road" but abandoned the claims after 1953.

Between 1970 and 1993 the Antimony Queen mine was held by a series of different individuals and companies. While most of these claimants held the mine by assessment work for one or more years, little actual development work was apparently accomplished. The most notable work was reported in the Proofs of Labor filed by claimant Francis J. Reeves in 1971 and 1972; built access road and bridge structure, cleaned out main drift and second level, installed 200 feet of tunnel rail and mined 4 tons of ore. Forest Service records (Appendix F) indicate that this work was done by a lessee, **Cheryl Lee Mines, Inc**., a Washington corporation based in Renton, Washington, but no agreement or lease document was found recorded with the county. Other individual locators included R. D. Holmes and Kenneth A. Hoeft of Kent, WA with Frank Bissile, Washington, MT; Edwin D. Norquest, Renton, WA; and David Flannegan, Cashmere, WA.

Beginning in 1986 several contemporary firms blanketed the Antimony Queen mine under large exploration claim blocks: **Reliant Resources, Inc., Canevex Resources, Inc.[4] and Cameco US, Inc**. All are or were Nevada Corporations. Apparently only Cameco US was registered in Washington State but that registration was allowed to die by 1995. Legal ownership of the Site by Reliant Resources is questionable, however, because Flannegan's Antimony Queen claim was located prior to the establishment of Reliant's Alalfa claim group. Both claimants held their claims through 1988. **Canevex Resources, Inc.** and **Cameco US, Inc**. began staking the Goldridge lode claims in the Gold Creek area in 1989, eventually encompassing over 3,400 acres. A portion of this claim block included the Antimony Queen mine. Canevex transferred its interests in the Goldridge group to Cameco US on June 21, 1991. Consequently, both Canevex Resources and Cameco US owned the Site for a short period. Cameco US exploration targets were centered on the ridge north of the Site, however, and no noticeable work was completed at the Antimony Queen mine by either entity. The Antimony Queen mine has been inactive since 1970 and abandoned since 1993.

Claimant/Operator Status Table 2 lists available addresses for the known claimants and operators. The following are known corporate operators of the Antimony Queen mine:

- Antimony Queen Mining Company, circa 1906-7
- Gold Creek Antimony Mines and Smelter Company, circa 1907-19
- G. O. P. Antimony, Inc., circa 1951-53

---

[1] Oldfield 5/06/1941 Proof of Labor describes the assessment work being done for the "lessors", Johnsten, LaMotte & Gibson; Huntting (1956).
[2] A railroad car typically carries about 90 tons, but Huntting (1956) reports that only 20 tons of ore was produced in 1941 from Antimony Queen mine.
[3] Kiilsgaard (1998)
[4] Reliant Resources and Canevex Resources were apparently related; Reliant's address was the same as Canevex's, as shown on BLM claim records and other legal documents (e.g. Bill of Sale for Goldridge lode claims).

- Cheryl Lee Mines, Inc., circa 1970

Articles of incorporation for all of these were filed with the Washington Secretary of State. These corporations were ultimately stricken from the records or dissolved by the Secretary of State (Appendix B-E). Articles of incorporation for all but Cheryl Lee Mines were also found recorded in Okanogan County, Washington. No record of Cheryl Lee Mines was located in Okanogan County. Alicia Bennett, OGC, Region 2 was unable to locate any information on the status or fate of any of the above four companies.

Individual claimants and operators associated with the Site before 1950 are deceased or presumed deceased. Internet searches were conducted in an attempt to confirm the known address-of-record or to discover the current address of the more recent claimants/operators. When available this information is shown in Table 2.

Leasable and Salable Minerals

The subject lands are not and have not been included in any mineral lease or lease application submitted under the authority of the Mineral Leasing Act of 1920, as amended. Nor are the lands subject to any outstanding mineral material sale or free use permit authorized under the material Sale Act of 1947, as amended.

REFERENCES

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Purdy, C. P., Jr., 1951, Antimony occurrences of Washington: Washington Div. of Mines and Geology Bulletin No. 39, 186 p.

USDA Forest Service, 1989, Okanogan National Forest Land and Resource Management Plan: USDA Forest Service, Pacific Northwest Region, Okanogan National Forest.

USDA Forest Service & USDI Bureau of Land Management, 1994, Record of Decision/Standards and Guidlines, Northwest Forest: USDA Forest Service, Pacific Northwest Region, Okanogan National Forest.

Table 1. Antimony Queen Ownership/Operator History

Date	Owner/Operator	Remarks
8/29/1906	L. W. Barton	Staked original Antimony group claims; (Dixie Queen, Minnie, Blue Bell, Lucky Ike); Held by Proof of Labor through 1907
10/19/1906	L. W. Barton	Lease with option to sell Dixie Queen to Perry H. Newberry and Steven C. Rose.
10/22/1906	**Antimony Queen Mining Company (AQM**)	**AQM** was incorporated in Okanogan County on this date (and with the Secretary of State on 10/26/1906) Original trusties were: Perry H. Newberry, Methow, WA Steven C. Rose, Methow, WA
1/25/1907	Perry H. Newberry and Steven C. Rose	Assigned Barton lease/option to **Antimony Queen Mining Company**;
3/22/1907	L. W. Barton	Lease with option to sell Minnie and Lucky Ike to Antimony Queen Mining Company
11/02/1907	L. W. Barton	Quitclaim deed to B. P. Kunkler (Trustee GCAMS) for Dixie Queen, Lucky Ike, Minnie and Blue Bell lode claims
12/02/1907	**Gold Creek Antimony Mines and Smelter Company (GCAMS)**	**GCAMS** was incorporated in Okanogan County on this date (and with the Secretary of State on 12/7/07): company property included the Antimony Queen Group Original trusties were: Harry L. Osborne – Wichita, KS B. P. Kunkler – Methow, WA Frank B. Sayre – Seattle, WA
5/09/1908	B. P. Kunkler	Quitclaim deed to **GCAMS** for Dixie Queen, Lucky Ike, Minnie and Blue Bell lode claims
7/11/1908	B. P. Kunkler	Quitclaim deed to **GCAMS** for Hooter lode claim
1908-19	**GCAMS**	Group held by assessment work and Notice to Hold; work includes mainly tunnel work and general mining on Dixie Queen; Purdy (1951) reports 1000 tons of stibnite ore shipped from mine in about 1916.
12/06/1919	**GCAMS**	Last GCAMS Notice of Intent to Hold/ Proof of Labor filed, claims abandoned.
7/10/1937	W. B. C. (W. B.) Smith (wife = Clara Smith)	Located old Dixie Queen workings as the New Deal lode claim
7/18/1937	Harry B. Johnsten W. B. C. Smith	Relocated New Deal as the Silver Seal #1 lode claim
7/18/1938	Harry B. Johnsten W. B. C. Smith	Located Silver Seal #3 lode claim
7/18/1939	Harry B. Johnsten W. B. C. Smith	Located Silver Seal #2 lode claim
11/27/39	Harry B. Johnsten- ½ interest Vernon LaMotte-1/4 interest Geo. M. Gibson- 1/4 interest	Located Jumbo lode claim

Table 1. Con't

Date	Owner/Operator	Remarks
5/06/1941	Wm. E. Oldfield	Proof of Labor - Silver Seal #1-3 & Jumbo lodes for Johnsten, LaMotte, Gibbson (claimants) by lessee Oldfield.[5] Purdy (1951) reports 2/3rds car of ore shipped (Huntting, 1956, shows 20 tons) in 1941
11/09/1943	W. B. C. and Clara (wife) Smith	Quitclaim deed, ¼ interest in Silver Seal # 1-3 and Jumbo to Vernon LaMotte, Twisp, WA
8/24/1945	Vernon and Beulah (wife) LaMotte (both now deceased) 146 Twisp-Carlton Rd Carlton, WA 98814	Quitclaim deed, ½ interest in Silver Seal #1-3 and Jumbo lode claims to H. B. Johnsten
9/28/1945	Harry B. and Addie M. (wife) Johnsten 10741 Palatine Ave Seattle, WA 98644	Quitclaim deed, 49/100 interest in Silver Seal #1-3 and Jumbo lode claims to A. A. Hunt
1938-53	H. B. Johnsten, et al.	Antimony Group held by assessment work and Notices of Intent to Hold, claims abandoned after 1953.
3/27/1951	H. B. & Addie M. Johnsten	Mining Agreement & Quitclaim deed to Joseph R. Gray & Ernest Oberbillig for Silver Seal # 1-3 & Jumbo lode mining claims
4/19/1951	**G. O. P. Antimony, Inc. (GOPA)**	**GOPA** was incorporated in Okanogan County (and with the Secretary of State on 5/3/1951) Prelim. Directors: Ernest Oberbillig, Twin Springs[6], ID Gilbert C. Pearson[7], Atlanta, ID Norton Pearson, Yakima, WA Joseph R. Gray, Twisp, WA Jess B. Hawley[6], Jr., Boise, ID
1951-53	**GOPA**	Group held by assessment work. 1952 Proof of Labor lists assessment work as "110' drift, 20' bridge, 1000' road"
6/29/1953	**GOPA**	Last **GOPA** Proof of Labor, claims abandoned.
3/14/1970	Francis J. Reeves **Cheryl Lee Mines, Inc.**	Located old Dixie Queen workings as Antimony Queen lode claim; opened workings, mined 4 tons ore, built bridge framework. Work was done by Lessees Phil Plano and Don Broughton of **Cheryl Lee Mines, Inc.**[8]

[5] No lease or other agreement between Johnsten or his co-claimants and Wm. E. Oldfield was located in the County Records.
[6] State incorporation documents gives Ernest's address as Atlanta, ID.
[7] From State incorporation documents.
[8] From Forest Service File, Antimony Queen and Silver Seal #4. No lease or other agreement between Frances Reeves and Cheryl Lee Mines or individuals associated with that company was located in the County Records. Cheryl Lee Mines was incorporated with the Washington Secretary of State on 9/21/70.

Table 1. Con't

Date	Owner/Operator	Remarks
10/31/72	Francis J. Reeves	Last Reeve's Proof of Labor, claims abandoned.
8/30/1977	R. D. Holmes, Kent, WA Kenneth A. Hoeft, Kent, WA Frank Bissile, Washington, MT	Relocated Antimony Queen lode claim
8/31/1978	Ditto	Last Proof of Labor, claims abandoned? No appreciable work accomplished at mine.
1/24/1980	Edwin D. Norquest Renton, WA	Relocated Antimony Queen lode claim;
7/23/1981	Edwin D. Norquest	Last Proof of Labor, claims abandoned? No appreciable work accomplished at mine.
2/19/1983	David Flannegan Cashmere, WA	Relocated Antimony Queen lode claim
1983-88	David Flannegan	Group held by assessment work. No appreciable work accomplished at mine.
8/23/1988	David Flannegan	Last Proof of Labor, claims abandoned.
8/05/1986	**Reliant Resources, Inc.** **Reno, NV**	Staked Alalfa lode claim group which included the Antimony Queen mine (however Flannegan's claim preexisted the Alalfa claims)
8/05/1988	**Reliant Resources, Inc.**	Last Proof of Labor; no known work accomplished at Antimony Queen mine
11/27/1989	**Canevex Resources, Inc.** Reno, NV	Staked Goldridge #1-48 lode claim group which included Antimony Queen mine. Held by Notice of Intent to Hold.
6/20/1991	**Canevex Resources, Inc.**	Conveyed to **Cameco US, Inc**. the Goldridge #1-48 claims (included the Antimony Queen mine)
3/20/1992	**Cameco US, Inc.** Reno, NV	Last Proof of Labor; conducted surface exploration work in sections 2 & 3 during this time; no known work accomplished at Antimony Queen mine
2/12/1993	**Cameco US, Inc.**	Quitclaim deed to **Canevex Resources, Inc**. for Goldridge #1-173. Claims abandoned?
8/31/1993	**Canevex Resources, Inc.**	BLM closes Goldridge claim case file for failure to file assessment work afidavids, claims abandoned.

Table 2. Addresses of Known Owners/Operators

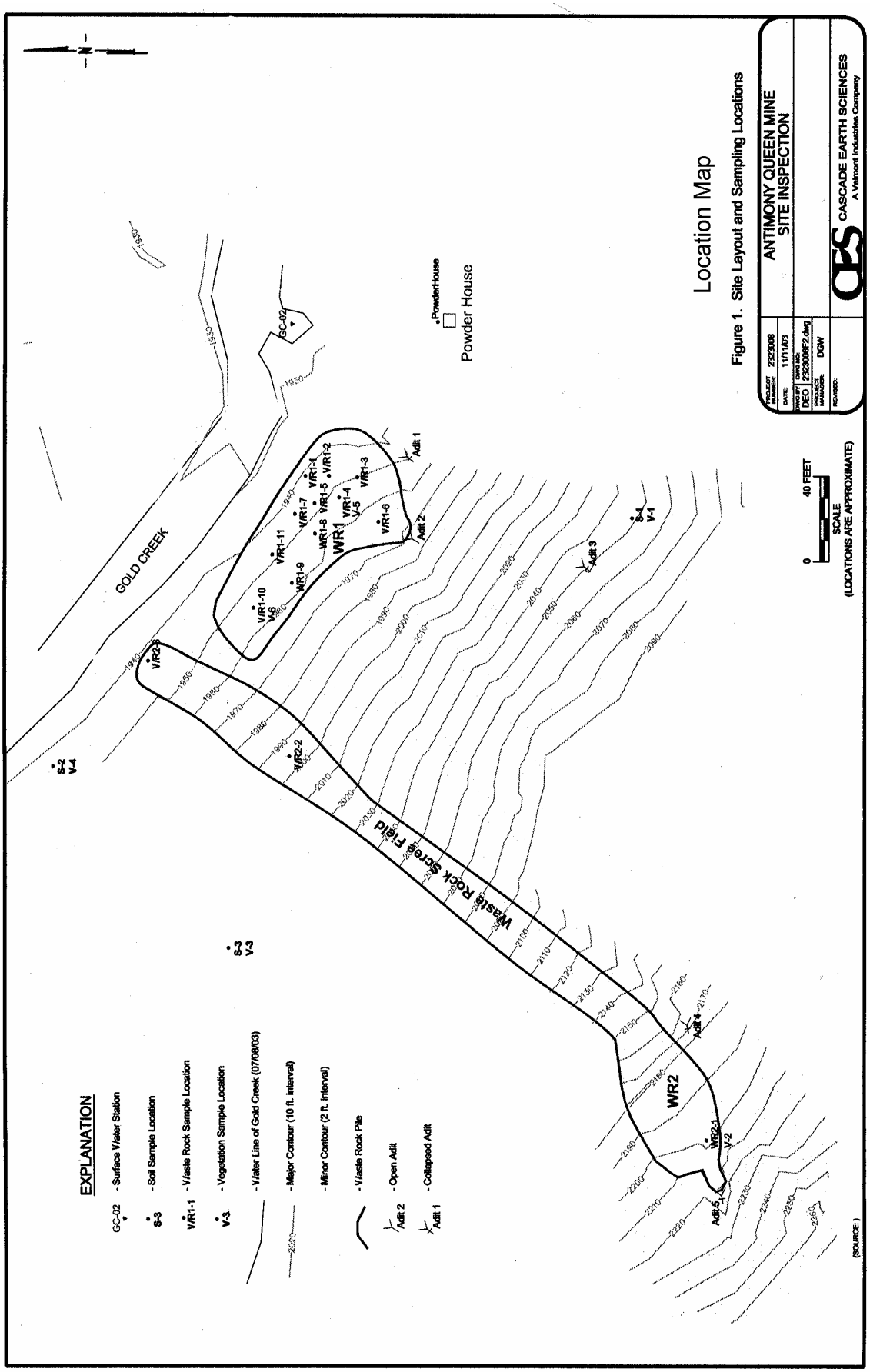
Relevant Dates	Owner/Operator	Address	Current Address
1906-07	L. W. Barton	Unknown	Presumed Deceased
1906-07	**Antimony Queen Mining Company (AQM)** Original trusties were: Perry H. Newberry Steven C. Rose	**Methow, WA** Methow, WA Methow, WA	**Dissolved by** WA Sec. of State July 1, 1923 Presumed Deceased Presumed Deceased
1907-19	**Gold Creek Antimony Mines and Smelter Company (GCAMS)** Original trusties were: Harry L. Osborne B. P. Kunkler Frank B. Sayre	**Methow, WA** Wichita, KS Methow, WA Seattle, WA	**Dissolved by** WA Sec. of State July 1, 1923 Presumed Deceased Presumed Deceased Presumed Deceased
1937-43	W. B. C. (W. B.) Smith Clara Smith (wife)	Unknown	Presumed Deceased Presumed Deceased
1937-53	Harry B. Johnsten Addie M. Johnsten (wife)	10741 Palatine Ave. Seattle, WA 98644	Presumed Deceased Presumed Deceased
1939-45	Vernon LaMotte Beulah LaMotte (wife)	146 Twisp-Carlton Rd Carlton, WA 98814	Deceased Deceased
1939-49	Geo. M. Gibson	Twisp, WA	Deceased
1941	Wm. E. Oldfield	Unknown	Presumed Deceased
1951-53	**G. O. P. Antimony, Inc. (GOPA)** Prelim. Directors: Ernest Oberbillig Norton Pearson Joseph R. Gray	**Okanogan County** Twin Springs, ID Yakima, WA Twisp, WA	**Dissolved by** WA Sec. of State July 1, 1956 Unknown Unknown Unknown
1970-72	Francis J. Reeves	P.O. Box 221 Entiat, WA 98822	F. Reeves (?)[9] 13095th St. N.E. East Wenatchee, WA 98802

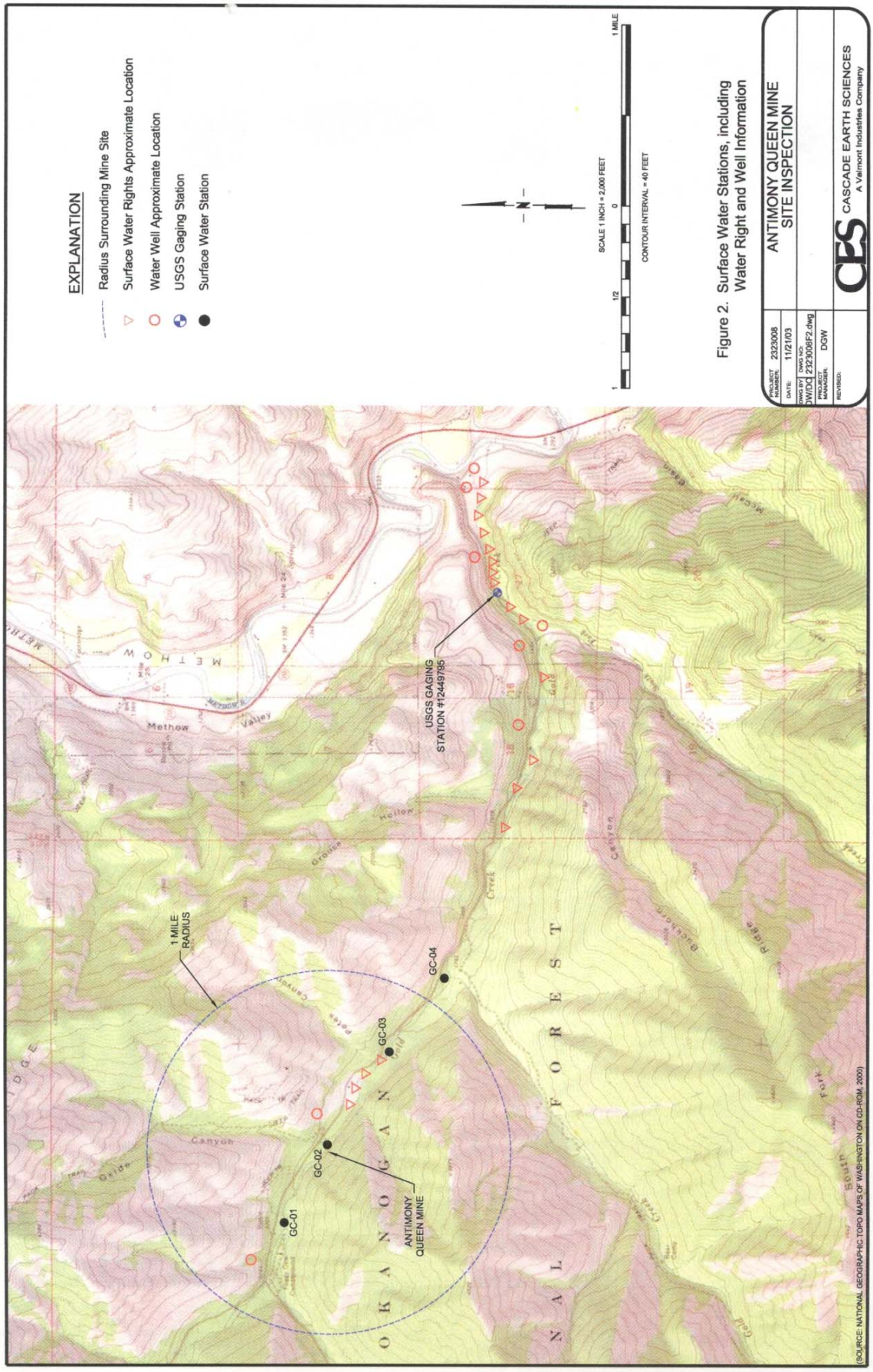
[9] Unconfirmed. Address from qwestdex.com

Table 2. Con't.

Relevant Dates	Owner/Operator	Contemporary Address	Current Address
1970	**Cheryl Lee Mines, Inc.** Officers: John Garney, Pres. Phil Plano, Jr., Sec/Treas Daniel Sullivan, V-Pres	**907 Harrington NE #6** **Renton WA 98055** 13800 NE 12th, Apt. 101 Bellevue,WA 907 Herrington NE, Renton, WA 5250 39th Ave S. Seattle, WA	**Dissolved by** WA Sec. of State July 1, 1974 Unknown Unknown Unknown
1977	R. D. Holmes Kenneth A. Hoeft Frank Bissile	Kent, WA Kent, WA Washington, MT	Unknown Unknown Unknown
1980	Edwin D. Norquest	18827 129th PL SE Renton, WA 98035 or 19243 116th Ave. SE Renton, WA 98055	Unknown
1983-88	David Flannegan	305 Cottage Ave, Cashmere, WA	Unknown
1986-88	**Reliant Resources, Inc.**	**6121 Lakeside Dr 240** **Reno, NV 89570**	Nevada Incorporation Revoked **1000 Main Street**[10] **Houston, TX 77002** **Phone: (713) 497-3000**
1989-92	**Canevex Resources, Inc.**	**240-6121 Lakeside Dr.** **P.O. Box 70250** **Reno, NV 89570-0250**	Nevada Corporation Permanently Revoked by NV Secretary of State
1991-92	**Cameco US, Inc.**	**P.O. Box 6446** **Reno, NV 89513** or **110 325 Howe St** **Vancouver, BC** or **2121-11th Street West** **Saskatoon SK S7M 1J3**	**Dissolved by** WA Sec. of State July 1, 1995 **Cameco (US) Inc.**[11] **6121 Lakeside Dr.** **Suite 260** **Reno, NV 89511** **Cameco Corporation**[12] **2121-11th Street West** **Saskatoon, Saskatchewan** **S7M 1J3** **Phone: (306) 956-6200**

[10] Address unconfirmed, from http://www.reliantresources.com/
[11] NV Secretary of State Records (Appendix G)
[12] Address unconfirmed, from http://www.cameco.com/


Location Map
Figure 1. Site Layout and Sampling Locations
ANTIMONY QUEEN MINE
SITE INSPECTION
CASCADE EARTH SCIENCES
A Valmont Industries Company
PROJECT NUMBER: 2323008
DATE: 11/11/03
DRAWN BY: DEO
DWG NO: 2323008F2.dwg
PROJECT MANAGER: DGW
REVISED:
0
40 FEET
SCALE
(LOCATIONS ARE APPROXIMATE)
EXPLANATION
GC-02 - Surface Water Station
S-3 - Soil Sample Location
WR1-1 - Waste Rock Sample Location
V-3 - Vegetation Sample Location
- Water Line of Gold Creek (07/08/03)
- Major Contour (10 ft. interval)
- Minor Contour (2 ft. interval)
- Waste Rock Pile
Adit 2 - Open Adit
Adit 1 - Collapsed Adit
GOLD CREEK
Powder House
PowderHouse
Waste Rock Scree Field
WR1
WR2
Adit 1
Adit 2
Adit 3
Adit 4
Adit 5
(SOURCE:)


EXPLANATION
Radius Surrounding Mine Site
Surface Water Rights Approximate Location
Water Well Approximate Location
USGS Gaging Station
Surface Water Station
1 MILE RADIUS
GC-01
GC-02
GC-03
GC-04
ANTIMONY QUEEN MINE
USGS GAGING STATION #12449795
Methow
Valley
Canyon
Creek
Hollow
Grouse
Gulch
Ridge
O K A N O G A N
N A L F O R E S T
SCALE 1 INCH = 2,000 FEET
1/2
0
1 MILE
CONTOUR INTERVAL = 40 FEET
Figure 2. Surface Water Stations, including Water Right and Well Information
PROJECT NUMBER: 2323008
DATE: 11/21/03
DWG BY: DW/DG
DWG NO: 2323008F2.dwg
PROJECT ENGINEER: DGW
REVISED:
ANTIMONY QUEEN MINE SITE INSPECTION
CES CASCADE EARTH SCIENCES
A Valmont Industries Company
(SOURCE: NATIONAL GEOGRAPHIC TOPO MAPS OF WASHINGTON ON CD-ROM, 2000)

UNSURVEYED TOWNSHIP 31 NORTH RANGE 21 EAST OF THE WILLAMETTE MERIDIAN, WASHINGTON

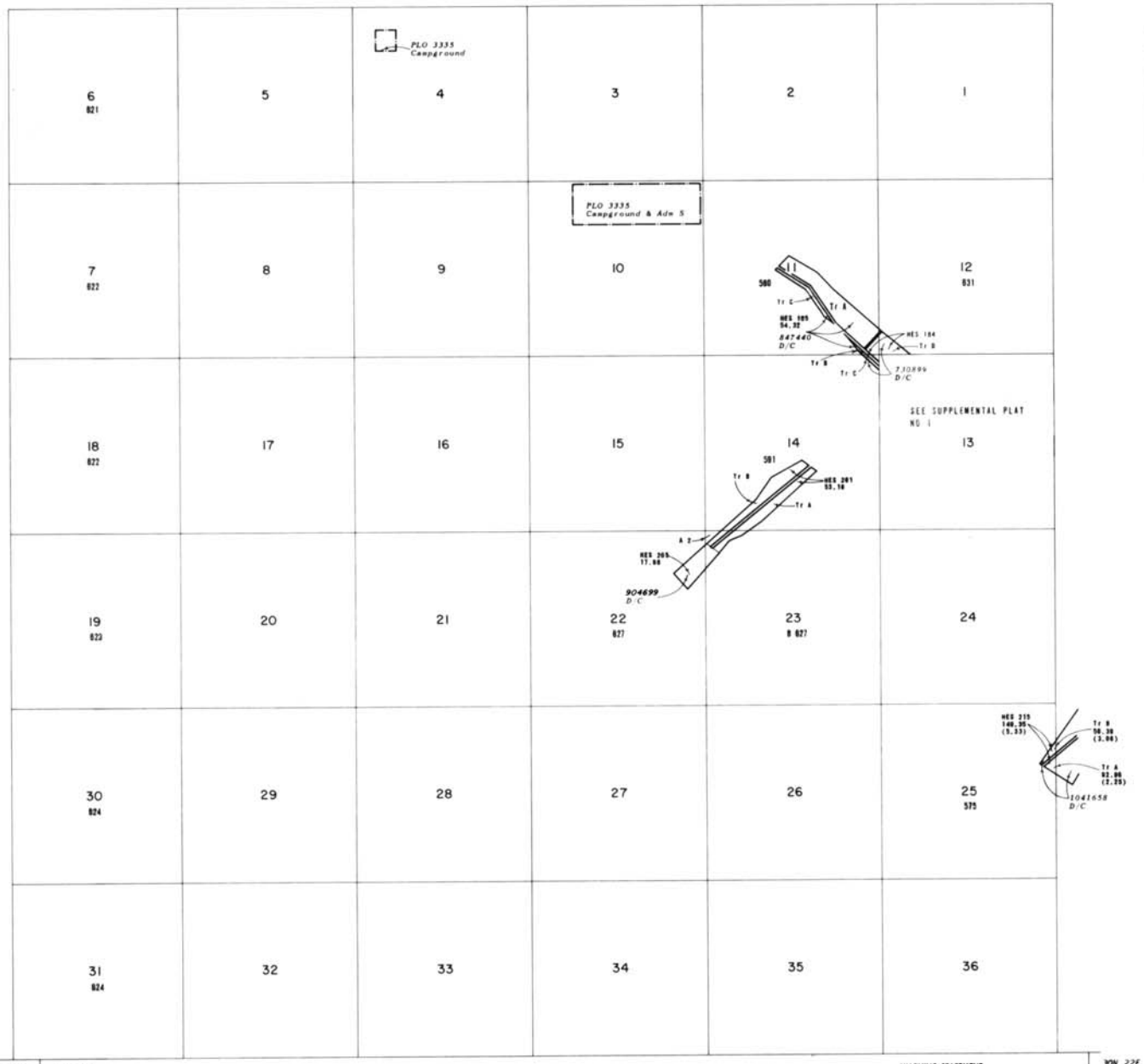
Protraction Diagram No. 5 effective 5/1/1964
File No 9 33FR2828 3/24/1964

OKANOGAN COUNTY

SPOKANE-WENATCHEE

STATUS OF PUBLIC DOMAIN
LAND AND MINERAL TITLES

MT PLAT



INDEX TO SEGREGATED TRACTS				
RESURVEY	ORIGINAL SURVEY			
TRACT NO	T	R	SEC	SUBDIVISION

All lands other than BLM, for PL 1GT, R/W, Esmt. 44LD513 refer to MI

All Tp included in Wdl Okanogan NF

FOR ORDERS EFFECTING DISPOSAL OR USE OF UNIDENTIFIED LANDS REFER TO INDEX OF MISCELLANEOUS DOCUMENTS

USGS

CURRENT TO	CURRENT TO
SEP 14 1998	

USE PLATS:

SCALE in Chains
10 5 0 10 20 30 60

WARNING STATEMENT
This plat is the Bureau's Record of Title, and should be used only as a graphic display of the township survey data. Records hereon do not reflect title changes which may have been effected by lateral movements of rivers or other bodies of water. Refer to the cadastral surveys for official survey information.

Will Mer
T 31 N
R 21 E

Figure 3

Engineering Evaluation/Cost Analysis
Antimony Queen Mine
Okanogan National Forest
Okanogan County, Washington

April 2006

Cascade Earth Sciences
12720 East Nora Avenue, Suite A
Spokane, Washington 99216
(509) 921-0290
www.cascade-earth.com

Engineering Evaluation/Cost Analysis
Antimony Queen Mine
Okanogan National Forest
Okanogan County, Washington

Principal Author and Investigator:

John D. Martin, RG, Principal Geologist
Dustin G. Wasley, PE, Managing Engineer II
Robert H. Lambeth, PE, Senior Engineer

Prepared For:

US Department of Agriculture Forest Service
Gifford Pinchot National Forest
10600 NE 51st Circle
Vancouver, Washington 98682

Prepared By:

Cascade Earth Sciences
12720 E. Nora Avenue, Suite A
Spokane, Washington 99216
(509) 921-0290

PN: 2423015
April 2006
Doc: 2423015 Ant Queen EECA.doc

Cover Photos: Adit 2 at the Antimony Queen Mine

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APPENDICES

Appendix A. Human Health and Ecological Risk Assessment
Appendix B. Applicable and Relevant and Appropriate Requirements

LIST OF ACRONYMS AND ABBREVERATIONS

ABA	Acid Based Accounting
ABP	Acid Based Potential
AGP	Acid Generating Potential
amsl	above mean sea level
ANP	Acid Neutralization Potential
ARAR	Applicable or Relevant and Appropriate Requirements
ARD	Acid Rock Drainage
bgs	below ground surface
CERCLA	Comprehensive Environmental Response and Liability Act
CES	Cascade Earth Sciences
cfs	cubic feet per second
COI	Contaminants of Interest
COPC	Contaminants of Potential Concern
COPEC	Contaminants of Potential Ecological Concern
CTE	Central Tendency Exposure
cy	cubic yards
EECA	Engineering Evaluation / Cost Analysis
ECR	Excess Cancer Risk
EPC	Exposure Point Concentration
ERA	Ecological Risk Assessment
ERBSC	Ecological Risk-Based Screening Concentration
HHRA	Human Health Risk Assessment
HI	Hazard Index
HQ	Hazard Quotient
mg/kg	milligrams per kilogram
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
ONF	Okanogan National Forest
PRG	Preliminary Remediation Goals
RCRA	Resource Conservation Recovery Act
RME	Reasonable Maximum Exposure
RTE	Rare, Threatened, and Endangered
SI	Site Inspection
SOC	Species of Concern
SPLP	Synthetic Precipitation Leaching Procedure
su	standard units
TCLP	Toxicity Characteristic Leaching Procedure
µg/L	micrograms per liter
USEPA	United States Environmental Protection Agency
USFS	United States Department of Agriculture, Forest Service

EXECUTIVE SUMMARY

Cascade Earth Sciences (CES) has prepared the following Engineering Evaluation / Cost Analysis (EECA) for completing a non-time-critical removal action related to metal contamination at the Antimony Queen Mine (Site). The Site is an abandoned antimony mine located in the Okanogan National Forest, 9 miles southwest of Carlton, Washington. The EECA is being performed by the United States Department of Agriculture, Forest Service (USFS) under the Comprehensive Environmental Response and Liability Act (CERCLA) cleanup authorities [42 USC 9604(a) and 7 CFR 2.60(m)] and Federal Executive Order 12580. This EECA has been prepared in accordance with the provisions of National Oil and Hazardous Substances Pollution Contingency Plan, 40 CFR 300.415(b)(4)(i). The purpose of the EECA is to evaluate and determine risks to human health and the environment, and to select an alternative to minimize or eliminate the risks associated with the release of a hazardous substance into the environment or impact on public health and welfare as outlined in 40 CFR 300.415(b)(2)(i)-(viii).

As part of the EECA, human health and ecological risk assessments were performed. A recreational user was identified as the only likely human receptor at the Site. Due to the isolated location and steep terrain and topography of the Site, recreational use is expected to be very limited. Potential unacceptable health impacts from ingestion and dermal contact with arsenic contaminated soils/wasterock may be present at the Site. However, it is highly unlikely that recreational users would engage in activities at the Site that could result in significant ingestion or dermal contact with soil and wasterock. Therefore, the most realistic and likely pathway of exposure at the Site is inhalation of particulates by hikers, hunters, or trespassers. The risk assessment determined that the inhalation pathway did not result in unacceptable non-carcinogenic or carcinogenic risks. Based on this, no human health risk is expected at the Site.

Elevated concentrations of metals are present in all of soil/wasterock samples collected from the Site, and it is likely that plants and invertebrates are affected within these localized areas. Given the highest risk ratios and most widespread distribution, antimony, arsenic (V, and total), iron, and manganese are the metals most likely to pose unacceptable risks in soil/wasterock. However, while the plants and invertebrates within the wasterock piles are predicted to be at risk, the populations are unlikely to be significantly affected within the vicinity of the Site because of the very limited area of potential exposure. In addition, the habitat lost due to any effects on plants is also unlikely to result in significant effects to upper trophic level species due to the large amount of relatively undisturbed habitat available surrounding the Site. Some upper trophic level species were predicted to be at risk due to metals in soil/wasterock. However, given the relatively large home ranges of the species in proximity to the Site, and the presence of a large amount of nearby suitable uncontaminated habitat, significant effects to these species are unlikely. Given the proximity to Gold Creek, the wasterock piles are likely past and current source areas for chemicals to be transported to Gold Creek. However, ecological impacts were not predicted for surface water. Thus, this transport of metals from soil/wasterock to surface water appears insignificant. In pore water, silver at GC-03 was the only metal predicted to present potentially ecological impacts. Ecological impacts due to silver in sediment are likely low given the predominantly low risk ratio and limited chemical distribution. Based on the information presented in the ecological risk assessment, significant ecological risks are not expected.

No removal action is recommended at the Site because unacceptable and significant human and ecological risks and hazards are not expected for the Site.

1.0 INTRODUCTION

Cascade Earth Sciences (CES) has prepared this Engineering Evaluation / Cost Analysis (EECA) Report for completing a non-time-critical removal action of metal contaminant material at the Antimony Queen Mine (Site) near Carlton, Washington. The EECA is being performed by the U.S. Department of Agriculture, Forest Service (USFS) under the Comprehensive Environmental Response and Liability Act (CERCLA) cleanup authorities [42 USC 9604(a) and 7 CFR 2.60(m)] and Federal Executive Order 12580. This EECA has been prepared in accordance with the provisions of National Oil and Hazardous Substances Pollution Contingency Plan (NCP), 40 CFR 300.415(b)(4)(i). The purpose of this EECA is to evaluate and determine risks to human health and the environment, and to select an alternative to minimize or eliminate the risks associated with the release of a hazardous substance into the environment or impact on public health and welfare as outlined in 40 CFR 300.415(b)(2)(i)-(viii).

This project has been prepared utilizing the U.S. Environmental Protection Agency (USEPA) *Guidance on Conducting Non-Time-Critical Removal Actions under CERCLA* (USEPA, 1993). Other relevant guidance includes:

- *Forest Service Guide to CERCLA* (USDA, 1996);
- *Field Operations Plan – Site Inspection of the Antimony Queen Mine, Okanogan National Forest, Okanogan County, Washington* (CES, 2003); and
- *Site Inspection, Antimony Queen Mine,* Okanogan National Forest (CES, 2004).

2.0 SITE CHARACTERIZATION

2.1 Site Description and Background

2.1.1 Site Location and Status

The Site is located in the Okanogan National Forest (ONF) in Okanogan County, approximately 9 miles southwest of Carlton, WA, (Figure 1). According to the USGS 7 ½ Minute Quadrangle Map - Hungry Mountain, the Site location is described as:

- Section 11, Township 31 North, Range 21 East of the Willamette Meridian
- Latitude – 48° 06’ 22”; Longitude – 120° 02’ 21”
- Elevation – 2,050 to 2,550 feet above mean sea level (amsl)

The Site is accessed by traveling from State Route 153 and turning west onto Gold Creek Loop Road. Continue on Gold Creek Loop Road and turn west on Forest Service Road (FR) 4340 (Gold Creek Road) and travel approximately 4 miles west. At the ONF sign, turn south on an unnamed access road, which dead ends into Gold Creek. Accessing the Site requires crossing Gold Creek on foot, as there are no bridges or roads to the Site. The Site is situated on steep slopes adjacent to southern bank of Gold Creek. Approximately two acres are disturbed and the Site is inactive.

2.1.2 Site Physiography

The Site is situated on the east flank of Sawtooth Ridge, a major divide between drainage to Lake Chelan to the west and to the Methow River to the east. It is situated on Gold Creek within the Methow River watershed. Gold Creek, which originates west of the Site, borders the northeast side of the Site and flows east approximately 5.5 miles to the confluence with the Methow River. The natural vegetation classification for the area of the Site is Grand Fir zone, which occurs on the east side of the Cascade Mountains where moisture and temperature conditions are not extreme. This zone also includes Douglas fir in warmer, drier areas.

Figure 2 provides a general layout of the Site, including 2-foot contours and pertinent features. Topography of the Site is steep with a southwest to northeast slope of approximately 80% (Figure 1). Surface topography has been altered by the past mining activities. The Site is bordered on the northeast by Gold Creek and an unnamed access road, and by ONF land on all other sides and beyond Gold Creek to the northeast.

Five adits exist at the Site, four are collapsed or partially collapsed (Adits 1, 3, 4, and 5) and one is open (Adit 2). The lower most adit (Adit 1) is located at an elevation of 1,940 feet amsl and reportedly consisted of 220-230 lineal feet of underground workings. The main haulage adit (Adit 2) is located approximately 50 feet west and upslope of Adit 1 at an elevation of approximately 1,970 feet amsl, and has between 500 to 550 lineal feet of underground workings. Adit 3 is located upslope and approximately 80 feet south of Adit 2 at an elevation of approximately 2,050 feet amsl. No ore was extracted from this adit, as it reportedly only extended 30 to 35 lineal feet into the hillside. Adit 4 is located approximately 2,100 feet southwest and upslope of Adit 3 at an elevation of approximately 2,160 feet amsl. No ore was extracted, as the adit reportedly only extended 40 lineal feet into the hillside. The uppermost adit (Adit 5) is located 70 feet southwest and upslope of Adit 4 at an elevation of approximately 2,200 feet amsl. This adit reportedly has between 160 to 175 lineal feet of underground workings, which includes a stope that daylights 50 feet upgradient of the portal. Little is known about the production from this adit. However, judging from the wasterock pile and scree field located downgradient from the adit, a limited amount of ore was probably extracted from this adit.

With the exception of what appeared to be a small empty "powder house" located 100 feet east of Adit 1, no structures were present at the Site. Two wasterock piles were observed during the Site Inspection (SI) field activities. Wasterock from both piles was observed in Gold Creek. Wasterock Pile 1 (WR1) is associated with Adit 2. Most of the ore that was extracted from the mine came from this adit. Based on the topographic survey and field observations, the volume of WR1 is estimated at 925 cubic yards (cy). Wasterock Pile 2 (WR2) is associated with Adit 5 and is situated along the steep slope above WR1. Wasterock from WR2 is scattered, at an average depth of 1.5 to 2 feet, for approximately 400 feet downhill to Gold Creek, the volume of WR2 is estimated at 650 cy. Gold Creek flows adjacent to WR1 and the base of WR2.

2.1.3 Mining History

Little information is available regarding the operational history of the Site. However, the following information was gleaned from *Inventory of Washington Minerals – Part II Metallic Minerals* (Huntting, 1956), *Metal Mines of Washington Preliminary Report* (Derkey, et. al, 1990), and *USFS Report of Mineral Examination of the Antimony Queen Mine* (Garrett, 1970). The Site was also known as the New Deal, Dixie Queen, Reedy, Silver Seal, and Jumbo Mines; and consists of four unpatented claims (Jumbo and Silver Seal Nos. 1, 2, and 3). All workings and production at the Site has been done on the Silver Seal No. 1 claim. Commodities produced from the Site consisted mainly of antimony, with minor amounts of gold, lead, zinc, tungsten, and arsenic. The following information is a chronological summary of the operational history and production of the Site.

- 1906 – Site owned by Antimony Queen Mining Company, small amount of ore was extracted and shipped for smelting.
- 1916 – The Gold Creek Antimony Mine and Smelting Co. reportedly shipped 1,000 tons of stibnite ore and several hundred tons of antimony oxide, which had been milled and concentrated in a small plant near the Site, for offsite smelting.
- 1940 – Owned by H.B. Johnston, Vernon LaMotte, George Gibson, and C.E. Baker.
- 1941 – Site leased by William Oldfield. Oldfield reported that about one ton of ore was being hand sorted per day during that time.
- 1949 – H.B. Johnston retained ownership of the Site.
- 1951 to 52 - Site leased to G.O.P. Antimony, Inc., by H.B. Johnston.

- 1970 – Francis Reeves began redevelopment of the Site; activities included partial construction of a bridge over Gold Creek near Adit 1, leveling of the mill site on the north side of Gold Creek, and excavation of exploratory pits to access ore body. Due to the decline in antimony prices, Francis never completed the redevelopment of the Site.

2.1.4 Previous Removal Actions

No previous CERCLA or other regulatory removal actions have been conducted at the Site. Previous environmental regulatory activities related to the Site are:

- *Second Screening Investigation of Water and Sediment Quality of Creeks in Ten Washington Mining Districts, with Emphasis on Metals*, Washington Department of Ecology (Ecology, 2002).
- *Site Inspection, Antimony Queen Mine,* Okanogan National Forest conducted by CES in 2004 (CES, 2004).

2.1.5 Climate and Meteorology

The information presented in this section was compiled from the Western Regional Climate Center website (WRCC, 2003). Climate in Okanogan County varies depending on elevation and distance from the Cascade summit. Precipitation decreases as elevation decreases in an easterly direction from the summit of the Cascade Range. The Site lies along the east slope of the Cascade Range at an elevation of between 2,000 to 2,300 feet amsl. The following data were compiled from the Stockdill Ranch Monitoring Station, located approximately 13 miles north of the Site at an elevation of 2,201 feet amsl.

- The total average precipitation is 19 inches per year; total average snowfall is 109 inches per year.
- The average minimum temperature of approximately 6° F occurs in January.
- The average maximum temperature of approximately 85° F occurs in July.
- Temperature extremes range from approximately 104° F in summer to -32° F in winter months.

2.1.6 Geologic Setting

Regional geologic information presented in this section was obtained from the Washington State Department of Natural Resource, Division of Geology and Earth Resources (2003) and Orr and Orr (2002). Site-specific geology was compiled from Derkey (1990) and Bunning (1990), as well as site-specific reconnaissance performed by a CES Registered Geologist registered in the State of Washington.

2.1.6.1 Regional Geology

The Site is located in the Methow Terrane in the northeastern Cascade Range geologic province. The North Cascades consist of jagged mountains with numerous glaciers and are composed predominantly of Mesozoic crystalline and metamorphic rocks. The structural fabric is extremely complex because of the unrelated terranes that have been brought in contact with each other by strike-slip and thrust faults. The eastern boundary of the North Cascades province is the Chewack-Pasayten fault zone, located approximately 12 miles to the east of the Site. The Site lies within the Methow Basin, which is bounded on the west by the Ross Lake Fault and on the east by the Chewack-Pasayten Fault. The terrane is approximately 160 miles long and 20 miles wide tapering to the north.

The Methow Basin was a shallow marine inlet separated from the open ocean by a chain of volcanic islands (Orr et. al., 2002). Sediments filled the basin in Late Jurassic and were folded by compression and uplift in Late Cretaceous. A network of north-south trending faults separated and shifted the basin in the Early Tertiary to where it is today.

Geology in the vicinity of the Site consists of sedimentary rocks of the undivided Newby Group of Cretaceous-Jurassic age (Bunning, 1990). These rocks consist of irregularly interbedded, fine- to coarse-grained feldspathic volcanic lithic sandstones (graywacke), conglomerate, siltstones, and silty black shales (argillite). Quartz, plagioclase, and opaque minerals are found in sandstones and as matrix material. In places clasts and matrix have been altered to calcite, sericite, pyrite, hematite, and other opaque minerals. In some areas, such as the Gold Creek shear zones (in the South Fork Gold Creek area), the rocks have been dynamothermally metamorphosed under greenschist-facies and deformed in the ductile and/or brittle-ductile-transitional regimes. Quartz and calcite occur in both composite and monomineralic veins (Bunning, 1990).

Numerous folds and faults are mapped in the area around the Site. A buried axis of an anticline is mapped directly through the Site. During the SI field event, near the upper adit, the attitude of an exposed bed was measured at N 50 ^{o} W and dips 85° north (CES, 2004). This correlates well with published fault data in the area.

2.1.6.2 Site Specific Mining Geology

Minerals include stibnite, pyrite, scheelite, pyrrhotite, galena, jamesonite, sphalerite, arsenopyrite, and chalcopyrite. The gangue is quartz and calcite. The ore deposits are found in quartz veins and breccia zones in calcareous argillite. Ore veins are reportedly up to 2 feet wide and 40 feet long. One vein reportedly contained from 10 to 90% stibnite and was 2 to 12 inch wide.

The following site-specific geology is summarized from a detailed report by Purdy (1951).

- The Newby Formation in the vicinity of the Site has a general strike of N 30-40° W with dips varying from 50-80 ^{o} W.
- The mine workings trend along the eastward-striking vein system and extend from Gold Creek to elevations of about 383 feet above Gold Creek.
- No correlation could be made between rock types and quantity of sulfides.
- Fault displacement could not be determined.
- A quartz vein in Level No. 1 (Adit 1) reportedly contained pyrite, arsenopyrite, sphalerite, galena, jamesonite, stibnite, quartz, and calcite. A spectrographic analysis of some of the pyrite and arsenopyrite crystals showed a content of 1 to 3 ounces of gold per ton. Prominent jointing was observed to contain scheelite (tungsten ore).
- The principle workings of the property are contained in Level No. 2 (Adit 2), 30 feet above Level No. 1. The best stibnite ore at the Site was reportedly located at the intersection of Adit 2 with the drift on Vein C.
- Level No. 3 (Adit 3) was driven along a thin fault seam in a zone of crushed limonitized greywacke or argillilte about 2 feet thick.
- Level No. 4 (Adit 4) was a composite adit driven in badly crumpled and shattered greywacke or argillite stained with limonite.
- An assay collected from Level No. 5 (Adit 5) showed gold at 0.16 ounce/ton and silver at 0.46 ounce/ton, and arsenic at a concentration of 5.8%. Stibnite was present in a quartz vein varying from 2 inches to 1 foot thick with concentrations ranging up to 10% stibnite.

2.1.7 Hydrogeology

The Site is located within the Gold Creek watershed. A review of the State of Washington Water Resources Department (WRD) database for water wells Site shows over 28 wells located within a 4-mile radius of the Site. However, many of the wells are outside the Gold Creek drainage system (i.e., adjacent to the Methow River or along the Middle or South Fork). Therefore, only wells located directly along the North Fork and Main Stem of Gold Creek were reviewed in an attempt to gain understanding about the shallow aquifer in the area. One well is located upstream from the Site and five are located downstream; the closest downgradient well is located

approximately 2.5 miles southeast of the Site on the north side of Gold Creek. The approximate location of the wells are represented as circles and shown on Figure 1. Generally these wells are shallow, less than 100 feet deep. They are cased 18 to 55 feet below ground surface (bgs). There is a cemented or hardpan zone above the water bearing zone listed on some of the well logs, which may act to semi-confine the lower aquifer. Static water levels are noted from 18 to 21 feet bgs on the driller's logs. Copies of the state well logs reviewed are located in the SI Report (CES, 2004). None of the wells were sampled during the SI field activities (CES, 2004).

The shallow geology of the Gold Creek drainage can be summarized as interbeds of sand and gravel and clay to a depth of approximately 60 feet bgs. These unconsolidated sediments are likely a result of Holocene glaciation, which deposited glacial drift along the stream channels. Weathered bedrock (stated as granite on the logs) is encountered below the unconsolidated sediments. The depth of first water is not noted on the well logs; it is assumed that shallow groundwater would be found in the sand and gravel lenses. However, the shallow water table may not be laterally extensive, as clay and boulders are usually deposited contemporaneously in a glacial environment and may truncate water bearing lenses.

None of the five adits had flowing seeps during the SI field activities. However, Adit 1, which is collapsed, had evidence that seeps may occur during high flows times of the year.

2.1.8 Hydrology

The Site is bordered on the northeast by the Gold Creek (Figure 1). According to the USGS 7½ minute quadrangle maps (USGS, 1990) of the area, the Gold Creek watershed above the Site is approximately 29,000 acres or 45 square miles (CES, 2004). Various springs and unnamed tributaries flow into Gold Creek upgradient of the Site, the largest is Foggy Dew Creek, located approximately 1 mile upstream. During wet times of the year, as noted above, it appears that a seep emanates from Adit 1, which eventually discharges into Gold Creek, just downstream of WR1. However, during the field activities, no water was flowing from the adit. Based on field observations, the flow, when it occurs, appears to be relatively low (i.e., < 10 gallons per minute).

Approximately 1 mile below the Site, the Middle Fork of Gold Creek discharges to the main stem of Gold Creek; and another mile downstream, the South Fork of Gold Creek enters. Gold Creek eventually flows into the Methow River approximately 5.5 miles below the Site. The Methow River flows south and east, for approximately 20 miles, before the confluence with the Columbia River at Lake Pateros. Figure 1 also shows the 1- and 4-mile radius circles from the Site and the confluence of Gold Creek and the Methow River.

The flow rates in Gold Creek were measured on two different dates. On July 8, 2003, the flow rate in Gold Creek, approximately 300 feet upstream of the Site, was measured at approximately 92 cubic feet per second (cfs). Additional flow rate measurements were collected on July 20, 2003, (Table 1) at each Station; flow rates ranged from approximately 77 cfs at Station GC-01 (located upstream of the Site) to 95 cfs at Station GC-04 (located downstream of the Site). For comparison, the flow rates of the Methow River measured at USGS Station 12449760 in Carlton were 3,020 cfs on July 8, 2003, and 1,650 cfs on July 20, 2003, (USGS, 2003). In addition, USGS Station 12449795 is located on Gold Creek, approximately 0.5 miles upstream of the confluence with the Methow River. However, the Station has only been used once, on September 21, 2001, to collect water quality parameters (i.e., flow rates, major cation and anions, temperature, etc.). The flow rate on September 21, 2001, was measured at 4 cfs, which indicates that the flows in Gold Creek fluctuate dramatically throughout the year. The bedload of Gold Creek consists of mainly boulders, cobbles, gravels, and sands, with minor amounts of silt and clay.

2.1.9 Surrounding Land Use

2.1.9.1 Residential, Industrial, or Commercial

The Site is designated as industrial use for comparison with the USEPA Region 9 Preliminary Remediation Goals (PRGs) and other regulatory standards. The immediate area around the Site is part of the ONF. A USFS campground, Foggy Dew Campground, is located approximately 2,000 feet northwest and upstream of the Site on Gold Creek. The nearest occupied residence is located approximately 1,600 feet southeast and downstream of the Site on Gold Creek. Five additional residences are located along Gold Creek to the confluence with the Methow River. In addition, numerous wells and surface water rights are located within the Gold Creek valley above and below the Site.

2.1.9.2 Identification of Sensitive Populations and Targets

Sensitive populations are defined as receptors that are located within a target distance for a particular pathway. The target distances for the soil and air pathway are defined as the immediate area of the Site. There are no onsite workers. Public use of the Site is minimal due to the steep slopes and limited access across Gold Creek; however, public use of the area surrounding the Site is moderate. There is one occupied structure located within a 1-mile radius of the Site and five additional residences within four miles of the Site; it is unknown if these structures are occupied year round or seasonally. Land uses in this area are limited to timber harvesting, firewood cutting, recreation (hiking, camping, hunting, etc.), and some minerals prospecting.

For the groundwater pathway, the target distance has been defined as 4-miles and example targets are drinking water wells, wellhead protection areas, etc. There are five water wells located within four miles downstream of the Site and two upstream within a four-mile radius. The nearest downgradient well is located approximately 2.5 miles southeast of the Site on the north side of Gold Creek.

The target distance for the surface water pathway, has been defined as 15-miles; because Gold Creek empties into the Methow River, only targets above the confluence are considered targets because of the high flow rate and dilution of the Methow River when compared to Gold Creek. Based on a review of the Ecology's Water Rights Tracking System, there are reportedly 17 surface water rights along Gold Creek between the Site and the Methow River (Figure 1). The rights are located by Township, Range and Section, and therefore the exact location of the point of diversion cannot be accurately determined. The quantity of the water rights varies from 0.02 cubic feet per second (cfs) to 2.11 cfs. Several water rights indicate that the surface water use is for domestic activities, as well as irrigation or water for livestock.

2.1.10 Sensitive Ecosystems

2.1.10.1 Wetlands and Wildlife Breeding Areas

Maps outlining designated wetland areas were prepared by the National Wetlands Inventory (NWI), a division of the U.S. Fish and Wildlife Service. The document was prepared primarily by analysis of high altitude aerial photographs. Wetlands were identified based on vegetation, visible hydrology, and geography in accordance with Classification of Wetlands and Deepwater Habitats of the United States (USF&W, 1979). The following are considered "listed" on the NWI map (USF&W, 1995) that could be affected by the Site:

- Adjacent to the Site is designated as Palustrine, Forested, Temporarily Flooded (PFOA);
- Downstream of the Site is designated as PFOA and Riverine, Upper Perennial, Unconsolidated Shore, Temporarily Flooded (R3USA); and
- Approximately one mile downstream from the Site and continuing to the confluence with the Methow River, Palustrine scrub shrub seasonally flooded areas (PSSC) is present.

The NWI map does not clearly outline the boundaries of riverine wetland systems. Therefore, the lateral boundaries adjacent to the stream cannot be determined without a jurisdictional wetland delineation conducted in accordance with the U.S. Army Corps of Engineers (USACE) Technical Report/Y-87-1.

According to CERCLA (40 CFR 230.5) and USACE Technical Report/Y-87-1, "wetlands are those areas that are inundated or saturated by surface or groundwater at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions." A jurisdictional wetland delineation in accordance with USACE standards was not conducted during this investigation. As such, the exact boundaries and areas of potential wetlands were not defined. Based on field observations and measurements, other areas that exhibit some wetlands characteristics (i.e., plant types) are located adjacent to Adit 1.

There are no known designated wildlife breading areas in the vicinity of the Site.

2.1.10.2 Wild and Scenic Rivers

There are no Wild and Scenic Rivers near the Site. The nearest is the Skagit River, to the west and across the Cascade Mountain Divide. Only two other Wild and Scenic Rivers are identified in Washington State, the Klickitat and the White Salmon, both on the east side of the Cascade Mountains. Neither is in a drainage that would be affected by the Site.

2.1.10.3 Threatened and Endangered Species

A complete list of rare, threatened and endangered (RTE) species, species of concern (SOC), federal and state candidate species, state sensitive species, and state monitored species for wildlife and plants observed or expected to be present at or near the Site is provided in Attachment B of Appendix A. The following outlines the federal and state RTE species and SOC that were observed or have suitable habitat in the vicinity of the Site:

- Federal and state threatened Bald Eagle and Lynx; none were observed during the SI.
- State threatened and federal SOC Ferruginous Hawk; none were observed during the SI.
- Federal threatened and state endangered Spotted Owl; none were observed during the SI.
- State threatened Western Gray Squirrel; two were observed in the riparian area on the north side of Gold Creek during the SI.
- State endangered Spotted Frog, which was observed in the vicinity of the Site during the SI.
- Federally endangered anadromous Chinook salmon and steelhead trout; none were observed during the SI.
- Federally threatened Dolly Varden/bull trout; none were observed during the SI.

2.2 Source, Nature, and Extent of Contamination

This section describes the source, nature, and extent of contamination at the Site.

2.2.1 Surface Water Pathway

Surface water bodies at or near the Site that would be affected by the Site are identified in Section 2.1.8. During the 2003 SI (CES, 2004), a total of four surface water stations were established in Gold Creek (Figure 2) to assess the impact of the Site on surface water and aquatic organisms. Surface water, pore water, and stream sediment samples were collected; one upstream to represent background concentrations, one immediately downstream, and two farther downstream of the Site. Surface water station locations are depicted on Figure 1 and laboratory results are tabulated in Table 1, 2, and 3.

2.2.1.1 Surface Water

The following is a summary of the findings; surface water concentrations are reported as total recoverable metals.

- Two metals, arsenic and barium, were detected at concentrations exceeding the lowest regulatory comparison standard in all samples. Only arsenic was detected at concentrations higher than the upstream background sample and is therefore the only metal of concern in surface water.
- The highest concentration of arsenic in surface water (0.489 micrograms per liter [μg/L]) was detected at GC-SW-03, which is located 0.75 miles downstream from the Site on the north side of Gold Creek, and below the four nearest water right locations.
- Total arsenic in all samples exceeded the State of Washington and USEPA Ambient Water Quality Criteria (AWQC) for Protection of Human Health of 0.018 μg/L. However, no forms of arsenic (total, III, and V) exceeded any of the identified aquatic and ecological standards.

2.2.1.2 Pore Water

The following is a summary of the findings; pore water concentrations are reported as dissolved metals.

- Five metals (arsenic V, barium, iron, manganese, and silver) were detected at concentrations exceeding the lowest applicable regulatory standards and background concentrations and are, therefore, the only metals of concern in pore water.
  - The lowest applicable regulatory standard for arsenic V (3.1 μg/L) was exceeded in two downstream samples (GC-PW-2 = 4.04 μg/L and GC-PW-3 = 7.30 μg/L); these concentrations are approximately an order of magnitude higher than the background concentration of 0.36 μg/L.
  - Two samples, GC-PW-2 and GC-PW-3 (16 and 15 μg/L, respectively), exceeded the background concentration of 9 μg/L and the lowest regulatory standard of 4 μg/L for barium.
  - Only one sample, GC-PW-2 = 800 μg/L, exceeded the lowest regulatory standard of 158 μg/L for iron.
  - Only one sample, GC-PW-2 =294 μg/L, exceeded the lowest regulatory standard of 120 μg/L for manganese.
  - Pore water concentrations of silver is one sample (GC-PW-3 = 1.3 μg/L) exceeded background (<0.05 μg/L) and the lowest regulatory standard of 0.36 μg/L.
  - With the exception of silver, the highest metal concentrations in pore water were detected at Station GC-02, which is closest to the Site.
- At the farthest downstream Station (GC-04) all metal concentrations were similar to the background metal concentrations at Station GC-01. Barium was the only metal to exceed the lowest regulatory standard at Station 04 with a result that was equal to the background concentration of 9 μg/L.

2.2.1.3 Stream Sediment

The following is a summary of the findings; stream sediment concentrations are reported as total metals.

- Arsenic (both total and inorganic) was the only metal that exceeded any comparison standard and is, therefore, the only metal of concern in stream sediment. However, no sediment comparison standards have been established for the other forms of arsenic (III and V).
- Total arsenic concentrations ranged from 4.7 milligrams per kilogram (mg/kg) at GC-SS-1 to 16.3 mg/kg at GC-SS-4. Concentrations from all samples collected downstream from the Site exceeded the USEPA Freshwater Threshold Effects Level (TEL) and Washington's lowest proposed Sediment Quality Value (SQV), both at 5.9 mg/kg.

- Inorganic arsenic concentrations ranged from 1.688 mg/kg at GC-SS-1 to 7.612 mg/kg at GC-SS-2. Two samples collected downstream of the Site (GC-SS-2 and GC-SS-3) exceeded the USEPA Freshwater TEL and the lowest Washington proposed SQV of 5.9 mg/kg.

2.2.1.4 Surface Water Pathway Summary

Based on the data gathered and presented above, the surface water pathway is complete. Offsite migration of metals into Gold Creek is occurring at the Site; the main metal of concern for the surface water pathway is arsenic. Wasterock piles at the Site are most likely contributing the largest amount of metals to the surface water pathway because of overland sheet-flow runoff to Gold Creek during spring snowmelt and heavy rainstorms. However, analytical results from Station GC-04 indicate that dispersion/settling is occurring in Gold Creek, as most metal concentrations decrease with distance from the Site and are near background concentrations.

2.2.2 Groundwater Pathway

As outlined in Section 2.1.7, there are five wells located downgradient of the Site (Figure 1). The closest well is located 2.5 miles southeast of the Site on the north side of Gold Creek; the remaining four wells are located farther downstream also on the north side of Gold Creek. CES believes that it is unlikely that the wells would be affected by groundwater migrating from the Site, based on the following:

- The groundwater gradient in terrain such as the Gold Creek valley would most likely be related to the topography and the regional flow direction. In this case, groundwater migrating from the Site would flow in the same direction as the flow direction of Gold Creek with an eastward component resulting from the local topography, which dips to the southeast.
- Gold Creek would act as a hydraulic barrier to shallow groundwater migration across the valley. Groundwater encountering the low point in the valley (i.e., stream bed) during winter or spring would flow from either side into the stream (gaining stream). During dry periods, the stream may lose water to the groundwater table, in which case groundwater would flow away from the stream on either side. In both cases, the stream would act as a focus of groundwater flow, which would prevent groundwater on one side of the stream to migrate under the stream to the other side of the valley.
- Based on this information, the groundwater pathway is incomplete.

2.2.3 Air Pathway

The most likely air exposure pathway is inhalation of dust or particulate matter. However, most of the particulate matter in the air originates from the wasterock piles currently at the Site. Given this, and the remote location and limited use of the Site, the air pathway will be assessed under the soil pathway and no further assessment into Site-specific levels of compounds in the air is recommended.

2.2.4 Soil Pathway

The following sections summarize the background soil, wasterock, and plant tissue analytical results for the Site. A total of 3 background soil samples, 15 wasterock samples, and 6 vegetation samples (3 co-located with background soil samples and 3 co-located with wasterock samples) were collected around the Site. Due to the density and size of the wasterock, CES was only able to penetrate the wasterock piles at depths of 2 feet bgs or less. Sample locations for soils, wasterock, and tissue samples are shown on Figure 2. Analytical results for background soils are tabulated in Table 4; wasterock metal/pH results are in Table 5; toxicity characteristic leaching procedure (TCLP) and synthetic precipitation leaching procedure (SPLP) results are in Table 6; and plant tissue results are in Table 7.

2.2.4.1 Background Soil pH and Metal Results

Background soil paste pH ranged from 5.8 to 6.7 standard units (su) indicating slightly acidic soils. Background soils exhibit high levels of arsenic (all forms) exceeding the Oak Ridge National Laboratories (ORNL) PRG for soil of 9.9 mg/kg and USEPA Region IX Industrial PRG of 1.6 mg/kg (cancer endpoint) and 260 mg/kg (non-cancer endpoint). The concentration of cadmium exceeds the Washington - Method A Industrial Soil Cleanup Levels for Human Receptors of 2.0 mg/kg. In addition, concentrations of antimony, barium, chromium, cobalt, copper, lead, and vanadium exceed the ORNL PRGs for soil ecological receptors.

2.2.4.2 Wasterock pH and Metal Results

Wasterock paste pH ranged from 4.9 to 7.9 su indicating, which indicates the wasterock varies from slightly acidic to slightly alkaline. Antimony, arsenic, and cadmium exceeded the USEPA Region IX Industrial PRGs. Arsenic and cadmium were at concentrations that exceed the Washington Method A Industrial Cleanup Level of 20 mg/kg and 2 mg/kg, respectively. Aluminum, antimony, arsenic III and V, barium, cadmium, cobalt, copper, lead, manganese, nickel, selenium, silver, vanadium, and zinc were at concentrations that exceeded the lowest Washington Ecological Indicator Soil Concentrations, which exist for plants, soil biota, and wildlife receptors. Antimony, arsenic, chromium, copper, and zinc concentrations exceeded the lowest USEPA Ecological Soil Screening Levels, which were developed for plants, invertebrates, birds, and mammals for only 7 of the 23 metals. ORNL soil PRGs were exceeded for the following metals: antimony, arsenic, cadmium, chromium, cobalt, copper, lead, mercury, nickel, selenium, silver, vanadium, and zinc. The soil sample collected adjacent to the suspected Powderhouse exhibited a nitrate concentration of <0.5 mg/kg and sulfate of 17 mg/kg. These concentrations do not suggest that fertilizer based explosive residues are present in the soil adjacent to the suspected Powderhouse building. However, these analyses cannot rule other explosives (i.e., trinitrotoluene) that were used during this era.

2.2.4.3 Wasterock Acid Based Accounting and Sulfur Results

Ten wasterock samples were analyzed for static acid base accounting (ABA) using the Modified Sobek Method to evaluate the acid generating potential (AGP) and acid neutralization potential (ANP). The acid base potential (ABP) of the wasterock ranged from -28 to 505 t $CaCO_3$/Kt (ABP units are presented as tons of calcium carbonate needed to neutralize a kiloton of waste). ABP is the result of the ANP minus the AGP; a negative ABP indicates that the AGP is greater than the ANP. With the exception of AQ-WR1-6, the wasterock at the Site does not exhibit potential to produce acid rock drainage (ARD). AQ-WR1-6 also exhibited the highest total sulfur content at 1.09%, while the rest of the samples had less than 0.2% total sulfur.

2.2.4.4 Wasterock SPLP and TCLP Results

Ten wasterock samples were submitted for SPLP analyses for the eight Resource Conservation Recovery Act (RCRA) metals and eight wasterock samples were submitted for TCLP analysis for the eight RCRA metals. There are no applicable standards for SPLP; however, the results can be compared to RCRA TCLP disposal limits. None of the samples had SPLP or TCLP results in excess of the TCLP standard.

2.2.4.5 Plant Tissue Metal Results

Results indicate that antimony, arsenic, iron, and potassium plant tissue concentrations were generally higher in vegetation growing on waste piles when compared to background. All other metals in plant tissue growing on wasterock were similar or lower than the plant tissue samples collected from background locations. Arsenic concentrations in plant tissue samples collected from waste piles ranged up to ten times higher than the concentrations measured in tissue samples collected from background locations.

Vegetation on the waste piles and in the vicinity of the Site is sparse and there is a sufficient amount of available undisturbed forage area around the Site. Therefore, the risk posed to grazing wildlife (i.e., cattle, deer, elk, and sheep) is considered low. Furthermore, the lack of vegetation on the wasterock piles is most likely due to the lack of nutrients, organic material, and water. Because of the elevated concentrations of arsenic in plant tissue, and the fact that ecological receptors may feed on vegetation at the Site, a minor potential exists that ecological receptors could be affected.

2.2.4.6 Soil Pathway Summary

Metal concentrations in background soils are elevated; 11 metals are present at concentrations exceeding one or more comparison standard. Antimony and arsenic concentrations detected above several comparison standards have been identified in both background soils and wasterock at the Site. All samples collected from the wasterock exceeded the USEPA Industrial PRG for arsenic, and nine out of ten samples exceed the USEPA Industrial PRG for antimony. The following metals were detected in wasterock at concentrations exceeding both the mean background soil value and one or more comparison standard: antimony, arsenic (all forms), barium, cadmium, copper, lead, manganese, mercury, nickel, silver, and zinc. The soil exposure pathway is considered complete for both human and ecological receptors, and a release of hazardous substances has been documented in the SI (CES, 2004). The volume of wasterock piles was estimated by measuring the base of the pile, height, and slopes of sides and with the use of AutoCAD. Based on these calculations WR1 is estimated at 925 cy and WR2 is estimated at 650 cy.

3.0 STREAMLINED RISK EVALUATION AND ASSESSMENT

3.1 Streamlined Human Health Risk Assessment

The Human Health Risk Assessment (HHRA) evaluated the potential for adverse health effects that could result from current or future human exposures to hazardous substances present at the Site. Chemicals of potential concern (COPCs) were selected by screening contaminants of interest (COIs) using approved human health risk-based screening procedures; exposure doses were then calculated for each COPC and receptor. The exposure doses were then compared to acceptable doses of the COPCs using approved screening numbers to determine the potential risk or hazard associated with the COPCs. The following are the primary elements of the HHRA.

- Hazard Identification and Selection of COPCs
- Exposure Assessment
- Toxicity Assessment
- Risk Characterization
- Summary of Human Health Risks

The following sections briefly summarize the estimated human health risks and hazards. A more detailed discussion of the HHRA is provided in Appendix A.

3.1.1 Potential Receptors and Exposure Pathways

Due to the remote nature and difficult access conditions, long-term risk associated with the Site is considered low. However, recreational receptors (hikers, hunters, and campers) still have the potential to access the Site and were selected as the most likely current and future receptor. Complete exposure pathways were evaluated for the recreational receptor and included:

- Inhalation of wasterock particulates;
- Incidental ingestion of wasterock, surface water, and sediment; and
- Dermal contact with wasterock, surface water, and sediment.

Use of groundwater as potential drinking water was eliminated as a pathway of concern because the closest reported drinking water well is located approximately 2.5 miles downgradient from the Site, on the north side of Gold Creek. Fish consumption was also eliminated as a potential pathway of concern because of the following: 1) the number fish in Gold Creek is too small to support a recreational fisher scenario, and 2) Gold Creek is currently closed to all fishing from the confluence with Foggy Dew Creek (~0.5 miles upstream from the Site) to the mouth.

3.1.2 Hazard Identification and Selection of COPCS

The media of interest for human health included surface soil/wasterock, surface water, and sediment. Maximum concentrations of the COIs in these media were compared to USEPA Region IX PRGs. Industrial PRGs The following table lists the results of the COPCs screening.

Contaminants of Potential Concern for the Human Health Exposure Media

COPCs	Surface Soil/ Wasterock	Surface Water	Sediment
Antimony	X		
Arsenic	X	X	X

3.1.3 Risk and Hazard Estimates for the Recreational Receptor

The results of the quantitative risk assessment are summarized in this section. Calculations, assumptions, and exposure inputs are available in Appendix A. Risks and hazards were calculated for both the central tendency exposure (CTE) and reasonable maximum exposure (RME). In general, the RME scenario is a conservative or worst-case estimate of potential exposure, while the CTE scenario is typically more realistic and uses exposure factors that are more indicative of the average recreational user. The Hazard Quotient (HQ) is defined as a comparison of the estimated intake dose of a metal with the reference dose or concentration, expressed as a ratio. HQs greater than 1.0 indicate the potential for adverse health effects because the intake exceeds the reference dose. The sum of all individual chemical-specific HQs is termed the Hazard Index (HI) and is calculated under each exposure pathway. Thus, an HI less than 1.0 is not anticipated to produce unacceptable human health effects. The excess cancer risk (ECR) is defined as the incidence of cancer over and above known background (one case for every three people). The standard of one in one million (1E-06) sets the allowable "excess" cancer cases at one more case in a population of one million people. The following sections provide a brief summary of the non-carcinogenic and carcinogenic.

3.1.3.1 Non-carcinogenic Risk Results

Arsenic was identified as a non-carcinogenic COPC in soil, wasterock, surface water, and sediment; antimony was only identified as a non-carcinogenic COPC in soil and wasterock. A summary of the non-carcinogenic hazards are presented below.

Summary of Non-Carcinogenic Hazards

EXPOSURE ROUTE	COPC	HAZARD QUOTIENT	
		CTE	RME
Soil and Wasterock			
Ingestion	Antimony	5E-02	2E-01
	Arsenic	6E-01	2E+00
Dermal Contact	Antimony	2E-03	1E-02
	Arsenic	7E-02	5E-01
Surface Water			
Ingestion	Arsenic	3E-04	5E-04
Dermal Contact	Arsenic	2E-06	7E-06
Sediment			
Ingestion	Arsenic	4E-04	3E-03
Dermal Contact	Arsenic	8E-08	2E-06
HAZARD INDEX		**7E-01**	**3E+00**

For the soil/wasterock exposure route, the only HQ greater than 1.0 was the RME receptor for the ingestion of arsenic. The HQs for the surface water and sediment exposure routes were all below the regulatory standard of 1.0. Although the HI for the RME receptor is greater than 1.0, exposure to antimony did not result in any unacceptable health impacts because the HQs for antimony were below the regulatory standard of 1.0. However, non-carcinogenic hazards were predicted for the worst case exposure scenario (RME) from ingestion of arsenic-impacted soil and wasterock.

3.1.3.2 Carcinogenic Risk Results

Arsenic was identified as the only carcinogenic COPC at the Site; carcinogenic risks are summarized in the following table.

Summary of Carcinogenic Risks

EXPOSURE ROUTE	COPC	EXCESS CANCER RISK	
		CTE	RME
Soil and Wasterock			
Ingestion	Arsenic	1E-05	1E-04
Dermal Contact	Arsenic	2E-06	7E-05
Inhalation of Particles	Arsenic	4E-08	8E-07
Surface Water			
Ingestion	Arsenic	5E-09	4E-08
Dermal Contact	Arsenic	7E-11	1E-09
Sediment			
Ingestion	Arsenic	2E-08	1E-07
Dermal Contact	Arsenic	4E-12	4E-10
SUM OF EXCESS CANCER RISK		**1E-05**	**2E-04**

Ingestion and dermal contact of arsenic contaminated soil were the critical pathways. Arsenic concentrations in surface water and sediment did not pose an unacceptable ECR; nor did the inhalation of soil/wasterock particulates. However, ECRs for the CTE and RME receptors exceeded Ecology's regulatory standard of 1E-06, but did not exceed USEPA's acceptable risk range of 1E-06 to 1E-04.

3.1.4 Human Health Risk Evaluation Summary

Only antimony and arsenic were identified as COPCs at the Site. Based on current and future land use, individuals who might come in contact with Site-related contaminants through recreational activities (i.e., hunting, hiking, and camping) were identified as the only potential receptors.

The risk assessment determined that there were no unacceptable non-carcinogenic health effects expected from exposure to antimony in soil and wasterock, or from exposure to arsenic in surface water or sediment. Potential non-carcinogenic health effects from ingestion of arsenic in soil and wasterock were predicted for the RME (worst case) scenario.

Arsenic was the only carcinogenic COPCs identified at the Site. The HHRA determined that no unacceptable ECRs are expected from exposure to arsenic in surface water or sediment, or from inhalation of arsenic contaminated soil particles. However, ECRs from ingestion/dermal contact with soil and wasterock exceeded Ecology's regulatory standard of 1E-06, but were within the acceptable USEPA risk range of 1E-06 to 1E-04.

A screening level HHRA uses very conservative exposure assessments and assumptions. Based on the Site topography and isolated location within the ONF, it is highly unlikely that recreational users would engage in activities at the Site that could result in significant ingestion or dermal contact with wasterock. As outlined above, ingestion and dermal contact are the only two pathways of exposure that pose potential non-carcinogenic and carcinogenic risks. The most realistic and likely pathway of exposure at the Site is inhalation of particulates by recreational users (hikers, hunters, or trespassers). The HHRA determined that the inhalation pathway did not result in unacceptable non-carcinogenic or carcinogenic risks. Therefore, additional investigations or cleanup of the Site is not warranted for human health.

3.2 Streamlined Ecological Risk Assessment

The goal of the ecological risk assessment (ERA) is to determine whether there is an unacceptable ecological risk associated with the Site. This report, which is presented in Appendix A, consists of:

- Problem Formulation
- Risk-Based Screening
- Risk Characterization
- Uncertainty Analysis
- Summary of Ecological Risk

An ecological survey was conducted as part of a previously completed SI (CES 2003). The SI report documented ecological features and conditions at and near the Site. An Ecology terrestrial ecological exclusion (TEE) assessment was completed based on this survey, and is provided in Appendix A. Based on the TEE assessment, an exclusion from further terrestrial ecological evaluation is not acceptable. Based on Ecology guidance (2001), a site-specific terrestrial ERA is warranted. Ecology does not provide specific guidance for an ERA of water or freshwater sediment. Therefore, methods appropriate for Ecology (2001) and the USEPA (1997, 1999) were implemented to assess the potential for risks to be posed by Site-related COIs in soil (terrestrial receptors), surface water (aquatic receptors), pore water (aquatic receptors), and sediment (benthic receptors). This includes completing a problem formulation, risk-based screening, and risk characterization.

Appendix A presented the problem formulation, risk assessment data, ecological risk-based screening, risk characterization, uncertainty analysis, conclusions, and recommendations. The problem formulation determines the scope of the ERA and culminates in a conceptual ecological exposure model and assessment endpoints. The assessment endpoints tie the risk assessment results to risk management decisions and present the focus of the remainder of the ERA. The analytical data that were used for the ERA are briefly

described, and a risk-based screening is conducted, comparing the site data to ecological risk-based screening concentrations. The results of the risk-based screening are discussed along with the uncertainties inherent in the ERA process and, finally, conclusions and recommendations are provided regarding the potential for ecological risks to be posed by site-related chemicals and whether further investigation or remediation is warranted for the protection of ecological receptors.

3.2.1 Ecological Risk-Based Screening

Ecological risk-based screening begins with the list of COIs shown in Appendix A. Exposure point concentrations (EPCs) are then determined for each COI in each potential exposure medium, and compared to selected ecological risk based screening concentrations (ERBSCs) with consideration of bioaccumulation potential and exposures to multiple chemicals and multiple media. Risk ratios greater than 1 indicate a potential risk; COIs which potential ecological risks are indicated become the contaminants of potential ecological concern (COPECs). The results of the risk-based screening are provided in Tables 4-2 through 4-5 in Appendix A. The COPECs identified for the Site are outlined in the following table.

Selected Contaminants of Potential Ecological Concern

Chemicals of Interest	Surface Soil/ Wasterock	Surface Water	Pore Water	Sediment
Aluminum		No COPECs		X[1]
Antimony	X		X[1]	
Arsenic III	X			
Arsenic V	X			X
Arsenic, total	X			
Barium	X		X	X[1]
Cadmium				X
Cobalt	X[1]			
Copper	X			
Iron	X		X[1]	X[1]
Lead	X			
Manganese	X		X	X[1]
Mercury	X			
Nickel				X[2]
Selenium	X			X[1,3]
Silver	X		X	
Thallium	X[1]			
Vanadium				X[1]
Zinc	X			X

1 – Selected as COPEC because no ERBSC was available.
2 – Selected as COPEC because of inordinate contribution to overall risk.
3 – Selected as COPEC because of elevated reporting limits.

3.2.2 Ecological Risk Assessment Summary

Elevated concentrations of COPECs are present in all of soil/wasterock samples collected from the Site. It is likely that plants and invertebrates are affected within these localized areas, and vegetation within the wasterock piles appears to be bioaccumulating antimony and total arsenic. Given the highest risk ratios and most widespread distribution, antimony, arsenic (V, and total), iron, and manganese are the COPECs most likely to pose unacceptable risks in soil/wasterock. However, while the plants and invertebrates within the wasterock piles are predicted to be at risk, the populations are unlikely to be significantly affected within the vicinity of the Site because of the very limited area of potential exposure. In addition, the habitat lost due to any effects on plants is also unlikely to result in significant effects to upper trophic level species due to the large amount of relatively undisturbed habitat available surrounding the Site. Some upper trophic level species were predicted to be at risk due to COPECs in soil/wasterock. However, given the relatively large

home ranges of the species in proximity to the Site, and the presence of a large amount of nearby suitable uncontaminated habitat, significant effects to these species seem unlikely.

Given the proximity to Gold Creek, the wasterock piles are likely past and current source areas for chemicals to be transported to Gold Creek. However, ecological impacts were not predicted for COIs in surface water. Thus, this transport of COPECS from soil/wasterock to surface water appears insignificant.

In pore water, silver at GC-03 was the only COPEC predicted to present potentially ecological impacts. Ecological impacts due to COPECs in sediment are likely low given the predominantly low risk ratios and limited chemical distribution.

Based on the information presented in the ERA, significant ecological risks are not expected. Therefore, additional investigations or cleanup of Site is not warranted for the Site.

4.0 SITE CLEANUP CRITERIA

4.1 Applicable or Relevant and Appropriate Requirements

Federal, state, and local applicable or relevant and appropriate requirements (ARARs) are used to: 1) evaluate the extent of cleanup needed at the Site; 2) scope and develop removal action alternatives; and 3) guide the implementation and operation of the preferred alternative. The NCP (40 CFR 300.415(j)) establishes that removal action shall "to the extent practicable, considering the exigencies of the situation, attain applicable or relevant and appropriate requirements under federal or state environmental facility siting laws." To determine whether compliance with ARARs is practicable, two factors are specified in 40 CFR 415(j); the urgency and scope of the removal action. The scope of the removal action is often directed at minimizing and mitigating potential hazard rather than totally eliminating the hazard. Therefore, even though a particular standard may be an ARAR for a particular medium, it may be outside the scope of the immediate problem. For example, removal of a contaminant source that may improve groundwater or surface water quality, but not meet water quality criteria, thus not meeting the ARARs due to residual contamination.

ARARs are grouped as Federal or State of Washington ARARs; no specific local ARARs were identified (Appendix B). They are identified by a statutory or regulatory citation, followed by a brief explanation of the ARAR, and whether the ARAR is applicable, or relevant and appropriate. Administrative requirements are not ARARs and thus do not apply to actions conducted entirely onsite. Administrative requirements are those that involve consultation, issuance of permits, documentation, reporting, record keeping, and enforcement. The CERCLA program has its own set of administrative procedures, which assure proper implementation of CERCLA. In accordance with Section 121(e) of CERCLA, no permits are required for the removal action.

ARARs are chemical, location, or action specific:

- **Chemical Specific**. These requirements address chemical or physical characteristics of compounds or substances on sites. These values establish acceptable amounts or concentrations of chemicals, which may be found in or discharged to the ambient environment.
- **Location Specific**. These requirements are restrictions placed upon the concentrations of hazardous substances or the conduct of cleanup activities because they are in specific locations. Location specific ARARs relate to the geographical or physical positions of sites, rather than to the nature of contaminants at sites.
- **Action Specific**. These requirements are usually technology based or activity based requirements or limitations on actions taken with respect to hazardous substances, pollutants, or contaminants. A given cleanup activity will trigger an action specific requirement. Such requirements do not themselves determine the cleanup alternative, but define how chosen cleanup methods should be performed.

4.2 ARAR-Based PRGS

ARARs-based PRGS are not applicable because site-specific human and ecological risk assessments were completed.

4.3 Risk-Based PRGS

Human health risks (carcinogenic) and hazards (non-carcinogenic) were predicted from ingestion and dermal contact with arsenic in wasterock under the RME recreational exposure scenario. The HHRA used very conservative exposure assessments and assumptions. Based on the Site topography and isolated location within the ONF, it is highly unlikely that recreational users would engage in activities at the Site that could result in significant ingestion or dermal contact with wasterock. The most realistic and likely pathway of exposure at the Site is inhalation of particulates by hikers, hunters, or trespassers. The quantitative risk assessment determined that the inhalation pathway did not result in unacceptable non-carcinogenic or carcinogenic risks. Therefore, risk-based PRGs for human receptors were not developed.

As outlined in the ecological risk assessment, the ERBSC's used in the assessment would be overprotective of ecological receptors. Furthermore, population level effects could only occur for ecological species if the receptors were to forage predominantly at the Site. Considering localized and small exposure areas, this is unlikely. In addition, the habitat lost due to any effects on plants is also unlikely to result in significant effects to upper trophic level species due to the large amount of relatively undisturbed habitats available surrounding the Site. Based on this, risk-based PRGs for ecological receptors were not developed.

5.0 IDENTIFICATION OF REMOVAL ACTION OBJECTIVES

5.1 Removal Action Justification

The NCP states that an appropriate removal action may be conducted when a threat to human health or welfare or the environment is identified. The removal action is undertaken to abate, prevent, minimize, stabilize, mitigate, or eliminate the release or the threat of a release at a site. Section 300.415(b)(2) of the NCP outlines eight factors to be considered when determining the appropriateness of a removal action. The applicable factors are outlined below and provide justification for completing the removal action.

- "Actual or potential exposure to nearby human populations, animals, or the food chain from hazardous substances or pollutants or contaminants."
  - Complete exposure pathways to human (recreational) and ecological receptors (aquatic) have been documented during the risk assessment from exposure to wasterock, soil, and sediment. However, risks to human and ecological receptors are considered unlikely given the remote location.
- "Actual or potential contamination of drinking water supplies or sensitive ecosystems."
  - Drinking water supplies and sensitive ecosystems (e.g., wetlands) have been identified within four miles of the Site. However, because 1) the groundwater pathway was determined to be incomplete, 2) no risks were predicted from human exposure to surface water, and 3) ecological risks from exposure to surface water was determined to be unlikely, the drinking water supplies and sensitive ecosystems do not appear to be affected by the Site.
- "High levels of hazardous substances or pollutants or contaminants in soils largely at or near the surface that may migrate."
  - Surficial wasterock is contaminated with metals at the Site. The wasterock piles are situated adjacent to Gold Creek and minor erosion of wasterock into Gold Creek has been documented at the Site. However, the risk assessment determined that human and ecological receptors are unlikely to be affected by exposure to Gold Creek surface water and sediment.

- "Other situations or factors that may pose threats to public health or welfare of the United States or the environment."
  - The Site is located in the ONF, along a maintained county road where Site access is readily available to the public on the north side of Gold Creek. However, the Site is situated on the steep slopes of the south bank of Gold Creek and access to the Site is difficult because of the high flows of Gold Creek.

5.2 Removal Action Scope, Goals, and Objectives

The scope of the removal action is to achieve closure of the Site, while attaining ARARs to the extent practicable.

The goal of the removal action for the Site is to achieve final cleanup of Site-related materials to acceptable levels of risk to humans and the environment.

Since the evaluation in this EECA indicates that the scope and goal of the removal action are met because unacceptable human and ecological risks and hazards are not expected for the Site, no objectives for the removal action were developed and a detailed analysis of removal action alternatives was not performed.

6.0 CONCLUSION

No removal action is recommended at the Site because unacceptable human and ecological risks and hazards are not expected for the Site.

USFS Disclaimer: This abandoned mine/mill site was created under the General Mining Law of 1872 and is located solely on National Forest System (NFS) lands administered by the USDA Forest Service. The Forest Service has conducted a PRP search relating to this site and has been unable to identify any current claimants or viable PRPs at this time. The United States has taken the position and courts have held that the United States is not liable as an "owner" under CERCLA Section 107 for mine contamination left behind on NFS lands by miners operating under the 1872 Mining Law. Therefore, USDA Forest Service believes that this site should not be considered a "federal facility" within the meaning of CERCLA Section 120 and should not be listed on the Federal Agency Hazardous Waste Compliance Docket. Instead, this site should be included on USEPA's CERCLIS database. Consistent with the June 24, 2003 OECA/FFEO "Policy on Listing Mixed Ownership Mine or Mill Sites Created as a Result of the General Mining Law of 1872 on the Federal Agency Hazardous Waste Compliance Docket," we respectfully request that the USEPA Regional Docket Coordinator consult with the Forest Service and EPA Headquarters before making a determination to include this site on the Federal Agency Hazardous Waste Compliance Docket.

Prepared by:

CASCADE EARTH SCIENCES

Dustin G. Wasley, PE
Managing Engineer II

CASCADE EARTH SCIENCES

John D. Martin, RG
Principal Geologist

Reviewed by:

CASCADE EARTH SCIENCES

Robert H. Lambeth, PE
Senior Engineer

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TABLES

Table 1. **Surface Water Analytical Results**
Table 2. **Pore Water Analytical Results**
Table 3. **Sediment Analytical Results**
Table 4. **Background Soil Analytical Results**
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Table 7. **Plant Tissue Analytical Results**

Table 1. Surface Water Analytical Results
Antimony Queen Mine EECA, Okanogan National Forest, Okanogan County, Washington

Sample I.D. / Station No.	Sample Date	Pool (P) or Riffle (R)	Aluminum, TR	Antimony, TR	Arsenic III, Total	Arsenic V, Total	Arsenic, Total	Barium, TR	Beryllium, TR	Cadmium, TR	Calcium, TR	Chromium III, Total	Chromium VI, Total	Chromium, TR	Cobalt, TR	Copper, TR	Iron, TR	Lead, TR	Magnesium, TR	Manganese, TR	Mercury, Total	Nickel, TR	Potassium, TR	Selenium, TR	Silver, TR	Sodium, TR	Thallium, TR	Vanadium, TR	Zinc, TR
			Results in ug/L																										
GC-SW-1	7/10/2003	P	70B	<0.2	0.065	0.257	**0.322**	**11**	*<2*	<0.1	8,900	<5	*<5*	<10	<10	*<10*	<10	<0.1	1,800	<5	0.000732	<10	900B	*<2*	<0.05	1,600	<0.05	<5	20B
GC-SW-2	7/10/2003	P	<30	<0.2	0.063	0.323	**0.386**	**11**	*<2*	<0.1	9,000	<5	*<5*	<10	<10	*<10*	<10	<0.1	1,900	<5	0.000829	<10	700B	*<2*	<0.05	1,700	<0.05	<5	20B
GC-SW-3	7/9/2003	P	<30	<0.2	0.041	0.448	**0.489**	**10**	*<2*	<0.1	8,700	<5	*<5*	<10	<10	*<10*	<10	<0.1	1,800	<5	0.000716	<10	800B	*<2*	<0.05	1,700	<0.05	<5	10B
GC-SW-4	7/9/2003	P	<30	<0.2	0.084	0.333	**0.417**	**11**	*<2*	<0.1	8,800	<5	*<5*	<10	<10	*<10*	<10	<0.1	1,800	<5	0.000731	<10	800B	*<2*	<0.05	1,700	<0.05	<5	10B
Standards, corrected for hardness where applicable (used 30 mg/L as hardness average for Gold Creek samples)																													
Washington - Human Health [1]			NS	14	NS	NS	0.018	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	0.14	610	NS	170	NS	NS	1.7	NS	NS
Washington - Aquatic Life [2]			NS	NS	NS	NS	190	NS	NS	0.42	NS	66	10	NS	NS	4.1	NS	0.66	NS	NS	0.012	56.8	NS	5	NS	NS	NS	NS	38
EPA - Aquatic Life [3]			87	NS	NS	NS	150	4	0.66	0.11	NS	27.6	11	NS	23	3.2	1000	0.66	NS	120	0.77	18.8	NS	5	0.36	NS	12.00	20	42.6
EPA - Human Health [4]			NS	5.6	NS	NS	0.018	1000	4	5	NS	NS	NS	100	NS	1,300	300	15	NS	50	50	610	NS	170	NS	NS	1.7	NS	7,400
ORNL - Aquatic Life [5]			87	30	190	3.1	NS	4	0.66	0.15	116,000	44	2	NS	23	0.23	158	0.66	82,000	120	0.23	160	53,000	0.39	0.36	680,000	9	20	30

Sample I.D. / Station No.	Sample Date	Pool (P) or Riffle (R)	Flow Rate (7/20/03) in cubic feet per second	Cyanide, Total	Cyanide WAD	Temperature (Field)	pH (Lab)	pH (Field)	Conductivity @ 25C (Lab)	Conductivity (Field)	Dissolved Oxygen (Field)	Turbidity (Field)	Oxygen Reduction Potential (Field)	Hardness as CaCO3	Total Dissolved Solids (Field)	Residue, Filterable (TDS) @180	Residue, Non- Filterable (TSS) @105 C	Residue, Volatile (Filterable) @ 550 C	Total Organic Carbon	Sulfate
			cfs	mg/L		°C	su		uS		mg/L	NTU	mV	mg/L						
GC-SW-1	7/10/2003	P	NM	<0.01	<0.01	11.21	7.3	7.84	66	52	18.05	145	232	30	30	40	<5	<10	4B	<10
GC-SW-1	7/10/2003	R	77	NC	NC	11.22	NC	7.63	NC	52	16.8	153	256	NC	30	NC	NC	NC	NC	NC
GC-SW-2	7/10/2003	P	NM	<0.01	<0.01	10.82	7.3	7.38	74	52	14.5	93	61	30	30	50	<5	10B	3B	<10
GC-SW-2	7/10/2003	R	78	NC	NC	10/69	NC	7.42	NC	52	16.6	159	94	NC	30	NC	NC	NC	NC	NC
GC-SW-3	7/9/2003	P	NM	<0.01	<0.01	11.3	7.3	7.92	69	50	15.2	102	272	29	30	40	<5	10B	3B	<10
GC-SW-3	7/9/2003	R	89	NC	NC	11.26	NC	7.6	NC	50	13.8	145	275	NC	30	NC	NC	NC	NC	NC
GC-SW-4	7/9/2003	P	NM	<0.01	<0.01	9.91	7.2	7.8	64	51	14.36	92	234	29	30	40	<5	8B	3B	<10
GC-SW-4	7/9/2003	R	95	NC	NC	9.92	NC	8	NC	52	14.76	120	240	NC	30	NC	NC	NC	NC	NC

NOTES:
Analysis was conducted by ACZ Laboratories, Inc. in Steamboat Springs, CO.
TR = Total Recoverable Metals, Chromium III was calculated by subtracting Chromium VI from Total Chromium
mg/L = milligrams per liter
ug/L = micrograms per liter
su = standard units
uS = micro siemans
< value = analyte not detected above method detection limit (MDL)
B = analyte detected between method detection limit (MDL) and practical quantification limit (PQL)
NS = No Standard
Bolded values indicate that the value exceeds one or more standard
Italic values indicate that the MDL exceeds the lowest standard
NM - Not Measured
NC - Not Collected

STANDARD NOTES:
1 - State of Washington ambient water quality criteria for protection of human health (DOE, 2001)
2 - State of Washington chronic ambient water quality criteria for protection of aquatic life (DOE, 2001)
3 - EPA recommended chronic ambient water quality criteria for freshwater aquatic life used (EPA, 2002).
If none existed, used Tier II secondary chronic values (ORNL, 1996)
4 - EPA recommended ambient water quality criteria for protection of human consumption of water and fish (EPA, 2002)
5 - ORNL ecological screening level values for freshwater, lowest chronic value used (ORNL, 1996).

Table 2. Pore Water Analytical Results
Antimony Queen Mine EECA, Okanogan National Forest, Washington

Sample I.D. / Station No.	Sample Date	Pool (P) or Riffle (R)	Aluminum, Diss.	Antimony, Diss.	Arsenic III, Diss.	Arsenic V, Diss.	Arsenic Diss.	Barium, Diss.	Beryllium, Diss.	Cadmium, Diss.	Calcium, Diss.	Chromium III, Diss.	Chromium VI, Diss.	Chromium, Diss.	Cobalt, Diss.	Copper, Diss.	Iron, Diss.	Lead, Diss.	Magnesium, Diss.	Manganese, Diss.	Mercury, Diss.	Nickel, Diss.	Potassium, Diss.	Selenium, Diss.	Silver, Diss.	Sodium, Diss.	Thallium, Diss.	Vanadium, Diss.	Zinc, Diss.
			Results in µg/L																										
GC-PW-1	7/10/2003	P	<30	<0.2	0.022	0.36	0.38	**9B**	*<2*	<0.1	9,400	<5	*<5*	<10	<10	*<10*	10B	<0.1	1,800	<5	0.00106	<10	1,000	*<2*	<0.05	1,800	0.18B	<5	10B
GC-PW-2	7/10/2003	P	<30	0.4B	10.6	**7.30**	17.9	**16**	*<2*	<0.1	10,600	<5	*<5*	<10	<10	*<10*	**800**	0.2B	1,700	**294**	0.00822	<10	900B	*<2*	<0.05	1,700	0.08	<5	10B
GC-PW-3	7/9/2003	P	<30	0.8B	4.87	**4.04**	8.91	**15**	*<2*	<0.1	8,800	<5	*<5*	<10	<10	*<10*	120	<0.1	1,700	59	0.00153	<10	1,000	*<2*	**1.3**	1,600	0.13	<5	10B
GC-PW-4	7/9/2003	P	<30	<0.2	0.019	0.46	0.477	**9B**	*<2*	<0.1	8,600	<5	*<5*	<10	<10	*<10*	<10	<0.1	1,800	<5	0.000813	<10	800B	*<2*	<0.05	1,700	0.10B	<5	10B
Standards, corrected for hardness where applicable (used 30 mg/L as hardness average for Gold Creek samples)																													
Washington - Aquatic Life [1]			NS	NS	NS	NS	190	NS	NS	0.42	NS	66	10	NS	NS	4.1	NS	0.66	NS	NS	0.012	511	NS	5	NS	NS	NS	NS	38
EPA - Aquatic Life [2]			87	NS	NS	3.1	150	4	0.66	0.11	NS	27.6	11	NS	23	3.2	1000	0.66	NS	120	0.77	18.8	NS	5	0.36	NS	12	20	42.6
ORNL - Aquatic Life [3]			87	30	190	3.1	NS	4	0.66	0.15	1.2E5	44	2	NS	23	0.23	158	0.66	82,000	120	0.23	160	53,000	5	0.36	6.8E5	12	20	30

Sample I.D. / Station No.	Sample Date	Pool (P) or Riffle (R)	Cyanide, Total	Cyanide WAD	Temperature (Field)	pH (Lab)	pH (Field)	Conductivity @ 25C (Lab)	Conductivity (Field)	Dissolved Oxygen (Field)	Turbidity (Field)	Oxygen Reduction Potential (Field)	Hardness as CaCO3	Total Dissolved Solids (Field)	Residue, Filterable (TDS) @180	Residue, Non- Filterable (TSS) @105 C	Residue, Volatile (Filterable) @ 550 C	Sulfate
			mg/L		°C	su		uS		mg/L	NTU	mV	mg/L					
GC-PW-1	7/10/2003	P	<0.01	<0.01	13.2	7.0	7.68	68	52	15.15	351	233	31	30	40	6B	6B	<10
GC-PW-2	7/10/2003	P	<0.01	<0.01	14.03	6.6	7.74	74	62	9.34	201	18	34	30	50	<5	8B	<10
GC-PW-3	7/9/2003	P	<0.01	<0.01	NC	6.6	NC	67	NC	NC	NC	NC	29	30	40	<5	8B	<10
GC-PW-4	7/9/2003	P	NA	NA	12.24	7.1	7.84	66	51	14.6	91	265	29	30	40	54	26	<10

NOTES:
Analysis was conducted by ACZ Laboratories, Inc. in Steamboat Springs, CO.
Diss. = Dissolved Metals, Chromium III was calculated by subtracting Chromium VI from Total Chromium
mg/L = milligrams per liter
µg/L = micrograms per liter
su = standard units
uS = micro siemans
< value = analyte not detected above method detection limit (MDL)
B = analyte detected between method detection limit (MDL) and practical quantification limit (PQL)
NS = No Standard
NA = Not Analyzed
NC = Not Collected
Bolded values indicate that the value exceeds one or more standard
Italic values indicate that the MDL exceeds the lowest standard

STANDARD NOTES:
1 - State of Washington chronic ambient water quality criteria for protection of aquatic life (DOE, 2001)
2 - EPA recommended chronic ambient water quality criteria for freshwater aquatic life used (EPA, 2002).
If none existed, used Tier II secondary chronic values (ORNL, 1996)
3 - ORNL ecological screening level values for freshwater, lowest chronic value used (ORNL, 1996).

Table 3. Sediment Analytical Results
Antimony Queen Mine EECA, Okanogan National Forest, Okanogan County, Washington

Sample ID	Sample Date	Aluminum, Total	Antimony, Total	Arsenic III, Inorganic	Arsenic V, Inorganic	Arsenic, Inorganic	Arsenic, Total	Barium, Total	Beryllium, Total	Cadmium, Total	Calcium, Total	Chromium, Total	Cobalt, Total	Copper, Total	Iron, Total	Lead, Total	Magnesium, Total	Manganese, Total	Mercury, Total	Nickel, Total	Potassium, Total	Selenium, Total	Silver, Total	Sodium, Total	Thallium, Total	Vanadium, Total	Zinc, Total
		mg/kg																									
GC-SS-1	7/10/2003	4,550	<0.2	0.011	1.677	1.688	4.7	30.6	<0.2	0.1B	1,650	14	4	6.0	8,900	1.3	2950	127	<0.05	7.9	890	<2	<0.05	70 B	0.17	17.3	25
GC-SS-2	7/10/2003	4,660	0.3B	0.025	7.587	**7.612**	**6.9**	32.9	<0.2	<0.1	1,600	14	4	6.0	8,960	1.3	3040	122	<0.04	7.2	870	<2	<0.05	70 B	0.09 B	17.3	24
GC-SS-3	7/9/2003	4270	0.3B	0.037	6.129	**6.166**	**12.6**	27.2	<0.2	0.1B	1460	10	3	6.3	9310	1.3	2570	123	<0.04	6.1	590	<2	<0.05	70 B	0.09 B	16.5	21
GC-SS-4	7/9/2003	6360	0.6B	0.026	4.749	4.775	**16.3**	33.2	<0.2	0.2B	1740	20	4 B	9.6	13,800	1.6	4040	227	<0.04	9.6	660	<2	<0.05	50 B	0.07 B	23.0	29
Standards																											
WA - Freshwater (under development) [1]		NS	35	NS	NS	5.9	5.9	NS	NS	0.6	NS	26	NS	16	NS	31	NS	NS	0.17	16	NS	NS	3.9	NS	NS	NS	110
WA - Marine [2]		NS	NS	NS	NS	57	57	NS	NS	5.1	NS	260	NS	390	NS	450	NS	NS	0.41	NS	NS	NS	6.1	NS	NS	NS	410
EPA - Freshwater TEL [3]		NS	NS	NS	NS	5.9	5.9	NS	NS	0.596	NS	37.3	NS	35.7	NS	35	NS	NS	0.174	18	NS	NS	NS	NS	NS	NS	123
EPA - Freshwater PEL [4]		NS	NS	NS	NS	17	17	NS	NS	3.53	NS	90	NS	197	NS	91.3	NS	NS	0.486	35.9	NS	NS	NS	NS	NS	NS	315
ORNL - Freshwater [5]		NS	NS	NS	NS	42	42	NS	NS	4.2	NS	159	NS	77.7	NS	110	NS	NS	0.7	38.5	NS	NS	1.8	NS	NS	NS	270

Sample ID	Sample Date	Acid Volatile Sulfide	Simultaneously Extracted Metals					Texture by Hydrometer			Solids	Clay Mineralization						
			Cadmium	Copper	Lead	Nickel	Zinc	Clay	Sand	silt		Quartz	Plagioclase Feldspar	K-Feldspar	Mica/Illite	Chlorite	Clinoamphibole	Unidentified
		umol/g	mg/L					%										
GC-SS-1	7/10/2003	<0.02	<0.2	1.1B	<1	0.7B	14.5	1.3	97.5	1.3 B	81.2	32	49	9	<5	<5	<3	<5
GC-SS-2	7/10/2003	<0.02	<0.2	1.7B	1B	0.9B	17.2	<0.1	97.5	5	72.3	33	48	9	<5	<5	<3	<5
GC-SS-3	7/9/2003	<0.02	<0.2	2.2	<1	0.5B	3.7	<0.1	100	1.3 B	83.1	33	50	11	NA	<5	<3	<5
GC-SS-4	7/9/2003	<0.01	0.1B	1.4	<1	0.5B	3.5	<0.1	97.5	2.5 B	87.4	34	48	9	<5	<5	<3	<5

NOTES:
Analysis was conducted by ACZ Laboratories, Inc. in Steamboat Springs, CO and Brooks Rand in Portland, OR
mg/kg = milligrams per kilogram
mg/L = milligrams per liter
umol/g = micromole per gram
< value = analyte not detected above MDL
B = analyte detected between method detection limit (MDL) and practical quantification limit (PQL)
NS = No Standard

STANDARD NOTES:
1 - State of Washington, Development of Freshwater Sediment Quality Values (DOE, Sept 2002)
2 - State of Washington, Marine Sediment Management Standards (DOE, 1995)
3 - EPA Threshold Effects Level (NOAA, 1999)
4 - EPA Probable Effects Level (NOAA, 1999)
5 - ORNL ecological screening level values for freshwater, lowest chronic value used (ORNL, 1996)

Table 4. Background Soil Analytical Results
Antimony Queen Mine EECA, Okanogan National Forest, Okanogan County, Washington

Sample ID	Sample Date	Sample Depth (feet)	Paste pH (lab)	Aluminum, Total	Antimony, Total	Arsenic III, Inorganic	Arsenic V, Inorganic	Arsenic, Inorganic	Arsenic, Total	Barium, Total	Beryllium, Total	Cadmium, Total	Calcium, Total	Chromium, Total	Cobalt, Total	Copper, Total	Iron, Total	Lead, Total	Magnesium, Total	Manganese, Total	Mercury, Total	Nickel, Total	Potassium, Total	Selenium, Total	Silver, Total	Sodium, Total	Thallium, Total	Vanadium, Total	Zinc, Total
			su	mg/kg																									
AQ-S-1	7/8/2003	0.5	5.8	23,000	161	2.628	748	750	1,120	145	0.6 B	2.31	3,800	10	18	77	35,700	74.8	3,350	2,170	<0.05	16	1,430	<0.6	0.8	390	0.18	41.7	195
AQ-S-2	7/8/2003	0.5	6.7	17,200	56	1.708	1,315	1,317	1,020	130	0.4 B	2.03	7,820	11	19	93	36,500	38.5	4,630	2,360	<0.05	17	2,760	<0.6	1.01	330	0.14	44.6	190
AQ-S-3	7/8/2003	0.5	6.3	18,600	28	1.269	511	512	982	159	0.5 B	2.86	3,960	9	25	93	48,000	23.1	3,250	3,410	0.04 B	19	1,820	<0.6	0.88	270	0.15	51	190
Mean			6.3	19,600	82	1.868	858	860	1,040	145	0.5	2.4	5,193	10	21	88	40,067	45.5	3,743	2,647	0.04	17	2,003	NC	0.9	330	0.16	45.8	192
Standards																													
WA - Method A Indust. Soil Cleanup Levels - Human Receptors				NS	NS	NS	NS	NS	20	NS	NS	2.0	NS	19	NS	NS	NS	1,000	NS	NS	2	NS	NS	NS	NS	NS	NS	NS	NS
WA - Ecological Receptors (p=plant, b=soil biota, w=wildlife)				50p	5p	7w	10p	NS	NS	102w	10p	4p	NS	42p,b	20p	50b	NS	50p	NS	1,100p	0.1b	30p	NS	0.3w	2p	NS	1p	2p	86p
EPA Indust. PRGs - Human Receptors				100,000	410	NS	NS	260 / 1.6	260 / 1.6	67,000	1,900	7.4	NS	64	1,900	41,000	100,000	750	NS	19,000	310	20,000	NS	5,100	5,100	NS	67	7,200	100,000
EPA - Ecological Receptors (m=mammal, b=bird, i = invertebrate, p=plant)				NS	21m	NS	NS	37p	37p	NS	NS	29p	NS	5p	32b	61i	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	120i
ORNL - Ecological Receptors				NS	5	NS	NS	9.9	9.9	283	10	4	NS	0.4	20	60	NS	40.5	NS	NS	0.00051	30	NS	0.21	2	NS	1	2	8.5

NOTES: Analysis was conducted by ACZ Laboratories, Inc. in Steamboat Springs, CO, per EPA Method 6010/7000 series following Method 6030 digestion
mg/kg = milligrams per kilogram
su = standard units
< value = analyte not detected above MDL
B = analyte detected between method detection limit (MDL) and practical quantification limit (PQL)
NC = Not Calculated
EPA Industrial PRGs = Preliminary Remediation Goals - USEPA Region 9 (2002).
ORNL = Oak Ridge National Laboratory Preliminary Remediation Goals for Ecological Endpoints (1997)
WA = Washington State Department of Ecology, MTCA (2001)

Table 5. Waste Rock Analytical Results
Antimony Queen Mine EECA, Okanogan National Forest, Okanogan County, Washington

Sample ID	Sample Date	Sample Depth (feet)	Paste pH	Aluminum, Total	Antimony, Total	Arsenic III, Inorganic	Arsenic V, Inorganic	Arsenic, Inorganic	Arsenic, Total	Barium, Total	Beryllium, Total	Cadmium, Total	Calcium, Total	Chromium, Total	Cobalt, Total	Copper, Total	Iron, Total	Lead, Total	Magnesium, Total	Manganese, Total	Mercury, Total	Nickel, Total	Potassium, Total	Selenium, Total	Silver, Total	Sodium, Total	Thallium, Total	Vanadium, Total	Zinc, Total	Total Sulfur	ABAs: Acid Generation Potential	ABAs: Acid Neutralization Potential	ABAs: Acid-Base Potential
			su	mg/kg																										%	t $CaCO_3$/Kt		
AQ-WR1-1	7/9/2003	1.0	7.8	2,520	7,500	23.0	9,934	9,957	11,400	179	0.4 B	5.05	15,900	4	21	125	60,000	70.1	620	2,050	0.65	21	1,100	<0.6	1.56	50	0.49	11.4	297	0.03	1	506	505
AQ-WR1-2	7/9/2003	2.0	NA	NA	NA	40.6	8,904	8,945	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
AQ-WR1-3	7/9/2003	1.5	7.5	2,670	6,500	24.6	9,388	9,413	11,800	189	0.5	2.92	9,800	5	22	141	69,700	54	1,260	1,890	0.80	24	1,110	<0.6	1.68	40	0.31	13.7	253	0.11	3	503	500
AQ-WR1-4	7/9/2003	2.0	7.9	2,170	11,600	14.7	8,399	8,413	10,700	187	0.4	9.49	37,100	19	19	116	51,000	104	410	1,780	0.45	26	1,080	<0.6	2.01	40	0.71	10.4	331	0.03	1	91	90
AQ-WR1-5	7/9/2003	2.0	7.6	2,300	6,200	29.8	9,273	9,303	11,800	216	0.5	4.01	9,570	4	23	151	65,200	60.7	620	2,330	0.62	25	1,180	<0.6	1.76	50	0.37	12.5	293	0.05	2	27	25
AQ-WR1-6	7/9/2003	0.5	4.9	6,270	14,500	11.4	6,699	6,711	7,900	111	0.6	2.69	3,880	8	21	134	66,400	79.8	1,710	1,910	0.63	23	1,010	1.1 B	2.03	70	0.2	22.9	221	1.09	34	6	-28
AQ-WR1-7	7/9/2003	1.5	NA	NA	NA	11.0	5,541	5,552	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
AQ-WR1-8	7/9/2003	2.0	6.6	14,900	900	4.9	4,163	4,168	4,500	134	0.6	4.43	4,490	12	29	193	74,000	227	4,370	4,010	0.15	32	1,340	0.6 B	7.09	170	0.28	42	314	0.04	1	13	12
AQ-WR1-9	7/9/2003	1.0	NA	NA	NA	4.2	2,065	2,069	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
AQ-WR1-10	7/9/2003	1.0	6.5	12,900	330	2.4	1,831	1,833	2,300	117	0.6 B	2.85	6,440	10	28	173	66,800	56.2	3,460	3,750	0.13	36	1,700	<0.6	1.27	210	0.15	40.6	236	0.03	1	14	13
AQ-WR1-11	7/9/2003	1.5	6.7	8,620	3,360	16.4	3,936	3,953	5,700	145	0.5	2.19	8,170	8	25	135	57,100	49	3,280	3,050	0.66	28	1,460	<0.6	1.38	160	0.16	29.1	206	0.21	7	19	12
AQ-WR2-1	7/8/2003	1.0	6.7	6,650	4,530	20.7	8,183	8,204	10,300	165	0.6 B	4.41	5,340	6	19	159	74,300	74.9	1,360	2,590	0.39	11	1,280	<0.6	4.6	80	0.32	22.8	374	0.02	1	14	13
AQ-WR2-2	7/9/2003	2.0	NA	NA	NA	45.5	6,251	6,296	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
AQ-WR2-3	7/9/2003	1.0	7.2	7,050	3,310	33.7	10,102	10,135	10,300	159	0.6 B	3.04	7,950	5	25	137	66,800	97.5	2,260	2,390	0.54	15	1,750	<0.6	3.15	130	0.23	24.9	257	0.19	6	18	12
MEAN				6,605	5,873	20.21	6,762	6,782	8,670	160	0.52	4.11	10,864	8.1	23.2	146	65,130	87	1,935	2,575	0.50	24	1,301	NC	2.65	100	0.32	23	278	0.18	NC	NC	NC
Standards																																	
WA - Method A Indust. Soil Cleanup Levels - Human Receptors				NS	NS	NS	NS	NS	20	NS	NS	2	NS	19	NS	NS	NS	1,000	NS	NS	2	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
WA - Ecological Receptors (p=plant, b=soil biota, w=wildlife)				50p	5p	7w	10p	NS	NS	102w	10p	4p	NS	42p,b	20p	50b	NS	50p	NS	1,100p	0.1b	30p	NS	0.3w	2p	NS	1p	2p	86p	NS	NS	NS	NS	NS
EPA Indust. PRGs - Human Receptors				100,000	410	NS	NS	NS	260 / 1.6	67,000	1,900	7.4	NS	64	1,900	41,000	100,000	750	NS	19,000	310	20,000	NS	5,100	5,100	NS	67	7,200	100,000	NS	NS	NS	NS	NS
EPA - Ecological Receptors (m=mammal, b=bird, i = invertebrate, p=plant)				NS	21m	NS	NS	NS	37p	NS	NS	29p	NS	5p	32b	61i	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	120i	NS	NS	NS	NS	NS
ORNL - Ecological Receptors				NS	5	NS	NS	9.9	9.9	283	10	4	NS	0.4	20	60	NS	40.5	NS	NS	0.00051	30	NS	0.21	2	NS	1	2	8.5	NS	NS	NS	NS	NS

NOTES:

Analysis was conducted by ACZ Laboratories, Inc. in Steamboat Springs, CO.
mg/kg = milligrams per kilogram
mg/L = milligrams per liter
t $CaCO_3$/Kt = tons of calcium carbonate needed to neutralize 1,000 tons of waste/soil. Negative number indicates lack of $CaCO_3$; positive value indicates excess (no need).
su = standard units
< value = analyte not detected above MDL
B = analyte detected between method detection limit (MDL) and practical quantification limit (PQL)
NA = not analyzed
EPA Industrial PRGs = Preliminary Remediation Goals - USEPA Region 9 (2002).
ORNL = Oak Ridge National Laboratory Preliminary Remediation Goals for Ecological Endpoints (1997)
WA = Washington State Department of Ecology, MTCA (2001)

Table 6. Synthetic Precipitation Leaching Procedure and Toxicity Characteristic Leaching Procedure Results
Antimony Queen Mine EECA, Okanogan National Forest, Okanogan County, Washington

Sample ID	Sample Date	Sample Depth (feet)	SPLP Arsenic	TCLP Arsenic	SPLP Barium	TCLP Barium	SPLP Cadmium	TCLP Cadmium	SPLP Chromium	TCLP Chromium	SPLP Lead	TCLP Lead	SPLP Mercury	TCLP Mercury	SPLP Selenium	TCLP Selenium	SPLP Silver	TCLP Silver
			mg/L															
AQ-WR1-1	7/9/2003	1.0	2.33	NA	< 0.003	NA	< 0.001	NA	< 0.01	NA	< 0.001	NA	< 0.0002	NA	< 0.001	NA	< 0.005	NA
AQ-WR1-3	7/9/2003	1.5	1.8	NA	< 0.003	NA	< 0.001	NA	< 0.01	NA	< 0.001	NA	< 0.0002	NA	< 0.001	NA	< 0.005	NA
AQ-WR1-4	7/9/2003	2.0	1.8	NA	< 0.003	NA	< 0.001	NA	< 0.01	NA	< 0.001	NA	< 0.0002	NA	< 0.001	NA	< 0.005	NA
AQ-WR1-5	7/9/2003	2.0	1.75	NA	0.003 B	NA	< 0.001	NA	< 0.01	NA	< 0.001	NA	< 0.0002	NA	< 0.001	NA	< 0.005	NA
AQ-WR1-6	7/9/2003	0.5	0.855	NA	0.003 B	NA	< 0.0005	NA	< 0.01	NA	0.0017 B	NA	< 0.0002	NA	< 0.001	NA	< 0.005	NA
AQ-WR1-8	7/9/2003	2.0	0.356	NA	0.003 B	NA	< 0.0002	NA	< 0.01	NA	0.0047	NA	< 0.0002	NA	< 0.001	NA	< 0.005	NA
AQ-WR1-10	7/9/2003	1.0	0.247	NA	0.003 B	NA	< 0.0002	NA	< 0.01	NA	0.0011	NA	< 0.0002	NA	< 0.001	NA	< 0.005	NA
AQ-WR1-11	7/9/2003	1.5	0.461	NA	0.003 B	NA	< 0.0002	NA	< 0.01	NA	0.0011	NA	< 0.0002	NA	< 0.001	NA	< 0.005	NA
AQ-WR2-1	7/8/2003	1.0	2.48	NA	0.003 B	NA	< 0.001	NA	< 0.01	NA	0.002 B	NA	< 0.0002	NA	< 0.001	NA	< 0.005	NA
AQ-WR2-3	7/9/2003	1.0	1.74	NA	0.003 B	NA	< 0.001	NA	< 0.01	NA	< 0.001	NA	< 0.0002	NA	< 0.001	NA	< 0.005	NA
AQ-WR1-1	10/4/2004	0.5	NA	0.86	NA	0.112	NA	< 0.005	NA	< 0.01	NA	< 0.04	NA	< 0.0002	NA	< 0.04	NA	< 0.005
AQ-WR1-3	10/4/2005	0.5	NA	0.37	NA	0.134	NA	< 0.005	NA	< 0.01	NA	< 0.04	NA	< 0.0002	NA	< 0.04	NA	< 0.005
AQ-WR1-4	10/4/2005	0.5	NA	0.95	NA	0.205	NA	< 0.005	NA	< 0.01	NA	< 0.04	NA	< 0.0002	NA	< 0.04	NA	< 0.005
AQ-WR1-5	10/4/2005	0.5	NA	1.19	NA	0.097	NA	< 0.005	NA	< 0.01	NA	< 0.04	NA	< 0.0002	NA	< 0.04	NA	< 0.005
AQ-WR1-6	10/4/2005	0.5	NA	0.45	NA	0.086	NA	< 0.005	NA	< 0.01	NA	< 0.04	NA	< 0.0002	NA	< 0.04	NA	< 0.005
AQ-WR1-11	10/4/2005	0.5	NA	0.27	NA	0.095	NA	< 0.005	NA	< 0.01	NA	< 0.04	NA	< 0.0002	NA	< 0.04	NA	< 0.005
AQ-WR2-1	10/4/2005	0.5	NA	1.63	NA	0.092	NA	< 0.005	NA	< 0.01	NA	< 0.04	NA	< 0.0002	NA	< 0.04	NA	< 0.005
AQ-WR2-3	10/4/2005	0.5	NA	0.61	NA	0.063	NA	< 0.005	NA	< 0.01	NA	< 0.04	NA	< 0.0002	NA	< 0.04	NA	< 0.005
Applicable Standards																		
RCRA TCLP Disposal Limits			5	5	100	100	1	1	5	5	5	5	0.2	0.2	1	1	5	5

Notes: Analysis was conducted by ACZ Laboratories, Inc., Steamboat Springs, CO
B = analyte detected between MDL and practical quantification limit (PQL)
NA = not analyzed
mg/L = milligrams per liter
< value = Analyte not detected above Method Detection Limit (MDL, shown)
B = Analyte detected between MDL and Practical Quantification Limit (PQL, not shown)

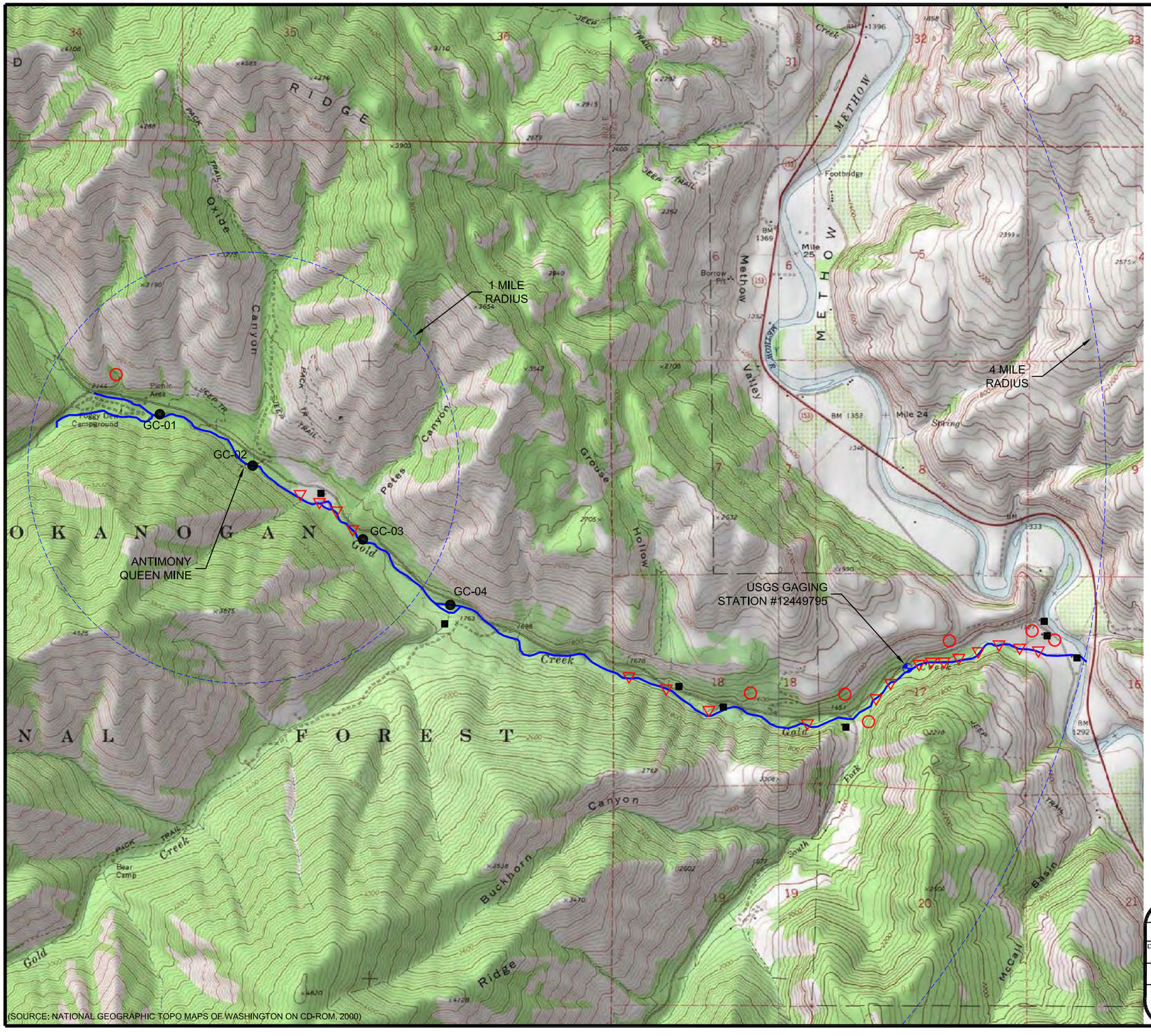
Table 7. Plant Tissue Analytical Results
Antimony Queen Mine EECA, Okanogan National Forest, Okanogan County, Washington

Sample ID	Sample Date	Onsite or Background (Bkg)	Aluminum	Antimony	Arsenic	Barium	Beryllium	Cadmium	Calcium	Chromium	Cobalt	Copper	Iron	Lead	Magnesium	Manganese	Mercury	Nickel	Potassium	Selenium	Silver	Sodium	Thallium	Vanadium	Zinc	Cyanide
			mg/kg																							
AQ-V-1	7/8/2003	Bkg	57	0.3B	2.1	76.6	<0.2	0.07B	13,400	<1	<1	5B	81	0.45	2,350	248	<0.1	<1	16,300	<0.6	0.05 B	<30	<0.03	<0.5	30	3.0
AQ-V-2	7/8/2003	Onsite	40	0.7	2.9	12.1	<0.2	<0.05	16,600	<1	<1	6	77	0.28B	3,140	89.9	<0.1	<1	15,500	<0.6	0.04 B	<30	<0.03	<0.5	32	1.1B
AQ-V-3	7/8/2003	Bkg	37	<0.5	1.8	32.0	<0.2	0.19B	16,000	<1	<1	7	82	0.3B	2,440	409	<0.09	<1	12,000	<0.6	<0.03	<30	0.1B	<0.5	35	12.5
AQ-V-4	7/9/2003	Bkg	18	1.4B	3.5	11.4	<0.2	<0.05	13,200	<1	<1	5	66	0.4B	2,680	160	<0.1	<1	22,700	<0.6	<0.03	<30	<0.1	<0.5	19	<0.5
AQ-V-5	7/9/2003	Onsite	58	18.8	24.0	4.6	<0.2	<0.05	13,200	<1	<1	7	249	1.2	3,160	236	<0.1	1B	24,700	<0.6	0.04B	<30	<0.1	0.6B	30	<0.5
AQ-V-6	7/9/2003	Onsite	39	2.5	5.7	6.2	<0.2	0.10B	13,100	<1	<1	6	104	0.3B	2,480	480	<0.1	<1	31,800	<0.6	<0.03	<30	<0.1	<0.5	30	<0.5

NOTES: Analysis was conducted by ACZ Laboratories, Inc. in Steamboat Springs, CO, per EPA Method 6010/7000 series.
mg/kg = milligrams per kilogram
< value = analyte not detected above MDL
B = analyte detected between method detection limit (MDL) and practical quantification limit (PQL)
The vegetation type for all samples was *amelanchier alnifolia* (serviceberry), except AQ-V-6 which was *symphoricarpos alba* (common snowberry)

FIGURES

Figure 1. **Surface Water Stations, including Water Right, Residences, and Well Information**
Figure 2. **Site Layout and Sampling Locations**



EXPLANATION

- Radius Surrounding Mine Site
- Surface Water Rights - Approximate Location
- Water Well - Approximate Location
- USGS Gaging Station
- Surface Water Station
- Residence - Approximate Location

N

SCALE 1 INCH = 2,000 FEET

1 1/2 0 1 MILE

CONTOUR INTERVAL = 40 FEET

Figure 1. Surface Water Stations, including Water Right, Residence & Well Information

PROJECT NUMBER: 2423015	ANTIMONY QUEEN MINE EECA
DATE: 01/15/06	
DWG BY: dgw / DWG NO: 2423015F1.dwg	
PROJECT MANAGER: DGW	
REVISED:	CASCADE EARTH SCIENCES A Valmont Industries Company

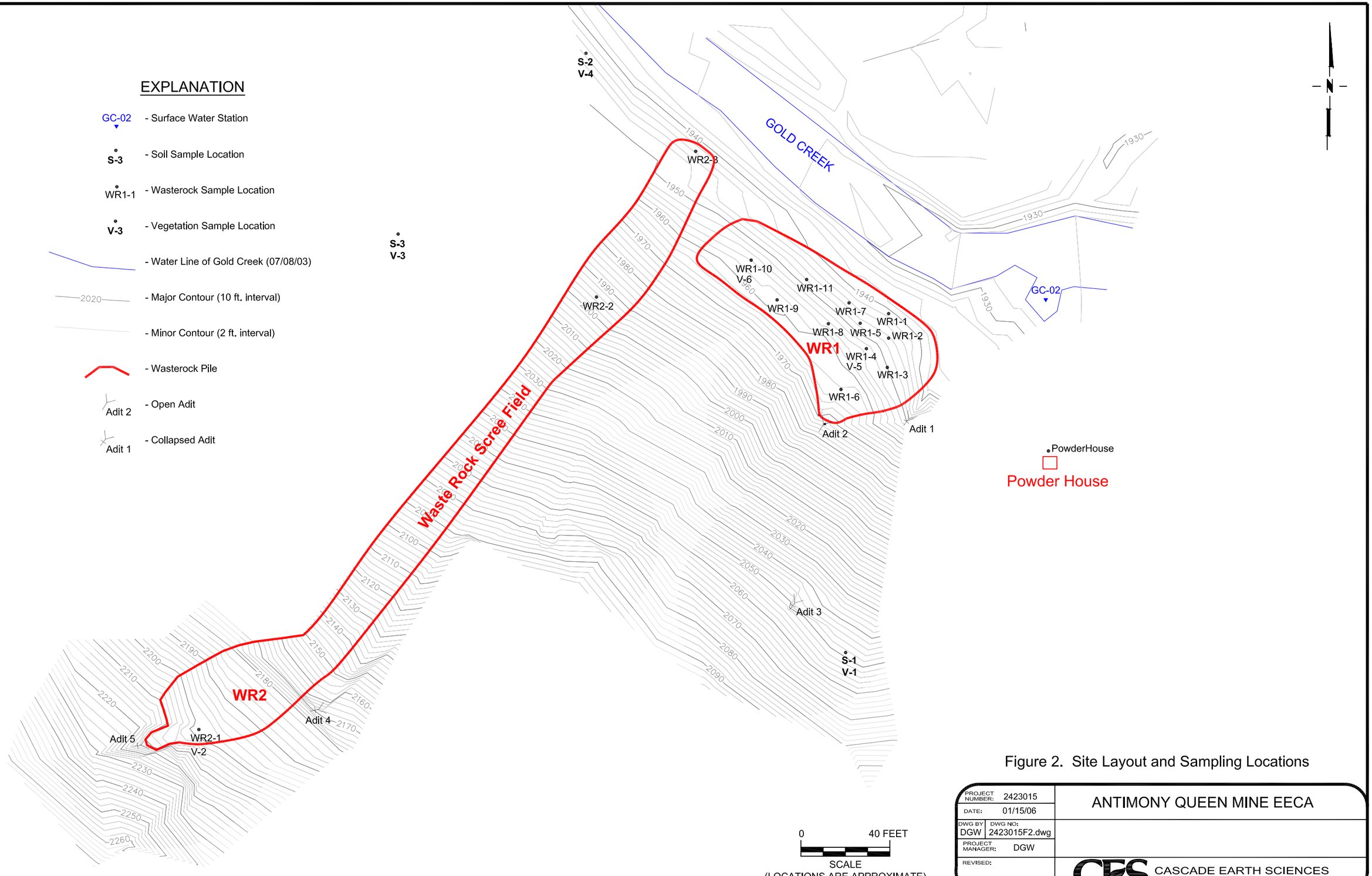


Figure 2. Site Layout and Sampling Locations

PROJECT NUMBER: 2423015	ANTIMONY QUEEN MINE EECA
DATE: 01/15/06	
DWG BY: DGW / DWG NO: 2423015F2.dwg	
PROJECT MANAGER: DGW	
REVISED:	CASCADE EARTH SCIENCES A Valmont Industries Company

APPENDICES

Appendix A. **Human Health and Ecological Risk Assessment**
Appendix B. **Applicable and Relevant and Appropriate Requirements**

Appendix A.

Human Health and Ecological Risk Assessment

STREAMLINED HUMAN HEALTH AND ECOLOGICAL RISK ASSESSMENT

Antimony Queen Mine
Okanogan National Forest
Carlton, Washington

Prepared For

USDA Forest Service
Okanogan National Forest

on behalf of

Cascade Earth Sciences
12720 East Nora Avenue, Suite A
Spokane, WA 99216

December 2005

TAS PROJECT NO: TAS03009

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ACRONYMS

95UCL	95th percentile upper confidence limit on the arithmetic mean
CEEM	conceptual ecological exposure model
CHHEM	conceptual human health exposure model
CES	Cascade Earth Sciences
CRAVE	carcinogen risk assessment verification endeavor
COI	chemical of interest
COPC	chemical of potential concern
COPEC	chemical of potential ecological concern
CTE	Central Tendency Exposure
Ecology	Washington State Department of Ecology
ERA	ecological risk assessment
ERBSC	ecological risk-based screening concentration
HHRA	human health risk assessment
PA	Preliminary Assessment
PRG	Preliminary Remediation Goals
SI	Site Inspection
SOC	species of concern
RME	reasonably maximally exposed
RTE	rare, threatened, or endangered
T&E	threatened and endangered
TAS	Technical Assessment Services
USEPA	United States Environmental Protection Agency
USFS	United States Forest Service

1.0 INTRODUCTION

Potential human health and ecological risks associated with mining-related contamination at the Antimony Queen Mine (Site) were assessed as part of the Engineering Evaluation and Cost Assessment (EECA) through a streamlined risk assessment process. In general, the risk assessment process follows U.S. Environmental Protection Agency (USEPA) and Washington State Department of Ecology (Ecology) guidelines. Potential risks and hazards were evaluated by comparing Site-specific chemical concentrations to readily available risk-based screening concentrations for selected human health and ecological exposure pathways. Section 2.0 describes the analytical data used and the initial screening which determines the chemicals of interest (COIs). The human health risk assessment (HHRA) and ecological risk assessment (ERA) are presented in Sections 3.0 and 4.0, respectively. Conclusions and recommendations based on the results of the risk assessments are presented in Section 5.0.

2.0 RISK ASSESSMENT DATA AND INITIAL SCREENING

This section describes the analytical data used in the risk assessment and the initial data screening process. The analytical data are from media samples collected from the Site during the Site Inspection (SI; CES, 2004). In accordance with SI methodology, media samples were selectively collected in areas where contamination was known or suspected to occur to identify worst case concentration at the Site. This approach is conservative in that it results in an over-estimation of concentrations rather than an underestimation, and is appropriate for screening level risk assessments.

Metals were the primary COIs. The analytical data incorporated into the risk assessment were based on the following samples collected during the SI (CES, 2004):

- 3 background surface soil samples;
- 3 background vegetation samples;
- 1 background surface water sample;
- 1 background pore water sample;
- 1 background sediment sample;
- 14 surface soil/wasterock samples;
- 3 vegetation samples;
- 3 surface water samples;
- 3 pore water samples; and
- 3 sediment samples.

These samples were analyzed primarily for metals. Soil samples were also analyzed for acid based accounting, pH, synthetic precipitation leaching procedure, and toxicity precipitation leaching procedure. Water samples were also analyzed for water quality parameters: pH, conductivity, dissolved oxygen, and hardness. Stream sediment samples were also analyzed for acid volatile sulfide and simultaneously extracted metals to determine the likely bioavailability of metals.

Standard laboratory quality control procedures were used and analytical results were quality assured and qualified, as necessary, by the laboratory. The analytical data were considered good quality and useable for the risk assessment.

The Site-related data collected during the SI were initially screened using the following criteria:

- Essential Nutrients: calcium, magnesium, potassium, and sodium were removed from further assessment because they are considered to be essential nutrients.
- Frequency of Detection: COIs that were detected in 5% or fewer of the samples were removed from further consideration.
- Background: maximum concentrations of metals that occurred at concentrations less than average background concentrations were eliminated from further assessment.
- Reporting Limits: COIs with maximum reporting limit concentrations greater than background concentrations and the lowest applicable human health or ecological screening risk-based screening concentration were retained for further assessment.

Table 2-1 lists the chemicals retained following the initial screening. Details of the initial screening are shown in Tables B1-1 through B1-5 (Appendix B1).

Table 2-1
Chemicals of Interest Remaining Following the Initial Screening

COIs	Surface Soil/ Waste Material		Vegetation		Surface Water		Pore Water		Sediment	
	HHRA	ERA	HHRA	ERA	HHRA	ERA	HHRA	ERA	HHRA	ERA
Aluminum	X	X		X					X	X
Antimony	X	X		X				X	X	X
Arsenic, III		X				X		X		
Arsenic, V		X				X		X		X
Arsenic, total	X	X		X				X	X	X
Barium	X	X						X	X	X
Beryllium	X	X								
Cadmium	X	X		X					X	X
Chromium, total	X	X							X	X
Cobalt	X	X								
Copper	X	X		X		X		X	X	X
Iron	X	X		X				X	X	X
Lead	X	X		X				X	X	X
Manganese	X	X		X				X	X	X
Mercury	X	X			X	X		X		
Nickel	X	X		X					X	X
Selenium	X	X								X
Silver	X	X		X				X		
Thallium	X	X								
Vanadium					X				X	X
Zinc	X	X			X				X	X

For the reporting limit screening, the risk-based screening concentrations for human health were the Industrial USEPA Region IX Preliminary Remediation Goals (PRGs). The ecological risk-based screening concentrations (ERBSCs) are shown in Table B1-6. There are no ERBSCs for vegetation, so COI concentrations and reporting limits for vegetation samples were compared only to background concentrations and not to a lowest available risk-based screening concentration.

3.0 HUMAN HEALTH RISK ASSESSMENT

The HHRA evaluated the potential for adverse health effects that could result from current or future human exposures to hazardous substances present at the Site. The purpose of this evaluation was to select chemicals of potential concern (COPCs) from the COIs using approved human health risk-based screening procedures, and to calculate the exposure doses for each COPC and receptor. The exposure doses were then compared to acceptable doses of the COPCs using approved screening numbers. The following are the primary elements of the HHRA.

- Hazard Identification and Selection of COPCs
- Exposure Assessment
- Toxicity Assessment
- Risk Characterization
- Summary of Human Health Risks

3.1 HAZARD IDENTIFICATION AND SELECTION OF COPCS

This section presents the rationale for the selection of the COPCs. The media of interest for human health included surface soil/wasterock, surface water, and sediment. Maximum concentrations of the COIs in these media were compared to USEPA Region IX PRGs. Industrial PRGs were selected as the most appropriate screening criteria for soil/wasterock and sediment, and tap water PRGs represented a very conservative screen for surface water. Table 3-1 lists the COPCs. Tables B2-1 and B2-2 in Appendix B2 present the PRG screening and results, respectively.

Table 3-1
Contaminants of Potential Concern for the Human Health Exposure Media

COPCs	Surface Soil/ Wasterock	Surface Water	Sediment
Antimony	X		
Arsenic	X	X	X

3.2 EXPOSURE ASSESSMENT

Assessing the exposure at a given Site includes: 1) the development of the conceptual human health exposure model (CHHEM), which includes identification of potentially exposed populations and the development of exposure pathways; and 2) the calculation of exposure point concentrations (EPCs) and average daily doses (ADD).

3.2.1 Conceptual Human Health Exposure Model

The CHHEM is a flow chart that outlines contaminant sources, release mechanisms, transport routes and media, potential receptor populations, and potential exposure routes. The CHHEM identifies the potential receptors and exposure pathways at the Site. The CHEEM for the Site is presented in Figure 3-1. Justification and further discussion on the exposure routes and receptors are provided in the following sections.

3.2.1.1 Potentially Exposed Population

Land uses in the area are limited to timber harvesting, firewood cutting, recreation (hiking, fishing, camping, hunting, etc.), and some minerals prospecting. A USFS campground, Foggy Dew Campground,

is located approximately 0.4 miles northwest and upstream of the Site on Gold Creek, and has 13 designated camp sites. There are no onsite workers, occupied structures, or people who live within 200 feet of the Site. Public use of the Site appears to be minimal, although public access records are not maintained**.** Access is currently not restricted by fencing, nor were any "No Trespassing" signs observed. The potential for significant activity or contact with COPCs at the Site is considered to be very low because:

- The Site is located in a relatively unpopulated area with no direct access or trail;
- There are no formal campsites located on the Site; and
- Access to the Site requires hiking across steep terrain and crossing Gold Creek, which is not passable during high flow and difficult at moderate flows.

In addition, the Site is not currently occupied on a regular basis and is unlikely be occupied for extensive periods. Therefore, the risk of long-term exposure to COPCs at the Site is considered very low. However, hikers, hunters, and campers still have the potential to access the Site and were selected as the potentially exposed current and future receptor populations at the Site.

3.2.1.2 Identification of Potential Exposure Pathways

This section evaluates potential pathways for human exposures to the identified COPCs. Complete exposure pathways were evaluated for receptors within the current and future potentially exposed populations and included:

- Inhalation of wasterock particulates;
- Incidental ingestion of wasterock, surface water, and sediment; and
- Dermal contact with wasterock, surface water, and sediment.

Use of groundwater as potential drinking water was eliminated as a pathway of concern because the closest reported drinking water well is located approximately 2.5 miles downgradient from the Site, on the north side of Gold Creek. Additional information regarding the hydrogeology surrounding the Site and groundwater pathway is presented in the EECA. Fish consumption was also eliminated as a potential pathway of concern because of the following: 1) the number fish in Gold Creek is too small to support a recreational fisher scenario, and 2) Gold Creek is currently closed to all fishing from the confluence with Foggy Dew Creek (~0.5 miles upstream from the Site) to the mouth.

3.2.2 Exposure Assumptions

Exposure assumptions include factors such as body weight, averaging time, exposure frequency, exposure duration, and chemical bioavailability. Separate assumptions were made for both the central tendency exposure (CTE) and reasonable maximum exposure (RME). In general, the RME scenario is a conservative or worst-case estimate of potential exposure, while the CTE scenario is typically more realistic and uses exposure factors that are more indicative of the average recreational user.

Neither the USEPA nor Ecology have developed default scenarios for recreational or camping exposure scenarios. Therefore, recreational exposure assumptions used for this HHRA were selected from those developed by USEPA for the Upper Tenmile Creek Mining Area Superfund site (CDM, 2000). Use of the exposure assumptions developed for a similar mine site were deemed appropriate. The exposure factors used in this risk assessment are presented in Table B2-3 in Appendix B-2.

3.2.3 Exposure Point Concentrations and Average Daily Dose

An exposure point concentration (EPC) represents the COPC concentration in each exposure medium that a receptor will potentially contact during the exposure period. Generally, the EPC is not the maximum concentration detected at the Site because, in most situations, it is not reasonable to assume long-term contact with the maximum concentration. As described by the USEPA (1997), where data were limited to less than 10 samples, the maximum detected concentration was used as the EPC. Where the data set contained 10 or more samples, the 95 percent upper confidence level on the arithmetic mean (95UCL) was calculated as per the USEPA (1997) and Ecology (1994) used as the EPC. The equations used to calculate the EPC are found in Appendix B2. These EPC's are presented in Table 3-2 along with the basis for the EPC.

Table 3-2
Exposure Point Concentrations For Human Exposure Media

COPC	Number of Samples	Maximum	EPC	Basis for EPC
SOIL (mg/kg)				
Antimony	10	14,500	8,470	95UCL
Arsenic	10	11,800	10,600	95UCL
SURFACE WATER (μg/L)				
Arsenic	3	0.489	0.489	Maximum
SEDIMENT (mg/kg)				
Arsenic	3	16.3	16.3	Maximum

Notes: mg/kg = milligrams per kilogram; μg/L = microgram per liter

The EPCs are used to calculate the ADD of a contaminant for each receptor type identified in the CHHEM. ADDs are used to determine the potential for adverse human health effects. Potential human health effects and toxicity values of the COPCs are discussed in the next section.

3.3 TOXICITY ASSESSMENT

The purpose of the toxicity assessment is to present the critical toxicity factors for the COPCs. The purpose of the toxicity assessment is twofold:

- To identify the cancer and non-cancer effects that may arise from direct or indirect exposure of humans to the COPCs ; and
- To provide an estimate of the quantitative relationship between the magnitude and duration of exposure, and the probability or severity of adverse effects.

3.3.1 Toxicity Values

Toxicity values are used to quantitatively describe the relationship between the extent of exposure to a COPC and the potential increased likelihood, or severity, of adverse effects. The sources for obtaining toxicity values are listed below.

- Integrated Risk Information System (IRIS) computer database (USEPA, 2004b)
- Health Effects Assessment Summary Table (HEAST) (USEPA, 1997)

Chemicals are classified into those that cause cancer and those that cause other, non-cancer, health effects. The method for assessing the potential for these two different types of health effects differ. Where

a chemical can cause both cancer and non-cancer health affects the risk evaluation calculates the potential for both types of effects. The following sections provide background information on the toxicity values for non-carcinogenic and carcinogenic chemicals.

3.3.2 Non-Carcinogenic Toxicity Values

The potential for toxicity of non-carcinogenic COPCs is determined using reference doses (RfDs). A RfD represents an estimated intake rate that is unlikely to produce measurable adverse effects over a lifetime of exposure. RfDs are determined by the USEPA RfD Work Group or from the health effects assessment documents developed by the USEPA Office of Research and Development.

An RfD assumes a threshold for adverse non-carcinogenic effects. That is, exposures below the RfD, are considered unlikely to cause any adverse health effects. RfDs are route-specific; that is, RfDs may be different for ingestion, inhalation, or other routes of exposure. The Critical Toxicity Values for the non-carcinogenic COPCs are presented in Table 3-3.

Table 3-3
Critical Toxicity Values for Non-carcinogenic COPCs

COPC	Chronic RfD (mg/kg-day) Oral	Source	Confidence in RfD	Endpoint
Antimony	4.00E-04	HEAST	low	blood/rats
Arsenic	3.00E-04	IRIS	med	skin/vascular

3.3.3 Carcinogenic Toxicity Values

Chemicals that cause cancer are classified according to the type of scientific information available about the types of cancer they might produce. This classification system is called the Weight of Evidence (WOE). The 1986 guidelines established five WOE categories, ranging from known human carcinogens (Group A) to chemicals which have been determined not to cause cancer (Group E). Of the COPCs identified at the Site, arsenic is the only carcinogen, and is a known human carcinogen.

Unlike noncarcinogens, carcinogenic chemicals are assumed to not to have a threshold value below which no human health effects are likely to be seen. The potential for developing cancer from exposure to a carcinogenic chemical (toxicity value) is determined using a slope factor. The slope factor represents a conservative estimate of the potential cancer risk associated with exposure. It is used with the ADD to calculate the increased probability of developing cancer over a lifetime. This is measured in terms of excess cancer risk (ECR). Slope factors are determined by the USEPA Carcinogen Risk Assessment Verification Endeavor (CRAVE) Workgroup, or from the health effects assessment documents developed by the USEPA Office of Research and Development. Based on USEPA guidelines documents, information on the slope factors derived for arsenic is presented in Table 3-4.

Table 3-4
Critical Toxicity Values for the Carcinogenic COPCs

COPC	CAS Number	Slope Factor $(mg/kg/day)^{-1}$		WOE Classification	Type of Cancer	Source
		Oral	Inhalation			
Arsenic	7440-38-2	1.5E+00	1.5E+01	**A**	Skin	Epidemiologic Studies

3.4 RISK CHARACTERIZATION

Potential human health impacts associated with exposure to COPCs at the Site were evaluated by estimating the potential for both non-carcinogenic and carcinogenic health effects. The following sections discuss the assessment of non-carcinogenic hazards and carcinogenic risks associated with exposure to COPCs at the Site. The SI sampling locations were selected as locations where levels of concentrations were suspected to be the highest. Targeted sampling identifies the worst-case situations, and is intended to be a conservative data set that is sufficient for the specific purposes of risk assessment.

Non-carcinogenic hazard is estimated as the ratio of the ADD of the non-carcinogenic chemical through a specific exposure route to the chronic RfD for that exposure route. The calculation of the ADD is outlined in Appendix B2. This ratio is called the Hazard Quotient (HQ). HQs greater than 1.0 indicate the potential for adverse health effects because the intake exceeds the RfD. An HQ is calculated for each chemical that elicits a non-carcinogenic health effect. The sum of all individual chemical-specific HQs is termed the Hazard Index (HI) and is calculated under each exposure pathway. Thus, a HI less than 1.0 is not anticipated to produce unacceptable human health effects.

Carcinogenic risk is estimated as the probability that a chemical will produce a carcinogenic effect. The excess lifetime carcinogenic risk is the incremental increase in the probability of developing cancer compared to a background probability of developing cancer with no exposure to Site contaminants. The potential for cancer is evaluated in terms of ECRs. The USEPA accepts a risk range of one in ten thousand (1E-04) to one in one million (1E-06); however, Ecology considers an ECR greater than one in one million (1E-06) to be unacceptable. For example, an ECR of 1E-06 represents an increase of one additional case of cancer (above background) in one million people exposed to a carcinogen over their lifetime (70 years).

The results of the quantitative risk assessment are presented below for each medium and summarized in Table 3-5. Calculations, assumptions, and exposure inputs are presented in Appendix B2.

3.4.1 Non-Carcinogenic Hazards

Antimony and arsenic were identified as the non-carcinogenic COPCs in soil and wasterock. A summary of the non-carcinogenic hazards are presented in Table 3-5. For the soil/wasterock exposure route, the only HQ greater than 1.0 was the RME receptor for the ingestion of arsenic. The HQs for the surface water and sediment exposure routes were all below the regulatory standard of 1.0. Although the HI for the RME receptor is greater than 1.0, exposure to antimony did not result in any unacceptable health impacts because the HQs for antimony were below the regulatory standard of 1.0. However, non-carcinogenic hazards were predicted for the worst case exposure scenario (RME) from ingestion of arsenic impacted soil and wasterock.

Table 3-5
Summary of Non-Carcinogenic Hazards

EXPOSURE ROUTE	COPC	HAZARD QUOTIENT	
		CTE	RME
Soil and Wasterock			
Ingestion	Antimony	5E-02	2E-01
	Arsenic	6E-01	2E+00
Dermal Contact	Antimony	2E-03	1E-02
	Arsenic	7E-02	5E-01
Surface Water			
Ingestion	Arsenic	3E-04	5E-04
Dermal Contact	Arsenic	2E-06	7E-06
Sediment			
Ingestion	Arsenic	4E-04	3E-03
Dermal Contact	Arsenic	8E-08	2E-06
HAZARD INDEX		**7E-01**	**3E+00**

3.4.2 Carcinogenic Risks

Arsenic was identified as the only carcinogenic COPC at the Site; carcinogenic risks are summarized in Table 3-6. Ingestion and dermal contact of arsenic contaminated soil were the critical pathways. Arsenic concentrations in surface water and sediment did not pose an unacceptable ECR; nor did the inhalation of soil/wasterock particulates. However, ECRs for the CTE and RME receptors exceeded Ecology's regulatory standard of 1E-06, but did not exceed USEPA's acceptable risk range of 1E-06 to 1E-04.

Table 3-6
Summary of Carcinogenic Risks

EXPOSURE ROUTE	COPC	EXCESS CANCER RISK	
		CTE	RME
Soil and Wasterock			
Ingestion	Arsenic	1E-05	1E-04
Dermal Contact	Arsenic	2E-06	7E-05
Inhalation of Particles	Arsenic	4E-08	8E-07
Surface Water			
Ingestion	Arsenic	5E-09	4E-08
Dermal Contact	Arsenic	7E-11	1E-09
Sediment			
Ingestion	Arsenic	2E-08	1E-07
Dermal Contact	Arsenic	4E-12	4E-10
SUM OF EXCESS CANCER RISK		**1E-05**	**2E-04**

3.5 SUMMARY OF HUMAN HEALTH RISKS

Of the 19 COIs identified at the Site, only antimony and arsenic were identified as COPCs. Based on current and future land use, individuals who might come in contact with Site-related contaminants through recreational activities (i.e., hunting, hiking, and camping) were identified as the only potential receptors.

The risk assessment determined that there were no unacceptable non-carcinogenic health effects expected from exposure to antimony in soil and wasterock, or from exposure to arsenic in surface water or sediment. However, potential non-carcinogenic health effects from ingestion of arsenic in soil and wasterock were predicted for the RME (worst case) scenario.

Arsenic was the only carcinogenic COPCs identified at the Site. The risk assessment determined that no unacceptable ECRs are expected from exposure to arsenic in surface water or sediment, or from inhalation of arsenic contaminated soil particles. However, ECRs from ingestion and dermal contact with surface soil and wasterock exceeded Ecology's regulatory standard of 1E-06, but were within the acceptable USEPA risk range of 1E-06 to 1E-04.

Arsenic levels in general are high at the Site; however, the highest arsenic concentration (10,135 mg/kg) at the Site was only 11.8 times higher than the average background concentration of 860 milligrams per kilogram (mg/kg). Therefore, no hotspots (i.e., areas of significantly high concentrations, generally defined as 100 times higher than background) were identified.

A screening level risk assessment uses very conservative exposure assessments and assumptions. Based on the Site topography and isolated location within the Okanogan National Forest, it is highly unlikely that recreational users would engage in activities at the Site that could result in significant ingestion or dermal contact with soil and wasterock such as camping. As outlined above, ingestion and dermal contact are the only two pathways of exposure which pose potential non-carcinogenic and carcinogenic risks. The most realistic and likely pathway of exposure at the Site is inhalation of particulates by hikers, hunters, or trespassers. The quantitative risk assessment determined that the inhalation pathway did not result in unacceptable non-carcinogenic or carcinogenic risks. Therefore, additional investigations or cleanup of the Site is not warranted.

4.0 ECOLOGICAL RISK ASSESSMENT

The goal of the ERA is to determine whether there is an unacceptable ecological risk associated with the Site. An ecological survey was conducted as part of a previously completed SI (CES, 2004). The SI report documented ecological features and conditions at and near the Site. A terrestrial ecological exclusion (TEE) assessment was completed based on this survey, in accordance with Ecology requirements (Ecology, 2001), and is provided in Appendix B3. Based on the TEE assessment, an exclusion from further terrestrial ecological exclusion is not acceptable and a Site-specific terrestrial ERA is warranted. Ecology does not provide specific guidance for ERA of water or freshwater sediment. Therefore, risk-based screening methods appropriate for Ecology (2001) and the USEPA (1997, 1999) were implemented to assess the potential for risks to be posed by Site-related COIs in soil and wasterock, surface water, pore water, and sediment. This report consists of the following:

- Problem Formulation
- Risk-Based Screening
- Risk Characterization
- Uncertainty Analysis
- Summary of Ecological Risk

4.1 PROBLEM FORMULATION

The scope of the ERA is defined through the "Problem Formulation" step which describes physical and chemical characteristics of the Site and the important ecological habitats, plants, invertebrates, fish, and wildlife. This information is utilized to identify the COIs and the ecological receptors of concern, and to develop a conceptual ecological exposure model (CEEM). The CEEM depicts the expected fate and transport of COIs at the Site, the potential exposure media, and likely exposure pathways for ecological receptors of concern. The problem formulation concludes with identification of the ecological endpoints that delineate the focus (i.e., objectives) of the remainder of the ERA. Generally, problem formulation includes a description of the Site and summary of previous investigations. However, extensive versions of these have been provided in the SI and EECA and, therefore, are not repeated herein.

4.1.1 Ecological Stressors

Ecological receptors may be affected through exposure to chemicals (i.e., toxicity), physical stresses (i.e., destruction of habitat), and biological stresses (i.e., viruses and bacteria). While biological stressors may affect ecological receptors, they are more frequently associated with waste food or human waste and in areas where wildlife congregate in large numbers. Because the remote nature of the Site limits human presence and wastes, biological stresses are not considered to pose a threat. Due to the lack of suitable habitat, ecological receptors are also unlikely to congregate in the vicinity of the Site in numbers that could result in significant biological infection or passage of wildlife diseases. Thus, biological stressors are unlikely to be a significant factor at the Site and are not considered further.

Past physical disturbances include the development of the Site and supporting structures and mining activities. The Site has been abandoned for decades and vehicle access is impossible, and current physical disturbance is limited to a low number of recreational visitors walking to the Site. Given the relatively remote nature of the Site within the Okanogan National Forest, the ecological impacts of current physical disturbances are very limited.

As described in Section 2.0, the primary COIs are metals. COIs retained for the ERA are listed in Table 2-1.

4.1.2 Ecological Setting

The regional and Site-specific ecology, sensitive environments, and rare, threatened, and endangered (RTE) species were presented in the ecological survey report, which was part of the SI (CES, 2004). None of the threatened or endangered (i.e., protected) species noted in the SI were likely to inhabit the Site. The RTE species expected or observed at the Site are listed in Tables B4-1 through B4-5 in Appendix B4.

Five distinct plant communities were observed on and adjacent to the Site. These included open coniferous forest over a majority of the onsite and offsite area, a meadow community at the east central border of the Site, riparian forest along undisturbed banks of Gold Creek, disturbed riparian along the Gold Creek bank, and disturbed upland vegetation on the wasterock piles. No sensitive environments were identified at or near the Site.

4.1.3 Conceptual Ecological Exposure Model

The CEEM depicts the sources of contamination, contaminant release and transport mechanisms, impacted exposure media, and exposure routes for ecological receptor types at the Site. The primary source of COIs are the wasterock piles. Based on previous investigations and current understanding of

Site conditions, the potentially contaminated exposure media for ecological receptors are outlined in Figure 4-1 and include:

- Soil and wasterock piles at the Site;
- Surface water in Gold Creek; and
- Sediment in Gold Creek.

Given these exposure media, terrestrial, aquatic, and benthic ecological receptors may be exposed to COIs as depicted in Figure 4-1.

4.1.4 Assessment Endpoints and Measures

Assessment endpoints are qualitative or quantitative expressions of the environmental values to be protected and, therefore, assessed in the ERA. As such, assessment endpoints link the ERA and risk management processes by highlighting ecological aspects that are of concern to risk managers. Assessment measures are characteristics of the Site, selected ecological receptors, or ecosystem that are measured through monitoring or sampling activities, and then related qualitatively or quantitatively to the selected assessment endpoint(s).

4.1.4.1 Assessment Endpoints

Within a screening level ERA, assessment endpoints are generalized to reflect the risk-based screening process and protective ERBSCs. The assessment endpoints for this ERA include:

- Protection of the reproduction and survival of protected and non-protected plants, invertebrates, reptiles, birds, and mammals due to COIs in soil and wasterock at the Site;
- Protection of reproduction and survival of protected and non-protected aquatic life (including amphibians) due to COIs in Gold Creek surface water and pore water; and
- Protection of reproduction and survival of benthic invertebrates, amphibians, birds, and mammals due to COIs in sediment within the Gold Creek.

4.1.4.2 Assessment Measures

Assessment measures are used to evaluate the response of the indicator communities/species when exposed to a stressor. Generally, they are measurable ecological characteristics and define what samples and/or data will be collected to address the assessment endpoints. For this ERA, the assessment measures are comprised of the following:

- Measured concentrations of COIs in soil/wasterock, surface water, pore water, and sediment; and
- Readily available ERBSCs available from Ecology guidance (Ecology, 2001) and other applicable guidance or in published literature (ODEQ, 2001).

4.2 ECOLOGICAL RISK-BASED SCREENING

Ecological risk-based screening begins with the list of COIs shown in Table 2-1. EPCs are then determined for each COI in each potential exposure medium, and compared to selected ERBSC with consideration of bioaccumulation potential and exposures to multiple chemicals and multiple media. The result is a list of Site-related contaminants of potential ecological concern (COPEC).

As described above in Section 3.2.3, the preferred EPCs used in the risk-based screening were the lower of the 95UCL or the maximum detected concentrations. If fewer than 10 samples were available, then the maximum detected concentration was used as the EPC. One-half the sample reporting limit was used in these calculations when a particular chemical was listed as not detected. The maximum sample reporting limit for a given chemical and medium was also included in the risk-based screening as secondary EPCs, to identify COIs with elevated reporting limits that may be contributing to ecological risks. The EPCs for each medium are listed in Table 4-1.

Table 4-1
Exposure Point Concentrations for Ecological Exposure Media

Chemical of Interest	Surface Soil/ Wasterock (mg/kg)	Surface Water (µg/L)	Pore Water (µg/L)	Sediment (mg/kg)
Aluminum				6,360
Antimony	8,560		0.8	0.6
Arsenic III	27.1	0.084	10.6	
Arsenic V	8,210	0.448	7.3	7.59
Arsenic, total	10,700	0.489	17.9	
Barium	180		16	33.2
Beryllium	0.588			
Cadmium	5.52			0.2
Chromium, total	11.8			20
Cobalt	25.3			
Copper	160	10 (SRL)	10 (SRL)	9.6
Iron	69,500		800	13,800
Lead	119		0.2	1.6
Manganese	3,050		294	227
Mercury	0.635	0.000829	0.00822	
Nickel	28.5			9.6
Selenium	0.555			2 (SRL)
Silver	4.04		1.3	
Thallium	0.424			
Vanadium				23
Zinc	310			29

SRL = Based on the Sample Reporting Limit

The preferred ERBSCs used in the risk-based screening were Ecology ecological soil screening values (2001) and water quality standards (2003). When one of these ERBSCs was not available for a COI, additional screening level values (SLVs) were selected from those provided by the Oregon Department of Environmental Quality (ODEQ, 2001) or an ERBSC for a surrogate chemical was substituted when appropriate. Exceptions to these are referenced in Table B1-6.

The EPCs were compared to the medium- and receptor group-specific ERBSCs to calculate chemical-specific risk ratios (R_{ij}), receptor group risk ratios (R_j; the sum of the chemical-specific risk ratios), and each COI was examined for the potential to bioaccumulate and to determine whether it contributed an inordinate amount to the overall risk. The results of the ecological risk-based screening are medium-specific lists of COPECs (Table 4-2). Risk ratios greater than 1 indicate a potential risk; COIs which potential ecological risks are indicated become the COPECs. The results of the risk-based screening are provided in Tables 4-2 through 4-5, below. No ERBSCs are available for screening chemical concentrations in vegetation so the potential risks are described below in Section 4.3.2.

Table 4-2
Selected Contaminants of Potential Ecological Concern

Chemicals of Interest	Surface Soil/ Wasterock	Surface Water	Pore Water	Sediment
Aluminum		No COPECs		X[1]
Antimony	X		X[1]	
Arsenic III	X			
Arsenic V	X			X
Arsenic, total	X			
Barium	X		X	X[1]
Cadmium				X
Cobalt	X[1]			
Copper	X			
Iron	X		X[1]	X[1]
Lead	X			
Manganese	X		X	X[1]
Mercury	X			
Nickel				X[2]
Selenium	X			X[1,3]
Silver	X		X	
Thallium	X[1]			
Vanadium				X[1]
Zinc	X			X

1 – Selected as COPEC because no ERBSC was available.
2 – Selected as COPEC because of inordinate contribution to overall risk.
3 – Selected as COPEC because of elevated reporting limits.

Table 4-3
Risk Ratios for Surface Soil/Wasterock

Contaminants of Potential Ecological Concern	Terrestrial Plants (R_{ij})	n	Terrestrial Invertebrates (R_{ij})	n	Birds (R_{ij})	n	Mammals (R_{ij})	n
Antimony	**1,711**	9	**570**	9	**No ERBSC**		**570**	9
Arsenic III	**3**	9	0.5		**4**	9	**4**	9
Arsenic V	**821**	12	**137**	12	**62**	12	**62**	12
Arsenic, total	**1,071**	9	**178**	9	**1,071**	9	**370**	9
Barium	0.4		0.06		**2**	6	**2**	6
Cobalt	1		0.03		**No ERBSC**		0.2	
Copper	**2**	9	**3**	9	0.7		**3**	
Iron	**6,951**	9	**348**	9	**No ERBSC**		**No ERBSC**	
Lead	**2**	8	0.2		1		1	
Manganese	**3**	3	**30**	3	**2**	3	**2**	3
Mercury	**2**	7	**6**	9	0.1		0.1	
Selenium	1		0.01		**2**	2	**2**	2
Silver	**2**	5	0.1		**No ERBSC**		**No ERBSC**	
Thallium	0.4		0.4		**No ERBSC**		0.4	
Zinc	**4**	9	**2**	9	0.9		0.9	
Total Receptor Group Risk (R_j)	**10,577**		**1,277**		**1,146**		**1,025**	

Bold = COPECs with risk ratio greater than acceptable levels (i.e., >1) or no ERBSC is available.
n = number of exceedances of both an ERBSC and average background concentration.

Table 4-4
Risk Ratios for Pore Water

Contaminant of Potential Ecological Concern	Aquatic Life (R_{ij})	n	Birds (R_{ij})	n	Mammals (R_{ij})	n
Antimony	0.0005		**No ERBSC**		0.0008	
Barium	**4**	3	0.0001		0.0004	
Iron	0.8		**No ERBSC**		**No ERBSC**	
Manganese	**2**	1	0.00004		0.0004	
Silver	**11**	3	**No ERBSC**		**No ERBSC**	
Total Receptor Group Risk (R_j)	**19**		0.002		0.008	

Bold = COPECs with risk ratio greater than acceptable levels (i.e., >1) or no ERBSC is available.
n = number of exceedances of an ERBSC and average background concentration.

Table 4-5
Risk Ratios for Sediment

Contaminant of Potential Ecological Concern	Benthic Invertebrates (R_{ij})	n	Birds and Mammals (R_{ij})	n
Aluminum	**No ERBSC**		**No ERBSC**	
Arsenic, V	1		**2**	
Barium	**No ERBSC**		**No ERBSC**	
Cadmium	0.3		**67**	1
Chromium, total	**IC**		0.005	
Iron	**No ERBSC**		**No ERBSC**	
Manganese	0.2		**No ERBSC**	
Nickel	**IC**		0.03	
Selenium	**No ERBSC**		**Reporting Limit**	
Vanadium	**No ERBSC**		**No ERBSC**	
Zinc	0.2		**10**	1
Total Receptor Group Risk (R_j)	**4**		**79**	

Bold = COPECs with risk ratio greater than acceptable levels (i.e., >1) or no ERBSC is available.
IC = Inordinate Contribution to receptor group risks;
n = number of exceedances of an ERBSC and average background concentration.

Overall, the ecological risk-based screening results indicate a potential for ecological risk due to many metals in soil/wasterock (primarily antimony, arsenic, and iron); a few metals in vegetation (primarily antimony and total arsenic); antimony, barium, iron, manganese, and silver in Gold Creek pore water; and several metals (primarily cadmium) in Gold Creek sediment. Arsenic V, barium, manganese, silver, and zinc were the only COPECs that exceeded ERBSCs in two or more media. The COPECs with risk ratios greater than 10 were antimony, arsenic V, total arsenic, iron, and manganese in soil/wasterock, silver in Gold Creek pore water, and cadmium in sediment. The results of the ecological risk-based screening are discussed further in Section 4.3 below.

4.3 ECOLOGICAL RISK CHARACTERIZATION

Risk characterization includes risk description and uncertainty analysis. Risk description involves examining the predicted risks to determine whether they are likely, or artifacts of the risk assessment process.

4.3.1 Soil/Wasterock

The COPECs for soil/wasterock were listed in Table 4-2. Cobalt and thallium were indicated as a COPECs solely because of a lack of an ERBSC for birds. Selenium had elevated detection limits in addition to detected concentrations slightly exceeding the bird and mammal ERBSCs. The elevated detection limits for selenium were nearly identical to the detected concentrations. Given the lack of an exceedance of three available ERBSCs for cobalt and thallium, the low risk ratio of two for birds and mammals exposed to selenium, and that selenium was only detected in two samples, significant risks are not expected due to these COPECs.

Given the multiple exceedances of maximum background concentrations and ERBSCs by multiple chemicals, it seems likely that ecological risks are posed by COPECs in soil/wasterock. The major COPECs (risk ratios >10) are antimony, arsenic (V and total), iron, and manganese. However, because the wasterock piles are relatively small and are distributed across the Site, the most significant risk would be posed to plants and invertebrates. More mobile and wide-ranging wildlife species are unlikely to spend large amounts of time on or around the wasterock piles, and thus, are less likely to be impacted by the COPECs.

4.3.2 Vegetation

No ERBSCs are available for vegetation so exceedances of background vegetation concentrations were examined. Nickel and vanadium were not detected in background samples so a comparison could not be made; however, these two COPECs were only detected in one of the three samples, so they do not appear to be widespread in vegetation at the Site. Aluminum, cadmium, copper, manganese, silver, and zinc exceeded respective background concentrations by less than a factor of 2. These COIs are very likely to be within the range of natural background concentrations and therefore, are not considered further. Iron and lead exceeded respective background concentrations by less than a factor of 4, and antimony and total arsenic exceeded background concentrations by factors of 10 and 30, respectively. Given this, antimony and total arsenic are the COPECs with the most potential to bioaccumulate in the terrestrial food chain.

4.3.3 Gold Creek Surface Water

There are no COPECs for surface water. Therefore, ecological risks are not expected due to Site-related chemicals in Gold Creek surface water.

4.3.4 Gold Creek Pore Water

The COPECs for pore water in Gold Creek are listed in Table 4-4. Of these, antimony and iron were indicated as COPECs solely because of a lack of ERBSCs for birds and/or mammals. Barium was the only COPEC with exceedances of ERBSCs in more than one of the three samples but only exceeded the background concentration by a factor of less than 2. Silver was the only COPEC with a risk ratio greater than 10. Given this, silver in pore water at GC-03 has the greatest potential for ecological impacts.

4.3.5 Gold Creek Sediment

The COPECs for Gold Creek sediment were shown in Table 4-5. Aluminum, barium, iron, manganese, vanadium, and zinc were selected as COPECs solely because of a lack of ERBSCs, and total chromium and nickel were selected as COPECs due to an inordinate contribution to the overall risks. However, all of these COPECs, zinc, and cadmium exceeded respective maximum background concentrations by less than or equal to a factor of 2. It is likely that these COPECs are present within normal background concentrations. The risk ratio for arsenic V is 2, which is only slightly above the acceptable limit of 1 so

any ecological impacts resulting from exposure to arsenic V in sediment are likely to be low. Thus, ecological impacts are unlikely due to these COPECs.

Selenium had elevated reporting limits that exceeded the available ERBSC for wildlife by a factor of 20, and was not detected in background concentrations. Selenium is highly toxic and does have a propensity to bioaccumulate, but the limited number of detections in soil/wasterock and the lack of detection of selenium in other media suggest selenium is not widespread at the Site, nor is it being transported in significant concentrations. Thus, selenium is not considered to be a concern at the Site.

4.4 UNCERTAINTY ANALYSIS

The primary uncertainties associated with this ecological risk-based screening and the impacts on the prediction of the potential for ecological risks are discussed below. This information is combined with that provided above in the risk characterization section to provide conclusions and recommendations regarding ecological risks.

4.4.1 Analytical Data

The analytical data are from samples collected in areas of known and suspected high contamination. This results in an overestimation of the potential chemical exposure of all species except those that are immobile, such as plants and invertebrates. And even in these cases, only individuals among the receptor population are likely to be impacted, which is critical only for protected species. More mobile species are exposed over a wider area that has lower concentrations or none of the Site-related chemicals. Thus, the calculated risks overestimate the actual risks posed to upper trophic level species (i.e., bird and mammals).

4.4.2 Risk-Based Screening Procedures

The use of maximum detected concentration or 95UCL as the EPC is a conservative approach that is purposefully designed to result in some overestimation of the potential ecological risks. Because of this, the risks predicted are likely to overestimate actual ecological risks at the Site.

Including a maximum sample reporting limit screening is a conservative approach that includes COIs as COPECs when they are actually not detected at elevated concentrations. Because the undetected COI is likely present at concentrations less than the reporting limit, including the COI as a COPEC, result in an overestimation of the potential for ecological risks.

4.4.3 Ecological Data Gaps

Silver was selected as a COPEC for upper trophic level ecological receptors due to the potential to bioaccumulate. However, a general lack of silver bioavailability data does not allow for a formal assessment of risks due to silver in soil for upper trophic level receptors (i.e., birds and mammals). In addition, silver was not detected in any of six plant tissue samples, suggesting that the silver is not bioavailable. Given this evidence, risks due to the bioaccumulation of silver from soil are not predicted. Overall, the use of a bioaccumulation screening is a conservative measure used to assess the potential for risks posed to upper trophic level ecological receptors when appropriate ERBSCS are missing.
The lack of ERBSCs for some receptors precludes the calculation of risk for those receptors. This may result in over- or underestimation of the potential for ecological risks.

4.4.4 Ecotoxicological Data

Many of the ERBSCs used for this ERA are intended to be a no-observed-adverse-effect-level (NOAEL). Because actual ecological effects occur at an unknown concentration somewhere between the NOAEL and the lowest-observed adverse effect level (LOAEL), simply exceeding an ERBSC does not necessarily indicate the potential for significant ecological effects. Thus, the use of NOAEL-based ERBSCs likely results in an overestimation of the potential for ecological risk.

4.5 SUMMARY OF ECOLOGICAL RISKS

Elevated concentrations of COPECs are present in all of soil/wasterock samples collected from the Site, and it is likely that plants and invertebrates are impacted within these localized areas and vegetation within the wasterock piles appears to be bioaccumulating antimony and total arsenic. Given the highest risk ratios and most widespread distribution, antimony, arsenic (V, and total), iron, and manganese are the COPECs most likely to pose unacceptable risks in soil/wasterock. However, while the plants and invertebrates within the wasterock piles are predicted to be at risk, the populations are unlikely to be significantly impacted within the vicinity of the Site because of the very limited area of potential exposure. In addition, the habitat lost due to any effects on plants is also unlikely to result in significant effects to upper trophic level species due to the large amount of relatively undisturbed habitat available surrounding the Site. Some upper trophic level species were predicted to be at risk due to COPECs in soil/wasterock. However, given the relatively large home ranges of the species in proximity to the Site, and the presence of a large amount of nearby suitable uncontaminated habitat, significant effects to these species seem unlikely.

Given the proximity to Gold Creek, the wasterock piles are likely past and current source areas for chemicals to be transported to Gold Creek. However, ecological impacts were not predicted for COIs in surface water. Thus, this transport of COPECS from soil/wasterock to surface water appears insignificant.

In pore water, silver at GC-03 was the only COPEC predicted to present potentially ecological impacts. Ecological impacts due to COPECs in sediment are likely low given the predominantly low risk ratios and limited chemical distribution.

Based on the information presented in the ERA, significant ecological risks are not expected. Therefore, additional investigations or cleanup of Site is not warranted.

5.0 CONCLUSIONS AND RECOMMENDATIONS

A recreational user was identified as the only likely human receptor at the Site. Due to the isolated location and steep terrain and topography of the Site, recreational use is expected to be very limited. Potential unacceptable health impacts from ingestion and dermal contact with arsenic impacted soils/wasterock may be present at the Site. However, it is highly unlikely that recreational users would engage in activities at the Site that could result in significant ingestion or dermal contact with soil and wasterock. The most realistic and likely pathway of exposure at the Site is inhalation of particulates by hikers, hunters, or trespassers. The quantitative risk assessment determined that the inhalation pathway did not result in unacceptable non-carcinogenic or carcinogenic risks. Concentrations at the Site exceeded background by slightly more than an order of magnitude or less, therefore no hotspots (i.e., areas of significantly high concentrations) were identified.

Elevated concentrations of COPECs are present in all of soil/wasterock samples collected from the Site, and it is likely that plants and invertebrates are impacted within these localized areas. Given the highest

risk ratios and most widespread distribution, antimony, arsenic (V, and total), iron, and manganese are the COPECs most likely to pose unacceptable risks in soil/wasterock. However, while the plants and invertebrates within the wasterock piles are predicted to be at risk, the populations are unlikely to be significantly impacted within the vicinity of the Site because of the very limited area of potential exposure. In addition, the habitat lost due to any effects on plants is also unlikely to result in significant effects to upper trophic level species due to the large amount of relatively undisturbed habitat available surrounding the Site. Some upper trophic level species were predicted to be at risk due to COPECs in soil/wasterock. However, given the relatively large home ranges of the species in proximity to the Site, and the presence of a large amount of nearby suitable uncontaminated habitat, significant effects to these species seem unlikely. Silver was the only pore water COPEC predicted to present potentially ecological impacts. Ecological impacts due to COPECs in sediment are likely low given the predominantly low risk ratios, and limited chemical distribution.

Based on the information presented in the HHRA and ERA, significant human and ecological risks are not expected. Therefore, additional investigations or cleanup of Site is not warranted.

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FIGURE 3-1: Conceptual Human Health Exposure Model

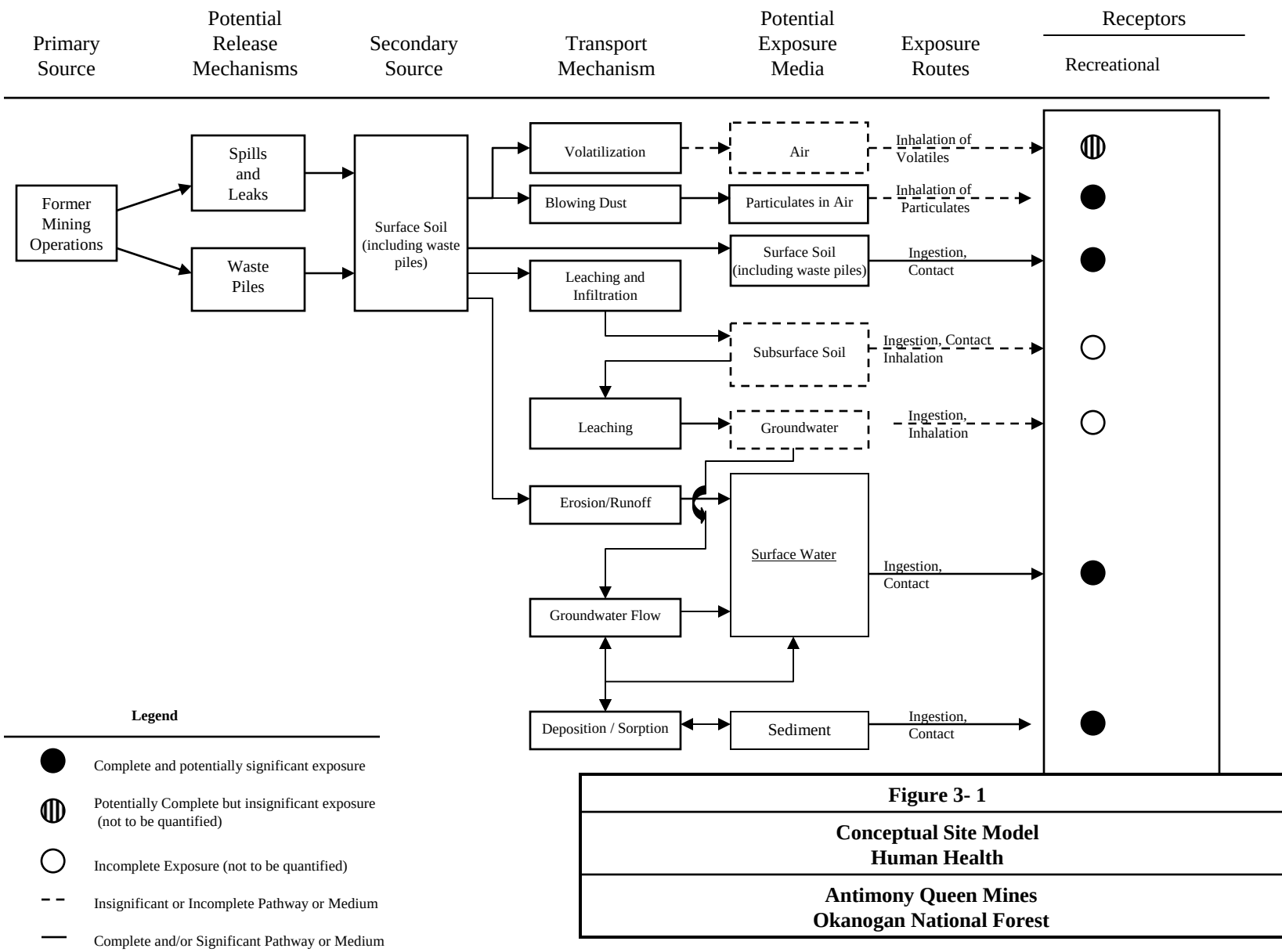
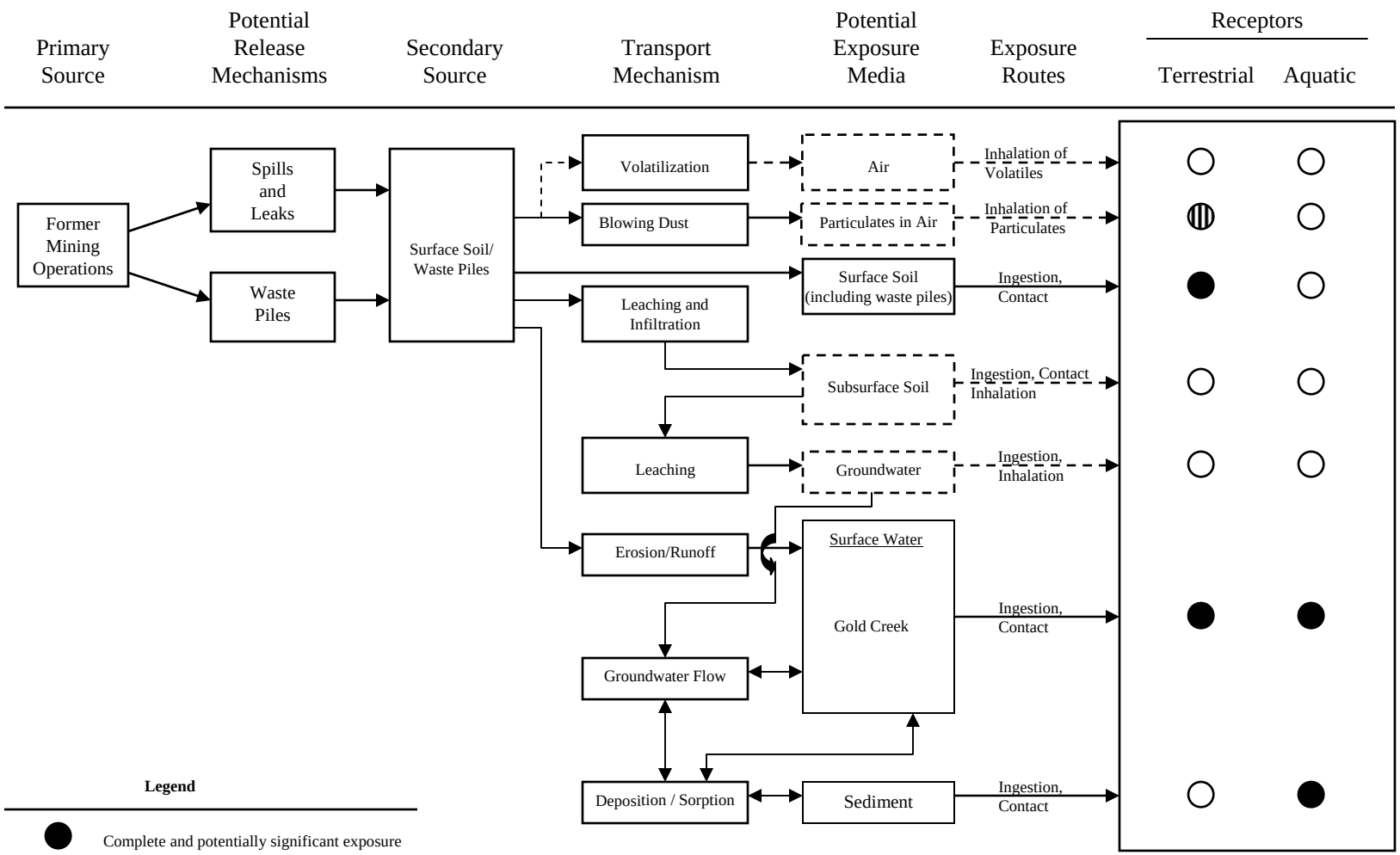


Figure 3- 1

Conceptual Site Model
Human Health

Antimony Queen Mines
Okanogan National Forest

FIGURE 4-1: Conceptual Ecological Exposure Model



Legend

- ● Complete and potentially significant exposure
- ◍ Potentially Complete but insignificant exposure (not to be quantified)
- ○ Incomplete Exposure (not to be quantified)
- - - Insignificant or Incomplete Pathway or Medium
- — Complete and/or Significant Pathway or Medium

Figure 4-1

Conceptual Ecological Exposure Model

Antimony Queen Mine
Okanogan National Forest
Carlton, Washington

APPENDIX B1: Initial Screening Results

TABLE B1-1
DATA SUMMARY AND INITIAL SCREENING FOR SURFACE SOIL

Chemical Of Interest	Number of Analyses	Number of Detections	Frequency of Detection	Minimum Detected Concentration (mg/kg)	Maximum Detected Concentration (mg/kg)	Minimum Sample Reporting Limit (mg/kg)	Maximum Sample Reporting Limit (mg/kg)	Minimum Soil Ecological Risk-Based Screening Concentration (mg/kg)	Minimum Human Health Risk-Based Screening Concentration (mg/kg)	Average Background Concentration (mg/kg)	Exceeds 5% Frequency of Detection?	Reporting Limit Too High For Ecological Receptors?	Reporting Limit Too High for Human Health?	Maximum Concentration Exceeds Background?	Ecological Chemical of Interest?	Human Health Chemical of Interest?
Metals																
Aluminum	10	10	100%	2,170	14,900	Not Applicable	Not Applicable	50	100,000	19,600	Yes	No	No	No	No	No
Antimony	10	10	100%	330	14,500	Not Applicable	Not Applicable	5	410	81.7	Yes	No	No	Yes	Yes	Yes
Arsenic III	14	14	100%	2.37	45.48	Not Applicable	Not Applicable	7	No Data	1.9	Yes	No	No	Yes	Yes	NA
Arsenic V	14	14	100%	1,831.07	10,101.76	Not Applicable	Not Applicable	10	No Data	857.8	Yes	No	No	Yes	Yes	NA
Arsenic, Total	10	10	100%	2,300	11,800	Not Applicable	Not Applicable	10	1.6	1,040.7	Yes	No	No	Yes	Yes	Yes
Barium	10	10	100%	111	216	Not Applicable	Not Applicable	102	67,000	144.7	Yes	No	No	Yes	Yes	Yes
Beryllium	10	10	100%	0.4	0.6	Not Applicable	Not Applicable	10	1,900	0.5	Yes	No	No	Yes	Yes	Yes
Cadmium	10	10	100%	2.19	9.49	Not Applicable	Not Applicable	4	450	2.4	Yes	No	No	Yes	Yes	Yes
Chromium, Total	10	10	100%	4	19	Not Applicable	Not Applicable	42	450	10	Yes	No	No	Yes	Yes	Yes
Cobalt	10	10	100%	19	29	Not Applicable	Not Applicable	20	1,900	20.7	Yes	No	No	Yes	Yes	Yes
Copper	10	10	100%	116	193	Not Applicable	Not Applicable	50	41,000	87.7	Yes	No	No	Yes	Yes	Yes
Iron	10	10	100%	51,000	74,300	Not Applicable	Not Applicable	10	100,000	40,066.7	Yes	No	No	Yes	Yes	Yes
Lead	10	10	100%	49	227	Not Applicable	Not Applicable	50	800	45.5	Yes	No	No	Yes	Yes	Yes
Manganese	10	10	100%	1,780	4,010	Not Applicable	Not Applicable	100	19,000	2,646.7	Yes	No	No	Yes	Yes	Yes
Mercury	10	10	100%	0.13	0.8	Not Applicable	Not Applicable	0.1	310	0.03	Yes	No	No	Yes	Yes	Yes
Nickel	10	10	100%	11	36	Not Applicable	Not Applicable	30	20,000	17.3	Yes	No	No	Yes	Yes	Yes
Selenium	10	2	20%	0.6	1.1	0.6	0.6	0.3	5,100	0	Yes	Yes	No	Yes	Yes	Yes
Silver	10	10	100%	1.27	7.09	Not Applicable	Not Applicable	2	5,100	0.9	Yes	No	No	Yes	Yes	Yes
Thallium	10	10	100%	0.15	0.71	Not Applicable	Not Applicable	1	67	0.2	Yes	No	No	Yes	Yes	Yes
Vanadium	10	10	100%	10.4	42	Not Applicable	Not Applicable	2	1,000	45.8	Yes	No	No	No	No	No
Zinc	10	10	100%	206	374	Not Applicable	Not Applicable	37.7	100,000	191.7	Yes	No	No	Yes	Yes	Yes

Notes:
kg = kilograms
mg = milligrams
NA = considered as total arsenic

TABLE B1-2
DATA SUMMARY AND INITIAL SCREENING FOR VEGETATION

Chemical Of Interest	Number of Analyses	Number of Detections	Frequency of Detection	Minimum Detected Concentration (mg/kg)	Maximum Detected Concentration (mg/kg)	Minimum Sample Reporting Limit (mg/kg)	Maximum Sample Reporting Limit (mg/kg)	Minimum Terrestrial Ecological Risk-Based Screening Concentration (mg/kg)	Average Background Concentration (mg/kg)	Exceeds 5% Frequency of Detection?	Reporting Limit Too High For Ecological Receptors?	Maximum Concentration Exceeds Background?	Ecological Chemical of Interest?
Metals													
Aluminum	3	3	100%	39	58	Not Applicable	Not Applicable	No Data	37.3	Yes	No	Yes	Yes
Antimony	3	3	100%	0.7	18.8	Not Applicable	Not Applicable	No Data	0.7	Yes	No	Yes	Yes
Arsenic, total	3	3	100%	2.9	24	Not Applicable	Not Applicable	No Data	2.5	Yes	No	Yes	Yes
Barium	3	3	100%	4.6	12.1	Not Applicable	Not Applicable	No Data	40	Yes	No	No	No
Beryllium	3	0	0%	Not Detected	Not Detected	0.2	0.2	No Data	0	No	No	No	No
Cadmium	3	1	33%	0.1	0.1	0.1	0.1	No Data	0.1	Yes	No	Yes	Yes
Cyanide	3	1	33%	1.1	1.1	0.5	0.5	No Data	5.3	Yes	No	No	No
Chromium, Total	3	0	0%	Not Detected	Not Detected	1	1	No Data	0	No	No	No	No
Cobalt	3	0	0%	Not Detected	Not Detected	1	1	No Data	0	No	No	No	No
Copper	3	3	100%	6	7	Not Applicable	Not Applicable	No Data	5.7	Yes	No	Yes	Yes
Iron	3	3	100%	77	249	Not Applicable	Not Applicable	No Data	76.3	Yes	No	Yes	Yes
Lead	3	3	100%	0.3	1.2	Not Applicable	Not Applicable	No Data	0.4	Yes	No	Yes	Yes
Manganese	3	3	100%	89.9	480	Not Applicable	Not Applicable	No Data	272.3	Yes	No	Yes	Yes
Mercury	3	0	0%	Not Detected	Not Detected	0.1	0.1	No Data	0	No	No	No	No
Nickel	3	1	33%	1	1	1	1	No Data	0	Yes	No	Yes	Yes
Selenium	3	0	0%	Not Detected	Not Detected	0.6	0.6	No Data	0	No	No	No	No
Silver	3	2	67%	0.04	0.04	0.03	0.03	No Data	0.027	Yes	No	Yes	Yes
Thallium	3	0	0%	Not Detected	Not Detected	0.03	0.1	No Data	0.1	No	No	No	No
Vanadium	3	1	33%	0.6	0.6	0.5	0.5	No Data	0	Yes	No	Yes	Yes
Zinc	3	3	100%	30	32	Not Applicable	Not Applicable	No Data	28.0	Yes	No	Yes	Yes

Notes:

kg = kilograms
mg = milligrams

TABLE B1-3
DATA SUMMARY AND INITIAL SCREENING FOR GOLD CREEK SURFACE WATER

Chemical Of Interest	Number of Analyses	Number of Detections	Frequency of Detection	Minimum Detected Concentration (mg/L)	Maximum Detected Concentration (mg/L)	Minimum Sample Reporting Limit (mg/kg)	Maximum Sample Reporting Limit (mg/kg)	Minimum Surface Water Ecological Risk-Based Screening Concentration (mg/L)	Minimum Human Health Risk-Based Screening Concentration (mg/L)	Average Background Concentration (mg/L)	Exceeds 5% Frequency of Detection?	Reporting Limit Too High For Ecological Receptors?	Reporting Limit Too High for Human Health?	Maximum Concentration Exceeds Background?	Ecological Chemical of Interest?	Human Health Chemical of Interest?
Metals																
Aluminum	3	0	0%	Not Detected	Not Detected	0.03	0.03	0.087	36	0.1	No	No	No	No	No	No
Antimony	3	0	0%	Not Detected	Not Detected	0.0002	0.0002	1	0.015	0	No	No	No	No	No	No
Arsenic III	3	3	100%	0.000041	0.000084	Not Applicable	Not Applicable	0.15	No Data	0.000065	Yes	No	No	Yes	Yes	NA
Arsenic V	3	3	100%	0.00032	0.00045	Not Applicable	Not Applicable	0.15	No Data	0.00026	Yes	No	No	Yes	Yes	NA
Arsenic, Total	3	3	100%	0.00039	0.00049	Not Applicable	Not Applicable	0.19	0.000045	0.00032	Yes	No	No	Yes	Yes	Yes
Barium	3	3	100%	0.01	0.011	Not Applicable	Not Applicable	0.004	2.6	0.011	Yes	No	No	No	No	No
Beryllium	3	0	0%	Not Detected	Not Detected	0.002	0.002	0.0053	0.073	0	No	No	No	No	No	No
Cadmium	3	0	0%	Not Detected	Not Detected	0.0001	0.0001	0.00042	0.018	0	No	No	No	No	No	No
Chromium III	3	0	0%	Not Detected	Not Detected	0.005	0.005	0.066	55	0	No	No	No	No	No	No
Chromium VI	3	0	0%	Not Detected	Not Detected	0.005	0.005	0.01	0.11	0	No	No	No	No	No	No
Chromium, Total	3	0	0%	Not Detected	Not Detected	0.01	0.01	0.01	No Data	0	No	No	No	No	No	No
Cobalt	3	0	0%	Not Detected	Not Detected	0.01	0.01	0.023	No Data	0	No	No	No	No	No	No
Copper	3	0	0%	Not Detected	Not Detected	0.01	0.01	0.0041	1.5	0	No	Yes	No	No	Yes	No
Iron	3	0	0%	Not Detected	Not Detected	0.01	0.01	1	1.5	0	No	No	No	No	No	No
Lead	3	0	0%	Not Detected	Not Detected	0.0001	0.0001	0.00066	No Data	0	No	No	No	No	No	No
Manganese	3	0	0%	Not Detected	Not Detected	0.005	0.005	0.12	0.88	0	No	No	No	No	No	No
Mercury	3	3	100%	0.00000072	0.00000083	Not Applicable	Not Applicable	0.000012	No Data	0.00000073	Yes	No	No	Yes	Yes	Yes
Nickel	3	0	0%	Not Detected	Not Detected	0.01	0.01	0.057	0.73	0	No	No	No	No	No	No
Selenium	3	0	0%	Not Detected	Not Detected	0.002	0.002	0.005	0.18	0	No	No	No	No	No	No
Silver	3	0	0%	Not Detected	Not Detected	0.00005	0.00005	0.00012	0.18	0	No	No	No	No	No	No
Thallium	3	0	0%	Not Detected	Not Detected	0.00005	0.00005	0.04	0.0024	0	No	No	No	No	No	No
Vanadium	3	0	0%	Not Detected	Not Detected	0.005	0.005	0.02	0.036	0	No	No	No	No	No	No
Zinc	3	3	100%	0.01	0.02	Not Applicable	Not Applicable	0.038	11	0.02	Yes	No	No	No	No	No

Notes:
L = liters
mg = milligrams
NA = considered as total arsenic

TABLE B1-4
DATA SUMMARY AND INITIAL SCREENING FOR GOLD CREEK PORE WATER

Chemical Of Interest	Number of Analyses	Number of Detections	Frequency of Detection	Minimum Detected Concentration (mg/L)	Maximum Detected Concentration (mg/L)	Minimum Sample Reporting Limit (mg/kg)	Maximum Sample Reporting Limit (mg/kg)	Minimum Surface Water Ecological Risk-Based Screening Concentration (mg/L)	Average Background Concentration (mg/L)	Exceeds 5% Frequency of Detection?	Reporting Limit Too High For Ecological Receptors?	Maximum Concentration Exceeds Background?	Ecological Chemical of Interest?
Metals													
Aluminum	3	0	0%	Not Detected	Not Detected	0.03	0.03	0.087	0	No	No	No	No
Antimony	3	2	67%	0.0004	0.0008	0.0002	0.0002	1	0	Yes	No	Yes	Yes
Arsenic III	3	3	100%	0.000019	0.011	Not Applicable	Not Applicable	0.15	0.000022	Yes	No	Yes	Yes
Arsenic V	3	3	100%	0.00046	0.0073	Not Applicable	Not Applicable	0.15	0.00036	Yes	No	Yes	Yes
Arsenic, Total	3	3	100%	0.00048	0.018	Not Applicable	Not Applicable	0.19	0.00038	Yes	No	Yes	Yes
Barium	3	3	100%	0.009	0.016	Not Applicable	Not Applicable	0.004	0.009	Yes	No	Yes	Yes
Beryllium	3	0	0%	Not Detected	Not Detected	0.002	0.002	0.0053	0	No	No	No	No
Cadmium	3	0	0%	Not Detected	Not Detected	0.0001	0.0001	0.00042	0	No	No	No	No
Chromium III	3	0	0%	Not Detected	Not Detected	0.005	0.005	0.066	0	No	No	No	No
Chromium VI	3	0	0%	Not Detected	Not Detected	0.005	0.005	0.01	0	No	No	No	No
Chromium, Total	3	0	0%	Not Detected	Not Detected	0.01	0.01	0.01	0	No	No	No	No
Cobalt	3	0	0%	Not Detected	Not Detected	0.01	0.01	0.023	0	No	No	No	No
Copper	3	0	0%	Not Detected	Not Detected	0.01	0.01	0.0041	0	No	Yes	No	Yes
Iron	3	2	67%	0.12	0.8	0.01	0.01	1	0.01	Yes	No	Yes	Yes
Lead	3	1	33%	0.0002	0.0002	0.0001	0.0001	0.00066	0	Yes	No	Yes	Yes
Manganese	3	2	67%	0.059	0.29	0.005	0.005	0.12	0	Yes	No	Yes	Yes
Mercury	3	3	100%	0.00000081	0.0000082	Not Applicable	Not Applicable	0.000012	0.0000011	Yes	No	Yes	Yes
Nickel	3	0	0%	Not Detected	Not Detected	0.01	0.01	0.057	0	No	No	No	No
Selenium	3	0	0%	Not Detected	Not Detected	0.002	0.002	0.005	0	No	No	No	No
Silver	3	1	33%	0.0013	0.0013	0.00005	0.00005	0.00012	0	Yes	No	Yes	Yes
Thallium	3	3	100%	0.00008	0.00013	Not Applicable	Not Applicable	0.04	0.00018	Yes	No	No	No
Vanadium	3	0	0%	Not Detected	Not Detected	0.0	0.0	0.02	0	No	No	No	No
Zinc	3	3	100%	0.01	0.01	Not Applicable	Not Applicable	0.038	0.01	Yes	No	No	No

Notes:
L = liters
mg = milligrams

TABLE B1-5
DATA SUMMARY AND INITIAL SCREENING FOR GOLD CREEK SEDIMENT

Chemical Of Interest	Number of Analyses	Number of Detections	Frequency of Detection	Minimum Detected Concentration (mg/kg)	Maximum Detected Concentration (mg/kg)	Minimum Sample Reporting Limit (mg/kg)	Maximum Sample Reporting Limit (mg/kg)	Minimum Sediment Ecological Risk-Based Screening Concentration (mg/kg)	Minimum Human Health Risk-Based Screening Concentration (mg/kg)	Average Background Concentration (mg/kg)	Exceeds 5% Frequency of Detection?	Reporting Limit Too High For Ecological Receptors?	Reporting Limit Too High for Human Health?	Maximum Concentration Exceeds Background?	Ecological Chemical of Interest?	Human Health Chemical of Interest?
Metals																
Aluminum	3	3	100%	4270	6360	Not Applicable	Not Applicable	No Data	100000	4550	Yes	No	No	Yes	Yes	Yes
Antimony	3	3	100%	0.3	0.6	Not Applicable	Not Applicable	3	410	0	Yes	No	No	Yes	Yes	Yes
Arsenic V	3	3	100%	4.75	7.59	Not Applicable	Not Applicable	4	No Data	1.68	Yes	No	No	Yes	Yes	NA
Arsenic, Total	3	3	100%	6.9	16.3	Not Applicable	Not Applicable	4	1.6	4.7	Yes	No	No	Yes	Yes	Yes
Barium	3	3	100%	27.2	33.2	Not Applicable	Not Applicable	No Data	67000	30.6	Yes	No	No	Yes	Yes	Yes
Beryllium	3	0	0%	Not Detected	Not Detected	0.20	0.20	122	1900	0	No	No	No	No	No	No
Cadmium	3	2	67%	0.1	0.2	0.10	0.10	0	450	0.10	Yes	No	No	Yes	Yes	Yes
Chromium, Total	3	3	100%	10	20	Not Applicable	Not Applicable	37	450	14	Yes	No	No	Yes	Yes	Yes
Cobalt	3	3	100%	3	4	Not Applicable	Not Applicable	No Data	1900	4	Yes	No	No	No	No	No
Copper	3	3	100%	6	9.6	Not Applicable	Not Applicable	10	41000	6	Yes	No	No	Yes	Yes	Yes
Iron	3	3	100%	8960	13800	Not Applicable	Not Applicable	No Data	100000	8900	Yes	No	No	Yes	Yes	Yes
Lead	3	3	100%	1.3	1.6	Not Applicable	Not Applicable	35	800	1.3	Yes	No	No	Yes	Yes	Yes
Manganese	3	3	100%	122	227	Not Applicable	Not Applicable	1100	19000	127	Yes	No	No	Yes	Yes	Yes
Mercury	3	0	0%	Not Detected	Not Detected	0.04	0.04	0.2	310	0	No	No	No	No	No	No
Nickel	3	3	100%	6.1	9.6	Not Applicable	Not Applicable	18	20000	7.9	Yes	No	No	Yes	Yes	Yes
Selenium	3	0	0%	Not Detected	Not Detected	2.00	2.00	0.1	5100	0	No	Yes	No	No	Yes	No
Silver	3	0	0%	Not Detected	Not Detected	0.05	0.05	4.5	5100	0	No	No	No	No	No	No
Thallium	3	3	100%	0.07	0.09	Not Applicable	Not Applicable	0.7	67	0.17	Yes	No	No	No	No	No
Vanadium	3	3	100%	16.5	23	Not Applicable	Not Applicable	No Data	1000	17.3	Yes	No	No	Yes	Yes	Yes
Zinc	3	3	100%	21	29	Not Applicable	Not Applicable	3	100000	25	Yes	No	No	Yes	Yes	Yes

Notes:
kg = kilograms
L = liters
mg = milligrams
NA = considered as total arsenic

APPENDIX B2: Human Health Risk Calculations

TABLE B2-1
PRG SCREENING

	Media: Soil				Media: Sediment				Media: Surface Water			
COI	PRG (mg/kg)	MDL (mg/kg)	Ri	Individual COPC	PRG (mg/kg)	MDL (mg/kg)	Ri	Individual COPC	PRG (µg/L)	MDL (µg/L)	Ri	Individual COPC
Aluminum					100,000	6.36E+03	6.4E-02	no				
Antimony	410	14,500	3.5E+01	**YES**	410	6.00E-01	1.5E-03	no				
Arsenic	1.6	11,800	7.4E+03	**YES**	1.6	1.63E+01	1.0E+01	**YES**	0.045	0.489	1.1E+01	**YES**
Barium	67,000	216	3.2E-03	no	67,000	3.32E+01	5.0E-04	no				
Beryllium	1,900	1	5.3E-04	no								
Cadmium	450	9	2.0E-02	no	450	2.00E-01	4.4E-04	no				
Chromium	450	19	4.2E-02	no	450	2.00E+01	4.4E-02	no				
Cobalt	1,900	29	1.5E-02	no								
Copper	4,100	193	4.7E-02	no	41,000	9.60E+00	2.3E-04	no				
Iron	100,000	74,300	7.4E-01	no	100,000	1.38E+04	1.4E-01	no				
Lead	800	227	2.8E-01	no	800	1.60E+00	2.0E-03	no				
Manganese	19,000	4,010	2.1E-01	no	19,000	2.27E+02	1.2E-02	no				
Mercury	310	1	3.2E-03	no					11	0.000829	7.5E-05	no
Methyl Mercury												
Nickel	20,000	36	1.8E-03	no	20,000	9.6	4.8E-04	no				
Selenium	5,100	1	2.0E-04	no								
Silver	5,100	7	1.4E-03	no								
Thallium	67	1	1.5E-02	no								
Vanadium					1,000	2.30E+01	2.3E-02	no				
Zinc	100,000	374	3.7E-03	no	100,000	2.90E+01	2.9E-04	no				

Notes:
COI = Chemicals of Interest
COPCs = Chemicals of Potential Concern
PRG = Preliminary Remediation Goal from USEPA Region IX PRG Tables
MDL = Method Detection Limit
Ri = MDL/PRG
mg/kg = milligrams per kilogram
µg/L = micrograms per liter

TABLE B2-2
SUMMARY OF EXPOSURE FACTORS

	Recreational			
	Child		Adult	
Exposure Factors	**CTE**	**RME**	**CTE**	**RME**
Body Weight (kilograms)	15	15	71.8	71.8
Exposure Frequency (days/year) soil	13	26	13	26
Exposure Frequency (days/year) sediment	10	40	10	40
Event time surface water (hours/event)	2	2	2	2
Event time soil (hours/event)	2	2	2	2
Event Frequency (events/day)	1	1	1	1
Exposure Duration (years) noncarcinogen	2	6	7	24
Exposure Duration (years) carcinogens	70	70	70	70
Averaging Time (day)				
carcinogens	25,550	25,550	25,550	25,550
non-carcinogens	730	2,190	2,555	8,760
Intake Factors				
Ingestion of soil (milligrams/day)	100	200	50	100
Incidental ingestion of sediment (milligrams/day)	50	100	25	50
Incidental surface water ingestion (Liter/hour)	0.05	0.05	0.05	0.05
Exposed skin surface area (cm^2)	6,600	7,300	18,000	22,000
Inhalation rate (m^3/hour)	2	2.3	2.1	3.9
Dermal absorption factor				
volatile vp> 12000 Pa	0.0005	0.0005	0.0005	0.0005
volatile vp< 12000 Pa	0.03	0.03	0.03	0.03
semivolatiles	0.1	0.1	0.1	0.1
inorganics	0.01	0.01	0.01	0.01
Soil Adherence Factor (mg/cm^2-event)	0.08	0.08	0.08	0.08
PEF (mg^3/kg)	1.32E+09	1.32E+09	1.32E+09	1.32E+09

Notes:

cm^2 = sqaure centimeters

m^3/hour - cubic meters per hour

m^3/kg - cubic meters per kilogram

mg/cm^2-event = milligram per square centimeter - event

Averaging Time = Exposure Duration (yrs) X 365 days/year

TABLE B2-3
Critical Toxicity Data for Non-Carcinogenic COPCs

Contaminant	CAS Number	Chronic RfD (mg/kg-day) Oral	Confidence in RfD	Endpoint
Antimony	7440-36-0	4.00E-04	low	blood/rats
Arsenic	7440-38-2	3.00E-04	med	skin/vascular

TABLE B2-4
Critical Toxicity Data for Carcinogenic COPCs

Contaminant	CAS Number	Slope Factor (mg/kg/day)-1		Weight of Evidence Classification Ingestion/Inhalation	Type of cancer Ingestion/ Inhalation	Basis of Slope Factor oral/inhalation
		Oral	Inhalation			
Arsenic	7440-38-2	1.5E+00	1.5E+01	A	skin	epi studies

Notes:
COPCs = Chemicals of Potential Concern
CAS Number = Chemical Abstracts Scientific (Registration) Number
A = Known Human Carcinogen
RfD = noncancer reference dose (from USEPA Region IX PRG Tables)
mg/kg-day = millgrams per kilogram-day
mg/kg/day = millgrams per kilogram per day

TABLE B2-5
Exposure Point Concentrations

COPC	Number of Samples	Maximum Concentration	EPC	Basis for EPC
SOIL (mg/kg)				
Antimony	10	14,500	8,469	95UCL
Arsenic	10	11,800	10,639	95UCL
SURFACE WATER (mg/L)				
Arsenic	3	0.000489	0.000489	MAX
SEDIMENT (mg/kg)				
Arsenic	3	16.3	16.3	MAX

Notes:
COPCs = Chemicals of Potential Concern
EPC = Exposure Point Concentration
mg/kg = milligrams per kilogram
mg/L = milligrams per liter

TABLE B2-6
INTAKE CALCULATIONS

EXPOSURE ROUTES (Recreational)	Carcinogen		Non-Carcinogen	
	CTE	RME	CTE	RME
	Soil-Surface (mg/kg-d)			
Ingestion	7.7E-10	9.6E-09	2.2E-08	8.7E-08
Inhalation of particulates	2.80E-13	5.27E-12	6.75E-12	3.45E-11
Dermal	7.44E-02	6.24E-01	9.57E-01	1.82E+00
	Surface Water (mg/kg-d)			
Ingestion	9.0E-06	7.3E-05	2.2E-04	4.0E-04
Dermal	5.7E-02	9.6E-01	7.4E-01	2.8E+00
	Sediments (mg/kg-d)			
Ingestion	1.2E-09	7.4E-09	8.4E-09	6.7E-08
Dermal	7.95E-05	2.18E-03	7.95E-04	6.36E-03

TABLE B2-7
Non-Carcinogenic COPCs Calculation of Dermal Intakes

DERMAL DAsoil	DAF	CF (kg/mg)	Adherence Factors (mg/cm^2-event)		DA Values (mg/cm2-event)	
			CTE	RME	CTE	RME
Antimony	0.01	1E-06	8E-02	3E-01	8E-10	3E-09
Arsenic	0.03	1E-06	8E-02	3E-01	2.4E-09	9E-09

TABLE B2-8
Carcinogenic COPCs Calculation of Dermal Intakes

DERMAL DAsoil	DAF	CF (kg/mg)	Adherence Factors (mg/cm^2-event)		DA Values (mg/cm2-event)	
			CTE	RME	CTE	RME
Arsenic	0.03	1E-06	8E-02	3E-01	2.4E-09	9E-09

Notes:
DAF = Dermal Absorption Factor (unitless)
CF = Conversion Factor kg/mg
CTE = Central Tendency Exposure
RME = Reasonably Maximally Exposed
DAsoil = Dermal Absorption (soil) (mg/cm2-event)

TABLE B2-9
RECREATIONAL SCENARIO NON-CARCINOGENS

Route of Exposure	COPC	EPC mg/kg	Intake mg/kg-d		RFD_o mg/kg/day	Hazard Quotient	
Soil			**CTE**	**RME**		**CTE**	**RME**
Ingestion	Antimony	8.47E+02	2.19E-08	8.74E-08	4.00E-04	5.E-02	2.E-01
	Arsenic	8.51E+03	2.19E-08	8.74E-08	3.00E-04	6.E-01	2.E+00
Dermal	Antimony	8.47E+02	7.65E-10	5.46E-09	4.00E-04	2.E-03	1.E-02
	Arsenic	8.51E+03	2.30E-09	1.64E-08	3.00E-04	7.E-02	5.E-01
Surface Water							
Ingestion	Arsenic	3.91E-04	2.21E-04	3.96E-04	3.00E-04	3.E-04	5.E-04
Dermal	Arsenic	3.91E-04	1.47E-06	5.60E-06	3.00E-04	2.E-06	7.E-06
Sediments							
Ingestion	Arsenic	1.30E+01	8.41E-09	6.72E-08	3.00E-04	4.E-04	3.E-03
Dermal	Arsenic	1.30E+01	1.91E-12	5.72E-11	3.00E-04	8.E-08	2.E-06
					Hazard Index	**7.E-01**	**3.E+00**

Notes:
COPC = Chemical of Potential Concern
CTE = Central Tendency Exposure
RME = Reasonably Maximally Exposed
EPC = Exposure Point Concentration
RfDo = Oral noncancer reference dose
RfDi = Inhalation noncancer reference dose
mg/kg = milligrams per kilogram
mg/kg/day = milligrams per kilogram per day
mg/kg-day = milligrams per kilogram-day

TABLE B2-10
RECREATIONAL SCENARIO CARCINOGENS

Route of Exposure	COPC	EPC mg/kg	Intake mg/kg-d		Sfo mg/kg/day	SFi mg/kg/day	EXCESS CANCER RISK	
Soil			**CTE**	**RME**			**CTE**	**RME**
Ingestion	Arsenic	8.51E+03	7.72E-10	9.62E-09	1.50E+00		1.E-05	1.E-04
Dermal	Arsenic	8.51E+03	1.79E-10	5.61E-09	1.50E+00		2.E-06	7.E-05
Inhalation of particulates	Arsenic	1.06E+04	2.80E-13	5.27E-12		1.50E+01	4.E-08	8.E-07
Surface Water								
Ingestion	Arsenic	3.91E-04	9.03E-06	7.32E-05	1.50E+00		5.E-09	4.E-08
Dermal	Arsenic	3.91E-04	1.14E-07	1.92E-06	1.50E+00		7.E-11	1.E-09
Sediments								
Ingestion	Arsenic	1.30E+01	1.17E-09	7.40E-09	1.50E+00		2.E-08	1.E-07
Dermal	Arsenic	1.30E+01	1.91E-13	1.96E-11	1.50E+00		4.E-12	4.E-10
						Excess Cancar Risk Summary	**1.2E-05**	**2.0E-04**

Notes:
COPC = Chemical of Potential Concern
EPC = Exposure Point Concentration
Sfo = Slope Factor - Oral
Sfi = Slope Factor - Inhalation
mg/kg = milligram per kilogram
mg/kg/day = milligrams per kilogram per day
mg/kg-day = milligrams per kilogram-day

Table B2-11
HOTSPOT ANALYSIS

Sample ID	Sample Date	Arsenic, Total	Hotspot Concentration	Hotspot?
		mg/kg	mg/kg	Yes/No
AQ-WR1-1	9/18/2003	11,400	35,500	no
AQ-WR1-3	9/18/2003	11,800	35,500	no
AQ-WR1-4	9/18/2003	10,700	35,500	no
AQ-WR1-5	9/18/2003	11,800	35,500	no
AQ-WR1-6	9/18/2003	7,900	35,500	no
AQ-WR1-8	9/18/2003	4,500	35,500	no
AQ-WR1-10	9/18/2003	2,300	35,500	no
AQ-WR1-11	9/16/2003	5,700	35,500	no
AQ-WR2-1	9/16/2003	10,300	35,500	no
AQ-WR2-3	9/16/2003	10,300	35,500	no

Notes:

mg/kg = milligrams per kilogram

This appendix presents the calculations used in the HHRA.

B2.1 Calculation of Exposure Point Concentrations

An exposure point concentration is needed to calculate the Average Daily Dose (ADD) of a contaminant. Generally, the exposure point concentration is not the maximum concentration detected at the Site because, in most situations, it is not reasonable to assume long-term contact with the maximum concentration. Average concentrations are used because toxicity criteria are based on lifetime average exposures, and an average concentration is most representative of the concentration contacted over time, based on the assumption that an exposed individual moves randomly across an exposure area. Exposure for a chemical can be calculated using the exposure point concentration in units of mg/L for water, mg/kg for soil, or mg/m^3 for air.

When data sets are small, the maximum concentration detected is used as the exposure point concentration. However, average concentrations represent more realistic exposure point concentrations as they assume equal access to all portions of the Site. Where the data set is greater than ten, statistical analysis and calculation of the 95 percent upper confidence level on the arithmetic mean (95UCL) can be used as the EPC assuming that a normal distribution of the data can be demonstrated. The 95UCL is a conservative estimate of the average chemical concentration.

There are several methods by which the normality of a data set can be tested. EPA has recommended the use of the W test (Shapiro and Wilk, 1965) or D'Agostino's Test. Both of these methods can be used to test whether the data differ significantly from a normal distribution. It cannot determine whether the data are normally distributed, but rather whether a normal distribution can be assumed. The W test is recommended for data sets with 50 or fewer samples; D'Agostino's for data sets great than 50.

$$95\text{UCL} = e^{\left(\bar{x} - 0.5s^2 + \frac{sH_{1-\alpha}}{\sqrt{n-1}}\right)}$$

Environmental data sets are often asymmetrical and frequently positively skewed. Transforming the raw data points by taking the natural log of each concentration can normalize the data set. This is calculated as follows:

(transformed data point) = ln (raw data point)

The logarithmically transformed data set can be tested for normality in several ways. If the W test or D'Agostino's test indicates that the assumption of normality is valid, the 95UCL on the mean is calculated using Land's Method (Gilbert, R. O., Statistical Methods for Environmental Pollution Monitoring, 1987).

$$95\text{UCL} = \exp(x + 0.5s^2 + sH/\sqrt{n-1})$$

For data sets wherein neither a normal nor a lognormal distribution could be demonstrated, a Z calculation adjusted for skewness was used to determine the 95UCL calculation. (EPA, 1997).

$$95\text{UCL} = x + Z_{a,adj} * s/n^{0.5}$$

Where:

X	=	sample mean
$Z_{a,adj}$	=	the Z value adjusted for skewness
S	=	sample standard deviation
N	=	sample size

And,

$$Z_{a,adj} = Z_a + k^2/6n^{0.5}\,(1 + 2Z_a^{\,2})$$

Where:

$Z_{a,adj}$	=	the Z value adjusted for skewness
K	=	sample coefficient of skewness
N	=	sample size
Z_a	=	the Z parameter for a one-sided upper 90 percent confidence limit

The EPCs for the Site COPCs are presented in TableB2-6 along with the basis for their selection.

B2.2 Calculation of Average Daily Dose

While presented individually in the equations, USEPA Region X allows for the calculation of Summary Intake Factors (Intake Factors). Intake Factors represent the sum lifetime exposure to contaminated soil, water, or air through the pathway. The Intake Factor represents everything except the chemical concentration in the generic intake equation.

$$I = \frac{CR * EFD}{BW} * \frac{1}{AT}$$

Where:

I	=	Intake Factor (mg/kg-BW-day;l/kg-BW-day)
CR	=	Media Contact Rate (mg/kg/day or L/kg/day)
EFD	=	Receptor exposure factors(days/year, years)
BW	=	Body weight (kg)
AT	=	Averaging Time (days)

B2.2.1 Ingestion of Soil and Sediment

The ADD from ingestion of soil is calculated as follows:

Carcinogens, other

$$ADD = \frac{EPC_s \cdot IRS \cdot CF_{km} \cdot \left(EF_{hd}/CF_{hd}\right) \cdot EF_{dy} \cdot ED}{BW \cdot AT_c}$$

Non-carcinogens

$$ADD = \frac{EPC_s \cdot IRS \cdot CF_{km} \cdot \left(EF_{hd}/CF_{hd}\right) \cdot EF_{dy} \cdot ED}{BW \cdot AT_n}$$

Where:

ADD	=	Average daily dose from incidental soil ingestion (mg/[kg·d])
EPC_s	=	Contaminant concentration in soil (mg/kg)
IRS_{adj}	=	Age-adjusted incidental soil ingestion factor ([mg·yr]/[kg·d])
IRS	=	Incidental soil ingestion rate (mg/d)
CF_{km}	=	Conversion factor (10^{-6} kg/mg)
EF_{hd}	=	Exposure frequency (hr/d)
CF_{hd}	=	Conversion factor (24 hr/d)
BW	=	Body weight (kg)
EF_{dy}	=	Exposure frequency (d/yr)
ED	=	Exposure duration (yr)
AT_n	=	Averaging time, noncarcinogens (d)
AT_c	=	Averaging time, carcinogens (d)

B2.2.2 Dermal Contact with Soil and Sediment

The ADD from dermal contact with soil is calculated as follows:

<u>*Carcinogens, other*</u>

$$ADD = \frac{DA_{soil} \cdot SA \cdot EF_{evd} \cdot EF_{dy} \cdot ED}{BW \cdot AT_c}$$

<u>*Non-carcinogens*</u>

$$ADD = \frac{DA_{soil} \cdot SA \cdot EF_{evd} \cdot EF_{dy} \cdot ED}{BW \cdot AT_n}$$

$$DA_{soil} = EPC_s \cdot AF \cdot DAF \cdot CF_{km}$$

Where:

ADD	=	Absorbed daily dose from contact with soil (mg/[kg·d])
SA	=	Exposed skin surface area (cm^2)
SFS_{adj}	=	Age-adjusted soil dermal contact factor ([mg·yr]/[kg·event])
EF_{dy}	=	Exposure frequency (d/yr)
EF_{evd}	=	Event frequency (events/d)
ED	=	Exposure duration (yr)
BW	=	Body weight (kg)
AT_n	=	Averaging time, noncarcinogens (d)
AT_c	=	Averaging time, carcinogens (d)
DA_{soil}	=	Absorbed dose per soil contact event (mg/cm^2·event)
EPC_s	=	Contaminant concentration in soil (mg/kg)
AF	=	Soil-to-skin adherence factor (mg/cm^2·event)
CF_{km}	=	Conversion factor (10^{-6} kg/mg)
DAF	=	Dermal absorption factor (unitless)
BW	=	Body weight (kg)

B2.2.3 Inhalation of Soil Particles

The ADD from inhalation of soil particles is calculated as follows:

<u>*Carcinogens, other*</u>

$$ADD = \frac{PM_{10} \cdot IRA \cdot \left(EF_{hd} / CF_{hd}\right) \cdot EF_{dy} \cdot ED}{BW \cdot AT_c}$$

<u>*Non-carcinogens*</u>

$$ADD = \frac{PM_{10} \cdot IRA \cdot \left(EF_{hd} / CF_{hd}\right) \cdot EF_{dy} \cdot ED}{BW \cdot AT_n}$$

$$PM_{10} = \left(\frac{EPC_s}{PEF} \right) \cdot F_s$$

Where:

ADD	=	Average daily dose from inhalation of particulates (mg/[kg·d])
PM_{10}	=	Concentration of respirable particulates in air (mg/m^3)
INF_{adj}	=	Age-adjusted inhalation factor ([m^3·yr]/[kg·d])
IRA	=	Inhalation rate (m^3/d)
F_s	=	Fraction of soil contaminated (unitless)
EF_{hd}	=	Exposure frequency (hr/d)
CF_{hd}	=	Conversion factor (24 hr/d)
EF_{dy}	=	Exposure frequency (d/yr)
ED	=	Exposure duration (yr)
BW	=	Body weight of *k*th age (kg)
AT_n	=	Averaging time, noncarcinogens (d)
AT_c	=	Averaging time, carcinogens (d)
PEF	=	Particulate emission factor (m^3/kg)

B2.2.4 Ingestion of Surface Water

The ADD from ingestion of surface water is calculated as follows:

Carcinogens, occupational

$$ADD = \frac{EPC_{sw} \cdot IRW \cdot \left(EF_{hd} / CF_{hd} \right) \cdot EF_{dy} \cdot ED}{BW \cdot AT_c}$$

Non-carcinogens

$$ADD = \frac{EPC_{sw} \cdot IRW \cdot \left(EF_{hd} / CF_{hd} \right) \cdot EF_{dy} \cdot ED}{BW \cdot AT_n}$$

Where:

ADD	=	Average daily dose from tap water ingestion (mg/[kg·d])
EPC_{sw}	=	Contaminant concentration in water (mg/L)
IRW_{adj}	=	Age-adjusted water ingestion factor ([L·yr]/[kg·d])
IRW	=	Drinking (tap) water ingestion rate (L/d)
EF_{hd}	=	Exposure frequency (hr/d)
CF_{hd}	=	Conversion factor (24 hr/d)
EF_{dy}	=	Exposure frequency (d/yr)
ED	=	Exposure duration (yr)
BW	=	Body weight (kg)
AT_n	=	Averaging time, noncarcinogens (d)
AT_c	=	Averaging time, carcinogens (d)

B2.2.5 Dermal Contact with Surface Water

The ADD from dermal contact with surface water is calculated as follows:

Carcinogens, occupational

$$ADD = \frac{DA_{sw} \cdot SA \cdot EF_{evd} \cdot EF_{dy} \cdot ED}{BW \cdot AT_c}$$

Non-carcinogens

$$ADD = \frac{DA_{sw} \cdot SA \cdot EF_{evd} \cdot EF_{dy} \cdot ED}{BW \cdot AT_n}$$

Inorganics in water

$$DA_{sw} = 10^{-3} \cdot \left(EPC_{sw} \cdot CF_{cl}\right) \cdot t_{event}$$

Where:

ADD	=	Absorbed daily dose from contact with water (mg/[kg·d])
SA	=	Exposed skin surface area (cm^2)
SAS_{adj}	=	Age-adjusted water dermal contact factor ([cm^2·yr]/kg)
EF_{evd}	=	Event frequency (events/d)
EF_{dy}	=	Exposure frequency (d/yr)
ED	=	Exposure duration (yr)
BW	=	Body weight (kg)
AT_n	=	Averaging time, noncarcinogens (d)
AT_c	=	Averaging time, carcinogens (d)
DA_{sd}	=	Dose absorbed per unit area per water contact event (mg/cm^2·event)
EPC_{sw}	=	Contaminant concentration in water (mg/L)
CF_{cl}	=	Conversion factor (10^{-3} L/cm^3)
t_{event}	=	Duration of exposure event (hr/event)
K_p	=	Dermal permeability coefficient (cm/hr)
τ	=	Lag time (hr/event)
t*	=	Time to reach steady-state (hr)
B	=	Relative contribution of permeability coefficients (unitless)
K_{ow}	=	*n*-Octanol-water partition coefficient
MW	=	Contaminant-specific molecular weight (g/mol)

APPENDIX B3: Terrestrial Ecological Exclusion Evaluation

Voluntary Cleanup Program

Washington State Department of Ecology – Toxics Cleanup Program

TERRESTRIAL ECOLOGICAL EVALUATION EXCLUSION

Some contaminated sites are excluded from conducting a Terrestrial Ecological Evaluation (TEE). If your site meets the criteria for exclusion as described in WAC 173-340-7491, please complete this form.

Please note that exclusion from the TEE does not exclude the Site for consideration of effects on aquatic or sediment ecological receptors.

SITE NAME: Antimony Queen Mine

SITE ADDRESS: Okanogan National Forest near Twisp Washington

EVALUATOR'S NAME: RONE BREWER, SOUND ECOLOGICAL ENDEAVORS

REASONS FOR EXCLUSION:
A site is eligible for exclusion if it meets any of the following criteria:

1. POINT OF COMPLIANCE WAC 173-340-7491(1)(A)

- No contamination present at site.
  1-☐

- All contamination is below 15 feet prior to remedial activities.
  2-☐

- All contamination is below six feet and an institutional control has been implemented, as required by WAC 173-340-440 .
  3-☐

- All contamination is below a site-specific point of compliance established in compliance with WAC 173-340-7490(4)(b) with an institutional control implemented as required by WAC 173-340-440.
  4-☐

  Please provide documentation that describes the rational for setting a site-specific point of compliance.

2. BARRIERS TO EXPOSURE WAC 173-340-7491(1)(B)

- All contaminated soil is or will be covered by physical barriers that prevent exposure to plants and wildlife and an institutional control has been implemented, as required by WAC 173-340-440.
  5-☐

An exclusion based on future land use must have a completion date for future development that is acceptable to Ecology.

Ecy# 090-300

3. Undeveloped land WAC 173-340-7491 (1)(c)

There is less than one-quarter acre of contiguous undeveloped land on or within 500 feet of any area of the site and any of the following chemicals is present: chlorinated dioxins or furans, PCB mixtures, DDT, DDE, DDD, aldrin, chlordane, dieldrin, endosulfan, endrin, heptachlor, heptachlor epoxide, benzene hexachloride, toxaphene, hexachlorobenzene, pentachlorophenol, or pentachlorobenzene.

6-☐

- For sites not containing any of the chemicals mentioned above, there is less than one-and-a-half acres of contiguous undeveloped land on or within 500 feet of any area of the site.
- 7-☐

"Undeveloped land" is land that is not covered by building, roads, paved areas, or other barriers that would prevent wildlife from feeding on plants, earthworms, insects, or other food in or on the soil.

"Contiguous" undeveloped land is an area of undeveloped land that is not divided into smaller areas of highways, extensive paving, or similar structures that are likely to reduce the potential use of the overall area by wildlife.

4. Background concentrations WAC 173-340-7491 (1) (d)

- Concentrations of hazardous substances in soil do not exceed background levels as described in WAC 173-340-709.

8-☐

Explanation of Exclusion (If required):

Exclusion not possible.

If your site does not meet the TEE exclusions, you may have to conduct a simplified TEE in accordance with WAC 173-340-7492 or a site-specific TEE in accordance with WAC 173-340-7493. Please contact regional VCP staff with questions about conducting a simplified or site-specific TEE.

Ecology is an equal opportunity employer. For alternative format, please contact the Toxic Cleanup Program at (360) 407-7170 or 711 or 1-800-833-6388 (TTY).

APPENDIX B4: Rare, Threatened, and Endangered Species

TABLE B4-1
SENSITIVE PLANT SPECIES LIST, USFS APRIL 1999
ANTIMONY QUEEN MINE, WASHINGTON

Scientific Name	Common Name	Federal Status (a)	State Status (b)
Agoseris elata	Tall agoseris		S
Agrostis borealis	Northern bentgrass		S
Anemone nuttalliana	Prairie crocus		S
Astragalus microcystis	Least bladdery milkvetch		S
Botrychium ascendens	Upswept moonwort	SoC	S
Botrychium campestre	Prairie dunewort		S
Botrychium crenulatum	Crenulate moonwort	SoC	S
Botrychium hesperium	Western moonwort		S
Botrychium lineare	Lance-leaved moonwort	SoC	S
Botrychium paradoxum	Two-spiked moonwort		S
Botrychium pedunculosum	Hairy pepperwort	SoC	S
Carex atrata var. atrosquama (C. atrosquama in WA)	Blackened sedge	SoC	S
Carex atrata var. erecta (C. heteroneura)	Black-scaled sedge		S
Carex capillaris	Hair-like sedge		S
Carex chordorrhiza	Cordroot sedge		S
Carex comosa	Bearded sedge		S
Carex dioica var. gynocrates (C. dioica in WA)	Yellow bog sedge		S
Carex flava	Yellow sedge		S
Carex hystericina	Porcupine sedge		S
Carex norvegica	Scandanavian sedge		S
Carex rostrata	Beaked sedge		S
Carex saxatilis var. major	Sedge		S
Carex scirpoidea var. scirpoidea	Single-spike sedge		S
Carex stenophylla (C. eleocharis)	Narrow-leaved sedge		S
Carex sychnocephala	Many-headed sedge		S
Carex tenuifolia	Sparse-leaved sedge		S
Carex vallicola	Valley sedge		S
Carex xerantica	Dryland sedge		S
Chrysosplenium tetrandrum	Golden saxifrage		S
Cicuta bulbifera	Bulb-bearing water hemlock		S
Claytonia lanceolata var. pacifica	Lance-leaved spring beauty		S
Collomia mazama	Mt. Mazama collomia	SoC	
Dodecatheon austrofrigidum	Tundra shootingstar	SoC	T
Draba cana	Lance-leaved draba		S
Dryas drummondii	Drummond's anemone		S
Eleocharis atropurpurea	Purple spikerush		X
Erigeron salishii	Star Peak fleabane		S
Eriophorum viridicarinatum	Thinleaf cottonsedge		S
Eritrichium nanum var. elongatum	Alpine forget-me-not		S
Gentiana glauca	Blue-green gentian		S
Gentianella tenella	Dane's dwarf gentian		S
Geum rivale	Water avens		S
Howellia aquatilis	Water howellia	LT	
Iliamna longisepala	Longsepal globemallow		S
Loiseleuria procumbens	Alpine azalea		S
Lycopodium dendroideum	Prickley prince's pine		S
Mimulus evanescens	Ephemeral monkeyflower		C
Mimulus pulsiferae	Pulsifer's monkeyflower		S
Mimulus suksdorfii	Suksdorf's monkeyflower		S
Nicotiana attenuata	Coyote tobacco		S
Oxytropis campestris var. gracilis	Slender locoweed		S
Parnassia kotzebuei	Grass-of-parnassus		S

TABLE B4-1
SENSITIVE PLANT SPECIES LIST, USFS APRIL 1999
ANTIMONY QUEEN MINE, WASHINGTON

Scientific Name	Common Name	Federal Status (a)	State Status (b)
Pellaea brachyptera	Baker Sierra cliffbrake		S
Platanthera obtusata	Blunt-leaf orchid		S
Polemonium viscosum	Sky pilot or Alpine skunkbush		S
Potentilla diversifolia var. perdissecta	Diverse-leaved cinquefoil		S
Potentilla nivea	Snow cinquefoil		S
Potentilla quinquefolia	Five-leaved cinquefoil		S
Rubus acaulis	Nagoonberry		S
Salix glauca	Grey-leaved willow		S
Salix pseudomonticola	Ball false mountain willow		S
Sanicula marilandica	Black snakeroot		S
Saxifraga cernua	Nodding saxifrage		S
Sisyrinchium septentrionale	Blue-eyed grass		S
Spiranthes diluvialis	Diluvim ladies' tresses	LT	T
Spiranthes porrifolia	Western ladies' tresses		S
Talinum sediforme	Okanogan fameflower		S
Teucrium canadense ssp. viscidum	Wood sage		S
Thalictrum dasycarpum	Purple meadow rue		S
Trimorpha elata	Tall bitter fleabane		S
Vaccinium myrtilloides	Velvet-leaved blueberry		S

Notes:

Blank status indicates no listing was available for the species.

(a) U.S. Fish and Wildlife Service Federal Status: SoC = Species of Concern, an unofficial status indicating the species appears to be in jeopardy, but there is insufficient data to list. LT = Listed Threated indicating the species is likely to become endangered.

(b) Washington State Status: S = State Sensitive. T = threatened indicating the species is likely to become endangered in Washington. X = Possibly Extinct.

TABLE B4-2
U.S. FOREST SERVICE PLANT MANAGEMENT LIST, USFS MARCH 2003
ANTIMONY QUEEN MINE, WASHINGTON

Scientific Name	Common Name	Federal Status (a)	State Status (b)
FUNGI			
Bridgeoporus nobilissimus (Oxyporus nobilissimus)	Fuzzy sandozi		
LICHENS			
Hypogymnia duplicata	Rare leafy lichen		
Leptogium cyanescens	Blistered jellyskin		
Lobaria linita	Cabbage lungwort		
Nephroma occultum	Paw		
Niebla cephalota	Niebla		
Pseudocyphellaria rainierensis	Old growth speckleberry		
Ramalina thrausta	Angel hair		
Teloschistes flavicans	Golden-hair lichen		
BRYOPHYTES			
Schistostega pennata	Schistostega		
Tetraphis geniculata	Bent-kneed four-tooth moss		
VASCULAR PLANTS			
Botrychium montanum	Desolation meadow grapefern		
Coptis asplenifolia	Spleenwort-leaved goldthread		
Coptis trifolia	Three-leaf goldthread		
Corydalis aquae-gelidae	Cold water corydalis		
Cypripedium montanum	Mountain lady's slipper		
Eucephalus vialis (syn. Aster vialis)	Bradshaw wayside aster		
Galium kamtschaticum	Boreal bedstraw		
Platanthera orbiculata var. orbiculata	Large round-leaved orchid		

Notes:

Blank status indicates no listing was available for the species.

(a) U.S. Fish and Wildlife Service Federal Status: SoC = Species of Concern, an unofficial status indicating the species appears to be in jeopardy, but there is insufficient data to list. LT = Listed Threated indicating the species is likely to become endangered.

(b) Washington State Status: S = State Sensitive. T = threatened indicating the species is likely to become endangered in Washington. X = Possibly Extinct.

TABLE B4-3
BIRD SPECIES POTENTIALLY INHHABITING THE VICINITY OF THE SITE
ANTIMONY QUEEN MINE, WASHINGTON

Scientific Name	Common Name	Federal Status	State Status
BIRDS			
Recurvirostra americana	American Avocet		SP
Botaurus lentiginosus	American Bittern		SP
Fulica americana	American Coot		
Pluvialis dominica	American Golden Plover		SP
Carduelis tristis (Spinus tristis)	American Goldfinch		SP
Falco sparverius	American Kestrel (Sparrow Hawk)		SP
Setophaga ruticilla	American Redstart		SP
Anas americana (Mareca americana)	American Wigeon (Widgeon)		
Gavia arctica	Arctic Loon		
Myiarchus cinerascens	Ash-throated Flycatcher		SM
Calidris bairdii (Erolia bairdii)	Baird's Sandpiper		SP
Haliaeetus leucocephalus	Bald Eagle	FT	ST
Columba fasciata	Band-tailed Pigeon		
Riparia riparia	**Bank Swallow**		**SP**
Tyto alba	Barn Owl		SP
Hirundo rustica	Barn Swallow		SP
Strix varia	**Barred Owl**		**SP**
Bucephala islandica	Barrow's Goldeneye		
Megaceryle alcyon	**Belted Kingfisher**		**SP**
Thryomanes bewickii	**Bewick's Wren**		**SP**
Cypseloides niger	Black Swift		SM
Chlidonias niger	Black Tern	FCo	SM
Picoides arcticus	**Black-backed Woodpecker**		**SC**
Pluvialis squatarola (Squatarola squatarola)	Black-bellied Plover		SP
Pica pica	**Black-billed Magpie**		
Parus atricapillus	**Black-capped Chickadee**		**SP**
Archilochus alexandri	**Black-Chinned hummingbird**		**SP**
Nycticorax nycticorax	Black-crowned Night Heron		SM
Pheucticus melanocephalus	**Black-headed Grosbeak**		**SP**
Himantopus mexicanus	Black-necked Stilt		SM
Dendroica nigrescens	**Black-throated Gray Warbler**		**SP**
Dendragapus obscurus	**Blue Grouse**		
Cyanocitta cristata	**Blue Jay**		**SP**
Anas discors	Blue-winged Teal		
Dolichonyx oryzivorus	Bobolink		SM
Bombycilla garrula	Bohemian Waxwing		SP
Larus philadelphia	Bonaparte's Gull		SP
Parus hudsonicus	**Boreal Chickadee**		**SM**
Aegolius funereus	**Boreal Owl**		**SM**
Euphagus cyanocephalus	**Brewer's Blackbird**		**SP**
Spizella breweri	**Brewer's Sparrow**		**SP**
Certhia familiaris	**Brown Creeper**		**SP**
Molothrus ater	**Brown-headed Cowbird**		**SP**
Tryngites subruficollis	Buffbreasted Sandpiper		SP
Bucephala albeoloa	Bufflehead		
Athene cunicularia (Speotyto cunicularia)	Burrowing Owl	FCo	SC
Larus californicus	California Gull		SP
Lophortyx californicus	**California Quail**		
Stellula calliope	Calliope Hummingbird		SP
Branta canadensis	Canada Goose		
Aythya valisineria	Canvasback		

TABLE B4-3
BIRD SPECIES POTENTIALLY INHHABITING THE VICINITY OF THE SITE
ANTIMONY QUEEN MINE, WASHINGTON

Scientific Name	Common Name	Federal Status	State Status
BIRDS			
Catherpes mexicanus	**Canyon Wren**		**SP**
Hydroprogne caspia	Caspian Tern		SM
Carpodacus cassinii	Cassin's Finch		SP
Bombycilla cedrorum	**Cedar Waxwing**		**SP**
Parus rufescens	**Chestnut-backed Chickadee**		**SP**
Spizella passerina	**Chipping Sparrow**		**SP**
Alectoris chukar (Alectoris graeca)	**Chukar**		
Anas cyanoptera	Cinnamon Teal		
Nucifraga columbiana	**Clark's Nutcracker**		**SP**
Petrochelidon pyrrhonota	**Cliff Swallow**		**SP**
Corvus brachyrhynchos	**American Crow**		
Casmerodius albus	Common Egret		SP
Colaptes auratus (Colaptes cafer)	**Common Flicker (Red-shafted Flicker)**		
Bucephala clangula	Common Goldeneye		
Gavia immer	Common Loon		SS
Mergus merganser	Common Merganser		
Chordeiles minor	**Common Nighthawk**		**SP**
Corvus corax	**Common Raven**		**SP**
Carduelis flammea (Acanthis flammea)	**Common Redpoll**		**SP**
Geothlypis trichas	**Common Yellowthroat**		**SP**
Accipiter cooperii	**Cooper's Hawk**		**SP**
Junco hyemalis	**Dark-eyed Junco (Slate-colored)**		
Cinclus mexicanus	**American Dipper**		**SP**
Phalacrocorax auritus	Double-crested Cormorant		SP
Picoides pubescens (Dendrocopos pubescens)	**Downy Woodpecker**		**SP**
Calidris alpina (Erolia alpina)	Dunlin		SP
Empidonax oberholseri	**Dusky Flycatcher (Wright's Flycatcher)**		**SP**
Podiceps nigricollis (Podiceps caspicus)	Eared Grebe		SP
Tyrannus tyrannus	**Eastern Kingbird**		**SP**
Anas penelope (Mareca penelope)	European Wigeon (Widgeon)		
Hesperiphona vespertina	**Evening Grosbeak**		**SP**
Buteo regalis	**Ferruginous Hawk**	**FCo**	**ST**
Otus Flammeolus	**Flammulated Owl**		**SC**
Sterna forsteri	Forster's Tern		SM
Passerella iliaca	**Fox Sparrow**		**SP**
Larus pipixcan	Franklin's Gull		SP
Anas strepera	Gadwall		
Larus hyperboreus	Glaucous Gull		SP
Larus glaucescens	Glaucous-winged Gull		SP
Aquila chrysaetos	Golden Eagle		SC
Regulus satrapa	**Golden-crowned Kinglet**		**SP**
Zonotrichia atricapilla	**Golden-crowned Sparrow**		**SP**
Accipiter gentilis	**Goshawk**	**FCo**	**SC**
Dumetella carolinensis	**Gray Catbird**		**SP**
Perisoreus canadensis	**Gray Jay**		**SP**
Perdix perdix	**Gray Partridge (Hungarian Partridge)**		
Leucosticte tephrocotis	**Gray-crowned Rosy Finch**		**SP**
Ardea herodias	**Great Blue Heron**		**SM**
Strix nebulosa	**Great Gray Owl**		**SM**
Bubo virginianus	**Great Horned Owl**		**SP**
Aythya marila	Greater Scaup		
Tringa melanoleucas (totanus melanoleucus)	Greater Yellowlegs		SP

TABLE B4-3
BIRD SPECIES POTENTIALLY INHHABITING THE VICINITY OF THE SITE
ANTIMONY QUEEN MINE, WASHINGTON

Scientific Name	Common Name	Federal Status	State Status
BIRDS			
Anas crecca (Anas carolinensis)	Green-winged Teal		
Ammodramus savannarum	**Grasshopper Sparrow**		**SM**
Falco rusticolus	**Gyrfalcon**		**SM**
Picoides villosus (Dendrocopos villosus)	**Hairy Woodpecker**		**SP**
Histrionicus histrionicus	**Harlequin Duck**	**FCo**	
Zonotrichia querula	**Harris' Sparrow**		**SP**
Surnia ulula	**Hawk Owl**		
Catharus guttatus (Hylochichla guttata)	**Hermit Thrush**		**SP**
Dendroica occidentalis	**Hermit Warbler**		**SP**
Larus argentatus	Herring Gull		SP
Carduelis hornemanni (Acanthis hornemanni)	**Hoary Redpoll**		**SP**
Lophodytes cucullatus	Hooded Merganser		
Podiceps auritus	Horned Grebe		SM
Eremophila alpestris	**Horned Lark**		**SP**
Carpodacus mexicanus	**House Finch**		**SP**
Passer domesticus	House Sparrow		
Troglodytes aedon	**House Wren**		**SP**
Limosa haemastica	Hudsonian Godwit		SP
Larus glaucoides	Iceland Gull		SP
Charadrius vociferus	Killdeer		SP
Calcarius lapponicus	Lapland Longspur		SP
Chondestes grammacus	**Lark Sparrow**		**SP**
Passerina amoena	**Lazuli Bunting**		**SP**
Empidonax minimus	**Least Flycatcher**		**SP**
Calidris minutilla (Erolia minutilla)	Least Sandpiper		SP
Aythya affinis	Lesser Scaup		
Tringa flavipes (Totanus flavipes)	Lesser Yellowlegs		SP
Melanerpes lewis (Asyndesmus lewis)	**Lewis' Woodpecker**		**SC**
Melospiza lincolnii	**Lincoln's Sparrow**		**SP**
Lanius ludovicianus	Loggerhead Shrike	FCo	SC
Numenius americanus	Long-billed Curlew		SM
Limnodromus scolopaceus	Long-billed Dowitcher		SP
Cistothorus palustris (Telmatodytes palustris)	Long-billed Marsh Wren		SP
Asio otus	**Long-eared Owl**		**SP**
Stercorarius longicaudus	Long-tailed Jaeger		SP
Oporornis tolmiei	**MacGillivray's Warbler**		**SP**
Anas platyrhynchos	Mallard		
Limosa fedoa	Marbled Godwit		SP
Circus cyaneus	**Northern Harrier**		**SP**
Falco columbarus	**Merlin (Pigeon Hawk)**		**SC**
Mimus polyglottos	Mockingbird		SP
Sialia currucoides	**Mountain Bluebird**		**SP**
Parus gambeli	**Mountain Chickadee**		**SP**
Charadrius montanas (Eupoda montana)	Mountain Plover		SP
Zenaida macroura (Zenaidura macroura)	**Mourning Dove**		
Vermivora ruficapilla	**Nashville Warbler**		**SP**
Icterus galbula (Icterus bullockii)	**Northern Oriole (Bullock's Oriole)**		**SP**
Lobipes lobatus	Northern Phalarope		
Anas clypeata (Spatula clypeata)	Northern Shoveler		
Lanius excubitor	**Northern Shrike**		**SP**
Picoides tridactylus	**Three-toed Woodpecker**		**SM**
Seiurus noveboracensis	Northern Waterthrush		SM

TABLE B4-3
BIRD SPECIES POTENTIALLY INHHABITING THE VICINITY OF THE SITE
ANTIMONY QUEEN MINE, WASHINGTON

Scientific Name	Common Name	Federal Status	State Status
BIRDS			
Clangula hyemalis	Long-Tailed Duck		
Nuttallornis borealis	**Olive-sided Flycatcher**	**FCo**	**SP**
Vermivora celata	**Orange-crowned Warbler**		**SP**
Pandion haliaetus	**Osprey**		**SM**
Calidris melonotos (Erolia melanotos)	Pectoral Sandpiper		SP
Falco peregrinus	**Peregrine Falcon**	**FCo**	**SS**
Podilymbus podiceps	Pied-billed Grebe		SP
Dryocopus pileatus	Pileated Woodpecker		SC
Pinicola enucleator	**Pine Grosbeak**		**SP**
Carduelis pinus (Spinus pinus)	**Pine Siskin**		**SP**
Anas acuta	Northern Pintail		
Phalaenoptilus nuttallii	Poor-will		
Falco mexicanus	**Prairie Falcon**		**SM**
Carpodacus purpureus	**Purple Finch**		**SP**
Progne subis	Purple Martin		SC
Sitta pygmaea	**Pygmy Nuthatch**		**SP**
Glaucidium gnoma	**Pygmy Owl**		
Loxia curvirostra	**Red Crossbill**		**SP**
Caldris canutus	Red Knot		SP
Mergus serrator	Red-breasted Merganser		
Sitta canadensis	**Red-breasted Nuthatch**		**SP**
Vireo olivaceus	**Red-eyed Vireo**		**SP**
Aythya americana	Redhead		
Podiceps grisegena	Red-necked Grebe		SM
Buteo jamaicensis	**Red-tailed Hawk**		**SP**
Agelaius phoeniceus	**Red-winged Blackbird**		**SP**
Larus delawarensis	Ring-billed Gull		SP
Aythya collaris	Ring-necked Duck		
Phasianus colchicus	Ring-necked Pheasant		
Turdus migratorius	**Robin**		**SP**
Columba livia	Rock Dove		
Salpinctes obsoletus	**Rock Wren**		**SP**
Chen rossii	Ross' Goose		
Buteo lagopus	**Rough-legged Hawk**		**SP**
Stelgidopteryx ruficollis	**Rough-winged Swallow**		**SP**
Regulus calendula	**Ruby-crowned Kinglet**		**SP**
Oxyura jamaicensis	Ruddy Duck		
Arenaria interpres	Ruddy Turnstone		SP
Bonasa umbellus	**Ruffed Grouse**		
Selasphorus rufus	Rufous Hummingbird		SP
Pipilo erythrophthalmus	**Spotted (Rufous-sided) Towhee**		**SP**
Euphagus carolinus	**Rusty Blackbird**		**SP**
Centrocercus urophasianus	Sage Grouse	FC	ST
Amphispiza belli	**Sage Sparrow**		**SC**
Oreoscoptes montanus	**Sage Thrasher**		**SC**
Calidris alba (Crocethia alba)	Sanderling		SP
Grus canadensis	Sandhill Crane		SE
Passerculus sandwichensis	**Savannah Sparrow**		**SP**
Aegolius acadicus	**Saw-whet Owl**		**SP**
Sayornis saya	**Say's Phoebe**		**SP**
Otus asio	**Screech Owl**		**SP**
Charadrius semipalmatus	Semipalmated Plover		SP

TABLE B4-3
BIRD SPECIES POTENTIALLY INHHABITING THE VICINITY OF THE SITE
ANTIMONY QUEEN MINE, WASHINGTON

Scientific Name	Common Name	Federal Status	State Status
BIRDS			
Calidris pusilla (Ereunetes pusillus)	Semipalmated Sandpiper		SP
Accipiter striatus	**Sharp-shinned Hawk**		**SP**
Pedioecetes phasianellus	Sharp-tailed Grouse	FCo	ST
Limnodromus griseus	Short-billed Dowitcher		SP
Asio flammeus	**Short-eared Owl**		**SP**
Plectrophenax nivalis	Snow Bunting		SP
Chen caerulescens (Chen hyperborea)	Snow Goose		
Nyctea scandiaca	Snowy Owl		SM
Tringa solitaria	Solitary Sandpiper		SP
Vireo solitarius	**Solitary Vireo**		**SP**
Melospiza melodia	**Song Sparrow**		**SP**
Porzana carolina	Sora		
Strix occidentalis	Spotted Owl	FT	SE
Actitis macularia	Spotted Sandpiper		SP
Canachites canadensis	**Spruce Grouse**		
Sturnus vulgaris	Starling		
Cyanocitta stelleri	**Steller's Jay**		**SP**
Micropalama himantopus	Stilt Sandpiper		SP
Melanitta perspicillata	Surf Scoter		
Buteo swainsoni	**Swainson's Hawk**		**SM**
Catharus ustulata (Hylocichla ustulata)	**Swainson's Thrush**		**SP**
Vermivora peregrina	**Tennessee Warbler**		**SP**
Myadestes townsendi	**Townsend's Solitaire**		**SP**
Dendroica townsendi	**Townsend's Warbler**		**SP**
Spizella arborea	**Tree Sparrow**		**SP**
Iridoprocne bicolor	**Tree Swallow**		**SP**
Olor buccinator	Trumpeter Swan		
Meleagris gallopavo	Turkey		
Cathartes aura	**Turkey Vulture**		**SM**
Bartramia longicauda	Upland Sandpiper		SE
Ixoreus naevius	**Varied Thrush**		**SP**
Chaetura vauxi	Vaux's Swift		SC
Catharus fuscescens (Hylocichla fuscescens)	Veery		SP
Pooecetes gramineus	**Vesper Sparrow**		**SP**
Tachycineta thalassina	**Violet-green Swallow**		**SP**
Rallus limicola	Viriginia Rail		
Vireo gilvus	**Warbling Vireo**		**SP**
Anthus spinoletta	Water Pipit		
Sialia mexicana	**Western Bluebird**		**SM**
Empidonax difficilis	**Western Flycatcher**		**SP**
Aechmophorus occidentalis	Western Grebe		SC
Tyrannus verticalis	**Western Kingbird**		**SP**
Sturnella neglecta	**Western Meadowlark**		**SP**
Calidris mauri	Western Sandpiper		SP
Piranga ludoviciana	**Western Tanager**		**SP**
Contopus sordidulus	**Western Wood Pewee**		**SP**
Numenius phaeopus	Whimbrel		SP
Olor columbianus	Tundra Swan		
Pelecanus erythrorhynchose	White Pelican		
Sitta carolinensis	**White-breasted Nuthatch**		**SP**
Zonotrichia leucophrys	**White-crowned Sparrow**		**SP**
Plegadis chihi	White-faced Ibis		SP

TABLE B4-3
BIRD SPECIES POTENTIALLY INHHABITING THE VICINITY OF THE SITE
ANTIMONY QUEEN MINE, WASHINGTON

Scientific Name	Common Name	Federal Status	State Status
BIRDS			
Anser albifrons	White-fronted Goose		
Picoides albolarvatus (Dendrocopos albolarvatus)	**White-headed Woodpecker**		**SC**
Calidris fusciocollis (Erolia fuscicollis)	White-rumped Sandpiper		SP
Lagopus leucurus	White-tailed Ptarmigan		
Zonotrichia albicollis	**White-throated Sparrow**		**SP**
Aeronautes saxatalis	White-throated Swift		SP
Loxia leucoptera	**White-winged Crossbill**		**SP**
Melanitta deglandi	White-winged Scoter		
Catoptrophorus semipalmatus	Willet		SP
Sphyrapicus thyroideus	**Williamson's Sapsucker**		**SP**
Empidonax traillii	**Willow Flycatcher (Traill's Flycatcher)**	**FCo**	**SP**
Capella gallinago	Common Snipe		
Steganopus tricolor	Wilson's Phalarope		SP
Wilsonia pusilla	**Wilson's Warbler**		**SP**
Troglodytes troglodytes	**Winter Wren**		**SP**
Aix sponsa	Wood Duck		
Dendroica petechia	**Yellow Warbler**		**SP**
Sphyrapicus varius	**Yellow-bellied Sapsucker**		**SP**
Coccyzus americanus	Yellow-billed Cuckoo	FC	SC
Icteria virens	**Yellow-breasted Chat**		**SP**
Xanthocephalus xanthocephalus	**Yellow-headed blackbird**		**SP**
Dendroica coronata	**Yellow-rumped Warbler**		**SP**

Notes:
Bold indicates species with suitable habitat at the Antimony Queen Mine.
Blank status indicates no listing was available for the species.
FC = Federal Candidate Species
FCo = Federal Species of Concern indicating there is not enough data to assess species status.
FE = Federal Endangered Species
FT = Federal Threatened indicating species is likely to become federally endangered.
SoC = Species of Concern, an unofficial status indicating species may be in jeopardy, but there is insufficient data to list.
SS = State Sensitive indicating species may exhibit declining populations but not enough data to assess species status.
ST = State Threatened indicating the species is likely to become state endangered
SX = Possibly Extinct in the State.
SP = Not listed but considered protected in the state.
SE= State Endangered
SM = State Monitor
SC = State Candidate

TABLE B4-4
MAMMALS SPECIES DOCUMENTED OR EXPECTED AT THE SITE
ANTIMONY QUEEN MINE, WASHINGTON

Scientific Name	Common Name	Federal Status	State Status
MAMMALS			
Alces alces	Moose		
Antozous pallidus	**Pallid Bat**		**SM**
Aplodontia rufa	**Aplodontia (Mountain Beaver)**		
Canis latrans	**Coyote**		
Canis lupus	**Gray Wolf**	**FT**	**SE**
Castor canadensis	**Beaver**		
Cervus canadensus nelsoni	Rocky Mountain Elk		
Clethrionomys gapperi	**Boreal Redback Vole**		
Coryhorhinus townsendii	**Townsend's Big-eared Bat**	**FCo**	**SC**
Eptisicus fuscus	**Big Brown Bat**		**SP**
Erethizon dorsatum	**Porcupine**		
Eutamias amoenus	**Yellow Pine Chipmunk**		**SC**
Eutamias minimus	**Least Chipmunk**		**SP**
Eutamias townsendi	**Townsend's Chipmunk**		**SP**
Felis concolor	**Hoary Bat**		**SP**
Felis concolor	**Mountain Lion (Cougar)**		
Glaucomys sabrinus	**Northern Flying Squirrel**		**SP**
Gulo luscus	**Wolverine**	**FCo**	**SC**
Lagurus curtatus	Sagebrush Vole		SM
Lasionycteris noctivagans	**Silver-haired Bat**		**SP**
Lasiurus borealis	**Red Bat**		**SM**
Lepus americanus	Snowshoe Hare		
Lutra canadensis	**River Otter**		
Lynx canadensis	**Lynx**	**FT**	**ST**
Lynx rufus	**Bobcat**		
Marmota caligata	**Hoary Marmot**		**SP**
Marmota flaviventris	**Yellow-bellied Marmot**		
Martes americana	**Marten**		
Martes pennanti	**Fisher**	**FCo**	**SE**
Mephitis mephitis	**Striped Skunk**		
Microsorex hoyi	**Pgymy Shrew**		**SM**
Microtus longicaudus	**Longtail Vole**		
Microtus montanus	**Mountain Vole**		
Microtus oregoni	**Oregon Vole**		
Microtus pennsylvanicus	Meadow Vole		
Microtus richardsoni	**Water Vole**		
Mus musculus	House Mouse		
Mustela erminea	**Shorttail Weasel (Ermine)**		
Mustela frenata	**Longtail Weasel**		
Mustela vision	**Mink**		
Myotis californicus	**California Myotis**		**SP**
Myotis evotis	**Long-eared Myotis**	**FCo**	**SM**
Myotis keeni	**Keen's Myotis**		**SC**
Myotis leibii	**Small-footed Myotis**	**FCo**	**SM**
Myotis lucifugus	**Little Brown Bat**		**SP**
Myotis thysanodes	**Fringed Myotis**	**FCo**	**SM**
Myotis volans	**Long-legged Myotis**	**FCo**	**SM**
Myotis yumanensis	**Yuma Myotis**	**FCo**	**SP**
Neotoma cinerea	**Busytail Woodrat**		
Neuotrichus gibbsi	**Shrew-mole**		
Ochotona princeps	**Pika**		**SP**

TABLE B4-4
MAMMALS SPECIES DOCUMENTED OR EXPECTED AT THE SITE
ANTIMONY QUEEN MINE, WASHINGTON

Scientific Name	Common Name	Federal Status	State Status
MAMMALS			
Odocoileus hemionus hemionus	**Mule Deer**		
Odocoileus virginianus ochrourus	White-tailed Deer		
Ondatra zibethica	Muskrat		
Oreamnos americanus	Mountain Goat		
Ovis canadensis	Bighorn Sheep		
Perognathus parvus	**Great Basin Pocket Mouse**		
Peromyscus maniculatus	**Deer Mouse**		
Phenacomys intermedius	**Heather Vole**		
Pipistrellus hesperus	Western Pipistrel		SM
Procyon lotor	**Raccoon**		
Rattus norvegicus	Norway Rat		
Reithrodontomys megalotis	Western Harvest Mouse		
Scapanus ororius	Coast Mole		
Sciurus griseus	**Western Gray Squirrel**	**FCo**	**ST**
Sorex cinereus	Masked Shrew		
Sorex merriami	Merriam's Shrew		SC
Sorex obscurus	**Dusky Shrew**		
Sorex palustris	**Northern Water Shrew**		
Sorex trowbridgei	**Trowbridge's Shrew**		
Sorex vagrans	Vagrant Shrew		
Spermophillus columbianus (Citellus columbianus)	Columbian Ground Squirrel		
Spermophillus sateratus (Citellus sateratus)	**Cascade Golden-mantled Ground Squirrel**		**SP**
Spermophilus lateralis	**Golden-mantled Ground Squirrel**		**SP**
Spilogale putorius	Spotted Skunk		
Sylvilagus nuttalli	Nuttal's Cottontail		
Synaptomys borealis	Northern Bog Lemming		SM
Tamiasciurus douglasi	**Douglas Squirrel - Chickaree**		**SP**
Tamiasciurus hudsonicus	Red Squirrel		SP
Taxidea taxus	Badger		
Thomomys talpoides	Northern Pocket Gopher		
Ursus americanus	Black Bear		
Ursus arctos	Grizzly Bear	FT	SE
Vulpes fulva	Red Fox		
Zapus princeps	Western Jumping Mouse		
Zapus trinotatus	Pacific Jumping Mouse		

Notes:
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FCo = Federal Species of Concern indicating there is not enough data to assess species status.
FT = Federally Threatened indicating species is likely to become federally endangered.
SoC = Species of Concern, an unofficial status indicating species may be in jeopardy, but there is insufficient data to list.
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ST = State Threatened indicating the species is likely to become state endangered
SX = Possibly Extinct in the State.
SP = Not listed but considered protected in the state.
SE= State Endangered
SM = State Monitor
SC = State Candidate

TABLE B4-5
HERPETILES DOCUMENTED OR EXPECTED AT THE SITE
ANTIMONY QUEEN MINE, WASHINGTON

Scientific Name	Common Name	Federal Status	State Status
AMPHIBIANS			
Ambystoma macrodactylum	**Long-toed Salamander**		
Ambystoma tigrinum	Tiger Salamander		SM
Ascaphus Truei	**Tailed Frog**	**FCo**	
Bufo boreas	Western Toad	FCo	SC
Hyla regilla	Pacific Treefrog		
Rana pretiosa	**Spotted Frog**	**FC**	**SE**
Scaphiopus intermontanus	Great Basin Spadefoot		
REPTILES			
Charina bottae	**Rubber Boa**		
Chrysemys picta	Painted Turtle		SP
Coluber constrictor	Western Yellow-Bellied Racer		
Crotalus viridis	**Western Rattlesnake**		
Eumeces Skiltonianus	**Western Skink**		
Gerrhonotus coeruleus	Northern Alligator Lizard		
Hypsiglena torquata	**Spotted Night Snake**		**SM**
Phrynosoma douglassi	**Short-horned Lizard**		
Pituophis melanoleucus	**Gopher Snake (Bull Snake)**		
Sceloporus graciosus	Sagebrush Lizard	FCo	SC
Sceloporus occidentalis	**Western Fence Lizard**		
Thamnophis elegans	**Western Garter Snake**		
Thamnophis sirtalis	**Common Garter Snake**		

Notes:
Bold indicates species with suitable habitat at the Antimony Queen Mine.
Blank status indicates no listing was available for the species.
SM = State Monitor Species
Fco = Federal Species of Concern
SC = State Candidate Species

APPENDIX B5: Ecological Risk-Based Screening Tables

TABLE B5-1
ECOLOGICAL RISK-BASED SCREENING
FOR SOIL/WASTEROCK

Chemical of Interest (COI) (a)	Exposure Point Concentration* (mg/kg)	Maximum Sample Reporting Limit (mg/kg)	Risk-Based Screening Value for Plants (mg/kg)	Risk-Based Screening Value for Invertebrates (mg/kg)	Risk-Based Screening Value for Birds (mg/kg)	Risk-Based Screening Value for Mammals (mg/kg)	Risk Ratio for Plants (Rij) (b)	Risk Ratio for Invertebrates (Rij) (b)	Risk Ratio for Birds (Rij) (b)	Risk Ratio for Mammals (Rij) (b)	Bioaccumulator? (c)	Risks Posed to Plants (Rij>1) (d)	Risks Posed to Invertebrates (Rij>1) (d)	Risks Posed to Birds (Rij>1) (d)	Risks Posed to Mammals (Rij>1) (d)	Risks Posed to Plants Due to Elevated Reporting Limit	Risks Posed to Invertebrates Due to Elevated Reporting Limit	Risks Posed to Birds Due to Elevated Reporting Limit	Risks Posed to Mammals Due to Elevated Reporting Limit	Inordinate Contribution to Overall Risk ($R_{ij}/R_i > 1/N_{ij}$)				Risks Posed?			
																				Plants	Invertebrates	Birds	Mammals	Plants	Invertebrates	Birds	Mammals
Metals																											
Antimony	8556.19	Not Applicable	5	15	No Data	15	**1711**	**570**	0	**570**	No	**Yes**	**Yes**	Not Calculated	**Yes**	No	No	No	No	**Yes**	**Yes**	**Unknown**	**Yes**	**Yes**	**Yes**	**Unknown**	**Yes**
Arsenic III	27.05	Not Applicable	10	60	7	7	**3**	0.5	**4**	**4**	Not Required	**Yes**	No	**Yes**	**Yes**	No	No	No	No	No	No	No	No	**Yes**	No	**Yes**	**Yes**
Arsenic V	8211.93	Not Applicable	10	60	132	132	**821**	**137**	**62**	**62**	Not Required	**Yes**	**Yes**	**Yes**	**Yes**	No	No	No	No	No	**Yes**	No	No	**Yes**	**Yes**	**Yes**	**Yes**
Arsenic, total	10705.27	Not Applicable	10	60	10	29	**1071**	**178**	**1071**	**369**	Not Required	**Yes**	**Yes**	**Yes**	**Yes**	No	No	No	No	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**
Barium	180.41	Not Applicable	500	3000	102	102	0.4	0.06	**2**	**2**	Not Required	No	No	**Yes**	**Yes**	No	No	No	No	No	No	No	No	No	No	**Yes**	**Yes**
Beryllium	0.59	Not Applicable	10	10	14	14	0.1	0.06	0.04	0.04	Not Required	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No
Cadmium	5.52	Not Applicable	4	20	6	125	1	0.3	1	0.04	Not Required	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No
Chromium, Total	11.85	Not Applicable	42	42	67	67	0.3	0.3	0.2	0.2	Not Required	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No
Cobalt	25.29	Not Applicable	20	1000	No Data	150	1	0.03	0	0.2	No	No	No	Not Calculated	No	No	No	No	No	No	No	**Unknown**	No	No	No	**Unknown**	No
Copper	160.30	Not Applicable	100	50	217	57	**2**	**3**	0.7	3	Not Required	**Yes**	**Yes**	No	Yes	No	No	No	No	No	No	No	No	**Yes**	**Yes**	No	**Yes**
Iron	69511.32	Not Applicable	10	200	No Data	No Data	**6951**	**348**	0	0	No	**Yes**	**Yes**	Not Calculated	Not Calculated	No	No	No	No	**Yes**	**Yes**	**Unknown**	**Unknown**	**Yes**	**Yes**	**Unknown**	**Unknown**
Lead	119.29	Not Applicable	50	500	118	118	**2**	0.2	1	1	Not Required	**Yes**	No	No	No	No	No	No	No	No	No	No	No	**Yes**	No	No	No
Manganese	3046.71	Not Applicable	1100	100	1500	1500	**3**	**30**	**2**	**2**	Not Required	**Yes**	**Yes**	**Yes**	**Yes**	No	No	No	No	No	No	No	No	**Yes**	**Yes**	**Yes**	**Yes**
Mercury	0.64	Not Applicable	0.3	0.1	6	6	**2**	**6**	0.1	0.1	Not Required	**Yes**	**Yes**	No	No	No	No	No	No	No	No	No	No	**Yes**	**Yes**	No	No
Nickel	28.52	Not Applicable	30	200	980	57	1	0.1	0.03	0.5	Not Required	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No
Selenium	0.55	0.60	1	70	0.3	0.3	1	0.01	**2**	**2**	Not Required	No	No	**Yes**	Yes	No	No	**Yes**	**Yes**	No	No	No	No	No	No	**Yes**	**Yes**
Silver	4.04	Not Applicable	2	50	No Data	No Data	**2**	0.1	0	0	**Yes**	**Yes**	No	Not Calculated	Not Calculated	No	No	No	No	No	No	**Unknown**	**Unknown**	**Yes**	No	**Unknown**	**Unknown**
Thallium	0.42	Not Applicable	1	1	No Data	1	0.4	0.4	0	0.4	No	No	No	Not Calculated	No	No	No	No	No	No	No	**Unknown**	No	No	No	**Unknown**	No
Zinc	309.88	Not Applicable	86	200	360	38	**4**	**2**	0.9	8	Not Required	**Yes**	**Yes**	No	Yes	No	No	No	No	No	No	No	No	**Yes**	**Yes**	No	**Yes**

Notes:	**10577**	**1277**	**1146**	**1025**	:Sum of Rij (Rj)
L = liters	19	19	19	19	:Number of COIs (Nij)
mg = milligrams	0.05	0.05	0.05	0.05	:1/Nij

Unknown = Chemical was detected, but no screening criteria are available.

Bold indicates chemicals of potential concern that may require further assessment at the site.

*95th percentile upper confidence limit on the mean or maximum (whichever is lower)

(a) Chemicals remaining following the frequency of detection, essential nutrient, and background concentrations screening procedures.

(b) The risk ratio is the exposure point concentration divided by the Screening Level Values (SLV).

(c) As listed in the Draft Sediment Evaluation Guidance (ODEQ, 2002). Bioaccumulation screening not required when a bird and mammal screening value are available.

(d) The COI is considered a COPEC if:
1) The risk ratio (Rij) is greater than 5 (non-protected) or 1 (protected)
2) The Chemical of Interest is a bioaccumulator
3) No SLV or bioaccumulation vaule is available.
4) Not Calculated = Risk was not calculated for analytes with no screening criteria or bioaccumulation data.

TABLE B5-2
ECOLOGICAL RISK-BASED SCREENING
FOR GOLD CREEK SURFACE WATER

Chemical of Interest (COI) (a)	Surface Water Exposure Point Concentration* (mg/L)	Maximum Sample Reporting Limit (mg/L)	Freshwater Risk-Based Screening Value for Aquatic Life (mg/L)	Freshwater Risk-Based Screening Value for Birds (mg/L)	Freshwater Risk-Based Screening Value for Mammals (mg/L)	Risk Ratio for Aquatic Life (Rij) (b)	Risk Ratio for Birds (Rij) (b)	Risk Ratio for Mammals (Rij) (b)	Bioaccumulator? (c)	Risks Posed to Aquatic Life (Rij>1) (d)	Risks Posed to Birds (Rij>1) (d)	Risks Posed to Mammals (Rij>1) (d)	Risks Posed to Aquatic Life Due to Elevated Reporting Limit	Risks Posed to Birds Due to Elevated Reporting Limit	Risks Posed to Mammals Due to Elevated Reporting Limit	Inordinate Contribution to Overall Risk? (Rij/Rj > 1/Nij)			Risks Posed?		
																Aquatic Life	Birds	Mammals	Aquatic Life	Birds	Mammals
Metals																					
Arsenic III	0.000084	Not Applicable	0.15	18	6	0.001	0.000005	0.00001	Not Required	No	No	No	No	No	No	No	No	No	No	No	No
Arsenic V	0.000448	Not Applicable	0.15	18	6	0.003	0.00002	0.00007	Not Required	No	No	No	No	No	No	No	No	No	No	No	No
Arsenic, total	0.000489	Not Applicable	0.19	18	6	0.003	0.00003	0.00008	Not Required	No	No	No	No	No	No	No	No	No	No	No	No
Copper	0	0.01	0.004	341	53	0	0	0	Not Required	No	No	No	No	No	No	No	No	No	No	No	No
Mercury	0.000000829	Not Applicable	0.000012	3.3	10	0.07	0.0000003	0.0000001	Not Required	No	No	No	No	No	No	No	No	No	No	No	No

Notes:

L = liters

mg = milligrams

Unknown = Chemical was detected, but no screening criteria are available.

Bold indicates chemicals of potential concern that may require further assessment at the site.

* 90th percentile upper confidence limit on the mean or maximum (whichever is lower)

(a) Chemicals remaining following the frequency of detection, essential nutrient, and background concentrations screening procedures.

(b) The risk ratio is the exposure point concentration divided by the Screening Level Values (SLV).

(c) As listed in the Draft Sediment Evaluation Guidance (ODEQ, 2002). Bioaccumulation screening not required when a bird and mammal screening value are available.

(d) The COI is considered a COPEC if:

1) The risk ratio (Rij) is greater than 5 (non-protected) or 1 (protected)

2) The Chemical of Interest is a bioaccumulator

3) No SLV or bioaccumulation vaule is available.

4) Not Calculated = Risk was not calculated for analytes with no screening criteria or bioaccumulation data.

TABLE B5-3
ECOLOGICAL RISK-BASED SCREENING
FOR GOLD CREEK PORE WATER

Chemical of Interest (COI) (a)	Porewater Exposure Point Concentration* (mg/L)	Maximum Sample Reporting Limit (mg/L)	Freshwater Risk-Based Screening Value for Aquatic Life (mg/L)	Freshwater Risk-Based Screening Value for Birds (mg/L)	Freshwater Risk-Based Screening Value for Mammals (mg/L)	Risk Ratio for Aquatic Life (Rij) (b)	Risk Ratio for Birds (Rij) (b)	Risk Ratio for Mammals (Rij) (b)	Bioaccumulator? (c)	Risks Posed to Aquatic Life (Rij>1) (d)	Risks Posed to Birds (Rij>1) (d)	Risks Posed to Mammals (Rij>1) (d)	Risks Posed to Aquatic Life Due to Elevated Reporting Limit	Risks Posed to Birds Due to Elevated Reporting Limit	Risks Posed to Mammals Due to Elevated Reporting Limit	Inordinate Contribution to Overall Risk? ($R_{ij}/R_j > 1/N_{ij}$)			Risks Posed?		
																Aquatic Life	Birds	Mammals	Aquatic Life	Birds	Mammals
Metals																					
Antimony	0.0008	0.0002	1.60	No Data	1	0.0005	0	0.0008	No	No	**Not Calculated**	No	No	No	No	No	No	No	No	**Unknown**	No
Arsenic III	0.0106	Not Applicable	0.15	18	6	0.07	0.0006	0.002	Not Required	No	No	No	No	No	No	No	No	No	No	No	No
Arsenic V	0.0073	Not Applicable	0.15	18	6	0.05	0.0004	0.001	Not Required	No	No	No	No	No	No	No	No	No	No	No	No
Arsenic, total	0.0179	Not Applicable	0.19	18	6	0.09	0.001	0.003	Not Required	No	No	No	No	No	No	No	No	No	No	No	No
Barium	0.016	Not Applicable	0.004	150	39	**4**	0.0001	0.0004	Not Required	**Yes**	No	No	No	No	No	**Yes**	No	No	**Yes**	No	No
Copper	Not Detected	0.01	0.0041	341	53	0	0	0	Not Required	No	No	No	No	No	No	Unkown	No	No	No	No	No
Iron	0.8	0.01	1	No Data	No Data	0.8	0	0	No	No	**Not Calculated**	**Not Calculated**	No	No	No	No	No	No	No	**Unknown**	**Unknown**
Lead	0.0002	0.0001	0.00066	28	323	0.3	0.000007	0.000001	Not Required	No	No	No	No	No	No	No	No	No	No	No	No
Manganese	0.294	0.005	0.12	7242	676	**2**	0.00004	0.0004	Not Required	**Yes**	No	No	No	No	No	No	No	No	**Yes**	No	No
Mercury	0.0000082	Not Applicable	0.000012	3.3	10	0.7	0.000002	0.000001	Not Required	No	No	No	No	No	No	No	No	No	No	No	No
Silver	0.0013	0.00005	0.00012	No Data	No Data	**11**	0	0	**Yes**	**Yes**	**Not Calculated**	**Not Calculated**	No	No	No	**Yes**	No	No	**Yes**	**Unknown**	**Unknown**

Notes:	**19**	0.0021	0.0076	:Sum of Rij (Rj)
L = liters	11	11	11	:Number of COIs (Nij)
mg = milligrams	0.09	0.09	0.09	:1/Nij

Unknown = Chemical was detected, but no screening criteria are available.

Bold indicates chemicals of potential concern that may requir further assessment at the site.

* 95th percentile upper confidence limit on the mean or maximum (whichever is lower)

(a) Chemicals remaining following the frequency of detection, essential nutrient, and background concentrations screening procedures.

(b) The risk ratio is the exposure point concentration divided by the Screening Level Values (SLV).

(c) As listed in the Draft Sediment Evaluation Guidance (ODEQ, 2002). Bioaccumulation screening not required when a bird and mammal screening value are available.

(d) The COI is considered a COPEC if:
1) The risk ratio (Rij) is greater than 5 (non-protected) or 1 (protected)
2) The Chemical of Interest is a bioaccumulator
3) No SLV or bioaccumulation vaule is available.
4) Not Calculated = Risk was not calculated for analytes with no screening criteria or bioaccumulation data.

TABLE B5-4
ECOLOGICAL RISK-BASED SCREENING FOR GOLD CREEK SEDIMENT

Chemical of Interest (COI) (a)	Sediment Exposure Point Concentration* (mg/L)	Maximum Sample Reporting Limit (mg/kg)	Freshwater Sediment Risk-Based Screening Value for Benthic Invertebrates (mg/kg)	Freshwater Sediment Risk-Based Screening Value for Bioaccumulation (mg/kg)	Risk Ratio for Benthic Invertebrates (Rij) (b)	Risk Ratio for Wildlife (Rij) (b)	Bioaccumulator? (c)	Risks Posed to Invertebrates? (Rij>1) (d)	Risks Posed to Wildlife? (Rij>1) (d)	Risks Posed to Invertebrates Due to Elevated Reporting Limit?	Risks Posed to Wildlife Due to Elevated Reporting Limit?	Inordinate Contribution to Overall Risks? ($R_{ij}/R_j > 5/N_{ij}$)		Risks Posed?	
												Benthic Invertebrates	Wildlife	Benthic Invertebrates	Wildlife
Metals															
Aluminum	6360	Not Applicable	No Data	No Data	0	0	No	Not Calculated	Not Calculated	No	No	No	No	**Unknown**	**Unknown**
Antimony	0.6	Not Applicable	3	10	0.2	0.06	Not Required	No	No	No	No	No	No	No	No
Arsenic III	0.037	Not Applicable	6	4	0.01	0.01	Not Required	No	No	No	No	No	No	No	No
Arsenic V	7.59	Not Applicable	6	4	1.26	**1.9**	Not Required	No	**Yes**	No	No	**Yes**	No	**Yes**	**Yes**
Barium	33.2	Not Applicable	No Data	No Data	0	0	No	Not Calculated	Not Calculated	No	No	No	No	**Unknown**	**Unknown**
Cadmium	0.2	0.1	0.6	0	0.33	**66.67**	Not Required	No	**Yes**	No	**Yes**	No	**Yes**	No	**Yes**
Chromium, Total	20	Not Applicable	37	4200	0.54	0.0048	Not Required	No	No	No	No	**Yes**	No	**Yes**	No
Copper	9.6	Not Applicable	36	10	0.27	0.96	Not Required	No	No	No	No	No	No	No	No
Iron	13800	Not Applicable	No Data	No Data	0	0	No	Not Calculated	Not Calculated	No	No	No	No	**Unknown**	**Unknown**
Lead	1.6	Not Applicable	35	128	0.05	0.01	Not Required	No	No	No	No	No	No	No	No
Manganese	227	Not Applicable	1100	No Data	0.21	0	No	No	Not Calculated	No	No	No	No	No	**Unknown**
Nickel	9.6	Not Applicable	18	316	0.53	0.03	Not Required	No	No	No	No	**Yes**	No	**Yes**	No
Selenium	0	2	No Data	0.1	0	0	Not Required	Not Calculated	No	No	**Yes**	No	No	**Unknown**	**Yes**
Vanadium	23	Not Applicable	No Data	No Data	0	0	No	Not Calculated	Not Calculated	No	No	No	No	**Unknown**	**Unknown**
Zinc	29	Not Applicable	123	3	0.24	**9.67**	Not Required	No	**Yes**	No	No	No	**Yes**	No	**Yes**

Notes:
L = liters
mg = milligrams
Unknown = Chemical was detected, but no screening criteria are available.
Bold indicates chemicals of potential concern that may require further assessment at the site.
* 90th percentile upper confidence limit on the mean or maximum (whichever is lower)
(a) Chemicals remaining following the frequency of detection, essential nutrient, and background concentrations screening procedures.
(b) The risk ratio is the exposure point concentration divided by the Screening Level Values (SLV).
(c) As listed in the Draft Sediment Evaluation Guidance (ODEQ, 2002). Bioaccumulation screening not required when a bird and mammal screening value are available.
(d) The COI is considered a COPEC if:
1) The risk ratio (Rij) is greater than 5 (non-protected) or 1 (protected)
2) The Chemical of Interest is a bioaccumulator
3) No SLV or bioaccumulation vaule is available.
4) Not Calculated = Risk was not calculated for analytes with no screening criteria or bioaccumulation data.

TABLE B5-5
ECOLOGICAL RISK-BASED SCREENING CONCENTRATIONS

Chemical of Interest (COI)	Screening Level Values for Plants (mg/kg)		Soil Screening Level Values for Invertebrates (mg/kg)		Soil Screening Level Values for Birds (mg/kg)		Soil Screening Level Values for Mammals (mg/kg)		Freshwater Screening Level Values for Aquatic Life (mg/L)		Freshwater Screening Level Values for Birds (mg/L)		Freshwater Screening Level Values for Mammals (mg/L)		Freshwater Sediment Screening Level Values (mg/kg)	
Aluminum	50	Ecology, 2001	600	ODEQ, 2001	450	ODEQ, 2001	107	ODEQ, 2001	0.1	ODEQ, 2001	797	ODEQ, 2001	8	ODEQ, 2001	No Data	ODEQ, 2001
Antimony	5	Ecology, 2001	15	DMHSPE 2001	No Data	ODEQ, 2001	15	ODEQ, 2001	1.6	ODEQ, 2001	No Data	ODEQ, 2001	1	ODEQ, 2001	3	ODEQ, 2001
Arsenic III	10	ODEQ, 2001	60	ODEQ, 2001	7	Ecology, 2001	7	Ecology, 2001	0.2	ODEQ, 2001	18	ODEQ, 2001	6	ODEQ, 2001	6	ODEQ, 2001
Arsenic V	10	Ecology, 2001	60	Ecology, 2001	132	Ecology, 2001	132	Ecology, 2001	0.2	ODEQ, 2001	18	Arsenic III	6	Arsenic III	6	Arsenic III
Arsenic, Total	10	Arsenic III	60	Arsenic III	10	Arsenic III	29	Arsenic III	0.2	Ecology, 2003	18	Arsenic III	6	Arsenic III	6	Arsenic III
Barium	500	Ecology, 2001	3000	ODEQ, 2001	102	Ecology, 2001	102	Ecology, 2001	0.004	ODEQ, 2001	150	ODEQ, 2001	39	ODEQ, 2001	No Data	ODEQ, 2001
Beryllium	10	Ecology, 2001	10	froymsen et al. 1997	14	Ecology, 2001	14	Ecology, 2001	0.0053	ODEQ, 2001	No Data	ODEQ, 2001	No Data	ODEQ, 2001	No Data	ODEQ, 2001
Cadmium	4	Ecology, 2001	20	Ecology, 2001	6	ODEQ, 2001	125	ODEQ, 2001	0.00042	Ecology, 2003	10	ODEQ, 2001	8	ODEQ, 2001	0.6	ODEQ, 2001
Chromium III	1	ODEQ, 2001	0.4	ODEQ, 2001	4	ODEQ, 2001	340000	ODEQ, 2001	0.1	Ecology, 2003	7.2	ODEQ, 2001	21000	ODEQ, 2001	37	Chromium, Total
Chromium VI	1	Chromium III	0.4	Chromium III	4	Chromium III	410	ODEQ, 2001	0.01	Ecology, 2003	7.2	Chromium III	25	ODEQ, 2001	37	ODEQ, 2001
Chromium, Total	42	Ecology, 2001	42	Ecology, 2001	67	Ecology, 2001	67	Ecology, 2001	0.01	Chromium III	7.2	Chromium III	25	Chromium VI	37	Chromium, Total
Cobalt	20	Ecology, 2001	1000	ODEQ, 2001	No Data	ODEQ, 2001	150	ODEQ, 2001	0.023	ODEQ, 2001	No Data	ODEQ, 2001	9	ODEQ, 2001	No Data	ODEQ, 2001
Copper	100	Ecology, 2001	50	Ecology, 2001	217	Ecology, 2001	56.8	Ecology, 2001	0.0041	Ecology, 2003	341	ODEQ, 2001	53	ODEQ, 2001	36	ODEQ, 2001
Iron	10	ODEQ, 2001	200	ODEQ, 2001	No Data	ODEQ, 2001	No Data	ODEQ, 2001	1	ODEQ, 2001	No Data	ODEQ, 2001	No Data	ODEQ, 2001	No Data	ODEQ, 2001
Lead	50	Ecology, 2001	500	Ecology, 2001	118	Ecology, 2001	118	Ecology, 2001	0.00066	Ecology, 2003	28	ODEQ, 2001	323	ODEQ, 2001	35	ODEQ, 2001
Manganese	1100	Ecology, 2001	100	ODEQ, 2001	1500	Ecology, 2001	1500	Ecology, 2001	0.12	ODEQ, 2001	7242	ODEQ, 2001	676	ODEQ, 2001	1100	ODEQ, 2001
Mercury	0.3	Ecology, 2001	0.1	Ecology, 2001	5.5	Ecology, 2001	5.5	Ecology, 2001	0.000012	Ecology, 2003	3.3	ODEQ, 2001	10	ODEQ, 2001	0.2	ODEQ, 2001
Mercury, Methyl	0.0002	ODEQ, 2001	No Data	ODEQ, 2001	0.4	Ecology, 2001	0.4	Ecology, 2001	No Data	ODEQ, 2001	0.1	ODEQ, 2001	0.25	ODEQ, 2001	No Data	ODEQ, 2001
Nickel	30	Ecology, 2001	200	Ecology, 2001	980	Ecology, 2001	56.8	Ecology, 2001	0.057	Ecology, 2003	562	ODEQ, 2001	38	ODEQ, 2001	18	ODEQ, 2001
Selenium	1	Ecology, 2001	70	Ecology, 2001	0.3	Ecology, 2001	0.3	Ecology, 2001	0.005	Ecology, 2003	3.6	ODEQ, 2001	1.5	ODEQ, 2001	No Data	ODEQ, 2001
Silver	2	Ecology, 2001	50	ODEQ, 2001	No Data	ODEQ, 2001	No Data	ODEQ, 2001	0.00012	ODEQ, 2001	No Data	ODEQ, 2001	No Data	ODEQ, 2001	4.5	ODEQ, 2001
Thallium	1	Ecology, 2001	1	CCME 1999	No Data	ODEQ, 2001	1	ODEQ, 2001	0.04	ODEQ, 2001	No Data	ODEQ, 2001	0.06	ODEQ, 2001	No Data	ODEQ, 2001
Vanadium	2	Ecology, 2001	No Data	ODEQ, 2001	47	ODEQ, 2001	25	ODEQ, 2001	0.02	ODEQ, 2001	82	ODEQ, 2001	1.6	ODEQ, 2001	No Data	ODEQ, 2001
Zinc	86	Ecology, 2001	200	Ecology, 2001	360	Ecology, 2001	37.7	Ecology, 2001	0.038	Ecology, 2003	105	ODEQ, 2001	1230	ODEQ, 2001	123	ODEQ, 2001

No Data = No Data Available.
CWQG = Canadian Water Quality Guideline
Use of surrogate chemical toxicity data indicated by chemical name adjacent to concentration.

TABLE B5-5
ECOLOGICAL RISK-BASED SCREENING CONCENTRATIONS

Chemical of Interest (COI)	Sediment Bioaccumulation Screening Level Values (mg/kg)		Marine Sediment Screening Level Values (mg/kg)		Marine Screening Level Values for Aquatic Life (mg/L)		Lowest Required Detection Limit for Soil (mg/kg)	Lowest Required Detection Limit for Fresh Surface Water (mg/L)	Lowest Required Detection Limit for Freshwater Sediment (mg/kg)	Lowest Required Detection Limit for Marine Sediment (mg/kg)	Lowest Required Detection Limit for Marine Surface Water (mg/L)
Aluminum	No Data	ODEQ, 2001	No Data		2.71E-03	EPA 1999a	5.00E+01	8.7E-02	No Data	No Data	2.7E-03
Antimony	10	ODEQ, 2001	9.00E+00		5.00E-01	EPA 1999	5.00E+00	1.0E+00	3.0E+00	9.0E+00	5.0E-01
Arsenic III	4	ODEQ, 2001	7.00E+00		3.60E-02	EPA 1999	7.00E+00	1.5E-01	4.0E+00	4.0E+00	3.6E-02
Arsenic V	4	Arsenic III	7.00E+00	Arsenic III	3.60E-02	EPA 1999	1.00E+01	1.5E-01	4.0E+00	4.0E+00	3.6E-02
Arsenic, Total	4	Arsenic III	7.00E+00	Arsenic III	3.60E-02	EPA 1999	1.00E+01	1.9E-01	4.0E+00	4.0E+00	3.6E-02
Barium	No Data	ODEQ, 2001	4.80E+01		5.00E+00	EPA 1999	1.02E+02	4.0E-03	No Data	4.8E+01	5.0E+00
Beryllium	122	ODEQ, 2001	No Data		No Data		1.00E+01	5.3E-03	1.2E+02	1.2E+02	No Data
Cadmium	0	ODEQ, 2001			9.30E-03	EPA 2001	4.00E+00	4.2E-04	3.0E-03	3.0E-03	9.3E-03
Chromium III	4200	Chromium, Total	5.20E+01	Chromium VI	1.03E-01	EPA 2001	4.00E-01	6.6E-02	3.7E+01	5.2E+01	1.0E-01
Chromium VI	4200	ODEQ, 2001	5.20E+01		5.00E-02	EPA 2001	4.00E-01	1.0E-02	3.7E+01	5.2E+01	5.0E-02
Chromium, Total	4200	Chromium, Total	5.20E+01	Chromium VI			4.20E+01	1.0E-02	3.7E+01	5.2E+01	No Data
Cobalt	No Data	ODEQ, 2001	No Data		No Data		2.00E+01	2.3E-02	No Data	No Data	No Data
Copper	10	ODEQ, 2001	1.90E+01		3.10E-03	EPA 1999b	5.00E+01	4.1E-03	1.0E+01	1.0E+01	3.1E-03
Iron	No Data	ODEQ, 2001	No Data		No Data		1.00E+01	1.0E+00	No Data	No Data	No Data
Lead	128	ODEQ, 2001	3.00E+01		8.10E-03	EPA 1999	5.00E+01	6.6E-04	3.5E+01	3.0E+01	8.1E-03
Manganese	No Data	ODEQ, 2001	No Data		No Data		1.00E+02	1.2E-01	1.1E+03	No Data	No Data
Mercury	No Data	ODEQ, 2001	1.00E-01		9.40E-04		1.00E-01	1.2E-05	2.0E-01	1.0E-01	9.4E-04
Mercury, Methyl	No Data	ODEQ, 2001	No Data		No Data		2.00E-04	5.0E-02	No Data	No Data	No Data
Nickel	316	ODEQ, 2001	1.60E+01		8.20E-03	EPA 1999	3.00E+01	5.7E-02	1.8E+01	1.6E+01	8.2E-03
Selenium	0.1	ODEQ, 2001	1.00E+00		7.10E-02	EPA 2001	3.00E-01	5.0E-03	1.0E-01	1.0E-01	7.1E-02
Silver	No Data	ODEQ, 2001	7.00E-01		2.30E-04	EPA 2001	2.00E+00	1.2E-04	4.5E+00	7.0E-01	2.3E-04
Thallium	0.7	ODEQ, 2001	No Data		2.00E-02	EPA 1999	1.00E+00	4.0E-02	7.0E-01	7.0E-01	2.0E-02
Vanadium	No Data	ODEQ, 2001	5.70E+01		No Data		2.00E+00	2.0E-02	No Data	5.7E+01	No Data
Zinc	3	ODEQ, 2001	1.24E+02		8.10E-02	EPA 1999	3.77E+01	3.8E-02	3.0E+00	3.0E+00	8.1E-02

No Data = No Data Available.
CWQG = Canadian Water Quality Guideline
Use of surrogate chemical toxicity data indicated by chemical name adjacent to concentration.

Appendix B.

Applicable and Relevant and Appropriate Requirements

Table 1
Chemical-Specific Applicable or Relevant and Appropriate Requirements
Antimony Queen Mine, Washington

Standard, Requirement Criteria, or Limitation	Citation	Description	Applicable/Relevant and Appropriate?
FEDERAL			
Safe Drinking Water Act	40 USC § 300		
National Primary Drinking Water Regulations	40 CFR Part 141	Establishes health-based standards, maximum contaminant levels (MCLs) and MCL goals (MCLGs), for public water systems.	Applicable, not Relevant and Appropriate because no public water systems are present
National Secondary Drinking Water Regulations-	40 CFR Part 143	Establishes secondary MCLs for aesthetic standards for public water systems.	Applicable, not Relevant and Appropriate because no public water systems are present
Clean Water Act	33 USC § 1251-1376		
National Recommended Water Quality Criteria	Section 304(a)	Guidelines established for evaluating toxic effects on human health and aquatic organisms.	Relevant and Appropriate
National Ambient Water Quality Criteria	40 CFR Part 131	Sets criteria for water quality based on toxicity to aquatic organisms and human health.	Applicable
Clean Air Act	40 USC § 7409		
National Primary and Secondary Ambient Air Quality Standards	40 CFR Part 50	Establishes air quality levels that protect public health.	Not an ARAR, only "major" sources are subject to requirements related to NAAQS.
Preliminary Remediation Goals (PRGs) for soil and water	US Environmental Protection Agency (EPA) Region 9	PRGs are tools for evaluating and cleaning up contaminated sites. They are risk-based concentrations that are intended to assist risk assessors and others in initial screening-level evaluations of environmental measurements. The PRGs contained in the Region 9 PRG Table are generic; they are calculated without site specific information. However, they may be re-calculated using site specific data. PRGs are EPA guidelines, not legally enforceable standards.	Relevant and Appropriate
Resource Conservation and Recovery Act	40 USC § 7601		
Lists of Hazardous Wastes	40 CFR Part 261, Subpart D and C	Defines those solids wastes which are subject to regulation as hazardous wastes under 40 CFR Parts 262-265 and Parts 124, 270, and 271.	Not an ARAR, mine waste is not a listed hazardous waste, Bevill exempt. Even if TCLP testing confirmed a characteristic waste (Subpart C), it is still exempt. Parts of the RCRA regulations may be relevant and appropriate; however, and are discussed under action-specific requirements.

Table 1
Chemical-Specific Applicable or Relevant and Appropriate Requirements
Antimony Queen Mine, Washington

Standard, Requirement Criteria, or Limitation	Citation	Description	Applicable/Relevant and Appropriate?
STATE OF WASHINGTON			
Model Toxics Control Act (MTCA) Cleanup Regulations	WAC 173-340	Establishes administrative processes and standards to identify, investigate, and cleanup where hazardous substances have been released.	Relevant and Appropriate
MTCA Surface Water Cleanup Standards	WAC 173-340-730	Establishes surface water cleanup criteria based on estimates of highest beneficial use and reasonable maximum exposure for current and potential users.	Relevant and Appropriate
MTCA Soil Cleanup Standards – Residential Soils	WAC 173-340-740	Establishes soil cleanup levels for current and potential site use conditions.	Not an ARAR, because the Site is located in a remote area of the ONF.
MTCA Soil Cleanup Standards – Industrial Soils	WAC 173-340-745	Establishes soil cleanup levels where industrial site use represents reasonable maximum exposure.	Relevant and Appropriate
MTCA Air Quality Standards	WAC 173-340-750	Sets cleanup standards to protect air quality based on current and future site uses.	Relevant and Appropriate
MTCA Groundwater Cleanup Standards	WAC 173-340-720	Establishes clean-up levels based on the highest beneficial use and the reasonable maximum exposure expected.	Relevant and Appropriate
MTCA Human Health Risk Assessment	WAC 173-340-708	Defines the risk assessment framework to establish cleanup levels, and remediation levels using a quantitative risk assessment.	Relevant and Appropriate
MTCA Terrestrial Ecological Evaluation Procedures	WAC 173-340-7490	Establishes site specific cleanup standards for protection of terrestrial plants and animals. Does not include ecological receptors in sediment, surface water or wetlands.	Relevant and Appropriate
MTCA Simplified Terrestrial Ecological Evaluation Procedures	WAC 173-340-7492	Outlines the process for evaluating sites which do not have a substantial potential for posing a threat of significant adverse effects to terrestrial receptors.	Relevant and Appropriate
Water Quality Standards for Groundwater	WAC 173-200	Establishes groundwater quality standards to provide for the protection of public health, and current and future beneficial uses. This rule exempts CERCLA and MTCA cleanup actions.	Applicable, not Relevant and Appropriate because the groundwater pathway is incomplete.
Washington Department of Health Standards for Public Water Supplies	WAC 246-290	Establishes the regulatory requirements to protect consumers using public drinking water supplies.	Applicable, not Relevant and Appropriate because no public water systems are present.
Washington Dangerous Waste Regulations	WAC 173-303	Establishes the methods and procedures to determine if solid waste requires management as dangerous waste.	Relevant and Appropriate

Table 1
Chemical-Specific Applicable or Relevant and Appropriate Requirements
Antimony Queen Mine, Washington

Standard, Requirement Criteria, or Limitation	Citation	Description	Applicable/Relevant and Appropriate?
STATE OF WASHINGTON (cont.)			
Surface Water Quality Standards	WAC 173-201A	Establishes water quality standards to protect public health, and the propagation and protection of fish, shellfish, and wildlife.	Relevant and Appropriate
Sediment Management Standards	WAC 173-204	Establishes standards to reduce and eliminate adverse effects on biological resources and significant health threats to humans from surface sediment contamination.	Relevant and Appropriate

Table 2
Location-Specific Applicable or Relevant and Appropriate Requirements
Antimony Queen Mine, Washington

Standard, Requirement Criteria, or Limitation	Citation	Description	Applicable/Relevant and Appropriate?
FEDERAL			
Resource Conservation and Recovery Act	40 USC § 7601		
Hazardous and Solid Waste Regulations	40 CFR Part 264.18	Location standards and restrictions for hazardous waste treatment, storage, and disposal (TSD) facilities.	Relevant and Appropriate
	40 CFR §§ 257.3-1 through 257.3-4	Location standards and restrictions for municipal solid waste (MSW) facilities.	Not an ARAR, no MSW facilities at the Site.
National Historic Preservation Act	16 USC § 470; 36 CFR Part 800 40 CFR 6.301(b)	Requires federal agencies to take into account the effect of any federally assisted undertaking or licensing on any property with historic, architectural, archeological, or cultural value that is included in or eligible for inclusion in the National Register of Historic Places.	Applicable
Historic Site, Buildings, Objects, and Antiquities Act	16 USC § 461-467	Requires preservation of historic sites, buildings, and objects that are discovered that national significance.	Applicable
Archeological and Historic Preservation Act	16 USC § 469 40 CFR 6.301(c)	Establishes procedures to provide for preservation of significant scientific, prehistoric, historic, and archeological data that might be destroyed through alteration of terrain as a result of a Federal construction project or a Federally licensed activity or program.	Applicable
The Archaeological Resources Protection Act of 1979	16 USC § 470	Regulates requirements for authorized removal of archaeological resources from public or tribal lands.	Applicable
Executive Order 11593	16 USC § 469 40 CFR § 6.301(c)	Provides for the inventory and nomination of historical and archeological sites.	Applicable

Table 2
Location-Specific Applicable or Relevant and Appropriate Requirements
Antimony Queen Mine, Washington

Standard, Requirement Criteria, or Limitation	Citation	Description	Applicable/Relevant and Appropriate?
FEDERAL			
Native American Graves Protection and Repatriation Act	25 USC 3001-3013 43 CFR Part 10	Regulations that pertain to the identification, protection, and appropriate disposition of human remains, funerary objects, sacred objects, or objects of cultural patrimony.	Applicable
Protection of Wetlands Executive Order No. 11990	40 CFR Part 6; Appendix A, 40 CFR 6.302(a)	Avoid adverse impacts associated with the destruction or loss of wetlands and avoid support of new construction in wetlands if a practicable alternative exists.	Applicable
Dredge and Fill Regulations	33 USC § 1344, 33 CFR 323.1 et. seq.	Prohibits discharge of dredged or fill material into waters of the United States without a permit	Applicable, not Relevant and Appropriate, no dredge or fill material anticipated to be discharged
Fish and Wildlife Coordination Act	16 USC § 661-667 40 CFR 6.302(g)	Requires consultation when Federal department or agency proposes or authorizes any modification of any stream or other water body to assure adequate protection of fish and wildlife resources.	Applicable, not Relevant and Appropriate because no modification is likely.
Fish and Wildlife Conservation Act	16 USC § 2901-2911	Promotes conservation of non-game fish and wildlife	Applicable
Wilderness Act	16 USC § 1131-1136	Requires that wilderness areas are left unimpaired for future use as a wilderness	Not an ARAR, the Site is not in a wilderness area
Federal Land Policy and Management Act of 1976	43 USC § 1701	Provides for multiple use and inventory, protection, and planning for cultural resources on public lands.	Relevant and Appropriate
Floodplain Management Executive Order No. 11988	40 CFR Part 6, Appendix A 40 CFR 6.302(b)	Requires Federal agencies to evaluate the potential effects of actions they may take in a floodplain to avoid the adverse impacts associated with direct and indirect development of a floodplain to the extent possible.	Applicable
National Forest Management Act	16 USC § 1600-1614	The NFMA is the primary statute that requires the management of national forests to be based on multiple-use and sustained-yield principals.	Relevant and Appropriate

Table 2
Location-Specific Applicable or Relevant and Appropriate Requirements
Antimony Queen Mine, Washington

Standard, Requirement Criteria, or Limitation	Citation	Description	Applicable/Relevant and Appropriate?
Executive Order No. 11593 – Protection and Enhancement of the Cultural Environment	Executive Order No. 11593	Requires federal agencies to nominate historic properties to the National Register of Historic Places and to treat eligible properties as if on the list.	Applicable
Executive Order No. 13007 – Indian Sacred Sites	Executive Order No. 13007	Required federal agencies to avoid disturbing and access to sacred Indian sites.	Applicable
The American Indian Religious Freedom Act	16 USC § 1996	The Act requires that federal agencies protect the right of Indian tribes to exercise their traditions.	Applicable
Endangered Species Act	16 USC § 1531-1544; 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.	Relevant and Appropriate
Migratory Bird Treaty Act	16 USC § 703 et seq.	Establishes 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.	Relevant and Appropriate
Bald Eagle Protection Act	16 USC § 668 et seq.	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 or golden eagle.	Relevant and Appropriate

Table 2
Location-Specific Applicable or Relevant and Appropriate Requirements
Antimony Queen Mine, Washington

Standard, Requirement Criteria, or Limitation	Citation	Description	Applicable/Relevant and Appropriate?
STATE OF WASHINGTON			
Washington Department of Game	WAC 232-012	Defines the requirements that the Department of Game must take to protect endangered or threatened species.	Relevant and Appropriate
Washington State Shoreline Management Act	RCW Ch. 90.58 WAC 173-18, 22, 27	The substantive requirements of this statute and its implementing regulations apply to activities within 200 feet of shorelines in the state, which includes the shoreline of Gold Creek.	Relevant and Appropriate

Table 3
Action-Specific Applicable or Relevant and Appropriate Requirements
Antimony Queen Mine, Washington

Standard, Requirement Criteria, or Limitation	Citation	Description	Applicable/Relevant and Appropriate?
FEDERAL			
Clean Water Act Section 402. National Pollutant Discharge Elimination System	33 USC § 1342 33 USC § 1342 40 CFR Part 122.26	In general, Part 122 provides permit requirements for the discharge of pollutants from any point source into waters of the United States. Part 122.26 requires permits for storm-water discharges.	Substantive Requirements are Applicable, but not Relevant and Appropriate because permits are not required under CERCLA.
Section 404. Discharge of Dredge and Fill Materials	33 USC § 1344	Establishes program to regulate the discharge of dredged and fill materials into the waters of the US.	Substantive Requirements are Applicable, but not Relevant and Appropriate because permits are not required under CERCLA.
Surface Mining Control and Reclamation Act	30 USC §§ 1201-1328	Performance standards for surface mining activities.	Relevant and Appropriate
Hazardous Materials Transportation Act	49 USC §§ 1801-1813 49 CFR Parts 10, 171-177	Regulates transportation of hazardous materials.	Relevant and Appropriate, if any hazardous materials are transported offsite.
Resource Conservation and Recovery Act	46 USC § 7601		
Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal (TSD) Facilities	40 CFR Part 264.13.14	Requirements for proper handling, treatment, storage, and disposal of hazardous wastes.	Relevant and Appropriate
Land Disposal Restrictions (LDRs)	40 CFR Part 268	LDRs place specific restrictions (conc. or trmt) on RCRA hazardous wastes prior to their placement in a land disposal unit. Relevant and appropriate LDR requirements will be met if any material accumulations are treated *ex situ*.	Relevant and Appropriate
Disposal of Solid Waste	RCRA 42 U.S.C. § 6901 *et seq*; 40 CFR 257	Facility or practices in floodplains will not restrict flow of basic flood, reduce the temporary water storage capacity of the floodplain or otherwise result in a wash-out of solid waste.	Relevant and Appropriate
Closure Requirements	RCRA/HWMA 40 CFR & 264, Subpart G	Closure of hazardous waste repositories must meet protective standards. Regulations to minimize contaminant migration, provide leachate collection and prevent contaminant exposure will be met.	Relevant and Appropriate

Table 3
Action-Specific Applicable or Relevant and Appropriate Requirements
Antimony Queen Mine, Washington

Standard, Requirement Criteria, or Limitation	Citation	Description	Applicable/Relevant and Appropriate?
FEDERAL			
Landfill Design and Construction	RCRA/HWMA 40 CFR & 264, Subpart N	Hazardous waste landfills must meet minimum design standards. Protectiveness will be achieved through capping and institutional controls.	Relevant and Appropriate
Ground Water Monitoring	RCRA/HWMA 40 CFR & 264, Subpart F 40 CFR & 264, Subpart X	Establishes standards for detection and compliance monitoring. Site wide monitoring will accommodate specific ground water monitoring requirements.	Applicable, not Relevant and Appropriate because the groundwater pathway is incomplete.
Clean Air Act	42 USC § 7401 40 CFR 50	The Act establishes requirements to protect ambient air quality by limited air emissions.	Applicable
Criteria for Classification of Solid Waste Disposal Facilities and Practices	40 CFR Part 257	Establishes criteria for determining which solid waste disposal practices pose threats to human health and the environment.	Relevant and Appropriate
Occupational Exposure to Asbestos	29 CFR Parts 1910 and 1926.	Establishes OSHA requirements for asbestos-related work in the construction and demolition industry. Requirements on exposure limits, work practices and engineering controls to provide worker safety in handling, removal, disposal, or other workplace exposure to asbestos.	Applicable, not Relevant and Appropriate because no asbestos is present at the Site.
Fugitive Dust Emissions	40 CFR Section 50.6	Establishes standards for PM-10	Relevant and Appropriate

Table 3
Action-Specific Applicable or Relevant and Appropriate Requirements
Antimony Queen Mine, Washington

Standard, Requirement Criteria, or Limitation	Citation	Description	Applicable/Relevant and Appropriate?
STATE OF WASHINGTON			
MTCA	RCW Ch. 70.105D WAC 173-340	MTCA establishes administrative processes and standards to investigate and remediate sites where hazardous substances are present.	Relevant and Appropriate
Hazardous Waste Management Act and Dangerous Waste Regulations	RCW Ch. 70.105 WAC 173-303	Regulations that apply to handling and disposal of dangerous wastes.	Applicable
Solids Waste Management, Recovery, and Recycling Act	RCW Ch. 70.95 WAC 173-350	Substantive provisions and requirements may be applicable if a removal action is taken.	Relevant and Appropriate
General Closure and Post-Closure Requirements, Landfilling Standards	WAC 173-304 – 407 WAC 173-460	Outlines capping requirements for onsite repositories.	Relevant and Appropriate
Criteria for Municipal Solid Waste Landfills	WAC 173-351	Establishes minimum state-wide standards for all municipal solid waste landfills.	Not an ARAR, no municipal solid waste landfill is present at the Site.
State Waste Discharge Program	WAC 173-216	Requirements of this program may be applicable if removal action includes discharge to the ground surface.	Relevant and Appropriate
National Pollution Elimination System Permit Program	WAC 173-220	Establishes state program pursuant to the federal NPDES program. Substantive sections may be applicable if removal action involves discharge to waters of the state.	Relevant and Appropriate
Aquatic Lands Management	RCW Ch. 79.90 WAC 332-30	Establishes criteria for managing state-owned aquatic lands to promote uses and protect resources.	Relevant and Appropriate
Maximum Noise Levels	RCW Ch. 70.107 WAC 173-60	Establish maximum noise levels allowed in identified environments and use standards related to reception of noise within areas.	Applicable
State Environmental Policy Act	RCW 43.21C WAC 197-11	SEPA legislation is to ensure that federal agencies consider the environmental impacts of an action prior to implementation.	Substantive Requirements are Applicable
Washington Clean Air Act	RCW Ch. 70.94 RCW Ch. 43.21A	Substantive requirements may be applicable if removal action results in release of fugitive emissions.	Applicable

- **<u>Acronyms</u>**
    - APA – Abbreviated Preliminary Assessment
    - CES – Cascade Earth Science
    - CEE – Center of Environmental Excellence – basically the database that the WO and USDA uses for tracking and budgeting purposes.
    - CERCLA – Comprehensive Environmental Response, Compensation and Liability Act
    - ROD – Record of Decision
    - EE/CA – Engineering Evaluation/Cost Analysis
    - OSC – On-Scene Coordinator
    - NFA – No Further Action
    - PRP – Potentially Responsible Party
    - SI – Site Inspection
    - ICIM – Initiation of CERCLA Investigation Memorandum
    - COR – Contracting Officer Representative