FINAL

Record of Decision for the Ballard Mine

Caribou County, Idaho

August 2019

Prepared by
U.S. Environmental Protection Agency, Region 10

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RECORD OF DECISION
FOR
THE BALLARD MINE
CARIBOU COUNTY, IDAHO
FINAL

Part 1
Declaration

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Site Name and Location

The Ballard Mine Site (U.S. Environmental Protection Agency [EPA] ID No. IDN001002859) is a former open-pit phosphate mine located in the Phosphate Resource Area of southeastern Idaho. The Site is located approximately 13 miles north of Soda Springs, Idaho, in Caribou County.

To facilitate site management, the Site has been divided into two operable units: the area of the Ballard Mine Site (Operable Unit 1 or OU1), and the Ballard Shop Area (OU2). Only OU1 is being addressed in this Record of Decision (ROD).

Statement of Basis and Purpose

This decision document presents EPA's Selected Remedy for OU1 of the Ballard Mine Site. The remedy described in this ROD was chosen in accordance with the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) and, to the extent practicable, the National Oil and Hazardous Substance Pollution Contingency Plan (NCP). The decision is based on the Administrative Record for the Site. This document is issued by EPA Region 10, the lead agency. The Idaho Department of Environmental Quality (DEQ), as a support agency, provided assistance during development of the remedial investigation (RI) and feasibility study (FS). The State of Idaho concurs with the Selected Remedy.

Assessment of Site

The response action selected in this ROD is necessary to protect the public health or welfare or the environment from actual or threatened releases of hazardous substances, pollutants, or contaminants into the environment. Such a release or threat of release may present an imminent and substantial endangerment to public health, welfare, or the environment.

Description of Selected Remedy

This ROD selects a final remedy for the Ballard Mine Site (OU1). The Selected Remedy for the Site is a combination of engineered source controls, treatment technologies, and other approaches and components that will work together to achieve remedial action objectives (RAOs). A key element of the combined remedy is controlling the release of contaminants from waste rock dumps and mine pits by backfilling pits; consolidating, grading, and shaping waste rock; and constructing an approximately 5- to 6-foot-thick engineered cover system over more than 500 acres. Isolating the waste rock by constructing the cover system addresses direct contact risks with contaminants and vegetative uptake, reduces deep infiltration of water, and minimizes release of contaminants to surface water and groundwater.

Permeable reactive barriers, sediment control best management practices (BMPs), and engineered wetland treatment cells will be used to treat runoff, residual seepage, and contaminated shallow groundwater. These other elements will work in conjunction with the cover system to address impacts to surface water, shallow groundwater and sediment, and may be phased out in the longer term if no longer needed. It is expected that groundwater cleanup levels will be attained at the completion of the remedial action (RA). If low levels of groundwater contamination remain, monitored natural attenuation (MNA) of groundwater will be used as a 'polishing step' or a final stage of treatment, relying on natural processes of dilution and dispersion to further reduce contaminant concentrations. Contaminated sediment in intermittent streams on the margins of the site will be addressed by controlling sources of contamination to the streams and monitored natural recovery (MNR).

The combined remedy includes several other elements to evaluate and optimize the performance of source controls and treatment technologies and to ensure protectiveness. An adaptive management approach will be used to guide implementation of source controls and treatment technologies until RAOs are achieved. The combined remedy also includes institutional controls (ICs), operation and maintenance (O&M) requirements, and long-term effectiveness monitoring requirements.

The Selected Remedy recognizes that P4 Production LLC (P4) intends to recover phosphate ore concurrent with implementation of the remedy. Information collected during site characterization activities confirmed that about 4 million tons of phosphate ore remain at the Site, both exposed at the surface and in the bottoms and sidewalls of existing mine pits. Although potential ore recovery is not part of the remedy, EPA is selecting a remedy that allows for and is compatible with remining. EPA assumes that remining will happen for purposes of designing and implementing the remedy and for estimating the cost.

The amount of ore P4 intends to recover is an approximation based on currently available information and may change as more information becomes available or economic considerations change. Specific plans for possible remining would be accommodated during the remedial design phase of the project. The key elements of the design (identified in the bullets below) would be implemented even if plans for remining change (for example, if there is limited or no remining performed) although such implementation and/or cost of the remedy might change. The potential remining activities are expected to generate additional waste rock and overburden material for backfill of mine pits and construction of the evapotranspiration (ET) cover. In addition, the earthworks associated with potential remining (such as excavation and placement of fill, grading and shaping waste dumps, and backfilled pits) will also advance remediation efforts, thereby reducing the costs associated with remediation. No ore processing would occur at the Site. Instead, ore would be transported to a processing facility about 10 miles away.

For ore to be recovered during implementation of the remedy, P4 would need to acquire a federal mineral lease and seek approval from the Bureau of Land Management of a plan for ore recovery. If P4 does not obtain legal authority to remine, or if P4 does less (starts and then stops) or more remining than currently anticipated, then the design, implementation schedule and costs of the remedy would differ, but the key elements of the remedy (listed below) would remain the same. Such changes arising from remining are not anticipated to require changes to the Selected Remedy itself.

The Selected Remedy includes the following key components:

- **Engineered Cover System**. Mine pits will be backfilled regardless of the performed amount of remining, but the extent of pit backfill and the final shape of remediated surfaces may differ depending on its scope. At a minimum, mine pits will be backfilled to cover exposed ore beds and shale units of the Phosphoria Formation. Waste rock dumps and backfilled pits will be graded and shaped to ensure geotechnical stability and to promote runoff. An ET cover system, approximately 5 to 6 feet thick, will be constructed over the more than 500 acres of the Site where wastes are left in place.
- **Permeable Reactive Barriers (PRBs)**. A series of PRBs will be constructed downgradient of the source areas to intercept and treat contaminated shallow alluvial groundwater. The PRBs may be phased out in the future if no longer needed, as source controls become effective.
- **Wetland Treatment Cells**. A series of semi-passive bioreactors will be constructed on Site margins to treat contaminated residual seeps and springs. These treatment units will be designed and operated to remove selenium and other contaminants. Some of the treatment units may be phased out in the future as the engineered cover system reduces the infiltration of water and the flow discharging at seeps and springs is reduced or eliminated.
- **Groundwater MNA**. The primary strategy to restore groundwater is the implementation of source controls (cover system) and treatment (PRBs and wetland treatment cells). It is expected that these technologies will greatly reduce flow and may eliminate many contaminated seeps and springs. These components are also expected to greatly reduce contaminant concentrations in

groundwater. If necessary, MNA will be used as a polishing step to further reduce contaminant concentrations to achieve RAOs.

- **Stormwater and Sediment Control BMPs**. During the construction phase, sediment ponds and other sediment control BMPs would be constructed to control release of sediment to downstream waterbodies. BMPs will be specified during remedial design (in a stormwater pollution prevention plan) and will include a broad suite of techniques to control erosion, such as use of compaction, construction sequencing, straw mulch and wattles, silt fences, and other techniques.
- **Sediment MNR.** Intermittent and ephemeral stream sediment and riparian soil will be addressed through a combination of sediment traps and basins in headwater drainage locations and MNR for downstream reaches. Over time, natural processes of dilution and dispersion are expected to result in natural recovery of these impacted areas and attainment of RAOs. Long-term monitoring (LTM) and a sitewide adaptive management planning approach will be used to evaluate progress and trigger follow-up actions as needed.
- **Adaptive Management**. A sitewide adaptive management plan will be developed and implemented to evaluate critical elements of the remedy and make revisions (such as design modifications or operational changes) that are within the scope of the Selected Remedy.
- **O&M**. An O&M plan will be developed and implemented to ensure the integrity, proper functioning and performance of all engineering controls (for example, ET cover system) and treatment facilities (for example, PRBs, wetland treatment cells, and BMPs).
- **LTM**. Monitoring will be conducted to assess the effectiveness of various components of the remedy and progress toward achieving RAOs.
- **ICs and Access Restrictions**. ICs will be applied to protect the remedy and prevent human exposure by limiting land and resource use. In addition, fences, gates and, physical barriers will be built to prevent damage to engineered and vegetated components of the remedy.

Remedial construction will be implemented in phases, aligning with the anticipated recovery of phosphate ore from different areas of the Site. The overall timeline for construction is estimated to be 6 to 8 years. The cost of implementing the Selected Remedy, expressed as the present value of future costs, is approximately $41 million.

A final remedy for the Ballard Shop Area of the Site (OU2) is not being selected in this ROD. P4 intends to continue the use of the Ballard Shop Area, which covers approximately 10 acres on the southwestern edge of the Site, to support remedy implementation and nearby mining operations. A focused FS and Proposed Plan will be developed for this small portion of the Site and a final remedy selected in a separate ROD. This ROD, however, selects ICs and fencing as interim actions at the Ballard Shop Area to limit potential exposure to construction and mine workers until a final remedy is selected and implemented. ICs will include restrictions on the use of this area, including its groundwater.

Statutory Determinations

The Selected Remedy is protective of human health and the environment. It complies with all federal and state requirements that are applicable or relevant and appropriate to the RA. It is cost-effective and uses permanent solutions and alternative treatment technologies or resource recovery technologies to the maximum extent practicable.

The remedy does not satisfy the statutory preference for treatment as a principal element of the remedy. The NCP establishes an expectation that treatment will be used to address the principal threats posed by a site whenever practicable. Principal threat waste is defined in EPA guidance as highly toxic or highly mobile source materials that generally cannot be contained in a reliable manner or that present a significant risk should exposure occur. No principal threat wastes have been identified at the Site. Source materials at the Site are waste rock located in the mine dumps and backfilled pits. The waste rock is present in large volumes, which makes treatment impracticable. The source materials, however, can be reliably contained by using engineering controls.

Because the Selected Remedy will result in hazardous substance, pollutants, or contaminants remaining onsite above levels that would allow for unlimited use and unrestricted exposure, a statutory review of the Site will be conducted within 5 years of initiation of the RA to ensure the remedy is, or will be, protective of human health and the environment.

ROD Data Certification Checklist

The following information is included in the Decision Summary (Part 2) of this ROD. Additional information can be found in the Administrative Record for this Site.

- Chemicals of concern and their concentrations (Section 5 – Summary of Site Characteristics)
- Baseline risks represented by the chemicals of concern (Section 7 – Summary of Risks)
- Cleanup levels established for the chemicals of concern and the basis for these levels (Section 8 – Remedial Action Objectives)
- How source materials constituting principal threats are addressed (Section 11 – Principal Threat Wastes)
- Current and reasonably anticipated future land use assumptions and current and potential future beneficial uses of groundwater used in the baseline risk assessment and ROD (Section 6 – Current and Potential Future Land and Resource Use)
- Potential land and groundwater use that will be available at the Site because of the Selected Remedy (Section 12 – Selected Remedy)
- Estimated capital, annual O&M, and total present value (worth) costs, discount rate, and the number of years over which the remedy cost estimates are projected (Section 12 – Selected Remedy)
- Key factors that led to selecting the remedy (Section 12 – Selected Remedy)

Authorizing Signature

R. David Allnutt
Acting Division Director
Superfund and Emergency Management Division
EPA Region 10

9/24/19
Date

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RECORD OF DECISION
FOR
THE BALLARD MINE
CARIBOU COUNTY, IDAHO

Part 2
Decision Summary

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Acronyms

<	less than
>	greater than
%	percent
°F	degree(s) Fahrenheit
µg/L	microgram(s) per liter
$\mu g/m^3$	microgram(s) per cubic meter
AMSL	above mean sea level
AOC	area of concern
ARAR	applicable or relevant and appropriate requirements
ASTDR	Agency for Toxic Substances and Disease Registry
AWQC	ambient water quality criteria
bgs	below ground surface
BLM	Bureau of Land Management
BMP	best management practice
BTAG	Biological Technical Assistance Group
CCC	Continuous Chronic Criteria
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	*Code of Federal Regulations*
cfs	cubic feet per second
CIP	Community Involvement Plan
COC	chemical of concern
COEC	chemical of ecological concern
COPC	chemical of potential concern
COPEC	chemical of potential ecological concern
CSF	cancer slope factor
CSM	conceptual site model
CTE	central tendency exposure
CWA	Clean Water Act
DAR	Data Approval Request
DEQ	Idaho Department of Environmental Quality
DQUR	Data Quality and Usability Report
EcoSSL	Ecological Soil Screening Level
EE/CA	engineering evaluation/cost analyses
EPA	U.S. Environmental Protection Agency

EPC	exposure point concentration
ERA	ecological risk assessment
ESA	Endangered Species Act
ET	evapotranspiration
FS	feasibility study
FYR	Five-Year Review
GCLL	geosynthetic clay laminate liner
gpm	gallon(s) per minute
GW	groundwater [alternatives]
GYC	Greater Yellowstone Coalition
HASP	health and safety plan
HHRA	human health risk assessment
HI	hazard index
HQ	hazard quotient
HQ_{LOAEL}	hazard quotient lowest observed adverse effect level
HQ_{NOAEL}	hazard quotient no observed adverse effects level
IC	institutional control
ID	identification
IDAPA	Idaho Administrative Procedure Act
ILCR	incremental lifetime carcinogenic risk
IRIS	Integrated Risk Information System
LOAEL	lowest observed adverse effect level
LRA	livestock risk assessment
LTM	long-term monitoring
LUC	land use controls
MCL	maximum contaminant level
mg/kg	milligram(s) per kilogram
mg/kg-day	milligram(s) per kilogram per day
mg/L	milligram(s) per liter
mg/m^3	milligram(s) per cubic meter
Monsanto	the Monsanto Company
MNA	monitored natural attenuation
MNR	monitored natural recovery
MRL	minimal risk level
MWH	Montgomery Watson Harza

No.	number
NCP	National Contingency Plan
NOAA	National Oceanic and Atmospheric Administration
NOAEL	no observed adverse effects level
NPL	National Priority List
NPV	net present value
O&M	operation and maintenance
OR&R	(NOAA) Office of Response and Restoration
ORNL	Oak Ridge National Laboratory
OSWER	(EPA) Office of Solid Waste and Emergency Response
OU	Operable Unit
P4	P4 Production LLC, a subsidiary of Bayer
pCi/g	picocurie(s) per gram
pCi/m^3	picocurie(s) per cubic meter
PRB	permeable reactive barrier
PRG	preliminary remediation goal
RA	remedial action
RAGS	*Risk Assessment Guidance for Superfund*
RAO	remedial action objective
RAWP	remedial action work plan
RBCL	risk-based concentration level
RD	remedial design
RD/RAWP	remedial design and remedial action work plan
RfC	reference concentration
RfD	reference dose
RI	remedial investigation
RME	reasonable maximum exposure
ROD	Record of Decision
S/RS	stream channel sediment and riparian soil [alternatives]
SI	site investigation
Simplot	J.R. Simplot Company
Site	Ballard Mine Site
SQuiRTs	(NOAA) Screening Quick Reference Tables
SW	surface water [alternatives]
TBC	to be considered

TRV	toxicity reference value
TRV_{LOAEL}	toxicity reference value lowest observed adverse effect level
TRV_{NOAEL}	toxicity reference value no observed adverse effect level
UCL	upper confidence limit
UMTRCA	Uranium Mill Tailing Radiation Control Act
URF	unit risk factor
USFS	U.S. Forest Service
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
USL	upper simultaneous limit
USWR	upland soil and waste rock [alternatives]
UTL	upper tolerance level
yd^3	cubic yard

Section 1 – Site Name, Location, and Description

This section summarizes general information about the Ballard Mine Site.

1.1 Introduction

The Ballard Mine Site (U.S. Environmental Protection Agency [EPA] ID No. IDN001002859) is a former open-pit phosphate mine located in the Phosphate Resource Area of southeastern Idaho (Figure 1-1). Operation of the mine generated waste rock enriched with various inorganic contaminants, including selenium, arsenic, uranium, and other elements. Contaminants have been released to soils, surface water, groundwater, sediment, and vegetation.

The Site is not listed on the National Priority List (NPL). It is a Superfund equivalent site, with EPA directing and providing oversight of a remedial investigation (RI) and feasibility study (FS) undertaken and financed by the responsible party (P4 Production LLC, a subsidiary of Bayer [P4]). The RI/FS and remedy selection followed the structured process established by the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) and the National Contingency Plan (NCP) to guide the cleanup of contaminated sites. As discussed in the Proposed Plan for the Site (EPA, 2018), the process includes various steps leading from discovery of a site through investigation, remedy selection, and implementation of a remedy. The NCP includes procedures, expectations, and program management principles to guide the process.

EPA is the lead regulatory agency. Other agencies providing technical support and assistance throughout the process included the Idaho Department of Environmental Quality (DEQ), U.S. Fish and Wildlife Service (USFWS), and Shoshone-Bannock Tribes.

1.2 Site Name and Location

The Ballard Mine Site is located in Caribou County in the southeastern corner of Idaho, approximately 13 miles north-northeast of the city of Soda Springs. The Site is situated about 20 miles west of the Wyoming border and 50 miles north of the Utah border. The Site is located, specifically, within Sections 1, 6, 7, 12, 13, 18, Township 7 South, Range 42-43 East.

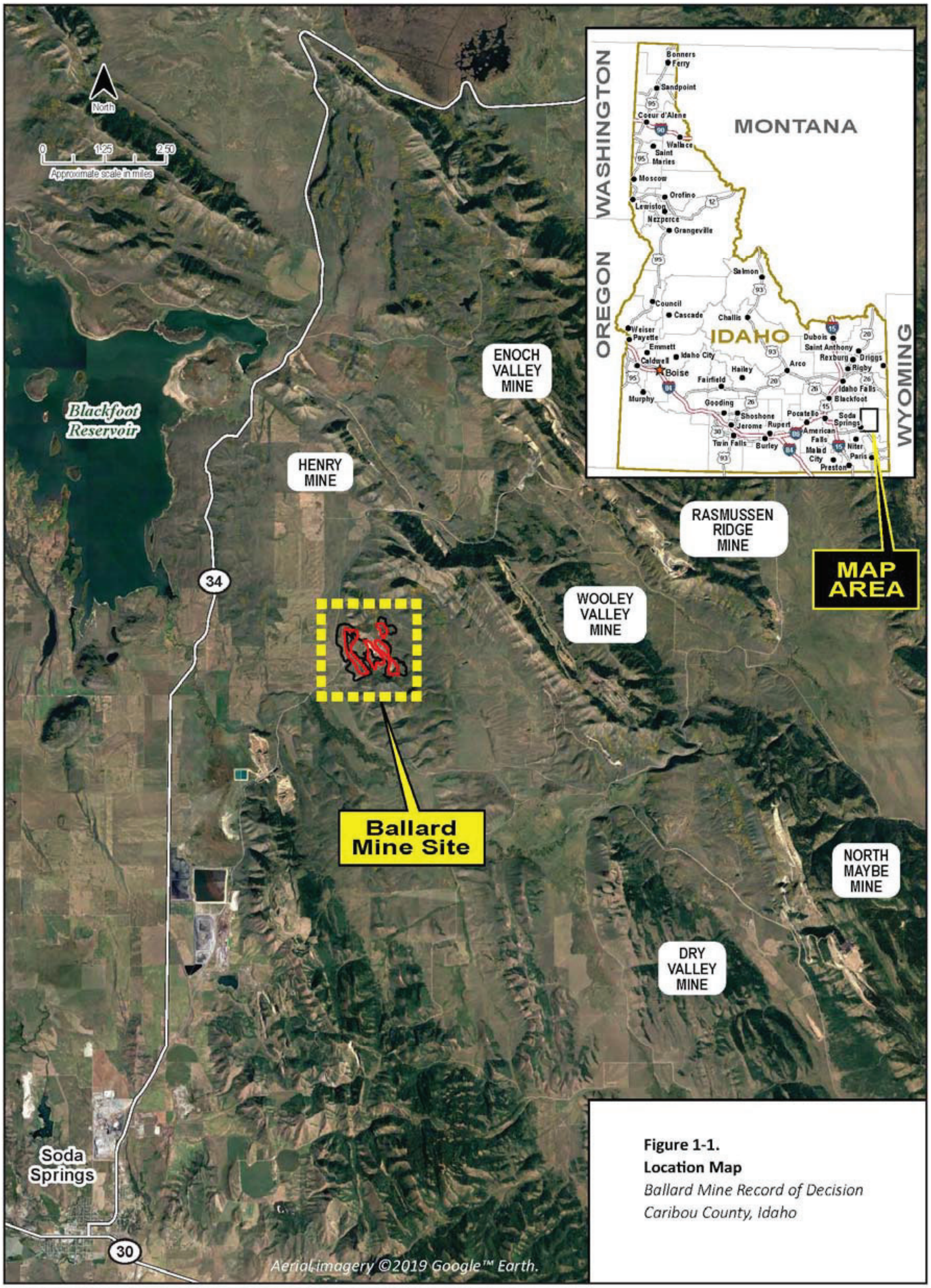
1.3 General Description of Site

The Ballard Mine Site is a historical open-pit phosphate mine located in southeastern Idaho, an area where phosphate-rich sedimentary rock formations are present at or near the surface. This area has been mined for more than 100 years; there are many historical mines within the mining district, as well as four active and several proposed mines.

The Ballard Mine was operated by the Monsanto Company (Monsanto) from 1951 to 1969 and includes approximately 534 acres of mining disturbance consisting of six open pits, six external waste rock dumps, an abandoned haul road, the Ballard Shop Area, and ancillary facilities. Most of the Site has been revegetated, except for some mine pit areas and steep waste rock dump slopes (Figure 1-2).

The lands at the Site are owned by P4 Production LLC, a wholly-owned subsidiary of Monsanto (which was acquired by Bayer in 2018), and the state of Idaho. P4 has a surface easement on the state lands. Adjoining properties are privately owned and used for seasonal ranching and farming.

Figure 1-1. Location Map



Amended from P4 Productions, LLC, Remedial Investigation, MHW, 2014.

The Site is within the aboriginal territory of the Shoshone and Bannock Tribes. Although the Site is outside the boundary of the Fort Hall Reservation, the Shoshone-Bannock Tribes have treaty rights on unoccupied federal lands in the vicinity of the Site for hunting, gathering, and ceremonial uses. The nearest federal land where treaty rights apply is a 40-acre Bureau of Land Management (BLM) parcel located about 1 mile southeast of the Site. A map of the area near the Site, with information on land ownership, is included as Figure 1-3 and the configuration of the waste rock dumps and pits is illustrated on Figure 1-4.

The Site is in an arid upland area with the footprint of disturbance on a ridgeline that trends north-northwest/south-southeast and rises to 7,000 feet above mean sea level (AMSL). The Site is bounded by three relatively low-gradient drainage basins containing ephemeral and intermittent streams that originate near the Site.

The primary source of contaminants at the Site is waste rock from historical mining operations; approximately 19 million cubic yards of waste rock are present at the Ballard Site. The middle waste shale component of the waste rock dumps is enriched with various naturally occurring contaminants, including selenium, arsenic, uranium, and uranium-daughter products (for example, radium-226 and radon-222).

Contaminants from the source material in the waste dumps have been released to various media, including soil, surface water, groundwater, sediment, and vegetation. Dissolved selenium and other contaminants have been transported from the source areas by surface water runoff to downstream waterbodies. Water that infiltrates down through the waste rock dumps may reappear as contaminated seeps or springs below the dumps or mix with underlying groundwater forming plumes downgradient of the source material. Vegetation growing on the contaminated surface material is elevated in selenium. Some plant species (known as hyper-accumulators) can accumulate very high concentrations of selenium.

Figure 1-2. Remnant Partially Vegetated Waste Rock Dump (Eastern Side of Site)

Figure 1-3. Ballard Site – Land Ownership

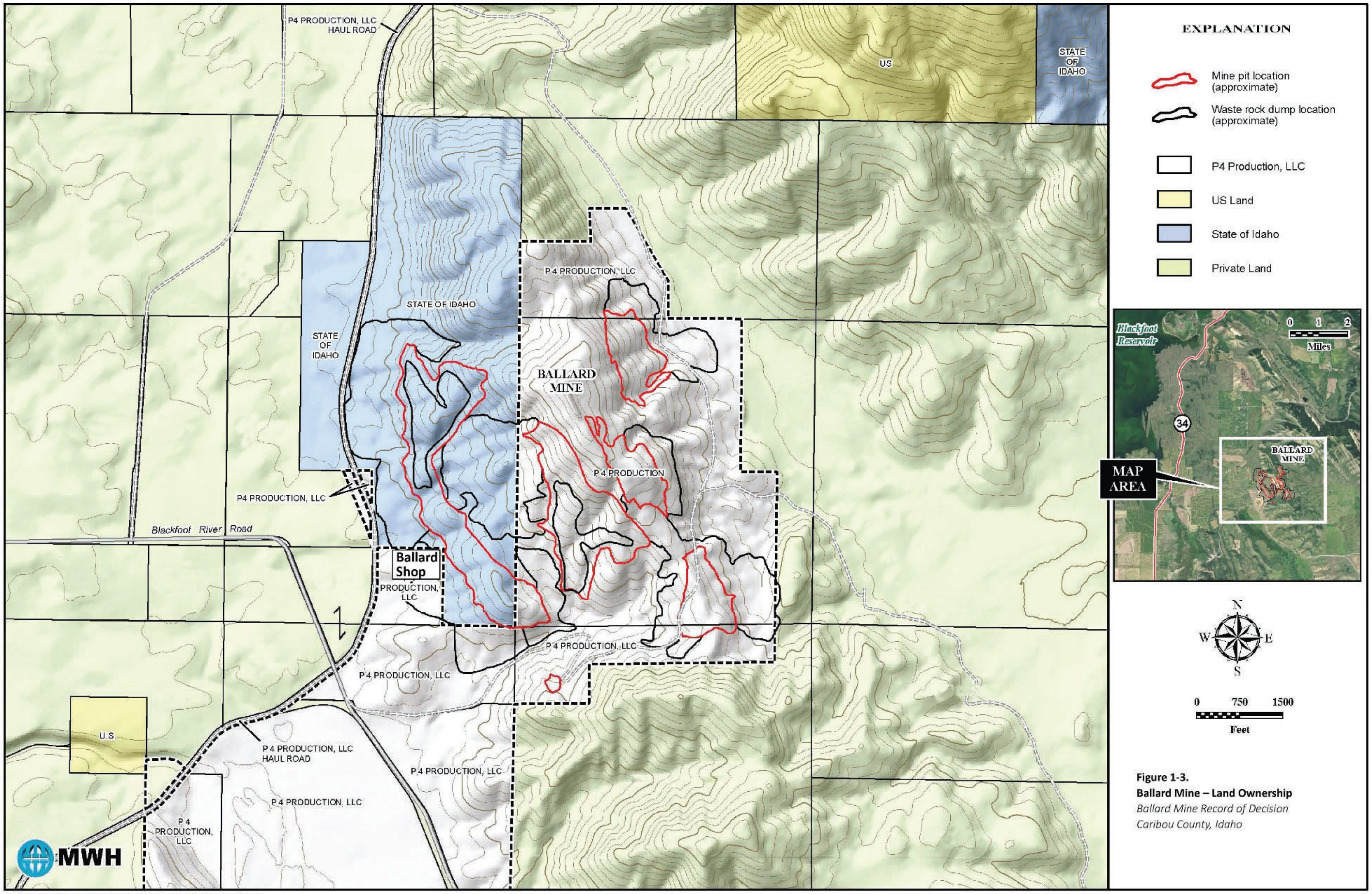
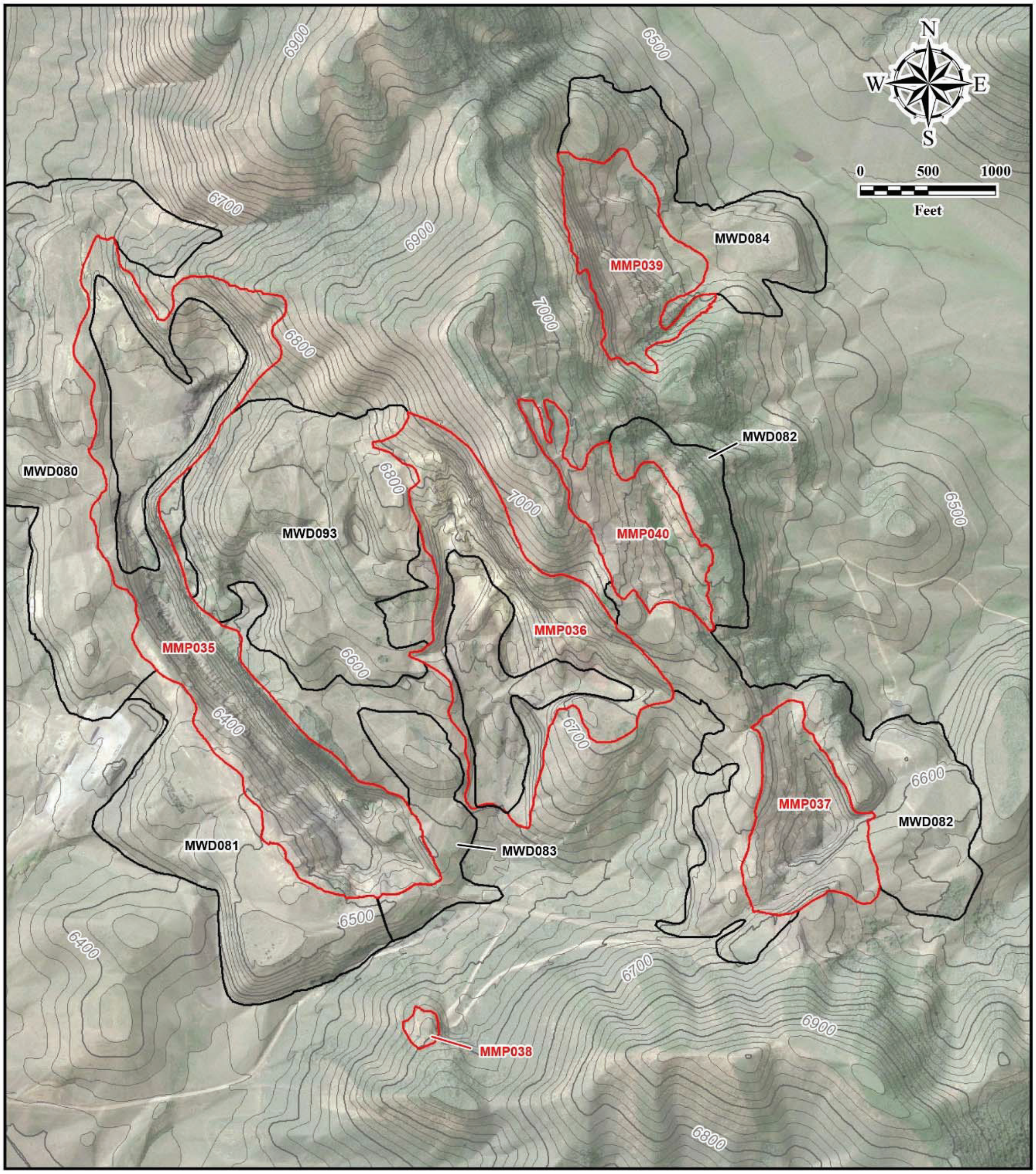


Figure 1-3.
Ballard Mine – Land Ownership
Ballard Mine Record of Decision
Caribou County, Idaho

Amended from P4 Production LLC, RI; MWH 2015.

Figure 1-4. Ballard Site Topography and Mine Features (MWH, 2015)



Approximate mine pit location as shown in FS Memo No. 1

Approximate waste rock dump location as shown in FS Memo No. 1

Amended from P4 Production LLC, FS Technical Memorandum #2, MWH 2017

Figure 1-4.
Ballard Mine – Mining Features
Ballard Mine Record of Decision
Caribou County, Idaho

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Section 2 – Site History and Enforcement Activities

This section summarizes the history of the Site, including previous investigations and removal activities that predate the start of the RI/FS.

2.1 Site History

Key milestones in the exploration, development, and operation of the Ballard Mine are described below.

- December 1948 – The area where the Site is located was originally leased to the J. R. Simplot Company (Simplot) under federal mineral lease BL-055875. Simplot never developed the lease.
- May 23, 1951 – Simplot assigned the lease to Monsanto, which started exploration and stripping of overburden in June 1951. Mining started in 1952 on the southern portion of lease BL-055875 and expanded to the north.
- July 1955 – Monsanto received a second Ballard Mine BLM lease that included additional phosphate ore deposits immediately to the west of the initial lease area (I-05723). In 1955, Monsanto initiated mining operations within this new lease, referred to as Ballard Mine Pit No. 1 or the West Ballard Pit (location number MMP035, Figure 1-4). Ballard Mine Pit No. 1 contained the largest ore reserves of the five pits at the Ballard Mine and was operated for a longer period than any of the other pits.
- The Ballard Mine eventually consisted of several side-hill and open-pit excavations. Trucks and conveyors moved ore to the loading facilities. The loading facilities included tipples, screens, conveyors, weigh bins, and automatic samplers. Trucks hauled ore from the mine loading facilities to the elemental phosphorus plant at Soda Springs, Idaho, using public roads until the private haul road was completed in July 1958. No ore processing was conducted onsite.
- Monsanto operated the Ballard Mine until 1969 and then moved their active mining operations to the nearby Henry Mine. Monsanto relinquished the Ballard Mine mineral leases to the BLM in April 1984, and BLM accepted relinquishment in July 1984.
- During the 17 years of operations at the Ballard Mine, Monsanto recovered 10.4 million dry net tons of phosphate rock that were hauled to Monsanto's elemental phosphorus plant at Soda Springs. During this period, Monsanto excavated approximately 20 million cubic yards of waste rock; of that amount, two million cubic yards were used to backfill the pits, with the remaining 18 million cubic yards hauled to the waste rock dumps (Lee, 2001).

2.2 Enforcement and Investigation Activities

Investigations to assess the impacts of phosphate mining in southeastern Idaho on human health and the environment increased after several horses (pastured in another part of the mining district) were diagnosed with selenosis (i.e., selenium poisoning) in 1996 and were subsequently euthanized. Some of these early studies were conducted by the U.S. Geological Survey (USGS) and the University of Idaho. Other investigations in the late 1990s were conducted under direction of the Idaho Mining Association's Selenium Subcommittee. These studies contributed to EPA's understanding of how phosphate mining affects the environment.

In 2001, DEQ assumed leadership of an areawide investigation of the contamination caused by phosphate mining, with participation by other state and federal agencies and the mining companies with operations in southeastern Idaho. These areawide investigations led the agencies to conclude that site-specific investigations were warranted on the larger historical and active open-pit mines located in the mining district, including the Ballard Mine.

These conclusions led to negotiations with P4 to conduct site-specific investigations at the historical mines for which it is responsible: the Ballard Mine, Henry Mine, and Enoch Valley Mine. In October 2003, DEQ, EPA, the U.S. Forest Service (USFS), the Shoshone-Bannock Tribes, the Bureau of Indian Affairs, BLM, and P4 (the latter as Respondent) entered into a legal agreement (EPA, 2003) calling for P4 to conduct investigations and develop site investigation (SI) and engineering evaluation/cost analyses (EE/CA) reports for the Ballard, Henry, and Enoch Valley mine sites. These efforts followed a streamlined removal approach. DEQ was designated the lead agency to oversee this work, which resulted in the collection of a considerable amount of information and a better understanding of site conditions. Work under the 2003 removal agreement was halted before the SI reports were prepared, for a variety of reasons, including recognition that using the removal approach would be inappropriate for sites as large and complex as the Ballard, Henry and Enoch Valley mine sites. All data collected under the 2003 removal agreement, however, were validated by procedures prescribed by EPA and included in the RI.

In November 2009, a new legal agreement transitioned work at the P4 sites into a more thorough remedial approach, and from DEQ-led to EPA-led. The 2009 agreement superseded the 2003 agreement and called for performance of an RI and FS at each of the three P4 mine sites. The 2009 agreement included EPA, DEQ, USFS, the Department of the Interior (for USFWS), BLM, the Shoshone-Bannock Tribes, and P4 (EPA, 2009a).

Key investigation reports and data submittals relevant to the investigation of the Ballard Mine include the following:

- Community Involvement Plan Update for Ballard, Enoch Valley, and Henry (P4) Mines (DEQ, 2017)
- Final Revision 2 Data Quality and Usability Report (DQUR) and Data Approval Request (DAR) (MWH, 2010)
- Ballard, Henry and Enoch Valley Mines, Remedial Investigation and Feasibility Study Work Plan (MWH, 2011)
- Background Levels Development Technical Memorandum, Ballard, Henry, and Enoch Valley Mines, Remedial Investigation and Feasibility Study (MWH, 2013a)
- Final Ballard Mine Remedial Investigation and Feasibility Study, Remedial Investigation Report, Baseline Risk Assessment Addendum (MWH, 2014)
- Final Baseline Risk Assessment Addendum (MWH, 2015c)
- Final On-Site and Background Areas Radiological and Soil Investigation Summary Report – P4's Ballard, Henry, and Enoch Valley Mines Remedial Investigation and Feasibility Study (MWH, 2015b)
- Final Ballard Mine Feasibility Study Report – Memorandum 1 – Site Background and Screening Technologies (MWH, 2016a)
- Final Ballard Mine Feasibility Study Report – Memorandum 2 – Screening, Detailed and Comparative Analysis of Assembled Remedial Alternatives (MWH, 2017a)
- Ballard Mine Monitored Natural Attenuation Technical Memorandum (MWH, 2017b)
- Ballard Mine Proposed Plan. Caribou County, ID (EPA, 2018)

Section 3 – Community and Tribal Participation

3.1 Overview

A variety of tribal and community involvement activities have occurred during development of the RI/FS and in conjunction with issuance of the Proposed Plan. These activities are described in a Community Involvement Plan (CIP), which has been updated periodically since 2008.

In developing the CIP, EPA interviewed the following area stakeholders:

- Elected officials (such as mayors, city council members, and county commissioners)
- Staff representatives for Senators Mike Crapo and James Risch and Representative Mike Simpson
- Local legislative representatives
- Area landowners and residents

General information was asked about properties, community concerns, and how best to communicate with the public through the investigative process.

During development of the RI/FS, EPA and support agencies distributed Site-specific and area-wide fact sheets, established local information repositories, hosted community meetings, developed an informational display for the local library, and implemented other actions.

The following sections summarize tribal engagement efforts throughout the RI/FS process and community engagement efforts performed in conjunction with issuance of the Proposed Plan.

3.2 Tribal Engagement

The Ballard Mine Site is within the aboriginal territory of the Shoshone and Bannock Tribes. Although the Site is outside the boundaries of the Fort Hall Reservation, the Shoshone-Bannock Tribes have rights under the Fort Bridger Treaty to use unoccupied federal lands in the area for hunting, gathering, and ceremonial uses. These treaty rights apply to BLM lands approximately 1 mile downstream of the Site along the Blackfoot River, and to other federally managed lands in the area. The land at the Site is currently owned by the State of Idaho and P4.

The Shoshone-Bannock Tribes are a signatory to the 2009 legal agreement for performance of an RI/FS and serve as a Support Agency on investigations at the three P4 sites. Tribal staff in the Environmental Waste Management Program have actively participated throughout the RI/FS process and have provided valuable input and assistance in site investigations and in developing cleanup plans.

Because of the history of tribal engagement on the P4 projects and treaty interests on federally managed lands in the watershed, EPA met with members of the Fort Hall Business Council on November 8, 2018 and engaged in Government-to-Government Consultation on the proposed cleanup action for the Site. During the consultation, the Tribes expressed serious and long-standing concerns about the impacts of phosphate mining and expressed support for making progress on cleaning up historic phosphate mines in southeastern Idaho. With respect to the Ballard Mine Site, the Tribes raised many questions and concerns and offered recommendations but did not object to the Preferred Alternative. The issues that have been raised do not change the analysis supporting the Selected Remedy.

3.3 Community Engagement

Local Repository

The administrative record, which includes the RI/FS and other documents that form the basis of EPA's Selected Remedy, is housed at the EPA Superfund Records Center located at 1200 Sixth Avenue, Suite 155, OMP-161, Seattle, Washington, 98101. The center can be reached by telephone at 206-553-4494 or (toll-free) 800-424-4372.

Additional information repositories have been established at the following locations:

EPA Idaho Operations Office
950 W. Bannock Street
Suite 900
Boise, Idaho 83702
Phone: 208-378-5746
Monday through Friday

DEQ Pocatello Regional Office
444 Hospital Way, #300
Pocatello, ID 83201
208-236-6160

Soda Springs Public Library
149 S Main St
Soda Springs, ID 83276-1496
208-547-2606

Shoshone-Bannock Tribes Library
P.O. Box 306
Fort Hall, ID 83203
208-478-3882

Email and Postal Updates

EPA and DEQ maintained a list of all interested stakeholders that included a base list of residents derived from Caribou County property ownership information. An email message containing a link to the Proposed Plan and information on how to submit comments was sent to a distribution list. A postcard containing the same information was mailed to the regular mailing list. Paper copies of the Proposed Plan were mailed upon request.

Paid Notices and Media Coverage

Paid notices were placed in the *Caribou County Sun*, the *Idaho State Journal* (the Pocatello newspaper), and the *Sho-Ban News* in April 2018 to announce issuance of the Proposed Plan and provide information on public involvement opportunities.

Project Web Site

EPA created the following project website to provide access to documents and information about the Site: https://cumulis.epa.gov/supercpad/cursites/csitinfo.cfm?id=1002859

Proposed Plan and Public Meeting

EPA issued a Proposed Plan for the Site on April 2, 2018. An open house and public meeting for the Proposed Plan were held in the afternoon and evening, respectively, of April 11, 2018. EPA provided a visual display of the project and a formal presentation. EPA and DEQ representatives were present to answer questions about the remedial alternatives considered and the preferred remedial option selected. The public had the opportunity to provide spoken comments during the public meeting or written comments during the 30-day comment period, which closed on May 2, 2018. EPA received comments from three individuals and one organization. The comments presented in the written comments are summarized with EPA's responses in the Responsiveness Summary, Part 3 of this document.

Section 4 – Scope and Role of the Operable Unit

In 2009, EPA entered into a settlement agreement with P4 calling for the production of an RI/FS for each of the three historic phosphate mine sites for which P4 is responsible: the Ballard, Henry and Enoch Valley mine sites. Planning and data collection activities were implemented concurrently for the three sites. The Ballard Mine Site is the first of the three sites for which a ROD is being issued; decision documents for the other two sites will follow.

As with many Superfund sites, the problems at the Ballard Mine Site are complex. As a result, EPA has organized the Site into two operable units (OUs).

- Operable Unit 1 (OU1): Contamination associated with the area of the Ballard Mine Site that was mined historically, including impacts to all environmental media. This OU comprises most of the Site, about 550 acres of historical mining disturbance. Also included are surrounding areas, such as receiving waters and aquifers, where contaminants have come to be located.
- Operable Unit 2 (OU2): Contamination associated with the Ballard Shop Area. This OU covers a smaller portion of the Site, approximately 10 acres. This is an area that is currently being used to support nearby mining operations, and is used for equipment storage, fuel storage, stockpiling of slag material used as aggregate for active haul roads, and other activities.

A map of the Site showing the location and size of the Ballard Shop Area (OU2) relative to the area of the Ballard Mine Site (OU1) is shown on Figure 4-1. The following sections describe the overall cleanup strategy for the Site.

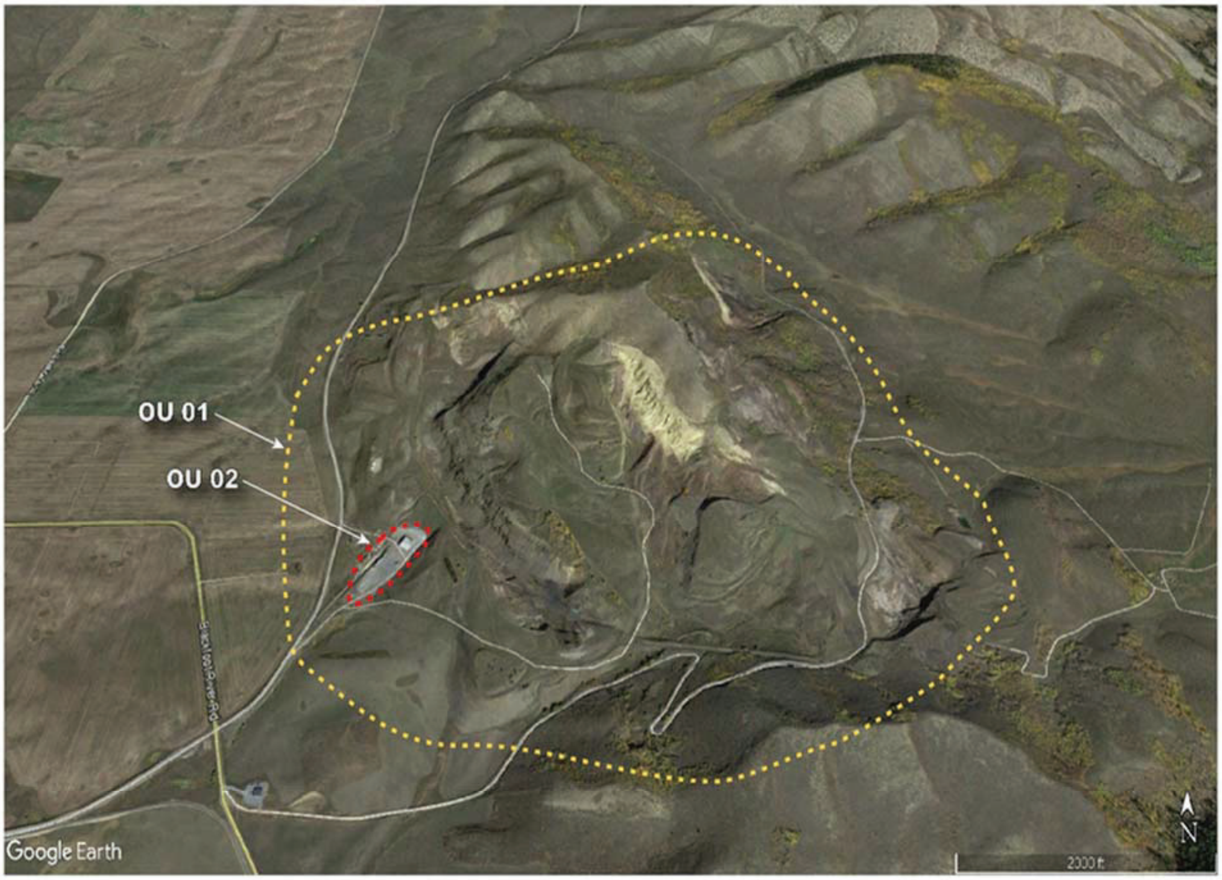
4.1 Response Action for Ballard Mine Site (OU1)

This ROD selects a final remedy for the Ballard Mine Site (OU1). The Selected Remedy for OU1 is a combination of engineered source controls, treatment technologies, and other approaches and components that will work together to achieve the remedial action objectives (RAOs). A key element of the combined remedy for OU1 is controlling the release of contaminants from the waste rock dumps and mine pits. This will be accomplished by backfilling pits; consolidating, grading and shaping waste rock; and constructing a 5- to 6-foot-thick engineered cover system over the more than 500 acres of mining disturbance. Isolating the waste rock by constructing the cover system addresses direct contact risks with contaminants and vegetative uptake, reduces deep infiltration of water, and minimizes release of contaminants to surface water and groundwater.

4.2 Response Action for the Ballard Shop Area (OU2)

A final remedy for the Ballard Shop Area of the Site (OU2) is not being selected in this ROD and will be deferred until the OU is no longer in use. P4 intends to continue the use of the Ballard Shop Area, which covers approximately 10 acres on the southwestern edge of the Site, to support remedy implementation and nearby mining operations. A focused FS and Proposed Plan will be developed for this small portion of the Site and a final remedy selected in a separate ROD. This ROD, however, selects institutional controls (ICs) and fencing as interim actions at the Ballard Shop Area to limit potential exposure to construction and mine workers until a final remedy is selected and implemented. ICs will include restrictions on the use of this area, including its groundwater.

Figure 4-1. Ballard Mine Operable Units 01 and 02



Legend

- OU 01 Approximate boundaries of surface disturbance (includes Groundwater plumes) - Ballard Mine Site
- OU 02 Approximate boundaries of surface disturbance - Ballard Shop Area

Figure 4-1
OPERABLE UNITS 01 AND 02

BALLARD MINE
RECORD OF DECISION
Caribou County, ID

"Amended from P4 Production LLC, FS Technical Memorandum #2, MWH 2017".

Section 5 – Summary of Site Characteristics

This section contains an overview of the Site and the conceptual site model (CSM). Detailed information on sampling results and risks are presented in Section 7 and the tables in Appendix A.

5.1 Site Overview

5.1.1 Surface Features and Size

The Site is located about 13 miles north-northeast of Soda Springs, Idaho, in mountainous, semi-arid Caribou County. P4 owns approximately 865 acres of surface rights and has a surface easement from the state of Idaho on an additional 360 acres. These properties encompass the entire area disturbed by mining (Figure 1-4). The adjoining properties are all privately held ranching and farming properties. The nearest downstream federal land is a 40-acre BLM parcel, approximately 1 mile southeast of the Site.

The topography of this area is dominated by north-northwest/south-southeast-trending ridgelines of moderate relief, ranging in elevation from 6,300 to 7,000 feet AMSL. The Site is located on one such ridgeline and is bounded to the east and west by three low-gradient drainage basins containing intermittent or ephemeral streams that originate from, or flow past, the Site (including Long Valley Creek and Wooley Valley Creek).

On the northwestern edge of the Ballard Mine Site, Long Valley Creek drains northward to the Little Blackfoot River, which empties into the northeastern corner of the Blackfoot Reservoir. Wooley Valley Creek originates in the basin to the east of the Site and flows about 5 miles to its confluence with the Blackfoot River. Wooley Valley Creek is intermittent for most of its length, becoming perennial about 1 mile above its confluence with the Blackfoot River. Intermittent stream channels originating near the eastern side of the Site lead to Wooley Valley Creek. The upper reaches of Wooley Valley Creek flow during the snowmelt and peak runoff periods in the spring but are often dry in the summer. The Blackfoot River is located approximately 1 mile to the south of the Site. An intermittent stream channel (Ballard Creek) leads from the southern portion of the Site to the Blackfoot River.

Significant features at the Site include mine pits (see Figure 5-1), waste rock dumps, a primary haul road, and a Shop area (approximately 534 acres of mining disturbance). Because of the age of the mine, much of the area is vegetated, except for some mine pit areas and steep waste-rock dump slopes.

Mine Pits and Waste Rock Dumps

The configuration of the mine pits and waste rock dumps is shown on Figure 1-4. There are six mine pits at the Ballard Site, with the largest pits (MMP035 [West Ballard Pit] and MMP036 [Central Ballard Pit]) on the western edge and in the central portion of the Site, respectively. Three other pits (MMP037, MMP039, and MMP040) are in the eastern portion of the Site. The MMP038 pit is a much smaller pit located south of the other mine features.

Figure 5-1. West Ballard Mine Pit

There are six waste rock dumps at the Site: MWD080, MWD081, MWD082, MWD083, MWD084, and MWD093. The waste rock dumps are located adjacent to the mine pits from which the waste rock was excavated. These features are generally flat-topped with angle-of-repose outer slopes. Waste rock was also placed in MMP035 and MMP036, partially backfilling these mine pits. The total volume of waste rock present is about 19 million cubic yards. The waste rock dumps range in volume from 600,000 to about 5,000,000 cubic yards of waste rock. Further information on the areas and volumes of the waste rock dumps and pits is provided in the RI report (MWH, 2014).

Ancillary Facilities

Ancillary facilities remaining at the Ballard Mine include remnants of a partially paved haul road, various unimproved soft-surface two-track roads, and the Shop area (consisting of a large garage/shop building, various small storage sheds and buildings, and a stockpile of slag from the P4 Soda Springs plant). The stockpiled slag is used for maintenance of active haul roads and associated facilities. No ore processing was conducted at the Site, so except for the slag pile at the Shop area, no process wastes are present.

Surface Materials and Vegetation

Surface material and vegetation at the Site were characterized during the 2009 upland soil and vegetation investigation (MWH, 2014). Surficial material on mine waste dumps consists of an approximate 2:1 mixture of weathered brown shale and black shale. The weathered brown shale represents the weathered rock stripped from the near surface during mining to reach the ore beds of the Meade Peak Member of the Phosphoria Formation, and the black shale is typically the waste shale that was located between and immediately above and below the Meade Peak Member ore beds. The surface materials found in the walls and floors of the mine pits reflect the geology of the sedimentary formations encountered during mining. Limestone and sandstone are typically found at, or near, the base of Wells Formation highwalls.

The Site is generally well vegetated, consisting of a combination of grasses, forbs (broadleaf plants such as alfalfa), shrubs, and some trees. Several steep slopes, primarily highwalls and angle-of-repose slopes in the southern portion of the Site, are unvegetated. The vegetation at the Site was altered in 2012 by a rangeland fire that burned parts of MMP035, MWD080, MWD093, and MMP036 (MWH, 2014).

5.1.2 Climate

The climate of southeastern Idaho is semi-arid with hot summers and cold winters. The topography strongly influences wind patterns, temperature, and precipitation. North-trending mountain ranges in the region create a natural barrier for water-saturated Pacific air masses. Precipitation during the colder months is snow, while precipitation during the summer is primarily localized thunderstorms.

Because meteorological data are not directly available for the Site, data were obtained from nearby stations, including the meteorological station at the Blackfoot Bridge Mine. Precipitation is distributed through the year, with spring and summer having some of the wetter months. The data collected at the Blackfoot Bridge Mine suggest that the average annual precipitation near the Site is on the order of 13 inches per year. July and August are the warmest months of the year, while December and January are the coldest. Average temperatures range from a minimum of 7.9 degrees Fahrenheit (°F) in December to a maximum of 80.9°F in July.

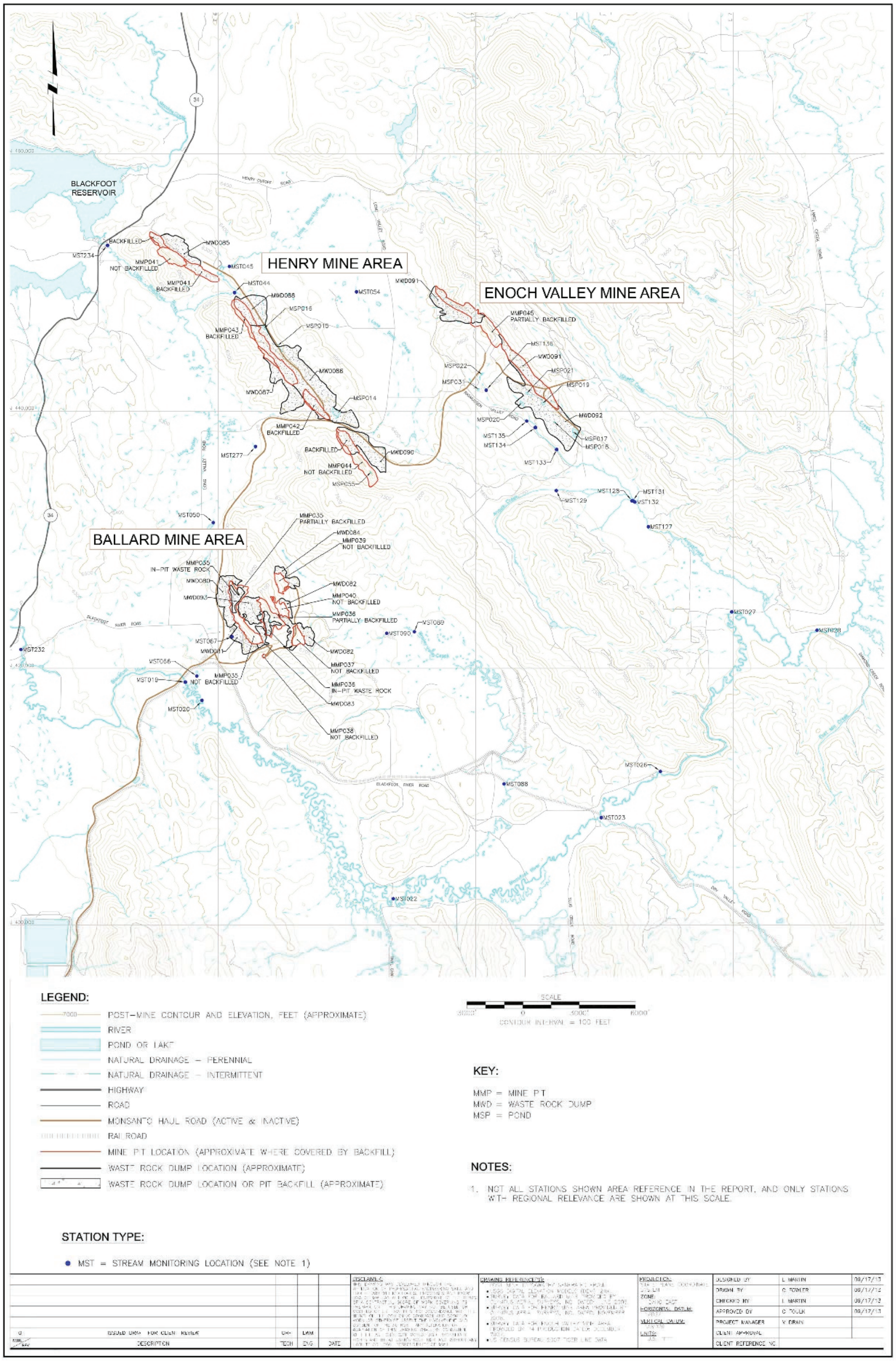
5.1.3 Geology

The geology in the Ballard Mine area is transitional between the Basin and Range and Rocky Mountain Physiographic Provinces. Figure 5-2 depicts the topography of the area and the locations of the three P4 mine sites (Ballard, Henry, and Enoch Valley). The geology of the area is complex, characterized by linear, north-south-trending, fault-bounded ranges and basins.

Ranges in southeastern Idaho are generally composed of deformed sedimentary rock of the Paleozoic and Mesozoic age, and include thick marine clastic units, cherts, and limestones. The valleys are largely filled with Quaternary alluvium and colluvium. In some areas, the Quaternary alluvial deposits overlie Pleistocene basalt flows. Thick basaltic flows of the Snake River Plain and rhyolite domes south of the Blackfoot Reservoir are also present in other parts of the region.

The Paleozoic and Mesozoic sedimentary rocks cover a large area of eastern Idaho, southwestern Montana, and northern Utah. During the Permian geologic period, the Phosphoria Formation was deposited, creating the western phosphate field that includes the southeast Idaho Phosphate Resource Area. The Phosphoria Formation has four members (from oldest to youngest): the Meade Peak Phosphatic Shale, Rex Chert, Cherty Shale, and Retort Phosphatic Shale. The Meade Peak Member, which ranges in thickness from about 55 to 200 feet, is the source of most of the extracted phosphate ore. This is the oldest member of the Phosphoria Formation and is typically overlain by either the Rex Chert or the Cherty Shale and underlain by the upper unit of the Wells Formation, which consists of sandstone interbedded with limestone and dolomite. Figure 5-3 presents a generalized stratigraphic column, while Figure 5-4 shows a generalized cross section through a generic mine pit.

Figure 5-2. Topography and Proximity to other P4 Mines



Amended from P4 Production LLC, RI, Drawing 2-1, MWH, 2014.

Figure 5-3. Generalized Stratigraphic Column for the Phosphate Resource Area of Southeastern Idaho.

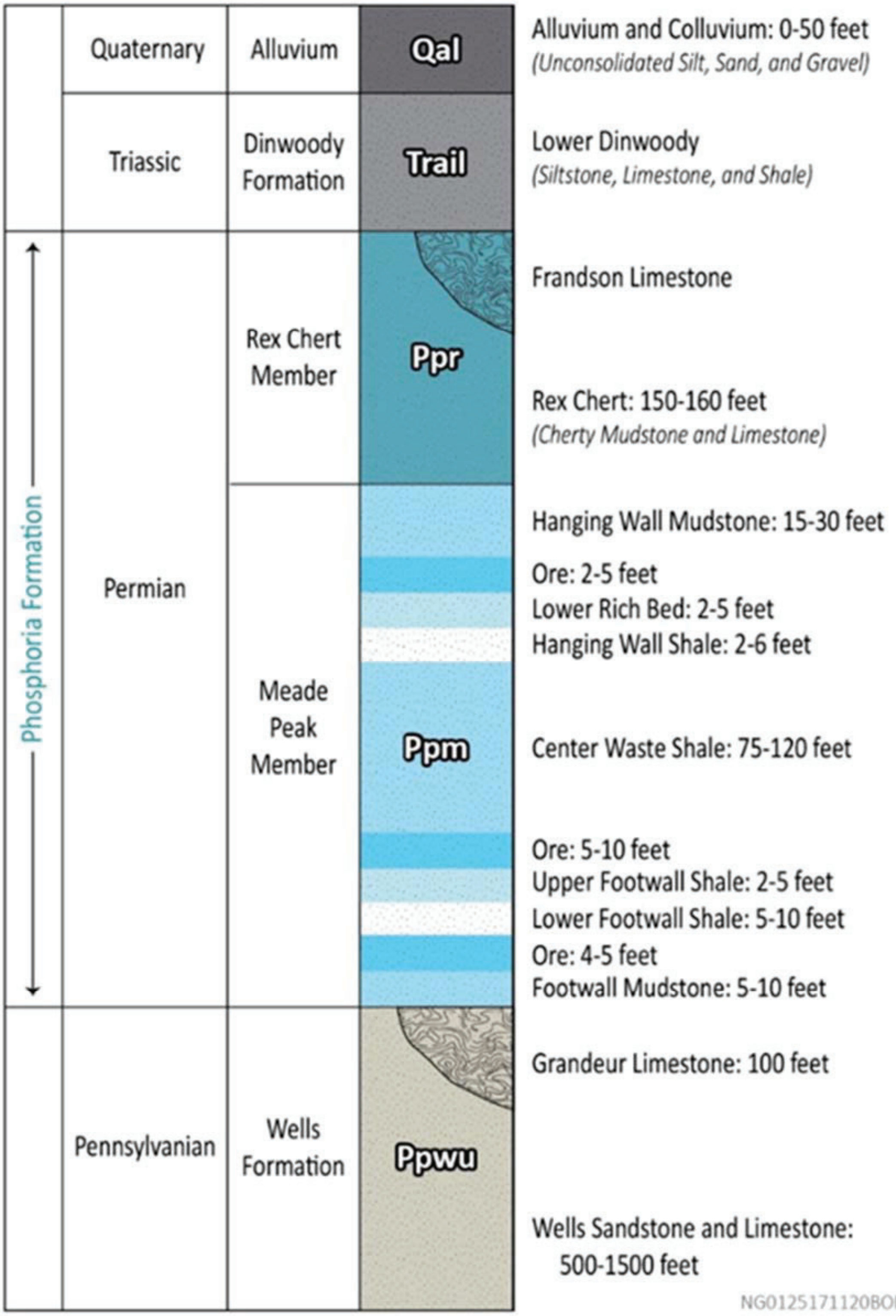
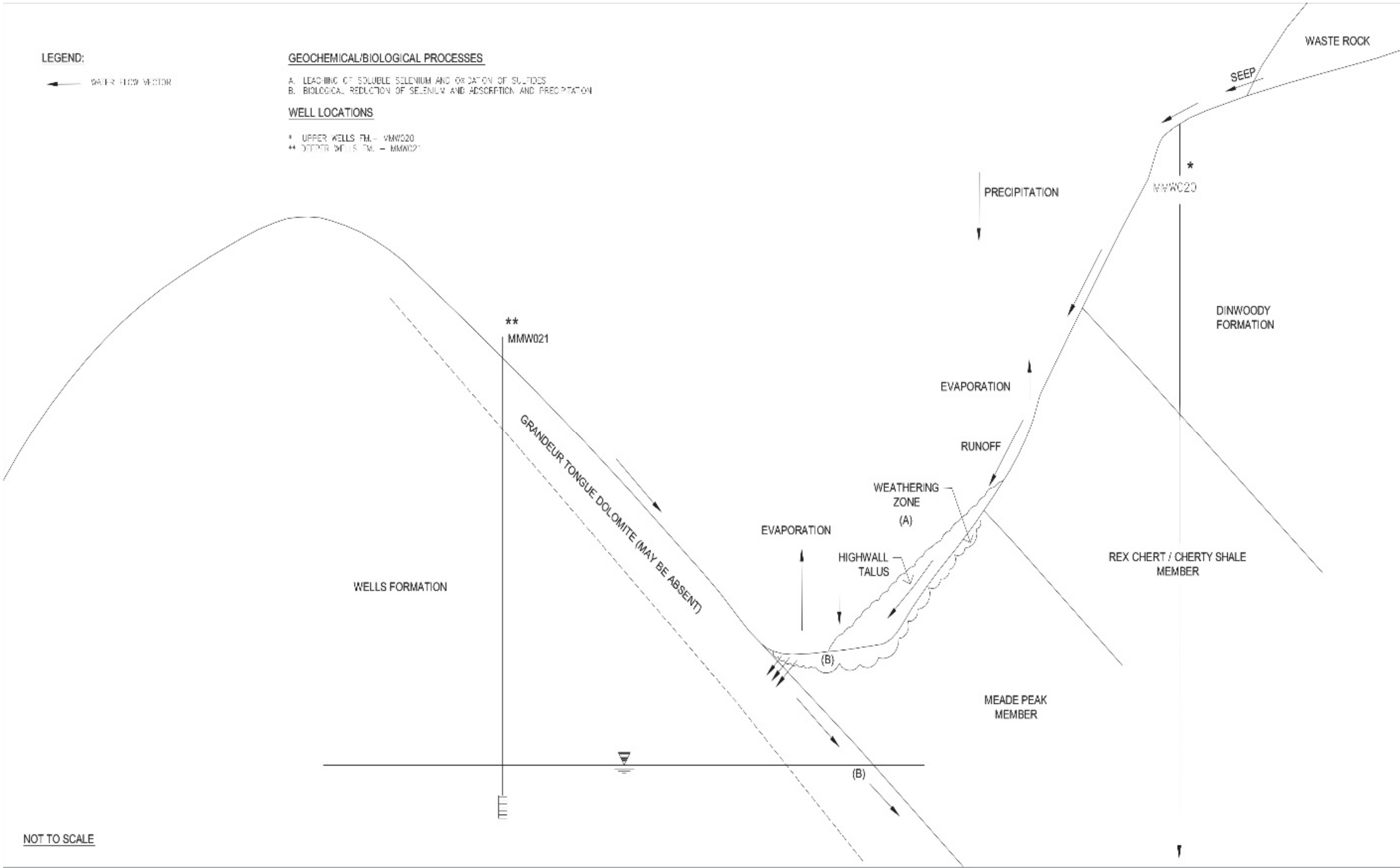


Figure 5-4. Generalized Cross Section through Generic Mine Pit



Another significant sedimentary unit in the area is the Triassic Dinwoody Formation, which is made up of upper and lower units consisting of limestone, siltstone, and shale layers. The lower Dinwoody Formation directly overlies the Phosphoria units in the stratigraphic section.

5.1.4 Surface Water

The Site is in a watershed catchment ranging in elevation from 6,000 to 7,000 feet AMSL and is bounded by three relatively low-gradient drainage basins (Figure 5-5). The Site is a headwater area for ephemeral and intermittent streams flowing towards larger drainages off the Site. Most of the streams in the area flow only during snowmelt runoff and intense precipitation events; however, a few intermittent streams are fed by perennial springs. There is no reliable flow in these stream channels for approximately 9 months of the year. Drainages fed by perennial seeps and springs dry up through evaporation and infiltration within about 100 feet of the source during baseflow months. On the eastern side of the Site, the surface tributary system drains to Wooley Valley Creek, which becomes perennial approximately 3 to 4 miles downgradient of the Site. There are some ponds along Wooley Valley Creek below the Site that retain water throughout the year.

The following sources of water at the Site discharge to surface water or groundwater:

- Intermittent stormwater and snowmelt surface runoff. Runoff is generally diffuse with very few defined overland runoff channels. Much of the runoff reaches the offsite channels as interflow in the waste rock and adjacent soils.
- Mine dump seeps and associated springs. These features discharge during snowmelt and runoff events. The springs are primarily mine dump seepage, but do not always discharge directly from the toe of a mine waste rock dump. Flow from these discharges range from a peak of approximately 90 gallons per minute (gpm) to 4.5 gpm during snowmelt and from 4.5 gpm to dry during the baseflow period. Most of the contaminant loading to the drainages originates from the mine dump seeps and associated springs (Figure 5-6).
- Five small seasonal ponds are located within the mining disturbed area. These ponds form naturally in depressions in the mine pit floors. These onsite ponds are all less than 0.25 acre in size and are dry during parts of the year.

Runoff and stormwater contribution from the Site to the Blackfoot River is seasonal and a very minor contributor to flow in the Blackfoot River. The Site contributes very little flow to Long Valley Creek (north of the Site). Additional information on runoff and baseflow discharges can be found in the RI report (MWH, 2014).

Figure 5-5. Watershed Features near the Ballard Mine

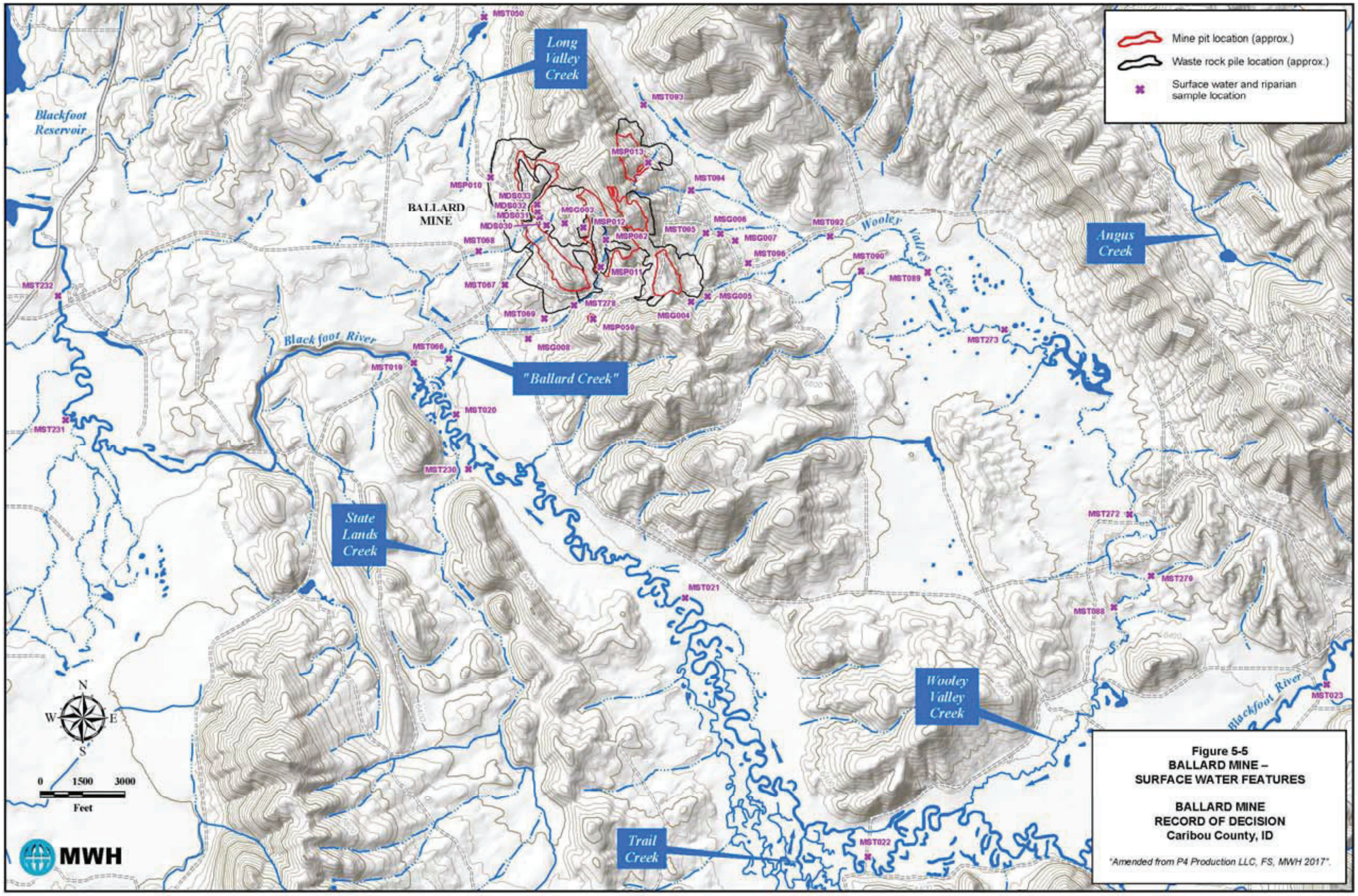
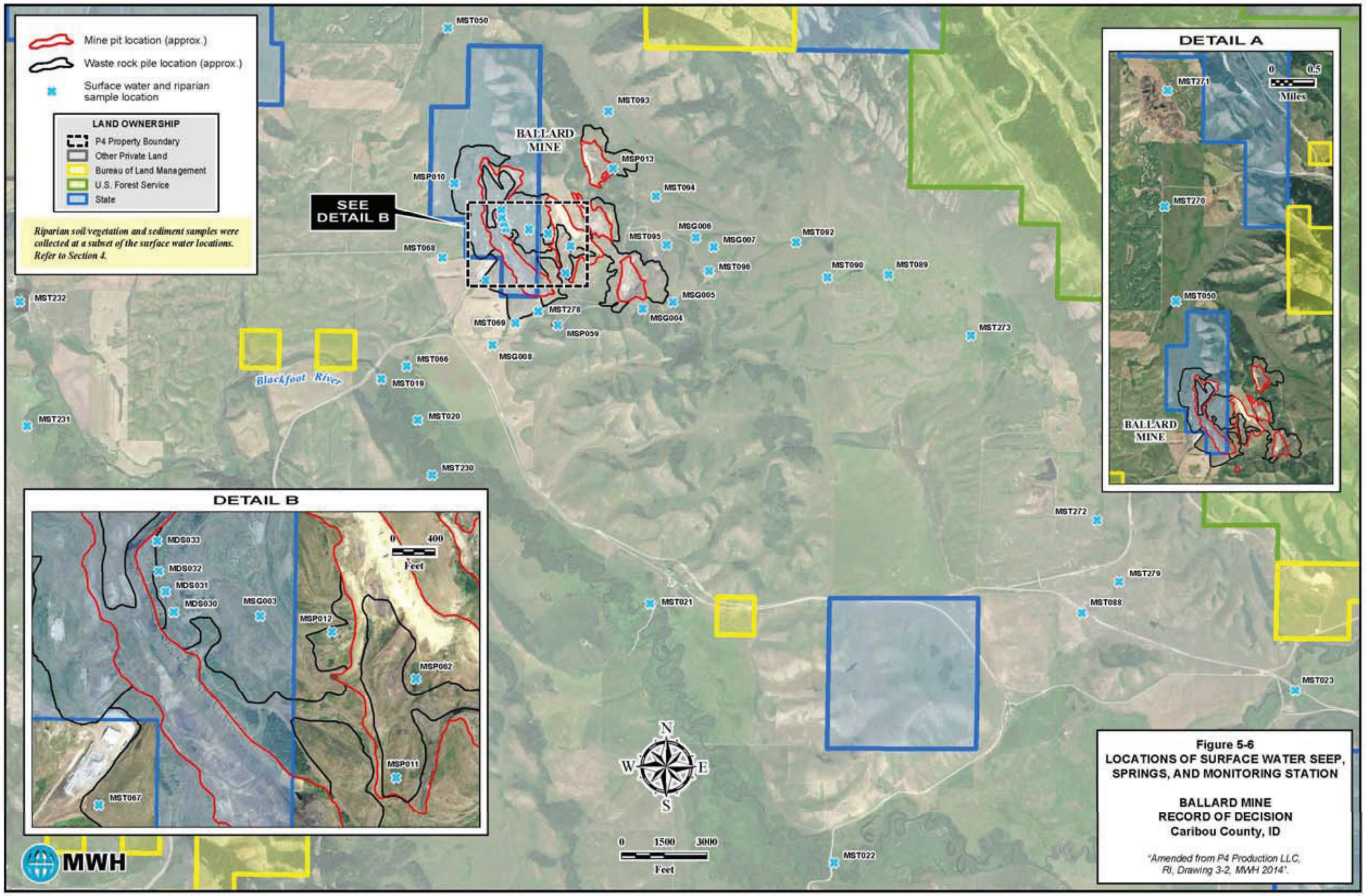


Figure 5-6. Surface Water Monitoring Locations



5.1.5 Groundwater

Groundwater at the Site can be divided into the following three types of aquifers:

- Local shallow groundwater systems within basin-fill alluvium
- Shallow to deep intermediate systems within sedimentary bedrock units (Dinwoody Formation)
- Regional groundwater flow systems within deeper sedimentary bedrock units (Wells Formation)

The Ballard Mine RI report (MWH, 2014) identified two of the groundwater systems with contaminant concentrations above cleanup levels: the alluvial aquifer on the eastern, southern, and western sides of the Site (Figures 5-7 and 5-8) and portions of the regional aquifer (Wells Formation) beneath, and adjacent to, the West Ballard Mine Pit (MMP035).

The depth to first groundwater in the alluvial system ranges from 1 foot below ground surface (bgs) to 15 feet bgs, but rarely as deep as 20 feet bgs. The groundwater in the alluvial system is contained in alternating sand, clay, and silt beds with rare gravel beds of colluvial and alluvial origin. Beds are typically thin, being 1 foot thick or less, but they can be highly variable. Alluvial groundwater is best characterized as being unconfined to semiconfined between clay beds. Hydraulic testing of alluvial wells indicates that the average hydraulic conductivity of the water-bearing portions of the unit is on the order of 10^{-4} centimeters per second, and groundwater flow velocities were estimated as ranging from 17 to 109 feet per year at the Site.

The hydrogeologic setting of the Wells Formation system is markedly different than the alluvial system. Groundwater contained in the Pennsylvanian Wells Formation is dominated by sand and limestone beds tens of feet thick. Water-bearing beds have hydraulic conductivities on the order of 10^{-3} to 10^{-2} centimeters per second and can produce significant groundwater. Within the Site, the bedrock units are folded and faulted, resulting in compartmentalization and complex groundwater flow systems through fractures and geologic formation boundaries. The depth to groundwater in the Wells Formation at the Site ranges between 200 and 400 feet bgs in the West Ballard Mine Pit (MMP035) and between 100 to 200 feet bgs in the other perimeter areas. The regional groundwater flow in the Wells Formation is to the northwest, but because of the complex hydrogeologic conditions of the Site, a specific flow field has not been defined.

Figure 5-7. Selenium Plume in Alluvial Aquifer on Eastern Side of Ballard Mine

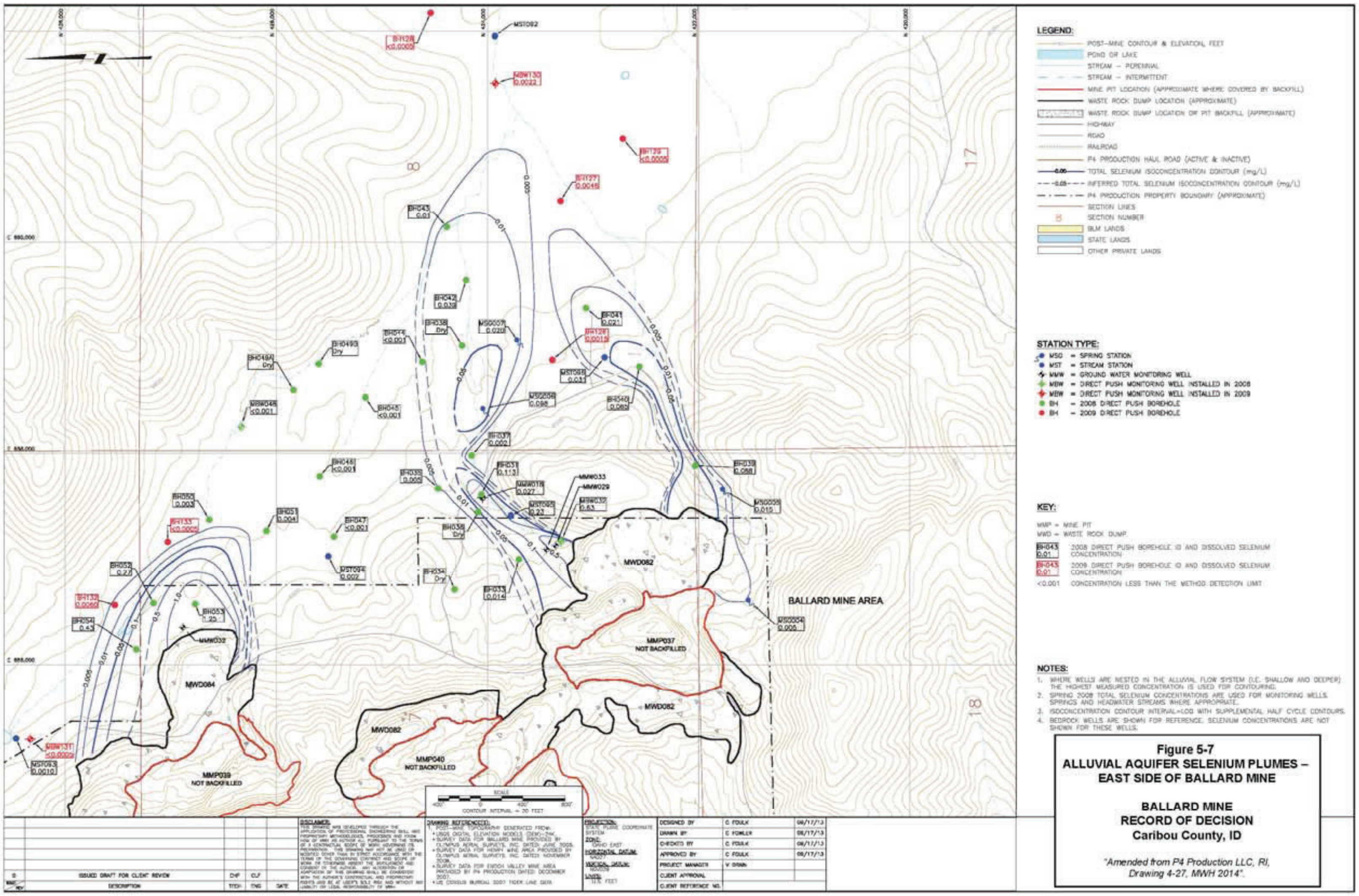


Figure 5-8. Selenium Plume in Alluvial Aquifer on Western Side of Ballard Mine

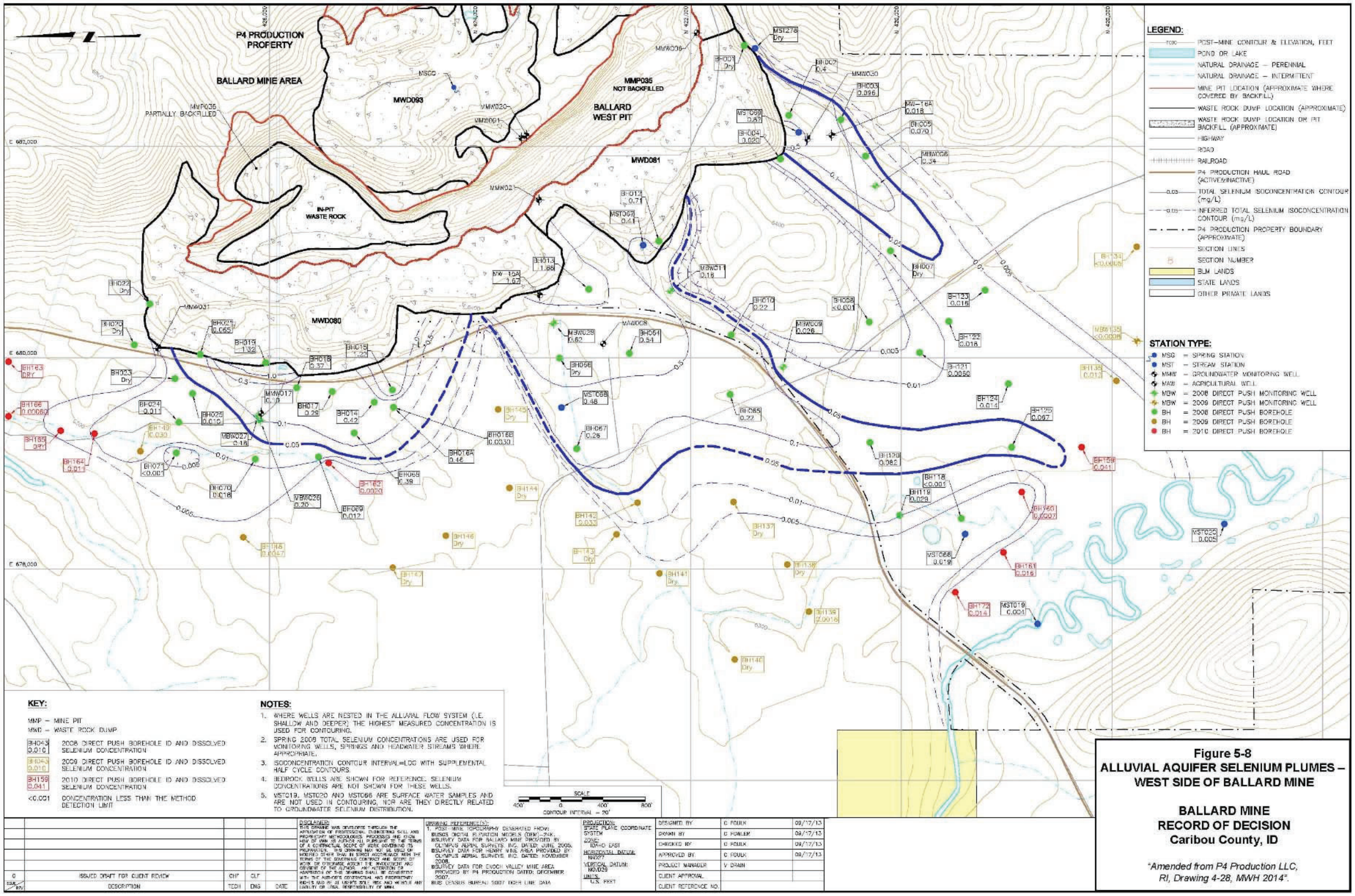
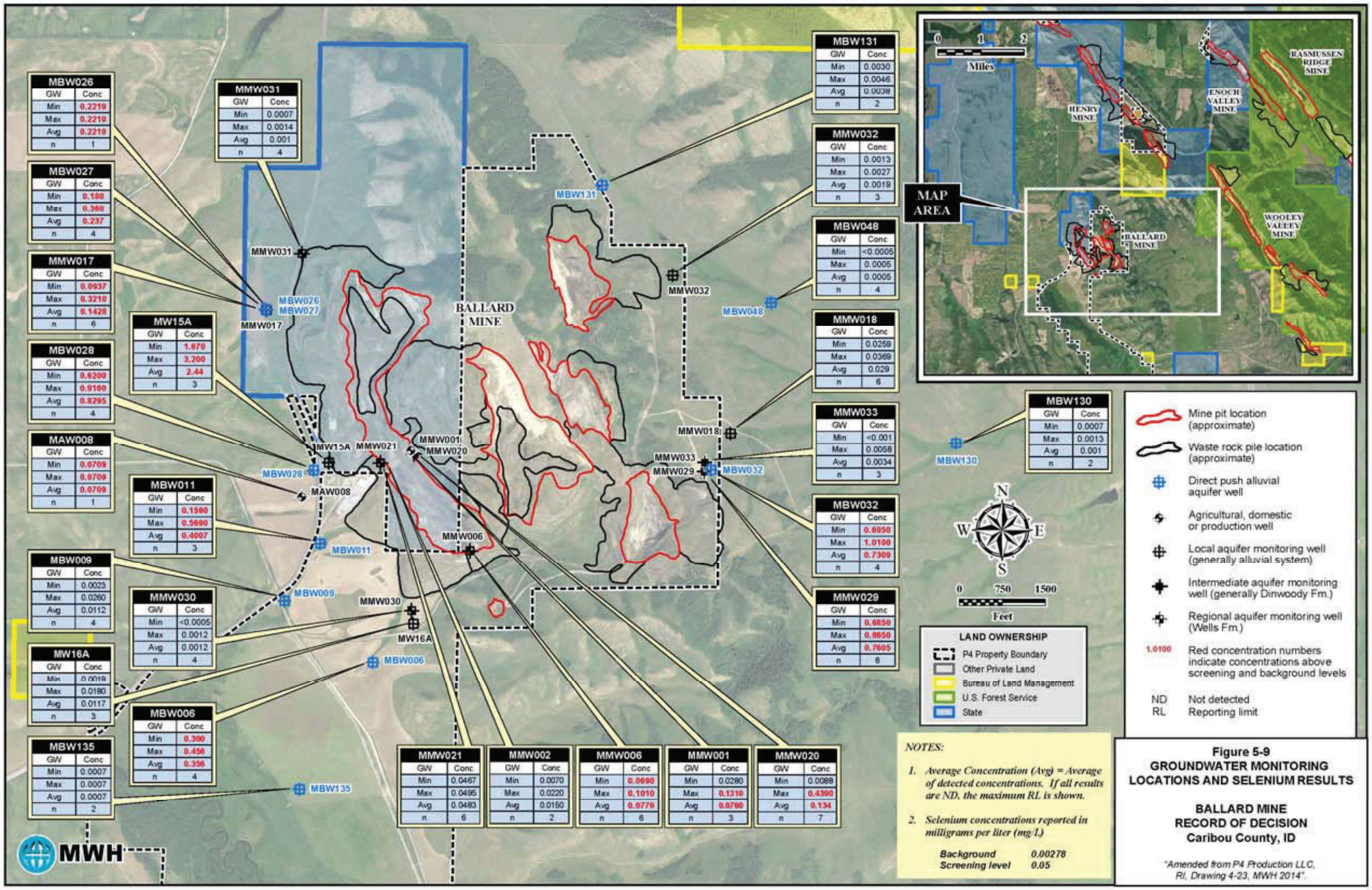


Figure 5-9. Groundwater Monitoring Well Locations



Three Wells Formation monitoring wells detected concentrations of chemicals of concern (COCs) at greater than the groundwater cleanup levels (see Figure 5-9 for locations). One monitoring well on the western side of the pit has elevated COC concentrations but does not exceed the groundwater cleanup levels. Other Wells Formation wells at the perimeter of the Site were found to contain background concentrations of COCs.

The extent of the affected alluvial groundwater is illustrated by groundwater plumes delineated during the RI. The locations of the six identified plumes are shown on Figures 5-7 and 5-8. These plumes are associated with waste rock dumps that act as sources of contamination and are labeled accordingly (MWD084, MWD082 North, MWD082 South, MWD080 North, MWD081 South, and MWD080/081 Central). The plumes originating from MWD081 South and MWD080/081 Central flow toward the Blackfoot River (Figure 5-8).

Monitoring results from the Blackfoot River upgradient and downgradient of the plume in this area do not show a measurable change in selenium concentration. No other plumes have reached a potential discharge location along the Blackfoot River.

5.1.6 Surface Water/Groundwater Interactions

Runoff at the Site is generally diffuse with very few defined overland runoff channels. Precipitation and snowmelt that infiltrate waste rock dumps reach the offsite channels as interflow in the waste rock and adjacent soils or enters the shallow alluvial aquifer.

Groundwater flow in the shallow alluvial aquifers typically follows the local topography. If the alluvium intercepts an abrupt change in topography, bedrock elevation, an erosion/mining feature, or stream channel, the shallow groundwater will daylight as a discrete spring or seep, or contribute to stream flow (Figure 5-13).

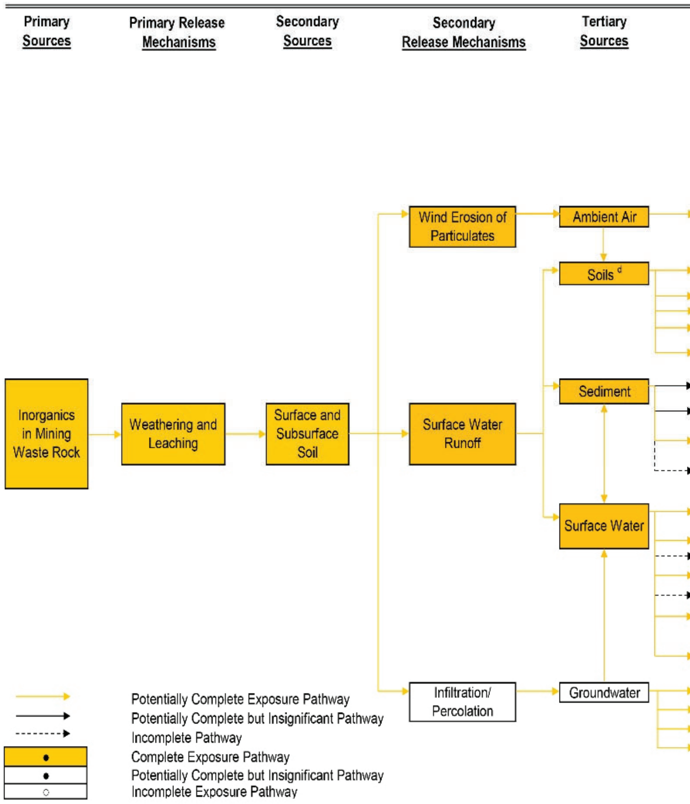
Seeps and springs (MDS030 to MDS033, and MSG003) that do not discharge offsite are located on the hill above the West Ballard Mine Pit (MMP035). These seeps and springs discharge to the mine pit where the impacted seepage-derived surface water infiltrates to the regional groundwater system. Groundwater in the Wells Formation was found to contain elevated concentrations of COCs around the West Ballard Mine Pit.

The flow direction within the regional aquifer, composed primarily of the Wells Formation at the Site, is to the northwest toward a series of prolific springs near the village of Henry. These springs represent a recognized discharge area for the regional groundwater system for this part of southeast Idaho (MWH, 2008). Sampling of three large springs in the area occurred in fall 2017 and showed no water quality impacts from mining activity (Stantec, 2018).

5.2 Conceptual Site Model

A CSM was developed to show the relationship between the sources of contaminants at the Site, mechanisms for release of contaminants, and transport pathways to various environmental media (Figures 5-10 through 5-12). The model provides a framework to assess risks from contaminants and develop cleanup strategies.

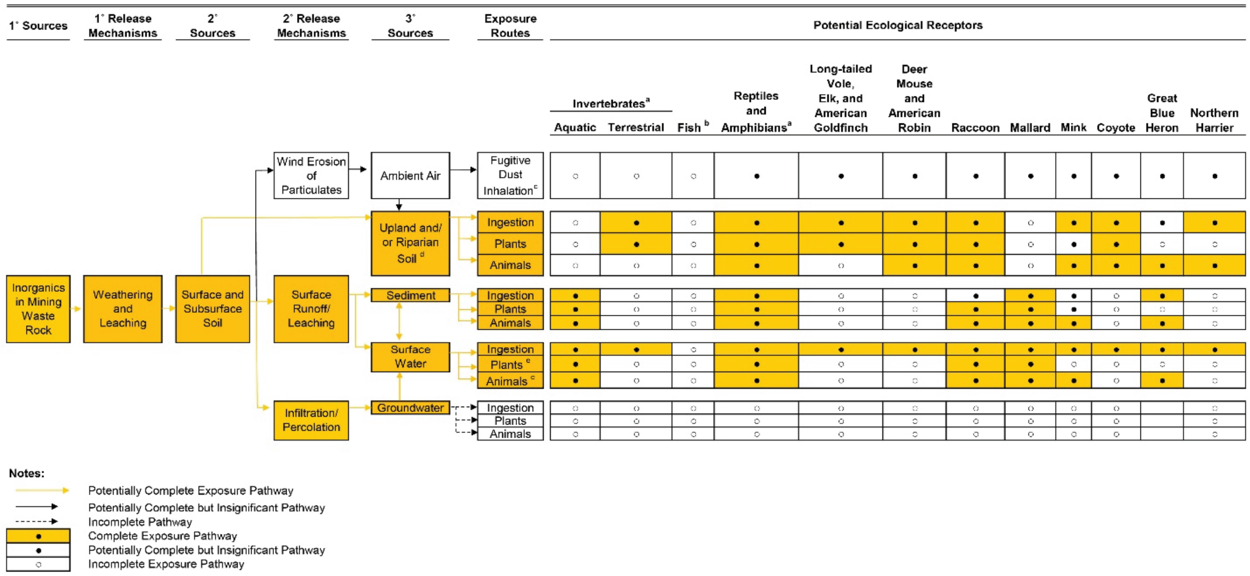
Figure 5-10. Human Health Conceptual Site Model



Tertiary Source	Exposure Route	Recreational Hunter	Recreational Fisher [c]	Recreational Camper/Hiker	Native American	Hypothetical Future Resident	Seasonal Rancher
Ambient Air	Fugitive Dust Inhalation	●	○	●	●	●	●
Soils [d]	Incidental Ingestion	●	○	●	●	●	●
	Dermal Contact	●	○	●	●	●	●
	Uptake by Plants	○	○	○	●	●	○
	Uptake by Moose, Elk, and other Wild Game	●	○	○	●	●	○
	Uptake by Beef Cattle and Livestock	○	○	○	○	●	●
Sediment	Incidental Ingestion	○	○	●	●	●	○
	Dermal Contact	○	○	●	●	●	○
	Uptake by Plants	○	○	○	●	○	○
	Uptake by Fish [e]	○	○	○	○	○	○
Surface Water	Incidental Ingestion [f]	○	○	●	●	●	●
	Dermal Contact [f]	○	○	●	●	●	○
	Inhalation	○	○	○	○	○	○
	Uptake by Plants	○	○	○	●	○	○
	Uptake by Fish [e]	○	○	○	○	○	○
	Uptake by Moose, Elk, and other Wild Game	●	○	○	●	●	○
	Uptake by Beef Cattle and Livestock	○	○	○	○	●	●
Groundwater	Ingestion	○	○	○	○	●	●
	Washing/Bathing	○	○	○	○	●	●
	Irrigation of Plants	○	○	○	○	●	○
	Water for Livestock	○	○	○	○	○	●

Notes:
[a] All potential receptors are both current and future receptors except for hypothetical future residential receptor.
[b] It is also possible that some biota consumption pathways could be applicable to multiple receptors. For example, a recreational camper/hiker could hunt. Such alternative exposure pathways are evaluated qualitatively in the Uncertainty Analysis section of the HHERA.
[c] All exposure pathways are incomplete for the current/future recreational fisher because the surface water bodies in the Ballard Mine do not support fish, as described in the Remedial Investigation and Feasibility Study Work Plan (MWH, 2011).
[d] Exposure to constituents in soil for the current/future recreational hunter, current/future camper/hiker, hypothetical future resident, and current/future seasonal rancher will only be evaluated quantitatively for upland soil because these receptors are not expected to spend a significant amount of time near surface water because no fish are present in Ballard Mine surface bodies and swimming is an insignificant pathway due to low surface water temperatures.
[e] The consumption of fish pathway is incomplete for all receptors because the surface water bodies in the Ballard Mine do not support fish, as described in the Remedial Investigation and Feasibility Study Work Plan (MWH, 2011).
[f] Direct surface water pathways are only complete for the current/future Native American because the other receptors are unlikely to spend a significant amount of time near surface water because no fish are present in Ballard Mine surface bodies and swimming is an insignificant pathway due to low surface water temperatures.

Figure 5-11. Ecological Conceptual Site Model



[a] Potential effects to invertebrates and reptiles will be evaluated qualitatively.

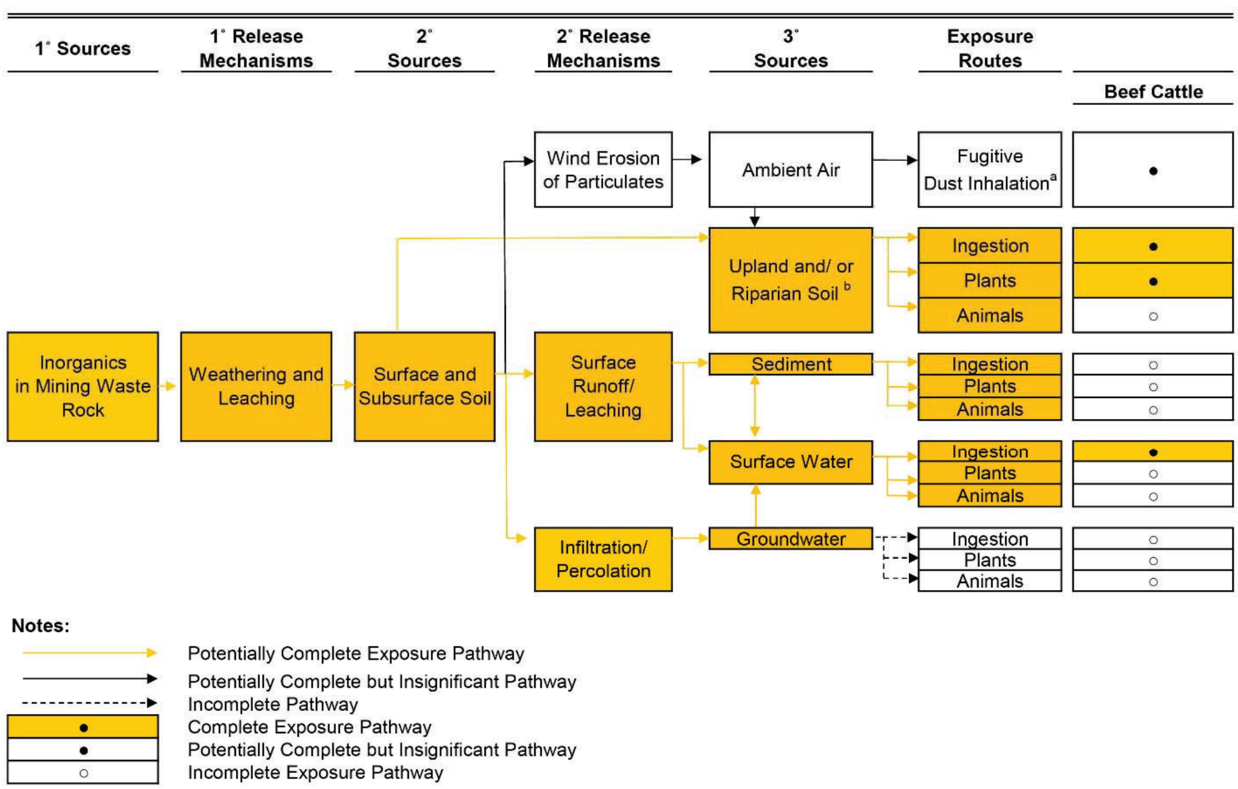
[b] The surface water bodies in the Ballard Mine do not support fish, as described in the Remedial Investigation and Feasibility Study Work Plan (MWH, 2011).

[c] The inhalation pathway is minor relative to the incidental ingestion pathway and there is a lack of relevant toxicological information; therefore this pathway was not evaluated quantitatively for ecological receptors.

[d] For the purpose of the risk assessment, American goldfinch, American robin, coyote, deer mouse, elk, long-tailed vole, and Northern harrier will only be exposed to upland soil; and mink, great blue heron and raccoon will only be exposed to riparian soil.

[e] Exposure to chemicals of potential ecological concern in surface water through the ingestion of aquatic plants and/or animal pathways were quantitatively evaluated using sediment data when sediment data were available.

Figure 5-12. Livestock Conceptual Site Model



[a] The inhalation pathway is minor relative to the ingestion pathway and there is a lack of relevant methods and information for evaluating the inhalation pathway in cattle. Therefore this pathway was not evaluated quantitatively for beef cattle.

[b] For the purpose of the livestock risk assessment (LRA), beef cattle are assumed to only be exposed to upland soil.

The following sections present additional information describing sources of contamination and affected media. Additional information on exposure pathways and potential receptors is presented in Section 7—Summary of Risks.

5.2.1 Sources of Contamination

The nature and extent of contamination associated with the Ballard Mine was investigated through review of background information and extensive sampling of the various media within and near the Site. The primary source of contaminants at the Site is waste rock located in partially backfilled mine pits and waste rock dumps. The shale material represents a significant portion of the waste rock stockpiled in waste rock dumps.

The concentrations of contaminants in waste rock are spatially variable and reflect the chemical composition of the types of waste rock located on the surface of the dumps. Waste rock produced during mining included shale, chert, and limestone, with the Center Waste Shale of the Phosphoria Formation containing the highest concentration of selenium and other contaminants.

This shale material is enriched with selenium (a nonmetal) as well as metals, metalloids and uranium daughter products (for example, radium and radon). Mine pit walls and roads associated with the Site represent minor source areas.

Another potential source area within the Site is the Shop (Figure 1-3). As stated in Section 1.3.2, the Shop will continue to be used for equipment storage, fuel storage, stockpiling of slag material used for active haul roads, and other activities as needed. Previous investigations identified the presence of organic contaminants, primarily fuel and solvent-related organic compounds, in soil and groundwater at the Shop. Selection of a final remedy for the Shop area will be deferred until this area is no longer in use.

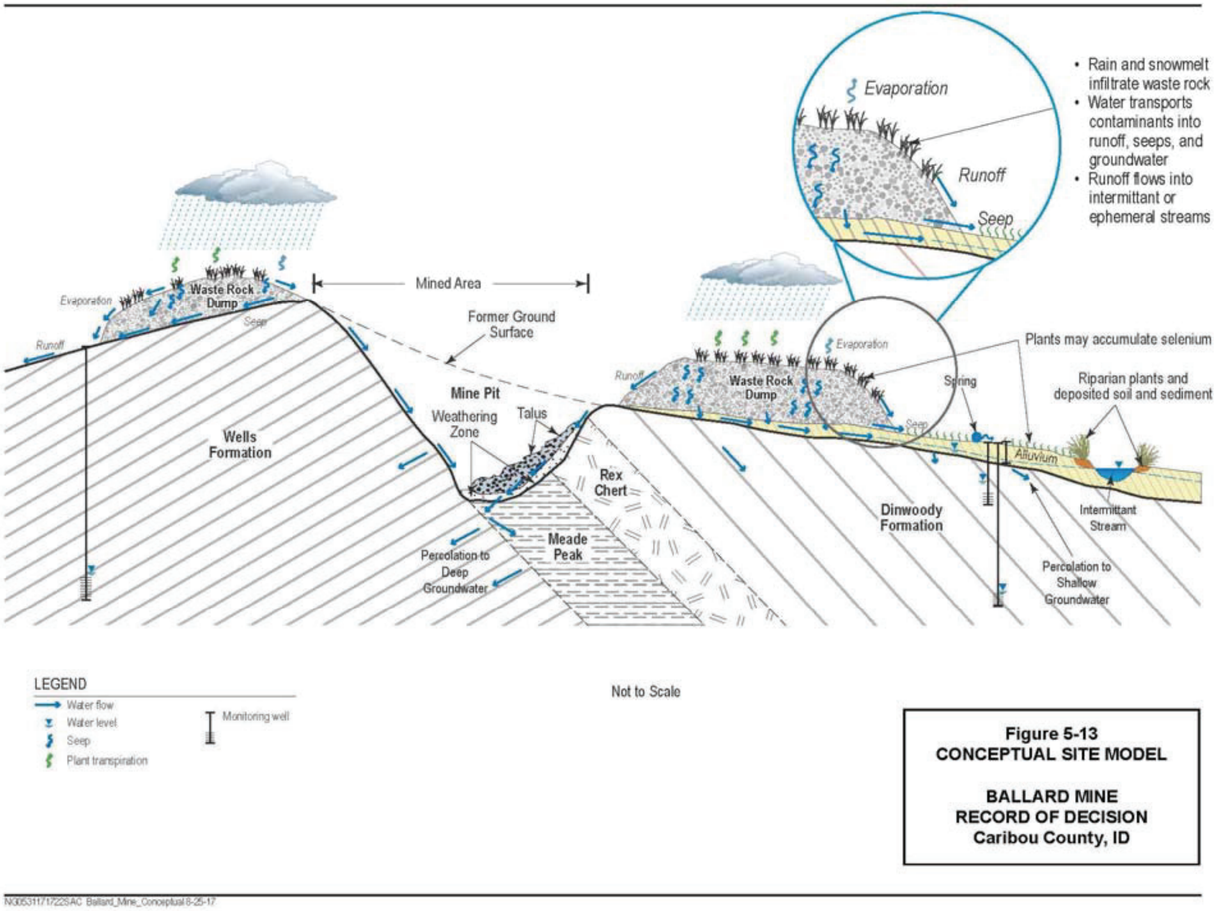
5.2.2 Affected Media

One objective of the RI was to better understand the release of contaminants from source areas and their subsequent transport to other media. Media affected by mine waste and associated contaminants include the following:

- Upland soil, surface material/waste rock (18 million cubic yards [yd^3])
- Riparian soil and sediment (approximately 5 acres of impacted stream channel sediments and riparian soil in the Ballard Creek and Wooley Valley Creek drainages)
- Surface water (ephemeral and intermittent streams, ponds, seeps)
- Groundwater (alluvial, and regional bedrock aquifers)
- Upland and riparian vegetation (secondary medium)

Mine-related constituents are released as the result of dissolution or leaching (from contact with rain or snowmelt) of contaminants from center waste shales present in source areas, and the subsequent migration (movement) of dissolved constituents into surface water (runoff and seeps) and groundwater. There has also been erosion of contaminated particles from waste rock dumps, transport off the dumps, and subsequent deposition in ephemeral and intermittent streams, resulting in impacts to both stream sediment and riparian soil downgradient of source areas.

Figure 5-13. Conceptual Site Model Cross Section



In addition, vegetation growing on mine waste and in contaminated riparian areas near the Site contain elevated levels of selenium. This occurs through uptake of selenium through the root system and into plant tissue. Certain types of plants, such as milk-vetch or asters, concentrate (hyper-accumulate) selenium. Animals that graze on such hyper-accumulating plants growing on mine materials may be fatally poisoned. Insects and amphibians may be exposed to contaminated water and sediment in intermittent streams.

Evidence suggests that wind erosion and dispersion does not play a significant role in transporting contaminants. Figure 5-13 illustrates the relationships between source areas, release and transport mechanisms, and affected media.

During the RI, a list of COCs was developed for each affected media. COCs are those chemicals that pose unacceptable risks to human health or the environment. The range of concentrations of COCs in affected media at the Site are presented in Tables 5-1 and 5-2. Background concentrations for the same contaminants are presented for comparison. Although there are several COCs associated with the Site, there has been a focus on selenium because it is widespread and is found to highly exceed risk-based concentration levels (RBCLs).

Table 5-1. Data Summary for Contaminants of Concern in Soil, Sediment, and Vegetation
Ballard Mine Site, Caribou County, Idaho

Contaminant	Number of Samples	Maximum Concentration (mg/kg)	Minimum Concentration (mg/kg)	Mean Concentration (mg/kg)	Exposure Point Concentration[a] (mg/kg)	Background[b] (mg/kg)
Upland Soil						
Antimony	94	10.9	0.621	4.61	4.89	3.60
Arsenic	94	45.5	3.51	20.0	21.8	15.6
Cadmium	104	167	1.44	32.7	37.6	41.0
Chromium	104	594	0.600	230	327	410
Copper	104	174	6.80	69.8	87.2	51.9
Molybdenum	104	48.7	2.36	20.5	20.0	29.0
Nickel	104	635	4.80	186.5	205	220
Radium-226[c]	> 300,000[d]	82.4	0.4	12.7	29.2	15.1
Selenium	130	209	0.120	38.0	53.5	29.0
Thallium	94	3.68	0.176	1.08	1.2	1.10
Uranium	94	87.1	1.10	29.8	38.3	36.0
Vanadium	104	808	1.06	200	239	300
Zinc	104	1,810	38.5	764	835	1,200
Riparian Soil						
Arsenic	14	8.91	1.83	4.47	5.83	5.93
Cadmium	44	131	0.440	16.7	25.4	7.24
Chromium	44	2,780	13.9	200	503	43.3
Copper	44	272	7.00	40.3	71.1	24.3
Molybdenum	44	48.6	0.33	9.34	16.4	0.653
Nickel	44	1,620	10.7	108	281	29.6
Selenium	44	570	0.70	34.5	89.5	2.03
Thallium	14	0.681	0.164	0.292	0.376	2.03
Vanadium	44	773	22.2	123	233	0.483
Sediment						
Antimony	7	6.60	4.60	5.88	6.05	5.00
Arsenic	7	13.4	3.33	6.06	13.0	4.55
Cadmium	32	138	0.550	19.6	42.1	4.17
Copper	7	70.6	13.2	29.0	51.1	25.5
Molybdenum	7	12.8	8.80	10.8	12.8	0.541
Selenium	32	1,300	0.60	120	208	1.48
Thallium	7	1.63	0.122	0.536	1.30	0.378
Vanadium	32	920	25.0	152	321	113
Upland Vegetation (All Plants)						
Arsenic	128	14.2	0.075	0.806	1.42	–
Cadmium	129	4.54	0.0257	1.17	1.55	–
Selenium	160	366	0.304	26.2	39.7	–

[a] An upper estimate (95 percent) of the mean used for calculation of Site risk exposure point concentration is the level of a chemical to which a receptor is potentially exposed with the exception of radium-226 that provides the estimated maximum value as predicted using a uranium sequential decay model.

[b] The 95 to 95 upper threshold limit was selected as the proposed background level for upland soils collected in 2009 and 2014. The 95 percent upper simultaneous limit (USL) was selected as the proposed background level for sediment and riparian soil data sets collected in 2004 and 2010 (MWH 2013a, 2013b).

[c] Radium-226 are in pCi/g (MWH, 2015b) and the values provided are the maximum, minimum and mean detected values as predicted from Site gamma counts.

[d] Greater than 300,000 discrete gamma count measurements were collected to predict radium-226 concentrations in upland soil.

Notes:

> = greater than
mg/kg = milligram(s) per kilogram
pCi/g = picocuries per gram

Table 5-2. Data Summary for Contaminants of Concern in Surface Water and Groundwater Ballard Mine Site, Caribou County, Idaho

Contaminant	Number of Samples	Maximum Concentration (mg/L)	Minimum Concentration (mg/L)	Mean Concentration (mg/L)	Background[a] (mg/kg)
Surface Water (Dissolved, all locations)					
Arsenic	63	0.0556	0.0005	0.01	0.00109
Cadmium	184	0.0044	0.0000350	0.000837	0.0001
Selenium (Total)	187	2.84	0.000758	0.334	0.000772
Groundwater (Total)					
Arsenic	16	0.0267	0.000456	0.00491	0.00103
Cadmium	84	0.0215	0.00017	0.00333	0.000401
Selenium	148	3.2	0.000534	0.273	0.00278

[a] Background concentration is equal to the 95% USL of background data set (MWH, 2013a).

Notes:

All concentrations are mg/L.

% = percent

mg/L = milligram(s) per liter

In surface water, sampling shows that the highest concentrations of selenium and other contaminants are typically found in seeps and intermittent streams close to the waste rock dumps on the margins of the Site. Concentrations decrease moving away from the source areas because of dilution and attenuation.

In groundwater, sampling shows that the highest concentrations of selenium are found in three places: close to the waste rock dumps, in the alluvial aquifers on the margins of the Site, and in the bedrock aquifer in the southwest portion of the Site. Contaminant plumes in groundwater dissipate moving away from the source areas.

With respect to sediment and riparian soil, sampling shows a similar pattern, with the most impacted areas close to the waste rock source areas, with contaminants found in and along intermittent stream corridors and dissipating downstream.

Section 6 – Current and Potential Future Land and Resource Use

6.1 Land Use

6.1.1 Current Land Use

The Site is in a rural and sparsely populated area; the nearest town is Soda Springs, approximately 13 miles away. Farming and seasonal ranching are the dominant land uses in vicinity of the Site. There are many active and inactive phosphate mines in the area. The surrounding area is also used for recreation, including hunting on private and public lands, and fishing on the Blackfoot Reservoir and Upper Blackfoot River.

The Site includes the former mine area and contaminated portions of adjacent properties. The former mine area is fenced, and access is restricted. The mining haul road on the western edge of the Site is still used. Current land uses of the adjoining properties include dry-land farming and seasonal ranching (grazing of cattle). There is likely some limited recreational and tribal use of the state lands at the Site as well. There are no residences at, or near, the Site. The Site provides suitable habitat to support wildlife (birds and mammals). Specific habitats and species, including the potential presence of threatened and endangered species, are described in Section 7.

6.1.2 Reasonably Anticipated Future Land Uses

Reasonably anticipated future uses of the land at the Site include agriculture, seasonal grazing of cattle and sheep, recreation, and tribal hunting, gathering, and ceremonial use. Residential use of the Site is unlikely because of the remote location and limited accessibility to existing infrastructure. In addition, the Selected Remedy assumes that remining will occur during implementation of the remedial action (RA) (contingent on BLM issuing a phosphate mineral lease and approving a mine plan for extraction of ore). It is expected that potential remining would end with completion of the remedy.

6.2 Surface Water and Groundwater Use

Surface water resources at and near the Site currently support stock watering, irrigation, and wildlife uses. These uses are expected to continue. Because of the intermittent nature of the streams in the Site vicinity, there is limited potential for use of surface water resources for other uses, such as industrial and recreational use. The streams in the vicinity of the Ballard Mine are intermittent and support the following organisms: aquatic invertebrates, amphibians, and aquatic dependent wildlife when water is present. As previously stated, runoff and baseflow from the area near the Site seasonally contribute to flows in Wooley Valley Creek (on the east) and Ballard Creek (on the south and west) as tributaries to the Blackfoot River, with very little flow draining to Long Valley Creek to the north. The surface water bodies in the Ballard Mine area do not sustain fish.

Groundwater use in the Site vicinity is dependent on population, land use, and availability and quality of surface water and groundwater. Groundwater use near the Site is limited; it is used for livestock watering and as a water supply for P4's operations. Farming is primarily not irrigated. It is not anticipated that the shallow alluvial aquifer near the Site will be used for domestic use in the future. It is possible that water from the Regional Wells Formation aquifer near the Site may be used for domestic purposes if land uses change in coming decades.

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Section 7 – Summary of Risks

Baseline human health risk assessments (HHRAs) and ecological risk assessments (ERAs) for the Site are presented in Appendix A of the RI and in the Ballard Mine RI Report Baseline Risk Assessment Addendum (MWH, 2014). This section summarizes the risk assessments and provides the basis for taking remedial actions. Methods used to evaluate human health and ecological risks were in accordance with EPA guidelines for evaluating risks at Superfund sites (EPA, 1989; 1997a). Detailed explanations of the steps used to conduct the risk assessment are provided in the RI report, including background information, the exposure model and quantification of exposure, a toxicity assessment, risk characterization, and an evaluation of uncertainties. Tables associated with Section 7 are presented in Appendix A.

7.1 Human Health Risk

A baseline HHRA was completed in November 2014 to assess potential risks to humans (both current and future) from Site-related contaminants. The following sections summarize key elements and findings of the HHRA.

7.1.1 Chemicals of Potential Concern

Chemicals of potential concern (COPCs) identified in the RI from historical mining operations were based on inorganic constituents detected in media samples, including soil (collected from 0 to 2 feet bgs), surface water, sediment, groundwater, and vegetation. The data used in the risk assessment were collected during the RI, validated and evaluated per EPA's guidance for data usability, and determined to be usable in the HHRA.

7.1.2 Exposure Assessment

The exposure assessment identified human health exposure scenarios through which a receptor could contact COPCs in Site media and provide quantitative estimates of the extent of exposure.

7.1.2.1 Exposure Model

Figure 5-10 presents a CSM depicting contaminant sources, release mechanisms, impacted media, exposure routes, and potential exposed human receptors that were evaluated in the HHRA. Human health risks were estimated for each exposure scenario, based on current and reasonably anticipated future land uses (as presented in Section 6), including current and future Native American (e.g., elk hunting and harvesting vegetation by the Shoshone-Bannock Tribe), current and future seasonal rancher, current and future recreational hunter, and current and future recreational camper/hiker. Although future residential use is unlikely, a residential use scenario was used in the HHRA to determine if land use controls restricting residential use would be warranted. These scenarios evaluated the exposure to historical mining-related contaminants in environmental media (soil, sediment, surface water, and groundwater) at the Site.

The routes of exposures evaluated included ingestion, inhalation, dermal contact, and direct radiation. More specifically, the following exposure routes were evaluated:

- Current/future recreational hunters – Direct soil contact (incidental soil ingestion, dermal contact with soil, and inhalation of fugitive dust) and consumption of wild game
- Current/future recreational campers/hikers – Direct soil contact
- Current/future Native American hunters and gatherers – Direct soil contact, direct surface water contact, and consumption of elk and vegetation

- Current/future seasonal ranchers – Direct soil contact, direct contact with groundwater used as a potable water supply (ingestion and dermal contact with groundwater), and consumption of beef cattle that ingest contaminants while grazing at the Site
- Hypothetical future residents – Direct soil contact, direct contact with groundwater used as a potable water supply, and consumption of homegrown fruits and vegetables

In addition, radiological risk from exposure to uranium decay products (such as radium-226 or radon gas) that emit high-energy electromagnetic radiation was evaluated.

7.1.2.2 Exposure Estimation

The HHRA calculated risks using central tendency exposure (CTE) and reasonable maximum exposure (RME) assumptions and used the lower of the maximum detected concentration or an upper-bound average concentration for the exposure point concentration (EPC). The RME is defined as the highest exposure that is reasonably expected to occur at a site, which in practice combines the 90th to 95th percentile exposure assumptions for some but not all exposure assumptions. The intent of the RME scenario is to estimate a conservative exposure case that is still within the range of possibilities. The CTE uses 50th percentile or median exposure assumptions to approximate an average exposure scenario. Risks were also calculated for background concentrations. Tables 5-1 and 5-2 show the range of detected concentrations, the EPC, and background concentrations for the COCs identified at the Site. Exposure assumptions used for each receptor are presented in Table A-1. Detailed information on the methods and equations used for calculating the exposure estimates were provided in Appendix A, Section 3.3.2.2, of the RI report (MWH, 2014).

In addition to exposure to non-radionuclide COPCs, human receptors can be exposed to direct radiation from uranium-238 and its decay products found in upland soil and from radon-222, a decay product from uranium-238, in indoor air. Therefore, risk estimates for exposures to uranium-238 and its decay products in upland soil (for all receptors) and radon-222 in indoor air (for hypothetical future residents) were also evaluated in the HHRA.

7.1.3 Toxicity Assessment

The toxicity assessment involved a critical review and interpretation of toxicology data from epidemiological, clinical, animal, and in vitro studies. A review of toxicology data ideally determines both the nature of health effects associated with a COPC and the probability that a given dose of a COPC could result in an adverse health effect. The toxicity assessment considered the adverse health effects associated with exposure to individual and multiple COPCs for long-term health effects. The potential for adverse health effects was evaluated separately for the following two categories:

- Potential for carcinogenic health effects
- Potential for chronic noncarcinogenic, adverse health effects

Risks of getting cancer because of site exposures were evaluated using cancer slope factors [CSF] and inhalation unit risk values developed by EPA. Quantification of noncancer hazards relied on published reference doses (RfD) or reference concentrations (RfC). CSFs are used to estimate the probability of a receptor getting cancer during their lifetime given exposure to Site-specific contamination; this Site-specific risk is in addition to the risk of developing cancer because of other causes. RfDs are threshold values that represent a daily contaminant intake below which no adverse human health effects are expected even for sensitive receptors (e.g., children or the elderly) exposed over long periods of time. To evaluate noncarcinogenic health effects, a hazard quotient (HQ) is calculated. The HQ is the ratio of the Site-specific exposure dose with the chemical-specific RfD. Table A-2 provides the toxicity values used in the HHRA.

7.1.4 Risk Characterization

The baseline human health risk characterization for the Site integrated results of the exposure and toxicity assessments to derive a quantitative and qualitative evaluation of potential risks to current and potential future human receptors. Calculated exposure doses for each COPC identified for a medium were used to estimate chemical-specific and cumulative carcinogenic risks, and noncarcinogenic HQs and hazard indices (HI). Methods that were used in the characterization of human health risks are summarized below.

7.1.4.1 Carcinogenic Risk Characterization

The pathway-specific risk of developing carcinogenic exposure to a carcinogenic chemical was estimated by multiplying the CSF by the exposure dose, or the unit risk factor (URF) by the concentration as presented in the following equation:

$$\text{ILCR(unitless)} = \text{CSF (or URF)} \times \text{Dose (or Concentration)}$$

Where:

ILCR = Incremental lifetime carcinogenic risk (unitless)
CSF = Carcinogenic slope factor (milligrams per kilogram per day [mg/kg-day)$^{-1}$
URF = Unit risk factor (micrograms per cubic meter [µg/m^3])$^{-1}$
Concentration = Exposure concentration (µg/m^3)
Dose = Exposure dose (mg/kg-day)

Carcinogenic risks from multiple COPCs identified for a Site medium are assumed to be additive and were summed to estimate a cumulative ILCR for all carcinogenic Site COPCs for a given medium. In addition, carcinogenic risks calculated for various Site media were summed, as appropriate, to estimate cumulative ILCRs for each receptor.

7.1.4.2 Noncarcinogenic Risk Characterization

The HQ describes the potential for Site COPCs to produce noncarcinogenic effects. The pathway-specific HQ is defined as the ratio of the exposure dose to the RfD, or the concentration to the RfC (EPA, 1989), as presented in the following equation:

$$\text{HQ (unitless)} = \frac{\text{Dose (or Concentration)}}{\text{RfD (or RfC)}}$$

Where:

HQ = Hazard quotient (unitless)
Concentration = Exposure concentration (milligrams per cubic meter [mg/m^3])
Dose = Exposure dose (mg/kg-day)
RfC = Reference concentration (mg/m^3)
RfD = Reference dose (mg/kg-day)

A chemical-specific HQ was derived by summing the pathway specific hazards. An HQ greater than 1 indicates that exposure to that COPC may not be protective of noncarcinogenic adverse health effects. An HQ of less than 1 means that adverse health effects are unlikely to occur. Individual HQs for Site COPCs were summed to produce a cumulative HI. In cases where the cumulative HI exceeds 1, the HI was re-evaluated based on target organ effects, and a maximum target organ-specific HI was reported. This procedure is consistent with EPA risk assessment guidance (EPA, 1989).

In addition to the estimation of Site risk, Site-specific background data for metals were used to estimate the risk attributable to naturally occurring concentrations of COPCs. Methods and procedures that were used in the derivation of background statistics for background data sets are presented in the final background-levels technical memorandum (MWH, 2013a). Background data were used to calculate background risks for metals that were retained as refined COPCs using the same process as described above. In addition, incremental risk estimates were calculated for each Site by subtracting ambient carcinogenic risk and noncarcinogenic estimates from total carcinogenic risk and noncarcinogenic hazards for each receptor and COPC combination. The rationale for calculating incremental risk estimates for metals in environmental media is that some fraction of the concentration of a metal is naturally occurring. Therefore, an incremental risk estimate represents that portion of the total risk (Site-related and ambient risk) that is above natural, baseline conditions.

7.1.4.3 Summary of Carcinogenic and Non-Carcinogenic Risk Characterization

Human health RME risk estimates are described here and summarized in Table A-3. Total site risk and incremental risk estimates are provided for each human health exposure scenario. The HHRA used acceptable risk and hazard values defined by CERCLA to determine if the contamination at the Site poses an unacceptable risk to human health. EPA established an acceptable excess cancer risk range under CERCLA, from 1 in 1,000,000 [1×10^{-6}] to 1 in 10,000 [1×10^{-4}], of developing cancer from cumulative exposure to nonradiological Site contaminants over a person's lifetime. The established threshold below which noncancer health effects are not expected is a hazard index of 1 (EPA, 1997a). Risk characterization findings are presented separately for radiological and nonradiological exposures. Cumulative Site cancer risk and noncancer hazard estimates for nonradionuclide contaminants are shown relative to the regulatory limits on Figures 7-1 and 7-2, respectively. For the recreational hunter and camper/hiker exposure scenario, cancer risk and noncancer hazard estimates for nonradiological contaminants were less than EPA-acceptable levels, indicating that these current and anticipated future land uses are not adversely affected at the Site. For other exposure scenarios evaluated (Native American, seasonal rancher, and future resident), cancer risk and noncancer hazard estimates for nonradiological contaminants were greater than EPA-acceptable levels.

Figure 7-1. Human Health RME and CTE Cumulative Site Cancer Risk for all Nonradionuclide Contaminants

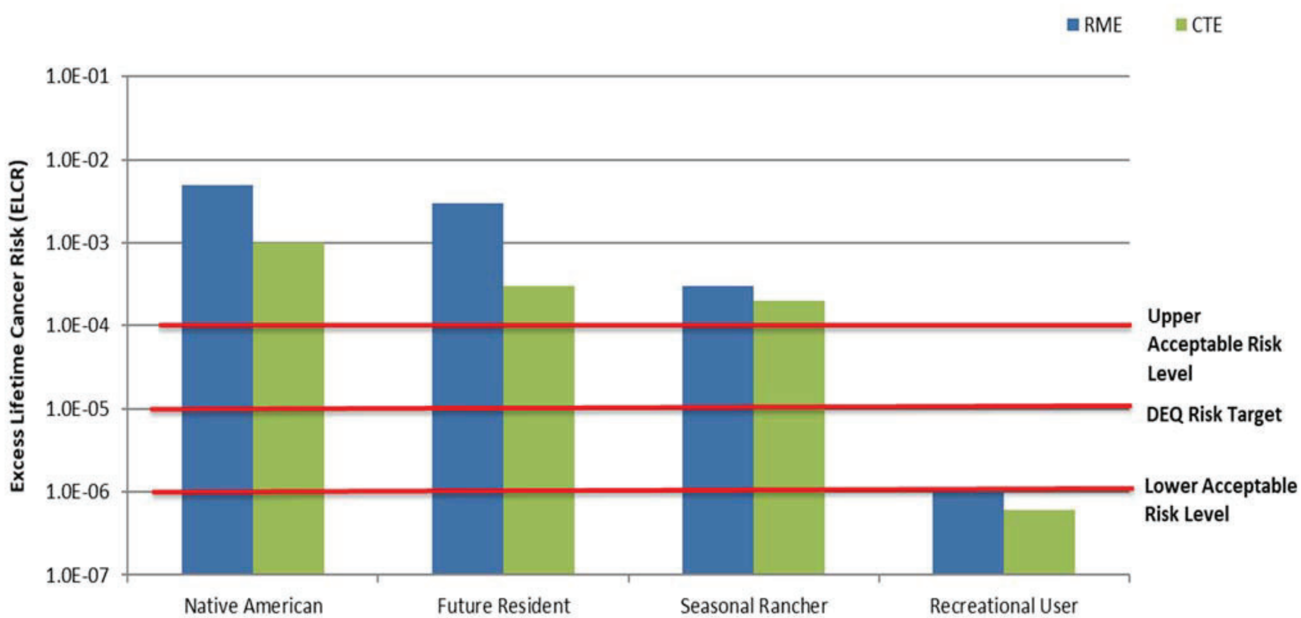
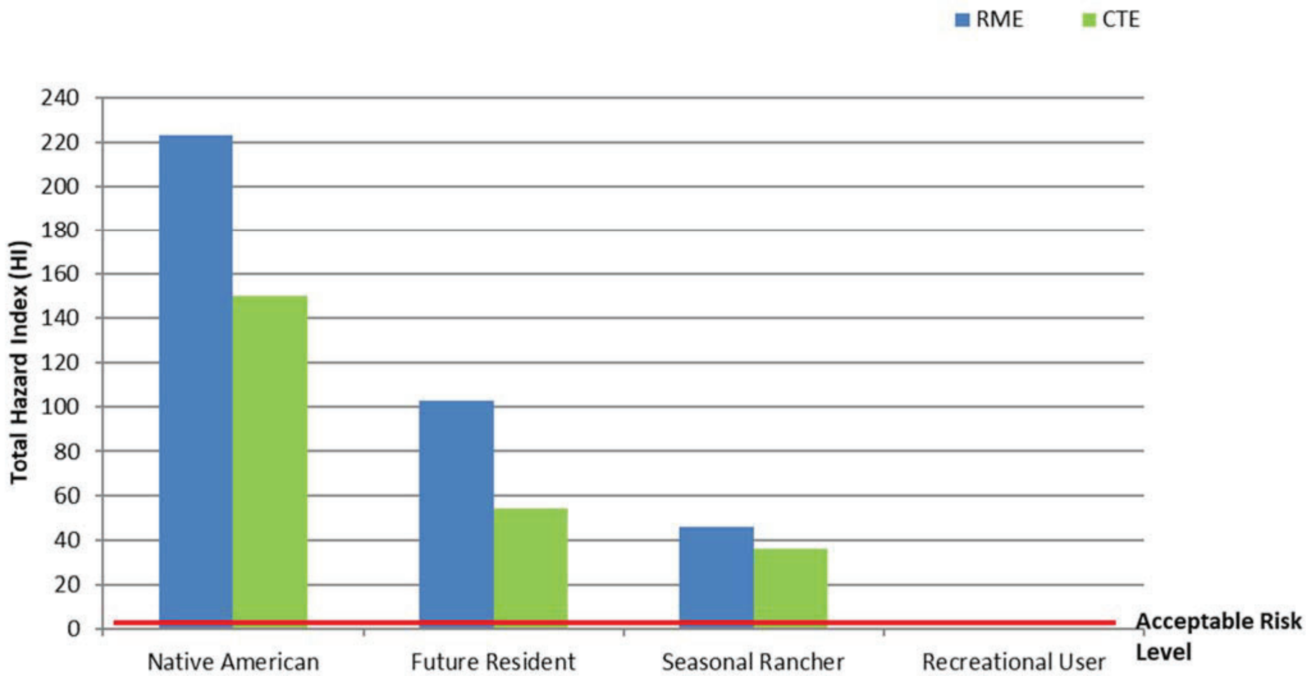


Figure 7-2. Human Health RME and CTE Cumulative (all media) Noncancer Hazard Index for all Nonradionuclide Contaminants



The following identifies contaminants and media contributing the greatest to cancer risk and noncancer hazard indices for exposure scenarios that exceeded regulatory limits:

- Native American Hunting and Gathering - The primary contributor to risk is incidentally ingested arsenic in upland soil, incidentally ingested Site surface water, and culturally significant plants harvested from riparian soil. Primary contributors to the hazard estimate, in order of decreasing contribution to the HI, are vanadium, nickel, and arsenic in culturally significant plants harvested from riparian soil.
- Future Resident - The primary contributor to risk is arsenic in upland soil and ingestion of groundwater. Primary contributors to the hazard estimate, in order of decreasing contribution to the HI, are thallium, selenium, and molybdenum in fruits and vegetables grown in upland soil and irrigated with Ballard Mine groundwater and selenium and arsenic in Site groundwater used as a drinking water source.
- Seasonal Rancher - The primary contributor to risk is arsenic in cattle tissue that have grazed on upland soil and have ingested Site groundwater or surface water. Primary contributors to the hazard estimate, in order of decreasing contribution to the HI, are thallium and selenium in cattle that have grazed on upland soil and have ingested Site groundwater or surface water.

Summary of Radiological Risk

Radiological risk was evaluated during the HHRA using sequential decay modeling from total uranium concentrations and EPA's radiological risk calculator tool (EPA, 2014). All human exposure scenarios were above EPA's cancer risk threshold except for the recreational camper/hiker. Radium-226 and radon-222 (hypothetical future resident only) were identified as COCs. A supplemental radiological Site and background investigation was conducted in 2014 with the results reported in the background and radiological soil report (MWH, 2015b). There are four distinct lithologies onsite and at background areas that underlie the surface soils: Dinwoody shales, Meade Peak shales and phosphate ore beds, Rex Chert, and Wells Formation limestone. Sampling showed that uranium, Radium-226 and other COCs (e.g., selenium) are highly variable and are particularly elevated in soils overlying the Meade Peak. The pooled (combined) background data set results in a mean of 4.72 pCi/g and a 95-95 upper tolerance limit of 15.1 pCi/g. The supplemental radiological investigation found that radiological cancer risk estimates predicted from maximum gamma count results in upland soils and radon flux measurements confirmed risks were above EPA's cancer risk threshold. The maximum predicted onsite concentrations of radium-226 and radon-222 are 82.4 pCi/g and 15,600 picocuries per cubic meter (pCi/m^3), respectively. The maximum radium-226 concentration in Site soils (82.4 pCi/g) was found to be about threefold higher than the maximum radium-226 concentration in background areas (27.2 pCi/g); maximum radon-222 concentrations measured onsite and in background areas were roughly equivalent. Considering this, the total cumulative radiological cancer risk estimates for exposures to radionuclides in Site areas were higher than, but similar to, risk in background areas.

7.1.5 Uncertainty Analysis

Risk assessment methods used, and exposure assumptions made in assessing potential human health risks, are subject to uncertainty. To compensate for these uncertainties, inherent and intentional conservatism is generally used to result in protective estimates of risk. However, cancer risk estimates for radionuclides are generally more accurate than cancer risk estimates for other chemicals. Arsenic is a notable exception because its cancer risk is likely underestimated based on ongoing EPA studies to assess its carcinogenicity. In cases where information is limited, assumptions may be based on professional judgment or subjective estimates that may under or overestimate risks. To assist with interpretation of the HHRA results, the primary sources of conservatism and uncertainty were described in the Appendix A, Section 6, of the 2014 RI report (MWH, 2014). Key uncertainties are described in the following section.

7.1.5.1 Uncertainties in Exposure

Medium-specific EPCs used to quantify exposures are intended to reflect RMEs and there is uncertainty in what the actual exposure to humans would be. To address this potential uncertainty, maximum or 95 percent upper confidence limit (UCL) of the mean concentrations are used to estimate exposure doses for current and hypothetical future receptors exposed to Site-related media. Where the number of samples are insufficient to calculate 95 percent UCL of the mean concentrations, maximum concentrations of Site COPCs were used to quantify exposure doses and risk estimates. Based on these considerations, the exposure doses that are used in the HHRA are believed to represent protective estimates of exposure.

The risk from an ingested chemical depends on how much is absorbed from the gastrointestinal tract. This is important for metals in soil at mining sites because some metals exist in poorly absorbable forms. Failure to account for this may result in a substantial overestimation of exposure and risk. EPCs for all metals/metalloids, used to evaluate both cancer and noncancer health effects associated with exposure, assume a bioavailability of 100 percent, except for arsenic, which used EPA's default bioavailability of 60 percent. The bioavailability assumptions are protective and likely overestimate the actual risk associated with exposure.

Exposure assumptions (e.g., incidental soil ingestion rates, exposure duration and frequency, and ingestion of wild game and water) for each exposure scenario were selected, with the intention of reflecting RMEs. It is unlikely any actual exposure would exceed the levels assumed based on these assumptions. The exposure pathways evaluated in the HHRA were identified based on current and anticipated future land use. If Site use changes significantly in the future, exposure pathways and assumptions may require further evaluation.

7.1.5.2 Uncertainties in Toxicity Assessment

Toxicity information for many chemicals is often limited. Consequently, there are varying degrees of uncertainty associated with toxicity values (cancer slope factors, reference doses). For example,

(1) uncertainties can arise from extrapolation from animal studies to humans, from high dose to low dose, and from continuous exposure to intermittent exposure and (2) EPA uses the linearized multistage mathematical model to extrapolate animal toxicological data for carcinogens, which assumes that there is no threshold for carcinogenic substances. In addition, some uncertainties exist not only in the dose response curve but also in the nature and severity of the adverse effects the chemical may cause. EPA typically deals with this uncertainty by applying an uncertainty factor of 10 to 100 to account for limitations in the database. As a result, in cases where available data do identify the most sensitive endpoint of toxicity, risk estimates will substantially overestimate true hazard. In general, uncertainty in toxicity factors is one of the largest sources of uncertainty in risk estimates at a site; however, is mitigated here because cancer risks are driven by radionuclides and arsenic. Cancer risk estimates for radionuclides are generally more accurate than cancer risk estimates for other chemicals. Arsenic is a notable exception because its cancer risk is likely underestimated based on ongoing EPA studies to assess its carcinogenicity (National Research Council, 2013).

Dermal toxicity criteria are generally not available from EPA. Typically, a simple route-to-route (oral-to-dermal) extrapolation is assumed such that the available oral toxicity criteria (RfD and CSF) are used to quantify potential effects associated with dermal exposure. However, as noted in the EPA *Risk Assessment Guidance for Superfund, Part E Supplemental Guidance for Dermal Risk Assessment* (2004), depending upon the COPC being evaluated, there is uncertainty and underestimation of risk and hazard to human health associated with this approach because the oral toxicity criteria are based on an administered dose and not an absorbed dose. In general, EPA guidance recommends an adjustment to the oral toxicity criteria to convert an administered dose into an absorbed dose (EPA, 2004). The adjustment accounts for the absorption efficiency of the constituent in the "critical study" that is the basis of the oral toxicity criterion. If the gastrointestinal absorption in the critical study is a high percent, then the absorbed dose is assumed to be equivalent to the administered dose and no adjustment is necessary. If the gastrointestinal absorption of a constituent in the critical study is poor (less than 50 percent), an adjustment to the oral toxicity criteria is recommended to reduce uncertainty.

7.1.5.3 Uncertainties in Risk Characterization

In general, uncertainty is inherent in the risk characterization step by adding HIs and cancer risks across chemicals and media for each receptor. This assumption of additive risk from multiple chemical exposures may overestimate or underestimate risk because actual interactions among chemicals may be synergistic or antagonistic rather than additive.

7.1.6 Summary of Human Health Risk Assessment

The conclusions from the HHRA are as follows:

- For the future residential exposure scenario, risk and hazard estimates were much greater than the acceptable regulatory limits. Risks are driven by arsenic in soil (incidental ingestion and uptake into homegrown produce), uranium decay products in soil (direct radiation from radium-226 and inhalation of radon gas in indoor air), and arsenic in groundwater used by a resident as drinking water and to water garden vegetables. Noncancer hazards are driven by uptake into homegrown produce from arsenic, cadmium, molybdenum, tin, selenium, and thallium in soil or groundwater used for drinking.
- For the seasonal rancher exposure scenario, risk and hazard estimates were greater than the acceptable regulatory limits. Risks are driven by arsenic in soil (incidental ingestion and uptake into beef consumed by the rancher), uranium decay products in soil (direct radiation), and ingestion of arsenic in groundwater. Noncancer hazards are driven by consumption of beef that uptakes arsenic, cobalt, selenium, and thallium from soil, surface water, and groundwater into beef.
- For the Native American exposure scenario, risk and hazard estimates were much greater than the acceptable regulatory limits. Cancer risks are driven by arsenic in soil (incidental ingestion and

uptake into vegetation) and sediment (uptake into vegetation) and uranium decay products in soil (uptake into vegetation). Noncancer hazards are driven by uptake into vegetation from arsenic, cadmium, cobalt, manganese, molybdenum, nickel, tin, selenium, thallium and vanadium in soil, sediment, or surface water.

- For the recreational hunter and camper/hiker exposure scenario, cancer risk and noncancer hazard estimates for nonradiological contaminants were less than EPA-acceptable levels, indicating that these current and anticipated future land uses are not adversely affected at the Site.

Arsenic (in soil and groundwater) and uranium decay products (in soil; radium-226 and radon-222) were identified as the contaminants that pose the greatest risk to humans. Risks associated with Site-related activities are higher than, but similar to, risks in background areas.

7.2 Ecological Risk

ERAs evaluate the likelihood that adverse ecological effects may occur or are occurring at a Site because of exposure to single or multiple chemical stressors. Risk of such effects results from contact between ecological receptors (wildlife and aquatic organisms) and stressors (mining-related contaminants) that are of sufficient exposure to elicit adverse effects. The primary purpose of an ERA is to identify, evaluate, and describe actual or potential conditions stemming from releases of Site-related contaminants that can result in adverse effects to existing or future ecological receptors. The following sections summarize key elements of the ERA.

7.2.1 Chemicals of Potential Ecological Concern

Chemicals of potential ecological concern (COPECs) identified in the RI from mining operations were based on inorganic constituents detected in media samples, including soil (collected from 0 to 2 feet bgs), surface water, sediment, and vegetation. Concentrations of COPECs were initially screened against published screening benchmarks and promulgated standards to refine the list of COPECs evaluated further in the ERA.

7.2.2 Exposure Assessment

The exposure assessment identified scenarios through which a receptor could contact COPECs in Site media and provide quantitative estimates of the extent of exposure. Figure 5-11 presents a CSM depicting contaminant sources, release mechanisms, impacted media, exposure routes, and potential exposed ecological receptors that were evaluated in the ERA. Ecological receptors are exposed to COPECs through direct contact with contaminated media and through food web transfer. More specifically, the following exposure routes were evaluated:

Terrestrial (Upland) Wildlife

- Incidental ingestion of contaminants in source materials, soil, and surface water through feeding, foraging, or grooming
- Plant uptake of contaminants in source materials and soil
- Dietary uptake of contaminants in prey (food web transfer)

Terrestrial (Riparian) Wildlife

- Incidental ingestion of contaminants in soil, sediment, and surface water through feeding, foraging, or grooming
- Plant uptake of contaminants in soil, sediment, and surface water
- Dietary uptake of contaminants in prey (food web transfer)

Aquatic and Benthic Receptors

- Direct contact with surface water and sediment
- Dietary uptake (food web transfer)

7.2.2.1 Ecological Resources at Risk

Disregarding the influence of environmental contaminants, the abundance and diversity of wildlife in an area is dependent on habitat characteristics such as type, quality, and quantity. The Site exists in a transitional ecosystem between the Great Basin vegetation to the south and the Rocky Mountain vegetation to the north and east. Land within the area is managed by the state of Idaho, USFS, and BLM. There is also private land ownership, and parts of the area are developed and used for agriculture or grazing.

Habitats

There are several terrestrial plant communities present because of variations in elevation, moisture, temperature, soil type, slope, and aspect. Plant communities include mixed conifer/aspen forest, sagebrush/grassland, aspen forest, and riparian/wetlands. The mixed aspen and conifer forests are characterized by occasional dense stands of aspen surrounded by open stands of aspens or conifers. Dominant conifer species within the vicinity of the Site include lodgepole pine, Douglas fir, and subalpine fir with understory plants including snowberry, serviceberry, chokecherry, and various grasses and forbs. The sagebrush communities occur mainly on dry soils or rocky outcrops. Dominant species include big sagebrush, mountain snowberry, yellow rabbitbrush and antelope bitterbrush, and various forbs (alfalfa, lupine, scorpion weed, white sage, sticky geranium and mule's ears), as well as various grass species. Riparian and wetland vegetation is similar in composition to other vegetation communities, with willow, cattail, rush, and sedge species often present. Surface water features provide riparian and wetland habitats that support periphyton, plankton, macrophytes, and benthic invertebrates.

These habitats support a variety of mammalian and avian species. Conifer-aspen communities support black bear, snowshoe hare, yellow pine chipmunk, great horned owl, downy woodpecker, and western bluebird. Animals that the sagebrush-grass communities support include but are not limited to coyote, deer mouse, prairie falcon, sage grouse, and mourning dove. Animals that the riparian and marsh communities support include but are not limited to moose, beaver, muskrat, belted kingfisher, mallard duck, great blue heron, sandhill crane, and common snipe.

An aquatic functional use survey of ponds (nonregulated surface water features) was conducted in June 2004 (DEQ, 2004a). None of the ponds at the Site were characterized as adequate open water, emergent vegetation, protective cover, and food sources to support a local resident migratory bird population during typical nesting/breeding seasons. In addition, none of the streams at the Site had, or were likely to have, supported fish.

Ecological Receptors

This section details specific invertebrates, reptiles and amphibians, birds, mammals, and threatened and endangered species that have been identified at, or near, the Site.

Invertebrates - Invertebrates such as worms, insects, crustaceans, and spiders are present at the Site. These organisms are important prey for birds, reptiles, amphibians, and small mammals.

Reptiles and Amphibians - Amphibians include the tiger salamander, the western toad, the leopard frog, and the western chorus frog. Reptiles include the sagebrush lizard, the gopher snake, the western and common garter snake, the racer, and the western skink. These organisms are secondary consumers and may be prey for higher trophic level species.

Birds - Birds near the Site exist in all trophic levels. Species like the house finch, the mourning dove, and the trumpeter swan are all herbivores. Most species such as the robin, the crow, and nuthatch, sparrow, and warbler species consume both invertebrates and plant materials. There are also several species that are primarily carnivorous, including the great blue heron, which consume a diet dominantly composed of fish (piscivorous), and hawks such as the red-tailed hawk, the northern harrier and the Cooper's hawk, and several owl species all of which eat mostly small mammals including mice and voles.

Mammals - Mammal species include species at many trophic levels. These species include primary consumers and omnivores such as the deer mouse, the long-tailed vole, the least chipmunk, and the Uinta ground squirrel. These species are often prey for upper trophic level consumers like coyotes. The mink, which dominantly feeds on area fish, is also a high-trophic-level species potentially occurring in the Site vicinity. Elk are also present near the Site as primary consumers. Other mammals may include bats, gophers, beavers, chipmunks, deer, raccoons, porcupines, and hares.

Threatened and Endangered Species – The only threatened or endangered species to potentially use the Site is the Canada lynx (*Lynx canadensis*). The greater sage-grouse (*Centrocercus urophasianus*), listed as a candidate species, and the North American wolverine (*Gulo gulo luscus*), listed as a proposed threatened or endangered species, may use the Site. None of these species have been observed at the Site to date.

Endpoint Receptor Selection

Endpoints define the focus of the ERA and include both assessment and measurement endpoints. Assessment endpoints are explicit statements about what aspects of the ecological system are valued for protection. Each assessment endpoint is evaluated for risk, which may not be directly quantifiable. In general, assessment endpoints are populations or communities of ecological receptors (EPA, 1997a). Measurement endpoints are the various means by which the assessment endpoints are evaluated. Measurement endpoints are quantifiable indicators of the state of the valued conditions or processes through laboratory or field experimentation that are related to the characteristic chosen as the assessment endpoint. The assessment and measurement endpoints for this ERA are shown in Table A-4.

Measurement endpoints for upper-trophic-level wildlife are evaluated based on an evaluation of risk to specific target receptors, because it is neither possible nor practical to evaluate the risk posed to every potentially exposed species. Therefore, representative species from each feeding guild potentially using the Site habitats were identified. A feeding guild represents a group of species that exploit the same ecosystem resources in the same way, and therefore could be expected to have the same exposure to environmental contaminants. Representative wildlife receptors selected for the ERA are American goldfinch, American robin, coyote, deer mouse, elk, great blue heron, long-tailed vole, mallard, mink, raccoon, and northern harrier. In addition, aquatic organisms as a group were evaluated.

Exposure Estimation for Wildlife

The ERA calculated risks using the lower of the maximum detected concentration or an upper-bound average concentration for the EPC. Risks were also calculated for background concentrations. Tables 5-1 and 5-2 show the range of detected concentrations, the EPC, and background concentrations for the chemicals of ecological concern (COECs) identified at the Site. Exposure assumptions used for each receptor are presented in Table A-5. Detailed information on the methods and equations used for calculating the exposure estimates were provided in the RI (MWH, 2014).

The exposure model used for wildlife was focused on ingestion exposure pathways that may include the ingestion of food, water, or soils and sediments. Food ingestion is the pathway by which most of the exposure occurs, particularly for bioaccumulative chemicals.

7.2.3 Effects Assessment

7.2.3.1 Wildlife

Ecological effects associated with exposure to COPECs in the environment were evaluated by comparing dose estimates to toxicity reference values (TRV). Avian and mammalian TRVs are reported in terms of mg/kg-day to correspond to the daily dose exposure units for wildlife. Two TRVs were determined for each avian and mammalian receptor evaluated: (1) the TRV_{NOAEL} is defined as the highest dose at which adverse effects are unlikely to occur and (2) the TRV_{LOAEL} is defined at the lowest dose where a specific biological effect is expected to occur. Toxicity reference values used in the ERA for mammalian and avian receptors are presented in Tables A-6 and A-7, respectively.

7.2.3.2 Ecological Screening Levels for Aquatic Receptors

Table A-8 presents surface water screening levels used to evaluate effects to aquatic receptors.

7.2.4 Risk Characterization

Risk characterization is the final phase of risk assessment, in which the likelihood of adverse effects is evaluated by combining the exposure analysis and effects analysis. Risk characterization consists of estimating and describing risk, including the assumptions and associated level of confidence. The assessment endpoints are evaluated, and each evaluation method is a line of evidence. In this ERA, the analyses and risk characterization phases are reported for each assessment endpoint.

The risk characterization for aquatic receptors (amphibians) compared measured COEC concentrations in surface water to the appropriate water quality criteria to calculate a HQ as described by the following:

$$HQ = \frac{C_{sw}}{AWQC}$$

Where:

HQ = Hazard quotient
C_{sw} = Measured surface water concentration (mg/L)
AWQC = Ambient water quality criteria (mg/L)

The risk characterization for wildlife integrates the modeled dietary receptor exposures and chemical toxicity information. Wildlife exposure and toxicity data were used to calculate the HQ, as follows:

$$HQ = \frac{Dose}{TRV}$$

Where:

HQ = Hazard quotient
Dose = Total ingested daily dose of a chemical (mg/kg-d)
TRV = Toxicity reference value (mg/kg-d)

The ERA used the following to interpret HQs:

- An HQ_{NOAEL} less than (<) 1.0 indicates that toxicological effects and potential risk are likely not occurring.
- An HQ_{NOAEL} > 1.0 and an HQ_{LOAEL} < 1.0 generally indicate that toxicological effects and potential risk may occur. Whether or not risks occur is dependent on the confidence in the toxicity values used and the LOAEL's magnitude relative to the NOAEL.
- An HQ_{LOAEL} >1.0 indicates that toxicological effects and potential risk may occur.

7.2.4.1 Risks to Aquatic Life

The streams at or near the Site do not support fisheries because of their intermittent or ephemeral nature; however, these tributaries do flow seasonally into Wooley Valley Creek and the Blackfoot River. HQs for aquatic organisms (e.g., amphibians) exposed to contaminants in surface water at the Site are greater than EPA's acceptable hazard criterion of 1 for dissolved barium (HQ=10), boron (HQ=19), dissolved cadmium (HQ=2), dissolved manganese (HQ=3), total selenium (HQ=101), and dissolved uranium (HQ=4).

7.2.4.2 Risks to Wildlife

NOAEL- and LOAEL-based ecological hazard estimates for representative wildlife receptors exposed to environmental media at the Site and background are summarized in Table A-9. The following discusses LOAEL-based HQs for the Site and background areas.

Long-tailed Vole

HQ estimates for the long-tailed vole exposed to upland surface soil, surface water, and vegetation range from less than 1 to 90. Selenium was the only COEC with a HQ exceeding 10. Other COECs exceeding an HQ of 1, in order of decreasing magnitude, are molybdenum, thallium, nickel, and total chromium. The background HQ for selenium was 1.5, which is well less than the HQ for the Site.

American Goldfinch

HQ estimates for the American goldfinch exposed to upland surface soil, surface water, and vegetation range from less than 1 to 34. COECs with hazard estimates greater than an HQ of 10, in order of decreasing magnitude, are selenium and vanadium. One additional COEC, total chromium, has a hazard estimate exceeding an HQ of 1. The background HQ for selenium was 1.6, which is well less than the HQ for the Site.

Deer Mouse

HQ estimates for the deer mouse exposed to upland surface soil, surface water and vegetation, and modeled invertebrates range from less than 1 to 46. COECs with hazard estimates exceeding an HQ of 10, in order of decreasing magnitude, are selenium and cadmium. Additional COECs exceeding an HQ of 1, in order of decreasing magnitude, are nickel, total chromium, thallium, and molybdenum. The only COEC with a background hazard estimate exceeding the ecological hazard criterion of 1 is cadmium.

Raccoon

HQ estimates for the raccoon exposed to riparian surface soil, surface water, sediment, and vegetation and modeled terrestrial small vertebrates and invertebrates and aquatic invertebrates range from less than 1 to 1.2. The only COEC with an HQ that exceeds the ecological hazard criterion of 1 is selenium. Background HQs for were all less than 1.

American Robin

HQ estimates for the American robin exposed to upland surface soil, surface water, and vegetation, and modeled invertebrates range from less than 1 to 13. The only hazard estimate exceeding an HQ of 10 is for selenium. Additional COECs exceeding an HQ of 1 are, in order of decreasing magnitude, vanadium, cadmium, total chromium, nickel, and zinc. Background HQs were all less than 1.

Mallard Duck

HQ estimates for the mallard duck exposed to surface water, sediment, and vegetation, and modeled aquatic plants and invertebrates, range from less than 1 to 7. The only HQ exceeding 1 is for selenium. Background HQs were all less than 1.

Coyote

HQ estimates for a coyote exposed to Site upland surface soil, surface water, and vegetation, and modeled small mammals and invertebrates, are less than 1. Background HQs were all less than 1.

Northern Harrier

HQ estimates for a northern harrier exposed to upland surface soil and surface water and modeled terrestrial small vertebrates, range from less than 1 to 1.1. The only COEC with HQ that exceeds 1 is selenium. Background HQs were all less than 1.

Great Blue Heron

HQ estimates for a great blue heron exposed to riparian surface soil, surface water, and sediment, and modeled terrestrial small vertebrates and aquatic invertebrates range from less than 1 to 7. COECs with HQs that exceed 1, in order of decreasing magnitude, are selenium and vanadium. Background HQs were all less than 1.

Mink

HQ estimates for a mink exposed to riparian surface soil, surface water, and sediment, and modeled terrestrial small vertebrates and aquatic invertebrates, range from less than 1 to 94. COECs with HQs exceeding 10 for the mink are, in order of decreasing magnitude, selenium, and total chromium. COECs with HQs that exceed 1 are, in order of decreasing magnitude, thallium, nickel, cadmium, molybdenum, vanadium, antimony, copper, and zinc. The background HQ for selenium is 2.9, which is well less than the Site HQ.

7.2.4.3 Uncertainty Analysis

Risk assessment methods used, and assumptions made in assessing potential risks to ecological receptors, are subject to a certain degree of uncertainty. To compensate for these uncertainties, inherent and intentional conservatism is generally used to result in protective estimates of risk. In cases where information is limited, assumptions may be based on professional judgment that may under or overestimate risks. To assist interpretation of the ERA results, the primary sources of conservatism and uncertainty were described in Appendix A, Section 6, of the RI report (MWH, 2014). The following describes key uncertainties related to exposure, effects, and risk characterization.

Uncertainties in Exposure

Major sources of uncertainty in the exposure assessment include the values used to represent the magnitude and distribution of medium-specific contamination. Because all media cannot be sampled at all locations, modeling and data extrapolation is necessary. The most likely causes of uncertainty in the exposure portion of this assessment are the COEC concentrations selected as EPCs for risk estimation. Contaminants in soils are most often unevenly distributed, and there are uncertainties in the mean, maximum, and 95 percent UCL values. It is believed, however, that sufficient samples have been collected and appropriately analyzed to adequately describe the nature and extent of chemical contamination at the Site.

The risk from an ingested chemical depends on how much is absorbed from the gastrointestinal tract. This is important for metals in soil at mining sites because some metals are likely not very bioavailable. Failure to account for this may result in a substantial overestimation of exposure and risk. EPCs for all metals/metalloids, used to evaluate both cancer and noncancer health effects associated with exposure, assume a bioavailability of 100 percent. The bioavailability assumptions are protective and likely overestimate the actual risk associated with exposure.

The selection of representative ecological receptors to evaluate ecological risks in the ERA can be a source of uncertainty in the risks to receptors. For example, although representative ecological receptors were chosen for feeding guilds, exposure for risk to piscivorous receptors, including mink and great blue heron, is likely overestimated because the Site does not support fish.

Concentrations of COECs in biotic media were estimated using literature-derived bioaccumulation factors when Site-specific biota concentrations were not available. Uncertainty is associated with using literature values because the data used to derive those may have been obtained from sites with different environmental conditions than the Site.

Area-averaging of data over the entire Site potentially underestimates exposures to receptors with small foraging areas.

Uncertainties in Toxicity Assessment

Toxicity data and other information providing the basis for most of screening benchmarks and TRVs are commonly based on effects experienced by individual organisms under controlled laboratory conditions. There is, therefore, considerable concern regarding the ability of these data to reflect or predict population-level or community-level effects in the field. Adequate field data are lacking for most chemical stressors and receptor species, and laboratory-based data are therefore used and accepted in most cases to estimate effects in the field. Effects to individuals in the laboratory may or may not be representative of effects that may be seen in populations and communities in the field.

Screening benchmarks are generally protective values that likely overestimate risk when used as thresholds for adverse effects. TRVs derived from lab animals may under or overestimate the actual toxicity to wildlife. However, because the ERA relied on screening benchmarks and TRVs from a large variety of appropriate and relevant data sources, the overall uncertainty should decrease compared to assessments based on only one or a few data sources.

Uncertainties in Risk Characterization

The risk characterization method itself can contribute to uncertainties in the ERA. These uncertainties are reduced by not relying only on a line of evidence.

7.2.5 Summary of Ecological Risk Assessments

7.2.5.1 Risks to Wildlife Receptors

Effect-based (LOAEL-based) ecological HQs were calculated for terrestrial and riparian upper trophic level wildlife exposed to contaminants in combined media (soil, sediment, and surface water) at the Site. Eleven representative upland/riparian receptors were evaluated in the baseline ERA: American goldfinch, American robin, coyote, deer mouse, elk, great blue heron, long-tailed vole, mallard, mink, raccoon, and northern harrier. Table A-9 shows the range of sitewide HQs for ecological receptors and COECs that exceed a HQ of 1. Wildlife risks from exposure to COECs at the Site are summarized as follows:

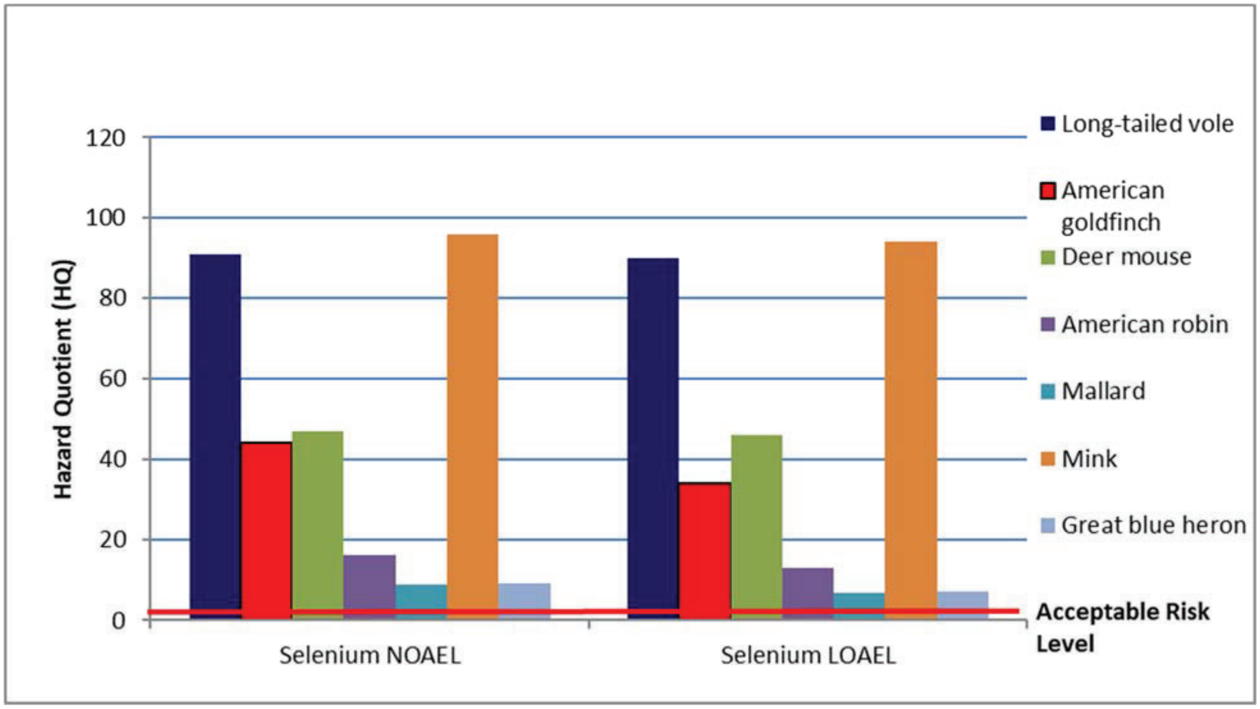
- Four types of COECs resulted in HQ estimates above acceptable thresholds (listed by medium):
  - **Upland Soil -** antimony, cadmium, chromium, copper, molybdenum, nickel, selenium, thallium, vanadium, and zinc
  - **Riparian Soil -** antimony, cadmium, chromium, copper, molybdenum, nickel, selenium, thallium, and vanadium
  - **Surface Water -** selenium
  - **Sediment -** antimony, cadmium, copper, molybdenum, selenium, and thallium
- HQ estimates greater than 1 were calculated for the following receptors: long-tailed vole, American goldfinch, deer mouse, raccoon, American robin, mallard, mink, great blue heron, and northern harrier.

- The greatest risk to wildlife was identified from exposure to selenium (Figure 7-3). Comparisons of Site and background HQ indicate that risk from exposure to selenium is largely attributable to historic mining activities.
- Risk estimates for the mink and great blue heron are likely significantly overstated because current conditions in Site waters do not support fish (their preferred prey) to forage upon.

7.2.5.2 Risks to Aquatic Receptors

The streams at or near the Site do not support fisheries because of their intermittent or ephemeral nature; however, these tributaries do flow seasonally into Wooley Valley Creek and the Blackfoot River. HQs for aquatic organisms (e.g., amphibians) exposed to contaminants in surface water at the Site are greater than EPA's acceptable hazard criterion of 1 for dissolved barium (HQ=10), boron (HQ=19), dissolved cadmium (HQ=2), dissolved manganese (HQ=3), total selenium (HQ=101), and dissolved uranium (HQ=4).

Figure 7-3. Selenium Hazard Quotients for Wildlife



7.3 Livestock Risk

A livestock risk assessment (LRA) is not typically performed for a CERCLA site; however, an LRA was performed at the Site to evaluate potential impacts of selenium to livestock and to provide land managers with information that can be used for developing grazing plans and BMPs. Beef cattle, sheep, and horses currently graze on reclaimed mine sites in the southeastern Idaho Phosphate Resource Area. These animals graze near the Site, but not currently on the mine itself. Sheep prefer forbs that may include selenium hyper-accumulator plant species, while beef cattle prefer grasses. As described in the RI report (MWH, 2014), sheep-grazing on the Site is not allowed under current Site BMPs. However, the use of the land for the grazing of beef cattle may be a desired beneficial use of reclaimed mine sites. Based on this information, beef cattle were selected as the livestock indicator receptor for evaluation in the LRA. Figure 5-12 depicts the livestock exposures pathways evaluated for the Site.

Potential risks to beef cattle were evaluated following the methods and assumptions used to model exposures for large herbivorous ecological receptors. Beef cattle exposures were modeled for all

COPECs identified in surficial media at the Site. HQ estimates for beef cattle ranged from 0.32 to 2.5. The only COEC identified with a HQ greater than 1 for beef cattle was selenium in upland soil.

Note that there are several documented cases of livestock mortality occurring at or near phosphate mine sites in southeastern Idaho, including the Site. These incidents are believed to have occurred during acute short-term exposures when grazing animals ingest vegetation with high concentrations of selenium. Some species of plants (such as milk-vetch and asters) are known to hyper-accumulate selenium when rooting in surface materials with selenium, such as the waste rock from the Phosphoria Formation.

7.4 Basis of Action

The response action selected for the Site in this ROD is necessary to protect the public health or welfare or the environment from actual or threatened releases of hazardous substances, pollutants, or contaminants into the environment. Such a release or threat of release may present an imminent and substantial endangerment to public health, welfare, or the environment. A response action is necessary for the Site because of the following:

Ecological Risk: Individual receptor-specific HQ estimates greater than 50 were associated with selenium (long-tailed vole and mink) and thallium (mink); individual receptor-specific HQ estimates between 20 and 50 were associated with antimony (mink), molybdenum (long-tailed vole and mink), selenium (American goldfinch and deer mouse), and thallium (deer mouse); and individual receptor-specific HQ estimates between 10 and 20 were associated with cadmium (deer mouse), total chromium (mink), molybdenum (deer mouse), selenium (American robin), thallium (long-tailed vole), and vanadium (American goldfinch and American robin).

In addition, the chemical-specific HQs for amphibians exposed to surface water selenium (HQ greater than 100) is well greater than EPA's acceptable hazard criterion of 1.

Human Health Risk: The cumulative excess cancer risks for an individual under Native American and seasonal rancher exposure scenario exceed 1×10^{-4} (using reasonable maximum exposure assumptions). This risk is a result of, in large part, exposure to arsenic in soil, groundwater, surface water and vegetation, as well as exposure to radium-226 from site soils.

Th noncancer hazard index is greater than 1 for Native American and seasonal rancher exposure scenarios. These risks are associated with exposure to several noncarcinogenic metals in Site soils, surface water, and groundwater.

In addition, in some portions of the Site, drinking water standards are exceeded in groundwater.

Section 8 – Remedial Action Objectives and Cleanup Levels

This section presents the RAOs and cleanup levels for the Ballard Mine Site (OU1). The RAOs and cleanup levels pertain to all portions of the Site except the Ballard Shop Area (OU2). The RAOs provide a general narrative description of what the Selected Remedy is expected to accomplish. The cleanup levels are medium-specific standards that will be used to provide a design basis for the Selected Remedy and evaluate the attainment of RAOs. The RAOs and cleanup levels are based on identified current and potential future land uses (described in Section 6), results of the human health and ecological risk assessments (described in Section 7) and identified applicable or relevant and appropriate requirements (ARARs) (Appendix B).

8.1 Remedial Action Objectives

The following sections describe the RAOs by medium.

8.1.1 Waste Rock and Upland Soils

- For Human Health – Prevent or reduce risks to seasonal ranchers or tribal users through direct contact (incidental ingestion) of waste rock and upland soils contaminated with COCs, including arsenic or uranium (radionuclides of concern: radium-226, radon-222) and others.
- For the Environment – Prevent or reduce risks to birds and mammals from incidental ingestion of waste rock and upland soil particles and ingestion of prey contaminated with COCs (antimony, cadmium, chromium, copper, molybdenum, nickel, selenium, thallium, vanadium, and zinc).
- Prevent or reduce migration of selenium, arsenic and cadmium from waste rock and upland soils to groundwater and surface water to protect human and ecological receptors.

8.1.2 Stream Sediments and Riparian Overbank Deposits

- For Human Health – Prevent or reduce risks to seasonal ranchers or tribal users from direct contact (dermal contact or incidental ingestion) of stream sediment and riparian overbank material containing arsenic or radionuclides of concern.
- For the Environment – Prevent or reduce risks to amphibians and macroinvertebrates and birds and mammals by incidental ingestion of sediments and riparian overbank deposits and ingestion of prey contaminated with COCs (antimony, cadmium, chromium, copper, molybdenum, nickel, selenium, thallium, vanadium, and zinc).

8.1.3 Vegetation

- For Human Health – Prevent or reduce risks to tribal users or seasonal ranchers from ingestion of vegetation contaminated with arsenic, selenium, or uranium.
- For the Environment – Prevent or reduce risks to aquatic (amphibians and macroinvertebrates) and terrestrial receptors (mammals) from ingestion of vegetation contaminated with selenium.

8.1.4 Surface Water

- For Human Health – Prevent or reduce risks to seasonal ranchers or tribal users from direct contact (dermal contact or incidental ingestion) of surface water, and the uptake of surface water containing arsenic, cadmium, and consumption of selenium in food (for example, livestock and vegetation); comply with ARARs.

- For the Environment – Prevent or reduce risk to amphibians and macroinvertebrates from direct contact with surface water contaminated with cadmium and selenium; comply with ARARs.

8.1.5 Groundwater

- For Human Health – Prevent or reduce risks to seasonal ranchers from ingestion of groundwater containing arsenic, cadmium, or selenium; comply with ARARs; return useable groundwater to beneficial uses within a reasonable timeframe.

8.2 Cleanup Levels

The cleanup levels presented here establish acceptable exposure levels for each medium that are protective of human health and the environment. The cleanup levels specify concentration thresholds for each contaminant of concern for each medium of concern. The cleanup levels were determined by considering several factors, including the (1) ARARs, (2) acceptable exposure levels or RBCLs for human and ecological receptors, and (3) background concentrations of contaminants in soil and sediment. The cleanup levels will be used as a design basis for and to evaluate the protectiveness of the remedy.

Table 8-1 presents the cleanup levels for surface water and groundwater; these are based primarily on the ARARs. The exception is the cleanup level for arsenic in surface water, the basis for which is described in the notes to Table 8-1.

Table 8-1. Surface Water and Groundwater Cleanup Levels
Ballard Mine Site, Caribou County, Idaho

Medium COC	Background Concentration[a] (µg/L)	Cleanup Level (µg/L)	Basis
Surface Water			
Arsenic	1.09	6.2	[b]
Cadmium	0.10	0.6	IDAPA 58.01.02[c]
Selenium	0.772	3.1	FWQC[d] (EPA, 2016)
Groundwater[e]			
Arsenic	1.03	10	MCL
Cadmium	0.401	5	MCL
Selenium	2.78	50	MCL

[a] Background concentration is equal to the upper threshold value (95% USL) of the background data set.

[b] Letter to Barry Burnell, DEQ from Daniel Opalski, EPA Region 10, dated September 15, 2016, Re: EPA Disapproval of Idaho's Arsenic Human Health Water Quality Criteria, and Letter to Barry Burnell, DEQ from Daniel Opalski, EPA Region 10, dated September 27, 2016, Re: Arsenic Human Health Water Quality Standards for Surface Waters in Idaho.

[c] State of Idaho Surface Water Quality for Aquatic Life (IDAPA 58.01.02); Criterion Continuous Concentration for Water and Organisms. Note that criterion is hardness-dependent and that progress toward attaining PRGs needs to consider Site-specific hardness.

[d] Federal Water Quality Criterion. Aquatic Life Ambient Water Quality Criterion for Selenium – Freshwater 2016 (EPA 822-R-16-006, June 2016). Note that the criterion includes elements for concentration in both fish tissue and water. If fish-tissue data become available at any monitoring stations, they will be compared with fish-tissue element(s) of the criterion to evaluate progress toward attaining PRGs. Fish-tissue elements, in order of hierarchy are: (1) Egg-Ovary = 15.1 mg/kg dry weight; (2) Whole Body = 8.5 mg/kg dry weight; and (3) Muscle = 11.3 mg/kg dry weight.

[e] EPA National Primary Drinking Water Regulations

Notes:

µg/L = microgram(s) per liter

IDAPA = Idaho Administrative Procedure Act

MCL = maximum contaminant level

PRG = preliminary remediation goal

Table 8-2 presents cleanup levels for COCs in solid media. The cleanup level for each COC in soil or sediment is equal to the lowest RBCL developed for a human that may be exposed under the current and reasonably anticipated land uses (seasonal ranching, recreation, and tribal use) and ecological receptors, unless the background concentration is greater. In cases where the background level is greater than the RBCL, the cleanup level is set at background. For most contaminants in soil and sediment, cleanup levels are based on background levels. By setting cleanup levels at background, this remedy will reduce Site-related risks to levels associated with natural conditions. For contaminants with a cleanup level based on RBCLs, the cleanup level used an HQ of 1.

Additional information on the derivation of background levels can be found in the Baseline Risk Assessment, Appendix A of the Ballard Mine RI Report (MWH, 2014), and the *On-Site and Background Areas Radiological and Soil Investigation Summary Report – P4's Ballard, Henry, and Enoch Valley Mines Remedial Investigation and Feasibility Study* (MWH, 2015b). Background samples were collected from locations near the P4 mine sites that were unimpacted by historical mining activities. In addition, for upland soil, the background data set was supplemented by samples collected at two reference areas in the watershed. These reference areas are locations unimpacted by mining and where the range of lithologies (sedimentary rock formations) are present.

Table 8-2. Soil and Sediment Cleanup Levels
Ballard Mine Site, Caribou County, Idaho

Primary Media COC	Background Value[a] (mg/kg)	Cleanup Levels[b,e] (mg/kg)	Basis[f]
Upland Soil			
Antimony	3.60	3.60	Background
Arsenic	15.6	15.6	Background
Cadmium	41.0	41.0	Background
Chromium	410	410	Background
Copper	51.9	74.5	Risk-based
Molybdenum	29.0	29.0	Background
Nickel	220	220	Background
Radium-226[c]	15.1	15.1	Background
Radon-222[d]	--	--	d
Selenium	29.0	29.0	Background
Thallium	1.10	1.10	Background
Uranium	36.0	36.0	Background
Vanadium	300	300	Background
Zinc	1,200	1,200	Background
Riparian Soil			
Arsenic	5.93	5.93	Background
Cadmium	5.02	7.24	Risk-based
Chromium	43.3	43.3	Background
Copper	24.3	24.3	Background
Molybdenum	0.653	0.653	Background

Table 8-2. Soil and Sediment Cleanup Levels
Ballard Mine Site, Caribou County, Idaho

Primary Media COC	Background Value[a] (mg/kg)	Cleanup Levels[b,e] (mg/kg)	Basis[f]
Nickel	29.6	29.6	Background
Selenium	2.03	2.03	Background
Thallium	0.483	0.483	Background
Vanadium	57.9	57.9	Background
Sediment			
Antimony	5.00	5.00	Background
Arsenic	4.55	4.55	Background
Cadmium	4.17	4.17	Background
Copper	25.5	25.5	Background
Molybdenum	< 0.5	0.541	Risk-based
Selenium	1.48	1.48	Background
Thallium	0.378	0.378	Background
Vanadium	49.1	113	Risk-based

[a] The 95 to 95% upper threshold limit was selected as the background level for upland soils collected in 2009 and 2014. The 95% USL was selected as the background level for sediment and riparian soil data sets collected in 2004 and 2010.(MWH 2013a; 2015b)

[b] The cleanup level is equal to the greater of the background concentration or the lowest human health and ecological RBCL.

[c] Radium-226 are in pCi/g.

[d] Radon is an inhalation risk, typically associated with residential indoor air scenario, which is not a foreseeable future use.

[e] All cleanup levels for soil and sediment are based on background levels, except those noted by footnote f, unless otherwise noted

[f] Risk level for copper (based on HQ = 1 for birds [American robin]; cadmium (based on a HQ = 1 for protection of Native Americans consuming culturally significant vegetation in riparian areas); molybdenum (based on HQ = 1 for mammals [mink]); vanadium (based on a HQ = 1 for birds [great blue heron])

Performance targets will be used to monitor the uptake of selenium in vegetation. It is expected that meeting the soil cleanup levels (by constructing the ET cover system over source materials in upland areas and by monitored natural recovery [MNR] in riparian areas) will result in meeting RAOs for vegetation. The performance targets for the acceptable concentration of selenium in vegetation will be based on published research related to toxic substances in the diets of animals.

Section 9 – Description of Alternatives

This section summarizes and presents the remedial alternatives evaluated in detail in the FS. It is organized into three subsections: Section 9.1 describes the alternative development process, Section 9.2 describes the elements that are common to all action of alternatives, and Section 9.3 describes for each medium the alternatives evaluated in detail and provides a summary of remedy components, distinguishing features, and expected outcomes.

9.1 Development of Alternatives

Initially, a broad range of alternatives were identified and screened, in accordance with the NCP. These alternatives included a variety of remedial technologies and process options that were potentially useful to address the RAOs for contaminated media. Cleanup methods and technologies were evaluated for each of the following media: upland soils and waste rock, stream channel sediment and riparian soil, surface water, and groundwater.

A list of the alternatives considered for each medium during detailed evaluation is shown in Table 9-1. The numbering of alternatives in the table is not sequential because some alternatives were screened out during an initial screening step and the remaining alternatives were not renumbered. For each medium-specific alternative retained for detailed evaluation, basic information about the components, distinguishing features, expected outcomes, cost, and other information is summarized.

The Selected Remedy for the Site, presented in Section 12 of this ROD, is the combination of medium-specific alternatives. Table 9-1 identifies the alternative included in the Selected Remedy for each medium.

Table 9-1. Alternatives Considered During Initial Screening and During Detailed Evaluation Ballard Mine Site, Caribou County, Idaho

No.	Remedial Alternative	Cover Notes	Selected Remedy	ICs	LUCs	O&M	LTM
Upland Soil/Waste Rock Alternatives (USWR)							
1	No Action	No cover					
4	Grading and Consolidation with ET Cover	5 feet alluvial soil, 1 foot capillary break		Y	Y	Y	Y
6	Grading and Consolidation, with Potential Incidental Ore Recovery, ET Cover	5 feet alluvial soil, 1 foot capillary break	Y	Y	Y	Y	Y
7	Consolidation of Upland Soil/Waste Rock into Pits, ET Cover	5 feet alluvial soil, 1 foot capillary break		Y	Y	Y	Y
Surface Water Alternatives[a] (SW)							
1	No Action						
2	Sediment traps			Y	Y	Y	
3	In Situ Biological Treatment (Wetlands) of Seeps		Y	Y	Y	Y	Y
Sediment/Riparian Soil[a] (S/RS)							
1	No Action						
3	Sediment Traps/Basins and MNR		Y	Y	Y	Y	Y
4	Removal with Onsite Disposal and MNR			Y	Y		Y

Table 9-1. Alternatives Considered During Initial Screening and During Detailed Evaluation
Ballard Mine Site, Caribou County, Idaho

No.	Remedial Alternative	Cover Notes	Selected Remedy	ICs	LUCs	O&M	LTM
Groundwater[a] (GW)							
1	No Action						
2	MNA			Y			Y
3	Limited PRB Treatment (Alluvial Groundwater) and MNA		Y	Y		Y	Y
5b	Extraction and Treatment of Alluvial and Wells Formation Groundwater			Y		Y	Y

[a] Except for the No Action alternatives, all SW, S/RS, and GW alternatives rely on upland soil/waste rock source control measures to mitigate future generation of contaminated surface water, sediment and groundwater, respectively.

Notes:

ET = evapotranspiration
LTM = long-term monitoring
LUC = land use control
MNA = monitored natural attenuation
MNR = monitored natural recovery
O&M = operation and maintenance
PRB = permeable reactive barrier

9.2 Elements Common to All Alternatives

All alternatives (except the No Action Alternative) include ICs, O&M requirements, LTM, and adaptive management planning. All these elements supplement the engineering controls and treatment technologies included in the medium-specific alternatives. Costs for these common elements are included in the medium-specific alternatives described in Section 9.3.

9.2.1 Institutional Controls

ICs are administrative and/or legal mechanisms intended to control land use and site access and to maintain the integrity of the remedy. There are four categories of IC included in the alternatives:

- **Governmental Controls –** Imposed land or resource restrictions under the authority of an existing unit of government. Such controls may include use or changes in local zoning, permits, codes, or regulations. The alternatives include restrictions on drilling of water supply wells where contaminated groundwater is present. These restrictions would remain in place until cleanup levels are achieved.
- **Legal Controls –** Various legal instruments based on state law, such as easements or covenants, which prohibit activities that could pose an unacceptable risk from exposure to contamination or compromise the effectiveness of the remedy components. The alternatives include deed restrictions, such as easements and covenants, to prevent future land and resource uses that are incompatible with the remedy. For example, restrictions that are legally enforceable against current and future land owners would be placed on the lands comprising the Site, to prevent any future residential use. These deed restrictions would also be structured to prevent or limit future land uses that may adversely impact the cover system or treatment components of the remedy.
- **Communication –** Includes community outreach. Risk communications also may be used to provide notice of contamination on the property and discourage uses that could lead to unacceptable exposures to such contamination. The alternatives include use of communication

tools such as information notices, fact sheets, model grazing plans, and other communication methods to educate neighboring land owners and potential user groups (such as hunters, hikers and tribal members) on issues, concerns, and best practices related to Site use.

- **Enforcement Tools –** States often play a major role in implementing and enforcing ICs. The NCP requires the state to ensure that any ICs implemented as part of the Selected Remedy are in place, are reliable, and will remain in place after the RA is complete and the post-RA monitoring occurs. CERCLA and the NCP do not specify a role for local governments in implementing the IC instruments identified for the Selected Remedy. However, a local government is often the only entity that has the legal authority to implement, monitor, and enforce certain types of ICs, particularly governmental controls such as zoning changes. In addition, difficulties implementing ICs may be encountered because the property is privately owned, requiring coordination for access, implementation, and operations of the Selected Remedy.

Because the Site is large and includes several owners (the state, P4, and landowners adjacent to the mining disturbance), ICs may be selected and implemented on a parcel basis or implemented for specific components of the Selected Remedy. LUCs such as fences, gates, signs, and similar measures are also included in the alternatives.

9.2.2 Operation and Maintenance

O&M is an integral component of all alternatives to ensure the integrity of engineering controls such as the cover system and the proper functioning of treatment facilities, sediment control BMPs, and others. Each medium-specific alternative includes a variety of O&M requirements. The specific O&M requirements vary depending on the cleanup method or technology and will be refined during remedial design.

9.2.3 Long-term Monitoring

Monitoring is also an integral component of all alternatives to assess the performance of different components of the remedy and the effectiveness of the remedy at attaining cleanup levels.
The monitoring program will include periodic inspections of engineered facilities, and sampling and analysis of groundwater, surface water, sediment, riparian soil, vegetation, and upland soil.

The information collected through the LTM program would support the Five-Year Review (FYR) process. FYRs will be performed because site conditions and facilities would not allow for unlimited use and unrestricted exposure under the current and potential future land uses. These reviews will be used to evaluate where the remedy is functioning as intended and whether RAOs are being attained.

9.2.4 Adaptive Management Planning

Adaptive management is a structured, iterative process for making decisions on complex projects where there is uncertainty about the effectiveness of cleanup methods or technologies. Adaptive management for the Site will create a structured process for measuring and/or monitoring elements of the remedy, and determine if additional designs, design modifications, or operational changes are necessary to achieve RAOs. An adaptive management plan will be developed for the selected combined remedy during remedial design. None of these modifications are anticipated to constitute a significant or fundamental change to the remedy selected in the ROD.

9.2.5 Key ARARs

This section identifies ARARs that drive the RAOs and response options. These key ARARs are those that provide a basis for developing an alternative or that help distinguish between alternatives. Additional information on all ARARs is presented in Appendix B, including information on type (i.e., chemical-, location-, and action-specific) and status (i.e., applicable or relevant and appropriate), a synopsis of the requirement, and a summary of the action to be taken to attain requirements.

Key ARARs include the following:

- Idaho Water Quality Standards, including water quality criteria
- National Recommended Water Quality Criteria established under the Clean Water Act (CWA)
- National Primary Drinking Water Regulations, including MCLs, established under the Safe Drinking Water Act
- Idaho Ground Water Quality Rule
- Portions of the regulations established under the Uranium Mill Tailing Radiation Control Act (UMTRCA)
- Regulations established under the Mineral Leasing Act that control the development and reclamation of phosphate mines
- Regulations under the Idaho Surface Mine Reclamation Act pertaining to reclamation of surface mining operations

Cleanup levels for surface water are based on federal and state water quality criteria for surface waters, while cleanup levels for groundwater are based on MCLs. These chemical-specific ARARs influenced development and evaluation of surface water and groundwater alternatives and the treatment elements included in those alternatives. These chemical-specific ARARs also drove development of the USWR alternatives. Action-specific ARARs, including state and federal mining and reclamation requirements, also influenced development of USWR alternatives. These action-specific ARARs also establish performance requirements for the remediated areas, including the source areas and intermittent and ephemeral drainages, to ensure the effectiveness and integrity of the cleanup actions. A key ARAR for developing and distinguishing between sediment and riparian soil alternatives is Section 404 of the CWA, which requires avoiding disturbances to riparian areas (wetlands) and minimizing disturbances where they cannot be avoided.

9.3 Description of Alternatives for each Medium

The following subsections provide general descriptions and expected outcomes of the alternatives considered during the detailed evaluation in the FS. Complete descriptions of the alternatives are provided in the FS report (MWH, 2017a).

9.3.1 No Action Alternative

Superfund regulations require a No Action Alternative be evaluated for comparison with other alternatives. For each medium, a No Action Alternative was developed. Under the No Action Alternative, mine materials would be left in their current condition and no additional cleanup action would be performed. FYRs would be performed as required by law where the remedy leaves contamination in place. Monitoring would only be performed as necessary to support FYRs.

Costs associated with the No Action Alternative (for all media) are summarized in Table 9-2. The expected outcomes for the No Action Alternative are as follows:

- RAOs for upland soil and waste rock would not be attained. Direct exposure risks would persist. Release and transport of contaminants to other media would continue unabated.
- RAOs for vegetation would not be attained. Uptake of contaminants into plant tissue would continue, posing risks to humans and ecological receptors.
- RAOs for groundwater and surface water would not be attained. Risks to humans and ecological receptors would continue unabated.
- RAOs for sediment and riparian soil would not be attained. Risks to humans and ecological receptors would continue unabated.

Table 9-2. Costs and Construction Timeframe, Alternative 1: No Action
Ballard Mine Site, Caribou County, Idaho

	Estimated Cost/Time
Capital Costs	$0
Total O&M Costs (30 years)	$0
Total Periodic Costs (30 years)	$107,885
Total Present Value Costs	$108,000
Construction Timeframe	None
Time to Achieve RAOs	Will never comply with RAOs

9.3.2 Upland Soil and Waste Rock (USWR) Alternatives

Three alternatives were evaluated to address risks associated with upland soil and waste rock. Each of these alternatives share some common elements. All would grade and shape waste rock dumps to promote runoff, but with varying degrees of pit backfill and earthworks. All alternatives would include construction of a cover system over the mine wastes that are left at the Site, an area of more than 500 acres. One alternative (USWR 6, developed at the request of P4) allows for the possibility of ore recovery during implementation of the remedy and two others (USWR 4 and USWR 7) assume no ore recovery during the RA. All the retained USWR alternatives will achieve RAOs for soil and waste rock in a reasonable timeframe through construction of an ET cover system. All USWR remedial alternatives will comply with federal and state mine reclamation requirements. The cover system will also meet requirements under UMTRCA that engineering controls be designed to be effective for at least 200 years.

The Selected Remedy includes USWR 6.

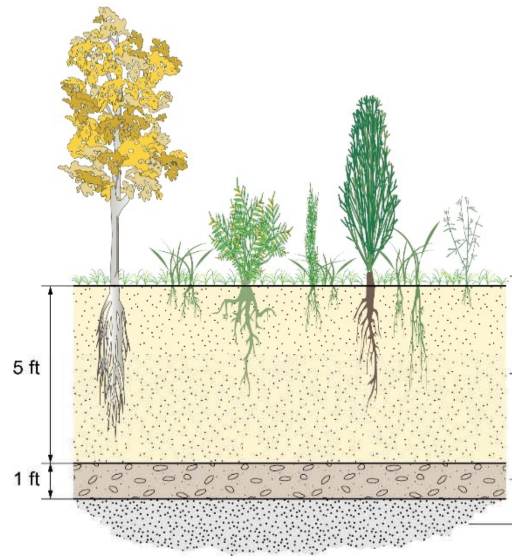
USWR 4—Grading and Consolidation with an Evapotranspiration Cover System, Institutional Controls, and Operations and Maintenance/Long-term Monitoring

Under USWR 4, portions of the upland soil/waste rock dumps throughout the Site would be excavated and consolidated in the onsite pits to cover any exposed beds of the Phosphoria Formation or graded/contoured in-place to create slopes that effectively shed stormwater and snowmelt (maximum of 3:1 slopes). The new USWR surfaces inside and outside of the pits would be capped with an ET cover system. The ET cover would be constructed of materials from designated borrow sources onsite and adjacent to the Site. The ET cover system would be designed to store water that would evaporate or be transpired by the vegetation planted on the surface of the cover system, thus minimizing infiltration into the underlying waste rock. Based on current information regarding nearby borrow material and a preliminary cover analysis (modeling), the selected ET cover would require 3.7 million yd^3 of material and would consist of (starting from the top of the cover) the following layers (Figure 9-1):

- Approximate 5-foot thickness of medium-grained, unimpacted alluvial material
- At least 1-foot thickness of high-permeability (coarse grained), unimpacted fill material as a capillary break

An ET cover would also extend over areas where the original waste rock was excavated for placement into the pits, thereby exposing the underlying native surface soils (assumed to have elevated residual contaminant concentrations).

Figure 9-1. Conceptual Monolithic ET Cover



Amended from P4 Productions, LLC, FS Technical Memorandum #2; ET Cover Conceptual Design, 2017.

Figure 9-1.
Monolithic ET Cover
Ballard Mine, Caribou County, ID–Record of Decision
Caribou County, Idaho

ch2m

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Reclamation vegetation types would be selected to form an extensive root system to effectively mitigate stormwater and snowmelt sheet flow and rill erosion of the cover surface and to transpire water that infiltrates the upper layer of the cover system. LTM and O&M would be necessary to ensure that revegetation is successful and is not incompatible with the selected cover system (such as vegetation with roots that could penetrate the ET cover system) and to repair any stormwater erosion that might occur to the cover system. ICs, fencing, and signage would be implemented to preserve the integrity of the waste rock cover by preventing activities that could compromise the cover.

USWR 4 effectively reduces infiltration of water through the waste rock, which prevents or reduces migration of contaminants and, therefore, is protective of human health and the environment. This cover is made of earthen materials that are available onsite or adjacent to the Site.

The schedule and costs associated with USWR 4 are summarized in Table 9-3. The expected outcomes for USWR 4 are as follows:

- RAOs for USWR will be attained by construction of an ET cover system, which will isolate the waste rock (source materials) from direct contact by receptors.
- The cover system will also contribute to achieving RAOs for all other media, by isolating source materials from surface runoff, minimizing deep infiltration of precipitation and snowmelt into waste rock and subsequent release of contaminants to groundwater, providing clean growth media to minimize uptake of selenium into vegetation, and minimizing release of contaminants from source areas into the ephemeral and intermittent channels on the margins of the Site.

Table 9-3. USWR 4, Estimated Cost and Construction Timeframe
Ballard Mine Site, Caribou County, Idaho

	Estimated Cost/Time
Capital Costs	$50,099,136
Institutional Control Costs	$25,000
Total O&M Costs (30 years)	$388,294
Total Periodic Costs (30 years)	$215,770
Total Present Value Costs	$50,679,000
Construction Timeframe	3 to 5 years
Time to Achieve RAOs	3 to 5 years

USWR 6—Grading and Consolidation, Possibility of Incidental Ore Recovery, Evapotranspiration Cover System, Institutional Controls, and Operations and Maintenance/Long-term Monitoring

USWR 6 is similar to USWR 4 in most respects. The primary differences arise because USWR 6 allows for the possibility that phosphate ore would be recovered during remedy implementation. Information collected during site characterization activities confirmed that approximately 4 million tons of phosphate ore remain at the Site, both exposed at the surface and in the bottoms and sidewalls of existing mine pits. Although ore recovery is not part of USWR 6, the alternative was developed to be compatible with ore recovery.

The amount of ore P4 intends to recover is an approximation based on currently available information and may change as more information becomes available or economic considerations change. Specific plans for potential remining would be accommodated during the remedial design phase of the project. If plans for remining change, for example if there is more or less remining performed, EPA would evaluate the nature of the changes. However, while the cost or implementation schedule of the remedy could change, EPA does not expect the key elements of the remedy—engineered cover system, permeable reactive barriers, wetland treatment cells, and others—to change.

In addition, the CERCLA 121(e) permit exemption does not apply to BLM mineral leasing and mine permitting requirements. For ore to be recovered during implementation of the remedy, P4 would need to acquire a federal mineral lease and seek BLM approval of a plan for ore recovery. The CERCLA process cannot authorize ore recovery activities. EPA would coordinate remedial design/remedial action (RD/RA) activities with concurrent remining through coordination with P4 and BLM.

USWR 6 has the following features that distinguish it from USWR 4 and USWR 7:

- Potential remining activities are expected to generate additional waste rock and overburden material for backfill of mine pits and for construction of portions of the ET cover system (such as the capillary break layer). As a result, under USWR 6, mine pits would be backfilled to a greater extent than USWR 4, creating landforms that are more prominent in appearance. Because plans for remining may change, and because of uncertainty associated with acquiring a mineral lease and BLM approval of a mine plan, USWR 6 includes backfilling of mine pits regardless of the amount of remining. However, the extent of pit backfilling and the final shape of remediated surfaces may differ depending on the scope of remining. At a minimum, mine pits will be backfilled to cover exposed ore beds and shale units of the Phosphoria Formation. Waste rock dumps and backfilled pits will be graded and shaped to ensure geotechnical stability and promote runoff. The conceptual cover design is the same for all alternatives and will cover all mining wastes. The exterior boundaries of the cover system under USWR 6 would be similar to USWR 4 and USWR 7, but there will be some differences in the placement of cover within the footprint of the mining disturbance.

Under USWR 6, the cover system is expected to be more contiguous within the exterior boundaries. The expected performance of the cover system is similar for all alternatives. The sequence and timing of remedial actions, as well as the plans and specifications for the USWR component of the remedy, will be developed during remedial design.

- The cost associated with earthworks also distinguishes USWR 6 from USWR 4 and USWR 7. Earthworks associated with potential remining (such as excavation and placement of waste rock, grading and shaping waste dumps and backfilled pits) will also advance remediation efforts, thereby reducing costs associated with remediation. Of the total capital cost of all earthworks, approximately 75 percent are associated with potential remining and 25 percent are associated with remediation. The estimated cost for USWR 6 is $36.9 million, which is significantly less than for USWR 4 and USWR 7. Costs associated with USWR 6 are summarized in Table 9-4. Additional documentation of cost estimates is presented in the FS.

The expected outcomes for USWR 6, with respect to RAOs, are the same as for USWR 4 and USWR 7.

Table 9-4. USWR 6, Estimated Cost and Construction Timeframe
Ballard Mine Site, Caribou County, Idaho

	Estimated Cost/Time
Capital Costs	$36,974,250
Institutional Control Costs	$50,000
Total O&M Costs (30 years)	$388,294
Total Periodic Costs (30 years)	$215,770
Total Present Value Costs*	$36,974,250
Construction Timeframe	6 to 8 years
Time to Achieve RAOs	6 to 8 years

USWR 7—Complete Consolidation of Existing Upland Soil/Waste Rock into the Pits, Evapotranspiration Cover System, Institutional Controls, and Operations and Maintenance/Long-term Monitoring

USWR 7 would excavate and consolidate all waste rock from external waste rock dumps and fill the existing pits. The volume of existing waste rock is sufficient to fill existing pits from crest to crest, cover the exposed ore beds, and create 3:1 maximum slopes and a topographic surface that directs stormwater out of the pits and away from the source area. The graded upland soil and waste rock surfaces (including external waste rock dump areas where contamination remains) would be capped with the ET cover system, as described in USWR 4. As with USWR 4 and USWR 6, this alternative includes ICs to restrict activities that could disturb the cover systems and O&M and LTM to maintain the integrity of the cover system and limit growth of plants that are incompatible with the selected cover system.

Under this alternative, the final landforms following remediation would be different than USWR 4 or USWR 6. Much of the waste rock in the external dumps would be removed and mine pits would be backfilled to a greater extent than USWR 4 or USWR 6. Implementation of this alternative would cost significantly more than USWR 4 or USWR 6.

The schedule and costs associated with USWR 7 are summarized in Table 9-5. The expected outcomes for USWR 7, with respect to RAOs, are the same as for USWR 4 and USWR 6.

Table 9-5. USWR 7, Estimated Cost and Construction Timeframe
Ballard Mine Site, Caribou County, Idaho

	Estimated Cost/Time
Capital Costs	$112,540,985
Institutional Control Costs	$25,000
Total O&M Costs (30 years)	$388,294
Total Periodic Costs (30 years)	$215,770
Total Present Value Costs	$113,121,000
Construction Timeframe	5 to 7 years
Time to Achieve RAOs	5 to 7 years

9.3.3 Surface Water (SW) Alternatives

Two alternatives were evaluated to address impacts to surface water: SW 2 focuses on ICs, while SW 3 focuses on treatment of contaminated seeps and springs. This section presents a general description of each alternative.

Both SW alternatives would work in concert with other components of the remedy described in the USWR alternatives, GW alternatives, and S/RS alternatives. The ET cover system, included in the USWR alternatives, will substantially contribute to meeting surface water RAOs because releases of contaminants to surface water will be greatly reduced over time. These load reductions will occur because stormwater runoff from the cover system will not contact source materials, and because the cover system will reduce recharge to the seeps over time. The seeps and springs located below waste rock dumps are expected to dry up or significantly decrease in flow over time; however, residual seeps and springs would remain in some locations for an indefinite period. PRBs, described in the groundwater component of the Selected Remedy, will also reduce the concentrations of contaminants that discharge to ephemeral and intermittent headwater reaches of area streams, contributing to achievement of surface water RAOs. Sediment traps/basins, described in the S/RS alternatives, will also address releases of contaminants to headwater reaches during construction of the cover system.

The other components of the remedy (i.e., cover system, PRBs, and sediment basins) summarized in this section and described in greater detail under the USWR, GW, and S/RS alternatives are expected to substantially contribute to attainment of surface water RAOs over the long term. The two alternatives that were evaluated address remaining impacts to surface water by focusing on the residual seeps and springs, and these elements may be phased out over time depending on the effectiveness of the cover system (under the USWR alternatives).

The Selected Remedy includes SW 3.

SW 2—Institutional Controls

Under this alternative, ICs and fencing would restrict access to surface water until source controls (cover system) and treatment (PRBs) described under the alternatives for other media have substantially reduced mine-affected seep/spring discharge or until cleanup levels are achieved.

The schedule and costs associated with SW 2 are summarized in Table 9-6. The expected outcomes for SW 2 are as follows:

- RAOs will be attained in the long term by relying on components of the remedy described in other media alternatives, including the cover system, PRBs, and sediment basins.
- In the short term, RAOs will not be fully attained. Discharges of contaminated water at springs and seeps would persist until the cover system is constructed and effective.

Table 9-6. SW 2, Estimated Cost and Construction Timeframe
Ballard Mine Site, Caribou County, Idaho

	Estimated Cost/Time
Capital Costs	$86,112
Institutional Control Costs	$50,000
Total O&M Costs (30 years)	$497,924
Total Periodic Costs (30 years)	$215,770
Total Present Value Costs	$850,000
Construction Timeframe	5 to 10 years (constructed with cover)
Time to Achieve RAOs	5 to 10 years (after construction)

SW 3—In Situ Biological (Wetlands) Treatment of Source Area Seepage

Under alternative SW 3, in situ biological treatment cells (or constructed wetlands), would be constructed at mine-affected seep/spring locations. The residual mine-affected water at the seeps/springs would be treated via biologically mediated reactions, including reduction using anaerobic bacteria, resulting in the removal of contaminants through precipitation or sorption. The treated water would flow out of the treatment cells to the downstream drainages or evapotranspire within the treatment cells. ICs and fencing would be used to control human exposure at the treatment cells. Treatment cells may be phased out over the long term as source controls (i.e., cover system) and treatment technologies (e.g., PRBs) described in other media alternatives become effective and reduce mine-affected seep/spring discharge or as cleanup levels are achieved.

The schedule and costs associated with SW 3 are summarized in Table 9-7. The expected outcomes for SW 3 are as follows:

- RAOs will be attained at the conclusion of RA, more quickly than SW 2. The quality of surface water in drainages near the site would improve soon after the treatment units are constructed and operational.
- Treatment of seeps and springs will also contribute to water quality improvement in shallow alluvial aquifer, as some treated water will infiltrate and recharge the alluvial aquifer.
- ICs and fencing will be used to control human exposure.

Table 9-7. SW 3, Estimated Cost and Construction Timeframe
Ballard Mine Site, Caribou County, Idaho

	Estimated Cost/Time
Capital Costs	$576,835
Institutional Control Costs	$50,000
Total O&M Costs (30 years)	$589,254
Total Periodic Costs (30 years)	$215,770
Total Present Value Costs	$1,432,000
Construction Timeframe	5 to 10 years (concurrent with cover construction)
Time to Achieve RAOs	5 to 10 years (after construction)

9.3.4 Stream Channel Sediment and Riparian Soil (S/RS) Alternatives

Two alternatives were evaluated to address sediment and riparian soil in the ephemeral and intermittent drainages near the Site. S/RS 3 relies on MNR, over time, as a primary element of the alternative to achieve RAOs. S/RS 3 also includes use of sediment traps and basins near the source areas to capture sediment that may be mobilized during RA. S/RS 4 focuses on excavation of all contaminated material in stream corridors followed by reconstruction and revegetation of the stream corridor to a naturally functioning condition. A general description of each alternative for stream channel sediment/riparian soil is presented in the following paragraphs. RAOs for sediment and riparian soil are expected to be achieved by both alternatives.

Both S/RS alternatives rely on construction of the cover system (described in the USWR alternatives). The cover system will contribute to attaining RAOs by isolating source materials from surface runoff and eliminating or minimizing the erosion and transport of contaminated particles into the ephemeral and intermittent stream channels on the margins of the Site. The cover system will also reduce contaminant loading from seeps and springs.

The Selected Remedy includes S/RS 3.

S/RS 3—Sediment Traps/Basins, Monitored Natural Recovery, and Institutional Controls

Under S/RS 3, MNR will reduce concentrations of contaminants through natural processes. Over time, clean runoff, and associated sediment transport and erosion will disperse and dilute or cover contaminated stream channel/overbank deposits and thus reduce risks to receptors. Implementation of MNR during the RA includes routine sediment/riparian soil sampling in impacted stream corridors down to the confluence with the Blackfoot River, and periodic data evaluations to monitor the progress of natural recovery and to support CERCLA FYRs. S/RS 3 also includes sediment traps and basins that would be installed below source areas in the upper reaches of the mine-affected drainages to capture contaminated sediment entrained in the stormwater runoff during construction of the remedial cover. Sediment in these traps would be cleaned out and disposed of in a designated area under the USWR cover system. This alternative also includes fencing and implementation and enforcement of ICs to prevent human exposure to contaminated sediment and riparian soil until RAOs are achieved.

The schedule and costs associated with S/RS 3 are summarized in Table 9-8. The expected outcomes for S/RS 3 are as follows:

- Sediment mobilized by construction activities would be captured in sediment traps, preventing transport during runoff events.
- Intrusive physical damage to existing riparian environment will be minimal, as construction activities will avoid or minimize impacts to intermittent stream channels.
- RAOs will be attained by controlling sources of contamination to the intermittent streams, MNR, and ICs.
- Time to achieve RAOs is uncertain, but conditions are expected to improve slowly over time, taking more than 10 years beyond remedy completion.

Table 9-8. S/RS 3, Estimated Cost and Construction Timeframe
Ballard Mine Site, Caribou County, Idaho

	Estimated Cost/Time
Capital Costs	$240,433
Institutional Control Costs	$75,000
Total O&M Costs (30 years)	$204,216
Total Periodic Costs (30 years)	$215,770
Total Present Value Costs	$736,000
Construction Timeframe	5 to 10 years (concurrent with cover construction)
Time to Achieve RAOs	10+ years after construction

S/RS 4—Removal and Onsite Disposal, Monitored Natural Recovery, and Institutional Controls

Sediment and riparian soil and associated vegetation in the upper reaches of the mine-affected drainages, where the highest contaminant concentrations are detected, would be excavated, transported, and consolidated under the ET cover system. Impacted drainages would then be reconstructed and revegetated to a naturally functioning condition. MNR, ICs, and fencing would be implemented, in a similar fashion as described in S/RS 3, for sediment and riparian soil in the distal reaches of the mine-affected drainages where contaminant concentrations are lower.

The schedule and costs associated with S/RS 4 are summarized in Table 9-9. The expected outcomes for S/RS 4 are as follows:

- In reaches where excavation of contaminated sediment occurs, cleanup levels will be achieved quickly. In the more distal reaches where MNR is implemented, conditions will improve slowly over time, likely taking more than 10 years after construction to achieve RAOs.
- Excavation of contaminated sediment from stream channels and adjacent riparian zones will temporarily destroy stream channels. There is significant uncertainty about the recovery of ecological functions and values in these sensitive areas.

Table 9-9. S/RS 4, Estimated Cost and Construction Timeframe
Ballard Mine Site, Caribou County, Idaho

	Estimated Cost/Time
Capital Costs	$1,219,988
Institutional Control Costs	$75,000
Total O&M Costs (30 years)	$80,126
Total Periodic Costs (30 years)	$215,770
Total Present Value Costs	$1,591,000
Construction Timeframe	5 to 10 years (concurrent with cover construction)
Time to Achieve RAOs	10 years after construction

9.3.5 Groundwater (GW) Alternatives

Three alternatives were evaluated to address impacts to groundwater. The alternatives ranged from a passive approach using MNA (GW 2) to a semipassive approach using PRBs (GW 3) and an active approach including pumping and treatment of groundwater (GW 5b). This section presents a general description of each alternative.

All three alternatives would rely primarily on other components of the remedy to attain RAOs. The ET cover system (included in the USWR alternatives) is a key element that will substantially contribute to meeting groundwater RAOs. The cover system will greatly reduce deep infiltration of precipitation and snowmelt, recharge to groundwater, and contaminant release to groundwater. In addition, collection and treatment of contaminated seeps and springs (under SW 3) will also contribute to meeting groundwater RAOs because the seeps and springs recharge shallow alluvial groundwater. In the longer term, groundwater RAOs are expected to be attained through implementation of the USWR and SW alternatives.

The GW alternatives described here will provide a higher level of confidence that RAOs will be achieved. Alternatives GW 3 and GW 5b, which include treatment components, will accelerate progress toward achieving RAOs. All alternatives include implementation and enforcement of ICs to prevent well drilling and domestic use of groundwater in areas where contaminant plumes are located until RAOs are attained.

The Selected Remedy includes GW 3.

GW 2—Monitored Natural Attenuation and Institutional Controls

All GW alternatives rely primarily on the strategy of constructing a cover system (under the USWR alternatives) and treating seeps and springs (under the SW 3) to reduce the concentration of contaminants in groundwater.

GW 2 includes MNA, which relies on physical, chemical, and biological processes to further reduce contaminant concentrations in groundwater over time. It may be used as a polishing step depending on the effectiveness of source controls and treatment. It is anticipated that GW 2 would require more time to achieve RAOs than GW 3 and GW 5b, which include treatment. Use of MNA during the RA would require routine groundwater monitoring, periodic data evaluations to track the progress of natural attenuation, and implementation of an adaptive management strategy. The schedule and costs associated with GW 2 are summarized in Table 9-10. The expected outcomes for GW 2 are as follows:

- In the short term, RAOs will not be fully attained. Implementation and enforcement of ICs regarding well drilling and use of groundwater will prevent direct human exposure until cleanup levels are achieved.
- RAOs will be attained in the long term by relying on components of the remedy described in other media alternatives, including the cover system and treatment of seeps and springs.
- MNA would be used as a polishing step to dilute and disperse contaminants in the existing plumes over time. The length of time needed to achieve RAOs is uncertain, but conditions are expected to improve slowly over time, taking more than 10 years beyond remedy completion.

Table 9-10. GW 2, Estimated Cost and Construction Timeframe
Ballard Mine Site, Caribou County, Idaho

	Estimated Cost/Time
Capital Costs	$166,222
Institutional Control Costs	$125,000
Total O&M Costs (30 years)	$881,076
Total Periodic Costs (30 years)	$215,770
Total Present Value Costs	$1,389,000
Construction Timeframe	5 to 10 years (constructed concurrent with cover)
Time to Achieve RAOs	10+ years after cover construction

GW 3—Limited Permeable Reactive Barrier Treatment of Alluvial Groundwater, Monitored Natural Attenuation, and Institutional Controls

Similar to GW 2 and GW 5b, this alternative also relies on the strategy of constructing a cover system (under the USWR alternatives) and treating seeps and springs (under SW 3) to reduce the concentration of contaminants in groundwater.

Under this alternative, PRBs (trenches filled with reactive media to treat groundwater via precipitation) would be constructed near the margins of waste rock dumps to intercept and treat shallow alluvial groundwater. The PRBs would be sited upgradient of perennial seeps/springs. In some cases where the affected alluvial groundwater is excessively deep, extraction wells may supplement the system and discharge to the PRBs. PRBs will also reduce the concentrations of contaminants that discharge to ephemeral and intermittent headwater reaches of area streams. If contaminant concentrations are not reduced to cleanup levels through the use of PRBs, MNA would be used as a polishing step to further reduce concentrations of contaminants in groundwater plumes. Implementation and enforcement of ICs will prevent human exposure to contaminated groundwater until RAOs are achieved.

The schedule and costs associated with GW 3 are summarized in Table 9-11. The expected outcomes for GW 3 are as follows:

- It is expected that RAOs would be attained at RA completion (10+ years following construction of the cover system). If low levels of groundwater contamination remain, MNA would be used as a polishing step to further reduce the concentration of contaminants in groundwater plumes.
- Use of PRBs will accelerate progress toward meeting RAOs compared to GW 2.
- If contaminant concentrations are not reduced to cleanup levels through the use of PRBs (and construction of the cover system), MNA would be used as a polishing step.
- Implementation and enforcement of ICs will prevent human exposure to contaminated groundwater until RAOs are achieved.

Table 9-11. GW 3, Estimated Cost and Construction Timeframe
Ballard Mine Site, Caribou County, Idaho

	Estimated Cost/Time
Capital Costs	$727,004
Institutional Control Costs	$125,000
Total O&M Costs (30 years)	$1,004,968
Total Periodic Costs (30 years)	$215,770
Total Present Value Costs	$2,073,000
Construction Timeframe	5 to 10 years (constructed concurrent with cover)
Time to Achieve RAOs	10+ years after cover construction

GW 5b—Groundwater Recovery and Treatment and Institutional Controls

Similar to GW 2 and GW 3, this alternative relies on the strategy of constructing a cover system (under the USWR alternatives) and treating seeps and springs (under SW 3) to reduce the concentration of contaminants in groundwater.

This alternative includes extraction and treatment of mine-influenced groundwater, including the alluvial and Wells Formation groundwater (deep regional water). Extraction trenches, or a limited number of extraction wells in areas of deep alluvium, would be used to remove mine-affected alluvial groundwater upgradient of the perennial seeps and springs and in downgradient locations on the eastern and western sides of the Site. Extraction wells would be used to remove groundwater from the Wells Formation. The extracted groundwater would be treated to remove selenium and other contaminants using a physical, chemical, or biological treatment system (for the Wells Formation either alone or in combination with alluvial water). Water from the Wells Formation would be returned to the Wells Formation through engineered infiltration wells following treatment. Water from the alluvial aquifer would be discharged to a constructed basin and allowed to infiltrate back into the alluvial aquifer following treatment. Implementation and enforcement of ICs will prevent human exposure to contaminated groundwater until RAOs are achieved.

The schedule and costs associated with GW 5b are summarized in Table 9-12. The expected outcomes for GW 5b are as follows:

- It is expected that RAOs would be attained at RA completion (10+ years after construction of the cover system).
- Extracting and treating contaminated groundwater will accelerate progress toward meeting RAOs, compared to GW 2.
- Implementation and enforcement of ICs will prevent human exposure to contaminated groundwater until RAOs are achieved.

Table 9-12. GW 5b, Estimated Cost and Construction Timeframe
Ballard Mine Site, Caribou County, Idaho

Estimated Cost/Time	
Capital Costs	$15,271,969
Institutional Control Costs	$100,000
Total O&M Costs (30 years)	$8,631,241
Total Periodic Costs (30 years)	$215,770
Total Present Value Costs	$24,219,000
Construction Timeframe	5 to 10 years (constructed concurrent with cover)
Time to Achieve RAOs	10+ years after cover construction

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Section 10 – Comparative Analysis of Alternatives

This section summarizes the comparative analysis of alternatives that was presented in the FS. The Superfund regulations require that alternatives be evaluated using the nine criteria presented here, which are organized into three groups: Threshold Criteria, Primary Balancing Criteria, and Modifying Criteria.

- **Threshold Criteria (2) –** The two threshold criteria must be satisfied by any alternative to be eligible for selection:
  1. **Overall Protection of Human Health and the Environment** evaluates whether an alternative eliminates, reduces, or controls threats to public health and the environment through ICs, engineering controls, or treatment.
  2. **Compliance with ARARs** evaluates whether the alternative meets federal and state environmental statutes, regulations, and other requirements that pertain to the Site, or whether a waiver is justified.
- **Primary Balancing Criteria (5) –** The five balancing criteria are used to make comparisons and to identify tradeoffs among alternatives:
  1. **Long-term Effectiveness and Permanence** considers the ability of an alternative to maintain protection of human health and the environment over time.
  2. **Reduction of Toxicity, Mobility, or Volume of Contaminants through Treatment** evaluates an alternative's use of treatment to reduce the harmful effects of principal contaminants, their ability to move in the environment, and the amount of contamination present.
  3. **Short-term Effectiveness** considers the length of time needed to implement an alternative and the risks the alternative poses to workers, the community, and the environment during implementation.
  4. **Implementability** considers the technical and administrative feasibility of implementing the alternative, including factors such as the relative availability of goods and services.
  5. **Cost** includes estimated capital and annual O&M costs, as well as present value cost. Present value cost is the total cost of an alternative over time in terms of today's dollar value. Cost estimates are expected to be accurate within a range of +50 to -30 percent.
- **Modifying Criteria (2) –**Assessment of modifying criteria is based on public comments on the Proposed Plan, discussions with the state, and consultation with affected Tribes.
  1. **State/Tribal Acceptance** considers whether the state and affected Tribes agree with EPA's analyses and recommendations.
  2. **Community Acceptance** considers whether the local community agrees with EPA's analyses and Preferred Alternative.

Using these criteria, the alternatives that were carried forward following screening were evaluated in detail independently and then compared to identify the relative advantages and disadvantages. This section summarizes the results of this evaluation for each media. A more thorough evaluation of the alternatives in relation to each criterion is provided in the FS report (MWH, 2017a).

10.1 Overall Protection of Human Health and the Environment (Threshold Criterion)

All action alternatives for each medium are expected to be protective of human health and the environment. An alternative is protective if it achieves RAOs though some combination of engineering controls, treatment, and ICs.

As required by the NCP, a No Action Alternative was developed to provide a baseline for comparing other alternatives. The No Action Alternative (Alternative 1 for each medium) would not be protective of human health and the environment. Contaminants in source materials would continue to be released and transported to nearby surface water, groundwater, and sediment and riparian soils. Risks associated with exposure to waste rock and vegetation would remain. RAOs and cleanup levels for various contaminants would not be achieved and the alternative is not discussed further.

This section summarizes the comparative evaluations for medium-specific alternatives.

Upland soil and waste rock alternatives USWR 4, USWR 6, and USWR 7 would be protective of human health and the environment. These alternatives all include a similar remedial strategy consisting of a combination of grading and consolidation of waste materials, construction of an ET cover system over areas where waste rock is left in place, ICs, O&M, and LTM. The primary difference between the alternatives is the amount of grading and consolidation of waste materials and the extent to which open pits are backfilled. In addition, USWR 6 would allow for the possibility of remining phosphate ore during implementation of the remedy.

For each USWR alternative, RAOs would be achieved by isolating the source materials (upland soil, waste rock, and exposed ore beds) under an ET cover system that would prevent direct exposure of people and wildlife to COCs. The cover system would provide clean growth material for vegetation that would address risks associated with ingestion of vegetation that contains elevated levels of selenium. All alternatives would stabilize waste material and reduce the release of COCs from source materials to downgradient groundwater, surface water, and sediment and riparian soil. ICs would be applied to limit future uses of the Site that are incompatible with the remedy and to protect the integrity of the remedy.

Surface water alternatives SW 2 and SW 3 would be protective of human health and the environment. Both alternatives rely on source controls described in the USWR alternatives. Implementation of the USWR alternatives would result in two important effects. First, snowmelt and runoff from the historical mining disturbance would no longer contact source materials. Any surface runoff to nearby intermittent streams will meet RAOs. Second, the cover system would greatly reduce the infiltration of precipitation through waste rock, which over time will reduce or eliminate the flow of springs and seeps near the waste rock dumps and the concentration of COCs in remaining seeps and springs. Both alternatives include ICs and fencing to limit access until the cover system becomes fully effective and RAOs are achieved. The key difference between the two SW alternatives is that SW 3 also includes the capture and treatment of residual seepage prior to discharge into downstream intermittent drainages using constructed in situ biological treatment cells. Therefore, SW 3 is more effective in the short term than SW 2, which relies on ICs and source controls to achieve RAOs.

Stream channel sediment and riparian soil alternatives S/RS 3 and S/RS 4 would be protective of human health and the environment. Both alternatives rely on source control measures described in the USWR alternatives to minimize the delivery of contaminated particles to downgradient intermittent streams and riparian areas.

S/RS 3 includes sediment traps and basins, MNR, and ICs. Sediment traps and settling basins would be constructed to capture sediment leaving the Site during construction of the soil cover. Once the source of contamination is controlled, MNR is the mechanism for further reducing contamination to protective levels. A monitoring program will be established to track progress. ICs will be applied to limit access to impacted areas until cleanup levels are achieved. An adaptive management plan will provide a structured process for making management decisions to improve remedy performance.

S/RS 4 includes excavations and removal of contaminated sediment and riparian soil from most contaminated reaches of the intermittent and ephemeral drainages. The contaminated material would be disposed of under a designated portion of the cover system. While both alternatives are expected to achieve RAOs, S/RS 4 would destroy ecological functions and values during construction, and there is uncertainty regarding the recovery of ecological values in excavated areas.

Groundwater alternatives GW 2, GW 3, and GW 5b would be protective of human health and the environment over time. All three rely on the cover system described in the USWR alternatives to reduce the concentration of contaminants in groundwater.

GW 2 includes MNA and ICs. Once the release and transport of COCs from the source areas are controlled by the cover system, MNA will further reduce concentration of contaminants over time.

GW 3 includes the elements of GW 2 and also includes use of PRBs to treat shallow alluvial groundwater along selected flow paths. If low levels of contamination remain following treatment by PRBs, MNA would be used as a polishing step to further reduce the concentration of contaminants. Under this approach, RAOs in shallow groundwater would be achieved sooner than GW 2.

GW 5b includes extraction and treatment of groundwater from the alluvial and Wells Formation aquifers. This approach is expected to meet RAOs by removing contaminants from areas of impacted groundwater. A number of technical factors (such as the influence of geologic structures on groundwater flow direction) introduce some uncertainty into the effectiveness of this approach. Both GW 3 and GW 5b include treatment of contaminated groundwater and would meet RAOs more quickly than GW 2.

ICs would be applied to restrict well drilling and use of groundwater in impacted areas until cleanup levels are achieved. An adaptive management plan would be developed to provide a structured process for evaluating progress and making defensible management decisions to improve overall remedy performance.

10.2 ARARs (Threshold Criterion)

All action alternatives for each medium will attain ARARs under federal environmental laws and state environmental or facility-siting laws. Key ARARs that drove development of alternatives are summarized in this section. A complete list of ARARs and a discussion of how the alternatives would comply is presented in Appendix B.

Key ARARs at the Ballard Mine include the following:

- Idaho Water Quality Standards, including surface water quality criteria
- National Recommended Water Quality Criteria, established under the CWA
- National Primary Drinking Water Regulations, including MCLs, established under the Safe Drinking Water Act
- Idaho Ground Water Quality Rule, which provides minimum requirements for the protection of groundwater quality
- Regulations established under the Mineral Leasing Act that control the development and reclamation of phosphate mines
- Regulations under the Idaho Surface Mine Reclamation Act pertaining to reclamation of surface mining operations
- CWA Section 404 and implementing regulations, which regulate actions that discharge fill material into waters of the United States, including wetlands

Chemical-specific ARARs that strongly influenced the development of alternatives included the state and federal water quality criteria for surface waters and MCLs for groundwater. Cleanup levels for these media are based on these ARARs. All SW and GW alternatives are expected to comply with key ARARs. Achieving ARARs for groundwater and surface water are the action-driving requirements of the remedy and led to development of the source controls described in the USWR alternatives, as well as the SW and GW alternatives.

Action-specific ARARs that influenced the development of alternatives included state and federal mining and reclamation requirements. These ARARs establish performance requirements for the remediated areas, including the source areas to ensure the effectiveness and integrity of the cleanup actions. In general, all USWR and S/RS alternatives are expected to comply with key ARARs. For S/RS alternatives, ARARs will more readily be achieved by S/RS 3, which relies on MNR to remedy impacted reaches (rather than S/RS 4, which includes excavation and reconstruction of impacted reaches). S/RS 3 also complies with Section 404 of the CWA, which requires consideration of impacts to wetlands and waters of the United States and evaluation of opportunities to avoid and minimize impacts.

10.3 Long-term Effectiveness and Permanence (Balancing Criterion)

Upland soil and waste rock alternatives USWR 4, USWR 6, and USWR 7 are similar with respect to long-term effectiveness and permanence. They all include excavation, consolidation, or grading, followed by construction of a cover system to meet RAOs. All use ET covers constructed with locally sourced natural materials and are expected to be durable over the long term. There are differences in the amount of earthworks between the alternatives but these differences do not affect the expected long-term effectiveness and permanence. These differences include the extent to which waste rock is consolidated and mine pits backfilled. The exterior boundaries of the cover system are similar under all alternatives, but the cover system under USWR 6 would be more contiguous within the boundaries of the mining disturbance. In addition, there are differences between the alternatives in the final landforms created through excavation and backfilling. USWR 6 and USWR 7 would be more mounded and prominent than USWR 4. All alternatives are expected to function effectively and be resilient under various climate change scenarios.

USWR 6 anticipates the possibility of remining of phosphate ore during RA, while USWR 4 and USWR 7 do not. Removal of some near-surface ore removes source material containing contaminants and would generate additional waste rock that may be used for backfilling of mine pits or construction of portions of the cover system. With respect to long-term effectiveness and permanence, these are minor considerations. All candidate alternatives rank similarly highly with respect to long-term effectiveness and permanence.

Surface water alternatives SW 2 and SW 3 rank similarly highly with respect to long-term effectiveness and permanence. They both rely on source controls described in the USWR alternatives to reduce the release and transport of contaminants in runoff and seepage to surface water. SW 3 would be effective as soon as the cover system (under USWR alternatives) and wetland treatment cells are constructed and operational and would continue to be effective in the long term. The wetland treatment cells may be phased out once the cover system is effective. Alternative 2 is effective in the long term but relies on the cover system to control release of contaminants to surface water (in runoff and seepage) and ICs in the short term to prevent human exposure.

Sediment and riparian soil alternatives S/RS 3 and S/RS 4 offer different remedial strategies that carry advantages and disadvantages with respect to this criterion. S/RS 3 would rely on MNR combined with sediment basins constructed in the upper reaches of the mine-affected drainages to capture sediment entrained in runoff. S/RS 4 relies on excavation of contaminated sediment and riparian soils from the areas close to the mine dumps and MNR for reaches further from the Site. Both include implementation of ICs. Both alternatives also rely on source controls described in the USWR alternatives to reduce the release and transport of contaminants that may accumulate in sediment in downstream waterbodies. Over the long term, these alternatives both rank highly for this criterion, although excavation under S/RS 4 introduces uncertainty over recovery of ecological functions and values in the area that would be excavated.

Groundwater alternatives GW 2, GW 3, and GW 5b rely heavily on the cover system previously described under the USWR alternatives. With source controls in place, and once RAOs are achieved, all alternatives should be effective in maintaining protection over time. The GW alternatives include elements to more quickly achieve and maintain RAOs. GW 2 includes ICs and MNA to maintain protectiveness over time. GW 3 and GW 5b include treatment to reduce the concentration of contaminants in a relatively short timeframe, and these treatment elements would remain in place as long as necessary to maintain protectiveness. GW 3 also includes MNA which may be used as a polishing step, if necessary, to achieve and maintain protectiveness. Overall, GW 3 and GW 5b rank more highly than GW 2 with respect to this criterion.

10.4 Reduction of Toxicity, Mobility or Volume of Contaminants through Treatment (Balancing Criterion)

Upland soil and waste rock alternatives USWR 4, USWR 6, and USWR 7 reduce contaminant mobility in a similar way by isolating source material under a cover system to prevent direct contact and reduce potential for migration of contaminants from source areas. None of the USWR alternatives, however, reduce toxicity or volume of contamination through treatment. Therefore, all rank similarly with respect to this criterion.

S**urface water** alternative SW 3 ranks higher than SW 2 with respect to this criterion. Under SW 3, discharges from seeps and springs would be collected and treated using constructed wetlands. Treatment would be implemented at various locations until seeps or springs diminish in flow and cleanup levels are met. Treatment media would be replaced as needed and disposed of onsite under the USWR cover system. SW 2 ranks low because it does not actively reduce toxicity, mobility, or volume of contaminants through treatment.

For **sediment and riparian soil,** neither of the alternatives include treatment. S/RS 4 would, however, result in the greatest reduction in volume and mobility of contamination because some contaminated sediment is removed through excavation, reducing the contaminants available for remobilization.

Groundwater alternative GW 5b includes extraction and treatment of mine-affected groundwater in the shallow alluvial aquifer and the deeper regional aquifer. GW 3 treats shallow alluvial groundwater by installing PRBs along selected flow paths near the source areas. GW 2 doesn’t actively treat groundwater. Overall, GW 5b ranks most highly with respect to this criterion.

10.5 Short-term Effectiveness (Balancing Criterion)

Upland soil and waste rock alternatives USWR 4, USWR 6, and USWR 7 all involve extensive earthworks to implement. The differences in the extent of earthworks are reflected in the amount of time needed to complete construction of the alternative and achieve RAOs. USWR 4 would achieve RAOs in 3 to 5 years, USWR 6 in 6 to 8 years, and USWR 7 in 5 to 7 years.

All alternatives would use similar construction and worker protection practices and protocols to protect the community and workers during implementation of the remedy. Earthworks associated with all alternatives, including excavation, hauling, and grading of mine materials, introduce short-term risks for construction workers, which would be mitigated with safety measures, including personal protective gear and appropriate training. These short-term risks will be mitigated through measures including dust suppression, use of green-remediation practices, and carefully controlled access to haul routes near the Site.

In addition, transport of ore under USWR 6, which assumes potential remining concurrent with remedy implementation, from the Site to P4's processing facility near Soda Springs creates short-term risks for workers, the community, and the environment. These risks are not specific to the cleanup of the Site, mitigation measures are already in place for the haul road, with oversight from other agencies.

In summary, short-term effectiveness is similar among the alternatives, although USWR 6 would take slightly longer to implement and additional care would be necessary when transporting ore to the processing facility.

Surface Water alternative SW 2 is not as effective in the short-term as SW 3, because it relies on ICs (and the cover system in the USWR alternatives) and does not include treatment of seepage. SW 3 includes treatment of seepage to remove contaminants and is expected to be effective in the short term. Under SW 3, significant improvement in surface water quality is expected within a year of constructing the wetland treatment cells. The time needed to fully attain RAOs is uncertain and depends on cover system effectiveness, taking 5 to 10 years following construction for both alternatives.

Risks to the community and workers during implementation of the remedy are limited and would be mitigated by implementation of a health and safety plan and restrictions on access.

Sediment and riparian soil alternative S/RS 3 (which relies on sediment traps and MNR) has a shorter construction time than S/RS 4 (which involves excavation of some sediment and riparian soil). In the short term, risks to workers and the community are greater for S/RS 4. These risks, however, would be mitigated by implementation of a worker health and safety plan and access controls. In the short term, risks to the environment are lower for S/RS 4 because contaminants are removed from impacted stream reaches rather than relying on MNR. Implementation of S/RS 4, however, would harm ecological functions and values in the short term in the reaches of intermittent streams that are excavated. These corridors would need to be reconstructed, introducing uncertainty about the length of time needed to recover ecological functions and values. The time needed to achieve RAOs under S/RS 4 is estimated to be 10 years following construction. For S/RS 3, there is considerable uncertainty, but it is anticipated to take 10 or more years to achieve RAOs. Overall, S/RS 3 ranks more highly than S/RS 4 with respect to this criterion.

For **groundwater**, all the alternatives depend on source controls described in the USWR alternatives and would require many years to achieve cleanup levels. GW 5b and GW 3 include removal of contaminants through treatment in the short term, and thus are likely to reduce the concentration of contaminants in groundwater plumes and achieve RAOs more quickly than GW 2. The timeframe necessary to achieve RAOs is uncertain and depends on implementation and performance of source controls and treatment. All are expected to take 10 years or more to achieve RAOs following construction of the cover system. The construction of treatment elements of GW 3 and GW 5b would involve use of heavy equipment and would introduce short-term risks to workers. GW 5b also has the largest environmental footprint because of the scope of construction activities. Transport of construction equipment and materials on county roads also introduces a minor risk to the community. Overall, GW 3 ranks most highly with respect to this criterion.

10.6 Implementability (Balancing Criterion)

All **upland soil and waste rock** alternatives include extensive but varying degrees of earthworks. USWR 4 is easier to construct than USWR 6 and USWR 7 because of less extensive earthworks. All alternatives use technologies that are demonstrated to be reliable and would use equipment and expertise that are locally available. USWR 6 has greater administrative complexity than USWR 4 and

USWR 7 because of the approvals and coordination associated with potential remining. Overall, USWR 4 ranks more highly than USWR 6 and USWR 7 with respect to this criterion.

Surface water alternative SW 2 is easier to implement than SW 3 because it relies on ICs and does not include any construction. SW 3 involves the strategic placement and construction of wetland treatment cells in addition to ICs. SW 3 also requires substantive compliance with ARARs, including CWA Section 404, as construction work may occur in or near wetlands. In addition, SW 3 requires specialized expertise to design the wetland treatment cells. Overall, SW 2 ranks more highly than SW 3 with respect to this criterion.

Sediment and riparian soil alternative S/RS 3 would be easier to implement than S/RS 4, as it only includes construction of sediment basins and implementation of ICs and MNR. S/RS 4 would be more difficult to implement because, in addition to ICs and MNR (in the lower, less-contaminated reaches), it includes excavation of contaminated material, confirmation sampling, onsite disposal under the USWR cover system, and restoration of the stream reaches where excavation occurred. The services, materials, and equipment necessary for implementation of S/RS 3 and S/RS 4 are available regionally and are not a distinguishing factor. Overall, S/RS 3 ranks more highly than S/RS 4 with respect to this criterion.

Groundwater alternative GW 2 (MNA and ICs) ranks most highly with respect to technical feasibility because no construction or O&M are required. GW 3 (PRBs, MNA, and ICs) and GW 5b (pump and treat) follow, respectively, with construction, O&M, and additional infrastructure needs.

Technical feasibility challenges associated with GW 3 and GW 5b are installing the treatment cells, extraction wells, and treatment equipment specific to each reclamation alternative. These alternatives are considered equivalent with respect to technical implementability and rank below GW 2.

Spent reactive barrier media generated by groundwater movement through the PRB may need to be stabilized or treated prior to placement in an onsite repository. Wastes associated with treatment by membrane technology would also require disposal in an approved manner. GW 2, with no sludge or waste disposal, would rank higher than GW 3 and GW 5b.

Most of the services and materials associated with the implementation of each of the GW alternatives would be available regionally. However, specialized drilling services and treatment equipment and dedicated facility required by GW 5b would be more difficult to obtain than the other equipment associated with implementation of GW 3; therefore, GW 5b is ranked below GW 3 in availability of services and materials.

10.7 Cost (Balancing Criterion)

Cost represents the balancing criteria that most clearly differentiates the alternatives. The present value costs for all alternatives were evaluated over a 30-year period (0 to 29 years).

Upland soil and waste rock alternative USWR 4 is estimated to cost $51 million, USWR 6 is estimated to cost $36.9 million, and USWR 7 is estimated to cost $113 million. These costs reflect the relative amount and cost of earthworks associated with each alternative. The cost of USWR 6 is lower because earthworks associated with possible remining would involve waste consolidation and pit backfilling and reduce cost associated with remediation. Therefore, USWR 6 ranks most highly with respect to this criterion.

Surface water alternative SW 2 is estimated to cost $850,000 and SW 3 is estimated to cost $1.4 million. Both include similar costs for implementation of ICs, but SW 3 also includes design, construction and operation of wetland treatment cells. Therefore, SW 2 ranks slightly more highly than SW 3 with respect to this criterion.

Sediment and riparian soil alternative S/RS 3 (MNR focused) is estimated to cost $736,000 and S/RS 4 (excavation and MNR) is estimated to cost $1.59 million. Therefore, S/RS 3 ranks slightly more highly with respect to this criterion.

Groundwater alternative 2 (MNA and ICs) is estimated to cost $1.4 million, GW 3 (treatment of shallow groundwater using PRBs) is estimated to cost $2.1 million, and GW 5b (groundwater extraction and treatment) is estimated to cost $24 million. GW 3 requires more construction than GW 2, but is in the same general range. GW 5b would likely achieve RAOs more quickly, but at a much higher cost. GW 2 and GW 3 rank more highly than GW 5b with respect to this criterion.

10.8 State Acceptance (Modifying Criterion)

The Idaho DEQ has been an active participant and has been fully engaged throughout the RI and FS process and development of the Proposed Plan. Idaho, through DEQ, concurs with the Selected Remedy in this ROD. A copy of the concurrence letter is included as Appendix C.

In addition to state acceptance through DEQ, information on tribal engagement is presented in Section 3.2.

10.9 Community Acceptance (Modifying Criterion)

EPA issued a Proposed Plan for the Ballard Mine Site on April 2, 2018, and accepted comments during a public comment period that ran from April 2 to May 1, 2018. During the formal comment period, comments were received from three individuals and one organization.

The comments received covered a range of topics. Some commenters expressed preferences among the alternatives and provided opinions about the importance of recovering the remaining phosphate resources during implementation. Commenters also expressed concerns about the Superfund cleanup process, adequacy of outreach to stakeholders during the process, and risks posed by current conditions. One organization stated concerns about various elements of the Preferred Alternative and provided recommendations to address concerns. No significant changes were made to the Preferred Alternative in response to the comments.

Part 3 of this ROD, the Responsiveness Summary, presents the comments submitted and EPA's responses. In addition, the original comments and a transcript of the public meeting are available in the Administrative Record for the Site.

Section 11 – Principal Threat Wastes

The NCP establishes an expectation that EPA will use treatment to address principal threats posed by a site wherever practicable (NCP at 40 *Code of Federal Regulations* [CFR] § 300.430(a)(1)(iii)(A)). Principal threat waste is defined in EPA guidance as source materials that are highly toxic or highly mobile that generally cannot be contained in a reliable manner or would present a significant risk to human health or the environment should exposure occur. Conversely, non-principal threat wastes are those source materials that generally can be reliably contained and that would present only a low risk in the event of exposure.

A source material is one that includes or contains hazardous substances, pollutants, or contaminants that act as a reservoir for migration of contamination to groundwater, surface water, or air, or acts as a source for direct exposure. At the Ballard Mine Site, source materials consist primarily of waste rock of various lithologies located in mine dumps and backfilled pits. These source materials contain contaminants that can be released to groundwater and surface water and are a source for direct exposure.

Source materials present at the Ballard Mine Site are not principal threat wastes, as follows:

- Source materials are not highly toxic, considering current and reasonably anticipated future land uses.
  - For non-radiological contaminants, cumulative ILCR and noncancer HI estimates for the Native American exposure scenario are 1×10^{-3} and 150, respectively. Cumulative ILCR and noncancer HI estimates for a seasonal rancher are 2×10^{-4} and 36, respectively, and risks for a recreational hunter and camper/hiker are less than the EPA risk range. Cancer risks are driven by arsenic in soil (incidental chronic ingestion, uptake into vegetation and uptake into beef [consumed by rancher]) and sediment (uptake into vegetation). Background concentrations account for much of the cumulative ILCR. For example, concentrations of arsenic in upland soil used for Site and background risk estimates were 21.8 and 15.6 mg/kg, respectively.
  - For radiological contaminants, Native American, seasonal rancher, recreational hunter, and recreational camper/hiker had risk estimates greater than the EPA acceptable risk range at 1×10^{-2}, 5×10^{-4}, 2×10^{-4} and 1×10^{-4}, respectively. The primary radiological risk driver was radium-226. However, because of naturally elevated levels of uranium in soil in background reference areas, the estimated Site risk was found to be only marginally different from background risk.
- Source materials present at the Site are not highly mobile.
  - Contaminants present at the Site are inorganics that are generally bound as part of mineral assemblages in waste rock and are only mobile when exposed to air and water.
- Source materials present at the Site can be reliably contained.
  - Waste rock can be reliably contained by using engineering controls (grading, shaping, and construction of a cover system) to prevent direct exposure and minimize release of contaminants to other media.

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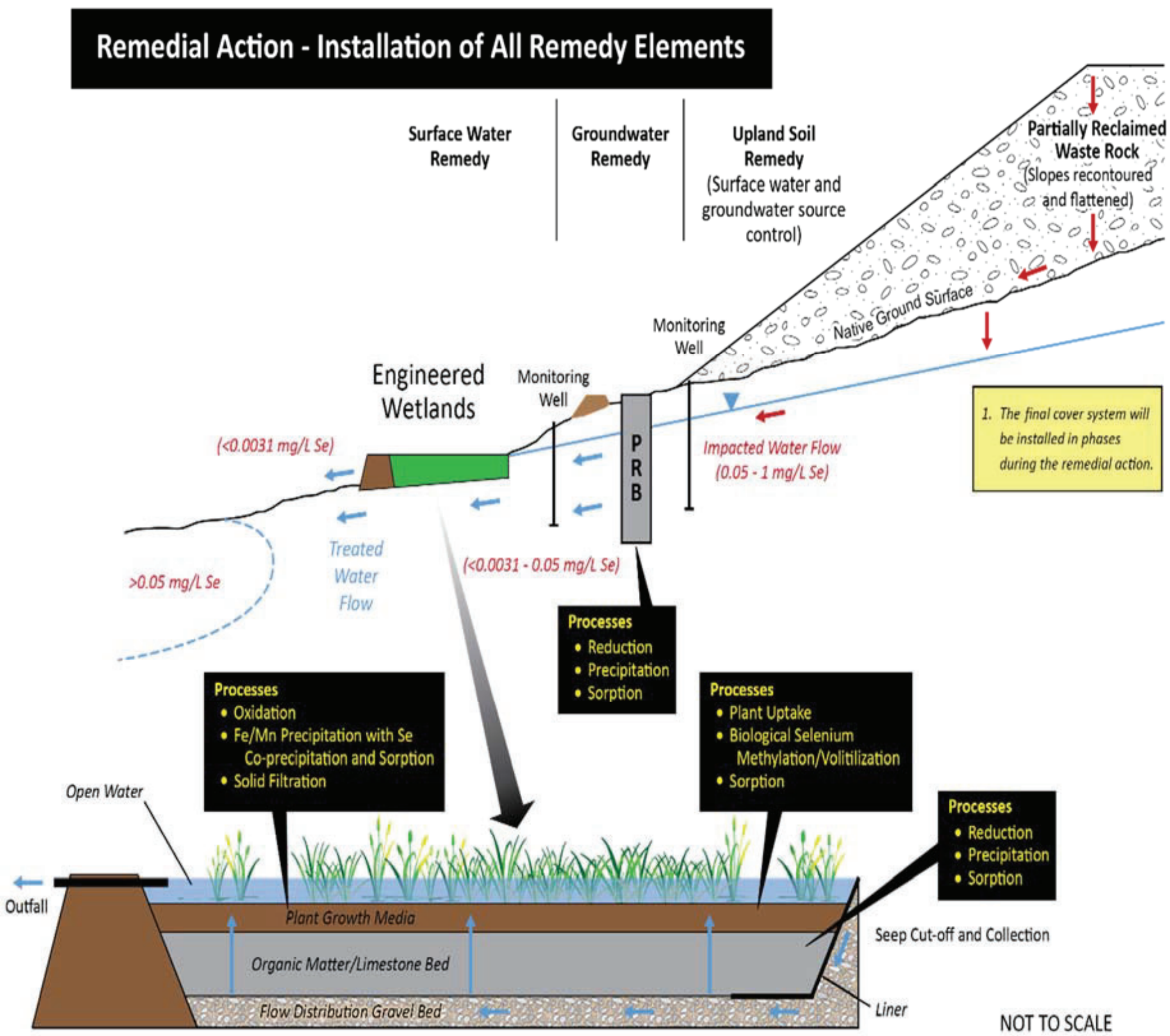
Section 12 – Selected Remedy

This section describes the Selected Remedy for OU1 of the Ballard Site. Included is a summary of the rationale for the Selected Remedy, a description of the key components and outcomes expected to be achieved, and a summary of the estimated remedy costs.

The Selected Remedy for the Site is a combination of medium-specific components and the elements common to all alternatives. The selected medium-specific components are USWR 6 (Grading and Consolidation, Possibility of Incidental Ore Recovery, Evapotranspiration Cover System, Institutional Controls, and Operations and Maintenance/Long-term Monitoring), SW 3 (In Situ Biological [Wetlands] Treatment of Source Area Seepage), S/RS 3 (Sediment Traps/Basins, Monitored Natural Recovery, and Institutional Controls), and GW 3 (Limited Permeable Reactive Barrier Treatment of Alluvial Groundwater, Monitored Natural Attenuation, and Institutional Controls). The other selected elements are ICs, O&M, LTM, and adaptive management planning. The relationship between the elements of the combined remedy are illustrated in conceptual cross sections shown on Figures 12-1 and 12-2.

Figure 12-1. Conceptual Cross Section of Key Elements of the Selected Remedy during the Construction Phase

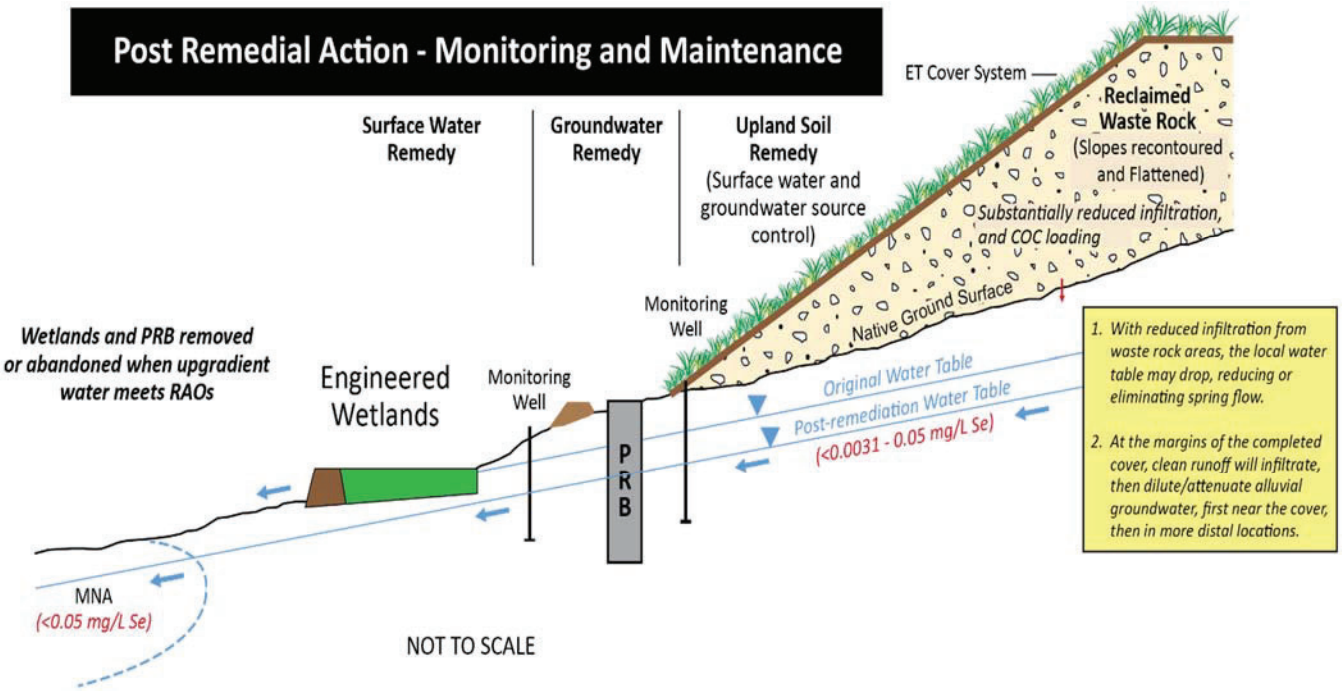


Note: Water quality concentrations are projected values to convey the cleanup concept.

The medium-specific alternatives of the Selected Remedy are described in more detail in the FS report (MWH, 2017). The Selected Remedy mirrors the Preferred Alternative, with minor modification and clarifications, and did not change in response to public comment or new information.

Implementation of the Selected Remedy will achieve the RAOs and cleanup levels listed in Section 8, return useable groundwater to beneficial uses within a reasonable timeframe, and restore the environmental media in the area to levels that are compatible with reasonably anticipated future land uses: recreation, seasonal ranching, and tribal hunting and gathering. It will also address ecological risks. Sections 7, 8 and 9 of this ROD contain additional information about the Selected Remedy, including RAOs for each media for current and potential future land uses, methods and approaches and timeframe to achieve RAOs, expected outcomes, and risk associated with the cleanup levels.

Figure 12-2. Conceptual Cross Section of Key Elements of the Selected Remedy after the Construction Phase



Note: Water quality concentrations are projected values to convey the cleanup concept.

12.1 Rationale for the Selected Remedy

The Selected Remedy achieves the threshold criteria and provides the best balance of tradeoffs with respect to the balancing and modifying criteria. The Selected Remedy is a comprehensive cleanup of the Site that will protect human health and the environment and that complies with ARARs (described more fully in Section 13.2). It has long-term effectiveness and permanence because it reliably consolidates and contains source materials (primarily waste rock) under a robust ET cover. The cover will be designed to eliminate direct exposure to source materials and minimize contact between waste rock and infiltrating surface water. The Selected Remedy is feasible and implementable, does not require offsite transport and disposal of waste rock, and has long-term cost effectiveness. Consolidation and covering of waste rock are remedial actions selected and applied at other area phosphate mines similar to the Site. The Selected Remedy includes requirements for ICs, monitoring (visual inspections), access controls, and maintenance of the cover to prevent exposure of source materials and maintain protectiveness. EPA will formally review the protectiveness of the remedy at least every 5 years after the remedy has been initiated.

The following key factors led to selection of this remedy:

- The selected upland soil and waste rock cover alternative (USWR 6) provides a similar level of protectiveness compared to the other two alternatives (USWR 4 and USWR 7), but costs significantly less. A significant portion of the cost of all earthworks (excavation, consolidation, backfilling, grading tasks) is attributed to the potential ore recovery, which reduces the scope and cost of remaining earthworks associated with implementation of the remedy.
- The selected surface water alternative collects and treats contaminated seepage near the dumps during remedial construction and in the post-construction period. In the longer term, seeps and springs are expected to dry up or reduce in flow in response to source controls. In the short-term, the concentration of contaminants is reduced quickly and the timeframe needed to achieve cleanup levels is shortened relative to alternatives without treatment.
- The selected surface water alternative uses wetland cells to treat contaminated seeps and springs, increasing the reliability of the remedy in meeting RAOs compared to use of MNA (in conjunction with source controls).
- The selected sediment and riparian soil alternative focuses on sediment-control BMPs (sediment traps and basins adjacent to the source areas) and MNR and avoids extensive excavation in the corridors around the intermittent streams near the Site. It is uncertain whether ecological function and values could be fully restored in excavated reaches.
- The selected groundwater alternative treats contaminated groundwater using PRBs along alluvial flowpaths near the margins of the Site. Short-term human health exposures during construction are reduced compared to the groundwater pump and treat alternative, and the timeframe to meet PRGs in shallow groundwater is shortened compared to the alternative that relies on MNA and ICs.
- The PRB treatment process will be more adaptable than MNA and pump and treat alternatives to expected changes in flow and contaminant concentrations over time, as the shallow groundwater system responds to upland soil and waste rock source controls. PRBs can be maintained as needed, providing more certainty than the MNA alternative that RAOs will be achieved.
- The Selected Remedy, which relies on a combination of source controls (ET cover), treatment (PRBs and wetlands), MNA, and ICs is expected to restore mining-influenced groundwater to beneficial uses within a reasonable timeframe. Although it is anticipated that RAOs will be achieved more than 10 years after remedial construction, this timeframe is considered reasonable because there are no current users of mine-affected groundwater, and ICs will restrict use of groundwater until cleanup levels are met.

12.2 Description of the Selected Remedy

The following sections describe the Selected Remedy and how the medium-specific elements work together to achieve RAOs. Minor changes to the remedy may occur during RD/RA to adapt the elements of the Selected Remedy to its location and optimize effectiveness. Changes to the RD and RA will remain protective and comply with ARARs.

12.2.1 Waste Rock Consolidation and Engineered Cover System

The RAOs for upland soil and waste rock will be met by consolidation of waste rock into mine pits, regrading of waste rock in the backfilled mine pits and external waste rock dumps, and construction of an ET cover to isolate contaminated source materials. The ET cover system is a key element that will substantially contribute to the success of the other remedial components and to meeting RAOs.

The Selected Remedy recognizes that P4 intends to recover phosphate ore concurrent with implementation of the remedy. Information collected during site characterization activities confirmed that about 4 million tons of phosphate ore remain at the Site, both exposed at the surface and in the bottoms and sidewalls of existing mine pits. The amount of ore P4 intends to recover is an approximation based on currently available information and may change as more information becomes available or economic considerations change. Specific plans for possible remining would be accommodated during the remedial design phase of the project.

Although potential ore recovery is not required as part of the remedy, the Selected Remedy allows for and is compatible with remining concurrent with remedy implementation. The key elements of the design (including the engineered cover system, permeable reactive barriers, wetland treatment cells, and other elements identified in Section 12.2) would be implemented even if plans for remining change – for example, if there is more or less remining performed – although the specifics of the design, implementation schedule or cost may change.

The potential remining activities are expected to generate additional waste rock and overburden material for backfill of mine pits and construction of the evapotranspiration (ET) cover. In addition, the earthworks associated with potential remining (such as excavation and placement of fill, grading and shaping waste dumps, and backfilled pits) will also advance remediation efforts, thereby reducing the costs associated with remediation. No ore processing would occur at the Site. Instead, ore would be transported to P4's existing processing facility about 10 miles away.

In addition, the CERCLA 121(e) permit exemption does not apply to BLM mineral leasing and mine permitting requirements. The CERCLA process cannot authorize ore recovery activities. Thus, for ore to be recovered during implementation of the remedy, P4 would need to acquire a federal mineral lease and seek approval from BLM of a plan for ore recovery. If P4 does not obtain legal authority to remine or if P4 does less (starts and then stops) or more remining than currently anticipated, then the design, implementation schedule and costs of the remedy would change, but the key elements would remain the same. Such changes related to the amount of remining are not anticipated to require changes to the Selected Remedy itself. EPA would integrate RD/RA activities with concurrent remining through coordination with P4 and BLM.

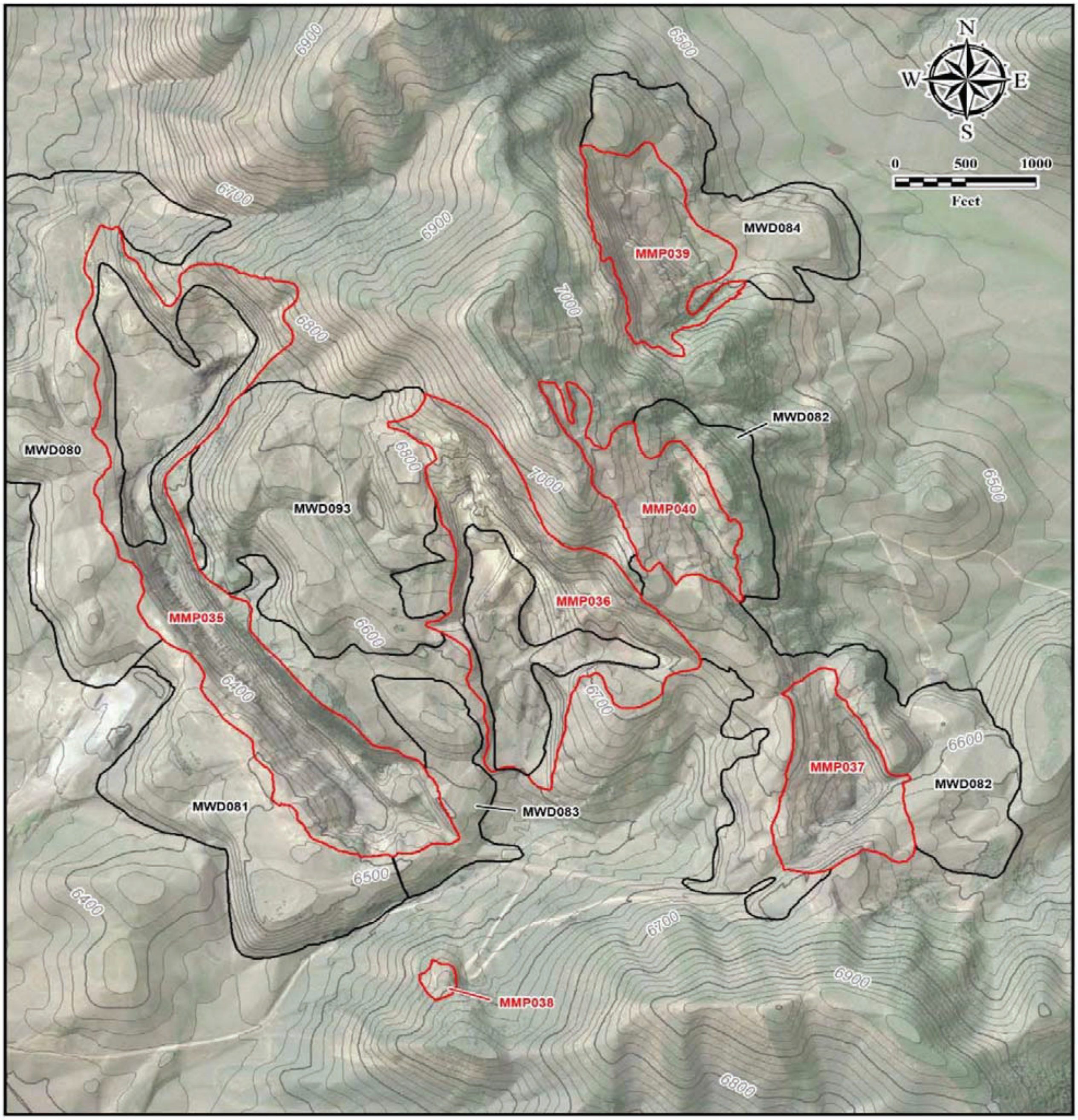
Key features of this element of the Selected Remedy include:

- During remedial construction, waste rock dumps will be partially excavated, transported, and placed into mine pits to cover exposed ore beds and shale units of the Phosphoria Formation. Waste rock dumps and backfilled pits will be graded and shaped to ensure geotechnical stability, typically to a 3:1 slope or less, and to promote runoff away from potential source areas. Grading plans developed during remedial design will minimize expansion of the exterior boundaries of existing disturbance. Remedial construction activities will be sequenced so that excavated and regraded waste rock will be covered soon after grading to limit environmental exposures of fresh waste rock surfaces. Figure 12-3 presents the existing mine features prior to remediation.

- An ET cover system, approximately 5 to 6 feet thick, will be constructed over all areas of the Site where waste rock is present. This cover system is expected to cover more than 500 acres of the Site. In concert with the grading plan, the ET cover will be designed and constructed to cover and isolate all waste rock, establish drainage and minimize infiltration into waste rock, and promote clean runoff without causing erosion.

- To the degree possible, the ET cover will be constructed concurrently as the waste rock is placed and final grading is completed. The anticipated footprint of the cover is presented on Figure 12-4. In addition to covering all source materials in the backfilled mine pits and the external dumps, the cover will also extend over areas where original waste rock dumps were excavated for placement into pits, to prevent exposure of contaminated soils.

Figure 12-3. Existing Conditions prior to Remediation



Approximate mine pit location as shown in FS Memo No. 1

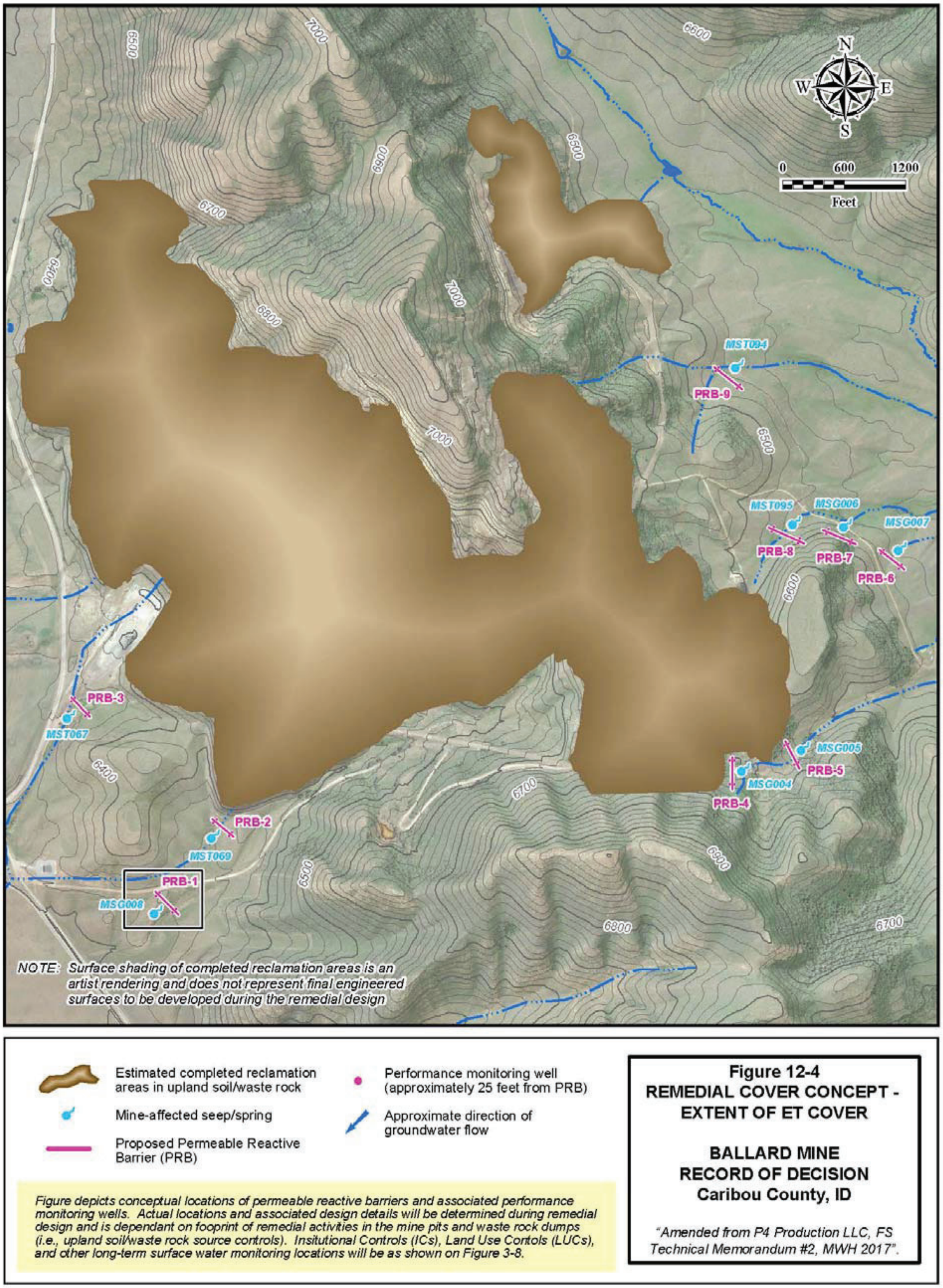
Approximate waste rock dump location as shown in FS Memo No. 1

Figure 12-3
EXISTING CONDITIONS PRIOR TO REMEDIATION

BALLARD MINE
RECORD OF DECISION
Caribou County, ID

"Amended from P4 Production LLC, FS Technical Memorandum #2, MWH 2017".

Figure 12-4. Remedial Cover Concept – Extent of ET Cover



- The ET cover system will be comprised of two layers. A layer of coarse unimpacted material (such as chert) will be placed above the regraded waste rock surface to serve as a capillary break (approximately 1 foot thick). Above the capillary break layer, an approximately 5-foot-thick layer of medium-textured alluvium will be placed. The cover material will be designed to store water during wet periods and release water back to the atmosphere via evapotranspiration during dry periods. The cover will be constructed of material of suitable quality to sustain and perpetuate healthy vegetation, to accommodate the rooting depth of native plants without intercepting waste rock. The final configuration and dimensions of the cover as well as material properties and thicknesses will be refined during remedial design.
- The cover system will be designed to achieve RAOs by eliminating direct contact with waste rock by human and ecological receptors and minimizing the migration of selenium, arsenic, and cadmium from waste rock and upland soils to groundwater and surface water. During remedial design, cover system details will be refined and infiltration models will be validated using data on performance of engineered cover systems from nearby sites. The design of the cover system (and other elements of the remedy) will be optimized to the extent practicable. Performance of the cover system will be evaluated by inspections, spring and seep surveys, instrumentation, and by comparing concentration of contaminants in downgradient surface water and groundwater monitoring stations with cleanup levels. Fill material for the various construction phases will be imported from the borrow areas used to construct the cover or from borrow sources exposed or waste rock produced during potential ore recovery. This work could be accomplished at any point during the remediation process. Final ET cover design and geometry will be optimized during remedial design to shed runoff and blend into the surrounding natural topography. O&M requirements will be defined and applied and ICs and LUCs will be implemented to restrict access and protect human health and the environment.
- Native seed mixes and vegetation types will be selected to form an extensive root system to penetrate the majority of the vertical cover profile (without intercepting waste rock), slow the flow of stormwater and snowmelt runoff, limit erosion, and transpire water that infiltrates the cover. Frequent and consistent LTM will be performed to inspect the cover for plants incompatible with the cover system (i.e., deep rooted species and selenium accumulators such as Asters).
- Remedial action will be implemented using a phased construction approach, with the actual number and sequence of construction phases refined during remedial design to optimize implementation. However, any modifications would not fundamentally change the remedy components or ability to achieve remedial objectives. For this ROD, remedial construction is assumed to occur in three phases, consistent with the concept presented in the Proposed Plan. The conceptual RA presented is based on current information regarding the location and volume of cover materials (and potential ore deposits) (MWH, 2017a). Existing mine features (dumps and pits) are indicated on Figure 12-3. As explained in Section 9.3.2, remining is not a required part of the Selected Remedy. Rather, the remedy assumes that P4 will recover phosphate ore concurrent with implementation of the remedy. Plans for remining will be accommodated during the remedial design stage. As with remedial construction, remining will be sequenced and completed in phases.

12.2.2 Permeable Reactive Barriers

Use of PRBs is one element of an overall approach for meeting groundwater RAOs. PRBs will be installed downgradient of the source areas, near the margins of the waste rock dumps, to intercept and treat contaminated, shallow alluvial groundwater to reduce selenium and COC concentrations to less than cleanup levels. The PRBs will be sited upgradient of select perennial seeps and springs. PRBs are trenches filled with reactive media selected to treat specific target contaminants in groundwater, in this case via reduction and precipitation. The approximate number and locations of PRBs are illustrated on Figure 12-5.

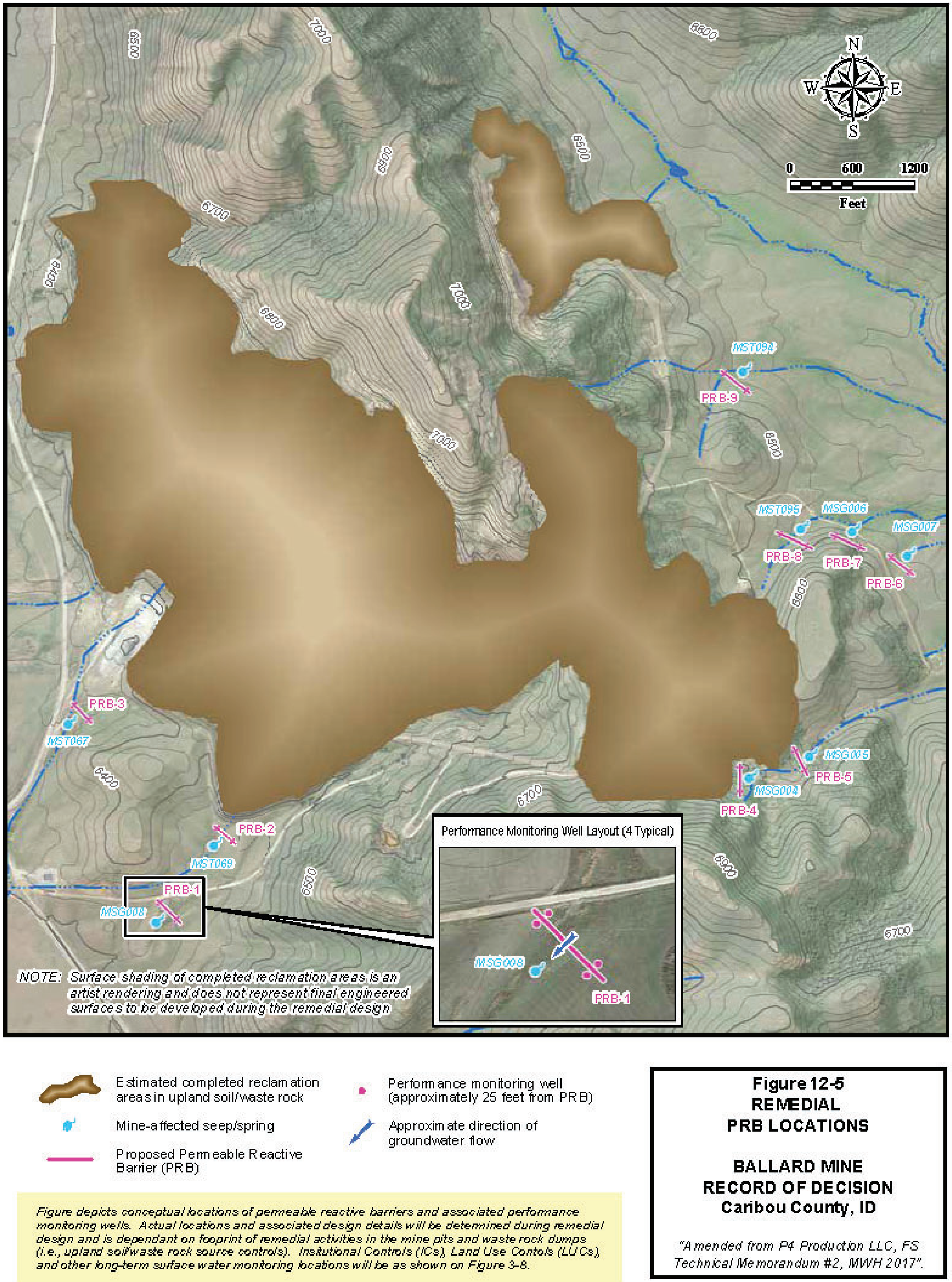
The actual geometry and composition of each PRB will be determined by the results of RD treatability studies along with other directly applicable research involving similar COCs from local phosphate mines, to optimize treatment effectiveness. Each PRB will be designed for its unique location. In some cases, where the affected alluvial groundwater is excessively deep, extraction wells may supplement the system and discharge to the PRB.

Each PRB will comprise a trench filled with reactive media that is designed to intercept and treat shallow alluvial groundwater. Treatability testing will determine an appropriate reactive media mix for Site COCs (e.g., organic materials, sand and limestone, iron filings, or other media combinations). The selected medium will have permeabilities appropriate for the hydraulic conductivities of surrounding materials and adequate retention times to treat the target contaminants to cleanup levels.

Performance of the PRBs will be assessed using monitoring wells located up- and downgradient of the PRBs and at downgradient springs and seeps where groundwater discharges. If contaminant concentrations in groundwater are not reduced to cleanup levels by the PRBs, an adaptive management strategy will guide decisions on follow-up actions, which may include revisions to the PRBs. MNA will be used as a polishing step to further reduce concentrations of contaminants in distal portions of alluvial aquifers (see Section 12.2.4).

Decision rules for determining media testing, replacement, disposal procedures, and whether PRBs may be decommissioned in place (after groundwater treatment is complete and meets cleanup levels) will be developed during remedial design. ICs will be implemented to protect the integrity of these remedial elements.

Figure 12-5. Approximate Location of PRBs



12.2.3 Wetland Treatment (Bioreactor) Cells

Wetland treatment cells are one element of an overall approach to attaining RAOs for surface water. The approach includes collection and treatment of contaminated seeps and springs, along with installation of the ET cover. A series of wetland treatment cells will be constructed and operated, on Site margins, to treat contaminated, perennial mine-affected seeps and springs. The approximate number and location of the wetland treatment cells are identified on Figure 12-6. As illustrated on Figure 12-6, flow from other nearby springs and seeps will be captured and conveyed to one of the wetland treatment cells. Likewise, flow from seeps and springs within the footprint of waste rock and upland soil will be captured and conveyed downstream to a wetland treatment cell.

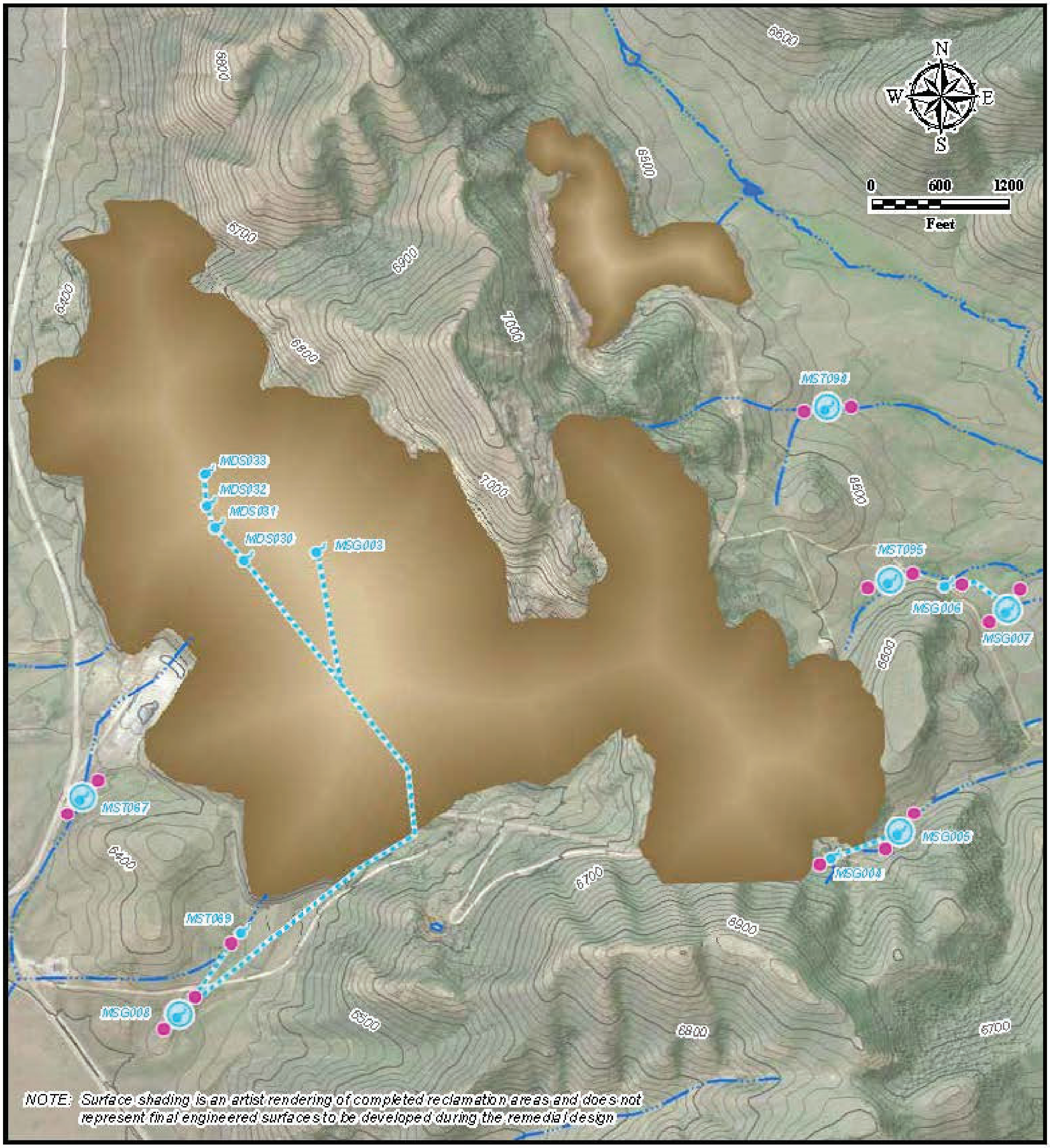
A cross section of a conceptual treatment wetlands is presented on Figure 12-2. Actual dimensions and construction details, flow rates, and water retention times will be determined during remedial design. In general, the bioreactors will consist of plant growth media placed on a bed of organic matter and limestone underlain by a gravel base, constructed either atop or just downgradient of the seep locations so water flows up through the system. The treatment cells will be designed and operated to remove selenium and other contaminants. The residual mine-affected water at the seeps and springs will be captured and treated via biologically mediated reactions, including reduction by anaerobic bacteria, resulting in the removal of contaminants through precipitation or sorption. The treated water would flow out of the treatment cells to the downstream drainages or evapotranspire within the treatment cells. Cleanup levels will be met where treated water is discharged to waters of the United States. A monitoring program will be implemented to assess effectiveness of the wetland treatment cells and will include periodic testing of influent and effluent.

The treatment effectiveness of the biochemical reactors in some areas will be enhanced by the PRBs that are installed upgradient to treat the shallow groundwater before it discharges at the seep locations (see Figure 12-5 and the groundwater discussion in Section 12.2.2). These PRBs will have the effect of reducing the concentration of contaminants in the influent to the wetland treatment cells.

During RD, the number, location and size of the wetland treatment cells will be refined. In siting the location of wetland treatment cells, potential impacts to delineated wetlands and other waters of the United States (Newfields, 2017) will be considered as part of substantive compliance with Section 404 of the CWA.

Treatment cells may be phased out over the long-term as source controls (cover system) and treatment technologies (PRBs) described in other media alternatives become effective and reduce mine-affected seep and spring discharge or as cleanup levels are achieved. Decision rules for determining media testing, replacement, disposal procedures, and whether wetlands may be decommissioned in place will be developed during remedial design. ICs will be implemented to prevent human exposure to contaminants at the treatment facilities and to protect the integrity of these features.

Figure 12-6. Approximate Location of Wetland Treatment Cells



Approximate extent of reclamation areas in upland soil/waste rock

Potential location of water conveyance line or trench

Potential location of in-situ constructed wetland

Mine-affected seep/spring

Assumed future long-term surface water monitoring location. Samples will be collected from both influent and effluent at each constructed wetland.

Figure depicts conceptual locations of constructed in-situ wetlands and associated water conveyance lines. Actual locations will be determined during remedial design/remedial action and is dependant on footprint of remedial activities in the mine pits and waste rock dumps (i.e., upland soil/waste rock source controls). Insitutional Controls (ICs), Land Use Contols (LUCs), and other long-term surface water monitoring locations will be as shown on Figure 3-4.

Figure 12-6
REMEDIAL TREATMENT WETLANDS LOCATIONS

BALLARD MINE
RECORD OF DECISION
Caribou County, ID

"Amended from P4 Production LLC, FS Technical Memorandum #2, MWH 2017".

12.2.4 Monitored Natural Attenuation of Groundwater

The primary strategy for remediating groundwater is the implementation of source controls (cover system) and treatment (PRBs and wetland treatment cells). These technologies are expected to reduce contaminant concentrations in groundwater to the cleanup levels over time.

If levels of contaminants in groundwater remain elevated above cleanup levels following implementation of other elements of the remedy, MNA will be used as a polishing step to achieve cleanup levels. MNA relies on physical, chemical, and biological processes to further reduce contaminant concentrations in groundwater, primarily through dilution and dispersion. Additional data (evaluation of the minerology of aquifer solids, dissolved organic carbon, redox conditions, and other relevant information) will be obtained during remedial design to refine estimates of contaminant sorption and attenuation rates. MNA will help reduce contaminant concentrations over the long term, approximately 10 to 20 years after remedy implementation. Use of MNA during the RA will require routine groundwater monitoring, periodic data analysis to evaluate removal mechanisms and track the progress of natural attenuation, and implementation of an adaptive management strategy (see Section 12.2.7).

12.2.5 Stormwater and Sediment Control Best Management Practices

Sediment control is predicated on successful implementation of source controls (i.e., waste rock consolidation, surface grading, and cover installation) to prevent contaminant transport from the mine area into downstream sediment and riparian soil. In the long-term, source controls will minimize or eliminate erosion of source materials, and downstream transport of contaminants as stormwater and snowmelt will no longer contact waste rock before flowing off the mine site.

During the construction phase, sediment traps or basins will be constructed in the upper reaches of mine-affected drainages. These features will be sited in the upper drainage reaches to capture or control mine-affected sediment entrained by stormwater, allowing sediment to settle out and less turbid water to continue downstream. The basins will provide control points for sediment laden runoff from the Site during construction and through maturation of the remedy and establishment of vegetation on the cover. During RD, the number, location and size of the sediment basins will be refined. In siting the location of these BMPs, potential impacts to delineated wetlands and other waters of the United States (Newfields, 2017) will be considered as part of substantive compliance with Section 404 of the CWA. In addition, other BMPs will be specified during remedial design and will include a broad suite of techniques to control erosion, such as use of compaction, construction sequencing, straw mulch and wattles, silt fences, and other methods.

Downstream in mine-affected drainages, natural recovery will be monitored over time (see Section 12.2.6). Disposal of contaminated sediment from these structures over the long term will consist of placement under the ET cover during the RA, and disposal in a designated, properly designed, onsite landfill after RA completion, as needed.

Sediment traps and basins will require appropriate planning during RD to confirm geotechnical stability and protection of human health and the environment, and to track progress toward meeting RAOs. Siting and construction of sediment traps and basins are predicated on an approved RD/RAWP. The RD/RAWP would include sediment trap and basin design information, design of temporary roads, engineered access restrictions, a site restoration plan, an HASP, and a stormwater management plan. ICs will be implemented to protect the integrity of these features and to prevent human exposure to contaminated sediment until RAOs are achieved. Effectiveness will be evaluated through monitoring.

12.2.6 Monitored Natural Recovery for Sediment

Contaminants in intermittent and ephemeral stream sediment and riparian soil will be addressed through a combination of sediment traps and basins in headwater drainage locations (see Section 12.2.5) and MNR for downstream reaches.

MNR will reduce concentrations of contaminants through natural processes. Over time, clean runoff and associated sediment transport, decaying organic debris, and erosion will disperse and dilute or cover contaminated stream channel and overbank deposits and therefore reduce risks to receptors. Implementation of MNR during the RA includes routine sediment and riparian soil sampling in impacted stream corridors down to the confluence with the Blackfoot River, and periodic data evaluations to monitor the progress of natural recovery and to support CERCLA FYRs. This remedial element requires implementation and enforcement of ICs to prevent human exposure to contaminated sediment and riparian soil until RAOs are achieved (more than 10 years beyond remedy completion).

MNR requires no construction or O&M. Implementation of MNR will require a preliminary study to predict the effectiveness of the MNR process, identify and designate downstream sampling stations, and collect baseline samples. Initiation of MNR during RA will require an approved long-term sampling and analysis plan, designated riparian soil and vegetation sampling frequencies over a specified timeframe, and periodic data evaluations to track progress and support CERCLA FYRs.

12.2.7 Adaptive Management

A sitewide adaptive management plan will be developed during RD and implemented during RA. The adaptive management plan will describe a structured iterative process for making management decisions for elements of the remedy with significant uncertainty or vulnerability regarding performance. The plan will provide a linkage and feedback loop between various stages of remedy implementation, including design, construction, monitoring and comparison to cleanup levels and performance specifications, and potential management actions and responses.

The adaptive management plan will include the following elements:

- Problem statement, including a description of vulnerabilities, uncertainties, and potential consequences associated with key components of the remedy.
- Monitoring strategy that includes specific indicators and describes the type, amount, and quality of information needed to make management decisions.
- Performance thresholds for initiating follow-up actions, including cleanup levels, and performance goals and specifications.
- Potential management actions and responses to address unanticipated monitoring results or conditions. These may include additional designs, design modifications, or operational changes to optimize the performance of remedy components, correct design oversights or construction defects, or other actions necessary to achieve intended remedial outcomes.

Follow-up actions and modifications made through the adaptive management process would be consistent with and within the scope of the Selected Remedy and would not constitute a significant or fundamental change to the Selected Remedy.

12.2.8 Operation and Maintenance

O&M is an integral part of every component of the Selected Remedy and is necessary to ensure the success of engineering controls. An O&M plan will be developed and implemented to ensure the proper functioning and performance of all engineering controls. The specific O&M requirements will vary depending on the cleanup method or technology and will be developed during remedial design.

The plan will address maintenance and repairs of the permanent and secondary access roads, associated stormwater control and drainage features, and the ET cover (e.g., erosion of cover material, drainage issues, enhancing vegetative growth on the cover, and other issues to ensure sustainability). The plan will address all aspects of operation, maintenance, and repair of the PRBs, engineered wetland cells, sediment traps and basins, groundwater monitoring well networks, and general BMPs for treatment facilities (e.g., dike or berm repairs, spent media replacement, proper disposal of excavated sediment trap and basin material, rodent control, maintaining engineered ICs to restrict access, and other issues as needed). The plan will include best practices for operating and maintaining treatment features, schedules (short- and long-term) for implementing maintenance of all remedial site features, and records for documenting conditions encountered and remedial action applied. The plan will be updated annually.

12.2.9 Long-term Monitoring

Monitoring is also an integral part of every component of the Selected Remedy. LTM will be designed and implemented to assess the performance of different components of the remedy and the effectiveness of the remedy at attaining cleanup levels. To track and measure progress toward achieving RAOs and cleanup goals at the Site, an LTM program that includes physical, chemical, and biological components will be prepared and implemented. The monitoring program will include sampling and analysis of groundwater, surface water, sediment, riparian soil, vegetation, and upland soil. Frequency of monitoring, specific data quality objectives, and requirements for appropriate monitoring will be developed during remedial design and initial operations.

The information collected through the LTM program will support the FYR process. FYRs are required under the CERCLA process because Site conditions do not allow for unlimited use and unrestricted exposure under the current and potential future land uses. These reviews will be used to evaluate where the remedy is functioning as intended and whether RAOs are being attained.

12.2.10 Institutional Controls and Access Restrictions

ICs are administrative or legal mechanisms, or a combination of both, intended to control land use and Site access and to maintain the integrity of the remedy. The ICs will be tailored to the property to provide protection of human health and to maintain protectiveness until cleanup objectives are met. The general categories of ICs (i.e., Government Controls, Legal Controls, and Communication and Enforcement Tools) are explained in detail in Section 9.2.1. Because the Site is large and includes multiple private and government owners, ICs may be selected and implemented on a parcel basis or implemented for specific components of the Selected Remedy. Site-specific ICs will be determined during RD/RA and will include the following:

- Restrictions on drilling of water supply wells where contaminated groundwater is present. These restrictions would remain in place until cleanup levels are achieved.
- Legally enforceable deed restrictions applied to current and future owners of lands that comprise the Site to prevent any future residential use. These deed restrictions would also be structured to prevent or limit future land uses to preserve and safeguard the cover system or treatment components of the remedy.
- Community outreach distributed through public notices, fact sheets, or onsite signage to provide notice of contamination on the property and to discourage uses that could lead to unacceptable exposures. Communication methods will target and educate neighboring land owners and potential user groups (such as seasonal ranchers, hunters, hikers, and tribal members) on issues, concerns, and best practices related to Site use.
- LUCs such as fencing (an engineering control), locked gates, and signage to discourage public access (offroad vehicles) to the cover, PRBs, wetland treatment cells, and areas where MNR is being implemented, to protect the integrity of the remedy.

12.2.11 Green Remediation

To the extent practicable, the RA will be carried out consistent with EPA's Region 10 Clean and Green Policy (EPA, 2009b), including the following practices:

- Use renewable energy and energy conservation and efficiency approaches, including Energy Star equipment.
- Use cleaner fuels such as low sulfur fuel or biodiesel, diesel emissions controls and retrofits, and emission reduction strategies.
- Use water conservation and efficiency approaches including WaterSense products.
- Use locally sourced materials when available and financially competitive.
- Use reused or recycled materials within regulatory requirements.
- Minimize transportation materials and use rail rather than truck transport to the extent practicable.

12.3 Estimated Cost of the Remedy

The costs for the Selected Remedy presented in this section are estimates, with an accuracy expectation of +50 percent to -30 percent. The estimates will be refined as the remedy is designed and implemented. Even after the remedial action is constructed, the total project costs will be reported as an estimate because of the uncertainty associated with the O&M and LTM expenditures. Periodic costs are those costs that occur only once every few years or expenditures that occur only once during the entire O&M and LTM period or remedial timeframe (e.g., Site closeout or remedial feature replacement resulting from chemical or physical degradation). These costs may be either capital or O&M and LTM costs. Because of the duration of the cost evaluation for this ROD (30 years), periodic costs were primarily associated with O&M and LTM and the FYRs. It is believed that a 30-year cost evaluation is justified for this project, because implementation of the ROD is expected to take up to 10 years. Table 12-1 presents a breakdown of the cost estimate for the Selected Remedy, including net present value (NPV) analysis on a year-by-year basis (discounted by 7 percent per year). A detailed cost breakdown of each remedial component is provided in Appendix D.

Costs for the selected remedy are summarized in the following points:

1) The NPV cost for the remedy is approximately $41,214,250. The individual components of this cost are as follows:
   a) Estimated total capital costs: $148,837,186
   b) Estimated total O&M costs (first 30 years): $2,136,732
   c) Estimated construction time: 10 Years (3-phased Construction Approach)

Table 12-1. Cost Summary Estimate for Selected Remedy
Ballard Mine Site, Caribou County, Idaho

Item No.	Item	Description	Quantity	Unit	Unit Cost ($)	Item Cost ($)
1	**Direct Capital Costs**					
	Mobilization/Demobilization (Combined Remedy Totals)					
	Mobilization/Demobilization of Equipment		1	LS		$91,824
	Construction Field Offices, Facilities, and Utilities		1	LS		$325,035
	Preparation of Institutional Control Implementation and Assurance Plan and Plans		1	LS		$363,895

Table 12-1. Cost Summary Estimate for Selected Remedy
Ballard Mine Site, Caribou County, Idaho

Item No.	Item	Description	Quantity	Unit	Unit Cost ($)	Item Cost ($)
	Upland Soil and Waste Rock					
	Site Consolidation, Grading, and ET Cover		538	ac	$214,868	$115,599,206
	Surface Water					
	Constructed Wetlands at six seep/springs areas		6	ea	$57,082	$342,492
	Sediment					
	Sediment Traps		6	ea	$3,500	$21,000
	Groundwater					
	Installation of nine PRBs and associated monitor wells		9	ea	$37,322	$335,894
				Subtotal Capital Costs		**$117,079,346**
	Project Management			Capital Costs		$5,878,505
	Remedial Design			Capital Costs		$7,111,097
	Construction Management and Oversight			Capital Costs		$7,060,305
	Contingency Costs[a]			Capital Costs		$11,707,935
				Other Direct Costs		**$31,757,841**
	Total Capital Costs (including ore recovery and remedial action)					**$148,837,186**
1a	Total Capital Costs adjusted for Remediation Costs only (Item 1 * 25.47%)					$37,914,438
2	**Annual Costs (O&M)**					
	Long-term Inspections (on 1-year and 5-year schedules)		1	LS		$202,870
	30-year Present Worth					**$2,136,732**
3	**Summary Report (Every 5 years for each medium)**		4	5 years	$100,000	$400,000
	30-year Present Worth Summary (i=7%; P/F = 0.7130+0.5083+0.3624+0.2584+0.1842+0.1314=2.1577)					**$863,080**
4	**Institutional Controls** [b]			EA	$25,000	**$300,000**
	Subtotal: 30-year Present Worth Cost (Items 1+2+3+4)					$152,137,000
5	**Site Remedy Total**[c]**: 30-year Present Worth Cost (Items 1a+2+3+4)**					**$41,214,250**

[a] For an FS that represents 0% to 10% design completion, scope contingency typically ranges from 10% to 25%. The July 2000 EPA guidance, *A Guide to Developing and Documenting Cost Estimates During the Feasibility Study* (EPA 540-R-00-002) shows a rule-of-thumb scope contingency of 10% to 30%.

[b] ICs are non-engineering or legal/administrative measures to reduce or minimize the potential for exposure to site contamination or hazards by limiting or restricting site access. These controls could include IC plans, restrictive covenants, property easements, zoning, deed notices, advisories, groundwater use restrictions, and site information database, as referenced in EPA 540-R-00-002. Costs are determined by number of landowners affected by each medium where ICs will be necessary.

[c] Earthworks associated with potential remining will also advance remediation efforts, thereby reducing costs associated with remediation. Of the total capital cost of all earthworks, approximately 75 percent are associated with assumed ore recovery and approximately 25 percent are associated with remediation. The basis for this apportionment is provided in the FS.

Notes:

ac = acre

ea = each

LS = lump sum

Section 13 – Statutory Determinations

Under CERCLA Section 121 and the NCP, EPA must select a remedy that is protective of human health and the environment, complies with ARARs (unless a statutory waiver is justified), is cost-effective, and uses permanent solutions and alternative treatment technologies or resource recovery technologies to the maximum extent practicable. Furthermore, CERCLA includes a preference for remedies that include treatment that permanently and significantly reduces the volume, toxicity, or mobility of hazardous wastes as a principal element. The following sections discuss how the Selected Remedy meets these statutory requirements.

13.1 Protection of Human Health and the Environment

The Selected Remedy will protect human health and the environment. The Selected Remedy is a combination of source controls, treatment technologies, and other elements that will work together to achieve RAOs.

For **upland soil and waste rock**, RAOs will be attained by construction of an ET cover system that will isolate the waste rock (source materials) from direct contact by receptors. The cover system will be constructed by backfilling mine pits; consolidating, grading and shaping waste rock; and constructing a 5- to 6-foot-thick engineered cover system over all source materials present at the Site. The cover system will cover more than 500 acres. The cover system will be constructed of clean materials that meet cleanup levels and will therefore address direct contact risks. The cover system will also contribute to achieving RAOs for other media by isolating source materials from surface runoff, minimizing deep infiltration of precipitation and snowmelt into waste rock and subsequent release of contaminants to groundwater, providing clean growth media to minimize uptake of selenium into vegetation, and minimizing release of contaminants from source areas into the ephemeral and intermittent channels on the margins of the Site.

For **surface water**, RAOs will be attained by capturing and treating contaminated seepage using constructed wetland treatment cells prior to discharge. ICs and fencing will be used to control human exposure. The cover system, described in detail in Section 12.2.1, will substantially contribute to meeting surface water RAOs because releases of contaminants to surface water will be greatly reduced over time. These load reductions will occur because stormwater runoff from the cover system will not contact source materials and the cover system will reduce recharge to the seeps over time. PRBs, described in Section 12.2.4, will also reduce the concentrations of contaminants that discharge to ephemeral and intermittent headwater reaches of area streams, contributing to achievement of surface water RAOs.

For **groundwater**, RAOs will be attained by constructing PRBs near the margins of the waste rock dumps to intercept and treat shallow contaminated groundwater. Extraction wells may be used to supplement the system in areas where groundwater is deeper and cannot be intercepted by PRBs. The cover system described in Section 12.2.1 will substantially contribute to meeting groundwater RAOs for shallow and deep aquifers because recharge to and releases of contaminants to groundwater will be greatly reduced over time. These actions are expected to result in groundwater meeting cleanup levels over time. If contaminant concentrations are not reduced to cleanup levels through the use of PRBs (and construction of the cover system), MNA would be used as a polishing step to further reduce concentration of contaminants in groundwater plumes. Implementation and enforcement of ICs will prevent human exposure to contaminated groundwater until RAOs are achieved.

For **sediment and riparian soil**, RAOs will be attained by controlling sources of contamination to the intermittent streams, MNR, and ICs. Engineering controls will include construction of the cover system described in Section 12.2.1 in combination sediment traps and basins near the margins of waste rock dumps. The engineering controls will minimize the erosion and transport of contaminated particles of source material into local ephemeral drainages during intermittent periods of storm and snowmelt runoff. MNR will further reduce concentrations of contaminants through natural processes. Over time, clean runoff, and associated sediment transport and erosion will disperse and dilute or cover contaminated stream channel/overbank deposits and therefore reduce risks to receptors. Implementation and enforcement of ICs will prevent human exposure to contaminated sediment and riparian soil until RAOs are achieved.

For **Vegetation**, RAOs will be achieved through construction of the ET cover system described in Section 12.2.1. The cover system will provide clean growth media for vegetation and prevent root uptake of selenium into plant tissue. In addition, vegetation will be surveyed and monitored periodically for the presence of plant species (such as asters or milk-vetch) known to biologically accumulate selenium from soil. These target species will be eradicated by use of herbicides. These actions will reduce selenium exposure to grazing deer, elk, domestic livestock, and other animals that will potentially feed on post-reclamation vegetation. Implementation and enforcement of ICs will prevent human exposure to contaminated vegetation until RAOs are achieved.

The Selected Remedy includes several other elements to evaluate and optimize the performance of source controls and treatment technologies, and to ensure protectiveness. An adaptive management approach will be used to guide implementation of source controls and treatment technologies until RAOs are achieved. The combined remedy also includes O&M and LTM requirements.

There are no short-term threats associated with the Selected Remedy that cannot be readily controlled through applicable health and safety requirements, monitoring, and standard construction practices. In addition, the Selected Remedy will not result in any adverse cross-media effects

13.2 Compliance with ARARs

The Selected Remedy will comply with all ARARs. The ARARs are presented in Appendix B and include information on type (i.e., chemical-, location-, and action-specific) and status (i.e., applicable or relevant and appropriate), a synopsis of the requirement, and a summary of the action to be taken to attain requirements.

Key ARARs for the Ballard Mine Site include the following:

- Idaho Water Quality Standards, including water quality criteria
- National Recommended Water Quality Criteria established under the CWA
- National Primary Drinking Water Regulations, including MCLs, established under the Safe Drinking Water Act
- Idaho Ground Water Quality Rule
- Portions of the regulations established under UMTRCA
- Regulations established under the Mineral Leasing Act that control the development and reclamation of phosphate mines
- Regulations under the Idaho Surface Mine Reclamation Act pertaining to reclamation of surface mining operations

Cleanup levels are based on federal water quality criteria for surface waters and MCLs for groundwater. During remedy implementation, the Selected Remedy will comply with action-specific ARARs, including state and federal mining and reclamation requirements. These ARARs establish performance requirements for the remediated areas, including the source areas and intermittent and ephemeral drainages, to ensure the effectiveness and integrity of the cleanup actions. The Selected Remedy will also comply with Section 404 of the CWA, which requires avoiding disturbances to riparian areas (wetlands) and minimizing disturbances where they cannot be avoided.

13.3 Cost Effectiveness

In EPA's judgement, the Selected Remedy is cost-effective and represents a reasonable value for the money to be spent. In making this determination, the following definition was used: "A remedy shall be cost effective if its costs are proportional to its overall effectiveness." (NCP §300.430(f)(1)(ii)(D)). This was accomplished by evaluating the "overall effectiveness" of those alternatives that satisfied the threshold criteria (i.e., were both protective of human health and the environment and were ARAR-compliant). Overall effectiveness was evaluated by assessing three of the five balancing criteria in combination (long-term effectiveness and permanence; reduction in toxicity, mobility, and volume through treatment; and short-term effectiveness). Overall effectiveness was then compared to costs to determine cost-effectiveness. The relationship of the overall effectiveness of the combined remedial alternative (being selected in this ROD) was determined to be proportional to its costs and this alternative therefore represents a reasonable value for the money to be spent.

The estimated present value cost of the Selected Remedy is approximately $41,323,000. The most-costly component of the Selected Remedy is the upland soil and waste rock component. The USWR alternative selected (USWR 6) provides a similar level of protectiveness compared to the other two alternatives (USWR 4 and USWR 7) evaluated, but costs significantly less ($37 million for USWR 6 compared to $51 million for USWR 4 and $113 million for USWR 7). The cost of the USWR component in the Selected Remedy (USWR 6) is considerably less than the other two alternatives because earthworks associated with potential ore recovery reduce the scope and cost of remaining earthworks associated with implementation of the remedy.

The Selected Remedy includes treatment of contaminated seeps discharging to surface water using constructed wetlands. Although this component of the Selected Remedy (SW 3) costs more than SW 2, which focuses on ICs ($1,430,000 versus $850,000), its overall effectiveness is greater because it reduces toxicity through treatment and has better short-term effectiveness.

For groundwater, the Selected Remedy includes treatment of shallow alluvial groundwater using PRBs. This component of the Selected Remedy (GW 3) costs significantly less than the groundwater extraction and treatment alternative (GW 5b) and more than the alternative focused on ICs and MNR (GW 2). The overall effectiveness of GW 3 is greater than GW 2 because it includes treatment to reduce toxicity and is more effective in the short term. Compared to GW 5, GW 3 provides an overall level of protection that is comparable at a significantly lower cost ($2.1 million versus $24.2 million).

For sediment and riparian soil, the selected alternative (S/RS 3) provides a similar level of protectiveness compared to S/RS 4 at a lower cost ($736,000 for S/RS 3 versus $1,591,000 for S/RS 4).

13.4 Use of Permanent Solutions and Alternative Treatment (or Resource Recovery) Technologies to the Maximum Extent Practicable

The Selected Remedy represents the maximum extent to which permanence and treatment can be practically used at the Site. NCP §300.430(f)(1)(ii)(E) provides that the balancing shall emphasize the factors of long-term effectiveness and reduction of toxicity, mobility or volume through treatment, and shall consider the preference for treatment and bias against offsite disposal. The modifying criteria were also considered in making this determination.

EPA has determined that the Selected Remedy represents the maximum extent to which permanent solutions and treatment technologies can be used in a cost-effective manner at the Site. Of the assortment of media alternatives evaluated that are protective of human health and the environment and comply with ARARs, EPA has determined that the Selected Remedy provides the best balance of tradeoffs in terms of the five balancing criteria, while also considering the statutory preference for treatment and bias against offsite disposal and considering state and community acceptance.

13.5 Preference of Treatment as a Principal Element

The Selected Remedy does not satisfy the statutory preference for treatment as a principal element. The NCP establishes the expectation that treatment will be used to address principal threat wastes whenever practicable (40 CFR 300.430[a][1][iii][A]). Principal threat wastes are those source materials considered to be highly toxic or highly mobile that generally cannot be contained in a reliable manner or will present a significant exposure risk to human health and the environment. The Ballard Mine waste rock (mine materials) are of large volume and generally low toxicity, which are difficult to treat effectively; however, they may be contained effectively. As discussed in Section 11, EPA has determined that the waste rock source material is not acutely toxic, direct exposure risk can be mitigated by ICs and LUCs, and it can be reliably contained; therefore, the waste rock source material does not constitute a principal threat waste.

13.6 Five-Year reviews

Because the Selected Remedy results in hazardous substances, pollutants, or contaminants remaining onsite (although contained within a robust ET cover) at greater than levels that allow for unlimited use and unrestricted exposure, FYRs will be performed pursuant to CERCLA §121(c) and NCP §300.430(f)(5)(iii)(C). EPA will perform a review of the RAs no less than 5 years after initiation of such RA to ensure the remedy is or will be protective of human health and the environment.

Section 14 – Documentation of Significant Changes

The Preferred Alternative described in the Proposed Plan remains unchanged as the Selected Remedy for the Site. During the public comment period, EPA received four comments from individuals, citizen groups, and the state. EPA reviewed all comments submitted during the public comment period and determined that no significant changes to the remedy, as originally identified in the Proposed Plan, were necessary or appropriate.

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Section 15 – References

Agency for Toxic Substances and Disease Registry (ATSDR). 2013. *Minimal Risk Levels (MRLs) for Hazardous Substances.*

Beyer, W.N., E.E. Connor, and S. Gerould. 1994. "Estimates of soil ingestion by wildlife." *Journal of Wildlife Management* Volume 58 Issue 2.

Buchman, M.F. 2008. *National Oceanic and Atmospheric Administration (NOAA) Screening Quick Reference Tables.* NOAA OR&R. Report 08-1. Seattle WA, Office of Response and Restoration Division, 34 pp.

California Department of Fish and Wildlife. 1988-1990. "Life History Accounts and Range Maps." *California's Wildlife*. Zeiner, D.C., editor. Maintained by California Wildlife Habitat Relationship Program of the California Department of Fish and Wildlife. https://www.wildlife.ca.gov/Data/CWHR/Life-History-and-Range.

Cornell Lab of Ornithology. n.d. www.birds.cornell.edu.

Digital Atlas of Idaho. n.d. http://imnh.isu.edu/digitalatlas/bio/mammal/mamfram.htm.

Formation Environmental LLC. 2013. *Screening Levels, Exposure Factors, Toxicity Factors for Smoky Canyon Mine Site-Specific Human Health Risk Assessment (Revised July 25, 2013).* Memorandum to Mary Kauffman, USDA Forest Service. Formation Environmental, LLC. July.

Idaho Department of Environmental Quality (DEQ). 2004a. *Area Wide Risk Management Plan: Removal Action Goals and Objectives, and Action Levels for Addressing Releases and Impacts from Historic Phosphate Mining Operations in Southeast Idaho*.

Idaho Department of Environmental Quality (DEQ). 2004b. Interagency nonregulated surface water inspection results for P4 Production's Ballard, Henry, and Enoch Valley Mine Sites. Memorandum from Rick Clegg, DEQ to Robert Geddes, P4, dated June 23, 2004.

Idaho Department of Environmental Quality (DEQ). 2017. *Community Involvement Plan Update for Ballard, Enoch Valley, and Henry (P4) Mines*. Prepared by North Wind Resource Consulting. March.

Johnson, P.C. and R.A. Ettinger. 1991. "Heuristic Model for Predicting the Intrusion Rate of Contaminant Vapors Into Buildings." *Environ. Sci. Technol.* 25. 1445-1452.

Kuck, L. 2003. *An evaluation of the effects of selenium on elk, mule deer, and moose in southeastern Idaho*. Prepared for Idaho Mining Association.

Lee, William H. 2001. *A History of Phosphate Mining in Southeastern Idaho*. CD-ROM Version 1.0. USGS Open-File Report 00-425. Boise, ID.

MacCracken, James G. and Richard M. Hansen. 1982. Seasonal Foods of Coyotes in Southeastern Idaho: A Multivariate Analysis.

Montgomery Watson Harza (MWH). 2008. *Interim Report for Hydrogeologic Investigation Revision 3 – 2007 Hydrogeologic Data Collection Activities and Updated Conceptual Models*.

Montgomery Watson Harza (MWH). 2010. *Data Quality and Usability Report (DQUR) and Data Approval Request (DAR).* Final Revision 2.

Montgomery Watson Harza (MWH). 2011. *Ballard, Henry and Enoch Valley Mines, Remedial Investigation and Feasibility Study Work Plan*.

Montgomery Watson Harza (MWH). 2013a. *Background Levels Development Technical Memorandum, Ballard, Henry, and Enoch Valley Mines, Remedial Investigation and Feasibility Study*.

Montgomery Watson Harza (MWH). 2013b. *Final Ballard, Henry, and Enoch Valley Mines, Remedial Investigation and Feasibility Study, 2010-2012 Data Summary Report*.

Montgomery Watson Harza (MWH). 2014. *Ballard Mine Remedial Investigation and Feasibility Study, Remedial Investigation Report, Baseline Risk Assessment Addendum*. Final. Revision 2. November.

Montgomery Watson Harza (MWH). 2015a. *Sampling and Analysis Plan for Long-term Monitoring of Surface Water and Groundwater at Ballard, Henry, and Enoch Valley Mines.* Final.

Montgomery Watson Harza (MWH). 2015b. *On-Site and Background Areas Radiological and Soil Investigation Summary Report – P4's Ballard, Henry, and Enoch Valley Mines Remedial Investigation and Feasibility Study*. Final.

Montgomery Watson Harza (MWH). 2015c. *Baseline Risk Assessment Addendum.*

Montgomery Watson Harza (MWH). 2016a. *Ballard Mine Feasibility Study Report – Memorandum 1 – Site Background and Screening Technologies*. Final.

Montgomery Watson Harza (MWH). 2016b. *Ballard Mine Cover Material Exploration Work Plan*. Final.

Montgomery Watson Harza (MWH). 2017a. *Ballard Mine Feasibility Study Report – Memorandum 2 – Screening, Detailed and Comparative Analysis of Assembled Remedial Alternatives*. Final. April.

Montgomery Watson Harza (MWH). 2017b. *Ballard Mine Monitored Natural Attenuation Technical Memorandum*.

Nagy, K. A. 2001. "Food requirements of wild animals: Predictive equations for free-living mammals, reptiles and birds." *Nutr. Abstr.* Rev. B 71,21R -32R.

National Research Council. 2013. *Critical Aspects of EPA's IRIS Assessment of Inorganic Arsenic: Interim Report*. Washington, DC: The National Academies Press. https://doi.org/10.17226/18594.

Newfields Mining and Energy Services, LLC (Newfields). 2017. Delineation of Waters of the United states, Ballard Mine Project. Prepared for P4 Production, LLC. December.

NorthWind Resource Consulting. 2017. *Community Involvement Plan Update for Ballard, Henry, and Enoch Valley (P4) Mines*. Prepared for DEQ. March.

Oak Ridge National Laboratory (ORNL). 1996a. *Toxicological Benchmarks for Wildlife: 1996 Revision*. ES/ER/TM-86/R3.

Oak Ridge National Laboratory (ORNL). 1996b. *Toxicological Benchmarks for Contaminants of Potential Concern for Effects on Aquatic Biota: 1996 Revision*. ES/ER/TM-96/R2.

Oak Ridge National Laboratory (ORNL). 1997a. *Toxicological Benchmarks for Screening Contaminants of Potential Concern for Effects on Terrestrial Plants: 1997 Revision*. ES/ER/TM-85/R3.

Oak Ridge National Laboratory (ORNL). 1997b. *Toxicological Benchmarks for Contaminants of Potential Concern for Effects on Soil and Litter Invertebrates and Heterotrophic Process: 1997 Revision*. ES/ER/TM-126/R2.

Oak Ridge National Laboratory (ORNL). 2013. *Risk Assessment Information System (RAIS)*. https://rais.ornl.gov/.

Senseman, R. 2002. "Cervus elaphus." Animal Diversity Web. Accessed February 22, 2011. http://animaldiversity.ummz.umich.edu/site/accounts/information/Cervus_elaphus.html.

Slater, Gary L. and Christine Rock. 2005. *Northern Harrier (Circus cyaneus): A Technical Conservation Assessment*. Prepared for the USDA Forest Service, Rocky Mountain Region, Species Conservation Project. September 30.

Stantec. 2018. *2017 Data Summary Report, Ballard, Enoch Valley and Henry Mines Remedial Investigation Activities; Long-term Groundwater and Surface Water Monitoring*. January.

TetraTech. 2002. *Final Area Wide Human Health and Ecological Risk Assessment, Selenium Project, Southeast Idaho Phosphate Mining Resource Area*. Prepared for Idaho Department of Environmental Quality by TetraTech EM, Inc. December.

U.S. Environmental Protection Agency (EPA). n.d. "Inorganic Arsenic Meetings & Webinars." *Integrated Risk Information System (IRIS)*. https://www.epa.gov/iris/inorganic-arsenic-meetings-webinars.

U.S. Environmental Protection Agency (EPA). 1989. *Risk Assessment Guidance for Superfund (RAGS). Volume I: Human Health Evaluation Manual (Part A), Interim Final*. EPA/540/1-89/002. December. http://www.epa.gov/oswer/riskassessment/ragsa/.

U.S. Environmental Protection Agency (EPA). 1993. *Wildlife Exposure Factors Handbook*. EPA/600/R-93/187. December.

U.S. Environmental Protection Agency (EPA). 1997a. *Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessments*. Interim Final. EPA 540-R-97-006. June.

U.S. Environmental Protection Agency (EPA). 1997b. Rules of Thumb for Superfund Remedy Selection (pp. 23). (EPA 540-R-97-013; OSWER 9355.0-69; PB97-963301). Washington D.C.: Office of Solid Waste and Emergency Response. http://www.epa.gov/superfund/policy/remedy/rules/rulesthm.pdf

U.S. Environmental Protection Agency (EPA). 1997c. *Exposure Factors Handbook*. Office of Emergency and Remedial Response. USEPA/600/P-95/002. August.

U.S. Environmental Protection Agency (EPA). 2000. *A Guide to Developing and Documenting Cost Estimates During the Feasibility Study*. EPA/540-R-00-002. July.

U.S. Environmental Protection Agency (EPA). 2003. Consent Order/Administrative Order on Consent for the Performance of Site Investigations (SIs) and Engineering Evaluations/Cost Analyses (EE/CAs) at P4 Production, L.L.C. Phosphate Mine Sites in Southeastern Idaho. United States Environmental Protection Agency, United States Forest Service, Idaho Department of Environmental Quality, in the Matter of Enoch Valley Mine, Henry Mine, Ballard Mine, P4 Production, L.L.C., respondent, August 20.

U.S. Environmental Protection Agency (EPA). 2004. *Risk Assessment Guidance for Superfund (RAGS) Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment*). EPA/540/R/99/005.

U.S. Environmental Protection Agency (EPA). 2005a. Ecological Soil Screening Levels for Antimony. Interim Final. OSWER Directive 9285.7-61, Revised. Office of Solid Waste and Emergency Response. February.

U.S. Environmental Protection Agency (EPA). 2005b. Ecological Soil Screening Levels for Cadmium. Interim Final. OSWER Directive 92857-65, Revised. Office of Solid Waste and Emergency Response. March.

U.S. Environmental Protection Agency (EPA). 2005c. Ecological Soil Screening Levels for Vanadium. Interim Final. OSWER Directive 92857-70, Revised. Office of Solid Waste and Emergency Response. April.

U.S. Environmental Protection Agency (EPA). 2007a. Ecological Soil Screening Levels for Copper. OSWER Directive 92857-68, Revised. Office of Solid Waste and Emergency Response. February.

U.S. Environmental Protection Agency (EPA). 2007b. Ecological Soil Screening Levels for Nickel. Interim Final. OSWER Directive 92857-76, Revised. Office of Solid Waste and Emergency Response. March.

U.S. Environmental Protection Agency (EPA). 2007c. Ecological Soil Screening Levels for Selenium. Interim Final. OSWER Directive 92857-72, Revised. Office of Solid Waste and Emergency Response. July.

U.S. Environmental Protection Agency (EPA). 2007d. Ecological Soil Screening Levels for Zinc. Interim Final. OSWER Directive 92857-73, Revised. Office of Solid Waste and Emergency Response. June.

U.S. Environmental Protection Agency (EPA). 2008a. Ecological Soil Screening Levels for Chromium. Interim Final. OSWER Directive 9285.7-66, Revised. Office of Solid Waste and Emergency Response. April.

U.S. Environmental Protection Agency (EPA). 2008b. Recommended Toxicity Value for Uranium, Noncancer Endpoint for the Eastern Michaud Flats Site. Technical memorandum from Marc Stifelman/EPA Region 10 to Office of Environmental Assessment.

U.S. Environmental Protection Agency (EPA). 2009a. Administrative Settlement Agreement and Order on Consent/Consent Order for Performance of Remedial Investigation and Feasibility Study at the Enoch, Henry, and Ballard Mine Sites in Southeastern Idaho. EPA Region 10, Idaho Department of Environmental Quality, United States Department of Agriculture, Forest Service Region 4, United States Department of the Interior, Bureau of Land Management, Shoshone-Bannock Tribes, in the Matter of Enoch Valley Mine, Henry Mine, Ballard Mine, P4 Production, L.L.C., Respondent. Effective Date of November 30, 2009.24.

U.S. Environmental Protection Agency (EPA). 2009b. *Region 10 Superfund, RCRA, LUST, and Brownfields Clean and Green Policy*. August 13.

U.S. Environmental Protection Agency (EPA). 2011. *Exposure Factors Handbook*. *Exposure Factors Handbook 2011 Edition (Final).* EPA/600/R-09/052F.

U.S. Environmental Protection Agency (EPA). 2013a. National Recommended Water Quality Criteria. Accessed August 2013. https://www.epa.gov/wqc/national-recommended-water-quality-criteria.

U.S. Environmental Protection Agency (EPA). 2013b. Integrated Risk Information System (IRIS) Database. http://cfpub.epa.gov/ncea/iris/index.cfm.

U.S. Environmental Protection Agency (EPA). 2013c. Region 3 BTAG Freshwater Sediment Screening Benchmarks. http://www.epa.gov/reg3hwmd/risk/eco/btag/sbv/fwsed/screenbench.htm.

U.S. Environmental Protection Agency (EPA). 2013d. Regional Screening Levels for Chemical Contaminants at Superfund Sites. May 2013. http://www.epa.gov/region9/superfund/prg/.

U.S. Environmental Protection Agency (EPA). 2014. Preliminary Remediation Goals for Radionuclides. November 11, 2014. https://epa-prgs.ornl.gov/cgi-bin/radionuclides/rprg_search.

U.S. Environmental Protection Agency (EPA). 2018. *Ballard Mine Proposed Plan, Caribou County, ID*. Final. April 2.

U.S. Fish and Wildlife Service (USFWS). 2018. *Threatened and Endangered Species Status for Caribou County, ID*. E-mail from J. Moore/USFWS to D. Tomten/EPA. December 6.

Woodruff, R.A. and B.L. Keller. 1982. "Dispersal, daily activity, and home range of coyotes in southeastern Idaho." *Northwest Science* 56:199-207.

Appendix A
Risk Summary Tables

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Table A-1
Exposure Parameters for Use in the Human Health Risk Assessment

Exposure Parameter		Units	Native American Child	Native American Adult		Hypothetical Future Resident Child	Hypothetical Future Resident Adult		Seasonal Rancher Adult		Recreational Hunter Adult		Recreational Camper / Hiker Child	Recreational Camper / Hiker Youth	Recreational Camper / Hiker Adult	
General																
BW = body weight		kg	15	70	a	15	70	a	70	a	70	a	15	55	70	a
ATc = averaging time for carcinogens		days	25,550		a	25,550		a	25,550	a	25,550	a		25,550		a
ATn = averaging time for non-carcinogens																
	CTE	days	584	2336	b	584	2336	b	2336	b	2336	b	584	876	1460	b
	RME	days	2,190	8,760	a	2,190	8,760	a	8,760	b	8,760	b	2,190	3,285	5,475	b
ED = exposure duration																
	CTE	years	1.6	6.4	b	1.6	6.4	b	6.4	b	6.4	b	1.6	2.4	4	b
	RME	years	6	24	a	6	24	a	24	b	24	b	6	9	15	b
Soil Direct Exposure Pathways - Oral, Dermal, and Inhalation																
EF = exposure frequency for soil exposures																
	CTE	days / year	183	183	e	183	183	e	90	f	8	c	3	3	3	d
	RME	days / year	270	270	e	270	270	e	120	f	14	c	7	7	7	d
IR_{soil} = soil intake rate																
	CTE	mg/day	100	50	g	100	50	g	50	g	50	g	100	50	50	g
	RME	mg/day	200	100	g	200	100	g	100	g	100	g	200	100	100	g
SA = surface area for soil dermal contact																
	CTE	cm^2	1,562	5,092	h	1,562	5,092	h	5,092	h	5,092	h	1,562	3,285	5,092	h
	RME	cm^2	2,434	5,657	h	2,434	5,657	h	5,657	h	5,657	h	2,434	2,434	5,657	h
AF = soil-to-dermal adherence factor																
	CTE	mg/cm^2	0.04	0.07	k	0.04	0.07	k	0.1	l	0.1	l	0.04	0.04	0.01	j
	RME	mg/cm^2	1	0.3	a	1	0.3	a	0.4	l	0.3	a	1	0.3	0.3	a
ABS = absorption fraction through skin		unitless	CS	CS	a	CS	CS	a	CS	a	CS	a	CS	CS	CS	a
ET = exposure time for dust inhalation																
	CTE	fraction of a day	1/24	1/24	m	1/24	1/24	m	4/24	n	12/24	l	12/24	12/24	12/24	l
	RME	fraction of a day	2/24	2/24	a	2/24	2/24	a	12/24	n	1	l	1	1	1	l
PEF = particulate emission factor																
	RME	m^3/kg	6.45E+09		a	6.45E+09		a	6.45E+09	a	6.45E+09	a		6.45E+09		a
Ingestion of Plants																
EF = exposure frequency for plant ingestion		days / year	350		o	350		o	NA		NA			NA		
IR_{plant} = plant intake rate																
	CTE	g/day	30	57	p	30	57	p	NA		NA			NA		
	RME	g/day	156	293	p	156	293	p	NA		NA			NA		
MLF = mass loading factor		unitless	0.26		r	0.26		r	NA		NA			NA		
Ingestion of Game																
EF = exposure frequency for game ingestion		days / year	350		o	NA			NA		350	o		NA		
IR_{game} = game intake rate																
	CTE	g/day	0.032	0.070	q	NA			NA		30.2	q		NA		
	RME	g/day	8.0	17.9	q	NA			NA		93.9	q		NA		
MLF = mass loading factor		unitless	0.25		r	NA			NA		0.25	r		NA		
Qp_e = elk fodder intake		kg/day	2.29		s	NA			NA		2.29	s		NA		
Fp_e = fraction of year animal on site		unitless	0.025		r	NA			NA		0.025	r		NA		

Table A-1
Exposure Parameters for Use in the Human Health Risk Assessment

Exposure Parameter		Units	Native American Child	Native American Adult	Hypothetical Future Resident Child	Hypothetical Future Resident Adult	Seasonal Rancher Adult	Recreational Hunter Adult	Recreational Camper / Hiker Child	Recreational Camper / Hiker Youth	Recreational Camper / Hiker Adult
Fs_e = fraction of animal's food on site		unitless	1 [t]		NA		NA	1 [t]		NA	
Qs_e = elk soil intake rate		kg/day	0.0459 [u]		NA		NA	0.0459 [u]		NA	
Qw_e = elk water intake rate		L/day	16.1 [v]		NA		NA	16.1 [v]		NA	
BWe = elk body weight		g	286,000 [w]		NA		NA	286,000 [w]		NA	
Ingestion of Beef											
EF = exposure frequency for beef ingestion		days / year	NA		NA		350 [o]	NA		NA	
IR_{beef} = beef intake rate											
	CTE	g/day	NA		NA		124 [x]	NA		NA	
	RME	g/day	NA		NA		476 [x]	NA		NA	
MLF = mass loading factor		unitless	NA		NA		0.25 [r]	NA		NA	
Qp_c = cattle fodder intake		kg/day	NA		NA		11.77 [r]	NA		NA	
Fp_c = fraction of year animal on site		unitless	NA		NA		0.33 [y]	NA		NA	
Fs_c = fraction of animal's food on site		unitless	NA		NA		1 [r]	NA		NA	
Qs_c = cattle soil intake rate		kg/day	NA		NA		0.39 [r]	NA		NA	
Qw_c = cattle water intake rate		L/day	NA		NA		53 [r]	NA		NA	
Surface Water Direct Exposure Pathways - Incidental Ingestion and Dermal Contact											
EF = exposure frequency for surface water											
	CTE	days / year	70	70 [z]	NA		NA	NA		NA	
	RME	days / year	122	122 [z]	NA		NA	NA		NA	
$IR_{surface\ water}$ = surface water incidental intake rate											
	CTE	mL/day	7.2	7.2 [aa]	NA		NA	NA		NA	
	RME	mL/day	21.6	21.6 [aa]	NA		NA	NA		NA	
SA = surface area for surface water dermal contact											
	CTE	cm^2	933	2,587 [ab]	NA		NA	NA		NA	
	RME	cm^2	1,968	6,362 [ab]	NA		NA	NA		NA	
DA = absorbed dose per dermal contact event		mg/cm^2-event	CS	CS	NA		CS	NA		NA	
ET = exposure time for dermal contact											
	CTE	hours / day	1	1 [ac]	NA		NA	NA		NA	
	RME	hours / day	2	2 [ac]	NA		NA	NA		NA	
Groundwater Direct Exposure Pathways - Ingestion and Dermal Contact											
EF = exposure frequency for groundwater											
	CTE	days / year	NA		350	350 [a]	90 [f]	NA		NA	
	RME	days / year	NA		350	350 [a]	120 [f]	NA		NA	
$IR_{groundwater}$ = groundwater intake rate											
	CTE	L/day	NA		0.315	0.922 [ad]	0.922 [ad]	NA		NA	
	RME	L/day	NA		1.5	2 [a]	2 [a]	NA		NA	
SA = surface area for groundwater dermal contact while showering											
	CTE	cm^2	NA		6,365	18,979 [ae]	18,979 [ae]	NA		NA	
	RME	cm^2	NA		7,694	23,654 [ae]	23,654 [ae]	NA		NA	
DA = absorbed dose per dermal contact event		mg/cm^2-event	NA		CS	CS	CS	NA		NA	
ET = exposure time for dermal contact											
	CTE	hours / day	NA		0.33	0.25 [af]	0.25 [af]	NA		NA	
	RME	hours / day	NA		1	0.58 [af]	0.58 [af]	NA		NA	

Table A-1
Exposure Parameters for Use in the Human Health Risk Assessment

Exposure Parameter	Units	Native American Child	Native American Adult	Hypothetical Future Resident Child	Hypothetical Future Resident Adult	Seasonal Rancher Adult	Recreational Hunter Adult	Recreational Camper / Hiker Child	Recreational Camper / Hiker Youth	Recreational Camper / Hiker Adult
J&E SOIL PARAMETERS										
Soil type		NA		SI [ag]		NA	NA		NA	
ρ_b = dry soil bulk density	g/cm³	NA		1.35 [ag]		NA	NA		NA	
n = total soil porosity	unitless	NA		0.489 [ag]		NA	NA		NA	
θ_w = water-filled soil porosity	cm³/cm³	NA		0.167 [ag]		NA	NA		NA	
θ_a = air-filled soil porosity	cm³/cm³	NA		0.322 [ag]		NA	NA		NA	
J&E MODEL PARAMETERS										
T_s = Average soil or groundwater temperature (Groundwater model)	°C	NA		8 [ah]		NA	NA		NA	
T_s = Average soil temperature (Soil model)	°C	NA		8 [ah]		NA	NA		NA	
L_F = Depth below grade to bottom of enclosed space floor	cm	NA		15 [ai]		NA	NA		NA	
L_{WT} = Depth below grade to water table	cm	NA		1,136 [aj]		NA	NA		NA	
Qsoil - Average vapor flow rate into building	L/m	NA		calculated in model		NA	NA		NA	
L_s - Depth below grade to soil sample	cm	NA		152 [ak]		NA	NA		NA	

Notes:

°C = degree(s) celsius
cm = centimeter(s)
cm² = square centimeter(s)
cm³ = cubic centimeter(s)
CTE = central tendency estimate
CS = chemical specific
g = gram(s)
kg = kilogram(s)
L = liter(s)
m = meter(s)
m³ = cubic meter(s)
mg = milligram(s)
mL = milliliter(s)
NA = not applicable
RME = reasonable maximum estimate

[a] Idaho Department of Environmental Quality (DEQ). 2004a. Idaho Risk Evaluation Manual.
[b] For the RME scenario, an adult recreational hunter who resides in the area was assumed to hunt every season for 24 years, an recreational camper/hiker was assumed to camp in the area as a child, youth, and adult for 30 years, and an adult seasonal rancher was assumed to graze cattle in the area for 24 years. These RME assumptions are consistent with an exposure duration of 30 years suggested in the Idaho Risk Evaluation Manual (DEQ, 2004a). For the CTE scenario, the exposure duration for all receptors were based on a 50th percentile residential occupancy period of 8 years (EPA, 2011). The CTE exposure durations were calculated by multiplying each RME exposure duration by a factor of 8/30.
[c] Archery season for elk is a month (September), any weapon season for elk is October 25 to November 15 and muzzle loader season is November 16 to 30. The exposure frequency is based on the assumption that a hunter goes out every weekend during the archery season (CTE) or a total of 14 days over the entire season (RME).
[d] Based on one 3-day weekend (CTE) or week-long (RME) camping trip per year.
[e] The RME exposure frequency for direct soil contact is from DEQ (2004a); the CTE exposure frequency assumes that the ground is covered in snow for half of the year.
[f] Cattle are assumed to graze at the Site for 90 (CTE) to 120 (RME) days per year; seasonal ranchers are conservatively assumed to reside at the site while cattle are grazing.
[g] The RME soil ingestion rates are from DEQ (2004a); CTE soil ingestion rates are central tendency values from Table 5-1 of EPA's Exposure Factors Handbook (2011).
[h] The RME dermal surface area for soil exposures is from DEQ (2004a). The CTE is from Table 7-2 of EPA's Exposure Factors Handbook (2011), and assumes that the face, forearms, hands, and lower legs are exposed to soil.
[i] Equal to the geometric mean (CTE) and 95th percentile (RME) for a farmer presented in EPA (2004) Exhibit 3-3.
[j] Equal to the geometric mean for a child playing in dry soil (child) and adult playing outdoor sports - soccer (adult) presented in EPA (2004) Exhibit 3-3.
[k] Equal to the geometric mean for a child playing indoors and outdoors (child) and an adult residential gardener presented in EPA (2004) Exhibit 3-3.
[l] Time outdoors for tent camping (RME) and RV camping (CTE).
[m] Based on 50% of the RME assumption (Refer to footnote "a").
[n] The exposure time for a seasonal rancher is assumed to be similar to the time spent outdoor for someone on a farm. The 95th and 50th percentile time spent outdoor for someone on a farm in the summer is 12 hours and 4 hours, respectively (EPA, 2011).
[o] Ingestion frequency (days per year) for homegrown, hunted, and foraged food was assumed to match the number of days at home in DEQ (2004). Although it is conservatively assumed that homegrown, hunted, and foraged foods are eaten daily, the daily food ingestion rates derived from EPA (2011) do not assume that these foods comprise an individual's entire daily food intake.
[p] Consumption of home grown produce from Table 13-1 of EPA (2011): per capita for populations that garden or farm, adjusted for cooking. Body weight specific ingestion rates in Table 13-1 were adjusted to total grams consumed using body weights in Table 8-1 of EPA (2011). The CTE and RME ingestion rates are equal to the mean and 95th percentile estimates of consumption rates, respectively.

Table A-1
Exposure Parameters for Use in the Human Health Risk Assessment

Exposure Parameter	Units	Native American		Hypothetical Future Resident		Seasonal Rancher	Recreational Hunter	Recreational Camper / Hiker		
		Child	Adult	Child	Adult	Adult	Adult	Child	Youth	Adult

[q] The ingestion of game rates for a seasonal hunter were time-weighted ingestion rate for ages 16-46 from Table 13-41 of EPA's Exposure Factors Handbook (2011) and adjusted for 29.7% meat preparation and cooking loss and 29.7% post-cooking loss (Table 13-69 from EPA, 2011), consistent with the human health risk assessment technical memorandum for the Smoky Canyon Mine Site (Formation Environmental LLC, 2013). The CTE (mean) and RME (99th percentile) adult Native American ingestion of game rates were obtained from Table 11-6 of the 1997 Exposure Factors Handbook (EPA, 1997c). The child Native American ingestion rates were estimated from the adult ingestion rates assuming a child eats 45% of the meat consumed by an adult (based on values in Table 13-1 of EPA, 2011). All grams per kilogram per day adult ingestion rates were converted to grams per kilogram assuming a body weight of 70 kilograms.

[r] Mass loading factor obtained from ORNL (2013). The fraction of an animal's food on site was assumed to be 100% during the time the animal is onsite.

[s] The game animal fodder intake was estimated using Equation 29 in Nagy (2001).

[t] The fraction of year an animal is on site was estimated using the Ballard Mine site area and a home range of 16,640 acre (Kuck, 2003).

[u] Soil ingestion rates as percent of diet from Beyer et al. (1994).

[v] Calculated using Equation 3-17 for ingestion rates for mammal from EPA, 1993.

[w] Senseman, R. 2002. "Cervus elaphus." Animal Diversity Web. Accessed February 22, 2011. http://animaldiversity.ummz.umich.edu/site/accounts/information/Cervus_elaphus.html.

[x] The CTE (50th percentile) and RME (95th percentile) consumer-only intake rates for home grown beef (g/kg-day) from Table 13-33 of EPA (2011); adjusted using adult body weight from Table 8-1 of EPA (2011).

[y] The beef cattle was assumed to graze the Ballard Mine 120 days/year because snowpack and ice are present approximately 6 months of the year.

[z] Native Americans are assumed to spend 2 hours per day gathering food or medical plants near streams, for 4 days per week during June, July, August, and September.

[aa] RME (upper confidence limit) and CTE (mean) incidental surface water ingestion rates for Native Americans while collecting culturally significant riparian vegetation were assumed to be similar to ingestion rates for fishing from Table 3-93 of EPA's Exposure Factors Handbook (2011). Native Americans are assumed to spend 2 hours per day gathering culturally significant riparian vegetation.

[ab] Native Americans are potentially dermally exposed to surface water while collecting culturally significant riparian vegetation; CTE assumes hands, forearms, and face are exposed, and RME assumes that feet and lower legs are also exposed. Surface areas were calculated according to Table 7-2 of EPA (2011). For the purposes of this calculation, the surface area of the face was assumed to be 1/3 that of the head, forearms were assumed to represent 45% of the arms, and lower legs were assumed to represent 40% of the legs (EPA, 2011)

[ac] Native Americans are assumed to spend 2 hours per day (RME) gathering food or medical plants near streams. The CTE is based on 50% of the RME assumption.

[ad] Intake rate is the mean from Table 3-1 of EPA (2011).

[ae] Mean (CTE) and 95th percentile (RME) From Table 7-1 of EPA (2011).

[af] EPA (2004) Exhibit 3-2.

[ag] A review of soil boring data for the Ballard Shop indicated the soil types of silt loam, silt, silty clay and clay were present. To be conservative, silt was selected as the soil type for the Ballard Shop. The soil parameters listed are default values from the Johnson and Ettinger model for the soil type selected.

[ah] Average groundwater temperature from the Spring/Fall 2010, Spring/Fall 2012, and Spring 2013 monitoring events.

[ai] The slab-on-grade mode was used because the maximum detected concentrations of volatile chemicals of potential ecological concern and chemicals of potential concern were found in soils shallower than 200 centimeters.

[aj] Average depth to groundwater for monitoring wells SB-01, SB-03 and SB-07 measured in July and November 2011.

[ak] Depth to the soil sample containing maximum detected concentration of each chemicals of potential concern and chemicals of potential ecological concern.

Table A-2

Toxicity Values used in the Human Health Risk Assessment

Chemical of Potential Concern	CAS Number	Cancer Slope Factor $(mg/kg\text{-}d)^{-1}$ Oral		Cancer Slope Factor Dermal[b]		URF (µg/m3)-1 Inhalation		Chronic Reference Dose - RfD (mg/kg-d) Oral		Chronic Reference Dose - RfD Dermal[b]		RfC (mg/m^3) Inhalation		ABS_{GI} [a] (%)	Critical Effect
Metals															
Antimony	7440-36-0	NA		NA		NA		4.0E-04	I	6.0E-05	R	NA		15%	Longevity, blood glucose, and cholesterol
Arsenic	7440-38-2	1.5E+00	I	1.5E+00	R	4.3E-03	I	3.0E-04	I	3.0E-04	R	1.5E-05	C	95%	Dermal effects: Hyperpigmentation and keratosis
Cadmium, soil	7440-43-9	NA		NA		1.8E-03	I	1.0E-03	I	2.5E-05	R	1.0E-05	A	2.5%	Hematologic: proteinuria
Cadmium, water	7440-43-9	NA		NA		1.8E-03	I	5.0E-04	I	2.5E-05	R	1.0E-05	A	5%	Hematologic: proteinuria
Chromium, total	16065-83-1	NA		NA		NA		1.5E+00	I	2.0E-02	R	NA		1.3%	NA
Manganese	7439-96-5	NA		NA		NA		1.4E-01	I	5.6E-03	R	5.0E-05	I	4%	Neurological and neuro-behavioral effects
Molybdenum	7439-98-7	NA		NA		NA		5.0E-03	I	5.0E-03	I	NA		100%	Increased uric acid levels
Nickel	7440-02-0	NA		NA		2.6E-04	C	2.0E-02	I	8.0E-04	R	9.0E-05	A	4%	Decreased body and organ weights
Selenium	7782-49-2	NA		NA		NA		5.0E-03	I	1.5E-03	R	2.0E-02	C	30%	Clinical selenosis
Thallium	7440-28-0	NA		NA		NA		1.0E-05	P	1.0E-05	R	NA		100%	Increased levels of SGOT and LDH
Uranium	NA	NA		NA		NA		6.0E-04	E	6.0E-04	R	4.0E-05	A	100%	Body weight loss and moderate nephrotoxicity
Vanadium	NA	NA		NA		NA		5.0E-03	U	1.3E-04	R	1.0E-04	A	2.6%	Decreased hair cystine
Zinc	7440-66-6	NA		NA		NA		3.0E-01	I	3.0E-01	R	NA		NA	Decrease in ESOD activity

Sources:

A Agency for Toxic Substances and Disease Registry (ATSDR) minimal risk levels (ATSDR, 2013)
E Office of Environmental Assessment (EPA, 2008b)
I Integrated Risk Information System (IRIS) Database (EPA, 2013c).
P Provisional Peer Reviewed Toxicity Values (PPRTVs) as cited in EPA's RSL Table (EPA, 2013a)
U United States Regional Screening Levels (RSLs) (EPA, 2013a)
C CalEPA Toxicity Values as cited in EPA's RSL Table (EPA, 2013a)
R Route Extrapolation

Notes:

% = percent
µg/m3 = microgram(s) per cubic meter
ABSGI = oral absorption efficiencies
CSF = cancer slope factor
EPA = U. S. Environmental Protection Agency
ESOD = erythrocyte superoxide dismutase
IRIS = Integrated Risk Information System
LDH = lactate dehydrogenase
mg/kg-d = milligram(s) per kilogram per day
mg/m3 = milligram(s) per cubic meter
NA = not available
RfC = reference concentration
RfD = reference dose
SGOT = serum glutamic-oxaloacetic transaminase
URF = unit risk factor

[a] Values are from EPA RAGS Part E. Where no specific ABSGI is available, the ABSGI is assumed to be 100%. (EPA 2004)

[b] The following equations are used as recommended by EPA (2004) to estimate dermal CSF and RFDs from the ingestion toxicity values when ABSGI is less than 50 percent: Dermal RFD = Oral RfD x ABSGI and Dermal CSF = Oral SF/ABSGI. When ABSGI is greater than 50 percent, the dermal CSF and/or RfD is assumed to be equal to the oral CSF and/or RfD (EPA, 2004).

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Table A-3
Summary of RME Cumulative Risk Estimates for Human Receptors

	Current/Future Native American				Hypothetical Future Resident				Current/Future Seasonal Rancher				Current/Future Recreational Hunter & Current/Future Recreational Camper/Hiker			
	ILCR [a]	COCs [b]	HI [a]	COCs [b]	ILCR [a]	COCs [b]	HI [a]	COCs [b]	ILCR [a]	COCs [b]	HI [a]	COCs [b]	ILCR [a]	COCs [b]	HI [a]	COCs [b]
Upland Soil																
Site-Related	**4E-05**	As	1	--	**4E-05**	As	1	--	**1E-05**	As	0.6	--	<1E-06	--	< 1	--
Background	**1E-05**	As	0.2	--	**1E-05**	As	0.2	--	**3E-06**	As	0.08	--	<1E-06	--	< 1	--
Incremental	**3E-05**	As	1	--	**3E-05**	As	1	--	**8E-06**	As	0.5	--	<1E-06	--	< 1	--
Riparian Soil																
Site-Related	**1E-05**	As	0.9	--												
Background	**8E-06**	As	0.2	--												
Incremental	**3E-06**	As	0.7	--												
Culturally Significant Plant - Upland Soil[c]																
Site-Related	**2E-03**	As	**169**	As, Cd, Co, Mn, Sb, Se, Tl, U												
Background	**6E-03**	As	**135**	As, Cd, Co, Mn, Sb, Tl, U												
Incremental	--	--	**149**	Cd, Sb, Se, U												
Culturally Significant Plant - Riparian Soil[c]																
Site-Related	**5E-03**	As	**221**	As, Cd, Co, Mn, Mo, Ni, Sb, Se, Tl, V												
Background	**4E-03**	As	**142**	As, Co, Mn, Ni, Sb, Tl, V												
Incremental	**1E-03**	As	**93**	As, Cd, Mo, Ni, Se, Tl, V												
Aquatic Plant - Sediment[c]																
Site-Related	**6E-04**	As	**82**	As, Cd, Mn, Mo, Se, Zn												
Background	**2E-04**	As	**4**	Cd												
Incremental	**4E-04**	As	**77**	As, Cd, Se												
Fruits and Vegetables - Upland Soil and Groundwater[c,e,f]																
Site-Related					**2E-03**	As	**94**	As, Cd, Mo, Sb, Se, Tl								
Background					**6E-03**	As	**152**	As, Cd, Co, Mn, Mo, Ni, Sb, Se, Tl, V								
Incremental					--	--	**46**	Mo, Se, Tl								
Surface Water[d]																
Site-Related	**2E-06**	As	0.01	--												
Background	1E-07	--	0.0006	--												
Incremental	**2E-06**	As	0.009	--												
Groundwater[e]																
Site-Related					**3E-04**	As	**7**	As, Se, Tl	**6E-05**	As	**2**	--				
Background					**2E-05**	As	1	--	**4E-06**	As	0.01	--				
Incremental					**3E-04**	As	**6**	As, Se	**5E-05**	As	**2**	--				
Cattle - Upland Soil and Surface Water[d,g]																
Site-Related									**2E-04**	As	**44**	As, Co, Se, Tl				
Background									**5E-05**	As	**11**	Co, Tl				

Table A-3
Summary of RME Cumulative Risk Estimates for Human Receptors

	Current/Future Native American				Hypothetical Future Resident				Current/Future Seasonal Rancher				Current/Future Recreational Hunter & Current/Future Recreational Camper/Hiker			
	ILCR [a]	COCs [b]	HI [a]	COCs [b]	ILCR [a]	COCs [b]	HI [a]	COCs [b]	ILCR [a]	COCs [b]	HI [a]	COCs [b]	ILCR [a]	COCs [b]	HI [a]	COCs [b]
Incremental									**1E-04**	As	**34**	Se, Tl				
Cattle - Upland Soil and Groundwater[e,g]																
Site-Related									**2E-04**	As	**44**	As, Co, Se, Tl				
Background									**5E-05**	As	**11**	Co, Tl				
Incremental									**1E-04**	As	**34**	Se, Tl				
Site-Related Cumulative Risk	**5E-03**		**223**		**3E-03**		**103**		**3E-04**		**46**		**7E-7/1E-6**		**0.03/0.04**	
Background Cumulative Risk	**6E-03**		**142**		**6E-03**		**153**		**6E-05**		**11**		**3E-7/4E-7**		**0.005/0.006**	

Notes:

[a] Media-specific cumulative ILCR and HI for all COPCs

[b] Analytes with a chemical-specific Incremental RME ILCR or HQ greater than the EPA's risk management range and/or DEQ's acceptable risk criteria are listed as media-specific COCs.

[c] All media-specific COPCs were evaluated for the indirect pathways in addition to direct exposure pathways (i.e., ingestion, inhalation, and dermal contact) except sediment COPCs, which were evaluated through the indirect uptake to aquatic culturally significant plant pathway only. The indirect exposure route - ingestion of elk tissue - was not evaluated in the Tier II risk assessment due to the absence of excess Tier I risk or hazard.

[d] Dissolved concentration of metals in surface water was used in human health risk and hazard calculations for all analytes except for selenium, where the total surface water concentration was used.

[e] Total concentration of metals in groundwater was used in human health risk and hazard calculations for all analytes.

[f] The indirect exposure route - ingestion of fruits and vegetables grown in upland soil and irrigated with groundwater - was evaluated for all soil and groundwater COPCs. For an analyte that was a COPC in soil only, the measured non-culturally significant plant concentration, when available, was used to represent the fruits and vegetables concentration. If an analyte was a COPCs in groundwater, the fruits and vegetables exposure concentration was equal to the modeled concentration from groundwater plus either the measured non-culturally significant plant concentration when available, or the modeled concentration from soil. Fruit and vegetable COPCs from resulting from elevated measured metals concentrations plant tissue are indicated as COPCs in upland soil as well as in measured plants.

[g] The indirect exposure route - ingestion of cattle grazed on upland pasture - was evaluated with either surface or groundwater ingestion. Excess human health risk due to arsenic in cattle tissue resulted from both pasture and livestock drinking water.

Bold indicates exceedance of EPA's risk management range and/or DEQ's acceptable risk criteria.
COC = chemical of concern
COPC = chemical of potential concern
EPA = U.S. Environmental Protection Agency
HI = hazard index
HQ = hazard quotient
DEQ = Idaho Department of Environmental Quality
ILCR = Incremental lifetime cancer risk
RME = reasonable maximum exposure

Key:

As = arsenic
Cd = cadmium
Co = cobalt
Mn = manganese
Ni = nickel
Rn = radon
Se = selenium
Tl = thallium
U = uranium
V = vanadium
Zn = zinc

Table A-4
Assessment Endpoints and Indicator Receptors

Feeding Guild	Assessment Endpoint	Receptor	Measures of Exposure	Measures of Effect
2 ˚ Consumers Amphipians	Protect amphibians from acute and chronic adverse effects from direct and/or secondary exposure to metals resulting from phosphate mining activities.	Frog	Measured surface water COPEC concentrations	Compare measured surface water concentration with acceptable levels
1 ˚ Consumers Terrestrial Herbivore	Protect herbivorous mammals (avian and terrestrial predator prey items) by limiting acute and chronic adverse effects from exposure to metals resulting from phosphate mining activities.	Long-tailed Vole	Calculated daily dosage using exposure models, measured chemical concentrations in abiotic and biotic media, and food web interactions.	Compare calculated dose to NOAEL and LOAEL dosages for similar prey species.
	Protect large herbivorous mammals (game species) by limiting acute and chronic adverse effects from exposure to metals resulting from phosphate mining activities.	Elk	Calculated daily dosage using exposure models, measured chemical concentrations in abiotic and biotic media, and food web interactions.	Compare calculated dose to NOAEL and LOAEL dosages for similar species.
1 ˚ Consumers Avian Herbivore	Protect herbivorous bird species from acute and chronic adverse effects from direct and/or secondary exposure to metals resulting from phosphate mining activities.	American Goldfinch	Calculate daily dosage using exposure models, measured chemical concentrations in abiotic and biotic media, and food web interactions.	Compare calculated dose to NOAEL and LOAEL dosages for similar species.
2 ˚ Consumers Terrestrial Omnivore	Protect small omnivorous mammals (avian and terrestrial predator prey items) by limiting acute and chronic adverse effects from exposure to metals resulting from phosphate mining activities.	Deer Mouse	Calculated daily dosage using exposure models, measured chemical concentrations in abiotic and biotic media, and food web interactions.	Compare calculated dose to NOAEL and LOAEL dosages for similar species.
	Protect omnivorous mammals by limiting acute and chronic adverse effects from exposure to metals resulting from phosphate mining activities.	Raccoon	Calculated daily dosage using exposure models, measured chemical concentrations in abiotic and biotic media, and food web interactions.	Compare calculated dose to NOAEL and LOAEL dosages for similar prey species.

Table A-4
Assessment Endpoints and Indicator Receptors

Feeding Guild	Assessment Endpoint	Receptor	Measures of Exposure	Measures of Effect
2 ° Consumers Avian Omnivore	Protect omnivorous bird species from acute and chronic adverse effects from direct and/or secondary exposure to metals resulting from phosphate mining activities.	American Robin	Calculate daily dosage using exposure models, measured chemical concentrations in abiotic and biotic media, and food web interactions.	Compare calculated dose to NOAEL and LOAEL dosages for similar species.
	Protect omnivorous water bird species from acute and chronic adverse effects from direct and/or secondary exposure to metals resulting from phosphate mining activities.	Mallard	Calculate daily dosage using exposure models, measured chemical concentrations in abiotic and biotic media, and food web interactions.	Compare calculated dose to NOAEL and LOAEL dosages for similar species.
3 ° Consumers Terrestrial Predator	Protect upper trophic level aquatic feeding terrestrial species from acute and chronic adverse effects from direct and/or secondary exposure to metals resulting from phosphate mining activities.	Mink	Calculated daily dosage using exposure models, measured chemical concentrations in abiotic and biotic media, and food web interactions.	Compare calculated dose to NOAEL and LOAEL dosages for similar prey species.
	Protect upper trophic level terrestrial species from acute and chronic adverse effects from direct and/or secondary exposure to metals resulting from phosphate mining activities.	Coyote	Calculated daily dosage using exposure models, measured chemical concentrations in abiotic and biotic media, and food web interactions.	Compare calculated dose to NOAEL and LOAEL dosages for similar prey species.
3 ° Consumers Avian Predator	Protect upper trophic level aquatic feeding avian species from acute and chronic adverse effects from direct and/or secondary exposure to metals resulting from phosphate mining activities.	Great Blue Heron	Calculated daily dosage using exposure models, measured chemical concentrations in abiotic and biotic media, and food web interactions.	Compare calculated dose to NOAEL and LOAEL dosages for similar prey species.
	Protect upper trophic level avian species from acute and chronic adverse effects from direct and/or secondary exposure to metals resulting from phosphate mining activities.	Northern Harrier	Calculated daily dosage using exposure models, measured chemical concentrations in abiotic and biotic media, and food web interactions.	Compare calculated dose to NOAEL and LOAEL dosages for similar prey species.

Notes:
COPEC = chemical of potential ecological concern
LOAEL = lowest observed adverse effects level
NOAEL = no observed adverse effects level

Table A-5
Exposure Parameters for Ecological Receptors

Exposure Parameter	Long-Tailed Vole *Microtus longicaudus*	Elk *Cervus elaphus*	American Goldfinch *Spinus tristis*	Deer Mouse *Peromyscus maniculatus*	Raccoon *Procyon lotor*	American Robin *Turdus migratorius*	Mallard *Anas platyrhynchos*	Mink *Mustela vison*	Coyote *Canis latrans*	Great Blue Heron *Ardea herodias*	Northern Harrier *Circus cyaneus*
	Exposure Value										
Body Weight (g) [a]	37 [h,i]	2.9E+05 [k]	16 [m]	19.5 [h]	5,800 [h]	82.0 [h]	1,178 [h]	1,075 [h]	13,600 [p]	2,336 [h]	449 [t]
Fraction of Prey Items in Diet (%)											
Terrestrial											
Plant	100 [h,i]	100 [k]	100 [m]	61.5 [h]	64 [h]	44.7 [h]	0	0	2 [q]	0	0
Invertebrates	0	0	0	38.5 [h]	19 [h]	55.3 [h]	0	0	2 [q]	12.5 [o]	2 [t]
Mammals/Birds	0	0	0	0	9 [h]	0	0	63 [h]	96 [q]	12.5 [o]	98 [t]
Aquatic											
Plant	0	0	0	0	0	0	25.3 [h]	0	0	0	0
Invertebrates	0	0	0	0	7 [h]	0	74.7 [h]	6 [h]	0	0	0
Fish	0	0	0	0	1 [h]	0	0	31 [h]	0	75 [o]	0
Ingestion Rate of Prey (g dw/d) [b]	11.5	2,294	4.10	3.8	154	11	56	516	4,286	145	49
Soil/Sediment Ingestion Rate (g dw/d) [c]	0.276	45.9	0.426	0.076	14.5	1.10	1.86	48.51	120.01	1.0	0.34
Fraction of Upland Soil in the Diet (%)	2.40 [i,j]	2 [j]	10.4 [j,n]	2 [j,n]	0	10.4 [j,n]	0	0	2.8 [j,n]	0	0.7 [s]
Fraction of Riparian Soil in the Diet (%)	0	0	0	0	9.40 [j]	0	0	9.4 [j,n]	0	0	0
Fraction of /Sediment in the Diet (%)	0	0	0	0	0	0	3.3 [j]	0	0	0.7 [s]	0
Water Ingestion Rate (L/d) [d]	0.00512	16.1	0.00362	0.00286	0.482	0.011	0.066	0.106	1.037	0.10	0.034
Home Range (acres)	0.0659 [h,i]	16,640 [l]	0.119 [o]	0.270 [h]	2,272 [h]	0.7 [h]	1,074 [h]	50 [h]	7,240 [r]	11 [h]	642 [t]
Area being Evaluated (acres) [e]	SS	SS	SS	SS	SS	SS	SS	SS	SS	SS	SS
Site Utilization Factor (unitless) [f]	SS	SS	SS	SS	SS	SS	SS	SS	SS	SS	SS
Exposure Duration (percent of year) [g]	1	1	1 [m]	1	1	1	1	1	1	1	1

Notes:

[a] Average body weight for males and females combined.

[b] Calculated using Equations 25 (mink and coyote), 29 (elk), 33 (raccoon), 37 (passerines), 61 (American robin and mallard), and 63 (great blue heron and northern harrier) from Nagy (2001). The food ingestion rate for the long-tailed vole and deer mouse were based on values in Table 1 (Nagy, 2001) for meadow vole and deer mouse, respectively. The cattle food ingestion rate is based on beef cattle fodder intake rates from Risk Assessment Information System (ORNL) (2013).

[c] Calculated as percent soil ingestion rate multiplied by the food ingestion rate (g/d).

[d] Calculated using Equation 3-15 (all birds) and Equation 3-17 (all mammals) from EPA, 1993.

[e] Exposure area based on the total area of

[f] Site utilization factors are calculated as the exposure area divided by the home range. Instances where the home range > exposure area are reported as 1.

[g] Exposure duration (percent of year exposed) is assumed to be 1 for most species based on species range maps.

[h] Wildlife Exposure Factors Handbook (EPA, 1993).

[i] Meadow vole used as a surrogate species.

[j] Soil ingestion rates as percent of diet from Beyer (1994).

[k] Senseman, R. 2002. "Cervus elaphus." Animal Diversity Web. Accessed February 22, 2011. http://animaldiversity.ummz.umich.edu/site/accounts/information/Cervus_elaphus.html.

[l] An Evaluation of the Effects of Selenium on Elk, Mule Deer, and Moose in SE Idaho (Kuck, 2003).

[m] From Cornell Lab of Ornithology web site (www.birds.cornell.edu).

[n] The American woodcock was used as a surrogates for the American goldfinch and American Robin. The white footed mouse was used as a surrogate for the deer mouse. The raccoon was used as a surrogate for the mink. The red fox was used as a surrogate for the coyote.

[o] Life history account from Zeiner, D.C. et al. (1988-1990). Maintained by California Wildlife Habitat Relationship Program of the California Department of Fish and Wildlife. Accessed at https://www.wildlife.ca.gov/Data/CWHR/Life-History-and-Range.

[p] Idaho digital atlas: http://imnh.isu.edu/digitalatlas/bio/mammal/mamfram.htm

[q] MacCracken and Hansen. 1982. Seasonal Foods of Coyotes in Southeastern Idaho: A Multivariate Analysis.

[r] Mean coyote homerange for southeastern Idaho from Woodruff and Keller (1982).

s Sediment ingestion percent for bald eagle from Pascoe et al. (1996) as cited in the Area Wide Risk Management Plan for the Southeast Idaho Phosphate Mining Resource Area (DEQ, 2004a) were used to calculate the sediment ingestion rate for the great blue heron and northern harrier.

[t] Northern harrier average body weight reported in Slater and Rock (2005).

% = percent | dw = dry weight | L = liter
d = day | g = gram | SS = site-specific

Table A-6
Toxicity Reference Values for Mammalian Receptors

	TRV_{NOAEL}						UF			TRV_{LOAEL}						UF	
Analyte	Toxicity Value (mg/kg-dry)	Test Species	Study Endpoint	Type	Effects	Source	LOAEL to NOAEL	Subchronic to Chronic	TRV_{NOAEL} (mg/kg-dry)	Toxicity Value (mg/kg-dry)	Test Species	Study Endpoint	Type	Effects	Source	Subchronic to Chronic	TRV_{LOAEL} (mg/kg-dry)
Metals																	
Antimony	0.059	Rat	NOAEL	Chronic	Reproduction	EcoSSLs (Antimony)	1	1	0.0590	0.590	Rat	LOAEL	Chronic	Reproduction	EcoSSLs (Antimony)	1	0.590
Cadmium	0.770	Rat	NOAEL	Subchronic	Growth	EcoSSLs (Cadmium)	1	1	0.770	0.909	Sheep	LOAEL	Subchronic	Growth	EcoSSLs (Cadmium)	1	0.909
Chromium	2.40	Cattle, Mouse, Pig, Rat,	NOAEL	Chronic	Growth [b]	EcoSSLs (Chromium)	1	1	2.40	2.82	Rat	LOAEL	Subchronic	Survival	EcoSSLs (Chromium)	1	2.82
Copper	5.60	Pig	NOAEL	Subchronic	Growth	EcoSSLs (Copper)	1	1	5.60	6.79	Mink	LOAEL	Subchronic	Reproduction	EcoSSLs (Copper)	1	6.79
Molybdenum	0.260	Mouse	NOAEL	Chronic	Reproduction	ORNL 1996	1	1	0.260	2.60	Mouse	LOAEL	Chronic	Reproduction	ORNL 1996	1	2.60
Nickel	1.70	Mouse	NOAEL	Subchronic	Reproduction	EcoSSLs (Nickel)	1	1	1.70	2.71	Mouse	LOAEL	Subchronic	Reproduction	EcoSSLs (Nickel)	1	2.71
Selenium	0.143	Pig	NOAEL	Subchronic	Growth	EcoSSLs (Selenium)	1	1	0.143	0.145	Mouse	LOAEL	Subchronic	Reproduction	EcoSSLs (Selenium)	1	0.145
Thallium	0.00740	Rat	NOAEL	Subchronic	Growth	ORNL 1996	1	2	0.00370	0.074	Rat	LOAEL	Subchronic	Growth	ORNL 1996	2	0.0370
Vanadium	4.16	Mouse	NOAEL	Chronic	Growth	EcoSSLs (Vanadium)	1	1	4.16	5.11	Rat	LOAEL	Subchronic	Growth	EcoSSLs (Vanadium)	1	5.11
Zinc	75.4	Various	NOAEL	Chronic	Growth and Reproduction [a]	EcoSSLs (Zinc)	1	1	75.4	75.9	Cattle	LOAEL	Subchronic	Reproduction	EcoSSLs (Zinc)	1	75.9

Notes:
[a] Geometric mean of NOAEL and LOAEL values for growth and reproduction were calculated as the TRV_{NOAEL} and TRV_{LOAEL} values, respectively.
[b] Geometric mean of NOAEL values for growth were calculated as the TRV_{NOAEL}.

Sources
EcoSSLs (Antimony) = Ecological Soil Screening Levels for Antimony (EPA, 2005a).
EcoSSLs (Cadmium) = Ecological Soil Screening Levels for Cadmium (EPA, 2005b).
EcoSSLs (Chromium) = Ecological Soil Screening Levels for Chromium (EPA, 2008a).
EcoSSLs (Copper) = Ecological Soil Screening Levels for Copper (EPA, 2007a).
EcoSSLs (Nickel) = Ecological Soil Screening Levels for Nickel (EPA, 2007b).
EcoSSLs (Selenium) = Ecological Soil Screening Levels for Selenium (EPA, 2007c).
EcoSSLs (Vanadium) = Ecological Soil Screening Levels for Vanadium (EPA, 2005c).
EcoSSLs (Zinc) = Ecological Soil Screening Levels for Zinc (EPA, 2007d).
ORNL 1996 = Toxicological Benchmarks for Wildlife: 1996 Revision (ORNL, 1996a).

EcoSSLs = Ecological Soil Screening Levels
LOAEL = lowest observed adverse effect level
UF = uncertainty factor

mg/kg-dry = milligram(s) per kilogram dry weight
NOAEL = no observed adverse effect level
TRV = toxicity reference value

Table A-7
Toxicity Reference Values for Avian Receptors

	TRV_{NOAEL}										TRV_{LOAEL}								
							UF										UF		
Analyte	Toxicity Value (mg/kg-dry)	Test Species	Study Endpoint	Type	Effects	Source	Acute LD_{50} to chronic NOAEL	LOAEL to NOAEL	Subchronic to Chronic	TRV_{NOAEL} [a] (mg/kg-dry)	Toxicity Value (mg/kg-dry)	Test Species	Study Endpoint	Type	Effects	Source	Acute LD_{50} to chronic LOAEL	Subchronic to Chronic	TRV_{LOAEL} (mg/kg-dry)
Metals																			
Antimony	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Cadmium	1.47	Chicken, Mallard duck	NOAEL	Chronic	Growth and Reproduction [a]	EcoSSLs (Cadmium)	1	1	1	1.47	2.37	Chicken	LOAEL	Subchronic	Reproduction	EcoSSLs (Cadmium)	1	1	2.37
Chromium	2.66	Chicken, Duck, Turkey	NOAEL	Chronic	Growth and Reproduction [a]	EcoSSLs (Chromium)	1	1	1	2.66	2.78	Duck	LOAEL	Subchronic	Reproduction	EcoSSLs (Chromium)	1	1	2.78
Copper	4.05	Chicken	NOAEL	Chronic	Reproduction	EcoSSLs (Copper)	1	1	1	4.05	4.68	Turkey	LOAEL	Subchronic	Growth	EcoSSLs (Copper)	1	1	4.68
Molybdenum	3.50	Chicken	NOAEL	Chronic	Reproduction	ORNL 1996	1	1	1	3.50	35.3	Chicken	LOAEL	Chronic	Reproduction	ORNL 1996	1	1	35.3
Nickel	6.71	Chicken, Duck	NOAEL	Chronic	Growth and Reproduction [a]	EcoSSLs (Nickel)	1	1	1	6.71	11.5	Chicken	LOAEL	Subchronic	Growth	EcoSSLs (Nickel)	1	1	11.5
Selenium	0.290	Chicken	NOAEL	Subchronic	Survival	EcoSSLs (Selenium)	1	1	1	0.290	0.368	Chicken	LOAEL	Subchronic	Reproduction	EcoSSLs (Selenium)	1	1	0.368
Thallium	34.6	Starling	LD_{50}	Acute	Mortality	Schafer 1983	100	1	1	0.346	34.6	Starling	LD_{50}	Acute	Mortality	Schafer 1983	10	1	3.46
Vanadium	0.344	Chicken	NOAEL	Subchronic	Growth	EcoSSLs (Vanadium)	1	1	1	0.344	0.413	Chicken	LOAEL	Subchronic	Reproduction	EcoSSLs (Vanadium)	1	1	0.413
Zinc	66.1	Chicken, Mallard duck, Japanese Quail, Turkey	NOAEL	Chronic	Growth and Reproduction [a]	EcoSSLs (Zinc)	1	1	1	66.1	66.5	Chicken	LOAEL	Subchronic	Reproduction	EcoSSLs (Zinc)	1	1	66.5

Notes:
[a] Geometric mean of NOAEL and LOAEL values for growth and reproduction were calculated as the TRV_{NOAEL} and TRV_{LOAEL} values, respectively.
[b] Geometric mean of NOAEL values for growth were calculated as the TRV_{NOAEL}.

Sources
EcoSSLs (Cadmium) = Ecological Soil Screening Levels for Cadmium (EPA, 2005b).
EcoSSLs (Chromium) = Ecological Soil Screening Levels for Chromium (EPA, 2008a).
EcoSSLs (Copper) = Ecological Soil Screening Levels for Copper (EPA, 2007a).
EcoSSLs (Nickel) = Ecological Soil Screening Levels for Nickel (EPA, 2007b).
EcoSSLs (Selenium) = Ecological Soil Screening Levels for Selenium (EPA, 2007c).
EcoSSLs (Vanadium) = Ecological Soil Screening Levels for Vanadium (EPA, 2005c).
EcoSSLs (Zinc) = Ecological Soil Screening Levels for Zinc (EPA, 2007d).
ORNL 1996 = Toxicological Benchmarks for Wildlife: 1996 Revision (ORNL, 1996a).

EcoSSLs = Ecological Soil Screening Levels
LC50 = lethal concentration to 50% of test population
LOAEL = lowest observed adverse effect level
mg/kg-dry = milligram(s) per kilogram dry weight
NOAEL = no observed adverse effect level
TRV = toxicity reference value
UF = uncertainty factor

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Table A-8
Ecological Hazard Calculations for Amphibians

COPEC	Surface Water Exposure Point Concentration [a] (mg/L)	Water Quality Criteria: National Standards Aquatic Life [b] (mg/L)	Water Quality Criteria: Tier II SCV [c] (mg/L)	Water Quality Criteria: Final Water Quality Criteria [d]	HQ
Barium, dissolved	0.0416	--	0.0040	0.0040	**10**
Boron, dissolved	0.0299	--	0.0016	0.0016	**19**
Cadmium, dissolved	0.000406	0.00025 [e]	--	0.00025	**1.6**
Manganese, dissolved	0.307	--	0.12	0.12	**2.6**
Selenium, total	0.506	0.0050 [f]	--	0.0050	**101**
Uranium, dissolved	0.0100	--	0.0026	0.0026	**3.8**

Notes:

[a] The surface water exposure point concentrations are equal to the lower of the maximum detected
[b] National Recommended Water Quality Criteria (EPA, 2013a); Freshwater CCC listed for all
[c] Tier II Secondary Chronic Value. Source: ORNL, 1996a.

[d] The final water quality criteria were obtained from the following hierarchy: (1) National Recommended Water Quality Criteria (EPA, 2013a) and (2) Tier II Secondary Chronic Value (ORNL, 1996a).
[e] The freshwater criterion for this metal is expressed as a function of hardness in the water column.
[f] The CMC = 1/[(f1/CMC1)+(f2/CMC2)] where f1 and f2 are the fractions of total selenium that are treated as selenite and selenate, respectively, and CMC1 and CMC2 are 0.1859 mg/L and 0.01282 mg/L, respectively.

"- -" = not available
CCC = Criterion Continuous Concentration
CMC = Criteria Maximum Concentration
COPEC = chemical of potential ecological concern
HQ = hazard quotient
mg/L = milligram(s) per liter
SCV = secondary chronic value

Table A-9
Contaminants of Ecological Concern

	Long-Tailed Vole	Elk	American Goldfinch	Deer Mouse	Raccoon	American Robin	Mallard	Mink	Coyote	Great Blue Heron	Northern Harrier
NOAEL-Based Ecological Hazard Estimates											
Site - Related:											
Hazard Range	< 0.1 - 91	--	< 0.1 - 44	< 0.1 - 47	< 0.1 - 1.2	< 0.1 - 16	< 0.1 - 8.5	< 0.1 - 96	< 0.1 - 1.4	< 0.1 - 9.0	< 0.1 - 1.3
COECs [a]	Cr Mo Ni Sb Se Tl	--	Cr Mo Se V	Cd Cr Mo Ni Sb Se Tl	Se	Cd Cr Cu Ni Se V Zn	Se V	Cd Cr Cu Mo Ni Sb Se Tl V Zn	Mo	Cd Se V	Se
Background:											
Hazard Range	< 0.1 - 2.6	--	< 0.1 - 2.0	< 0.1 - 4.3	< 0.1 - 0.17	< 0.1 - 1.3	< 0.1 - 0.12	< 0.1 - 25	< 0.1 - 0.24	< 0.1 - 0.39	< 0.1 - 0.21
COECs [a]	Mn Mo Se Tl	--	V	Cd Mo Ni Tl	--	Cd V	--	Cr Cu Ni Sb Se Tl	--	--	--
LOAEL-Based Ecological Hazard Estimates											
Site - Related:											
Hazard Range	< 0.1 - 90	--	< 0.1 - 34	< 0.1 - 46	< 0.1 - 1.2	< 0.1 - 13	< 0.1 - 6.7	< 0.1 - 94	< 0.1 - 0.76	< 0.1 - 7.1	< 0.1 - 1.1
COECs [a]	Cr Mo Ni Se Tl	--	Cr Se V	Cd Cr Mo Ni Se Tl	Se	Cd Cr Ni Se V Zn	Se	Cd Cr Cu Mo Ni Sb Se Tl V Zn	--	Se V	Se
Background:											
Hazard Range	< 0.1 - 1.5	--	< 0.1 - 1.6	< 0.1 - 2.2	< 0.1 - 0.031	< 0.1 - 0.96	< 0.1 - 0.096	< 0.1 - 2.9	< 0.1 - 0.080	< 0.1 - 0.34	< 0.1 - 0.18
COCs [a]	Mn Se	--	--	Cd	--	--	--	Cr Cu Ni Sb Se Tl	--	--	--

Notes:

[a] Contaminants of ecological concern (COECs) are analytes for which an analyte-specific greater than EPA's and DEQ's acceptable criterion of 1 was calculated.

< = less than
-- = not applicable
DEQ = Idaho Department of Environmental Quality
LOAEL = lowest observed adverse effects level
NOAEL = no observed adverse effects level
EPA = United States Environmental Protection Agency

Cd = cadmium
Cr = chromium
Cu = copper
Mo = molybdenum
Ni = nickel

Sb = antimony
Se = selenium
Tl = thallium
V = vanadium
Zn = zinc

Appendix B
Summary of Federal and State ARARs for the Selected Remedy at the Ballard Mine

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Appendix B. Summary of Federal and State ARARs and TBCs for the Selected Remedy at the Ballard Mine, Caribou County, Idaho

Medium	Type of ARAR[c]	Requirement[a]	Status	Synopsis of Requirement	Action to be Taken to Attain Requirement
Surface Water	Chemical-specific	National Recommended Water Quality Criteria[d] (33 U.S.C. § 1314(a) and 40 CFR Part 131)	Relevant and Appropriate	Under Section 304(a) of the Clean Water Act, EPA establishes National Recommended Water Quality Criteria that are protective of aquatic life and human health. Under CERCLA, water quality criteria for the protection of aquatic life are considered relevant and appropriate for actions that involve releases to surface waters or groundwater discharges to surface waters. The National Recommended Water Quality Criterion for selenium, published in 2016, provides the basis for the surface water cleanup level for selenium.	The Selected Remedy includes actions to be taken to achieve surface water cleanup levels. The Selected Remedy includes a combination of components that will work together to meet cleanup levels, including source controls (cover system), water treatment (engineered wetland treatment cells), implementation of BMPs, and other actions.
Surface Water	Action-specific	CWA (Sect. 402 NPDES)(33 U.S.C. § 1342) and implementing regulations (40 CFR Parts 122-125)	Relevant and Appropriate	The NPDES (also known as Section 402 of the CWA) program establishes a comprehensive framework for addressing waste water and storm water discharges under the program. Requires that point-source discharges not cause the exceedance of surface water quality standards outside the mixing zone. Specifies requirements under 40 CFR § 122.26 for point-source discharge of storm water from construction sites to surface water and provides for BMPs such as erosion control for removal and management of sediment to prevent run-on and run-off.	The Selected Remedy will comply with these regulations through implementation of actions to control discharges of pollutants from point sources to waters of the United States. Contaminated water discharging at springs and seeps will be collected and treated using engineered wetland treatment cells. Other elements of the remedy will also control releases, including construction of the cover system and implementation of stormwater BMPs. Discharges of treated effluent and runoff are expected to meet surface water cleanup levels where discharges enter waters of the United States.

Medium	Type of ARAR[c]	Requirement[a]	Status	Synopsis of Requirement	Action to be Taken to Attain Requirement
Surface Water	Chemical-specific	Idaho Water Quality Standards (IDAPA 58.01.02)	Applicable	The State of Idaho has established surface water quality standards that designate uses of the waters of the state and establish standards of water quality protective of those uses. These rules also restrict the discharge of wastewaters that may adversely affect water quality. The rules include many components: water quality criteria for aquatic life use designations (.250), designations of surface waters found within Blackfoot Basin (.150), general surface water quality criteria (.200), numeric criteria for toxic substances (.210), antidegredation policy (.051), and mixing zone policy (.060). The cleanup level for cadmium in surface water is based on these requirements. Other components of the rules that are ARARs for other components of the remedy are listed below.	The Selected Remedy will comply with these regulations through implementation of actions that will control releases of contaminants to surface water above cleanup levels. Specific actions to control releases include: construction of the cover system, BMPs, treatment of springs and seeps using engineered wetland treatment cells, and other measures. The Selected Remedy will achieve the surface water cleanup levels at the point where discharges of treated effluent enter waters of the United States and in downstream waters.
Surface Water	Chemical-specific	Letter to Barry Burnell, DEQ, from Daniel Opalski, EPA Region 10, dated September 15, 2016, Re: EPA Disapproval of Idaho's Arsenic Human Health Water Quality Criteria, and follow-up letter to Barry Burnell, DEQ, from Daniel Opalski, EPA Region 10, dated September 27, 2016, Re: Arsenic Human Health Water Quality Standards for Surface Waters in Idaho.	TBC	In 2016, EPA disapproved the State of Idaho's existing water quality criterion for arsenic. This letter provides guidance on protective levels of arsenic in surface water that EPA recommends using until the State of Idaho promulgates and EPA approves a revised criterion. The cleanup level for arsenic in surface water is based on this guidance.	The Selected Remedy includes actions to be taken to achieve surface water cleanup levels. The Selected Remedy includes a combination of components that will work together to meet cleanup levels, including source controls (cover system), water treatment (engineering wetland treatment cells), implementation of BMPs, and other actions. The Selected Remedy will achieve the surface water cleanup levels at the point where discharges of treated effluent enter waters of the U.S. and in downstream waters.

Medium	Type of ARAR[c]	Requirement[a]	Status	Synopsis of Requirement	Action to be Taken to Attain Requirement
Surface Water	Action-specific	Idaho Water Quality Standards, Rules Governing Point Source Discharges (IDAPA 58.01.02.400) and Idaho Water Quality Standards, Point Source Wastewater Treatment Requirements (IDAPA 58.01.02.401)	Applicable	This portion of the Idaho Water Quality Standards provides limits and restrictions on point source discharges, including limits on turbidity and temperature for wastewaters discharged into surface waters of the state.	The Selected Remedy will comply with these regulations by implementing remedial actions that control discharges of contaminants from point sources to the intermittent streams near the Site. Point source discharges may be associated with remedial features such as sediment control ponds and engineered wetland treatment cells. Points of compliance will be determined during remedial design and monitored for compliance with surface water quality standards once the remedial features are constructed and operating.
Surface Water	Action-specific	Idaho Water Quality Standards, Rules Governing Nonpoint Source Activities (IDAPA 58.01.02.350)	Applicable	This portion of the Idaho Water Quality Standards provides the policy and procedures for regulating nonpoint source activities. It also designates approved BMPs by reference, including for example the "Rules Governing Exploration, Surface Mining, and Closure of Cyanidation Facilities," (IDAPA 20.03.02) and other rules.	The Selected Remedy will comply with these regulations by implementing remedial actions that control nonpoint source activities and associated nonpoint source discharges of contaminants to the intermittent streams near the Site. Nonpoint source discharges would typically occur during remedy implementation, including construction of access roads and the cover system (before the vegetation is established). The selected remedy will comply with these requirements by implementing BMPs and actions to stabilize construction areas and control runoff. Specific BMPs will be specified during remedial design and refined as necessary during remedy implementation. Water quality monitoring and surveillance will be implemented

Medium	Type of ARAR[c]	Requirement[a]	Status	Synopsis of Requirement	Action to be Taken to Attain Requirement
Surface Water and Aquatic Resources	Location-specific and Action-specific	Clean Water Act Section 404 (33 U.S.C. § 1344) and implementing regulations (40 CFR Part 230)	Relevant and Appropriate	Section 404 of the CWA establishes a program to regulate the discharge of dredge to fill materials in the waters of the United States, including wetlands. The substantive provisions of this requirement are relevant and appropriate to remedial actions involving dredging, filling, diversion, and/or any construction activity in stream or wetlands at the Site.	These provisions are relevant to any work effecting wetlands, intermittent streams and other waters of the U.S. at the site. Impacts to wetlands were considered during the remedy selection process, particularly with respect to selection of remedy components for sediment and riparian soil. In addition, during remedial design and remedial action, potential impacts to wetlands will be further considered for discrete elements of the design. As various components of the remedy are sited, such as access roads, culverts, engineered wetland treatment cells, and other facilities during design, the project team will evaluate opportunities to avoid and minimize impacts to wetlands. If impacts cannot be avoided, wetland impacts will be mitigated.
Surface Water and Aquatic Resources	Location-specific and Action-specific	Considering Wetlands at CERCLA Sites (EPA Publication 9280.0-03, May 1994)	TBC	EPA guidance regarding the potential impacts of response actions on wetlands at Superfund sites.	Impacts to wetlands were considered during the remedy selection process, particularly with respect to selection of remedy components for sediment and riparian soil. In addition, this guidance may be useful during remedial design and remedial action. As various components of the remedy are sited, such as access roads, engineered wetland treatment cells, and other facilities during design, the project team will evaluate opportunities to avoid and minimize impacts to wetlands. If impacts cannot be avoided, wetland impacts will be mitigated.
Ground Water	Chemical-specific	National Primary Drinking Water Regulations (40 CFR Part 141)	Relevant and Appropriate	Groundwater at the Site is a potential source of drinking water. Under the Safe Drinking Water Act, EPA establishes health-based standards (MCLs and MCLGs) for public water systems. MCLs provide the basis for groundwater cleanup levels for selenium, arsenic, and cadmium. Secondary MCLs, which are not health-based but rather are based on aesthetic criteria, are not ARARs at the Site.	The Selected Remedy includes actions to be taken to achieve groundwater cleanup levels. Groundwater cleanup levels will be met in all areas of the Site where groundwater is a potential source of drinking water. The Selected Remedy includes a combination of components to meet cleanup levels, including construction of a cover system over source materials, treatment of groundwater using permeable reactive barriers, and use of monitoring natural attenuation, as needed, as a polishing step. In the short-term, until source controls and treatment are operational and effective, institutional controls will be used to restrict use of groundwater.

Medium	Type of ARAR[c]	Requirement[a]	Status	Synopsis of Requirement	Action to be Taken to Attain Requirement
Ground Water	Chemical-specific	Idaho Ground Water Quality Rule (IDAPA 58.01.11.200)	Applicable	The State of Idaho has established the Ground Water Quality Rule which identifies minimum requirements for protection of ground water quality through standards and an aquifer categorization process. The rules include standards for the protection of human health. The cleanup levels for selenium, arsenic and cadmium in groundwater are based on these requirements.	The Selected Remedy includes actions to be taken to achieve groundwater cleanup levels. These actions include construction of an ET cover system over source materials, treatment of groundwater using permeable reactive barriers, and use of monitoring natural attenuation, as needed, as a polishing step. It is expected to take 10+ years after the ET cover system is constructed to achieve groundwater cleanup levels. In the shorter-term, until source controls and treatment are operational and effective, institutional controls would be used to restrict use of groundwater.
Surface Water And Ground Water	Chemical-specific	Idaho Rules for Public Drinking Water Systems (IDAPA 58.01.08)	Applicable and/or Relevant and Appropriate	The State of Idaho has established rules to control and regulate the design, construction, operation, and quality control of public drinking water systems. These rules include health-based standards, or MCLs, to protect consumers using public drinking water systems. The MCLs are relevant and appropriate for surface water and groundwater at the Site and provide a basis for the groundwater cleanup levels for selenium, arsenic, and cadmium.	The Selected Remedy includes actions to be taken to achieve groundwater cleanup levels. These actions include construction of an ET cover system over source materials, treatment of groundwater using permeable reactive barriers, and use of monitoring natural attenuation, as needed, as a polishing step. It is expected to take 10+ years after the ET cover system is constructed to achieve groundwater cleanup levels. There are currently no public water systems at the Site that use impacted groundwater. Institutional controls will be used to restrict use of water as a potable water supply source until cleanup levels are achieved.
Ground Water	Action-specific	Idaho Well Construction Standards Rules (IDAPA 37.03.09)	Applicable	The State of Idaho has established rules providing minimum standards for the construction of all new wells and the modification and decommissioning (abandonment) of existing wells.	The Selected Remedy will comply with the substantive requirements of this regulation. The particular portions of the selected remedy to which this ARAR is applicable will be identified through the remedial design process, including any identified future site investigation activity.
Cultural Resources	Location-specific	National Historic Preservation Act (NHPA) [16 U.S.C. 470], and implementing regulations [36 CFR Part 800, 40 CFR 6.301(b)]	Applicable	Statute and implementing regulations require federal agencies to take into account the effect of a response action upon any district, site, building, structure, or object included in or eligible for the National Register of Historic Places (generally, 50 or more years old). NHPA requires federally funded projects to assess if cultural resources on or eligible for the National Register are present, determine if there will be an adverse effect and, if so, how the effect may be minimized/mitigated, in consultation with the appropriate State Historic Preservation Office.	Should NHPA issues arise during remedial design and action, they will be handled in compliance with this regulation. It is possible the mine itself or remnants of the first mining activities are of historic interest; however, no property/resources at the Site are currently included in the National Register and no building in the project area was constructed prior to 1950, a date typically used as an initial screen for determining eligibility for the Register.

Medium	Type of ARAR[c]	Requirement[a]	Status	Synopsis of Requirement	Action to be Taken to Attain Requirement
Cultural Resources	Location-specific	Archeological and Historic Preservation Act (52 USC 312501 et seq.) and implementing regulations	Applicable	For areas designated as historic sites, the RA should avoid undesirable impacts on landmarks and encourage the long-term preservation of nationally significant properties that illustrate or commemorate the history/prehistory of the US. In conducting an environmental review of a proposed action, the responsible official shall consider the existence and location of natural landmarks using information provided by the National Park Service pursuant to 36 CFR § 62.6(d) to avoid undesirable impacts on such landmarks.	The particular portions of the selected remedy to which this ARAR is applicable would be identified and complied with during the remedial design process. Previous archeological surveys of the property have not demonstrated any significant historic or cultural landmarks. A cultural resource survey will be completed for any portions of the Site not already surveyed.
Cultural Resources	Location-specific	Executive Order 11593 Protection and Enhancement of the Cultural Environment [36 CFR 8921]	Applicable	Requires federal agencies to consider the existence and location of potential and existing cultural landmarks to avoid undesirable impacts on them.	Applicability will be determined in conjunction with NHPA and other cultural resource statutes and regulations.
Cultural Resources	Location-specific	Archaeological and Historic Preservation Act (AHPA) [16 U.S.C. 469], and implementing regulations [40 CFR 6.301(c)] Archaeological Resources Protection Act of 1979, as amended 1988 [16 U.S.C. 470aa-470mm]	Applicable	The statutes and implementing regulations require federally approved projects to evaluate and preserve significant scientific, prehistoric, historic, and archaeological data which may be irreparably lost or destroyed through alteration of terrain as a result of a federal construction project or a federally licensed activity or program. The data must be preserved by the agency undertaking the project, or the Department of the Interior if requested by the agency.	The particular portions of the Selected Remedy to which this ARAR is applicable would be identified and complied with during the remedial design process.
Cultural Resources	Location-specific	Native American Graves Protection and Repatriation Act (NAGPRA) [25 U.S.C. §§ 3001 et seq.]	Relevant and Appropriate	Requires federal agencies and institutions that receive federal funding to return Native American cultural items to lineal descendants and culturally affiliated Indian tribes. NAGPRA also establishes procedures for the inadvertent discovery or planned excavation of Native American cultural items on federal or tribal lands.	The particular portions of the Selected Remedy to which this ARAR is applicable would be identified and complied with during the remedial design process.

Medium	Type of ARAR[c]	Requirement[a]	Status	Synopsis of Requirement	Action to be Taken to Attain Requirement
Cultural Resources	Location-specific	Idaho Preservation of Historical Sites (Idaho Code §§ 67-4111 to -4131 and 67- 4601 to -4619)	Applicable	Requirements for protection of public lands and preservation of historical or archaeological sites in consideration of waste disposal.	If historical or archeological sites are detected during remedial construction, the particular portions of the selected remedy to which this ARAR is applicable would be identified and complied with during the remedial design process. However, site activities are not anticipated to trigger compliance during the selected remedial action.
Waste	Chemical-specific and Action-specific	Uranium Mill Tailings Radiation Control Act (UMTRCA)— (42 U.S.C. §§ 7901 et seq.) and implementing regulations: Health and Environmental Protection Standards for Uranium and Thorium Mill Tailings, Subpart A – Standards for the Control of Residual Radioactive Materials from Inactive Uranium Processing Sites (40 CFR Part 192.02 (a))	Relevant and Appropriate	The Subpart A standards include design requirements for remedial actions at inactive uranium processing sites. The portion of the standards that is relevant and appropriate is the design standard requiring that control of residual radioactive materials and their listed constituents be designed to be effective for at least 200 years.	The selected remedy will comply with this requirement during remedial design by including design criteria for source controls, in particular for the ET cover system. The ET cover system will be designed to contain and prevent direct exposure to waste rock, which contain naturally occurring uranium and daughter products.
Waste	Action-specific	Resource Conservation and Recovery Act – Subtitle D [42 U.S.C. 6901 et seq.] and implementing regulations, Solid Waste, Criteria for Classification of Solid Waste Disposal Facilities and Practices [40 CFR 257]	Relevant and Appropriate	These regulations establish a framework for management of nonhazardous solid waste. The regulations include criteria for determining which solid waste disposal practices pose threats to human health and the environment, and control impacts to floodplains, endangered species, surface water, and groundwater. Relevant criteria may be useful for siting and design of a disposal facility.	Substantive provisions of the solid waste requirements will be identified and complied with during the remedial design process.

Medium	Type of ARAR[c]	Requirement[a]	Status	Synopsis of Requirement	Action to be Taken to Attain Requirement
Waste	Action-specific	RCRA: Subtitle D – Disposal of Nonhazardous Solid Waste [42 U.S.C. 6901 et seq., 40 CFR Part 258]	Relevant and Appropriate	Provides criteria for cover material, run-on/runoff control systems, access control, restrictions on disposal of liquid wastes.	Remedial cover design for the selected remedy will incorporate substantive features to control run on/off, site access, and disposal of liquid wastes in accordance with this regulation. Attainment will require careful implementation of these features during remedial construction.
Waste	Action-specific	Idaho Best Management Practices and Reclamation for Surface Mining Operations (IDAPA 20.03.02.140)	Applicable and/or Relevant and Appropriate	Provides requirements for design, construction and maintenance of BMPs and standards for reclamation of surface mining operations, including standards pertaining to nonpoint source controls, sediment controls, clearing and grubbing, overburden/topsoil management, roads, backfilling and grading, waste disposal, settling ponds, and revegetation.	The Selected Remedy will comply with these requirements during design and implementation of the remedy. During remedial design, appropriate design criteria will be developed to comply with the substantive portions of the regulations. During implementation of the remedial action, tasks will be implemented to comply with BMP requirements and reclamation standards for the various components of the remedy.
Waste	Action-specific	Idaho Solid Waste Management Rules (IDAPA 58.01.06)	Relevant and Appropriate	Provides substantive requirements for operation and closure of solid waste management facilities.	Only material uniquely associated with phosphate mining is being addressed in remediation, so these requirements are not applicable because the Site is not a solid waste management facility. See IDAPA 58.01.06.001.03(b)(iv). Some requirements may be relevant and appropriate with regard to regulated solid waste generated during the remedial action.
Hazardous Waste	Action-specific	Resource Conservation and Recovery Act (RCRA): Subtitle C – Exemption for Extraction, Beneficiation, and Processing Mining Waste [40 CFR 261.4(b)(7)]	Applicable	These provisions exempt mining wastes from the extraction, beneficiation, and some processing of ores and minerals from the RCRA Subtitle C requirements, in accordance with the Bevill amendment to RCRA.	No action needed. The waste rock at the Ballard Site is exempt from the Subtitle C requirements. If non-exempt wastes are encountered during remediation, then management of such wastes would comply with other ARARs.
Hazardous Waste	Action-specific	RCRA- Requirements for Hazardous Waste Transport 42 U.S.C §§ 6901 *et seq.* 40 CFR Parts 261-262	Relevant and Appropriate	Requirements for handling and transporting hazardous waste.	The Selected Remedy will comply with the requirements for transport of hazardous waste during implementation of the selected remedy. Although no hazardous wastes have been identified or anticipated, if hazardous wastes are encountered (e.g. removal and disposal of spent media from the PRBs) they would be handled and transported appropriately.

Medium	Type of ARAR[c]	Requirement[a]	Status	Synopsis of Requirement	Action to be Taken to Attain Requirement
Hazardous Waste	Action--specific	Resource Conservation and Recovery Act (RCRA): (40 CFR § 261.20)	Applicable	Generators of solid waste must determine whether the waste is hazardous. A solid waste is hazardous if it exhibits the toxicity characteristic (based on extraction procedure Method 1311).	The selected remedy addresses the source material as mining wastes that fall under the Bevill Amendment. For these mining wastes, no action is necessary. If other wastes are identified or generated during remedy implementation (such as spent reactive media from wetland treatment cells or PRBs), processes for characterization will be developed. Results of characterization will guide decisions on appropriate disposal methods.
Hazardous Waste	Action-specific	Hazardous Waste Operations and Emergency Response [29 CFR 1910.120, 40 CFR 311]	Applicable	Worker protection during hazardous waste cleanup and CERCLA removal actions	The selected remedy will incorporate work protection criteria to be in compliance with this regulation. Provisions will be identified during pre-design and construction planning activity.
Hazardous Waste	Chemical-specific	Idaho Rules and Standards for Hazardous Waste (IDAPA 58.01.05)	Relevant and Appropriate	Rules and standards for hazardous waste. Identifies characteristic and listed hazardous wastes and provides rules for hazardous waste permits	If hazardous waste is identified or generated during implementation of the selected remedy, (for example, removal and replacement of PRB media if such waste material meets the definition of hazardous waste) remedial design will identify the appropriate process for handling it in compliance with this regulation.
Hazardous Waste	Action-specific	Idaho Hazardous Waste and Hazardous Waste Management Act of 1983 (IDAPA 58.01.05 1993 Session Law, Ch. 291, Sections 1-8)	Applicable	Adopts federal RCRA regulations concerning the identification of hazardous waste and standards applicable to generators and transporters of hazardous waste as well as standards for owners and operators of hazardous waste treatment, storage and disposal facilities.	The selected remedy will comply with hazardous waste regulations. The particular portions of the selected remedy to which this ARAR is applicable will be identified and complied with through the remedial design process and implemented during construction activities at the Site.
Hazardous Waste	Action-specific	Idaho Storage of Hazardous and Deleterious Materials (IDAPA 58.01.02.800)	Applicable	Prohibits the storage, disposal or accumulation of hazardous and deleterious materials "adjacent to or in the immediate vicinity of state waters" without adequate measures and controls to insure the materials will not enter state waters.	Applicable if the remedial action results in the storage of hazardous and deleterious materials near state waters. Attainment of this regulation will be addressed during remedial design which will avoid the storage or disposal of hazardous and deleterious materials "adjacent to or in the immediate vicinity of state waters". An inventory of "state waters" has been completed to help guide the remedial design.

Medium	Type of ARAR[c]	Requirement[a]	Status	Synopsis of Requirement	Action to be Taken to Attain Requirement
Habitat	Location-specific	Endangered Species Act (ESA) [16 U.S.C. 1531] Responsible official requirements [40 CFR 6.302(h)] Endangered and threatened wildlife and plants [50 CFR 17] Interagency cooperation – ESA of 1973, as amended [50 CFR 402]	Applicable	Statute and implementing regulations require that federal activities not jeopardize the continued existence of any threatened or endangered species. Section 7 of the ESA requires consultation with the USFWS to identify the possible presence of protected species and mitigate potential impacts on such species.	None – to date, no threatened or endangered species have been identified within the Site.
Habitat	Location-specific	Migratory Bird Treaty Act [16 U.S.C. 703, et seq.] List of Migratory Birds [50 CFR 10.13]	Relevant and Appropriate	The Act makes it unlawful to “hunt, take, capture, kill,” or take other various actions adversely affecting a broad range of migratory birds, without the prior approval of the Department of the Interior.	The Selected Remedy, through careful remedial design, will be implemented in a manner to avoid taking or killing of protected migratory bird species, including individual birds, their nests, or eggs.
Habitat	Location-specific and Action-specific	Fish and Wildlife Coordination Act [16 U.S.C. § 661 *et seq*.]	Relevant and Appropriate	Requires that federal agencies involved in actions that will result in control or modification of any natural stream or water body must protect fish and wildlife resources that may be affected by the actions.	The substantive requirements of the Fish and Wildlife Coordination Act that are applicable to the selected remedy would be identified and complied with through the remedial design process. Consultation with the USFWS would be conducted during the design phase. Impacts to water or the stream channel would be monitored during implementation.
Habitat	Location-specific and Action-specific	Bald and Golden Eagle Protection Act [16 U.S.C. §§ 668 *et seq.* 50 CFR Part 22]	Relevant and Appropriate	Prohibits any person from knowingly, or with wanton disregard, selling, offering to sell, taking, purchasing, transferring, bartering, exporting, importing, or possessing or harming a bald or golden eagle, or any part, nest, or egg thereof without obtaining a permit.	Remedial action at the Site must be designed and implemented to avoid harm to bald or golden eagles, their nests, or eggs. The occurrence of these birds and nesting features within the Site will be determined during remedial design to comply with these requirements.
Habitat	Action-specific	Protection of Birds [Idaho Code Ann. § 36-1102]	Applicable	Prohibits the “take” or intentional disturbance or destruction of eggs or nests of any “game, song, rodent killing, insectivorous or other innocent bird.” The prohibition does not apply to English Sparrows or starlings.	The substantive requirements of the Idaho Protection of Birds regulation that are applicable to the selected remedy would be identified and complied with through the remedial design process. Critical periods include nesting and young rearing months of the year, which will be noted during remedial design to guide remedial construction.

Medium	Type of ARAR[c]	Requirement[a]	Status	Synopsis of Requirement	Action to be Taken to Attain Requirement
Habitat	Action-specific	Idaho Classification and Protection of Wildlife Rule [IDAPA 13.01.06.300]	TBC	Classifies fish and wildlife species; identifies threatened or endangered species; and specifies wildlife species that are protected from taking and possessing.	To be considered during mitigation of ecological risk.
Land	Location-specific and Action-specific	Mineral Leasing Act [30 U.S.C. §§ 181 *et seq.*] and implementing regulations 43 CFR Parts 3500 and 3590]	TBC and Relevant and Appropriate	Part 3500 establishes regulations pertaining to the leasing of federally-owned solid minerals, including phosphate. Part 3590 establishes regulations pertaining to mineral mining and reclamation operations.	The Selected Remedy was designed to be compatible with the possibility of ore recovery. Ore recovery is assumed, but is not part of the Selected Remedy. If ore recovery is implemented, provisions regarding mineral leasing must be considered because phosphate ore at the Site is a federally-owned mineral. For ore to be recovered during implementation of the remedial action, P4 must acquire a mineral lease prior to recovery of ore. In addition, provisions regarding mineral mining and reclamation are relevant and appropriate because assumed ore extraction would occur concurrent with implementation of the selected remedy, pursuant to a BLM-approved operating plan. The Selected Remedy will comply with the substantive requirements of the Part 3590 regulations, by incorporating relevant provisions of the BLM-approved mine plan in the remedial design
Land	Location-specific and Action-specific	Federal Land Policy and Management Act [43 U.S.C. §§ 1732 *et seq.*]	Applicable	Prevents unnecessary or undue degradation of public lands by operations authorized by the mining laws. Establishes public land policy and guidelines for the administration of public lands; provides for the management, use, occupancy, and development of public lands.	Provisions regarding multiple use and unnecessary or undue degradation are applicable to the extraction of minerals. If ore recovery is implemented, P4 will need to incorporate appropriate mining and reclamation practices into its BLM-approved mine plan, and remedial design documents.

Medium	Type of ARAR[c]	Requirement[a]	Status	Synopsis of Requirement	Action to be Taken to Attain Requirement
Land	Location-specific and Action-specific	U.S. Bureau of Land Management (BLM) Record of Decision and Pocatello Resource Management Plan (April 2012), as amended Sept. 21, 2015 Available online at https://eplanning.blm.gov/epl-front-office/projects/nepa/32803/38812/40712/RODandSIR_508.pdf	TBC	Resource Management Plan established to sustain the health, diversity, and productivity of the public lands. The plan provides objectives, land use allocations, and management direction to maintain, improve or restore resource conditions, and provide for the economic needs of local communities over the long term. The plan applies to BLM-managed public lands and split estate lands where minerals are federally owned in southeast Idaho.	Should be considered due to BLM's ownership of the mineral rights and authorized stewardship of this resource.
Land	Action-specific	Stream Channel Alteration Rules [IDAPA 37.03.07.055]	Applicable	Provides substantive construction standards for working in stream channels.	Applicable as a result of remedial action on stream channels and sediment basins; however, procedural requirements are not ARAR.
Land	Action-specific	Idaho Fences in General (LEAs) [Idaho Code §§ 35-101 to -112]	Applicable	Establishes construction requirements, such as height and distance between posts, for all types of fences. Defines who is responsible for construction and maintenance of enclosure and partition fences.	Requirement must be implemented when fencing is required to protect components of the selected remedy (e.g., a cover system; as institutional controls, etc.).
Air	Action-specific	Clean Air Act [42 U.S.C. §§ 7409 et seq. 40 CFR Part 50]	Potentially Applicable	Requirements for maintaining air quality.	The particular portions of the selected remedy to which this ARAR is applicable will be identified and complied with through the remedial design process and implemented prior to construction activities at the Site.
Air	Action-specific	Idaho Rules for Control of Fugitive Dust [IDAPA 58.01.01.650-651]	Applicable	Provides guideline and practices for controlling fugitive dust emissions, including use of water or chemicals, application of dust suppressant, and covering trucks.	The particular portions of the selected remedy to which this ARAR is applicable will be identified and complied with through the remedial design process and implemented during construction activities at the Site. BMPs that utilize a form of dust suppressant and institutional controls to restrict access to the public will help promote compliance.
Air	Action-specific	Idaho Toxic Air Pollutants [IDAPA 58.01.01.585-586]	Applicable	Requirements for maintaining air quality (none currently nor will they be likely associated with any remedial action).	The particular portions of the selected remedy to which this ARAR is applicable will be identified and complied with through the remedial design process and implemented during construction activities at the Site.

Medium	Type of ARAR[c]	Requirement[a]	Status	Synopsis of Requirement	Action to be Taken to Attain Requirement
Assessment	Action-specific	Idaho Uniform Environmental Covenants Act [Idaho Code §§55-3001 to -3015]	Applicable	Allows recordation of an environmental covenant, which is a written agreement where the parties bind themselves, and their successors in interest to the land, to comply with activity and use limitations.	This regulation endorses the use of some form of formal administrative land use or deed restriction (Land use controls) to sustain conditions achieved by remedial cleanup. The selected remedy will include institutional controls that limit access to the site until the Site is deemed functional and operational.
Assessment	Action-specific	DEQ Area Wide Risk Management Plan [DEQ, 2004a]	TBC	This plan offers guidance to agencies responsible for risk management decision-making at historic phosphate mines in Southeast Idaho. The plan includes goals and objectives for monitoring and for addressing releases and impacts from historical phosphate mining operations in southeast Idaho.	Portions of this guidance may be useful in developing the remedial design for the Site, including effectiveness monitoring.
Assessment	Action-specific	Idaho Risk Evaluation Manual [DEQ, 2004b] Available online at https://www.deq.idaho.gov/media/967298-risk_evaluation_manual_2004.pdf]	TBC	Provides guidelines and criteria to apply in risk-based decision making.	Framework for decision making should be considered in developing human and environmental risk-based cleanup levels

[a] Statute/Regulation/Standard/Policy (and appropriate citations) used to identify general category of ARAR/TBC. This listing does not indicate acceptance of the entire statute/regulation/standard/policy as an ARAR/TBC; specific ARARs/TBCs are addressed in the table for each general heading. Only substantive provisions of the specific requirement are considered potential ARARs/TBCs.

[b] The preamble to the NCP indicates that state regulations that are components of a federally authorized or delegated state program are generally considered federal requirements and potential federal ARARs for the purposes of ARARs analysis (55 Fed. Reg. 8666, 8742 [1990]). DEQ received final authorization for the regulation of hazardous wastes on September 21, 2015. Substantive RCRA requirements are applicable to response actions on CERCLA sites if the waste is a RCRA hazardous waste, and either: the waste was initially treated, stored, or disposed after the effective date of the particular RCRA requirement (1976 for RCRA, and 1984 for the amendments including land disposal restrictions); or the activity at the CERCLA site constitutes treatment, storage, or disposal as defined by RCRA EPA 1988a CERCLA Compliance With Other Laws Manual, Draft Guidance (Part I). Interim Final EPA/540/G 89/006, Office of Emergency and Remedial Response, Washington, D.C. August.

[c] Type of ARAR: C = Chemical-Specific; L= Location Specific; A = Action- Specific

[d] National Recommended Water Quality Criteria are available at http://www.epa.gov/ost/criteria/wqctable/

ARAR = Applicable or Relevant and Appropriate Requirements
BLM = Bureau of Land Management
BMPs = best management practices
CFR = Code of Federal Regulations
CWA = Clean Water Act
DEQ = Idaho Department of Environmental Quality
EPA = U.S. Environmental Protection Agency
ET = evapotranspiration
MCL = maximum contaminant level
MCLG = maximum contaminant level goal
NCP = National Contingency Plan
NPDES = National Pollutant Discharge Elimination System
PRB = permeable reactive barrier
RCRA = Resource Conservation and Recovery Act of 1976
TBC = To be considered

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Appendix C
State Concurrence Letter

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STATE OF IDAHO
DEPARTMENT OF
ENVIRONMENTAL QUALITY

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Brad Little, Governor
John H. Tippets, Director

August 22, 2019

R. David Allnutt, Acting Director
Superfund and Emergency Management Division
U.S. EPA Region 10
1200 6th Avenue 12-D12-1
Seattle, WA 98101

Subject: State of Idaho Concurrence on the Selected Remedy for the Record of Decision for Ballard Mine

Dear Mr. Allnutt:

This letter notifies the Environmental Protection Agency (EPA) that the State of Idaho, Department of Environmental Quality (IDEQ) concurs with the selected remedy outlined in the Record of Decision (ROD) for Ballard Mine. As summarized in the ROD it appears the selected remedy will address contaminants of concern identified in upland and riparian soils, sediment, surface water, and groundwater. IDEQ agrees the chosen remedy can meet all applicable or relevant and appropriate requirements (ARARs).

However, IDEQ does not fully agree that all requirements have been properly listed in the ROD. IDEQ believes that the state's surface water standard for arsenic of 0.010 mg/L should be the goal unless and until EPA approves a revised state criterion or promulgates a federal criterion.

IDEQ eagerly awaits implementation of this ROD as the project moves to the design phase. We look forward to working cooperatively with the EPA and the Tribes in implementing a remedy that best meets our mutual goal of protecting human health and the environment at Ballard Mine.

Sincerely,

John H. Tippets
Director

c: Bruce Olenick, DEQ-Pocatello
Doug Tanner, DEQ-Pocatello
Lisa O'Hara, DAG-Boise
Mark Cecchini-Beaver, DAG-Boise
Davis Zhen, EPA-Seattle

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Appendix D
Cost Estimate Breakdown of Remedy

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UPLAND SOIL ALTERNATIVE 6: ORE RECOVERY AND RECLAMATION
FEASIBILITY STUDY TECHNICAL MEMORANDUM #2
P4 Production LLC, Ballard Mine

Description : Alternative 6 - Ore Recovery/Waste Rock Grading and Consolidation with ET Cover, ICs, LUCs, and O&M/LTM. This alternative is similar to Alternative 4 except that incidental ore deposits would be recovered in a phased approach during the upland soil/waste rock removal, consolidation, grading and capping efforts. The cover system included in Alternative 6 would be the ET cover as described in Alternative 4. See Figures 3-3a through 3-3c for a depiction of this alternative. Additional details regarding Alternative 6 can be found in Section 3.

Item No.	Item Description	Quantity	Unit	Activity	Unit Cost ($)	Item Cost ($)	Comments/ Assumptions
1	**DIRECT CAPITAL COSTS**						
	Mobilization/Demobilization						
	Mobilization/Demobilization of Equipment (phase 1)	12	ea	Site mobilization, over 75 ton, + 10% per addn'l 5 mi mob dist. 01 54 36.50 0100/2500	$530.00	$10,176	Assumed fewer pieces of equipment (3 dozers and 3 loaders) due to phased nature of the ore recovery. Quantity accounts for both mob and demob of equipment. Unit cost escalated 60% to account for haul distance to site from Pocatello, ID. 2016 Means 01 54 36.50 0100/2500
	Mobilization/Demobilization of Equipment (phase 2)	7	ea	Site mobilization, over 75 ton, + 10% per addn'l 5 mi mob dist. 01 54 36.50 0100/2500	$530.00	$5,936	
	Construction Field Offices	85	ea	Field office, 32'x8', rent per month 01 52 13 13.20 0350	$270.00	$22,950	Assumed 3 - 32'x8' office trailers rented for monthly term. 2016 Means 01 52 13 13.20 0350
	Portable Toilets	11,420	ea	Blue rooms, /day 01 54 33 6410	$21.50	$245,530	Assumed 4 rental units. 2016 Means 01 54 33 6410
	Temporary Utilities						
	Power	246	ea	Power/HVAC combined, /month 01 51 13.80 0430	$176.00	$43,296	2016 Means 01 51 13.80 0430
	Heat	23			$68.50	$1,578	Assumed 768 sf of trailer. 2016 Means 01 51 13.8 0200
	Preparation of ICIAP	1	LS		$50,000.00	$50,000	Engineering Judgement - Cost is rough order of magnitude based on plan preparation from other similar projec
	Phase 1: Mine dumps MWD084, MWD082, and MWP035; Little Pit						
	Site Preparation						
	Clearing and Grubbing	223	ac	Selective clearing, with dozer and brush rake, light 31 11 13.10 0500	$262.00	$58,387	Assume dozer and brush rake, average brush diameter less than 4-inches. 2016 Means 31 11 13.10 0500. Crew = 1 operator and 1 laborer.
	Excavate Waste Rock for On-Site Consolidation						
	Mine dump MWD084	250,000	bcy	P4 Unit Rate for ROM LHD, Graded 3:1	$3.71	$927,500	Waste rock dump to be regraded to 3:1 slopes or less. material to be consolidated into open mine pits. Regrade volume provided by P4 in support of ore recovery operations.Material volumes based on output from mine planning software. Unit rates based on $3.71 to load, dump, and push at BFB in 2014. NAD trucks (777) are 40-48 bcy. Unit costs would be less for larger equipment. 777s are largest trucks that can mob with limited assembly
	Mine dump MWD082	1,311,111	bcy	P4 Unit Rate for ROM LHD, Graded 3:1	$3.71	$4,864,222	As above
	Mine dump within open pit MWP035	27,778	bcy	P4 Unit Rate for ROM LHD, Graded 3:1	$3.71	$103,056	As above
	Ore Recovery						
	Excavation of ore reserve	938,274	bcy	P4 Unit Rate for Haulage to Process Area	$3.88	$3,640,503	Material volumes based on output from mine planning software. Unit rates based on $3.88 for excavation and transport to plant.
	Load overburden from mined are to haul vehicles, haul to MMP040 and MMP035, and spread material with dozer (track compaction)	4,276,978	bcy	P4 Unit Rate for ROM LHD, Graded 3:1	$3.71	$15,867,588	Material volumes based on output from mine planning software. Unit rates based on $3.71 to load, dump, and push at BFB in 2014. NAD trucks (777) are 40-48 bcy. Unit costs would be less for larger equipment. 777s are largest trucks that can mob with limited assembly.
	Phase 2: Mine dump MWD093 (partial); Island Pit						
	Site Preparation						
	Clearing and Grubbing	77	ac	Selective clearing, with dozer and brush rake, light 31 11 13.10 0500	$262.00	$20,174	Assume dozer and brush rake, average brush diameter less than 4-inches. 2016 Means 31 11 13.10 0500. Crew = 1 operator and 1 laborer.
	Waste Rock Consolidation						
	Mine dump MWD093 (partial)	118,519	bcy	P4 Unit Rate for ROM LHD, Graded 3:1	$3.71	$439,705	Waste rock dump to be regraded to 3:1 slopes or less. material to be consolidated into open mine pits. Regrade volume provided by P4 in support of ore recovery operations.Material volumes based on output from mine planning software. Unit rates based on $3.71 to load, dump, and push at BFB in 2014. NAD trucks (777) are 40-48 bcy. Unit costs would be less for larger equipment. 777s are largest trucks that can mob with limited assembly
	Ore Recovery						
	Excavation of ore reserve	2,221,570	bcy	P4 Unit Rate for Haulage to Process Area	$3.88	$8,619,692	Material volumes based on output from mine planning software. Unit rates based on $3.88 for excavation and transport to plant.
	Load overburden from mined area into haul vehicles, haul to MMP040 and MMP035, and spread material with a dozer (track compaction)	7,648,656	bcy	P4 Unit Rate for ROM LHD, Graded 3:1	$3.71	$28,376,514	Material volumes based on output from mine planning software. Unit rates based on $3.71 to load, dump, and push at BFB in 2014. NAD trucks (777) are 40-48 bcy. Unit costs would be less for larger equipment. 777s are largest trucks that can mob with limited assembly.
	Phase 3: Mine dump MWD093 (parital), MWD080 (partial), and MWD081 (partial); Long Pit						
	Site Preparation						
	Clearing and Grubbing	208	ac	Selective clearing, with dozer and brush rake, light 3111 13.10 0500	$262.00	$54,496	Assume dozer and brush rake, average brush diameter less than 4-inches. 2016 Means 31 11 13.10 0500. Crew = 1 operator and 1 laborer.
	Waste Rock Consolidation						
	Mine dump MWD093 (partial)	790,741	bcy	P4 Unit Rate for ROM LHD, Graded 3:1	$3.71	$2,933,649	Waste rock dump to be regraded to 3:1 slopes or less. material to be consolidated into open mine pits. Regrade volume provided by P4 in support of ore recovery operations. Assumed 700hp dozer, 300 ft haul. 2016 Means 31 23 16.46 6060. Crew = 1 operator and one laborer.
	Mind dumps MWD080 and MWD081 (partial)	1,857,407	bcy	P4 Unit Rate for ROM LHD, Graded 3:1	$3.71	$6,890,980	Waste rock dump to be regraded to 3:1 slopes or less. material to be consolidated into open mine pits. Regrade volume provided by P4 in support of ore recovery operations. Assumed 700hp dozer, 300 ft haul. 2016 Means 31 23 16.46 6060. Crew = 1 operator and one laborer.
	Ore Recovery						
	Excavation of ore reserve	784,779	bcy	P4 Unit Rate for Haulage to Process Area	$3.88	$3,044,943	Material volumes based on output from mine planning software. Unit rates based on $3.88 for excavation and transport to plant.
	Load overburden from mined area into haul vehicles, haul to Island Pit, Long Pit, MMP035 and MMP036, and spread material with dozer (track compaction)	5,771,484	bcy	P4 Unit Rate for ROM LHD, Graded 3:1	$3.71	$21,412,206	Material volumes based on output from mine planning software. Unit rates based on $3.71 to load, dump, and push at BFB in 2014. NAD trucks (777) are 40-48 bcy. Unit costs would be less for larger equipment. 777s are largest trucks that can mob with limited assembly.
	Confirmation Sampling						
	Sample Collection		LS		$0	$0	It is assumed that waste rock will be graded and placed in existing mine pits without exposing the pre-mine ground surface. Therefore, this type of sampling is not included.
	ET Cover Construction (for entire area)						Cover construction will be done in phases but the costs herein are determined for the total acreage.
	Load from Borrow Area, Haul, Dump, and grade cover material (assume 5 ft of alluvium amended to support plant growth over entire area underlain by material derrived from the ore recovery operation)	4,339,867	bcy	P4 Unit Rate for ET Cover, LHD, Graded 3:1	$3.95	$17,142,473	Material volumes based on output from mine planning software. A total of 538 acres will be capped under this alternative. Equipment and task costs based on recent (2014) P4 competitive bid for similar work at active mine site. Assume that the coarse capillary break material underlying the 5 feet of alluvium will be produced as part of the ore recovery operation.
	Revegetation of all graded surfaces underlain by waste rock	23,435	msf	Revegetation, hydro or air seeding, with mulch and fertilizer 32 92 19.14 5400	$44.50	$1,042,870	A total of 538 acres. Cover surface area determined from mine planning and ArcMap software. Unit rate based on internal vegetation cost estimate of $1,550 per acre (or $35.60 per MSF) plus 25% increase to cover additional erosional controls .
	Landfill Cell for Miscellaneous Disposal						
	Load contaminated wastes from various locations throughout the project area for containment in this landfill at various times during the life of the landfill. Load clean material from Borrow Area, Haul, Dump, and grade cover material (assume 5 ft of alluvium amended to support plant growth over entire area underlain by 1 foot of coarse material for capillary break)	15,831	cy	Using One Conservative Unit Rate for all materials associated with the Landfill	$10.00	$158,310	Assume 10,000 cy of contaminated material will need to be disposed on-Site during the implementation of the Site remedy. Assume average thickness of placed waste is 15 feet thick and as a result, would cover an area of approximately 18,000 square feet or a repository of 150' by 150' feet (allows for cover to extend beyond the limits of the backfill). Assume base beneath landfill is compacted and 1 foot thick, cover is standard ET cover (1 foot coarse material, 5 feet of alluvium, with revegetation). Increased per yard cost is the result of numerous disposal events over life of landfill.
	Revegetation of landfill surface	44	msf	Revegetation, hydro or air seeding, with mulch and fertilizer 32 92 19.14 5400	$44.50	$1,938	Conservatively assume a total of 1 acre of disturbance. Unit rate based on internal vegetation cost estimate of $1,550 per acre (or $35.60 per MSF) plus 25% increase to cover additional erosional controls.
					Subtotal Capital Costs	**$115,978,672**	
	Project Management	5%	Capital Costs		$115,978,672	$5,798,934	Project management cost when the capital costs are greater than $10M is esitmated at 5 percent (Table 5-8, EPA 540-R-00-002).
	Remedial Design	6%	Capital Costs		$115,978,672	$6,958,720	Remedial Design costs when the capital costs are greater than $10M are estimated at 6 percent (Table 5-8, EPA 540-R-00-002).
	Construction Management and Oversight	6%	Capital Costs		$115,978,672	$6,958,720	Construction management costs, including construction QA/QC, when the capital costs are greater than $10M are estimated at 6 percent (Table 5-8, EPA 540-R-00-002).
	Contingency Costs	10%	Capital Costs		$115,978,672	$11,597,867	See Note 1
					Other Direct Costs	**$31,314,242**	
	TOTAL DIRECT COSTS					**$147,292,914**	Does not include subcontractor mark-up or profit

Description : Alternative 6 - Ore Recovery/Waste Rock Grading and Consolidation with ET Cover, ICs, LUCs, and O&M/LTM. This alternative is similar to Alternative 4 except that incidental ore deposits would be recovered in a phased approach during the upland soil/waste rock removal, consolidation, grading and capping efforts. The cover system included in Alternative 6 would be the ET cover as described in Alternative 4. See Figures 3-3a through 3-3c for a depiction of this alternative. Additional details regarding Alternative 6 can be found in Section 3.

Item No.	Item Description	Quantity	Unit	Activity	Unit Cost ($)	Item Cost ($)	Comments/ Assumptions
2	**ANNUAL COSTS**						
	Long-term Cover Inspections (Semi-annual basis)	1	LS		$27,262	$27,262	Assumes semiannual inspections performed by 2-man crew consisting of senior and prof level staff 56 hours per inspection; 6 days of per diem at $101 per day (lodging and food); Avis SUV rental 6 days at $99/day. Site inspection to be conducted on foot to mitigate disturbance of covers by motorized vehicles.
	30-YEAR PRESENT WORTH (i=7%;n=30,P/A=12.4090)					**$338,294**	
3	**SUMMARY REPORT (Every 5 Years)**	1	.5 Yrs		$100,000	$100,000	Engineering Judgement based on similar projects. Assumed LOE for summarizing inspection findings, summarizing operation and maintenance activities completed, preparing presentation graphics for EPA lead 5-year review meetings.
	30-YEAR PRESENT WORTH (i=7%; P/F=0.7130+0.5083+0.3624+0.2584+0.1842+0.1314=2.1577)					**$215,770**	
4	**INSTITUTIONAL CONTROLS**	2	EA		$25,000	**$50,000**	See Note 2. Assumed property easement and deed restriction will need to be exeed with 2 property owner (P4 and State of Idaho properties)
5	**ALTERNATIVE 6: 30 Year Present Worth Cost (Items 1+2+3+4)**					**$147,897,000**	

Notes:
1. For an FS which represents 0%-10% design completion, scope contingency typically ranges from 10 to 25 percent. The EPA guidance, "A Guide to Developing and Documenting Cost Estimates During the Feasibility Study,"July 2000, (EPA 540-R-00-002) shows a rule-of-thumb scope contingency of 10%-30%.

2. Institutional controls are non-engineering or legal/administrative measures to reduce or minimize the potential for exposure to site contamination or hazards by limiting or restricting site access. These controls could include institutional control plans, restrictive covenants, property easements, zoning, deed notices, advisories, groundwater use restrictions, and site information database, as referenced in EPA 540-R-00-002.

ac acre
bcy bank cubic yard
CSF Flr 100 square feet of floor
cy cubic yard
EA each
LOE Level of Effort
lcy loose cubic yard
LF linear feet
ls lump sum
MSF thousand square feet
QA/QC quality assurance / quality control
Yrs years

SEDIMENT AND RIPARIAN SOILS ALTERNATIVE 3: SEDIMENT TRAPS/BASINS, MNR, ICs, AND LUCs FEASIBILITY STUDY TECHNICAL MEMORANDUM #2
P4 Production LLC,
Ballard Mine

Description: Alternative 3 - Sediment Traps/Basins, MNR, ICs, and LUCs. This alternative uses sediment traps in the upper reaches of the mine-affected drainages to capture/control any mine-affected sediment entrained in the intermittent storm water/stream flow. MNR would be implemented in lower reaches, and relies on natural processes to disperse and ultimately reduce COC/COEC concentrations in the affected media over time. In order for MNR to be successful, source controls need to be implemented in the upland soil/waste rock to prevent migration of COCs/COECs to the downstream drainages. MNR also requires ICs and LUCs to restrict Site activities until the cleanup levels are achieved. See Figure 3-7 for general depiction of alternative. Additional details regarding Alternative 3 can be found in Section 3.

Item No.	Item Description	Quantity	Unit	Unit Cost ($)	Item Cost ($)	Comment
1	**DIRECT CAPITAL COSTS**					
	Sediment and Riparian Soil Remedial Components					
	Install Sediment Traps in upstream locations					
	Excavate, place, compact as necessary	6	per location	$3,500.00	$21,000	Assumed the sediment traps average 90 feet long, are 6 feet high, with a 12 foot base. Assume it will require one excavator or dozer and one laborer (with a hand operated compactor) 1 day to construct each of these sediment traps. Spillways will be cut into the adjacent native material around the edge and if necessary, lined with coarser materials or fabric. Assume mobilization of the equipment is included in this per day cost.
	MNR Plans/Implementation					
	Prepare Sampling and Analysis Plan	1	ls	$60,000	$60,000	Assumed preparation of sampling plan will require three iterations prior to approval by EPA. Engineering judgement based on other similar projects.
	MNR Baseline Sampling Program	1	ls	$37,135	$37,135	Assumed all drainages where PCLs are exceeded. Three discrete samples of soil, sediment, and vegetation will be collected from 25 locations resulting in a total of 75 samples. Assumed 15% for QA/QC resulting in 87 laboratory samples. Each sample will be analyzed for nine COC metals by SW6010C. Assumed one-person field crew and 1 hour per sample (layout to shipping). Includes preparation of summary report.
	Preparation of ICIAP	1	ls	$50,000	$50,000	Engineering Judgement - Cost is rough order of magnitude based on plan preparation from other similar projects.
				Subtotal Capital Costs	**$168,135**	
	Project Management	8%	Capital Costs	$168,135	$13,451	Project Management costs, when the capital costs are between $100 to 500K, are estimated at 8 percent (Table 5-8, EPA 540-R-00-002).
	Remedial Design	15%	Capital Costs	$168,135	$25,220	Remedial Design costs, when the capital costs are between $100 to 500K, are estimated at 15 percent (Table 5-8, EPA 540-R-00-002).
	Construction Management and Oversight	10%	Capital Costs	$168,135	$16,814	Construction management costs, including construction QA/QC, when capital costs are between $100 to 500K, are estimated at 10 percent (Table 5-8, EPA 540-R-00-002).
	Contingency Costs	10%	Capital Costs	$168,135	$16,814	See Note 1
				Other Direct Costs	**$72,298**	
	TOTAL DIRECT COSTS				**$240,433**	Does not include subcontractor mark-up or profit
2	**ANNUAL COSTS**					
	LTM and OM&M of sediment traps	1	annual	$10,000	$10,000	Assumes semiannual inspections performed by 1-man crew and that minor repairs will be necessary each year to the 6 sediment traps. See Note 2.
	30-YEAR PRESENT WORTH (i=7%;n=30,P/A=12.4090)				**$124,090**	
	Long-term MNR sampling	1	/5 Yrs	$37,135	$37,135	Assumed that sampling at the baseline monitoring locations will be repeated every 5 years for a period of 30 years.
	30-YEAR PRESENT WORTH (i=7%; P/F=0.7130+0.5083+0.3624+0.2584+0.1842+0.1314=2.1577)				**$80,126**	
			Subtotal Annual Costs		**$204,216**	
3	**SUMMARY REPORT (Every 5 Years)**	1	/5 Yrs	$100,000	$100,000	Engineering Judgement based on similar projects. Assumed LOE for summarizing inspection findings, summarizing operation and maintenance activities completed, preparing presentation graphics for EPA lead 5-year review meetings.
	30-YEAR PRESENT WORTH (i=7%; P/F=0.7130+0.5083+0.3624+0.2584+0.1842+0.1314=2.1577)				**$215,770**	
4	**INSTITUTIONAL CONTROLS**	3	EA	$25,000	**$75,000**	See Note 3. Assumed property easement and deed restriction will need to be executed with one property owner (Tucker Torgeson Farms, P4 Production LLC, Clair Holmgren)
5	**ALTERNATIVE 3: 30 Year Present Worth Cost (Items 1+2+3+4)**				**$736,000**	

Notes:
1. For an FS which represents 0%-10% design completion, scope contingency typically ranges from 10 to 25 percent. The EPA guidance, "A Guide to Developing and Documenting Cost Estimates During the Feasibility Study,"July 2000, (EPA 540-R-00-002) shows a rule- of-thumb scope contingency of 10%-30%.

2. Costs for installation of a on-Site landfill for disposal of sediments from these sediment traps are included in the upland soils/waste rock alternatives.

3. Institutional controls are non-engineering or legal/administrative measures to reduce or minimize the potential for exposure to site contamination or hazards by limiting or restricting site access. These controls could include institutional control plans, restrictive covenants, property easements, zoning, deed notices, advisories, groundwater use restrictions, and site information database, as referenced in EPA 540-R-00-002.

COC constituent of concern
EA each
ls lump sum
MNR monitored natural recovery
PCL preliminary cleanup level
QA/QC quality assurance / quality control
Yrs years

SURFACE WATER ALTERNATIVE 3: IN-SITU TREATMENT, ICs, and LUCs FEASIBILITY STUDY TECHNICAL MEMORANDUM #2
P4 Production LLC, - Ballard Mine

Description: Alternative 3 - ICs and LUCs would be implemented as in Alternative 2, and in-situ wetlands treatment would be constructed at mine-affected seep locations. Upon competition of source controls in the upland soil/waste rock, all surface water runoff would be unimpacted and only residual flows from seeps are expected to exceed cleanup levels for a period of time (i.e., until the regrading and cover systems mitigate the source of water that recharges through the upland soil/waste rock and ultimately discharges to the seeps). The wetlands would treat the residual mine-affected surface water at the perennial seeps via biologically mediated reactions including reduction using anaerobic bacteria resulting in precipitation and/or sorption of the COC/COECs. The treated water would discharge from the wetlands to the downstream drainages or evapotranspire within the wetlands. See Figure 3-6 for general depiction of alternative. Additional details regarding Alternative 3 can be found in Section 3.

Item No.	Item Description	Quantity	Unit	Unit Cost ($)	Item Cost ($)	Comments/Assumptions
1	**DIRECT CAPITAL COSTS**					
	Mobilization/Demobilization					
	Mobilization/Demobilization of Equipment	7	EA	$816	$5,712	Assumed 2 trackhoes, 1 dozer, and 3 off-road haul vehicles. Quantity accounts for both mob and demob of equipment. Unit cost escalated 60% to account for haul distance to site from Pocatello, ID. 2014 Means 01 54 36.50 0100/2500
	Construction Field Offices	2	month	$223	$446	Assumed 1 - 32'x8' office trailers rented for monthly term. 2014 Means 01 52 13 13.20 0350
	Portable Toilets	240	day	$13	$3,204	Assumed 4 rental units for 60 days each. 2014 Means 01 54 33 6410
	Temporary Utilities					
	Power	2	month	$2	$4	2014 Means 01 51 13.80 0430
	Heat	8	CSF Flr	$69	$526	Assumed 768 sf of trailer. 2014 Means 01 51 13.8 0200
	Preparation of ICIAP	1	ls	$50,000	$50,000	Engineering Judgement - Cost is rough order of magnitude based on plan preparation from other similar projects.
	Update to Surface Water Monitoring Plan	1	ls	$21,760	$21,760	Existing surface water monitoring plan will be updated to conform with post RA monitoring program.
	Surface Water Remedial Components					
	1A) Seep MST069/MSG008 - Constructed Wetlands (Refer to Figure 3-6)					
	Construction of collection basin at seep location MST069	1	LS	$4,749.00	$4,749	Assumed a 5ftx5ftx3ft excavation, lined with 60-mil HDPE. Collected water conveyed via 2-inch PVC pipeline to seep location MSG005. Component costs: Basin excavation-2014 Means 31 23 16.13 0050. Crew = I operator and I laborer. 60-mil HDPE (includes 20% increase to account for sag and anchor trenching)-2014 Means Site Work & Landscaping 33 47 13.53 120. Crew = 3 skilled workers. Pipeline trenching (900 feet, avg depth 4 ft)-2014 Means 31 23 16.13 0050. Crew = I operator and I laborer. 2-inch PVC piping-2014 Means Site Work & Landscaping 33 47 13.53 120. Crew = 1 foreman, 1 plumber. Pipeline backfill (Assumed 30% fluffing of excavated material)-2014 Means 31 23 16.13 3020. Crew = 1 operator and 1 laborer
	Excavation of wetland basin at seep location MSG008	1,966	bcy	$1.80	$3,538	Basin size based on 400 sf/gpm (engineers judgement) and 4 ft depth. Anticipated inflow to wetland of 33.1 gpm based on average Spring flow rate from seeps MST069, MSG008, MDS030 - MDS033, and MSG003. Assumed trackhoe with 3 CY bucket, 2014 Means 31 23 16.42 0300. Crew = 1 operator and 1 laborer.
	Placement of gravel bedding	491	cy	$133.00	$65,357	Assumed 13,268 sf of basin and pea gravel placed to a thickness of 1 ft. 2014 Means 32 91 13.16 1600. Crew = 1 foreman and 2 laborers.
	Load organic soil from on-site source into haul vehicles	1,597	bcy	$1	$958	Assumed a source of organic soil is available on-site and 30% increase in volume due to fluffing of excavated material. Assumed front loader with 10 cy bucket, 100% fill factor. 2014 Means 31 23 16.43 0450. Crew = 1 operator and 1 laborer.
	Haul to constructed wetland location	1,597	bcy	$3	$4,871	Assumed 42cy off-road vehicle, 1 mile cycle distance, 10 MPH speed limit. 2014 Means 31 23 23.20 7100. Crew = 1 driver.
	Spread material with dozer, no compaction	1,597	pcy	$4.70	$7,506	Assumed 300 hp dozer, max 300 ft push. 2014 Means 31 23 23.17 0190. Crew = 1 operator and 1 laborer.
	Installation of wetland plants	0.5	ac	$800.00	$400	Unit cost from a constructed wetland study by NC State University
	1B) Seeps MDS030-033/MSG003 to MSG008- Conveyance System (refer to Figure 3-6)					
	Construction of collection basin at each seep location	1	LS	$25,000.00	$25,000	Assumed a 5ftx5ftx3ft excavation, lined with 60-mil HDPE at each seep location. Collected water conveyed via 2-inch PVC pipeline to central location (MSG008). Component costs: Basin excavation-2014 Means 31 23 16.13 0050. Crew = I operator and I laborer. 60-mil HDPE (includes 20% increase to account for sag and anchor trenching)-2014 Means Site Work & Landscaping 33 47 13.53 120. Crew = 3 skilled workers. Pipeline trenching (7300 feet, avg depth 4 ft)-2014 Means 31 23 16.13 0050. Crew = I operator and I laborer. 2-inch PVC piping-2014 Means Site Work & Landscaping 33 47 13.53 120. Crew = 1 foreman, 1 plumber. Pipeline backfill (Assumed 30% fluffing of excavated material)-2014 Means 31 23 16.13 3020. Crew = 1 operator and 1 laborer
	2) Seep MST067 -Constructed Wetlands (refer to Figure 3-6)					
	Excavation of wetland basin at seep location MST067	1,067	bcy	$1.80	$1,920	Basin size based on 400 sf/gpm (engineers judgement) and 4 ft depth. Anticipated inflow to wetland of 18 gpm based on average Spring flow rate from seep MST067. Assumed trackhoe with 3 CY bucket, 2014 Means 31 23 16.42 0300. Crew = 1 operator and 1 laborer.
	Placement of gravel bedding	267	cy	$133.00	$35,467	Assumed 7200 sf of basin and pea gravel placed to a thickness of 1 ft. 2014 Means 32 91 13.16 1600. Crew = 1 forman and 2 laborers.
	Load organic soil from on-site source into haul vehicles	867	bcy	$1	$520	Assumed a source of organic soil is available on-site and 30% increase in volume due to fluffing of excavated material. Assumed front loader with 10 cy bucket, 100% fill factor. 2014 Means 31 23 16.43 0450
	Haul to constructed wetland location	867	bcy	$3	$2,643	Assumed 42cy off-road vehicle, 1 mile cycle distance, 10 MPH speed limit. 2014 Means 31 23 23.20 7100
	Spread material with dozer, no compaction	867	bcy	$4.70	$4,073	Assumed 300 hp dozer, max 300 ft push. 2014 Means 31 23 23.17 0190
	Installation of wetland plants	0.2	ac	$800.00	$160	Unit cost from a constructed wetland study by NC State University
	3) Seep MSG004/MSG005 - Constructed Wetlands (refer to Figure 3-6)					
	Construction of collection basin at seep location MSG004 and conveyance pipeline to MSG005	1	LS	$4,749.00	$4,749	Assumed a 5ftx5ftx3ft excavation, lined with 60-mil HDPE. Collected water conveyed via 2-inch PVC pipeline to seep location MSG005. Component costs: Basin excavation-2014 Means 31 23 16.13 0050. Crew = I operator and I laborer. 60-mil HDPE (includes 20% increase to account for sag and anchor trenching)-2014 Means Site Work & Landscaping 33 47 13.53 120. Crew = 3 skilled workers. Pipeline trenching (900 feet, avg depth 4 ft)-2014 Means 31 23 16.13 0050. Crew = I operator and I laborer. 2-inch PVC piping-2014 Means Site Work & Landscaping 33 47 13.53 120. Crew = 1 foreman, 1 plumber. Pipeline backfill (Assumed 30% fluffing of excavated material)-2014 Means 31 23 16.13 3020. Crew = 1 operator and 1 laborer
	Excavation of wetland basin at seep location MSG005	516	bcy	$1.80	$928	Basin size based on 400 sf/gpm (engineers judgement) and 4 ft depth. Anticipated inflow to wetland of 8.7 gpm based on average Spring flow rate from seeps MSG004 and MSG005. Assumed trackhoe with 3 CY bucket, 2014 Means 31 23 16.42 0300. Crew = 1 operator and 1 laborer.
	Placement of gravel bedding	129	cy	$133.00	$17,142	Assumed 3480 sf of basin and pea gravel placed to a thickness of 1 ft. 2014 Means 32 91 13.16 1600. Crew = 1 foreman and 2 laborers.
	Load organic soil from on-site source into haul vehicles	419	bcy	$1	$251	Assumed a source of organic soil is available on-site and 30% increase in volume due to fluffing of excavated material. Assumed front loader with 10 cy bucket, 100% fill factor. 2014 Means 31 23 16.43 0450. Crew = 1 operator and 1 laborer.
	Haul to constructed wetland location	419	bcy	$3	$1,278	Assumed 42cy off-road vehicle, 1 mile cycle distance, 10 MPH speed limit. 2014 Means 31 23 23.20 7100. Crew = 1 driver.
	Spread material with dozer, no compaction	419	pcy	$4.70	$1,969	Assumed 300 hp dozer, max 300 ft push. 2014 Means 31 23 23.17 0190. Crew = 1 operator and 1 laborer.
	Installation of wetland plants	0.1	ac	$800.00	$80	Unit cost from a constructed wetland study by NC State University
	4) Seep MSG006/MSG007 - Constructed Wetlands (refer to Figure 3-6)					
	Construction of collection basin at seep location MSG006 and conveyance pipeline to MSG007	1	LS	$4,749.00	$4,749	Assumed a 5ftx5ftx3ft excavation, lined with 60-mil HDPE. Collected water conveyed via 2-inch PVC pipeline to seep location MSG007. Component costs: Basin excavation-2014 Means 31 23 16.13 0050. Crew = I operator and I laborer. 60-mil HDPE (includes 20% increase to account for sag and anchor trenching)-2014 Means Site Work & Landscaping 33 47 13.53 120. Crew = 3 skilled workers. Pipeline trenching (900 feet, avg depth 4 ft)-2014 Means 31 23 16.13 0050. Crew = I operator and I laborer. 2-inch PVC piping-2014 Means Site Work & Landscaping 33 47 13.53 120. Crew = 1 foreman, 1 plumber. Pipeline backfill (Assumed 30% fluffing of excavated material)-2014 Means 31 23 16.13 3020. Crew = 1 operator and 1 laborer
	Excavation of wetland basin at seep location MSG007	1,304	bcy	$1.80	$2,347	Basin size based on 400 sf/gpm (engineers judgement) and 4 ft depth. Anticipated inflow to wetland of 22 gpm based on average Spring flow rate from seeps MSG006 and MSG007. Assumed trackhoe with 3 CY bucket, 2014 Means 31 23 16.42 0300. Crew = 1 operator and 1 laborer.
	Placement of gravel bedding	326	cy	$133.00	$43,348	Assumed 8800 sf of basin and pea gravel placed to a thickness of 1 ft. 2014 Means 32 91 13.16 1600. Crew = 1 forman and 2 laborers.
	Load organic soil from on-site source into haul vehicles	1,059	bcy	$1	$636	Assumed a source of organic soil is available on-site and 30% increase in volume due to fluffing of excavated material. Assumed front loader with 10 cy bucket, 100% fill factor. 2014 Means 31 23 16.43 0450
	Haul to constructed wetland location	1,059	bcy	$3	$3,231	Assumed 42cy off-road vehicle, 1 mile cycle distance, 10 MPH speed limit. 2014 Means 31 23 23.20 7100
	Spread material with Dozer, no compaction	1,059	pcy	$4.70	$4,979	Assumed 300 hp dozer, max 300 ft push. 2014 Means 31 23 23.17 0190
	Installation of wetland plants	0.2	ac	$800.00	$160	Unit cost from constructed wetland study by NC State University

SURFACE WATER ALTERNATIVE 3: IN-SITU TREATMENT, ICs, and LUCs
FEASIBILITY STUDY TECHNICAL MEMORANDUM #2
P4 Production LLC, Ballard Mine

Description: Alternative 3 - ICs and LUCs would be implemented as in Alternative 2, and in-situ wetlands treatment would be constructed at mine-affected seep locations. Upon competition of source controls in the upland soil/waste rock, all surface water runoff would be unimpacted and only residual flows from seeps are expected to exceed cleanup levels for a period of time (i.e., until the regrading and cover systems mitigate the source of water that recharges through the upland soil/waste rock and ultimately discharges to the seeps). The wetlands would treat the residual mine-affected surface water at the perennial seeps via biologically mediated reactions including reduction using anaerobic bacteria resulting in precipitation and/or sorption of the COC/COECs. The treated water would discharge from the wetlands to the downstream drainages or evapotranspire within the wetlands. See Figure 3-6 for general depiction of alternative. Additional details regarding Alternative 3 can be found in Section 3.

Item No.	Item Description	Quantity	Unit	Unit Cost ($)	Item Cost ($)	Comments/Assumptions
	5) Seep MST095 - Constructed Wetland (refer to Figure 3-6)					
	Excavation of wetland basin at seep location MST095	1,659	bcy	$1.80	$2,987	Basin size based on 400 sf/gpm (engineers judgement) and 4 ft depth. Anticipated inflow to wetland of 28 gpm based on average Spring flow rate from seep MST095. Assumed trackhoe with 3 CY bucket, 2014 Means 31 23 16.42 0300. Crew = 1 operator and 1 laborer.
	Placement of gravel bedding	415	cy	$133.00	$55,170	Assumed 11200 sf of basin and pea gravel placed to a thickness of 1 ft. 2014 Means 32 91 13.16 1600. Crew = 1 forman and 2 laborers.
	Load organic soil from on-site source into haul vehicles	1,348	lcy	$1	$809	Assumed a source of organic soil is available on-site and 30% increase in volume due to fluffing of excavated material. Assumed front loader with 10 cy bucket, 100% fill factor. 2014 Means 31 23 16.43 0450
	Haul to constructed wetland location	1,348	lcy	$3	$4,112	Assumed 42cy off-road vehicle, 1 mile cycle distance, 10 MPH speed limit. 2014 Means 31 23 23.20 7100
	Spread material with dozer, no compaction	1,348	lcy	$4.70	$6,336	Assumed 300 hp dozer, max 300 ft push. 2014 Means 31 23 23.17 0190
	Installation of wetland plants	0.3	ac	$800.00	$240	Unit cost from constructed wetland study by NC State University
	6) Seep MST094 - Constructed Wetland (refer to Figure 3-6)					
	Excavation of wetland basin at seep location MST094	711	bcy	$1.80	$1,280	Basin size based on 400 sf/gpm (engineers judgement) and 4 ft depth. Anticipated inflow to wetland of 12 gpm based on average Spring flow rate from seep MST094. Assumed trackhoe with 3 CY bucket, 2014 Means 31 23 16.42 0300. Crew = 1 operator and 1 laborer.
	Placement of gravel bedding	178	cy	$133.00	$23,644	Assumed 4800 sf of basin and pea gravel placed to a thickness of 1 ft. 2014 Means 32 91 13.16 1600. Crew = 1 forman and 2 laborers.
	Load organic soil from on-site source into haul vehicles	578	bcy	$1	$347	Assumed a source of organic soil is available on-site and 30% increase in volume due to fluffing of excavated material. Assumed front loader with 10 cy bucket, 100% fill factor. 2014 Means 31 23 16.43 0450
	Haul to constructed wetland location	578	bcy	$3	$1,762	Assumed 42cy off-road vehicle, 1 mile cycle distance, 10 MPH speed limit. 2014 Means 31 23 23.20 7100
	Spread material with dozer, no compaction	578	pcy	$4.70	$2,716	Assumed 300 hp dozer, max 300 ft push. 2014 Means 31 23 23.17 0190
	Installation of wetland plants	0.1	ac	$800.00	$80	Unit cost from constructed wetland study by NC State University
				Subtotal Capital Costs	**$424,143**	
	Project Management	6%	Capital Costs	$424,143	$25,449	Project management costs when the capital costs are greater than $500K are estimated at 6 percent (Table 5-8, EPA 540-R-00-002). Because our capital cost are close to $500K, we selected the $500K to $2M cost spread.
	Remedial Design	12%	Capital Costs	$424,143	$50,897	Remedial Design costs when the capital costs are greater than $500K are estimated at 12 percent (Table 5-8, EPA 540-R-00-002). Because our capital cost are close to $500K, we selected the $500K to $2M cost spread.
	Construction Management and Oversight	8%	Capital Costs	$424,143	$33,931	Construction management costs, including construction QA/QC, when the capital costs are greater than $500K are estimated at 8 percent (Table 5-8, EPA 540-R-00-002). Because our capital cost are close to $500K, we selected the $500K to $2M cost spread.
	Contingency Costs	10%	Capital Costs	$424,143	$42,414	See Note 1
				Other Direct Costs	**$152,692**	
	TOTAL DIRECT COSTS				**$576,835**	Does not include subcontractor mark-up or profit
2	**ANNUAL COSTS**					
	Long-term surface water monitoring (seeps/springs/wetlands) and maintenance of 6 wetlands	1	ls	$38,486	$47,486	Sampling will be conducted by a 2-person field crew over a 5-day period. Assumed 15 surface water locations to be monitored on a semi-annual basis. Includes field sampling activities, laboratory costs (including QA/QC samples), data validation, data summary report preparation, and field sampling activities. Assume maintenance of the each wetland will be $1,500/year.
	30-YEAR PRESENT WORTH (i=7%;n=30,P/A=12.4090)				**$589,254**	
3	**SUMMARY REPORT (Every 5 Years)**	1	/5 Yrs	$100,000	$100,000	Engineering Judgement based on similar projects. Assumed LOE for summarizing inspection findings, summarizing operation and maintenance activities completed, preparing presentation graphics for EPA lead 5-year review meetings.
	30-YEAR PRESENT WORTH (i=7%; P/F=0.7130+0.5083+0.3624+0.2584+0.1842+0.1314=2.1577)				**$215,770**	
4	**INSTITUTIONAL CONTROLS**	2	EA	$25,000	**$50,000**	See Note 2. Assumed property easement and deed restriction will need to be executed with two property owner (P4 production, LLC and Clair Holmgren)
5	**ALTERNATIVE 3: 30 Year Present Worth Cost (Items 1+2+3+4)**				**$1,432,000**	

Notes:

1. For an FS which represents 0%-10% design completion, scope contingency typically ranges from 10 to 25 percent. The EPA guidance, "A Guide to Developing and Documenting Cost Estimates During the Feasibility Study," July 2000, (EPA 540-R-00-002) shows a rule-of-thumb scope contingency of 10%-30%.

2. Institutional controls are non-engineering or legal/administrative measures to reduce or minimize the potential for exposure to site contamination or hazards by limiting or restricting site access. These controls could include institutional control plans, restrictive covenants, property easements, zoning, deed notices, advisories, groundwater use restrictions, and site information database, as referenced in EPA 540-R-00-002.

ac	acre
bcy	bank cubic yard
CSF Flr	100 square feet of floor
EA	each
pcy	placed cubic yard
ls	lump sum
ICs	Institutional Controls
LUCs	Land Use Controls
ICIAP	Institutional Controls Implementation and Assurance Plan
QA/QC	quality assurance / quality control
Yrs	years

GROUNDWATER ALTERNATIVE 3: LIMITED PRB TREATMENT, MNA, AND ICs FEASIBILITY STUDY TECHNICAL MEMORANDUM #2
P4 Production LLC, - Ballard Mine

Description: Alternative 3 - Limited Permeable Reactive Barrier (PRB) Treatment of Alluvial Groundwater, MNA and ICs. MNA and ICs would be implemented as in Alternative 2, and PRBs would be installed up gradient of select perennial seeps near the margins of the waste rock piles at the Site to treat shallow alluvial groundwater before it discharges at the seeps/springs. See Figure 3-10 for general depiction of alternative. Additional details regarding Alternative 2 can be found in Section 3.

Item No.	Item Description	Quantity	Unit	Unit Cost ($)	Item Cost ($)	Comment
1	**DIRECT CAPITAL COSTS**					
	Mobilization/Demobilization					
	Mobilization/Demobilization of Drilling Equipment	1	ls	$10,000	$10,000	Driller mobilization based on driller quote for similar work in SE Idaho
	Mobilization of Single-Pass Trencher for PRB Installation	1	ls	$60,000	$60,000	Mobilization of single-pass trencher from Michigan
	Construction Field Offices	3	month	$223	$669	Assumed 3 - 32'x8' office trailers rented for monthly term. 2014 Means 01 52 13 13.20 0350
	Portable Toilets	360	each	$13	$4,806	Assumed 4 rental units for 90 days each. 2014 Means 01 54 33 6410
	Temporary Utilities					
	Power	246	month	$2	$448	2014 Means 01 51 13.80 0430
	Heat	23	CSF Flr	$69	$1,578	Assumed 768 sf of trailer. 2014 Means 01 51 13.8 0200
	Preparation of ICIAP	1	ls	$50,000	$50,000	Engineering Judgement - Cost is rough order of magnitude based on plan preparation from other similar projects.
	Update to Groundwater Monitoring Plan to accommodate MNA work	1	ls	$45,000	$45,000	Existing groundwater monitoring plan will be updated to conform with post RA monitoring program.
	Groundwater Remedial Components					
	1) PRB Construction near (upslope of) seep location MSG008					
	Iron Filings (PMP Cast Iron Aggregate ETI 8/50) for the PRB	17	tons	$1,070	$18,538	50ftx10ftx0.6ftx1.1 at 150lb/cf; Includes shipping by flatbed trucks in 3,000 lb supersacks from Michigan to site; Includes material for construction of trench from 3 ft to 10 ft depth
	Crushed Limestone (Iron:limestone is 0.6 feet:0.9 feet) for the PRB	18	tons	$67	$1,204	50ftx10ftx0.9ftx1.1 at 1.4 ton/cy; Includes labor for mixing and delivering the limestone/iron mix to the trencher; Includes material for construction of trench from 3 ft to 10 ft depth
	ZVI PRB Installation	50	LF	$250	$12,500	The trencher will lay the PRB 10 feet bgs with automatic backfill with Iron/limestone mix
	Installation of four monitoring wells	40	LF	$77	$3,080	Assumed four piezometers per PRB to provide additional GW sampling locations. Assumes 2-inch SCH 40 PVC casing and well screen. Based on driller estimate from a similar site in SE Idaho
	Surface completion for monitoring well	4	ea	$500	$2,000	4-inch steel protective casing, four steel concrete filled bollards, and concrete pad. Based on driller estimate from a similar site in SE Idaho
	2) PRB Construction upslope from Seep location MST067					
	Iron Filings (PMP Cast Iron Aggregate ETI 8/50) for the PRB	17	tons	$1,070	$18,538	50ftx10ftx0.6ftx1.1 at 150lb/cf; Includes shipping by flatbed trucks in 3,000 lb supersacks from Michigan to site; Includes material for construction of trench from 3 ft to 10 ft depth
	Crushed Limestone (Iron:limestone is 0.6 feet:0.9 feet) for the PRB	18	tons	$67	$1,204	50ftx10ftx0.9ftx1.1 at 1.4 ton/cy; Includes labor for mixing and delivering the limestone/iron mix to the trencher; Includes material for construction of trench from 3 ft to 10 ft depth
	ZVI PRB Installation	50	LF	$250	$12,500	The trencher will lay the PRB 10 feet bgs with automatic backfill with Iron/limestone mix
	Installation of four monitoring wells	40	LF	$77	$3,080	Assumed four piezometers per PRB to provide additional GW sampling locations. Assumes 2-inch SCH 40 PVC casing and well screen. Based on driller estimate from a similar site in SE Idaho
	Surface completion for monitoring well	4	ea	$500	$2,000	4-inch steel protective casing, four steel concrete filled bollards, and concrete pad. Based on driller estimate from a similar site in SE Idaho
	3) PRB Construction near seep location MST069					
	Iron Filings (PMP Cast Iron Aggregate ETI 8/50) for the PRB	17	tons	$1,070	$18,538	50ftx10ftx0.6ftx1.1 at 150lb/cf; Includes shipping by flatbed trucks in 3,000 lb supersacks from Michigan to site; Includes material for construction of trench from 3 ft to 10 ft depth
	Crushed Limestone (Iron:limestone is 0.6 feet:0.9 feet) for the PRB	18	tons	$67	$1,204	50ftx10ftx0.9ftx1.1 at 1.4 ton/cy; Includes labor for mixing and delivering the limestone/iron mix to the trencher; Includes material for construction of trench from 3 ft to 10 ft depth
	ZVI PRB Installation	50	LF	$250	$12,500	The trencher will lay the PRB 10 feet bgs with automatic backfill with Iron/limestone mix
	Installation of four monitoring wells	40	LF	$77	$3,080	Assumed four piezometers per PRB to provide additional GW sampling locations. Assumes 2-inch SCH 40 PVC casing and well screen. Based on driller estimate from a similar site in SE Idaho
	Surface completion for monitoring well	4	ea	$500	$2,000	4-inch steel protective casing, four steel concrete filled bollards, and concrete pad. Based on driller estimate from a similar site in SE Idaho
	4) PRB Construction near seep location MSG004					
	Iron Filings (PMP Cast Iron Aggregate ETI 8/50) for the PRB	17	tons	$1,070	$18,538	50ftx10ftx0.6ftx1.1 at 150lb/cf; Includes shipping by flatbed trucks in 3,000 lb supersacks from Michigan to site; Includes material for construction of trench from 3 ft to 10 ft depth
	Crushed Limestone (Iron:limestone is 0.6 feet:0.9 feet) for the PRB	18	tons	$67	$1,204	50ftx10ftx0.9ftx1.1 at 1.4 ton/cy; Includes labor for mixing and delivering the limestone/iron mix to the trencher; Includes material for construction of trench from 3 ft to 10 ft depth
	ZVI PRB Installation	50	LF	$250	$12,500	The trencher will lay the PRB 10 feet bgs with automatic backfill with Iron/limestone mix
	Installation of four monitoring wells	40	LF	$77	$3,080	Assumed four piezometers per PRB to provide additional GW sampling locations. Assumes 2-inch SCH 40 PVC casing and well screen. Based on driller estimate from a similar site in SE Idaho
	Surface completion for monitoring well	4	ea	$500	$2,000	4-inch steel protective casing, four steel concrete filled bollards, and concrete pad. Based on driller estimate from a similar site in SE Idaho
	5) PRB Construction near seep location MSG005					
	Iron Filings (PMP Cast Iron Aggregate ETI 8/50) for the PRB	17	tons	$1,070	$18,538	50ftx10ftx0.6ftx1.1 at 150lb/cf; Includes shipping by flatbed trucks in 3,000 lb supersacks from Michigan to site; Includes material for construction of trench from 3 ft to 10 ft depth
	Crushed Limestone (Iron:limestone is 0.6 feet:0.9 feet) for the PRB	18	tons	$67	$1,204	50ftx10ftx0.9ftx1.1 at 1.4 ton/cy; Includes labor for mixing and delivering the limestone/iron mix to the trencher; Includes material for construction of trench from 3 ft to 10 ft depth
	ZVI PRB Installation	50	LF	$250	$12,500	The trencher will lay the PRB 10 feet bgs with automatic backfill with Iron/limestone mix
	Installation of four monitoring wells	40	LF	$77	$3,080	Assumed four piezometers per PRB to provide additional GW sampling locations. Assumes 2-inch SCH 40 PVC casing and well screen. Based on driller estimate from a similar site in SE Idaho
	Surface completion for monitoring well	4	ea	$500	$2,000	4-inch steel protective casing, four steel concrete filled bollards, and concrete pad. Based on driller estimate from a similar site in SE Idaho
	6) PRB Construction near seep location MSG007					
	Iron Filings (PMP Cast Iron Aggregate ETI 8/50) for the PRB	17	tons	$1,070	$18,538	50ftx10ftx0.6ftx1.1 at 150lb/cf; Includes shipping by flatbed trucks in 3,000 lb supersacks from Michigan to site; Includes material for construction of trench from 3 ft to 10 ft depth
	Crushed Limestone (Iron:limestone is 0.6 feet:0.9 feet) for the PRB	18	tons	$67	$1,204	50ftx10ftx0.9ftx1.1 at 1.4 ton/cy; Includes labor for mixing and delivering the limestone/iron mix to the trencher; Includes material for construction of trench from 3 ft to 10 ft depth
	ZVI PRB Installation	50	LF	$250	$12,500	The trencher will lay the PRB 10 feet bgs with automatic backfill with Iron/limestone mix
	Installation of four monitoring wells	40	LF	$77	$3,080	Assumed four piezometers per PRB to provide additional GW sampling locations. Assumes 2-inch SCH 40 PVC casing and well screen. Based on driller estimate from a similar site in SE Idaho
	Surface completion for monitoring well	4	ea	$500	$2,000	4-inch steel protective casing, four steel concrete filled bollards, and concrete pad. Based on driller estimate from a similar site in SE Idaho
	7) PRB Construction near seep location MSG006					
	Iron Filings (PMP Cast Iron Aggregate ETI 8/50) for the PRB	17	tons	$1,070	$18,538	50ftx10ftx0.6ftx1.1 at 150lb/cf; Includes shipping by flatbed trucks in 3,000 lb supersacks from Michigan to site; Includes material for construction of trench from 3 ft to 10 ft depth
	Crushed Limestone (Iron:limestone is 0.6 feet:0.9 feet) for the PRB	18	tons	$67	$1,204	50ftx10ftx0.9ftx1.1 at 1.4 ton/cy; Includes labor for mixing and delivering the limestone/iron mix to the trencher; Includes material for construction of trench from 3 ft to 10 ft depth
	ZVI PRB Installation	50	LF	$250	$12,500	The trencher will lay the PRB 10 feet bgs with automatic backfill with Iron/limestone mix
	Installation of four monitoring wells	40	LF	$77	$3,080	Assumed four piezometers per PRB to provide additional GW sampling locations. Assumes 2-inch SCH 40 PVC casing and well screen. Based on driller estimate from a similar site in SE Idaho
	Surface completion for monitoring well	4	ea	$500	$2,000	4-inch steel protective casing, four steel concrete filled bollards, and concrete pad. Based on driller estimate from a similar site in SE Idaho
	8) PRB Construction near seep location MST095					
	Iron Filings (PMP Cast Iron Aggregate ETI 8/50) for the PRB	17	tons	$1,070	$18,538	50ftx10ftx0.6ftx1.1 at 150lb/cf; Includes shipping by flatbed trucks in 3,000 lb supersacks from Michigan to site; Includes material for construction of trench from 3 ft to 10 ft depth
	Crushed Limestone (Iron:limestone is 0.6 feet:0.9 feet) for the PRB	18	tons	$67	$1,204	50ftx10ftx0.9ftx1.1 at 1.4 ton/cy; Includes labor for mixing and delivering the limestone/iron mix to the trencher; Includes material for construction of trench from 3 ft to 10 ft depth
	ZVI PRB Installation	50	LF	$250	$12,500	The trencher will lay the PRB 10 feet bgs with automatic backfill with Iron/limestone mix
	Installation of four monitoring wells	40	LF	$77	$3,080	Assumed four piezometers per PRB to provide additional GW sampling locations. Assumes 2-inch SCH 40 PVC casing and well screen. Based on driller estimate from a similar site in SE Idaho
	Surface completion for monitoring well	4	ea	$500	$2,000	4-inch steel protective casing, four steel concrete filled bollards, and concrete pad. Based on driller estimate from a similar site in SE Idaho

GROUNDWATER ALTERNATIVE 3: LIMITED PRB TREATMENT, MNA, AND ICs
FEASIBILITY STUDY TECHNICAL MEMORANDUM #2
P4 Production LLC, Ballard Mine

Description: Alternative 3 - Limited Permeable Reactive Barrier (PRB) Treatment of Alluvial Groundwater, MNA and ICs. MNA and ICs would be implemented as in Alternative 2, and PRBs would be installed up gradient of select perennial seeps near the margins of the waste rock piles at the Site to treat shallow alluvial groundwater before it discharges at the seeps/springs. See Figure 3-10 for general depiction of alternative. Additional details regarding Alternative 2 can be found in Section 3.

Item No.	Item Description	Quantity	Unit	Unit Cost ($)	Item Cost ($)	Comment
	9) PRB Construction near seep location MST094					
	Iron Filings (PMP Cast Iron Aggregate ETI 8/50) for the PRB	17	tons	$1,070	$18,538	50ftx10ftx0.6ftx1.1 at 150lb/cf; Includes shipping by flatbed trucks in 3,000 lb supersacks from Michigan to site; Includes material for construction of trench from 3 ft to 10 ft depth
	Crushed Limestone (Iron:limestone is 0.6 feet:0.9 feet) for the PRB	18	tons	$67	$1,204	50ftx10ftx0.9ftx1.1 at 1.4 ton/cy; Includes labor for mixing and delivering the limestone/iron mix to the trencher; Includes material for construction of trench from 3 ft to 10 ft depth
	ZVI PRB Installation	50	LF	$250	$12,500	The trencher will lay the PRB 10 feet bgs with automatic backfill with Iron/limestone mix
	Installation of four monitoring wells	40	LF	$77	$3,080	Assumed four piezometers per PRB to provide additional GW sampling locations. Assumes 2-inch SCH 40 PVC casing and well screen. Based on driller estimate from a similar site in SE Idaho
	Surface completion for monitoring well	4	ea	$500	$2,000	4-inch steel protective casing, four steel concrete filled bollards, and concrete pad. Based on driller estimate from a similar site in SE Idaho
				Subtotal Capital Costs	**$508,395**	
	Project Management	8%	Capital Costs	$508,395	$40,672	Project Management costs, when the capital costs are between $100 to 500K, are estimated at 8 percent (Table 5-8, EPA 540-R-00-002).
	Remedial Design	15%	Capital Costs	$508,395	$76,259	Remedial Design costs, when the capital costs are between $100 to 500K, are estimated at 15 percent (Table 5-8, EPA 540-R-00-002).
	Construction Management and Oversight	10%	Capital Costs	$508,395	$50,839	Construction management costs, including construction QA/QC, when capital costs are between $100 to 500K, are estimated at 10 percent (Table 5-8, EPA 540-R-00-002).
	Contingency Costs	10%	Capital Costs	$508,395	$50,839	See Note 1
				Other Direct Costs	**$218,610**	
	TOTAL DIRECT COSTS				**$727,004**	Does not include subcontractor mark-up or profit
2	**ANNUAL COSTS**					
	Long-term MNA Groundwater Monitoring and Reporting	1	ls	$80,987	$80,987	Sampling will be conducted by a 2-person field crew over a 15-day period. Assumed 78 groundwater locations to be monitored on an annual basis. Samples to be analyzed for site COCs using SW 6020 at $92.60 per sample. Includes field sampling activities, laboratory costs (including QA/QC samples), data validation, data summary report preparation, and field sampling activities.
	30-YEAR PRESENT WORTH (i=7%;n=30,P/A=12.4090)				**$1,004,968**	
3	**SUMMARY REPORT (Every 5 Years)**	1	/5 Yrs	$100,000	$100,000	Engineering Judgement based on similar projects. Assumed LOE for summarizing inspection findings, summarizing operation and maintenance activities completed, preparing presentation graphics for EPA lead 5-year review meetings.
	30-YEAR PRESENT WORTH (i=7%; P/F=0.7130+0.5083+0.3624+0.2584+0.1842+0.1314=2.1577)				**$215,770**	
4	**INSTITUTIONAL CONTROLS**	5	EA	$25,000	**$125,000**	See Note 2. Assumed property easement and deed restriction will need to be executed with one property owner (Tucker Torgeson Farms, Hunsaker Ranching, Nu West Industries, Mark & Beth Carter Trust, Clair Holmgren)
5	**ALTERNATIVE 3: 30 Year Present Worth Cost (Items 1+2+3+4)**				**$2,073,000**	

Notes:
1. For an FS which represents 0%-10% design completion, scope contingency typically ranges from 10 to 25 percent. The EPA guidance, "A Guide to Developing and Documenting Cost Estimates During the Feasibility Study," July 2000, (EPA 540-R-00-002) shows a rule-of-thumb scope contingency of 10%-30%.

2. Institutional controls are non-engineering or legal/administrative measures to reduce or minimize the potential for exposure to site contamination or hazards by limiting or restricting site access. These controls could include institutional control plans, restrictive covenants, property easements, zoning, deed notices, advisories, groundwater use restrictions, and site information database, as referenced in EPA 540-R-00-002.

ac	acre
bcy	bank cubic yard
CSF Flr	100 square feet of floor
EA	each
lcy	loose cubic yard
LF	linear feet
MSF	thousand square feet
Yrs	years

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RECORD OF DECISION
FOR
BALLARD MINE
CARIBOU COUNTY, IDAHO

Part 3
Responsiveness Summary

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Overview of Responsiveness Summary

This part of the Record of Decision (ROD), the Responsiveness Summary, presents the comments submitted during the public comment period on the Proposed Plan for the Ballard Mine Site (Site) and the U.S. Environmental Protection Agency (EPA) responses. EPA issued the Proposed Plan for the Ballard Mine Site on April 2, 2018, and accepted comments during a public comment period that ran from April 2 through May 1, 2018.

No one requested an extension to the public comment period. A public meeting was held in Soda Springs, Idaho, on April 11, 2018, to present information on the Proposed Plan, answer questions, and provide the public with an opportunity to give written and spoken comments. No spoken comments were made during the formal portion of the public meeting. Written comments were received from three individuals and one organization during the comments period. The original comments and a transcript of the public meeting is available in the Administrative Record.

The comments received covered a range of topics. Some commenters expressed preferences regarding the alternatives and potential ore recovery during implementation and stated concerns about the Superfund cleanup process, adequacy of outreach to stakeholders during the process, and risks posed by current conditions. One organization stated concerns and provided recommendations about various elements of the Preferred Alternative.

Comments and Responses

This section of the Responsiveness Summary presents each substantive comment received during the public comment period. Following each comment is a response that explains how the commenter's concerns were addressed and their preferences considered during the remedy selection process.

Comment 1: Support for preferred alternative and ore recovery

I am in favor of the EPA's Preferred Alternative as it meets the Remedial Action Objectives while also providing the money needed for the cleanup through ore recovery. As a former employee, I am personally aware of the effort, thought, and hours over many years that have been put into this cleanup plan by Monsanto, consultants, and government agencies and am satisfied that is the best step forward to make right now for the Ballard site. I am also a member of the local community and am supportive of this action for how it will improve the land on the Ballard site and for the revenue it will bring to the area.

EPA Response:

Comment noted. The Selected Remedy is consistent with the Preferred Alternative identified in the Proposed Plan.

Comment 2: Support for ore recovery and concern about whether risks justify cleanup

When mining was done these pits were left open specifically so that they could be reopened in the future. There should be no reshaping unless it goes hand-in-hand with total mining of all the remaining ore (I would guess that there is much more than 4M ton). This is a valuable resource in Caribou County that shouldn't be left up to the whims of some foreign owned multinational corporation whether or not to mine. This ore might be more desirable to another company. I do not believe that the environmental hazards warrant action that would destroy our natural resource. I do think that hand spraying the aster could be tried to control selenium problem until such time that the pits are re-mined.

EPA Response:

The Selected Remedy assumes that P4 will recover phosphate ore during the implementation of the remedy. EPA notes, however, that ore recovery is a business decision; cleanup of the Site does not depend on potential ore recovery.

During the Feasibility Study process, the project team developed and evaluated a range of alternatives for cleanup. EPA concluded that the Preferred Alternative (with potential ore recovery) meets the threshold criteria (of protectiveness and achieving Applicable or Relevant and Appropriate Requirements [ARARs]) and provides the best balance of tradeoffs among the other alternatives with respect to the modifying criteria. The Selected Remedy mirrors the Preferred Alternative identified in the Proposed Plan. However, potential ore recovery is a business decision that depends on many factors. Any decision on whether to recover ore during implementation of the cleanup would be up the owner of the mineral lease.

EPA's Selected Remedy assumes that remining will occur during implementation of the remedial action. For potential ore recovery to proceed, Bureau of Land Management (BLM) will need to issue a phosphate mineral lease and approve a mine plan for ore recovery. The Selected Remedy will be designed to accommodate, but not require, the recovery of ore during remedy implementation. EPA will work closely with P4 Production and BLM to coordinate the cleanup with ore recovery.

EPA disagrees with the comment expressing belief that risks do not warrant cleanup action. The remedial investigation of the Site documented the presence of many millions of tons of waste rock and ongoing releases of contaminants from the waste rock to upland soil, vegetation, groundwater, surface water, and sediment. In addition, the concentrations of contaminants in affected media exceed risk-based thresholds and present unacceptable risks to people and ecological receptors. Cleanup action is necessary to address the risks identified.

The commenter also notes that asters (a type of plant that may contain high levels of contaminants) may be controlled by hand spraying until the cleanup plan is implemented. EPA agrees with this suggestion. The land owner, P4, has implemented this method of controlling plants for several years as a best management practice (BMP). EPA anticipates continuing this BMP during remedial design and implementation. Following implementation, a monitoring and maintenance program will be prepared for the Site. EPA anticipates that preventing the occurrence and growth of known selenium bioaccumulating plants will be an important part of any long-term maintenance plan for the remediated mine site. The evapotranspiration (ET) cover will be planted with a mix of native plant species. Bioaccumulating species, such as asters, will not be included.

Comment 3: Concern about the length of time it has taken to study the site and develop a cleanup plan, and adequacy of outreach of stakeholders.

First I'd like to say that the presentation you put on was very informative and helpful. Second…..why has it taken this long to come to some sort of a plan to take care of a problem that the mining community and EPA have known about for some 20 years, if not more? Third, one of the familys' most effected by the Ballard Mine pollution expected more frequent and timely updates than were provided by agencies on the progress of the project.

EPA Response:

EPA acknowledges that it has taken many years to characterize site conditions and develop a cleanup plan. There are many factors that have contributed to the schedule for this project, some of which are described in the Introduction and Site Background sections of the Proposed Plan. EPA remains committed to advancing this project in a timely fashion. EPA acknowledges that more effort could have been focused on community outreach and engagement, particularly for landowners with property near the site. A summary of efforts on community involvement are included in the Site Background section of the Proposed Plan and Section 3 – Community Participation of this document. In addition, EPA has developed a Community Involvement Plan (CIP) for the project that is updated from time to time. EPA will review and update the CIP in the coming months and will strengthen components related to outreach to local landowners.

Comment 4: Greater Yellowstone Coalition (GYC) provided comments and recommendations on each of the four media-specific components of the combined preferred alternative.

GYC Comments on Upland Soil/Waste Rock Alternative 6:

GYC encourages the agencies to evaluate and confirm the effectiveness of the final cover…… In 2011, EPA reported that the ability to abate percolation is performance criteria for final cover systems, and only "limited data are available about percolation performance and alternative designs". Given this statement regarding limited data for cover design effectiveness, EPA should incorporate a significant factor of safety with regard to both cover infiltration and evapotranspiration for final designs. Alternatively providing for a robust cover infiltration monitoring system to provide options for adaptive management, should cover performance not meet the infiltration criteria.

GYC suggests that EPA and [I]DEQ monitor the following factors identified by EPA to maintain effectiveness of the cover system for an extended period of time: settlement effects, gas emissions, erosion, slope failure, and vegetative cover maintenance.

GYC further recommends that the agencies ensure that the ET cover in fact prevents or greatly reduces the release of contaminants to surface water and groundwater.

GYC additionally requests that the cover eliminates direct contact exposures, prevents vegetative uptake, and eliminates the releases of contaminants to riparian soil and sediment.

Given the last 20 years of experimentation on effectiveness of covers in southeast Idaho, GYC encourages EPA to fully understand what covers work in specific situations, and to employ a rigorous monitoring plan and adaptive management plan.

EPA Response:

EPA generally agrees with the comments and recommendations regarding the need for care in developing the design and performance monitoring strategy for the ET cover system. A detailed design, performance monitoring plan, and adaptive management plan will be developed during the remedial design phase of the project.

Effectiveness, both short- and long-term, are criteria by which EPA evaluates each of the proposed remedial alternatives. The ET cover was selected from a variety of proposed cover designs/configurations modeled for water infiltration effectiveness based on soil characteristics and design attributes (see the 2016 Ballard Mine Feasibility Study Report). Modeling results were compared with data from actual covers that had been constructed and monitored by other local mines to take advantage of lessons learned by others. The information obtained from these studies will be incorporated into the design of a remedial cover. Once constructed, the effectiveness of the cover to mitigate infiltration will be monitored by inspections, spring and seep surveys, instrumentation, and by comparing concentration of contaminants in downgradient surface water and groundwater monitoring stations with cleanup levels.

During the remedial design phase, a detailed design of the ET cover system will be developed. This will include specifications related to hydraulic conductivity and ability to retain water. The characteristics of the soil used for cover will dictate these attributes, and the thickness of the cover will be adjusted accordingly to be most effective. Factors of safety, with respect to cover infiltration and ET, will be addressed during remedial design.

A monitoring plan, describing specific methods, will also be developed during remedial design. The plan will include elements necessary to evaluate infiltration and soil moisture. It is anticipated that soil moisture monitoring will include installation of monitoring stations at strategic locations on the cover and at various depths within the cover profile.

An adaptive management plan will be prepared concurrently with the remedial design. The plan shall set performance criteria or targets for key performance measure (if other than state or federal standards) and identify potential follow-up actions to correct identified problems or optimize cover performance. Application of adaptive management actions will be guided by monitoring results.

Because contamination is left in place as part of the remedy, EPA will perform a Five-Year Review (FYR). The objective of the FYR is to evaluate whether the remedy is functioning as originally intended. If the integrity of the remedy has been compromised, specific actions are undertaken to mitigate the situation and restore the remedy. This includes inspection of the remedial cover for settlement effects, accelerated erosion, slope failure, and vegetative cover maintenance issues.

GYC Comments on Surface Water Alternative 3:

GYC encourages the agencies to identify and implement a rigorous monitoring plan to ensure that the wetland treatment cells do not themselves become sources of contamination.

GYC suggests EPA and [I]DEQ follow EPA's guidelines for a successful constructed treatment wetland, including site-specific examinations of soil suitability, hydrology, vegetation, the presence of endangered species, the presence of species of concern, critical wildlife corridors, and/or critical wildlife habitat.

GYC encourages the agencies to not only examine these qualities but identify a plan to protect conservation resources while avoiding further natural resource damage such as the introduction of invasive species.

Furthermore, EPA and [I]DEQ should consider potential water quality impacts as well as impacts to the surrounding future uses.

The adaptive management plan to be prepared during remedial design phase should set clear standards for monitoring contaminants in the wetland treatment cells, create well-defined decision rules for determining whether the wetland treatment cell may remain in place, and create a precise process for the disposal of spent treatment media.

Additionally, a rapid and reasonable time limit should be specified for the implementation of adaptive management actions.

EPA Response:

EPA generally agrees with the comments and recommendations regarding the need for care in developing the design and performance monitoring strategy for the wetland treatment cells. A detailed design, operation and maintenance (O&M) plan, performance monitoring plan, and adaptive management plan will be developed during the remedial design phase of the project.

Engineered wetlands were identified as a viable alternative at this site because they have proven to be effective at selenium removal, are simple to construct, and are relatively low cost. When these treatment cells are combined with the cover system and upgradient permeable reactive barriers (PRB), cleanup levels are expected to be attained where treated water enters waters of the United States.

The conceptual design for the engineered wetland treatment cells include an upflow anaerobic/aerobic wetlands system that includes seepage interception and collection, a gravel distribution bed, an anaerobic organic bed, and a growth bed for wetlands plants along with open water surface (aerobic portion of the system). Site-specific design variables (for example, residence time, peak and low flow requirements, and material needs) will be evaluated and considered in developing the design. Designs may later be modified to optimize performance and efficiency, and cells may be phased out once other elements of the remedy become effective.

EPA agrees with comments on the need to monitor the initial and sustained effectiveness of the wetland treatment cell, the need to site and construct the treatment cells to maximize their treatment effectiveness without compromising other natural resources, to avoid introduction of invasive species, evaluate residual effects of water quality impacts on future use, and be proactive in implementing adaptive management strategies.

During remedial design, a monitoring plan will be developed to assess the effectiveness of the wetland treatment cells. Monitoring will be conducted to evaluate contaminant removal rates and loading in the wetland media. Loading thresholds will be determined to prevent the wetlands from becoming a source of contamination. In addition, an O&M plan will be developed that will include decision rule and procedures for removal, replacement and disposal of the wetlands media, and decision rules for decommissioning treatment cells.

An adaptive management plan will be prepared concurrently with the remedial design. The plan shall set performance criteria or targets for key performance measures and identify potential follow-up actions to correct identified problems or optimize treatment performance. Application of adaptive management actions will be guided by monitoring results.

GYC Comments on Stream Channel Sediment and Riparian Soil Alternative 3:

GYC encourages the agencies to identify a rigorous monitoring plan to ensure that the sediment traps/basins do not themselves become sources of contamination.

GYC recommends the adaptive management plan to be prepared during the remedial design phase should set clear standards for monitoring contaminants in sediment traps/basins, create well-defined decision rules for determining whether the sediment traps/basins may remain in place, and create a precise process for disposal of contaminated sediment. Additionally, long term risks and effects of abandoned or buried in-place sediment traps becoming exposed and/or eroded should be evaluated on a site or individual basis.

EPA Response:

EPA agrees with the comments and recommendations regarding the need for care in developing the design and performance monitoring strategy for the sediment control features included in the selected alternative. A detailed design, O&M plan, performance monitoring plan, and adaptive management plan will be developed during the remedial design phase of the project.

EPA agrees with comments regarding the importance of monitoring the effectiveness of the sediment traps/basins to capture and retain sediment during and following construction of the ET cover system. A monitoring plan and O&M plan will be developed to evaluate these features and will address accumulation of sediment, and procedures for removal and disposal. The O&M plan will also include decision rules for decommissioning sediment traps/basins.

An adaptive management plan will be prepared concurrently with the remedial design. The plan shall set performance criteria for evaluating the effectiveness of the sediment control features and identify potential follow-up actions to correct identified problems or optimize performance. Application of adaptive management actions will be guided by monitoring results.

GYC Comments on Groundwater Alternative 3:

GYC encourages the agencies to identify a rigorous monitoring plan to ensure that the permeable reactive barriers (PRBs) do not themselves become sources of contamination…… Should the PRBs themselves become sources of contamination, the agencies should follow their guidelines for appropriate disposal of spent treatment materials and impacted area clean up. The adaptive management plan to be prepared during the remedial design phase should set clear standards for monitoring contaminants in the PRBs, create well-defined decision rules for determining whether the PRBs may remain in place, and create a precise process for the disposal of spent treatment media.

EPA Response:

EPA generally agrees with the comments and recommendations regarding the need for care in developing the design and performance monitoring strategy for the permeable reactive barriers included in the selected alternative. A detailed design, O&M plan, performance monitoring plan, and adaptive management plan will be developed during the remedial design phase of the project.

A monitoring plan will be developed to track variables that have a bearing on performance. In addition, bracketing monitoring wells will be used to measure the chemistry of influent and effluent groundwater and surface water. The plan will describe monitoring of the hydraulic conductivity, reactive condition of the PRB treatment media, and other measures.

A plan will also be developed to guide O&M of the PRBs, and will include procedures and decision rules for removal, replacement, and disposal of the wetlands media. The contaminant concentration thresholds linked to breakthrough that trigger removal and disposal of the treatment media will be described in the O&M plan. The plan will also describe abandonment of PRBs and decision rules for removal or abandonment in place.

An adaptive management plan will be prepared concurrently with the remedial design. The plan shall set performance criteria for evaluating the effectiveness of the PRBs and identify potential follow-up actions to correct identified problems or optimize performance. Application of adaptive management actions will be guided by monitoring results.

Together, implementation of monitoring, O&M, and adaptive management will ensure that the PRBs are working as designed and do not themselves become a source of contamination.