BALLARD MINE FEASIBILITY STUDY REPORT

MEMORANDUM 2 – SCREENING, DETAILED, AND COMPARATIVE ANALYSIS OF ASSEMBLED REMEDIAL ALTERNATIVES

FINAL - REVISION 2

Ballard Mine Site

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Acronyms and Abbreviations

AOC	Administrative Order on Consent
ARARs	applicable or relevant and appropriate requirements
A/Ts	Agencies and Tribes
BAT	best available technology
bcy	bank cubic yards
BLM	United States Department of the Interior, United States Bureau of Land Management
BMP	best management practices
BRA	Baseline Risk Assessment
CDs	Consent Decrees
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CO	Consent Order
COCs	contaminants of concern
COECs	contaminants of ecological concern
ET	evapotranspiration
FFAs	Federal Facility Agreements
GCLL	geosynthetic clay laminate liner
GRAs	general response actions
HASP	health and safety plan
ICs	Institutional Controls
ICIAP	Institutional Controls Implementation and Assurance Plan
IDEQ	Idaho Department of Environmental Quality
LTM	long-term monitoring
LUCs	Land Use Controls
MCL	maximum contaminant level
MNA	Monitored Natural Attenuation
MNR	Monitored Natural Recovery
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
NPDES	National Pollutant Discharge Elimination System
O&M	operation and maintenance
OMMP	operation, monitoring and maintenance plan
P4	P4 Production, LLC
PCE	tetrachloroethene
PCLs	preliminary cleanup levels
pcy	placed cubic yards

PPE	personnel protective equipment
PRB	Permeable Reactive Barrier
RA	remedial action
RAOs	remedial action objectives
RAWP	Remedial Action Work Plan
RD	remedial design
RI/FS	Remedial Investigation / Feasibility Study
RO	reverse osmosis
SAP	Sampling and Analysis Plan
SOW	Statement of Work
TBC	to be considered
TCE	trichloroethene
Tribes	Shoshone Bannock Tribes
USEPA	United States Environmental Protection Agency
USFS	United States Department of Agriculture, United States Forest Service
WTP	water treatment plant

1 INTRODUCTION

1.1 PURPOSE

In 2009, P4 Production, L.L.C. (P4) entered into an Administrative Settlement Agreement and Order on Consent/Consent Order (2009 CO/AOC; USEPA, 2009a) with the United States Environmental Protection Agency (USEPA); the Idaho Department of Environmental Quality (IDEQ); the United States Department of Agriculture, United States Forest Service (USFS); the United States Department of the Interior, United States Bureau of Land Management (BLM); and the Shoshone-Bannock Tribes (Tribes), collectively referred to as the Agencies and Tribes or A/Ts. The general objective of the 2009 CO/AOC was to conduct a remedial investigation and feasibility study (RI/FS) of P4's legacy mine sites, the oldest of which is Ballard Mine. The RI/FS is being conducted in accordance with the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), and the associated regulations of the National Oil and Hazardous Substances Pollution Contingency Plan (NCP). With A/T concurrence, P4 is performing this work sequentially, starting with the Ballard Mine and then moving onto the newer legacy mine sites. In 2014, P4 completed the RI for the Ballard Mine, which is summarized in the *Ballard Mine RI Report – Final Revision 2* (*Ballard RI Report;* MWH, 2014). The Ballard Mine FS is being presented in two technical memoranda and this submission (*Ballard FS Memorandum #2*) is the second of two memoranda that together comprise the FS for the Ballard Mine (Site or Ballard Site).

According to Appendix 1 Statement of Work (SOW), Task 5 of the 2009 CO/AOC, the general objective of the FS is to determine and evaluate alternatives for remedial action, if any, to prevent, mitigate, or otherwise respond to, or remedy, any release, or threatened release, of hazardous substances, pollutants, or contaminants at or from the Site. More particularly, the purpose of the FS is to, first assemble and screen remedial technologies for the identified contaminants of concern (COCs) and contaminants of ecological concern (COECs) in each environmental medium and second, use the selected technologies to create and evaluate remedial alternatives, in this case, for the Site. The A/T-approved *Ballard Mine Feasibility Study Report Memorandum 1 – Site Background and Screening of Technologies Final Revision 2* (*Ballard FS Memo #1*: MWH, 2016a) addressed the first objective by identifying and evaluating available remedial technologies. This second technical memorandum (*Ballard FS Memo #2*) addresses the second and final FS objective by assembling,

screening, analyzing, and comparing a wide variety of possible remedial alternatives for cleanup of each impacted medium at the Ballard Site.

The *Ballard FS Memo #1* contains the following information:

- Description of the Site's mining history, regulatory history, and physical characteristics.
- Key findings of *Ballard RI Report* and the *Baseline Risk Assessment (BRA* - presented in Appendix A of the *Ballard RI Report*).
- Applicable or relevant and appropriate requirements (ARARs), remedial action objectives (RAOs), general response actions (GRAs), and preliminary cleanup levels for the Ballard Site.
- Evaluations of available technologies for each medium when considering the Site-specific RAOs, GRAs, and preliminary cleanup levels. An initial screening of these technologies is performed based on their *technical implementability*. A second more detailed screening then is performed on the remaining technologies and uses effectiveness, implementability, and cost. These two screening steps ensure that only the viable technologies for each medium are used in the assembly of remedial alternatives presented in this *Ballard FS Memo #2*.

In this *Ballard FS Memo #2*, the retained technologies/process options from *Ballard FS Memo #1* are assembled into a range of media-specific remedial alternatives. The assembled remedial alternatives initially are screened by effectiveness, implementability, and cost. The alternatives that remain after the initial screening are evaluated using the CERCLA threshold and balancing criteria (USEPA, 1988). In these final evaluation steps, each retained alternative is evaluated independently without consideration of other alternatives (i.e., the detailed analysis), and then is compared to the others to identify the relative advantages and disadvantages between the alternatives (i.e., the comparative analysis). At the end of this document, the best media-specific alternatives are combined into a recommended combined remedy that addresses the entire Site.

1.2 MEDIA-SPECIFIC APPROACH

Alternatives for specific media and particular areas within the Site either can be carried through the FS process separately or combined into comprehensive alternatives for the entire site. The approach is flexible and allows the alternatives for the media to be combined at various points in the process. For the Ballard Site, because of the number of media involved in the process (i.e., upland soil/waste

rock, sediment/riparian soil, surface water, and groundwater), remedial alternatives are developed and fully screened separately by medium, and then are combined at the end of the process.

1.3 DOCUMENT ORGANIZATION

Ballard FS Memo #2 generally follows the suggested outline in *Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA, Interim Final* (*RI/FS Guidance*; USEPA, 1988) and consists of four sections and three appendices:

Section 1.0 Introduction

Section 2.0 Assembly and Screening of Remedial Action Alternatives – The viable remedial technologies and process options that were retained following the screening performed in the *Ballard FS Memo #1* are assembled into remedial action (RA) alternatives and screened according to effectiveness, implementability, and cost.

Section 3.0 Detailed and Comparative Analyses of Remedial Action Alternatives. The RA alternatives that are retained following the screening performed in Section 2.0 are evaluated against the seven CERCLA threshold and balancing criteria. The difference between the two steps is that in the detailed analysis, each alternative is evaluated independently without consideration of other alternatives. In contrast, the comparative analysis identifies the relative advantages and disadvantages between the alternatives.

Section 4.0 Recommended Combined Remedy – The best media-specific alternatives (based on the results of the comparative analyses) are combined into a recommended combined remedy that addresses the entire Site. Section 4.0 also includes a summary of recommended interim Institutional Controls (ICs) for the Ballard Shop intended to reduce potential exposures pending a focused FS and potential active remedial action in this area of the Site. As discussed in *Ballard FS Memo #1*, final RAs at the Ballard Shop are deferred until the area is no longer actively used.

Section 5.0 References

Appendix A FS Cost Estimate for Viable Alternatives by Medium

Appendix B *Cover System Evaluation Memorandum for the Ballard Mine Site*

Appendix C Comments and Comment Responses – Contains A/T comments and P4 responses on this document.

2 ASSEMBLY OF REMEDIAL ALTERNATIVES

The viable remedial technologies and process options that were retained following the screening performed in Section 5.0 of *Ballard FS Memo #1* are assembled into remedial alternatives and detailed in **Tables 2-1** through **2-4**. The remedial alternatives are assembled in accordance with the *EPA RI/FS Guidance*, which states: *"Assemble the selected representative technologies into alternatives representing a range of treatment*[1] *and containment combinations, as appropriate"* and "*Alternatives should be developed that will provide decision-makers with an appropriate range of options and sufficient information to adequately compare alternatives against one another. In developing alternatives, the range of options will vary depending on site-specific conditions."*

The assembled remedial alternatives then are screened in **Tables 2-1** through **2-4** based on their effectiveness, implementability, and cost and their ability to achieve the RAOs and ARARs (which are presented in Section 3.0 of *Ballard FS Memo #1*). This screening was performed in accordance with the *EPA RI/FS Guidance*, which states: *"Defined alternatives are evaluated against the short- and long-term aspects of three broad criteria: effectiveness, implementability, and cost. Because the purpose of the screening evaluation is to reduce the number of alternatives that will undergo a more thorough and extensive analysis, alternatives will be evaluated more generally in this phase than during the detailed analysis."*

In order to keep the overall number of possible remedial alternatives reasonable, given the number of Site media, the remedial alternatives are assembled and screened separately by medium in **Tables 2-1** through **2-4**. The media-specific remedial alternatives that are retained following the screening step performed in this section are carried forward into the detailed and comparative analyses presented in Section 3.0, and finally combined into a recommended complete Site-wide alternative in Section 4.0. The recommended Site-wide remedial alternative in Section 4.0 addresses RAOs and ARARs for all the impacted Site media.

2.1 COMMON/CORE ELEMENTS OF THE ASSEMBLED ALTERNATIVES

For each medium-specific assembled alternative (with the exception of the No Action alternative), there are common or core elements that will be incorporated into the remedial design (RD) and are

[1] The large volume of the upland soil/waste rock at the Site limits the feasibility of treating this medium to meet the RAOs. As a result, treatment technologies are not included in the assembled alternatives for the upland soil/waste rock medium because those technologies were eliminated during previous screening steps performed in *Ballard FS Memo #1*.

an integral part of each alternative. These core elements may vary somewhat from one assembled alternative to another and likely will not be fully defined until the RD. A general discussion of the core elements is provided below.

2.1.1 Contaminant-Source Controls

As discussed in the Nature and Extent of Contamination and Contaminant Fate and Transport sections of *Ballard FS Memo #1* (Sections 2.1 and 2.2, respectively), the COCs/COECs detected at the Site originate in the upland soil, waste rock dumps, and pit backfill throughout the former mined area. As precipitation falls on the Site, COCs/COECs are transported downslope/downgradient by surface water runoff and groundwater that contacted these source materials. As a result, the long-term success of any remedial alternative for surface water, groundwater, and sediment/riparian soil relies on source controls that isolate the upland soil/waste rock so transfer of COCs/COECs to these downslope/downgradient media is prevented or significantly reduced. Therefore, with the exception of the No Action alternatives, all assembled media-specific remedial alternatives assume that effective source controls would be implemented in varying degrees on the upland soil/waste rock medium to prevent or reduce long-term leaching/erosion of COCs/COECs from the upland source areas.

2.1.2 Institutional Controls and Land Use Controls

Land Use Controls (LUCs). LUCs are a limited action responses provided to limit human and in some cases ecological exposures. LUCs include engineered and physical barriers, such as fences and security guards, as well as ICs.

Institutional Controls (ICs). ICs are administrative actions to limit human and in some cases ecological exposures. ICs assist in achieving RAOs by: 1) limiting land or resource use/access, and 2) providing information that helps modify or guide human behavior at locations and in areas where COC/COEC concentrations prevent unlimited use and unrestricted exposure. ICs also are used to track changes in land use or ownership, and develop a notification system to ensure current and potential future owners are aware of possible exposure hazards on the subject property. USEPA defines ICs as "non-engineered instruments, such as administrative and legal controls, that help to minimize the potential for exposure to contamination and/or protect the integrity of a response action" (USEPA, 2012). USEPA generally divides the types of ICs available into four general categories:

1) **Governmental controls** (e.g., zoning, local ordinances) - impose restrictions on land or resource use using the authority of a government entity. Typical examples of governmental controls include zoning; building codes; state, tribal, or local groundwater use regulations; and commercial fishing bans and sports/recreational fishing limits posed by federal, state and/or local resources and/or public health agencies. In many cases, federal landholding agencies possess the authority to enforce ICs on their property.

2) **Proprietary controls** (often referred to as "deed restrictions[2]") - refer to controls on land use that are considered private in nature because they tend to affect a single parcel of property and are established by private agreement between the property owner and a second party who, in turn, can enforce the controls. Common examples include easements that restrict use (also known as negative easements) and restrictive covenants. These types of controls can prohibit activities that may compromise the effectiveness of the response action or restrict activities or future resource use that may result in unacceptable risk to human health or the environment. State and tribal law typically authorize proprietary controls.

3) **Enforcement and permit tools** - are legal tools, such as administrative orders, permits, Federal Facility Agreements (FFAs), and Consent Decrees (CDs), that limit certain site activities or require the performance of specific activities (e.g., monitor and report on IC effectiveness). These legal tools may be issued unilaterally or negotiated.

4) **Informational tools** (e.g., notices filed in the land records, advisories) - provide information or notification often as recorded notice in property records or as advisories to local communities, tourists, recreational users, or other interested persons that residual contamination remains on site. As such, informational devices generally do not provide enforceable restrictions. Typical informational devices include state registries of contaminated sites, notices in deeds, tracking systems, and fish consumption advisories.

Neither ICs nor LUCs reduce the mobility, toxicity, or volume of COCs/COECs; nor do ICs/LUCs limit exposures to all ecological receptors. However, ICs/LUCs may limit human and large mammal (e.g., livestock, elk, and deer) exposure to the COCs/COECs and preserve the integrity of the overall remedy.

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[2] "Deed Restriction" is not a traditional real property law term, but used in the NCP as a shorthand way to refer to various types of proprietary controls.

2.1.3 Long-Term Monitoring/Operation and Maintenance

Long-term monitoring (LTM) of various environmental media (e.g., groundwater, surface water, sediment/riparian soil, vegetation) would be required to evaluate the effectiveness of any selected remedy (with the exception of the No Action alternative, which assumes no monitoring would occur). The LTM results would be used to support the protectiveness evaluations during the CERCLA 5-year review process. The monitoring networks likely would be a combination of existing sampling locations (e.g., existing monitoring wells and historical surface water sampling locations) with additional locations added depending on the nature and requirements of the selected remedy. The assumptions used for estimating LTM in this FS are included in the descriptions of the retained alternatives that are carried through the detailed and comparative analyses (see Section 3.2) and in the cost estimates (see **Appendix A**). The actual LTM objectives and maintenance requirements would vary based on the selected remedy and would be established in detail during the RD process.

Any cover system installed as part of the selected remedy would require LTM and maintenance. This monitoring effort would be implemented to ensure the effectiveness and longevity of the various cover systems installed during the RA. The conceptual strategy for the cover system monitoring initially is developed in the detailed analysis of this FS and then will be finalized and designed in the RD. The cover system monitoring program would depend on the cover type, but in general the monitoring would include:

- Settlement monitoring
- Erosion monitoring (periodic and after certain storm events)
- Vegetation monitoring on the surface of the capped areas
- Security monitoring (fences, signage, etc.)
- Stormwater/precipitation drainage system monitoring

Operation and maintenance (O&M) of any active or permanent component of a remedy likely will be required to maintain the effectiveness/protectiveness of the component. O&M may be scheduled/routine or may be based on issues identified during LTM. For example, a cover system may require periodic O&M to maintain the desired vegetative cover or to repair damage caused by

erosion. Water treatment systems would require ongoing routine O&M to ensure the system continues to efficiently and effectively treat water to its design parameters.

2.1.4 Revegetation

Any remedial activity that involves earthmoving or ground disturbance would include revegetation to return the disturbed areas to a natural appearance and to reduce/prevent soil erosion. The revegetated areas of the soil covers would act to limit erosion and to reduce infiltration by transpiring precipitation. The revegetated areas would use native seed mixes and plant species that are known to not be selenium hyperaccumulators as identified by the NRC (NRC, 1983). These details will be defined in the RD.

2.2 SCREENING EVALUATION OF ALTERNATIVES

The purpose of the screening evaluation summarized in this section is to evaluate whether a proposed remedial alternative will undergo the more thorough and extensive detailed and comparative analyses presented in Section 3.0. The screening evaluation uses a smaller set of evaluation criteria than what is used for detailed analysis of retained alternatives after this screening step. Each of the proposed alternatives is screened using the short- and long-term aspects (where applicable) of three broad criteria: effectiveness, implementability, and cost as described below.

2.2.1 Effectiveness

Effectiveness relates to the ability of the remedial alternative to satisfy the following evaluation criteria:

- Overall protection of human health and the environment
- Compliance with ARARs
- Short-term effectiveness (during the remedial construction and implementation period)
- Long-term effectiveness and permanence (following remedial construction)
- Reduction of toxicity, mobility, or volume through treatment

2.2.2 Implementability

Implementability relates to the ability of the remedial alternative to satisfy the following evaluation criteria:

- Technical Feasibility

- ✓ Ability to construct, reliably operate, and meet technology-specific regulations for process options until a RA is complete
- ✓ Ability to operate, maintain, replace, and monitor technical components after the RA is complete

- Administrative Feasibility
  - ✓ Ability to obtain approvals from other agencies
  - ✓ Availability and capacity of treatment, storage, and disposal services
  - ✓ Availability of property, specific materials and equipment, and technical specialists required for a RA

2.2.3 Cost

With the exception of the Upland Soil/Waste Rock alternatives, a qualitative *relative* cost evaluation of each alternative is included in the initial screening of alternatives presented below. A quantitative cost evaluation was performed for each of the Upland Soil/Waste Rock alternatives because some of the alternatives are very similar with regards to effectiveness and implementability, but have significant cost differences which become a differentiating factor among the alternatives.

2.3 ASSEMBLED ALTERNATIVES AND INITIAL SCREENING BY MEDIUM

The following sections present the assembled remedial alternatives by medium and the results of the screening for effectiveness, implementability, and cost. The alternatives retained following this screening are carried forward to the more rigorous detailed and comparative analyses presented in Section 3.0. Additional specifics regarding the retained alternatives (including figures depicting the layout of the alternative, LTM requirements, etc.) are contained in Section 3.0.

2.3.1 Upland Soil/Waste Rock

The assembled remedial alternatives for the upland soil/waste rock are presented and screened for effectiveness, implementability, and cost in **Table 2-1**. A general description of each assembled alternative for upland soil/waste rock, and whether the alternative was retained for detailed and comparative analyses, is presented below. If an alternative is selected in this step additional details of the remedy are discussed in Section 3.0 to support the detailed and comparative analyses.

- **Alternative 1 – No Action** - The no action alternative would leave the Site in its existing condition. The No Action alternative does not protect human health and the environment or comply with ARARs so it would not be chosen for any of the upland soil/waste rock areas; however it is retained as required by the NCP as a baseline for comparison.

- **Alternative 2 – Upland Soil/Waste Rock Grading and Stormwater Controls, ICs, LUCs, and O&M/LTM** - Site grading involves altering the topography of the waste rock/adjacent land surfaces to mitigate erosion and to divert surface/storm water to reduce the amount of water that contacts and infiltrates the source materials. Under Alternative 2 the upland soil/waste rock dumps outside the pits would be graded to prevent ponding of stormwater and snowmelt on their surfaces (maximum of 3:1 slopes), and to effectively shed surface water to reduce infiltration while limiting erosion of the surface. There is waste rock in two of the existing pits (MMP035 and MMP036) and this material also would be graded. In addition, at strategic locations on and around the newly graded surfaces, stormwater controls in the form of erosion control channels would be constructed to direct the runoff from the impacted area. This alternative does not include any waste consolidation, pit backfill, or cover system. However, the surface would be seeded to promote vegetation growth. This alternative would include ICs and LUCs to limit Site access, and long-term operation O&M to maintain stormwater controls.

  As detailed in **Table 2-1**, Alternative 2 is not retained because it would not sufficiently prevent or reduce the migration of COCs/COECs from upland soil/waste rock to surface water and groundwater.

- **Alternative 3 – Upland Soil/Waste Rock Grading and Consolidation with Soil Cover, ICs, LUCs, and O&M/LTM** - Under Alternative 3, portions of the upland soil/waste rock dumps throughout the Site would be excavated and consolidated in the on-Site pits to cover any exposed beds (i.e., Meade Peak Member 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 upland soil/waste rock surfaces both inside and outside of the pits then would be capped with a simple soil cover system to prevent direct exposure to the underlying waste rock and to provide enough soil for establishment of a vegetative cover. These surfaces would be graded and the cover system would be placed as quickly as possible over exposed underlying surfaces and in pit backfill areas to limit exposure of fresh waste rock surfaces to the environment. Soil cover also would be placed in the areas where the original exterior waste rock dumps were excavated for placement into the pits, thereby exposing the underlying surfaces.

A cover system is necessary because the areas underlying the upland soil/waste rock dumps have likely been impacted by migration of constituents from the waste rock dumps into the underlying soil. Because the volumes of materials that would require excavation in order to achieve the cleanup levels is unknown, this evaluation assumes these surfaces would be regraded as necessary following waste rock removal then covered using the selected cover system and not excavated. Excavation was not considered because the amount of removed soil necessary to achieve the cleanup levels cannot be estimated with currently available data.

A key aspect of any cover is its ability to reduce infiltration water that could cause leaching of constituents from the underlying soil/waste rock and migration to surface water and groundwater. A cover is considered to be protective if it effectively reduces infiltration such that remedial goals are ultimately achieved in surface water and groundwater.

The soil cover in Alternative 3 would be comprised of approximately 12 to 18 inches of topsoil/ alluvial-growth medium as conceptualized on **Figure 2-1**. The thickness of a soil cover would be sufficient to limit uptake of COCs/COECs by vegetation selected to grow on the cover. Vegetation for the soil cover would be selected so roots do not penetrate the underlying source material (i.e., primarily shallow rooted grasses), and LTM/O&M would be necessary to inspect the cover for plants that are incompatible with the selected cover system (i.e., vegetation with roots that could penetrate the soil cover system) and to repair any stormwater erosion that might occur to the cover system. ICs and LUCs would be implemented to restrict activities that could disturb the covered waste rock and reduce exposure to potential selenium accumulators.

As detailed in **Table 2-1**, Alternative 3 is not retained because Alternative 3 would not effectively reduce precipitation from infiltrating into the upland soil/waste rock source area, resulting in continued migration of Site COCs/COECs to surface water and groundwater.

Alternative 4 – Upland Soil/Waste Rock Grading and Consolidation with an Evapotranspiration (ET) Cover System, ICs, LUCs, and O&M/LTM – Alternative 4 is similar to Alternative 3 except that the new upland soil/waste rock surfaces both inside and outside of the pits would be capped with an ET cover system (instead of the 12 to 18 inches of soil cover). The ET cover would be designed, under most conditions, to effectively shed and/or store infiltrating water, which then evaporates or is transpired by the vegetation

planted on the surface of the cover system before the water can infiltrate into the underlying waste rock.

Based on current information regarding nearby borrow material and a preliminary cover analysis (modeling), the selected ET cover would consist of (starting from the top of the cover): 1) 5-foot thickness of medium-grained, unimpacted alluvial material, and 2) underlain by a least 1-foot thickness of high-permeability (coarse grained) unimpacted fill material to act as a capillary break as shown on **Figure 2-1**. ET covers would be placed on the backfilled pit areas as wells as in the areas where portions of the original exterior waste rock dumps were excavated for placement into the pits, thereby exposing the underlying surface that is assumed to have elevated levels of Site COCs/COECs (through the leaching process). Similar to Alternative 3, surfaces would be graded and covers would be placed as quickly as possible over these exposed underlying surfaces and in pit backfill areas to limit exposure of fresh waste rock surfaces to the environment.

An initial modeling report for possible Ballard Site cover systems and its findings are evaluated in a memorandum entitled, *Cover System Evaluation Memorandum for the Ballard Mine Site* (MWH, 2016b). Refer to this memorandum in **Appendix B** for more details on the cover systems evaluated for the Site and their performance. The reclamation vegetation would be selected to form an extensive root system to effectively mitigate sheet flow and rill erosion of the cover surface, slow downward movement of stormwater and snowmelt, and to transpire water that infiltrates and accumulates in the upper layer of the cover system. LTM/O&M would be necessary to inspect the cover for plants that are incompatible with the selected cover system (i.e., vegetation with roots that could penetrate the ET cover system) and to repair any stormwater erosion that might occur to the cover system. ICs and LUCs would be implemented to limit activities that could disturb the covered waste rock.

As detailed in **Table 2-1**, Alternative 4 is retained because it effectively reduces infiltration of water through the waste rock which prevents or reduces migration of COCs/COECs and therefore is protective of human health and the environment. It also is made of earthen materials that are available on-Site or adjacent to the Site with comparatively low costs (when compared to other similar alternatives that also are protective such as Alternative 5).

- **Alternative 5 – Upland Soil/Waste Rock Grading and Consolidation with Multi-layered Cover System, ICs, LUCs, and O&M/LTM** - Alternative 5 is similar to

Alternatives 3 and 4 except that the new upland soil/waste rock surfaces both inside and outside of the pits would be capped with a multi-layer cover system. The multi-layer cover would be designed using materials that substantially reduce water infiltration into the underlying waste rock. The cap would contain at least one hydraulic barrier layer consisting of earthen materials of various gradations, a compacted clay layer, a geosynthetic clay layer, or a geomembrane layer (described below). In addition to the hydraulic barrier layer, the cap would incorporate a drainage layer installed just above the geomembrane. The cover would be vegetated with native grass/forb species to control erosion. The appropriately sloped capped-surface (maximum of 3:1) and drainage layer would allow stormwater and snowmelt to run off or drain to the edge of the cover system. In addition to the backfilled areas inside the various pits, this multilayer cover also would be placed in the areas where the original exterior waste rock dumps were excavated for placement into the pits, thereby exposing the underlying surface that is assumed to have elevated levels of Site COCs/COECs (through the leaching process). Surfaces would be graded and covers would be placed as quickly as possible over exposed underlying surfaces and in pit backfill areas to limit exposure of fresh waste rock surfaces to the environment.

Based on similar multi-layer covers installed at nearby mine reclamation projects, the multi-layer cover (see **Figure 2-1**) likely would be approximately 4-feet thick and consist of (starting from the top of the cover) 1) an alluvial material layer 3 feet thick to support plant growth, 2) a geocomposite material that acts as a drainage layer, 3) a geosynthetic clay laminate liner (GCLL) to act as the hydraulic barrier, 4) a protective subgrade that varies in thickness from 6 to 12 inches placed over waste rock material to prevent damage to the overlying GCLL. Vegetation for the soil cover would be selected so roots do not penetrate the hydraulic barrier layer and into the underlying waste rock. LTM/O&M would be necessary to inspect the cover for plants that are incompatible with the selected cover system (i.e., vegetation with roots that could penetrate the GCLL and compromise it) and to repair any stormwater erosion that might occur to the cover system. ICs and LUCs would be implemented to restrict activities that could disturb the covered waste rock.

As detailed in **Table 2-1**, although Alternative 5 prevents or reduces migration of COCs/COECs and therefore is protective of human health and the environment, <u>this alternative is not retained</u> because it 1) the multilayered cover under this alternative is more

difficult to install than the ET cover, 2) the GCLL material itself has a finite life expectancy because it is comprised of man-made materials, 3) a very shallow rooted plant community must be installed on the multilayered cover system so the underlying GCLL is not compromised and as a result it may not be as attractive to native wildlife as the vegetation typically grown on the thicker ET covers, and 4) it is more difficult to maintain when compared to Alternative 4 and provides no significant technical advantages over the comparable Alternative 4. In addition, it is more than double the cost of the similar Alternative 4 ($122.2M vs. $52.4M) which uses an ET cover system that effectively reduces infiltration and is equally protective.

- **Alternative 6 – Upland Soil/Waste Rock Grading and Consolidation, Incidental Ore Recovery, ET Cover System, ICs, LUCs, and O&M/LTM** - Alternative 6 is similar to Alternatives 3, 4, and 5, except that incidental ore deposits (i.e., the Meade Peak Member of the Phosphoria) would be recovered 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. This cover system was selected following the screening of Alternative 3 (Soil Cover), Alternative 4 (ET Cover), and Alternative 5 (Multi-layer Cover) as conceptualized on **Figure 2-1** and the evaluation of key trade-offs between the three cover types presented in **Table 2-1**.

  As summarized in Section 1 of Ballard FS Memo #1, phosphate ore was mined at the Ballard site from 1951 to 1969. At that time, mining activities were rapidly transitioned from the Ballard to the Henry Mine where lower carbon, higher grade phosphate ore was available. In 2015, P4 identified a need for phosphate ore with a higher carbon value for blending at their ongoing processing operations in Soda Springs, Idaho. A review of historical data, interviews with former employees, and recent borrow-area exploration data confirmed that approximately 4 million tons of varying grade carbon ore remain at the Site both exposed at the surface in the mine pit bottoms, in the pits walls, and underlying Rex Chert and/or Dinwoody Formation bedrock in the flanks of the current mine pits. The identification of the Ballard Site as a source of the needed high-carbon ore coincided with the FS phase of the CERCLA process for the Ballard Site. The FS process presented in this document provides an opportunity to integrate ore recovery into the CERCLA remedial alternative analysis and is the reason why an alternative with ore recovery is provided herein.

A three-phased remedial approach would be implemented under the incidental ore recovery alternative to recover ore bodies identified at the Site (as described in Section 3.0) resulting in a larger reclaimed area than Alternatives 3, 4, or 5.

Similar to Alternatives 3, 4, and 5, under Alternative 6, covers would be installed with placement and grading of waste rock as quickly as possible (in this case during the phasing of ore removal) to limit environmental exposures from fresh waste rock surfaces. In addition, this alternative would include ICs and LUCs to restrict activities that could disturb the final ET cover system and the underlying wastes, and O&M/LTM to confirm the integrity of the cover system and to prevent plants from growing on the capped surfaces that are incompatible with the selected cover system.

As detailed in **Table 2-1**, Alternative 6 is retained because it prevents or reduces migration of COCs/COECs from the covered waste rock, and therefore is protective of human health and the environment. This alternative also would have several benefits related to short- and long-term effectiveness including: production of additional unimpacted overburden in the selected cover system and waste rock for use as backfill. The result is that more material is available which would allow for a more natural, thorough reclamation that blends into the adjacent native upland surfaces and effectively drains the cover system and Site. Over the long term, ore recovery addresses the CERCLA principal of incorporating reasonably anticipated future land use into the remedy (USEPA, 2010) by implementing a reasonable land use (i.e., ore recovery) while attaining the CERCLA RAOs. Other long-term effectiveness benefits include recovery of a valuable resource that would be unattainable after the remedy is implemented and the remedy delays recovery of similar volumes of ore at other P4 mines in the immediate area. The cost for the remedial aspects of this alternative is estimated at $38.4M which is less than all of the other alternatives that have similar protectiveness (i.e., Alternatives 4, 5, and 7 refer to **Table 2-1**). Cost considerations for this alternative are described in detail in Section 3.2.3.

- **Alternative 7 – Complete Consolidation of Existing Upland Soil/Waste Rock into the Pits, ET Cover System, ICs, LUCs, and O&M/LTM** – Under Alternative 7, all upland soil/waste rock lying outside the existing pits would be excavated and consolidated in the existing pits to backfill the existing pits and to cover any exposed Meade Peak Member of the Phosphoria Formation (i.e., ore beds), then graded/contoured to create slopes that

effectively shed stormwater and snowmelt. The graded upland soil/waste rock surfaces in the pits and the areas underlying the former upland soil/waste rock dumps would be capped with the ET cover as described in Alternative 4 and shown on **Figure 2-1**. This cover was selected, similar to Alternative 6, following screening of the three types of cover systems evaluated in Alternatives 3, 4, and 5. The volume of existing waste rock material is not sufficient to completely fill the existing pits to pre-mining surface. The difference between the volume of materials that would be required to fill the pits to original contour and the volume of the existing upland soil/waste rock dumps is approximately 6.4 million cubic yards (refer to **Table 3-1b** in Section 3.0). This difference is approximately equal to the volume of ore that was originally mined from the Site and transported to the processing facility in Soda Springs. However, there is sufficient volume of waste rock in the waste rock dumps to contour the sides of the existing pits crest to crest, to cover the exposed ore beds, and to create 3:1 maximum slopes and topography that directs any stormwater out of the pits and away from the source area as discussed in detail in Section 3.2.4.

As with previous alternatives that include excavation and consolidation of portions of upland soil/waste rock into the pits, the underlying native ground surfaces also must be excavated until cleanup levels are achieved or capped using a cover system to be protective. Under this alternative, an ET cover also would be placed in the areas where the original waste rock dumps were removed for placement into the pits, thereby exposing the underlying surface that are assumed to have elevated levels of Site COCs/COECs (through the leaching process). As with Alternatives 3, 4, 5, and 6, this alternative would include ICs and LUCs to restrict activities that could disturb the cover systems and the underlying waste rock, and O&M/LTM to maintain the integrity of the cover system and to limit growth of plants that are incompatible with the selected cover system.

As detailed in **Table 2-1**, Alternative 7 has similar effectiveness and implementability to Alternatives 4 and 6, but has higher costs than Alternatives 4 and 6 with no significant advantages. However, Alternative 7 is retained in order to provide a range of waste consolidation scenarios for comparison in the detailed analysis as requested by the A/Ts.

2.3.2 Surface Water

The assembled remedial alternatives for Site surface water are presented and screened for effectiveness, implementability, and cost in **Table 2-2**. Surface water is unique because, once the

remedy for upland soil/waste rock is implemented the majority of the surface water at the Site would have no contact with Site COCs/COECs. However, small amounts of surface water from mine-affected seeps/springs would remain following remediation of the upland soil/waste rock and are addressed in a variety of ways in the alternatives below.

A general description of each assembled alternative for surface water, and whether the alternative was retained for detailed and comparative analyses, is presented below. If an alternative is retained in this step, it is discussed in more detail in Section 3.0 to support the detailed and comparative analyses.

- **Alternative 1 – No Action** - The no action alternative would leave the Site in its existing condition. The No Action alternative does not protect human health and the environment or comply with ARARs so would not be chosen for Site surface waters; however it is retained as required by the NCP as a baseline for comparison.
- **Alternative 2 – Institutional Controls (ICs) and LUCs, in conjunction with source controls in the upland soil/waste rock** - ICs and LUCs would be implemented to restrict surface water use and access until source controls have substantially reduced mine-affected seep/spring discharge or cleanup levels are achieved. In addition to the cover system selected for the upland soil/ waste rock to control release of particulates, sediment traps/basins would be installed to control ongoing contaminated sediment releases caused by stormwater. As detailed in **Table 2-2**, Alternative 2 is retained based on the screening of effectiveness, implementability, and cost.
- **Alternative 3 – In-Situ Biological (Wetlands) Treatment of Source Area Seepage, ICs, and LUCs, in conjunction with source controls in the upland soil/waste rock** - ICs and LUCs would be implemented as in Alternative 2, and in-situ wetlands treatment would be implemented at mine-affected perennial seep/spring locations. The wetlands would treat the residual mine-affected water at the seeps/springs via biologically mediated reactions including reduction using anaerobic bacteria resulting in precipitation and/or sorption of the COCs/COECs. The treated water would flow out of the wetlands to the downstream drainages or evapotranspire within the wetlands. As detailed in **Table 2-2**, Alternative 3 is retained based on the screening of effectiveness, implementability, and cost.

- **Alternative 4 – Ex-Situ Bioreactor Treatment of Source Area Seepage, ICs, and LUCs, in conjunction with source controls in the upland soil/waste rock** - ICs and LUCs would be implemented as in Alternative 2, and mine-affected seepage would be conveyed to a lined storage impoundment and then fed at a controlled rate to one or more bioreactors. The bioreactors would treat the residual mine-affected water at perennial seeps via biological reduction using anaerobic bacteria resulting in precipitation or sorption of the COCs/COECs. The treated water would discharge from the bioreactor to the surface water in downstream drainages. However, evaporation basins or infiltration would be used if discharge to surface water is prohibitive because of the substantive requirements of a Clean Water Act (National Pollutant Discharge Elimination System [NPDES]) permit. The bioreactor systems would be operated until source controls have significantly reduced mine-affected seep discharge.

  As detailed in **Table 2-2**, Alternative 4 is not retained because the effectiveness and implementability was judged to be lower than Alternative 3, because the ex-situ bioreactor facilities would have a larger environmental footprint (land surface disturbance), would lose effectiveness in cold weather if not in a heated building, would require decommissioning after cleanup levels are achieved, and would be more difficult to operate and maintain than the in-situ wetlands described in Alternative 3.

- **Alternative 5 – Ex-Situ Treatment of Source Area Seepage, ICs, and LUCs, in conjunction with source controls in the upland soil/waste rock** - This alternative is similar to Alternative 4 except that a physical/chemical treatment plant would be used to treat mine-affected seepage instead of a bioreactor. The treatment selected for this alternative would consist of a combination of separation/filtration, chemical precipitation, and oxidation/reduction but could also include other technologies discussed in Section 5 of *Ballard Mine FS Memo #1* (e.g., membrane technology). As detailed in **Table 2-2**, Alternative 5 is not retained because a conventional chemical treatment plant has: 1) less flexibility in dealing with changing influent concentrations, 2) long-term O&M challenges, 3) a larger environmental footprint, 4) would require decommissioning when cleanup levels are achieved, and 5) overall higher costs. In addition, seep flows are not large now and are expected to substantially decrease with time and improve in quality following implementation of source controls.

2.3.3 Sediment/Riparian Soil

The assembled remedial alternatives for the sediment/riparian soil are presented and screened for effectiveness, implementability, and cost in **Table 2-3**. A general description of each assembled alternative for sediment/riparian soil, and whether the alternative was retained for detailed and comparative analyses, is presented below. If an alternative is retained in this step, it is discussed in more detail in Section 3.0 to support the detailed and comparative analyses.

- **Alternative 1 - No Action** - The no action alternative would leave the Site in its existing condition. The No Action alternative does not protect human health and the environment or comply with ARARs so would not be chosen for any of the mine-affected sediment/riparian soil areas; however it is retained as required by the NCP as a baseline for comparison.

- **Alternative 2 – Monitored Natural Recovery (MNR), ICs, and LUCs, in conjunction with source controls in the upland soil/waste rock** - This alternative includes MNR, which relies on natural processes (i.e., physical, chemical, and biological processes) to reduce COC/COEC concentrations in the affected media over time. In order for MNR to be successful, source controls would need to be implemented in the upland soil/waste rock to prevent or reduce the migration of COCs/COECs to the downgradient drainages. Implementation of MNR might require a predesign/design study to demonstrate the effectiveness of MNR processes. Implementation of MNR during the RA would require preparation of a sampling and analysis plan (SAP), routine sediment/riparian sampling at known locations over a designated time frame, and periodic data evaluations to track the progress of natural recovery and to support CERCLA 5-year reviews. MNR also would require ICs and LUCs to restrict Site activities until the cleanup levels are achieved. As detailed in **Table 2-3**, <u>Alternative 2 is not retained</u> based on the screening of effectiveness, implementability, and cost, but primarily because it is less effective than Alternative 3 which includes sediment traps in addition to MNR and the other controls proposed under this alternative.

- **Alternative 3 – Sediment Traps/Basins, MNR, ICs, and LUCs, in conjunction with source controls in the upland soil/waste rock** - Sediment traps/basins would be installed in the upper reaches of the mine-affected drainages, where the highest concentrations of COCs/COECs are detected in sediment/riparian soil. The basins (installed at the lowest

elevation of the upper reaches) would capture mine-affected sediment entrained in the intermittent stream flow during the RA. Sediment retained in these traps would be cleaned out periodically and disposed under an adjacent upland soil/waste rock soil cover during the RA or in an on-Site landfill post-RA. MNR would be implemented as described in Alternative 2 for the lower reaches of the mine-affected drainages where COC/COEC concentrations are lower. ICs and LUCs also would be implemented as described in Alternative 2 for all mine-affected reaches of the drainages until cleanup levels are achieved. As shown in **Table 2-3**, Alternative 3 is more protective than Alternative 2 and presents minor additional administrative burden and capital costs to operate and maintain sediment traps/basins and to handle/dispose of accumulated sediment either on- or off-Site over the long term. As detailed in **Table 2-3**, Alternative 3 is retained based on the screening of effectiveness, implementability, and cost.

- **Alternative 4 – Removal and On-Site Disposal, MNR, ICs, and LUCs, in conjunction with source controls in the upland soil/waste rock** - Sediment/riparian soil (and all associated vegetation) in the upper reaches of the mine-affected drainages, where the highest concentrations of COCs/COECs are detected, would be excavated, transported, and consolidated with the upland soil/waste rock, then under the upland soil/waste rock cover system selected from the alternatives presented in Section 2.3.1. MNR, ICs, and LUCs would be implemented as described in Alternative 2 for sediment/riparian soil that is not removed in the lower reaches of the mine-affected drainages where COC/COEC concentrations are lower. As detailed in **Table 2-3**, Alternative 4 is retained based on the screening of effectiveness, implementability, and cost.

2.3.4 Groundwater

The assembled remedial alternatives for Site groundwater are presented and screened for effectiveness, implementability, and cost in **Table 2-4**. A general description of each assembled alternative for groundwater, and whether the alternative was retained for detailed and comparative analyses, is presented below. If an alternative is retained in this step, additional details of the remedy are discussed in Section 3.0 to support the detailed and comparative analyses.

- **Alternative 1 – No Action** - The no action alternative would leave the Site in its existing condition. The No Action alternative does not protect human health and the environment or comply with ARARs so would not be chosen for mine-affected alluvial or Wells

Formation groundwater; however it is retained as required by the NCP as a baseline for comparison.

- **Alternative 2 – Monitored Natural Attenuation (MNA) and ICs, in conjunction with source controls in the upland soil/waste rock** - This alternative includes MNA, which relies on natural attenuation processes to reduce COC concentrations in the Site groundwater over time. Implementation of source controls in the upland soil/waste rock to prevent or reduce migration of COCs to groundwater is necessary for MNA to be successful. Proper implementation of MNA would require a predesign/design study to demonstrate the effectiveness of MNA processes and possible modeling to provide an estimate of the cleanup time frame. Implementation of MNA during the RA would require preparation of an SAP, routine groundwater monitoring throughout the various plumes, and periodic data evaluations to track the progress of natural attenuation and to support CERCLA 5-year reviews. MNA also would require ICs to restrict groundwater use until the cleanup levels are achieved. As detailed in **Table 2-4**, Alternative 2 is retained based on the screening of effectiveness, implementability, and costs.

- **Alternative 3 – Limited Permeable Reactive Barrier (PRB) Treatment of Alluvial Groundwater, MNA, and ICs, in conjunction with source controls in the upland soil/waste rock** - Under this alternative, MNA, and ICs would be implemented as in Alternative 2, and PRBs would be constructed upgradient of select perennial seeps/springs near the margins of the former mined area. PRBs may be constructed utilizing inorganic, biological, or a combination of reactive reagents. The treatment media placed in the PRBs would have permeability appropriate for the hydraulic conductivity of surrounding material and with an adequate retention time to treat the intended contaminants to acceptable standards. It is likely that these PRBs would be designed based on tested PRBs at P4's South Rasmussen Mine since 2012 (Newfields, 2015 and 2016a, b, c). In some cases, where the affected alluvial groundwater is excessively deep, extraction wells may supplement the system and would discharge to the PRB. The PRBs would treat the mine-affected groundwater before it discharges at the seep/spring locations where exposures can occur. As detailed in **Table 2-4**, Alternative 3 is retained based on the screening of effectiveness, implementability, and costs.

- **Alternative 4 – In-Situ Treatment of Alluvial Plumes by Injection, MNA, and ICs, in conjunction with source controls in the upland soil/waste rock** - Alluvial groundwater plumes on the eastern (Wooly Valley Creek side) and western (Blackfoot River side) flanks of the Site would be treated via in-situ injection of chemical or biologic reagents. MNA would be implemented in the Wells Formation aquifer because monitoring reagent dispersion in the Wells Formation would be very difficult due to stratigraphic and structural complexity. ICs would be implemented for all mine-affected groundwater to restrict use until cleanup levels are achieved. As detailed in **Table 2-4**, Alternative 4 is not retained because in-situ treatment is not anticipated to be effective at reducing the toxicity and mobility, and volume of contaminants, other than in limited areas, due to the relatively low permeability of the alluvial unit and the heterogeneity of the shallow aquifer sediments. In addition, the potential re-release of retained contaminants without reinjection of reagents is a consideration in not retaining this alternative.

- **Alternative 5a – Groundwater Recovery and Treatment of Wells Formation Groundwater, MNA for Alluvial Groundwater, and ICs in conjunction with source controls in the upland soil/waste rock** - Groundwater would be extracted from the Wells Formation in the vicinity of the West Ballard Pit (MMP035), treated using a physical (including membrane technology), chemical, or biological treatment system (either alone or in combination), and then infiltrated back to the West Ballard Mine Pit. This in effect is aquifer flushing. If source controls (waste rock consolidation) result in the bottom of the pit not being accessible, then infiltration wells drilled through the backfill into the bottom of the pit may be needed. MNA would be implemented for the mine-affected alluvial groundwater, and ICs would be implemented to restrict groundwater use until cleanup levels are achieved. As detailed in **Table 2-4**, Alternative 5a is not retained because the component associated with the Wells Formation is judged to have low/moderate effectiveness and technical feasibility in addition to a high cost because of the geologic complexity and depth to the aquifer. Components of this alternative are retained in Alternative 5b (discussed below). Ultimately this alternative is unlikely to be more effective than MNA (Alternative 2) or PRB treatment (Alternative 3, which treats alluvial groundwater) at reducing risk, but at much higher costs.

- **Alternative 5b – Groundwater Recovery and Treatment of both Alluvial and Wells Formation Groundwater, and ICs, in conjunction with source controls in the upland soil/waste rock** - Same as Alternative 5a, but includes extraction and treatment of all mine-affected groundwater including the alluvial and Wells Formation groundwater. It is assumed that extraction trenches, or a limited number of extraction wells in areas of deep alluvium, could be used to extract mine-affected alluvial groundwater both upgradient of the perennial seeps/springs and on the east and west sides of the Site in appropriate downgradient locations. Extraction wells would be used to remove groundwater from the Wells Formation. The extracted groundwater would be treated using a physical, chemical, or biological treatment system (either alone or in combination). Extracted and treated water from the Wells Formation would be infiltrated back into the Wells Formation. Extracted and treated water from the alluvial aquifer would be discharged to a constructed basin and allowed to infiltrate back into the alluvial aquifer. This alternative extracts and treats water from both the alluvial and Wells Formation groundwater systems so it more protective than Alternative 5a. However, this alternative has low/moderate effectiveness and technical feasibility and has high cost. Alternative 5b is retained so that a full range of alternatives are included in the detailed and comparative analyses step of the FS as requested by the A/Ts.

3 DETAILED AND COMPARATIVE ANALYSES OF REMEDIAL ALTERNATIVES

This section presents both a detailed analysis and a comparative analysis of the remedial alternatives that were retained after the screening performed in Section 2.0. In both the detailed analysis and comparative analysis steps, each retained remedial alternative is evaluated against the NCP evaluation criteria, which are summarized below in Section 3.1.

The difference between the detailed and comparative analyses is that in the detailed analysis, each alternative is evaluated independently without consideration of other alternatives. The comparative analysis then compares the alternatives and identifies the relative advantages and disadvantages among the alternatives. The detailed analyses for the Site are presented by environmental medium in **Tables 3-1** through **3-4**.

The remainder of this section is organized as follows:

- Section 3.1 summarizes the NCP evaluation criteria used in the detailed and comparative analyses.
- Sections 3.2 through 3.5 (and associated **Tables 3-1** through **3-4**) present the detailed and comparative analyses for the retained remedial alternatives for each medium. The analyses are presented in tables and the sections provide specific supporting information for developing cost estimates (e.g., specifics related to source controls and the other common core elements that are identified in Section 2.1).

  The intent of presenting the detailed and comparative analyses together on these tables is to: 1) provide a uniform and comprehensive presentation of the evaluations against the NCP criteria, and 2) allow the detailed analysis of each alternative to be immediately followed by the comparative analysis for each NCP criterion. This presentation allows for a logical flow from the detailed analysis to the comparative analysis, with all the pertinent information contained on a common table (as opposed to a presentation format where the detailed and comparative analyses are presented separately.) Each of the four medium-specific tables (i.e., **Tables 3-1** through **3-4**) include the following information:

  - ✓ The retained remedial alternatives listed in columns across the top row on each page of the table.

- ✓ The NCP evaluation criteria are listed and evaluated in numbered rows. For example, "*1) Overall Protection of Human Health and the Environment*;" "*2) Compliance with ARARs*," etc.
- ✓ A detailed analysis is presented for each of the NCP evaluation criteria and sub criteria, and the individual criterion then is qualitatively ranked as low, medium, or high. For example, the detailed analysis for the NCP evaluation criterion "*1) Overall Protection of Human Health and the Environment*" is presented under the row labeled "*1A) Detailed Analysis*." In the detailed analyses, each remedial alternative is evaluated and ranked independently without consideration of other alternatives.
- ✓ Following the detailed analysis for each NCP criterion, a comparative analysis is presented. For example, the comparative analysis for the NCP evaluation criterion "*1) Overall Protection of Human Health and the Environment*" is presented under the row labeled "*1B) Comparative Analysis*."

- Section 3.6 presents the key tradeoffs that are identified in the comparative analyses performed for each medium. Section 3.6 also identifies which medium-specific alternative is recommended for inclusion in the overall remedy for the Site. A summary of the recommended overall remedy is presented in Section 4.0.

3.1 USEPA EVALUATION CRITERIA USED FOR THE DETAILED AND COMPARATIVE ANALYSES

In 40 CFR 300.430(e) (9), the NCP establishes nine criteria for evaluating RA alternatives. The *RI/FS Guidance* elaborates on these criteria and discusses how they are to be applied. The NCP divides the criteria into three categories (threshold, balancing, and modifying) as discussed below.

3.1.1 Threshold Criteria

These are the criteria that each alternative *must* satisfy to be eligible for selection based on statutory requirements. The two threshold criteria consist of:

Overall Protection of Human Health and the Environment – provides a final check to assess whether each alternative provides adequate protection of human health and the environment from unacceptable risks. The overall assessment of protection draws on the assessments conducted under other evaluation criteria, especially long-term effectiveness and permanence, short-term effectiveness, and compliance with ARARs. The overall assessment of protection also includes information regarding the methods for eliminating, reducing, or controlling the risks through treatment, removal, engineering controls, or ICs.

Compliance with ARARs – addresses whether the alternative complies with the chemical-specific, action-specific, and location-specific ARARs and other to-be-considered (TBC) state and federal

environmental laws. An ARAR waiver is required if the alternative does not meet this evaluation criterion.

3.1.2 Balancing Criteria

These are the technical criteria upon which the detailed and comparative analyses are primarily based. The five balancing criteria consist of:

Long-Term Effectiveness and Permanence - addresses the results of a RA in terms of the risk remaining at the site *after response objectives have been met.* The primary focus of this evaluation is the extent and effectiveness of the controls that may be required to manage the risk posed by treatment residuals and/or untreated wastes over the long term.

Reduction of Toxicity, Mobility, or Volume through Treatment - addresses the statutory preference for selecting RAs that employ treatment technologies that permanently and significantly reduce toxicity, mobility, or volume of the hazardous substances as their principal element. This preference is satisfied when treatment is used to reduce the principal threats at a site through destruction of toxic contaminants, reduction of the total mass of toxic contaminants, irreversible reduction in contaminant mobility, or reduction of total volume of contaminated media.

Short-Term Effectiveness - addresses the effects of the alternative *during the construction and implementation phase* until remedial response objectives are met (e.g., a cleanup target has been met). Under this criterion, alternatives are evaluated with respect to their effects on human health and the environment during implementation of the RA.

Implementability - addresses the technical and administrative feasibility/challenges of implementing an alternative and the availability of various services and materials required during its implementation.

Cost - Alternatives are assessed to determine costs, including capital costs, annual O&M costs, and the net present value of capital and O&M costs. These costs are based on a variety of information including vendor quotes on recent projects at the P4 mines, published cost estimating guides (e.g., Means Heavy Construction Cost Data), current knowledge of contaminated media/site conditions, and professional experience and carry a cost range of +50 to -30%. Specific location and number of RA features (e.g., sediment traps, constructed wetlands, and PRBs), if selected, shall be determined during the RD, along with construction specifications and a refined range of costs (e.g., +15 to -10%) as the design progresses from 30% to final (100%) design. This FS has determined net

present value costs for 30 years at a 7 percent discount rate, consistent with the USEPA guidance document entitled *A Guide to Developing and Documenting Cost Estimates During the Feasibility Study (*USEPA, 2000). The cost estimates for the retained remedial alternatives (and associated assumptions) are included in **Appendix A**.

3.1.3 Modifying Criteria

State Acceptance - Alternatives are assessed to determine the State's general acceptance or preferences, to the extent known, among the proposed alternatives.

Community Acceptance - Alternatives are assessed to determine the community's general acceptance of the proposed alternatives, to the extent their acceptance is known.

The modifying criteria are assessed formally after public review and comment on the Proposed Plan, which is the document that presents USEPA's Preferred Remedy. Therefore, the state and community acceptance criteria *are not included* in the detailed and comparative analyses.

3.2 UPLAND SOIL/WASTE ROCK ALTERNATIVES - DETAILED ANALYSES

This section presents the detailed analyses (and the associated supporting information) for the retained remedial alternatives from the initial screening in Section 2.0 for the upland soil/waste rock medium. The alternatives presented in this section focus on the waste rock dumps and open pits that are a remnant of past mining activities. The general locations of these waste rock dumps and open mine pits are presented in **Figure 3-1**. The complete detailed analyses for the upland soil/waste rock alternatives are presented in **Table 3-1a**. A summary of the detailed analysis for each retained remedial alternative is included in the narratives below.

The following descriptions of the retained alternatives build on the alternative descriptions for upland soil/waste rock included in Section 2.3.1. These descriptions provide additional information to support the analyses presented in **Table 3-1a**, specifics related to source controls and the other common core elements that are identified in Section 2.1, and other specific information used for developing the cost estimates contained in **Appendix A** (e.g., specifics of waste movements at each waste rock pile).

The four retained upland soil/waste rock remedial alternatives include:

- Upland Soil/Waste Rock Alternative 1 – No Action

- Upland Soil/Waste Rock Alternative 4 – Upland Soil/Waste Rock Grading and Consolidation with a Evapotranspiration (ET) Cover System, ICs, LUCs, and O&M/LTM (see **Figures 3-2a** and **3-2b**)
- Upland Soil/Waste Rock Alternative 6 – Upland Soil/Waste Rock Grading and Consolidation, Incidental Ore Recovery, ET Cover System, ICs, LUCs, and O&M/LTM (see **Figures 3-3a** through **3-3c**)
- Upland Soil/Waste Rock Alternative 7 – Complete Consolidation of Existing Upland Soil/Waste Rock into the Pits, ET Cover System, ICs, LUCs, and O&M/LTM (see **Figure 3-4**)

With the exception of the No Action alternative, the upland soil/waste rock remedial alternatives would: 1) prevent or reduce future human and wildlife exposures to COCs/COECs, and 2) isolate the waste rock from erosional forces and infiltrating stormwater and snowmelt. Isolating the waste rock, or "source controls," ultimately would substantially reduce the transfer of COCs/COECs from the upland soil/waste rock to the downgradient and downslope media (i.e., surface water, sediment/riparian soil, and groundwater). The retained upland soil/waste rock alternatives summarized in Section 2.3.1 are discussed below. For Alternatives 4, 6 and 7, during the RA, P4 would sequence the remedial components so that excavated/regraded waste rock would be covered soon after grading to limit environmental exposures of the fresh waste rock surfaces. In addition, proper grading and drainage would ensure that surface runoff through and over excavated waste rock is minimized prior to emplacement of the final cover system. Please note that, for Alternatives 6 and 7 discussed below, an ET cover as depicted on **Figure 2-1** has been selected for graded upland soil/waste rock surfaces based on the screening assessment of Alternative 3 (soil cover), Alternative 4 (ET cover), and Alternative 5 (multi-layer cover) in Section 2.0 against the screening criteria of effectiveness, implementability, and cost presented in **Table 2-1**.

3.2.1 Upland Soil/Waste Rock Alternative 1 – No Action

As required by the NCP, a No Action alternative is included to provide a comparison between potential remedial actions and current conditions at the Site. The No Action alternative does not include any remedial action, LTM, or administrative/engineering controls.

Detailed Analysis Summary. The No Action alternative for upland soil/waste rock does not satisfy the threshold criteria (i.e., protection of human health and the environment and compliance with ARARs) because it would not include any activities to reduce the identified unacceptable risks or meet the cleanup levels. As a result, the No Action alternative is not suitable for inclusion in the selected remedy for the Site. The complete detailed analyses for all of the upland soil/waste rock alternatives is presented in **Table 3-1a**.

3.2.2 Upland Soil/Waste Rock Alternative 4 – Upland Soil/Waste Rock Grading and Consolidation with a Evapotranspiration (ET) Cover System, ICs, LUCs, and O&M/LTM

Under Alternative 4, waste rock dumps would be partially excavated and consolidated in the on-Site mine pits to cover the exposed ore beds (i.e., Meade Peak Member of the Phosphoria Formation), and direct unimpacted surface water away from the potential sources areas (external waste rock dumps) and for those areas within the pits, into the Wells Formation. As schematically shown on **Figure 3-2a**, mine waste rock dump MWD084 would be partially excavated to provide cover over the Meade Peak Member that is exposed in the bottom of open mine pit MMP039. In addition, waste rock dump MWD082 would be partially excavated to provide cover over the ore bed that is exposed in the bottom of open mine pit MMP037. Finally, waste rock dumps MWD080, MWD081, and MWD083 would be partially excavated to provide cover over the exposed Meade Peak Member and Wells Formation located in open mine pit MMP035. Following partial excavation, the remaining waste rock would be graded to a 3:1 or less slope and covered in place.

The remaining waste rock dumps (i.e., MWD093 and MWD082) would be graded to a 3:1 or less slope and covered in place. Materials cut from these waste rock dumps would be placed directly into their associated mine pits, MMP036 and MMP040 respectively as shown on **Figure 3-2a**. In addition, MMP038 would require a minor amount of cover material to backfill and cap this small pit. It is assumed the fill material would be imported from the borrow area used to construct the cover system (discussed below).

The final consolidated and graded areas then would be capped with an ET cover system, the limits of which are presented on **Figure 3-2b**. An ET cover also would be placed in the areas where the original waste rock dumps were excavated for placement into the pits, thereby exposing the underlying surface that are assumed to have elevated levels of Site COCs/COECs (through the leaching process). The ET cover would substantially reduce water infiltration through the underlying waste rock and all stormwater shed from the surface would be unimpacted. It is

anticipated that the final ET cover would consist of (starting from the top of the cover) a 5-foot thick layer of medium-grained, alluvial material to store precipitation overlying a minimum of 1-foot of coarse material that serves as a capillary break as shown on **Figure 2-1**. For the purposes of this FS, the thicknesses of the various layers have been selected based on other covers that P4 currently is installing and following review and evaluation of the *Cover System Evaluation Memorandum for the Ballard Mine Site* (MWH, 2016b) in **Appendix B**.

The seed mixes and resulting vegetation types would be selected to form extensive root systems to limit erosion, to slow stormwater and snowmelt movement off the cap, to transpire water that infiltrates and accumulates in the upper layers of the cover system, and to penetrate the upper cap soil but not into the underlying waste rock. Long-term monitoring would be necessary to inspect the cover for plants that are incompatible with the selected cover system (i.e., vegetation with roots that could penetrate the ET cover system) and to repair any stormwater erosion that might occur to the cover system. ICs would be implemented to restrict activities that could disturb the covered upland soil/waste rock. The sloped cover surface and drainage layer would allow stormwater and snowmelt to efficiently run off the surface or drain to the edge of the cover or infiltrate into the Wells Formation in the pits that are not completely backfilled. The final configuration of the covers would be determined during the RD process once additional studies are completed.

Site grading and ET cover installation would require RD and a remedial action work plan (RAWP). The RD/RAWP would include necessary design elements including grading and cover installation procedures, depths, and materials, design of temporary roads, site restoration plan, a health and safety plan (HASP), and a stormwater management plan. ICs and LUCs are limited-action type remedial actions that require appropriate planning, monitoring, and periodic evaluations to confirm protection of human health and the environment and to track progress toward meeting the RAOs. ICs/LUCs would require preparation of an Institutional Controls Implementation and Assurance Plan (ICIAP), which typically requires legal support. Engineered LUCs (e.g., fencing, signage, gates) would require some construction and periodic inspection and maintenance. The adequacy of the ICs/LUCs require periodic evaluation during the CERCLA 5-year review process to confirm they remain adequate in relation to the nature and extent of COCs/COECs at the perennial seeps/springs, and that they are being enforced and maintained. Long-term O&M would require the preparation of an operation, monitoring and maintenance plan (OMMP) detailing the type and

frequency of inspection of the covers. Other assumptions to support the cost estimate for this alternative are included in **Appendix A**.

Detailed Analysis Summary. Upland Soil/Waste Rock Alternative 4 scores high for several of the NCP evaluation criteria such as overall protection of human health and environment, compliance with ARARs, short- and long-termed effectiveness, and implementability as it would prevent direct exposure to Site COCs/COECs and would substantially reduce migration of COCs/COECs to downgradient media. The estimated duration to complete Alternative 4 is 3 to 5 years depending on the equipment used and unforeseen weather related problems. The estimated costs for construction of Alternative 4 is approximately $52.4M (refer to **Appendix A**). The complete detailed analyses for all of the upland soil/waste rock alternatives including the FS-level costs are presented in **Table 3-1a.**

3.2.3 Upland Soil/Waste Rock Alternative 6 - Upland Soil/Waste Rock Grading and Consolidation, Incidental Ore Recovery, ET Cover System, ICs, LUCs, and O&M/LTM

Upland Soil/Waste Rock Alternative 6 includes all of the components of Alternative 4 along with recovery of a significant portion of the known remaining ore deposits that are exposed at the surface and in the mine pit bottoms, in the pit walls, and underlie Rex Chert and/or Dinwoody Formation bedrock in the flanks of the current mine pits at the Site. The incidental ore recovery would be conducted concurrent with waste rock removal, consolidation, grading, and capping efforts. The remediation under this alternative would be implemented in three phases, corresponding to the three ore bodies that have been identified within the Site. Following the remediation and ore recovery activities, all disturbed upland soil/waste rock areas would be consolidated or graded to drain properly, capped with an ET cover system and vegetated. Please note that the conceptual RA/ore recovery presented here is based on current information regarding the location and quantity of ore deposits, cover materials, etc. During the RD, the phasing of incidental ore recovery and remedial activities might be modified to optimize implementation based on new information available at that time. However, these modifications would not fundamentally change the remedy components or the ability to achieve remedial objectives.

An overview of the Alternative 6 conceptual RA follows:

- As presented on **Figure 3-3a**, Phase 1 includes grading of waste rock dumps MWD082 and MWD084 and consolidating the cut material into open mine pits MMP040 and MMP039 respectively. This phase also includes the grading of an existing waste rock dump present in

the bottom of open mine pit MMP035. The waste rock dumps would be graded to 3:1 slopes or less and covered with an ET cover system as described in Alternative 4. Following this grading effort, ore recovery operations would commence in the area identified as the "Little Pit" and "Little Pit Access Road" shown on **Figure 3-3a**. At the end of Phase 1, site reclamation would be complete in the northeast portion (MMP039/MWD084) and eastern portion (MMP040/MWD082) as indicated in green on **Figure 3-3a**.

- Phase 2 continues ore recovery activities with the grading of waste rock dump MWD093 and consolidating the material into open mine pit MMP036. Overburden present to the south of MMP036 would be stripped to expose the ore and used to backfill "Little Pit" and the "Little Pit Access Road". Following overburden removal, ore recovery would commence in the area identified as the "Island Pit" as shown on **Figure 3-3b**. At the end of Phase 2, site reclamation would be completed for the entire eastern portion of the site as indicated in green on **Figure 3-3b**.
- Phase 3 includes stripping of overburden in the area identified as the "Long Pit" on **Figure 3-3c** and consolidating the material in the "Island Pit" and open mine pit MMP036. After the overburden has been removed ore recovery in the "Long Pit" would be completed. Following completion of ore recovery operations, waste rock dumps MWD080, MWD081, and MWD083 would be graded and consolidated in the "Long Pit," MMP035, and MMP036. The waste rock dumps would be graded to 3:1 slopes or less and covered with an ET cover system as described in Alternative 4. At the end of Phase 3, site reclamation would be completed for the entire Site as indicated in green on **Figure 3-3c**.
- MMP038 would require a minor amount of cover material to backfill and cap this small pit. It is assumed the fill material would be imported from the borrow area used to construct the cover system or from borrow sources located during incidental ore recovery. This work could be accomplished at any point in the remediation process.

Extracting underlying ore would allow the existing waste rock (i.e., the source material) to be consolidated and/or capped during the mining operation, and would result in continuous covers throughout the Site which would enhance drainage and naturally blend with the surrounding native landscape. This alternative would result in more complete reclamation of the Site.

The ET cover design/geometry, O&M requirements, ICs and LUCs would be included as outlined previously for Alternative 4.

Detailed Analysis Summary. Upland soil/waste rock Alternative 6 scores high for several of the NCP evaluation criteria including 1) protectiveness to human health and the environment - because it would prevent direct exposure to Site COCs/COECs, and would substantially reduce migration of COCs/COECs to downgradient and down slope media (groundwater, surface water, sediment and riparian soil), 2) compliance with ARARs – would comply with all chemical, location and action-specific ARARs, 3) long-term effectiveness – ET covers would be constructed of earthen materials and they are viable over the long term with maintenance, and 4) implementability – both ore recovery and construction of the ET cover system use readily available equipment and standard construction/earthmoving procedures. The alternative scores moderately for reduction of toxicity, mobility, or volume through treatment since treatment of the contaminated soil/waste rock is not a component of the remedy (or any of the alternatives), although these sources are effectively isolated by the cover system and exposed ore is removed thereby eliminating direct contact with ore related COCs/COECs. Alternative 6 does have additional administrative implementation requirements related to ore recovery. However, the ore recovery component of Alternative 6 has positive environmental impacts that are ancillary to the main NCP criteria because it delays recovery of similar volumes of ore at other P4 mines in the immediate area and has other green and sustainable benefits as presented in Section 3.6.1.

Finally, the total estimated cost for implementation of Alternative 6 is $153.5M (refer to **Appendix A, Table A-1**). However, P4 has determined that this cost can be attributed to work related to either "ore recovery" or to "remedial action," as follows:

- "Ore recovery" costs are estimated at 75% of the total costs or $115.1M. These costs include activities necessary for: exposing ore (i.e., overburden removal), excavating ore, and reclaiming the ore removal locations. A portion of the ore recovery activities also addresses the CERCLA remedy (e.g., the overburden removed during ore recovery may be used to backfill an existing pit or to construct a remedial cover).

- "Remedial action" costs are estimated at 25% of the total costs or $38.4M. These costs include activities exclusively related to the CERCLA RA and its implementation (e.g., backfilling MMP038 mentioned above) and are used in this detailed analysis.

This apportionment is based on a consideration of the quantities of material that would be handled (i.e., excavation, transportation, grading), the areas of disturbance and remediation/reclamation, and the locations where work would be performed relative to the existing waste rock dumps/mine pits and ore bodies that would be recovered. The estimated duration to complete Alternative 6 is 6 to 8 years depending on the number of shovels used during the remediation. The complete detailed analyses for all of the upland soil/waste rock alternatives including the FS-level costs are presented in **Table 3-1a**.

3.2.4 Upland Soil/Waste Rock Alternative 7 - Complete Consolidation of Existing Upland Soil/Waste Rock into the Pits, ET Cover System, ICs, LUCs, and O&M/LTM

Under Upland Soil/Waste Rock Alternative 7, all upland soil/waste rock lying outside the existing pits would be excavated and consolidated in the existing pits. The consolidated material would be placed to cover any exposed ore beds similar to Alternative 4, then graded/contoured to create slopes that effectively shed stormwater and snowmelt to the exterior of the backfilled pits (e.g. open pit MMP035 would be backfilled so that stormwater would flow generally west off the capped area onto downslope areas). The graded upland soil/waste rock surfaces in the pits and the areas underlying the former upland soil/waste rock would be graded as necessary and capped with an ET cover system. This cover was selected, similar to Alternative 6, following screening of the three types of cover systems evaluated in Alternatives 3, 4, and 5. **Figure 3-4** depicts the Alternative 7 covered surfaces and directions of stormwater flow at the completion of this remedial action.

Table 3-1b provides the updated waste rock and pit volumes based on recent engineering estimates of the waste rock dumps and materials movements prepared for this memorandum using CAD. Using this information, we have developed the following conceptual approach for this alternative:

- The materials in waste rock dump MWD080, MWD081, MWD083, and a portion of MWD093 (737K bank cubic yards [bcy] – volume of materials in their current state prior to excavation) would be moved back into mine pit MMP035 so that it is backfilled and sloped to drain surface water away from the backfilled pit towards the west. Approximately 9.8M placed cubic yards (pcy; volume of materials after it has been disturbed) would be necessary to accomplish this backfilling effort.
- The other part of waste rock dump MWD093 (approximately 4.1M bcy) and a portion of MWD082 (690K bcy) would be used to backfill pit MMP036 (4.8M pcy). MMP036 volume is approximately 5.3M pcy; therefore, the backfill would be approximately 0.5M pcy from the

pre-mining surface. However, the material placed in the pit would be positioned and sloped to convey unimpacted stormwater within the pit downslope and generally to the south and off-Site (i.e., given the pit geometry and topography).

- All of the remaining waste rock volume in MWD082 (1.9M bcy) and a portion of MWD084 (513K bcy) would be used to backfill mine pits MMP037 (1.6M pcy) and MMP040 (0.8M pcy) on the east side of the Site. These backfilled pits then would shed stormwater off the covered surfaces in the headwaters of Wooley Valley Creek generally to the east.
- The remainder of MWD084 (0.421K bcy) with approximately 330K bcy of imported fill would be used to partially backfill mine pit MMP039 (750K pcy). This backfilling would allow the pit to shed water to the east as part of Wooley Valley Creek.
- MMP038 would require a minor amount of cover material to backfill and cap this small pit. It is assumed the fill material would be imported from the borrow area used to construct the cover system that would shed stormwater generally to the west.

It should be noted that the calculated volume of upland soil/waste rock lying outside the existing pits is not sufficient to completely fill the pits to their original surfaces. This is because the upland soil/waste rock volumes are missing approximately 6.4 million cubic yards of ore that was removed from the Site during the mining operations. Therefore, although Alternative 7 consolidates all of the upland soil/waste rock into the pits, the resulting ground surfaces (including the ET cover) would not match the pre-mining surfaces because of the volume of the ore and associated material removed (i.e., 6.4 million cubic yards) during mining and transported to Soda Springs for processing. The importation of clean backfill is proposed for this alternative for backfilling a portion of MMP039 and MMP038, although it isn't a large quantity (around 350K pcy).

Another important consideration for Alternative 7 (similar to Alternative 4) is that the underlying ground surfaces where upland soil/waste rock would be removed also must be excavated until cleanup levels are achieved *or* covered to be protective of human health and the environment. As previously discussed under other alternatives where waste rock dumps have been consolidated, this is necessary because the areas underlying the upland soil/waste rock dumps are assumed to have been impacted by migration of constituents from the waste rock dumps into the underlying soil. The assumption used is that these exposed exterior surfaces (remaining following waste rock

removal) would be graded as necessary to form stable surfaces that can be capped with an ET cover system.

The ET cover design/geometry, O&M requirements, ICs and LUCs would be included as outlined previously for Alternative 4.

Detailed Analysis Summary. Upland soil/waste rock Alternative 7 scores high for several of the NCP evaluation criteria including protectiveness because this alternative would prevent direct exposure to site COCs/COECs and would substantially reduce migration of COCs/COECs to downgradient media. The bulk of the residual risk (i.e., the consolidated upland soil/waste rock) would be isolated in the pits. However, the material backfilled into the pits would still require an ET cover (similar to Alternatives 4 and 6) to reduce infiltration and COC/COEC migration. In addition, the entire area outside the pits, where the upland soil/waste rock would be removed, would require a cover system because it is expected that COCs/COECs would have migrated from the upland soil/waste rock some unknown depth into the underlying native surfaces. This means that the total covered area is similar to other alternatives even with consolidation of all the waste rock in the pits. In addition, the existing pits under this conceptual alternative approach remain partially backfilled because the existing waste rock dumps do not have enough volume to completely fill the existing mine pits to the pre-mining surface, but it is sufficient to allow the backfill to be placed and graded to convey the stormwater downslope and off-Site.

Alternative 7 is not expected to have negative short-term impacts to the community or the environment. The estimated duration to complete Alternative 7 is 5 to 7 years depending on the equipment used and unforeseen weather-related problems. The estimated cost for construction of Alternative 7 is $117.3M. The complete detailed analyses for all of the upland soil/waste rock alternatives including the FS-level costs are presented in **Table 3-1a**.

3.3 SURFACE WATER ALTERNATIVES – DETAILED ANALYSES

This section presents the detailed analyses (and the associated supporting information) for the retained remedial alternatives for the surface water medium. The complete detailed analyses for the surface water alternatives are presented in **Table 3-2**. An additional summary of the detailed analysis for each retained remedial alternative is included in the narratives below.

The following descriptions of the retained alternatives build on the alternative descriptions included in Section 2.3.2. These descriptions provide additional information to support the analyses

presented in **Table 3-2**, specifics related to source controls and the other common core elements that are identified in Section 2.1, and other information used for developing the cost estimates contained in **Appendix A**. The three retained surface water remedial alternatives include:

- Surface Water Alternative 1 – No Action
- Surface Water Alternative 2 – Institutional Controls (ICs) and LUCs, in conjunction with source controls in the upland soil/waste rock (see **Figure 3-5**)
- Surface Water Alternative 3 – In-Situ Biological (Wetlands) Treatment of Source Area Seepage, ICs, and LUCs, in conjunction with source controls in the upland soil/waste rock (see **Figure 3-6**)

With the exception of the No Action alternative, it is assumed that all surface water remedial alternatives would be implemented in conjunction with source controls in the upland soil/waste rock. Effective source controls (i.e., waste rock consolidation, surface grading, and capping) have two key impacts on surface water at the Site which are critical to the analysis of the surface water alternatives:

1) All stormwater and snowmelt runoff from formerly mined areas would no longer exceed surface water cleanup levels because that runoff would not contact waste rock before discharging off-Site.
2) Surface water discharge from the mine-affected seeps/springs would eventually go dry permanently, or discharge from those seeps/springs would eventually meet the surface water cleanup goals. This is because the source controls in the upland soil/waste rock would substantially reduce precipitation and snowmelt from infiltrating through the consolidated and covered waste rock, thereby reducing the source of mine-affected seep/spring flow. Following source controls, mine-affected seep/spring discharge is expected to continue for an undetermined period of time until the residual mine-affected groundwater (the source of seep/spring flow) drains from the hydrogeologic system or otherwise naturally attenuates.

The following subsections present a description of the surface water remedial alternatives that were retained following the screening performed in Section 2.3.2. These descriptions provide the supporting information for the detailed and comparative analyses of the surface water remedial alternatives that are presented in **Table 3-2**.

3.3.1 Surface Water Alternative 1 – No Action

As required by the NCP, a No Action alternative is included to provide a comparison between potential RAs and current conditions at the Site. The No Action alternative does not include any remedial action, LTM, or administrative or engineering controls.

Detailed Analysis Summary. The No Action alternative does not satisfy the threshold criteria (i.e., protection of human health and the environment and compliance with ARARs) because it would not include any activities to reduce the identified unacceptable risks or meet the cleanup levels. As a result, the No Action alternative is not suitable for inclusion in the selected remedy for the Site. The complete detailed analyses for all of the surface water alternatives including the FS-level costs are presented in **Table 3-2**.

3.3.2 Surface Water Alternative 2 – Institutional Controls (ICs) and LUCs, in conjunction with source controls in the upland soil/waste rock

Under this alternative, ICs and LUCs would be implemented to restrict surface water use and access until cleanup levels are achieved for a prescribed duration. Once the upland soil/waste rock remedy is implemented, surface water runoff would not contact Site COCs/COECs (i.e., runoff would meet the cleanup levels because it would no longer contact waste rock). Only residual flows from mine-affected seeps/springs are expected to exceed cleanup levels for a period of time until the grading and cover systems mitigate the source of water that recharges through the upland soil/waste rock and ultimately discharges to the seeps/springs. The ICs/LUCs initially would be implemented along the reaches where COC/COEC concentrations historically have exceeded the surface water cleanup levels as shown on **Figure 3-5**. **Figure 3-5** also shows the anticipated long-term surface water monitoring locations, which comprise historical sampling locations along Ballard Creek and Wooley Valley Creek. For cost estimating purposes (see **Appendix A**), it is assumed that 1) the current surface water monitoring network along Ballard Creek and Wooley Valley Creek is sufficient, and 2) samples would be collected annually. These details would be refined during the RD process (discussed below).

The ICs/LUCs would remain in place until it is demonstrated through LTM that the surface water cleanup levels are achieved. It is anticipated that the ICs would include deed restrictions[3] to limit surface water use, and that LUCs would include fencing around the mine-affected seeps/springs to

[3] "Deed Restriction" is not a traditional real property law term, but used in the NCP as a shorthand way to refer to various types of proprietary controls.

limit human and livestock access, and signage to warn against contact with or use of the mine-affected surface water (see Section 2.1.2).

Although ICs and LUCs are limited-action type RAs, they require appropriate planning, monitoring, and periodic evaluations to confirm protection of human health and the environment and to track progress toward meeting the RAOs. LTM would require preparation of a SAP, routine surface water monitoring, and periodic data evaluations to confirm COC/COEC concentrations in the intermittent drainages are decreasing or trending toward the cleanup levels as a result of source controls. ICs/LUCs would require preparation of an ICIAP, which typically requires legal support. Engineered LUCs (e.g., fencing, signage, gates) would require some construction and periodic inspection and maintenance. The adequacy of the ICs/LUCs require periodic evaluation during the CERCLA 5-year review process to confirm they remain adequate in relation to the nature and extent of COCs/COECs at the perennial seeps, and that they are being enforced and maintained. Other assumptions to support the cost estimate for this alternative are included in **Appendix A**.

Detailed Analysis Summary. Surface Water Alternative 2 relies on ICs and LUCs to limit exposures to the residual mine-affected surface water flows at the seeps/springs located near the margins of the formerly mined areas. As a result, Alternative 2 is moderate to high for protection of human health and the environment and compliance with ARARs, and scores high with respect to long-term effectiveness/permanence because the only sources of mine-affected surface water will be on the margins of the cover system and IC/LUCs will be in place (although the seeps will not be treated). Once the upland soil/waste rock is capped, the volume of mine-affected surface water in the seeps/springs at the margin of the cover area is expected to significantly reduce and of course precipitation running off the cover system will be unimpacted. Over the long term all surface water at the Site should eventually meet the cleanup levels following implementation of source controls within a reasonable time period (e.g., within 10 years). Alternative 2 is easy to implement and has low costs because it does not include design, construction, or O&M of RA facilities. The complete detailed analyses for all of the surface water alternatives including the FS-level costs are presented in **Table 3-2**.

3.3.3 Surface Water Alternative 3 – In-Situ Biological (Wetlands) Treatment of Source Area Seepage, ICs, and LUCs, in conjunction with source controls in the upland soil/waste rock

Under this alternative, ICs and LUCs (in conjunction with source controls in the upland soil/waste rock) would be implemented as in Alternative 2, and in-situ wetlands would be constructed at

perennial mine-affected seep/spring locations as shown on **Figure 3-6**. The wetlands would treat the residual mine-affected water (following PRB treatment) at the perennial seeps/springs via biologically-mediated and redox-related reactions, resulting in precipitation and/or sorption of the COCs/COECs. As one specific example, oxygenation of the PRB-reduced seep/spring water would result in the precipitation of manganese and iron-hydroxides that would subsequently sorb and coprecipitate some COCs/COECs including arsenic and selenium. Other potential wetlands processes include: plant uptake of COCs/COECs with sequestration in the plant matter, methylation and subsequent volatilization of selenium, and filtration and binding of COC/COEC containing suspended solids including newly formed metal hydroxides (DWTTC, 1999; Stillings and Amacher, 2004; Lamothe and Herring, 2004; Mackowiak, et. al., 2004).

The treated water would flow out of the wetlands to the downstream drainages or evapotranspire within the wetlands. As with Alternative 2, other surface water that flows off of the graded and capped areas of the upland soil/waste rock would meet the cleanup levels because the runoff would no longer contact waste rock. A shown on **Figure 3-6**, it is anticipated that wetlands would be constructed at select seep/spring locations and flow from other nearby seeps/springs would be captured and conveyed to one of the constructed wetlands. Likewise, flows from any seeps/springs that are present within the footprint of upland soil/waste rock following reclamation would be captured and conveyed to downstream constructed wetlands.

Initial wetland delineations would be performed prior to the ROD based on Site-specific aerial photographs, photographs taken during the biannual surface water sampling events throughout the Ballard Site, and data from the National Wetlands Inventory. Additional wetland delineations would be completed during the pre-design phase in the late spring to mid-summer season, as necessary. Information regarding the size of engineered wetlands, use of existing wetlands during the RA, and potential impacts to any identified wetlands would be evaluated during the RD process. Wetlands would be removed and disposed in an on-Site landfill, once cleanup levels are reliably achieved.

The anticipated ICs and LUCs described in Alternative 2 would be expanded as necessary to limit unauthorized access or activities that might interfere with the constructed wetlands. It is anticipated that the LTM for this alternative would be the same as described in Alternative 2.

Construction of the in-situ wetlands would require RD and a RAWP. The RD/RAWP would include the wetland design information, design of temporary roads and engineered access

restrictions, site restoration plan, HASP, and stormwater management plan. The constructed wetlands also would require preparation of LTM and O&M plans and possibly closure plans (in the very long term). Periodic monitoring and data evaluations would be required to track the progress of the wetlands treatment and to support CERCLA 5-year reviews. Other assumptions to support the cost estimate for this alternative are included in **Appendix A**.

Detailed Analysis Summary. A key component of Surface Water Alternative 3 is that it includes in-situ wetlands treatment at the residual mine-affected seeps/springs near the margins of the formerly mined areas where COC/COEC concentrations are expected to exceed the cleanup levels for a period of time following source controls in the upland soil/waste rock. This in-situ treatment step scores high for protectiveness because it treats the surface water at locations where exposures are expected to occur. Alternative 3 satisfies USEPA's preference for treatment as a principal element of the remedy, is relatively easy to implement, and has moderate costs. The complete detailed analyses for all of the surface water alternatives including the FS-level costs are presented in **Table 3-2**.

3.4 SEDIMENT/RIPARIAN SOIL ALTERNATIVES – DETAILED ANALYSES

This section presents the detailed analyses (and the associated supporting information) for the retained remedial alternatives for the sediment/riparian soil medium. The complete detailed analyses for the sediment/riparian soil alternatives are presented in **Table 3-3**. An additional summary of the detailed analysis for each retained remedial alternative is included in the narratives below.

The following descriptions of the retained alternatives build on the alternative descriptions included in Section 2.3.3. These descriptions provide additional information to support the analyses presented in **Table 3-3**, specifics related to source controls and the other common core elements that are identified in Section 2.1, and other information used for developing the cost estimates contained in **Appendix A**.

The three retained sediment/riparian soil remedial alternatives include:

- Sediment/Riparian Soil Alternative 1 – No Action

- Sediment/Riparian Soil Alternative 3 – Sediment Traps/Basins, Monitored Natural Recovery (MNR), ICs, and LUCs, in conjunction with source controls in the upland soil/waste rock (see **Figure 3-7**)
- Sediment/Riparian Soil Alternative 4 – Removal and On-Site Disposal, MNR, ICs, and LUCs, in conjunction with source controls in the upland soil/waste rock (see **Figure 3-8**)

With the exception of the No Action alternative, all sediment/riparian soil remedial alternatives assume implementation in conjunction with source controls in the upland soil/waste rock. This is critical because source controls (i.e., waste rock consolidation, surface grading, and capping) would prevent the three mechanisms for COCs/COECs migrating to sediment/riparian soil in the drainages downstream of the mined area:

1) Following source controls in the upland soil/waste rock, the consolidated and covered waste rock would no longer be exposed at the surface, and therefore no longer available to be transported via erosional forces to the downstream drainages.
2) Following source controls in the upland soil/waste rock, stormwater and snowmelt would no longer contact the waste rock before running off the mined area. As a result, this unimpacted runoff would no longer contain elevated concentrations of suspended or dissolved COCs/COECs that could be transported to the sediment/riparian soil in the downstream drainages.
3) Following source controls in the upland soil/ waste rock, precipitation infiltration that might surface as seeps/springs at the margins of the waste rock dumps would be significantly reduced. Therefore, the source of impacted surface water from seeps/springs would be reduced or eliminated and would no longer contact sediment/riparian soil.

3.4.1 Sediment/Riparian Soil Alternative 1 – No Action

As required by the NCP, a No Action alternative is included to provide a comparison between potential RAs and current conditions at the Site. The No Action alternative does not include any RA, LTM, or administrative or engineering controls.

Detailed Analysis Summary. The Sediment/Riparian Soil No Action alternative does not satisfy the threshold criteria (i.e., protection of human health and the environment and compliance with ARARs) because it would not include any activities to reduce the identified unacceptable risks or

meet the cleanup levels. As a result, the No Action alternative is not suitable for inclusion in the selected remedy for the Site. The complete detailed analyses for all of the sediment/riparian soil alternatives including the FS-level cost information are presented in **Table 3-3**.

3.4.2 Sediment/Riparian Soil Alternative 3 – Sediment Traps/Basins, Monitored Natural Recovery (MNR), ICs, and LUCs, in conjunction with source controls in the upland soil/waste rock

This alternative uses sediment traps in the upper reaches of the mine-affected drainages where the highest concentrations of COCs/COECs are detected in sediment/riparian soil. The basins (installed at the lowest elevation of the upper reaches) would capture/control mine-affected sediment entrained in the intermittent storm water/stream flow and allow these surface waters with reduced turbidity to continue downstream of these structures. The basins would provide control points for containment of mine-affected sediment moving from the most contaminated upper reaches of the intermittent stream channels prior to completion of the RA. Sediment control basins are relatively easy to construct. O&M of these structures would require some long-term planning, but is similar to standard construction stormwater best management practices (BMPs). Disposal of any contaminated sediment retained in these structures over the long term should be relatively easy to place under an adjacent upland soil/waste rock soil cover during the RA and in an on-Site landfill post-RA, as necessary.

MNR would be implemented throughout the mine-affected drainages where COC/COEC concentrations are elevated. MNR relies on natural processes (i.e., physical, chemical, and biological processes) to reduce COC/COEC concentrations in the affected media over time. Additional details regarding MNR are included in Appendix B of *Ballard FS Memo #1*. In order for MNR to be successful, source controls would need to be implemented in the upland soil/waste rock to prevent or reduce migration of COCs/COECs to the downstream drainages. The sediment traps/basins also would help to capture any mine-affected sediment released during the RA as discussed above. These structures likely would be decommissioned post-RA (i.e., post establishment of vegetated covers) because any sediment coming off the covered surfaces would be unimpacted, and other clean sediments from adjacent native areas throughout the drainages would aid MNR processes lower in the drainages. Long-term sediment/riparian soil and vegetation sampling would be conducted to provide data for evaluation of the natural recovery progress (i.e., MNR). This alternative also requires ICs and LUCs to restrict Site activities until the cleanup levels are achieved. The LTM, ICs, and LUCs would be performed/ implemented throughout the mine-affected intermittent drainages as shown on **Figure 3-7** and described below.

Sediment traps/basins, MNR, ICs, and LUCs would require appropriate planning during the RD and monitoring and periodic evaluations following construction to confirm protection of human health and the environment and to track progress toward meeting the RAOs. Construction of the sediment traps would require some effort in the RD and development of a RAWP. The RD/RAWP for this alternative would include the sediment trap/basin design information, design of temporary roads and engineered access restrictions, site restoration plan, LTM, O&M, and HASPs, and stormwater management plan. Periodic monitoring and data evaluations would be necessary to track and evaluate the effectiveness of the RA and to support CERCLA 5-year reviews.

MNR requires no construction or O&M. Proper implementation of MNR might require a predesign/design study to demonstrate the effectiveness of the MNR processes. Implementation of MNR during the RA would require preparation of a LTM SAP, routine monitoring of sediment/riparian soil and vegetation at known locations over a designated time frame, and periodic data evaluations to track the progress of natural recovery and to support CERCLA 5-year reviews.

The anticipated LTM sampling locations are shown on **Figure 3-7** and include existing sampling locations and proposed new locations to provide a greater density and more uniform distribution of monitoring locations along the intermittent stream channels. For cost estimating purposes (see **Appendix A**), it is assumed that: 1) sediment traps and basins would be installed in six locations which cannot be positioned until the geometry of the Site is determined by the selection of the upland soil/waste rock alternative, and 2) LTM sediment/riparian soil/vegetation samples would be collected periodically. Sampling details would be refined during RD and preparation of a SAP.

ICs require preparation of an ICIAP, which typically requires legal support. It is anticipated that the ICs would include deed restrictions to limit certain activities in the mine-affected intermittent drainages (e.g., harvesting of culturally significant plants, livestock grazing); and that LUCs would include fencing at key access points to limit human and livestock access, and signage to warn against contact with or use of the mine-affected sediment/riparian soil and associated vegetation (see Section 2.1.2). Engineered LUCs (e.g., fencing, signage, gates) would require some construction and periodic inspection and maintenance. The adequacy of the ICs/LUCs require periodic evaluation (e.g., during the CERCLA 5-year review process) to confirm they remain adequate in relation to the nature and extent of COCs/COECs, and that they are being enforced and maintained. Other assumptions to support the cost estimate for this alternative are included in **Appendix A**.

Detailed Analysis Summary. Sediment/Riparian Soil Alternative 3 would rely on sediment traps/basins to contain downstream transport of the most contaminated sediment during the RA and over the long term. ICs and LUCs would be used to limit exposures until risks are reduced via natural recovery processes (MNR). This alternative scores high for long-term effectiveness and implementability, moderate to high for overall protection of human health and the environment considering short- and long- term aspects of the remedy, moderate for short-term effectiveness, and low to moderate for reduction in toxicity, mobility, or volume through treatment. Alternative 3 has favorable low costs. The complete detailed analyses for all of the sediment/riparian soil alternatives including the FS-level cost information are presented in **Table 3-3**.

3.4.3 Sediment/Riparian Soil Alternative 4 - Removal and On-Site Disposal, MNR, ICs, and LUCs, in conjunction with source controls in the upland soil/waste rock

Under this alternative, sediment/riparian soil (and all associated vegetation) where the highest concentrations of COCs/COECs are detected in the upper reaches of the mine-affected drainages, would be removed (excavated) as shown on **Figure 3-8**. MNR, ICs, and LUCs would be implemented as described in Alternative 3 for sediment/riparian soil that is not removed in the lower reaches of the mine-affected drainages where COC/COEC concentrations are lower.

The following assumptions were made for the purposes of estimating costs (see **Appendix A**):

- A selenium concentration of greater-than 25 mg/kg is the action level for removing sediment/riparian soil (see **Figure 3-8**). This action level is based on an upland soil selenium background concentration of 29 mg/kg. This level provides a reasonable distinction between detected selenium concentrations in the sediment/riparian soil located closer-to and further-from the COC/COEC sources in the mined areas.
- The excavation along each drainage would be (on average) 12 inches deep and 30 feet wide. Additional details regarding this assumption are included in Section 4.4.2 of *Ballard FS Memo #1*.

The removed materials would be transported to the mined area and handled in accordance with the selected alternative for the upland soil/ waste rock (i.e., consolidated and capped). The stream channels would be restored by re-contouring and re-vegetating the excavated areas. BMPs would be employed during the excavation and stream restoration activities to:

- Restore stream geometry, vegetation, and habitat

- Minimize sediment mobilization
- Control erosion and sediment mobilization
- Stabilize and rehabilitate riparian areas
- Avoid contaminant spills (e.g., excavation equipment fuel and hydraulic fluids)

The removal, transport of excavated media, and site restoration activities would require a RD and preparation of a RAWP. The RD/RAWP would include a confirmation SAP or reference a separate confirmation SAP for verifying removal of the mine-affected sediment/riparian soil near the mine waste dumps. The confirmation SAP would identify the performance criteria that would guide the extents of the excavations. The RD/RAWP also likely would include plans for gathering design information, design of temporary roads and engineered access restrictions, Site restoration plan, LTM, O&M, and HASP, and stormwater management plan during removal of mine-affected sediment/riparian soil. Periodic monitoring and data evaluations would be necessary following remediation to track the reclamation and recovery of the areas where sediment/riparian soil were removed and progress towards achieving the MNR goals in the lower segment of the affected drainages. This information would be used to support CERCLA 5-year reviews. Other assumptions supporting the cost estimate for this alternative are included in **Appendix A**.

Detailed Analysis Summary. A key component of Sediment/Riparian Soil Alternative 4 is that it includes removal/disposal of the most highly contaminated sediment/riparian soil in the intermittent drainages near the margins of the mined areas. However, any benefits associated with removal/disposal likely is offset by the resulting damage to approximately 3 ½ miles of natural habitat that would be caused by the removal activities. This alternative scores high only for long-term effectiveness, moderate to high for implementability, overall protection of human health and the environment, moderate for reduction in toxicity, mobility, or volume through treatment and compliance with ARARs and low to moderate for short-term effectiveness because of the damage to the drainages during remediation. In addition, this alternative similarly meets the criteria as Alternative 3, with a higher associated cost. The complete detailed analyses for all of the sediment/riparian soil alternatives including the FS-level costs are presented in **Table 3-3**.

3.5 GROUNDWATER ALTERNATIVES – DETAILED ANALYSES

This section presents the detailed analyses (and the associated supporting information) for the retained remedial alternatives for the groundwater medium. The complete detailed analyses for the groundwater alternatives are presented in **Table 3-4**. An additional summary of the detailed analysis for each retained remedial alternative is included in the narratives below.

The following descriptions of the retained alternatives build on the alternative descriptions included in Section 2.3.4. These descriptions provide additional information to support the analyses presented in **Table 3-4**, specifics related to source controls and the other common core elements that are identified in Section 2.1, and other information used for developing the cost estimates contained in **Appendix A**.

The four retained groundwater remedial alternatives include:

- Groundwater Alternative 1 – No Action
- Groundwater Alternative 2 – MNA and ICs, in conjunction with source controls in the upland soil/waste rock (see **Figure 3-9**)
- Groundwater Alternative 3 – Limited Permeable Reactive Barrier (PRB) Treatment of Alluvial Groundwater, MNA, and ICs, , in conjunction with source controls in the upland soil/waste rock (see **Figure 3-10**)
- Groundwater Alternative 5b – Groundwater Recovery and Treatment of both Alluvial and Wells Formation Groundwater, and ICs, in conjunction with source controls in the upland soil/waste rock (see **Figure 3-11**)

With the exception of the No Action alternative, all groundwater remedial alternatives assume implementation in conjunction with source controls in the upland soil/waste rock. This is critical because source controls (i.e., waste rock consolidation, surface grading, and capping) would substantially reduce precipitation and snowmelt from infiltrating through the consolidated and covered waste rock, thereby preventing or reducing the source of mine-affected groundwater.

3.5.1 Groundwater Alternative 1 – No Action

As required by the NCP, a No Action alternative is included to provide a comparison between potential remedial actions and current conditions at the Site. The No Action alternative does not include any remedial action, LTM, or administrative or engineering controls.

Detailed Analysis Summary. The Groundwater No Action alternative does not satisfy the threshold criteria (i.e., protection of human health and the environment and compliance with ARARs) because it would not include any activities to reduce the identified unacceptable risks or meet the cleanup levels. As a result, the No Action alternative is not suitable for inclusion in the selected remedy for the Site. The complete detailed analyses for all of the groundwater alternatives are presented in **Table 3-4**.

3.5.2 Groundwater Alternative 2 – MNA and ICs, in conjunction with source controls in the upland soil/waste rock

This alternative includes MNA, which relies on natural attenuation processes to reduce COC concentrations in the Site groundwater over time. Additional details regarding MNA are included in Appendix B of *Ballard FS Memo #1*. In order for MNA to be successful in groundwater, source controls would need to be implemented in the upland soil/waste rock to prevent or reduce migration of COCs to groundwater. Long-term groundwater sampling would be conducted to provide data to evaluate the progress of natural attenuation. This alternative also would require ICs to restrict groundwater use until the cleanup levels are achieved. The LTM and ICs would be performed/implemented throughout the areas of the shallow (alluvial) and deep (Wells Formation) COC plumes as shown on **Figure 3-9** and described below.

Although MNA and ICs are limited-action type responses, they require appropriate planning, monitoring, and periodic evaluations to confirm protection of human health and the environment and to track progress toward meeting the RAOs. MNA requires no construction or O&M. Proper implementation of MNA would require a predesign/design study to demonstrate the effectiveness of MNA processes and evaluate the complete remedy to provide an estimate of the cleanup time frame (this effort would include all the selected remedial components for upland soil/waste rock, surface water, and sediment/riparian soil).

The timeframe to achieve PCLs in the shallow alluvial aquifer, as well as in the deeper Wells Formation aquifer, cannot be well estimated using existing data due to the complexity of the Site. USEPA guidance for MNA (USEPA, 2015) provides context for MNA timeframes for inorganic plumes:

"While remediation timeframes for organic plumes may be on the order of a few tens of years to more than a hundred years, remediation timeframes for inorganic plumes may be substantially longer. Ultimately, the timeframe for remediation will be based on site-specific conditions and chemical characteristics. The longer timeframes for inorganic

plumes may be reasonable if the source term has already been addressed, the plume is stable or shrinking, the exposure risks for the source term and daughter products are acceptable, and when active measures have similar timeframes. Multiple lines of evidence are recommended for demonstrating "reasonable timeframe" considering the above factors in conjunction with the following: source control or removal is complete; there is high confidence in the attenuation mechanisms, rates and capacity identified; and contingency plans are included for both the monitoring program and containment or treatment approaches."

In evaluating whether PCLs in groundwater at the Site can be achieved in a reasonable timeframe, the following factors are considered based on the USEPA guidance:

- The source of contamination (waste rock) will be graded and covered to substantially reduce or eliminate precipitation from moving through this medium, thereby removing it as a continuing source of contaminants to surface water, sediments, and groundwater.
- Based on relatively static groundwater concentrations in most monitoring wells provided by LTM data, the Site groundwater plumes appear to be stable (MWH, 2014).
- Human health and ecological exposure pathways and resulting risks will be controlled and largely eliminated through the implementation of ICs and LUCs. The majority of the impacted alluvial and Wells Formation groundwater is located on P4 property and where it is not, P4 will pursue land purchase, land exchanges, or agreements with property owners to implement appropriate ICs in order to control the beneficial use in these areas. As a result, there would be no current or anticipated future users of the mine-affected groundwater (no complete pathway of exposure), so there is not a significant driver for a potentially faster, but more costly treatment alternative. POC well locations will monitor compliance with RAOs in the alluvial and Wells Formation aquifers.
- The complex geology and heterogeneity of the aquifers is such that groundwater withdrawal, treatment and discharge to wells/ponds is not feasible, possibly has similar cleanup time frames as MNA, and contaminant rebound in the alluvial and Wells Formation aquifers could occur when MCLs are achieved and pumping is discontinued.

Additional data collection and monitoring likely are necessary to evaluate the performance and timeframes involved with MNA of the alluvial and Wells Formation aquifers. Additional monitoring and evaluations would be performed through collection of groundwater and aquifer solids data from existing and new monitoring points. The Ballard Site MNA evaluation would follow the USEPA

tiered analysis approach and recommended analyses per USEPA guidance documents (e.g., groundwater chemistry, subsurface mineralogy, chemical speciation). Further MNA evaluations and LTM ultimately will provide the data as to whether the proposed remedies and factors mentioned immediately above can achieve PCLs in a reasonable timeframe.

Implementation of MNA during the RA would require preparation of a LTM SAP, routine groundwater monitoring throughout the various plumes, and periodic data evaluations to track the progress of natural attenuation and to support CERCLA 5-year reviews. The conceptual LTM monitoring well network is shown on **Figure 3-9** and includes existing sampling locations and proposed new locations to provide a greater density and more uniform distribution of monitoring locations. For cost estimating purposes (see **Appendix A**), it is assumed that LTM groundwater samples would be collected annually, but LTM may be necessary semi-annually during or following the RA depending on further evaluations. These details would be refined during RD and preparation of the LTM SAP.

ICs would require preparation of an ICIAP, which typically requires legal support. It is anticipated that the ICs would include deed restrictions to limit groundwater extraction and use (see Section 2.1.2). The adequacy of the ICs require periodic evaluation (e.g., during the CERCLA 5-year review process) to confirm they remain adequate in relation to the nature and extent of COCs, and that they are being enforced and maintained.

Detailed Analysis Summary. Groundwater Alternative 2 relies on ICs and LUCs to limit exposures to mine-affected groundwater until cleanup levels are achieved via MNA. This is a viable alternative considering there are no current or anticipated future users of the mine-affected groundwater. However, mine-affected groundwater is expected to continue to discharge at the seeps/springs located near the margins of the former mined area. As a result, suitable controls would be required as part of the selected surface water component of the overall remedy to reduce exposures at these mine affected seeps/springs (see Section 3.3). This alternative is protective of human health and the environment, reduces toxicity, mobility and volume of COCs/COECs through natural processes and therefore is effective over the long term as long as ICs are in place to prevent or reduce exposures and ranks moderate to moderately high in these categories. Alternative 2 also would comply with ARARs over time. This alternative is easily implemented following predesign/design studies and plans and is the most inexpensive of the viable groundwater

alternatives so ranks highly with respect to those categories. The complete detailed analyses for all of the groundwater alternatives including the FS-level cost information are presented in **Table 3-4**.

3.5.3 Groundwater Alternative 3 – Limited Permeable Reactive Barrier (PRB) Treatment of Alluvial Groundwater, MNA, and ICs, in conjunction with consolidation, grading, and capping of upland soil/waste rock

This alternative includes MNA (with source controls) and ICs as in Alternative 2, and PRB treatment in select areas of the alluvial aquifer. Additional details regarding PRBs are included in Appendix B of *Ballard FS Memo #1*. PRBs would be installed upgradient of select perennial seeps/springs to treat shallow groundwater before it discharges at the seep. Because there are no current or anticipated future users of the Site groundwater, the PRBs would be limited to the seep locations because these are the only locations where the groundwater exposure pathway is complete (i.e., where the mine-affected groundwater daylights and becomes surface water).

For cost estimating purposes (see **Appendix A**), it is assumed that:

- PRBs would be installed upgradient of nine (9) seep locations as shown on **Figure 3-10**.
- Each PRB would be comprised of a treatment-media filled trench (e.g., sand/hay/woodchip mix or an iron-filings fill) that is 50 feet long, 10 feet deep, and 1.5 feet wide. Additional treatability testing would be required during RD to determine the actual geometry of the PRBs and the optimal treatment media, whether iron-filings, organic media, or another media or combination, for Site COCs. The media placed in the PRBs would have permeabilities appropriate for the hydraulic conductivities of surrounding materials and with adequate retention times to treat the intended contaminants to acceptable standards. It is likely that these PRBs would be based on PRBs designed and tested at P4's South Rasmussen Mine since 2012 (Newfields, 2016a, b, c). The treatment media selection during the RD would consider both the COC removal in groundwater and also potential additions to enhance removal in potentially associated engineered wetlands. For example, the addition of some iron-filings to an organically-based PRB media, could result in additional iron precipitation in the wetlands with associated additional COC sorption. PRBs would be removed, incorporated with other mine wastes and placed under the cover during the RA or in an on-Site landfill post-RA, once cleanup levels are reliably achieved, to avoid re-mobilization of COCs and potential releases to the environment. P4 may choose to conduct additional testing during the RA to determine if the selenium and other COCs are immobile

in the PRB media when abandonment is imminent. Should testing indicate no release of COCs is likely, then the PRBs would be left in place based on discussions with the A/Ts.

Other assumptions to support the cost estimate for this alternative are included in **Appendix A**.

Installation of the PRBs would require RD and a RAWP. The RD/RAWP would include necessary design elements including PRB installation procedures, depths, and materials, design of temporary roads, site restoration plan, HASP, and a stormwater management plan. The PRBs also would require periodic O&M and LTM to evaluate performance. The performance monitoring planning can be a component of the RAWP or included in a separate SAP. The MNA (for the distal portions of the alluvial and Wells Formation aquifers) and ICs portions of this alternative have the same planning, monitoring, and evaluation requirements as described in Groundwater Alternative 2.

Detailed Analysis Summary. A key component of Groundwater Alternative 3 is that it includes PRB treatment upgradient of select residual mine-affected seeps/springs near the margins of the formerly mined areas where COC concentrations are expected to exceed the cleanup levels for a period of time following source controls in the upland soil/waste rock and where exposures to receptors could occur. This in-situ treatment when combined with MNA in remainder of the mine-affected groundwater in the shallow and Wells Formation aquifers scores high to moderately high for protection of human health and the environment because the remedy treats the alluvial groundwater before it discharges to the seeps/springs where exposures are expected to occur. It also ranks highly for compliance with ARARs, is effective over the short- and long-term because of the treatment of discharging shallow groundwater at its source and is easy to implement because PRBs, in this case, are relatively easy to construct. Alternative 3 satisfies USEPA's preference for treatment as a principal element of the remedy and it has moderate costs. The complete detailed analyses for all of the groundwater alternatives including the FS-level cost information are presented in **Table 3-4**.

3.5.4 Groundwater Alternative 5b – Groundwater Recovery and Treatment of both Alluvial and Wells Formation Groundwater, and ICs, in conjunction with consolidation, grading, and capping of upland soil/waste rock

This alternative includes extraction and ex-situ treatment of all mine-affected groundwater including the alluvial and Wells Formation groundwater as shown on **Figure 3-11**. Additional details regarding ex-situ treatment processes are included in Appendix B of *Ballard FS Memo #1*. This alternative also requires ICs to restrict groundwater use until the cleanup levels are achieved.

The general assumptions used for cost estimating include:

- Extraction trenches would be used to extract mine-affected alluvial groundwater and extraction wells would be used in the Wells Formation. A limited number of extraction wells may be considered in areas of deep alluvium.
- The extracted water would be treated using physical (including membrane technology), chemical, or biological treatment system (either alone or in combination).
- Extracted and treated water from the Wells Formation would be infiltrated back into the Wells Formation. Extracted and treated water from the alluvial aquifer would be discharged to an infiltration basin.

Additional assumptions are detailed in the cost estimating tables contained in **Appendix A**. Membrane technology was selected over other viable treatment processes in the cost estimate because it likely is best suited for removal of all COCs in the Site groundwater. Other treatment processes (e.g., chemical precipitation) likely would require additional treatment steps to address the Site-specific oxidation state of selenium. The result is that the higher capital costs associated with membrane technology likely would be offset by additional costs that would be associated with addressing the shortcomings of the other viable treatment processes.

This alternative would require significant predesign, design and construction planning efforts including:

- Predesign testing of membranes and other possible pilot testing (pre or post treatment processes)
- Extraction well and extraction trench designs
- Treatment system designs
- Injection well and infiltration basin designs
- RD/RAWP
- LTM SAP
- Preparation of a Performance Standard Verification Plan

The ICs portion of this alternative has the same planning, monitoring, and evaluation requirements as described in Groundwater Alternative 2.

Detailed Analysis Summary. Groundwater Alternative 5b scores moderately high to high for several of the NCP evaluation criteria including protection of human health and the environment, compliance with ARARs, reduction in toxicity, mobility, or volume through treatment and long-term effectiveness because it would remove contaminant mass from the mine-affected aquifers and satisfies USEPA's preference for treatment as a principal element of the remedy. However, this alternative scores low for implementability and costs because of the complex design, construction and long-term O&M requirements associated with a groundwater extraction and treatment system. Furthermore, effective groundwater extraction in the Wells Formation is expected to be problematic, and the timeframe to achieve complete achievement of the cleanup goals likely does not justify the implementability issues and costs (i.e., significant reduction in mass using pump and treatment under this alternative in the short term but achievement of RAOs could take decades or more). The complete detailed analyses for all of the groundwater alternatives including the FS-level cost information are presented in **Table 3-4**.

3.6 COMPARATIVE ANALYSES - SUMMARY OF KEY TRADEOFFS

This section presents the key tradeoffs between the media-specific alternatives, and the rationale for recommending which medium-specific alternative is best suited for inclusion in the overall remedy for the Site. A summary of the recommended overall remedy is presented in Section 4.0. Because the retained media-specific alternatives meet the required CERCLA threshold criteria (with the exception of the No Action alternatives), the discussions below focus on the key differentiators and rationale for recommending one medium-specific alternative over another.

3.6.1 Upland Soil/Waste Rock

The retained upland soil/waste rock Alternatives 4, 6, and 7 are similar in that they all, in varying degrees include: excavation, consolidation and/or grading, followed by construction of a cover system to meet the RAOs. The primary differences are that Alternative 6 includes recovery of phosphate ore during the RA, whereas Alternatives 4 and 7 do not. Alternative 7 consolidates all of the upland soil/waste rock at the Site into the mine pits, whereas Alternatives 4 and 6 include a combination of consolidating some of the upland soil/waste rock in the existing mine pits and grading/covering some of the upland soil/waste rock in areas outside of the mine pits.

When comparing the alternatives using the seven primary CERCLA evaluation criteria, the following conclusions are reached (also refer to **Table 3-1**).

- *Overall Protection of Human Health and the Environment.* Alternatives 4, 6, and 7 are all highly protective of human health and the environment as they prevent future human/wildlife contact with upland soil/waste rock/exposed ore beds by isolating these materials under an ET cover system and thereby preventing direct exposure and minimizing them as a source of COCs/COECs to downstream sediment/riparian soil, surface water, and groundwater. Although Alternative 7 results in all of the upland soil/waste rock being consolidated in the mine pits, the footprint of the cover system would be larger than Alternative 4 and similar to Alternative 6 because the areas underlying the upland soil/waste rock dumps are assumed to be impacted by migration of constituents from the waste rock dumps to the underlying soil and would have to be graded and covered after the waste rock is removed. The No Action alternative is not protective because it does not include any actions that would prevent human/wildlife contact with the waste rock, nor would it prevent the waste rock from contributing COCs/COECs to sediment/riparian soil, surface water and groundwater.

- *Compliance with ARARs.* Alternatives 4, 6, and 7 comply with applicable ARARs and are effective in the long term so rank highly. The No Action alternative fails to comply with many of the ARARs.

- *Long-term Effectiveness and Permanence.* Alternatives 4, 6, and 7 have similar high long-term effectiveness and permanence rankings because of the use of ET covers with native, earthen materials, which have long-term viability and durability. If maintained, the covered surfaces should be very protective over the long-term. The No Action alternative does not address these evaluation criteria because it does not meet the response objectives or include controls. Please refer to the evaluation and selection of the appropriate cover system for all Site upland soil remedies in **Appendix B**.

- *Reduction in Toxicity, Mobility, and Volume through Treatment.* Alternatives 4, 6, and 7 reduce the contaminant mobility in a similar way by isolating the waste rock and exposed ore beds to prevent direct contact and reduce migration of contaminants from the source area. However, none of the alternatives reduce the toxicity and volume of contamination through treatment because there is no treatment (low to moderate ranking). The No Action

alternative would not treat the waste rock or otherwise reduce the volume or mobility of the COCs/COECs.

- *Short-term Effectiveness.* Short-term effectiveness is similar for Alternatives 4, 6, and 7, although Alternative 6 is slightly longer in duration and additional care would be necessary when transporting ore to Soda Springs for processing. However, over the short term, the environmental benefits of Alternative 6 are many including: 1) use of a resource before it becomes inaccessible; 2) ore recovery would produce, as a byproduct, a portion of the borrow material and additional waste rock that will be necessary to construct the cover system and backfill the Site. This would allow for a more comprehensive reclamation and would reduce greenhouse gas emissions because these materials are produced on-Site. Alternatives 4 and 7 would need to obtain clean borrow from other locations. Alternative 6 also delays ore recovery in other areas mined by P4 (please review **Table 3-1a** for a complete list of environmental benefits). The No Action alternative does not include any remedial activities that would have a short-term impact on the public or Site workers. However, the No Action alternative would not address the unacceptable risks over the short- or long-term.

- *Implementability.* Alternative 4 (ranking high) is easier to implement than Alternative 6 because the ore recovery component of Alternative 6 requires additional coordination with the BLM and other prominent A/T stakeholders. Alternative 4 also is easier to implement than Alternative 7 because the majority of the upland soil/waste rock would be graded and covered in place under Alternative 4, whereas all of the upland soil/waste rock would be excavated and consolidated in the mine pits under Alternative 7. Alternatives 6 and 7 likely would be similar to implement because of their large scale and are ranked moderately to highly implementable. The No Action alternative by its nature has high implementability, but is not protective of human health and the environment.

- *Cost.* Alternative 7 is by far the most expensive alternative with an estimated costs of $113.1M. Alternative 4 estimated cost is $50.7M, whereas the remediation portion of Alternative 6 under CERCLA is $37.0M. Alternative 6 is more cost effective than Alternative 4 because a certain portion of the work attributed to ore recovery in Alternative 6 also would contribute to the completion of the RA for the Site. Therefore, there is remedial cost benefit associated with integrating ore recovery in the RA. The No Action alternative has administrative costs and an estimated total cost of $108.0K.

On balance, Alternative 6 is superior to Alternatives 4 and 7 because it is similar to Alternatives 4 and 7 for many of the NCP criteria discussed above, but also provides the following distinct advantages which are ancillary to the main NCP criteria:

- **Fill/Borrow Materials**. Much of the ore underlies or is adjacent to sources of suitable borrow material that is needed to backfill and grade the Site as well clean materials that can be used as earthen covers on the graded surfaces. If Alternatives 4 or 7 were selected, these materials largely would remain unused because they are in the footprint of and underlie the final capped surface. If Alternative 6 is selected, these on-Site materials would have to be handled during ore recovery and could be used to simplify, as well as enhance, the reclamation efforts and limit the amount of imported off-Site borrow material.
- **Green and Sustainable Benefits**. There would be several green and sustainable benefits to Alternative 6, including:
    - ✓ Ore recovery would allow for use of a resource of the United States that otherwise would be lost if not removed during the RA.
    - ✓ Ore recovery at the Ballard Site would delay recovery of similar volumes of ore at other P4 mines in the immediate area.
    - ✓ Ore recovery would result in less greenhouse gas emissions per ton of ore than if the ore were to be obtained from other more distant P4 properties (both present and future) due to its proximity to the P4 processing facility.
- **Aesthetics**. If the ore is recovered from the Site under Alternative 6, it would result in a reclaimed surface that would be a more natural, thorough reclamation that blends into the surrounding native landscape/landforms as compared to Alternatives 4 and 7.

As a result of these advantages, Upland Soil/Waste Rock Alternative 6 is recommended for inclusion in the overall remedy (see Section 4.0).

3.6.2 Surface Water

As discussed in Section 3.2, source controls in the upland soil/waste rock are expected to: 1) prevent stormwater and snowmelt runoff from contacting COCs/COECs (in waste rock) as a result of the covered surfaces resulting in stormwater that meets the surface water cleanup levels for Site COCs/COECs, and 2) cause the mine-affected seeps/springs near the margins of the former mined area to eventually go dry or otherwise meet the surface water cleanup levels over time through substantial reduction of precipitation infiltrating into upland soil/waste rock.

When comparing the alternatives using the seven primary CERCLA evaluation criteria, the following conclusions are reached (refer to **Table 3-2**).

- *Overall Protection of Human Health and the Environment.* Both Alternatives 2 and 3 are protective of human health and the environment as surface water running off the various cover systems would not be in contact with COCs/COECs once they are constructed. However, Alternative 3 is the most protective because it actively treats the only other source of mine-affected surface water (i.e., the seeps/springs) at the point of discharge and reduces potential exposures to this water. Alternative 2 has no provisions for treatment of mine-affected seeps/springs in the short term and only over time reduces human and ecological exposures so ranks lower (moderate to high ranking) than Alternative 3 (high ranking). The No Action alternative is not protective of human health and the environment because even if coupled with source controls, no ICs or LUCs would be implemented to prevent or reduce exposures at the mine-affected seeps in the interim before they go dry or meet the cleanup levels.

- *Compliance with ARARs.* Both Alternatives 2 and 3 comply with applicable chemical-, location-, and action-specific ARARs immediately for the surface water shed from the capped surfaces. However, Alternative 3 shortens the timeframe for the mine-affected seeps/springs to meet chemical-specific ARARs. However the constructed wetlands component of Alternative 3 has to substantively comply with location- and action-specific ARARs, which would not apply to Alternative 2. As a result, both rank similarly with respect to this criterion (moderate to high). The No Action alternative does not comply with chemical-specific ARARs.

- *Long-term Effectiveness and Permanence.* The long-term effectiveness and permanence of Alternatives 2 and 3 are similar (high ranking) in that they both rely on source controls in the upland soil/waste rock to prevent or reduce the source of COCs/COECs to both stormwater runoff from the capped areas and the mine-affected seeps/springs discharging from the margins of the waste rock dumps. Alternative 3 is effective as soon as the wetlands are constructed and continues to be effective over the long term. Alternative 2 is effective in the long term, but relies on the cover systems to reduce the COCs/COECs in the seeps/springs over time and IC/LUCs to prevent or reduce exposures. Alternative 2, over the long term, is effective similar to Alternative 3 and both rank high. No Action provides

the least long-term effectiveness/permanence because it does not include controls to prevent or reduce exposures to the residual risks. All surface water alternatives would be subject to CERCLA 5-year reviews.

- *Reduction in Toxicity, Mobility, and Volume through Treatment.* Alternative 3 ranks moderate to high for reducing the toxicity, mobility, and volume of COCs/COECs by treating the surface water from the mine-affected seep/springs as it passes through the constructed wetlands and disposing of the COC/COEC precipitate contained in the wetlands in an on-Site landfill when they are decommissioned. Alternatives 1 and 2 rank low because they do not actively reduce the toxicity, mobility, and volume of COCs/COECs in the mine-affected seep flows; any reductions would be attributable to the effective implementation of the upland soil/waste rock remedy.

- *Short-term Effectiveness.* For short-term effectiveness, Alternative 2 does not require construction or O&M activities that could pose risks to the community or workers; however, it is not as effective in the short term as Alternative 3 because it does not treat the mine-affected seeps and includes only IC/LUCs to prevent or reduce exposure so ranks moderately. Alternative 3 includes construction of the wetlands, but that construction poses little risks to the community and workers and it is effective in the short term so ranks highly. In addition, Alternative 3 reduces the time until RAOs are achieved because it actively treats residual mine-affected seep flows. The No Action alternative provides the least short-term effectiveness because it provides no controls to prevent or reduce exposures to the community or any measures to address environmental impacts.

- *Implementability.* Alternative 2 is easier to implement than Alternative 3 because there is no construction. As a result, it ranks higher with regard to implementability than Alternative 3 (ranks moderate to high), which involves construction and substantive compliance with action- and location-specific ARARs (e.g., construction in a wetlands area).

- *Cost.* Alternatives 2 and 3 have similar costs for implementation of ICs and LUCs; however, Alternative 3 requires construction of wetlands and is more costly than Alternative 2 so ranks lower than Alternative 2 with respect to the cost criterion.

Alternative 2 and 3 both prevent stormwater and snowmelt runoff from contacting COCs/COECs (in waste rock) as a result of the covered upland/waste rock surfaces resulting in stormwater that

meets the surface water cleanup levels for Site COCs/COECs. The primary advantage that Alternative 3 (in-situ wetlands and ICs/LUCs) has over Alternative 2 (ICs/LUCs only) is that mine-affected surface water that discharges from the seeps/springs would be treated during the years of remedial construction and in the post-construction period before the seeps/springs either go dry or meet the cleanup levels as a result of source controls. In addition to being more protective of human health and the environment, the in-situ wetlands are expected to be relatively easy and inexpensive to design, construct, operate, and monitor; as well as being relatively easy and inexpensive to decommission after the cleanup criteria are achieved (even with disposal of wetland sediment, if that is necessary). As a result, Alternative 3 is recommended for inclusion in the overall remedy (see Section 4.0) because of its overall protectiveness and adherence to the NCP criteria.

3.6.3 Sediment/Riparian Soil

When comparing the alternatives for sediment/riparian soil using the seven primary CERCLA evaluation criteria, the following conclusions are reached (refer to **Table 3-3**):

- *Overall Protection of Human Health and the Environment.* Both Alternatives 3 and 4 rely on ICs and LUCs to limit human and ecological (including livestock) contact with the mine-affected media in the interim before unacceptable risks are reduced by natural recovery processes and rank moderate to high for this criterion. Alternative 4 might be considered more protective than Alternative 3 in the short-term because the sediment/riparian soil with the highest COC/COEC concentrations in the drainages associated with the mined area would be removed and consolidated along with the upland soil/waste rock. However, Alternative 4 would have significant negative short-term impacts on the riparian corridors where approximately 3 ½ miles of sediment/riparian soil (and associated habitat) would be removed/destroyed. These negative short-term impacts to ecological/wildlife habitat likely outweigh the benefits associated with the sediment/riparian soil-removal component of Alternative 4 especially when considering that the sediment traps installed under Alternative 3 would limit the movement of the most contaminated sediment/riparian soil in the headwater locations. Alternative 3 does not have negative construction-related impacts to ecological/wildlife habitat, and ultimately would be as protective as Alternative 4 after natural recovery processes reduce COC/COEC concentrations to acceptable levels. As a result, Alternative 3 is considered slightly more protective of human health and the environment considering short- and long-term tradeoffs.

Under the No Action alternative, natural recovery would occur to some extent, but it would take substantially longer because it assumes no upland soil/waste rock areas source controls (i.e., cover systems). The No Action alternative also is the least protective because it does not include ICs or LUCs to limit human/livestock contact with the mine-affected media while natural recovery is occurring.

- *Compliance with ARARs.* Alternative 3 complies with chemical-specific ARARs in the long term and does not trigger any location- or action-specific ARARs due to the passive nature of MNR and ranks moderate to high. Installation of sediment traps/basins likely would be accomplished at least initially as a BMP under a construction stormwater pollution prevention plan. Alternative 4 also complies with chemical-specific ARARs in the upper drainages following the RA and the lower portions of these same drainages rely on MNR like Alternative 3. In addition, because of the excavation and reclamation activities associated with the upper drainages, Alternative 4 would require substantive compliance with location- and action-specific ARARs that likely would be difficult so overall Alternative 4 ranks moderate with respect to compliance with ARARs. The No Action alternative does not comply with chemical-specific ARARs.

- *Long-term Effectiveness and Permanence.* The long-term effectiveness and permanence (i.e., risks remaining after the RAOs have been met) are addressed in Alternative 4 by removal of the sediment/riparian soil with the highest COC/COEC concentrations in the upper drainages and in Alternative 3 by properly installed sediment traps that would restrict the movement of the sediment with the highest COCs/COECs from downstream movement. Over the long term, these alternatives should be similar (i.e., once the MNR process has reduced the COC/COEC concentrations throughout the length of the affected drainages) and they both are ranked high for this criterion. The ICs and LUCs are equally effective under both Alternatives 3 and 4; however, the footprint where ICs/LUCs would be applied is smaller under Alternative 4 after the sediment/riparian soil with the highest COC/COEC concentrations are removed and the disturbed areas are reclaimed.

  The No Action alternative does not address these evaluation criteria because it does not meet the response objectives or include controls. All sediment/riparian soil alternatives would be subject to CERCLA 5-year reviews.

- *Reduction in Toxicity, Mobility, and Volume through Treatment.* Alternative 3 does not result in treatment of COCs/COECs or reduction in volume of COCs/COECs so it would rank moderate with regard to reducing the toxicity and volume of COCs/COECs. However, Alternative 4 ranks moderate to high with respect to this criterion because it would result in the greatest reduction of mobility of COCs/COECs (and the greatest degree to which the remedy is irreversible) because it removes the sediment/riparian soil with the highest COC/COEC concentrations in the upper drainages adjacent to the mined area and places them under a cover system. The sediment traps installed under Alternative 3 would restrict the movement of the headwater sediment/riparian soil with the highest COC/COECs from downstream movement and so to some extent reduces mobility. Alternatives 3 and 4 both rely on natural recovery of sediment/riparian soil, although Alternative 4 would have the shortest reaches of drainages that rely on natural recovery as the remedy.

- *Short-term Effectiveness.* Alternative 3 provides the greatest protection of the community and workers during the RA and causes minimal disturbance of the riparian corridor because it includes only minor invasive construction activities and ranks moderate. Alternatives 3 and 4 present some environmental risk in that natural recovery processes may not occur under either of these alternatives (e.g., COCs/COECs would disperse but potentially at concentrations that continue to present unacceptable risks). Alternative 4 likely has the shortest time until RAOs are achieved because the sediment/riparian soil with the highest COC/COEC concentrations in the upper drainages adjacent to the mined areas would be removed and capped with the upland soil/waste rock. However, that benefit is offset by the damage that the sediment/riparian soil-removal component of Alternative 4 would have on the riparian corridors and associated ecological/wildlife habitat so Alternative 4 ranks low to moderate in relationship to the short-term effectiveness criterion considering the tradeoffs of invasive construction. The No Action alternative does not meet these criteria because it does not meet the RAOs.

- *Implementability.* Alternative 3 would be the simplest to implement as it only involves installing sediment traps/basins in the upper drainages and implementing ICs/LUCs and monitoring the natural recovery processes and is highly implementable. Alternative 4 is difficult to implement because in addition to implementing ICs/LUCs and monitoring the MNR processes, it would require construction activities to remove the sediment/riparian soil

in the drainages adjacent to the mined areas, transportation of the removed materials to the mined area, confirmation sampling, site restoration, and O&M of the disturbed areas until the riparian corridors, vegetation, and associated ecological/wildlife habitat is restored. The implementability of Alternative 4 is complicated by additional uncertainty related to the limits of the removal activities, and the potential difficulties presented by targeting excavation areas in the indistinct stream channels in the upper drainages near the mined area. The implementability of both Alternatives 3 and 4 also is complicated by the fact that additional background data (inclusive of all geologic formations including the Phosphoria Formation) may be necessary for sediment/riparian soil to refine the preliminary cleanup levels because as presented in *Ballard FS Memo #1* the cleanup levels are very low and might be unattainable. This uncertainty would need to be addressed during the RD for Alternative 4 (prior to excavation activities). The uncertainties associated with MNR over the long term are equal between Alternatives 3 and 4. Based on this evaluation, Alternative 3 is easier to implement and ranks higher than Alternative 4 (moderate to high). The No Action alternative is easy to implement, but does not meet the criteria because it does not assist in achieving the RAO for protection of human health and the environment.

- *Cost.* As one would expect, the no action alternative is the least expensive, but does not meet the RAO for protection of human health and the environment and fails all the criteria except this one. Alternative 3 (MNR) is approximately one half of the cost of Alternative 4 which includes excavation, consolidation and capping of the most contaminated sediment/riparian soil in the upper drainages in addition to MNR. As a result, Alternative 3 ranks more highly than Alternative 4 with respect to the cost criterion.

As mentioned above, there are considerable uncertainties related to background concentrations as calculated for COCs/COECs in sediment/riparian soil which directly affects the cleanup levels for these constituents and extent of possible downstream contamination from the source areas considered in these alternatives. A recent background investigation reported in *On-Site and Background Areas Radiological and Soil Investigation Summary Report* (MWH, 2015) shows that many Ballard Site COCs/COECs are naturally elevated in upland soil that are comprised of soil derived from the Meade Peak Member of the Phosphoria Formation indicating that the sediment/riparian soil also would likely have naturally elevated constituents. As currently established, COC/COEC background concentrations for the sediment/riparian soil for the P4 sites were not collected from

locations downslope of (and carry sediment from) the Meade Peak Member of the Phosphoria Formation, and therefore likely are not representative of actual background conditions in these former mine areas.

The selection of Alternative 4 is not justified because of the damage to natural habitat caused by invasive removal of sediment/riparian soil, the background constituent concentration uncertainties and the necessity to refine the cleanup levels which determine the extent of excavation, and the substantially higher costs. As a result, Sediment/Riparian Soil Alternative 3 (Sediment Traps/Basins, MNR, ICs, and LUCs) is recommended for inclusion in the overall remedy (see Section 4.0) because it is protective of human health and the environment without damaging ecological/wildlife habitat and does not have the uncertainties associated with Alternative 4.

3.6.4 Groundwater

When comparing the Groundwater Alternatives 1, 2, 3, and 5b using the seven primary CERCLA evaluation criteria, the following conclusions are reached:

- *Overall Protection of Human Health and the Environment.* Alternatives 3 and 5b are the most protective because they treat mine-affected groundwater before it discharges to the seeps/springs where exposures can occur. However, Alternative 3 does not treat Wells Formation groundwater or the eastern and western alluvial plumes on the flanks of the Site so ranks slightly lower (moderate to high) than Alternative 5b, which treats all mine affected groundwater and ranks high. Because Alternative 2 does not actively treat groundwater it is ranked as moderate because it relies on source controls and MNA to remediate alluvial and Wells Formation groundwater over the long term. The No Action alternative is not protective of human health and the environment because no ICs would be implemented to prevent or reduce exposure to mine-affected groundwater.

- *Compliance with ARARs.* Alternative 2 complies with chemical-specific ARARs in the long term and does not trigger any location- or action-specific ARARs because it does not involve construction. Alternative 3 includes installation of PRBs, but in the mine disturbed area, so in addition to compliance with chemical ARARs, it should easily substantively comply with action- and location-specific ARARs. Alternative 5b also complies with chemical-specific ARARs, but substantive compliance with location- and action-specific ARARs would be required and are difficult as it relates to disposal of treatment wastes (e.g., sludges) and treated groundwater. As a result, Alternative 2 and 5b are similar as to compliance to these

ARAR types with a moderate to high ranking, while Alternatives 3 ranks highest. The No Action alternative does not comply with chemical-specific ARARs so ranks lowest.

- *Long-term Effectiveness and Permanence.* The long-term effectiveness and permanence (i.e., risk remaining after the RAOs have been met) is similarly addressed by Alternatives 3 and 5b ranking moderate to high and slightly lower for Alternative 2 ranking moderate. Although Alternative 5b has the greatest potential to reduce the mass of COCs/COECs in groundwater in a relatively short timeframe, over the long term, it may offer no advantage because of aquifer heterogeneity in both the alluvial and Wells Formation aquifers. Alternative 5b groundwater withdrawal and reinjection also does not completely prevent contaminant rebound in the groundwater following initial cleanup. In addition, the extraction, treatment and reinjection processes and equipment is much more difficult to operate and maintain over the long term, and ultimately may be no more effective or faster than Alternative 3 in achievement of the groundwater cleanup levels in both the alluvial and Wells Formation aquifers. With source control in place over the long term, Alternative 2 (MNA) should be effective and permanent (rank high) for meeting cleanup levels within these aquifers, but likely in the short term, the speed with which RAOs are achieved is accelerated by using the treatment technologies in Alternatives 3 or 5b. The No Action alternative provides no long-term effectiveness/permanence.

- *Reduction in Toxicity, Mobility, and Volume through Treatment.* With respect to reduction in toxicity, mobility, or volume, Groundwater Alternative 5b best addresses this criterion because it includes extraction and treatment of mine-affected groundwater in both the alluvial and Wells Formation aquifers (ranks high). Whereas, Alternative 3 only treats portions of the alluvial groundwater so ranks moderate to high. Alternative 2 does not treat any portion of the Site groundwater actively, but MNA processes passively reduce COCs in groundwater through physical, biological, and chemical mechanisms so ranks moderately. Alternative 5b further reduces the mobility of COCs/COECs in groundwater because the extraction wells and trenches would provide some hydraulic capture to reduce downgradient migration of COCs/COECs. Alternative 3 would reduce the mobility of COCs/COECs upgradient of contaminated seeps/springs where transfer of COCs/COECs to surface waters occurs. An advantage to Alternative 3 over Alternative 5b is that PRBs do not generate residuals (unless they are fouled and require disposal which may or may not be

necessary), whereas the ex-situ treatment under Alternative 5b would generate material (e.g., brine or solid waste) that would require handling and disposal. The No Action alternative does not address this criterion.

- *Short-term Effectiveness.* Groundwater Alternative 2 would be effective in the short term (i.e., during the construction and implementation phase until the RAOs are met) in terms of protection of the public and construction workers because it does not require construction or O&M activities. However, Alternative 2 would not be as effective in the short term as Alternatives 3 and 5b that involve treatment because it is slower in achieving RAOs (i.e., reduction of the groundwater COC levels in the alluvial and Wells Formation aquifers to cleanup levels) so ranks low to moderate. The construction and O&M of the PRBs included in Alternative 3 presents little risk to the community and workers and treats shallow alluvial groundwater before it discharges to seeps/springs where exposures can occur, and this alternative ranks the highest for short-term effectiveness. Alternative 5b ranks moderate to high falling between Alternatives 2 and 3 as it is the least protective of the community and workers because the required construction, infrastructure, and O&M is relatively complicated. In addition, the residuals from the treatment process would require handling and disposal. Alternative 5b also has the largest environmental footprint (disturbance), followed by Alternative 3, with Alternative 2 having the smallest environmental footprint. Although Alternative 5b would reduce the mass of COCs the fastest, the time to complete achievement of the cleanup levels in groundwater is likely to be similar among Alternatives 2, 3, and 5b because of the many factors discussed in criteria 3, 4, and this criterion (5) herein. The No Action alternative does not meet these criteria, because it does not meet the response objectives.

- *Implementability.* Alternative 2 is the most implementable because MNA does not require any construction or O&M (ranking high). Alternative 3 is the next most implementable ranking moderate to high because construction and O&M of PRBs is much less difficult than construction, substantive compliance with regulations related to groundwater extraction, treatment, and disposal facilities and O&M requirements associated with Alternative 5b (which ranks low). In addition, the PRBs associated with Alternative 3 would effectively treat the mine-affected groundwater in-situ without a large environmental footprint (disturbance area), while ex-situ treatment under Alternative 5b would require extensive

infrastructure and O&M. The No Action alternative does not meet this criteria because it does not meet the remedial objectives.

- *Cost.* Alternative 2 uses MNA and ICs as a long-term remediation strategy and is the most inexpensive of the remedial alternatives for groundwater. Alternative 3 includes active treatment (PRBs) of the most contaminated shallow groundwater at the waste rock margins before it discharges to the surface at seeps/springs. It is more costly, but in the range of Alternative 2. Alternative 5b is the most expensive of the viable alternatives for the Site groundwater and is more than ten times the cost of Alternative 3. The No Action alternative is the cheapest by far, but it does not satisfy many of the detailed analysis criterion listed above (e.g., it is not protective) and therefore fails the criterion.

Key factors in evaluating the advantages and disadvantages of the groundwater remedial alternatives are:

1) There are no current or anticipated future users (with ICs) of the mine-affected groundwater. The only complete exposure pathway identified in the risk assessment is where mine-affected groundwater discharges and becomes surface water (i.e., at the seeps/springs located near the margins of the waste rock dumps).
2) Remedial actions in the upland soil/waste rock would prevent or reduce ongoing sources of COCs to groundwater.

A disadvantage to Alternative 2 (MNA, ICs, and LUCs) is that it does not actively treat mine-affected groundwater before it discharges to surface water. So the exposure pathways to human and ecological receptors identified in the risk assessment is not broken in the short term at the seeps/springs although LUCs and ICs will help to limit exposure.

Although Alternative 5b would remove the most contaminant mass over the shortest timeframe, and would treat mine-affected groundwater where it discharges to surface water, those advantages must be balanced against the significant monetary and environmental costs associated with design, construction, O&M, and eventual decommissioning of the entire treatment system; the associated ongoing handling and disposal of treatment residuals; and the handling and disposal of the treated water (including substantive compliance with ARARs).

Alternatively, Groundwater Alternative 3 (limited PRB treatment coupled with MNA, ICs, and LUCs) provides the following advantages:

- Groundwater would be treated at the seep/spring locations where there is the greatest potential for exposures to human and ecological receptors.
- Relatively low design, construction, O&M, and decommissioning costs (including treatment media disposal).
- No treatment residuals (with the possible exception of fouled or spent permeable reactive materials removed at the end of treatment along with a small amount of downgradient soil).
- The PRB treatment process would be more adaptable to changing conditions in water quantities and concentrations over time (both reduced over time) as the alluvial and Wells Formation aquifers are remediated.
- Water treatment is in-situ (no requirements for handling and disposal of treated water).

As a result, Groundwater Alternative 3 is recommended for inclusion in the overall remedy (see Section 4.0) because it provides the best balance of protectiveness of human health and the environment and costs.

4 RECOMMENDED COMBINED REMEDY

This section assembles the recommended media-specific alternatives identified in Section 3.6 into a combined or overall remedy that addresses all mine-affected media at the Site. It is important to note that the actual remedy for the Site would be selected by USEPA based on an evaluation of the information presented in this FS and input from the A/Ts and the community.

The recommended combined remedy includes the following medium-specific alternatives:

- Upland Soil/Waste Rock Alternative 6 – Upland Soil/Waste Rock Grading and Consolidation, Incidental Ore Recovery, ET Cover System, ICs, LUCs, and O&M/LTM
- Surface Water Alternative 3 – In-Situ (Wetlands) Treatment of Source Area Seepage, ICs, and LUCs, in conjunction with source controls in the upland soil/waste rock
- Sediment/Riparian Soil Alternative 3 – Sediment Traps/Basins, MNR, ICs, and LUCs, in conjunction with source controls in the upland soil/waste rock
- Groundwater Alternative 3 – Limited Permeable Reactive Barrier (PRB) Treatment of Alluvial Groundwater, MNA, and ICs, in conjunction with source controls in the upland soil/waste rock
- **Ballard Shop.** Interim ICs/LUCs are recommended at the Ballard Shop to limit potential exposures pending review of the *Ballard Mine Shop Area Closure Memorandum – Draft Revision 0* (*Ballard Mine Shop Closure Memo*; MWH, 2017) and potential active remedial action. Specific recommendations regarding interim ICs/LUCs at the Ballard Shop are presented in Section 4.2.

4.1 ELEMENTS OF THE RECOMMENDED COMBINED REMEDY

A summary of the recommended combined remedy, how the media-specific elements work together, and the approximate sequence of implementation are presented herein. **Figure 4-1** illustrates conceptual cross-sections of the combined remedy components (or elements). The first frame depicts the current Site condition and shows the initial implementation of sediment controls to prevent COC/COEC-affected sediment transport from the Site. Frame 2 illustrates the upgradient groundwater and surface water remedies implemented during the RA – PRB and engineered wetlands– and depicts details of the remediation processes. Frame 3 illustrates the on-

going monitoring and maintenance following completion of the remedy with the ET cover emplaced over the waste rock. With large reductions in COC/COEC loading from the upland soil/waste rock, surface water that meets PCLs would flow from the cover systems. Seeps/springs, as well as alluvial groundwater near the cover margin and Wells Formation groundwater, should meet (or be close to meeting) PCLs after construction of the cover system and after the existing contaminated interstitial groundwater drains out of the system. It is thought that the PRBs and wetlands would eventually be decommissioned (based on Site monitoring and comparison to PCLs). Over the longer term, with the sources of contamination removed and the constant influx of clean water off the cover system, MNA in the alluvial and Wells Formation aquifers should be effective in addressing the remaining areas of groundwater contamination, and MNR would reduce sediment/riparian soil concentrations in the downstream drainages. Further details of the remedy for each media are provided below.

4.1.1 Upland Soil/Waste Rock

The remedy for upland soil/waste rock is the key component in the discussions of Site restoration because it addresses the source of COCs/COECs detected in all Site media. The recommended combined remedy includes sequential grading, consolidating, and covering the mine-affected upland soil/waste rock to minimize environmental exposures, which would be implemented in conjunction with a phased recovery of incidental phosphate ore. Remedial activities would include moving portions of the existing waste rock dumps, in addition to the waste rock created while recovering ore, to backfill the existing and new open pits to create favorable Site grades and control stormwater runoff and erosion. The resulting graded surfaces would be contoured with the surrounding natural surfaces and would be capped with an ET cover system that is designed to shed or otherwise store and evapotranspire water before it infiltrates into and through the underlying waste rock. The cover system also would prevent human/wildlife contact with the underlying waste rock.

The ET cover system would be vegetated with native plant species that are selected to control erosion and to transpire moisture out of the cover materials, while not tapping into the underlying waste rock. The vegetated ET cover would shed unimpacted stormwater off-Site (in effect eliminating this source of mine-affected surface water), and would reduce precipitation from infiltrating through the underlying waste rock (reducing transport of mine-related constituents to the underlying groundwater and seeps/springs at the edges of the existing waste rock). The regrading

and ET cover also may facilitate increased selenium attenuation within the underlying waste rock as a result of decreased oxygen levels (Hay, et. al., 2016).

The recommended combined remedy for upland soil/waste rock would include ICs/LUCs to restrict traffic (and access to the waste rock under the ET cover) and the gathering of LTM data in underlying groundwater. These LTM data would be used to evaluate the performance of upland soil/waste rock remedial actions and to determine when RAOs are achieved. Cap integrity would be insured through LTM and maintenance. This would require the preparation of a RAWP during the RD which would include an OMMP for all the systems in the final remedy requiring O&M.

The construction of the upland soil/waste rock remedy would begin early during the remedy implementation and likely would take six to eight years to complete. The other remedy elements discussed below would address the other contaminated media in the short-term, until the positive effects of the upland soil/waste rock remediation (i.e., source containment) on these media are realized.

4.1.2 Surface Water

Mine-affected surface water at the Site includes: 1) intermittent stormwater/snowmelt flow in the drainages down gradient of the mined area, and 2) intermittent and perennial seeps/springs that discharge to the ground surface located at or near the toes of the existing waste rock dumps. The recommended combined remedy described above for the upland soil/waste rock would eliminate any mine-affected stormwater flow because runoff from the newly installed cover systems would not contact waste rock before discharging off-Site, and therefore would be shed unimpacted (i.e., below surface water cleanup levels) immediately after completion of the cover systems. In the interim, sediment control ponds/traps constructed as a BMP during ore recovery/capping under the selected sediment/riparian soil alternative would control any sediment discharge from the selected cover surface. This unimpacted surface water from the cover system would be channeled around any seeps/springs that are undergoing treatment in engineered wetlands.

The grading, consolidation, and capping of the upland soil/waste rock should substantially reduce precipitation and snowmelt from infiltrating through the waste rock. These activities likely would result in the "drying up" of most of the existing seeps/springs as any residual water in the waste rock and underlying alluvial groundwater drains through the hydrologic system. It is most likely that the interflow-dominated seeps/springs would completely dry up after capping. Likewise, in some

areas, the waste rock that is the source of the existing seeps/springs would be removed and used to backfill the open pits, resulting in immediate flux reduction from contaminated seeps/springs.

In the case of perennial springs with a deeper bedrock source (e.g., the Dinwoody or Wells Formation aquifers), the reduction in COC groundwater flux from the capped waste rock would result in improved water quality. In addition, because the recharge area for the groundwater feeding the perennial springs is largely within the Site, the capping may also reduce or eliminate the perennial spring flow (much like the interflow dominated springs).

In the interim (i.e., during the waste rock consolidation and cover system construction activities), surface water at perennial mine-affected seeps/springs would be treated by engineered wetlands constructed either atop or just downgradient of the seep locations and PRBs. Wetlands provide both aerobic and anaerobic processes that if designed properly can treat the Site COCs/COECs throughout the year. The relevant processes in the aerobic wetlands include: oxygenation and subsequent precipitation of iron and manganese hydroxides that would sorb and coprecipitate COCs/COECs including arsenic and selenium; plant uptake of COCs/COECs with sequestration in the plant matter; and methylation and volatilization of selenium in particular (Stillings and Amacher, 2004; Lamothe and Herring, 2004; and Mackowiak, et. al., 2004). If used, the anaerobic portion of the wetlands may largely replicate the PRB design, but could include additional media such as iron filings. The treatment effectiveness of the wetlands would be enhanced by the PRBs installed to treat the shallow alluvial groundwater before it discharges at the seep locations (refer to the selected groundwater remedy discussion below). In these cases, wetlands are installed as a polishing step should the PRB not be able to bring COC/COECs in the groundwater down to the surface water cleanup level (e.g., 0.0031 mg/l for total selenium) and can address secondary byproducts such as reducing the need for aeration (alleviate the low dissolved oxygen condition), containing precipitants, and settling suspended solids.

Wetlands would be installed along with PRBs in the early stages of Phase 1 upland soil/waste rock remedial construction (currently planned to begin on the east side of the Site). Based on the performance monitoring data from the Phase 1 PRBs/wetlands, the need for wetlands downgradient of PRBs, in subsequent phases (Phases 2 and 3), would be evaluated. Seeps and springs when treated by a combination of PRBs and wetlands as discussed above should attain cleanup levels within a matter of months, largely dependent upon season of installation and maturation of the treatment media.

Initial wetland delineations would be performed prior to the ROD based on Site-specific aerial photographs, photographs taken during the biannual surface water sampling events throughout the Ballard Site, and data from the National Wetlands Inventory. Additional wetland delineations would be completed during the pre-design phase in the late spring to mid-summer season, as necessary. Information regarding the size of engineered wetlands, use of existing wetlands during the RA, and potential impacts to any identified wetlands would be evaluated during the RD process. Wetlands would be removed once cleanup levels are reliably achieved and disposed of in an on-Site landfill when they are decommissioned.

The recommended combined remedy for surface water would include ICs/LUCs to limit Site access near the mine-affected seeps/springs and the gathering of LTM data. These LTM data would be used to evaluate the performance of the wetlands and to determine when the RAOs have been achieved in the seeps/springs. Typically, there would be annual summaries of these data, and at 5 year intervals, a CERCLA (5-year) review would occur where trends in the combined data are evaluated to determine the efficacy of the selected remedy and any adjustments that might be necessary in the approach. If proposed remedies for surface water do not achieve RAOs at approved compliance points within a reasonable time frame as established by USEPA in consultation with P4, the remedy would be evaluated and if necessary, adapted to include other viable remedial technologies for treating discharge. The LTM data, and possible alternative changes would be evaluated, discussed among stakeholders, and as necessary, implemented as part of the CERCLA 5-year review process. Additional details on the types of LTM are described in Section 4.1.5.

4.1.3 Sediment/Riparian Soil

The recommended combined remedy includes installation of sediment traps/basins in headwater locations and MNR for the sediment/riparian soil in the drainages located downstream of the Site. Sediment traps or basins would address contaminated sediment associated with overland flow from upland soil/waste rock by capturing this sediment and reducing potential sediment loading further downstream in the intermittent drainages during RA (construction). These features would be constructed at the beginning of the remedy implementation and would be maintained/modified as needed throughout the remedial construction of the ET cover. Once the cover system is in place, the sediment basins could be removed (i.e., post establishment of vegetated covers) to allow clean sediments from throughout the headwaters to migrate into the lower portion of these channels.

Disposal of any contaminated sediment retained in the sediment traps/basins prior to their removal should be relatively easy to place under an adjacent upland soil/waste rock soil cover during the RA or in an on-Site landfill post-RA.

Also it is likely that portions of impacted sediment/riparian soil in the upper intermittent drainages would be removed and/or ultimately covered as part of the upland soil/waste rock remedy (i.e., ore recovery, consolidation, and grading). In addition, sediment in some drainage sections would be excavated and removed as a result of installation of sediment traps, engineered wetlands, and PRB installations. All these mentioned remedy components likely would either remove or isolate under an ET cover some of the more highly contaminated sediment/riparian soil at the margins of the existing mine dumps. However, what would occur in those locations would only be understood once the design of the remedy is completed.

MNR is a feasible remedial alternative for these media because the recommended remedy for the upland soil/waste rock (i.e., the mining disturbed area) would restrict the source of elevated constituent concentrations in these drainages. Without an ongoing source of mine-related constituents, the sediment/riparian soil in the downstream drainages would disperse and be covered naturally over time by vegetation decay material, windblown dust, and unimpacted sediments entering these headwater drainages from surrounding consolidated, graded, and covered upland surfaces. This would result in constituent concentrations that do not pose unacceptable risks.

The MNR alternative would include ICs/LUCs to limit access and to restrict certain activities (e.g., harvesting culturally significant plants) until it can be demonstrated through LTM that natural recovery has occurred. Much like the other media described above, a LTM plan would be developed during the RD phase of the project (refer to Section 4.1.5 for additional details).

4.1.4 Groundwater

The recommended combined remedy includes a combination of PRBs, MNA, and ICs for the mine-affected groundwater. Where practicable at the margins of the final ET cover system, PRBs would be installed at locations upgradient of mine-affected perennial seeps/springs. PRBs would be constructed early during each phase of the upland soil/waste rock remedy construction (currently P4 is envisioning that Phase 1 would begin on the east side of the Site). The objective of the PRBs is to reduce constituent concentrations in alluvial groundwater before it discharges at the seep/spring location where there is potential for direct contact by humans or wildlife. Additional surface water

treatment would occur at these seep locations as discussed above for the surface water component of the remedy (i.e., engineered wetlands). The advantages to using PRBs to treat alluvial groundwater at these select locations include:

- PRBs would be relatively easy to install and effective due to the shallow depth to groundwater in areas near the perennial seeps/springs. PRB's have been successfully used at P4's South Rasmussen Mine to treat selenium and other COCs (Newfields, 2015, 2016a, 2016c) and can achieve cleanup levels below the PRBs in a matter of months. Also, PRBs at these locations do not need to be extensive (i.e., long or deep) in order to treat the groundwater that ultimately discharges at the downgradient seep location.
- Treating any residual constituent concentrations in the surface water that discharges from the perennial seeps/springs would be easier and potentially more effective if the constituent concentrations are first reduced by the PRB. In these cases, wetlands would be installed as discussed above as a polishing step should the PRB not be able to bring COC/COECs in the groundwater down to surface water cleanup levels (e.g., 0.0031 mg/l for total selenium) and to aid with treatment of any byproducts from PRB treatment.
- PRBs are passive systems that require minimal long-term O&M.

The PRBs would be maintained and evaluated via LTM until: 1) the seeps/springs dry up as a result of the cover systems installed in the upland soil/waste rock areas, or 2) cleanup levels are achieved in the groundwater upgradient of the PRBs. PRBs would be removed and the contents/mine-affected downgradient soils incorporated with the waste rock and placed under the cover systems during the RA or in an on-Site landfill post-RA, once cleanup levels are reliably achieved, to avoid re-mobilization of COCs and potential releases to the environment. P4 may choose to conduct additional testing during the RA to determine if the selenium and other COCs are immobile in the PRB media when abandonment is imminent. Should testing indicate no release of COCs is likely, then the PRBs would be left in place based on discussions with the A/Ts.

MNA is a feasible remedial alternative for remaining areas of the mine-affected groundwater, including the deeper Wells Formation groundwater, because:

- The recommended combined remedy described above for the upland soil/waste rock would substantially reduce the source of elevated COC concentrations in alluvial and Wells Formation groundwater. Emplacement of the ET covers would reduce the influx of

oxygenated COC-impacted water, and any residual infiltration from the waste rock may then be reduced (e.g., Hay, et al., 2016), which can assist in attenuation and stabilization of COCs in the aquifer on the upgradient end of the plumes. In addition, unimpacted surface water running off the newly constructed caps would infiltrate and mix with groundwater of the alluvial aquifer, thereby reducing constituent concentrations. Without an ongoing source of contamination and with the infiltration of unimpacted water from upland areas, the mine-affected alluvial and Wells Formation groundwater would be diluted and would naturally attenuate over time, resulting in constituent concentrations that do not pose unacceptable risks.

- Data from the Wells Formation indicates some attenuation potential ranging from 11 to 64 percent effectiveness (BLM/USFS, 2007; BLM, 2011). Others indicate there may be less attenuation potential for some pathways (Buck and Mayo, 2005). The uncertainty would be addressed for both the Wells Formation and alluvium aquifers during pre-design studies, which would evaluate attenuation and reduction potential (e.g., organic carbon availability). In both cases, lower attenuation capacity and longer clean up time may be offset by long flow paths and groundwater inaccessibility (e.g., Wells Formation depth, faulting/structural isolation, and heterogeneity).
- The majority of the alluvial and Wells Formation groundwater plumes are located on P4 property and where they are not, P4 is pursuing land purchase or land exchanges in order to control the beneficial use of these areas. As a result, there are no current nor would there be any anticipated future users of the mine-affected groundwater and as a result, there is not a significant risk driver for a potentially faster, but more costly treatment alternative.
- ICs/LUCs would be implemented on all the lands controlled by P4 to restrict withdrawal and use of shallow and deeper groundwater until LTM indicates the cleanup levels have been achieved.

Additional data collection and monitoring likely are necessary to evaluate the performance and timeframes involved with MNA of the alluvial and Wells Formation aquifers. P4 is proposing that additional monitoring and evaluations be performed through collection of groundwater and aquifer solids data from existing and new monitoring points. The Ballard Site MNA evaluation would

follow the USEPA tiered analysis approach and recommended analyses per the USEPA guidance document (e.g., groundwater chemistry, subsurface mineralogy, chemical speciation).

If proposed remedies for groundwater do not achieve RAOs at approved compliance point(s) within a reasonable time frame as established by USEPA in consultation with P4, the remedy would be evaluated and if necessary, adapted to include other viable remedial technologies for treating groundwater. The LTM data and possible alternative changes would be evaluated, discussed among stakeholders, and as necessary, implemented as part of the CERCLA 5-year review process.

4.1.5 Long-Term Monitoring

As discussed under each of the media above, LTM would be necessary to confirm that the RAOs are being achieved. The following LTM is anticipated:

- Upland Soils/Waste Rock – Cover systems overlying the waste rock would be inspected and maintained.
- Surface Water -
  - ✓ Monitor seasonal runoff to verify remedy is effective.
  - ✓ Monitor mine-affected seeps/springs to evaluate flow and COC/COEC concentration trends until the seeps/springs permanently go dry or cleanup levels are achieved.
- Sediment/Riparian Soil – Sediment/riparian soil and vegetation would be monitored at prescribed intervals to evaluate progress of the natural recovery processes.
- Groundwater – shallow alluvial and deep Wells Formation groundwater would be monitored throughout the Site to evaluate the progress of natural attenuation throughout the identified areas of elevated COCs.

Under CERCLA's review process, these LTM data would be summarized annually, then evaluated at 5-year intervals to determine if remedy components are achieving the RAOs (i.e., during the CERCLA 5-year reviews). Data trends for individual remedy components would be evaluated (e.g., MNA for groundwater, MNR for sediment/riparian soil, and for surface water monitoring of the wetlands outfall) and if they are not achieving the RAOs in a reasonable time frame, other remedial actions would be considered.

4.1.6 Institutional Controls and Land Use Controls

ICs and LUCs would be emplaced during and following the RA to limit human and to some extent ecological exposures while ongoing natural processes are remediating certain media (e.g., seeps/springs, riparian soil/sediment and groundwater). The following ICs/LUCs would be necessary:

- Removal of groundwater from both shallow and deep aquifers would be restricted to prevent or reduce exposure.
- Riparian corridor access/use would be restricted.
- Remediated upland soil/waste rock areas access/use would be restricted.

The effectiveness of the ICs/LUCs would be evaluated during the CERCLA 5-year reviews.

4.2 BALLARD SHOP

As discussed in *Ballard Mine FS Memo #1*, remedial actions at the Ballard Shop are deferred until the area is no longer actively used. Therefore, it is recommended that ICs be implemented at the Ballard Shop as an interim measure to limit potential exposures pending a focused FS and potential remedial action. The *Ballard Mine Shop Closure Memo* has been submitted for inclusion in the ROD.

The following is a summary of the unacceptable risks at the Ballard Shop as identified in the BRA presented in the A/T-approved *Ballard RI Report*, and the recommended interim ICs to address those risks:

- Detected concentrations of naphthalene and 1,2,4-trimethylbenzene in upland soil sampled at the Ballard Shop could result in unacceptable risk to breathing indoor air following vapor intrusion. The recommended interim ICs to address this risk include building restrictions to prevent indoor air exposure scenarios form occurring.
- Detected concentrations of trichloroethene (TCE) in groundwater sampled at the Ballard Shop could result in unacceptable risks if fruits and vegetables that are irrigated with Ballard Shop groundwater are consumed. The recommended interim ICs to address this risk include groundwater use restrictions to prevent use of the groundwater for irrigation.
- Detected concentrations of tetrachloroethene (PCE) in Ballard Shop monitoring well SB07 exceed its Federal Drinking Water Maximum Contaminant Level (MCL). The

recommended interim ICs to address this risk include groundwater use restrictions to prevent consumption of groundwater.

4.2.1 Proposed Interim Actions

Currently the Ballard Shop Area is not occupied full-time by on-site workers but used for parking and storage of vehicles/equipment and other infrequent activities that place humans in the area. The ICs proposed for this area of the Site are discussed above. P4 has prepared a brief FS-level closure plan (*Ballard Mine Shop Closure Memo)* for the Ballard Shop so that it can be included in the remedy. The Closure Memo includes discussion of 1) the Ballard Shop background, (i.e., including the nature and extent of contamination), 2) technologies suitable for remediation of the Shop COCs and possible alternatives, 3) plans for control of risks to human health and the environment during future industrial use of the area (e.g., during the construction phase of the RA) prior to final closure, and 4) plans for final closure of the Ballard Shop when the Shop is no longer used.

In general, following implementation of the overall Site remedy, there may have to be a supplemental investigation to confirm the extent of soil and groundwater contamination followed by a re-evaluation of cleanup alternatives for the Ballard Shop soil and groundwater. However, these potential actions are described in more detail in *Ballard Mine Shop Closure Memo.*

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TABLES

TABLE 2-1

INITIAL SCREENING OF ASSEMBLED ALTERNATIVES FOR UPLAND SOIL/WASTE ROCK
FEASIBILITY STUDY TECHNICAL MEMORANDUM #2
P4 Production LLC, Ballard Mine

Alternative Number/Name	Alternative Description	Effectiveness	Implementability	Cost	Retain for Detailed Analysis?
Alternative 1 - No Action	The no action alternative would leave the Site in its existing condition. The No Action alternative does not protect human health and the environment or comply with ARARs but is retained as required by the NCP.	*Protective of Human Health and the Environment?* ***Low*** - No remedial actions would be performed at the Site to prevent future exposure pathways so there would be no reduction in risks to human health or the environment. *Reduces Toxicity, Mobility, or Volume?* ***Low*** - No remedial actions would occur that would reduce the toxicity, mobility or volume (TMV) of Site constituents. *Short-Term Effectiveness:* ***Low*** *Long-Term Effectiveness:* ***Low*** *Compliance with ARARs*: ***Low*** - Given that no remedial actions would take place and the Site would remain in its current state, this alternative would not comply with ARARs and TBCs.	*Administrative Feasibility:* ***High*** - No associated administrative requirements other than the CERCLA 5-year reviews[1]. *Technical Feasibility:* ***High*** - No remedial actions to implement.	***$108K***	***Yes*** - The No Action alternative is retained as required by the NCP.
Alternative 2 – Upland Soil/Waste Rock Grading and Stormwater Controls, Institutional Controls (ICs)[2], Land Use Controls (LUCs)[3], and Operation and Maintenance (O&M)/Long Term Monitoring (LTM)	Under Alternative 2 – All upland soil/waste rock dumps outside and inside the pits would be graded to prevent ponding of stormwater and snowmelt on their surfaces (3:1 maximum slope), and to effectively shed surface water to limit infiltration while limiting erosion of the surface. In addition, at strategic locations on and around the newly graded surfaces, stormwater controls in the form of erosion control channels would be constructed to direct the runoff from the impacted area. This alternative does not include any waste rock consolidation, pit backfill, or cover system. The surface would be seeded to promote vegetation regrowth. This alternative would include ICs and LUCs to limit Site access, and long-term O&M to maintain stormwater controls.	*Protective of Human Health and the Environment?* ***Low*** - ICs/LUCs would limit human contact with the upland soil/waste rock. However, LUCs may not adequately limit exposures to wildlife and livestock. - Grading and associated stormwater controls would prevent unimpacted stormwater from adjacent areas from running onto the upland soil/waste rock, and generally would reduce the overall amount of water that infiltrates the upland soil/waste rock by shedding stormwater before it can infiltrate. However, grading in itself is not protective of human health and the environment because it would not prevent direct exposure to upland soil/waste rock; nor does it reduce stormwater and snowmelt from infiltrating and leaching constituents from the upland soil/waste rock to surface water and groundwater. The water that sheds from the graded upland soil/waste rock would continue to contribute constituents to media downgradient of the waste rock. *Reduces Toxicity, Mobility, or Volume?* ***Low*** - Grading would reduce the mobility of constituents somewhat by more effectively shedding stormwater and snowmelt from the upland soil/waste rock, thereby reducing the overall volume of infiltrating water and the resulting migration of constituents. However, without a cover system to preclude infiltration of stormwater and snowmelt, some level of constituent migration would continue to occur. In addition, any plants that establish on the graded upland soil/waste rock may uptake constituents. *Short-Term Effectiveness:* ***Low to Moderate*** - Risk of exposure to remediation workers to Site contaminants during grading activities can be mitigated using standard health and safety protocols (i.e., use of personal protective equipment [PPE]). - No increased risk to local communities during remedial action because all the work would be confined to the Site footprint. - Remedy would not reduce infiltration of precipitation through the upland soil/waste rock or the exposed ore beds in the short term. - The surface area following regrading of the existing waste rock dumps to a 3:1 slope is approximately 424 acres. It is anticipated that this work would require 2 to 4 years to accomplish. *Long-Term Effectiveness:* ***Low to Moderate*** - Although the Alternative 2 includes grading and stormwater controls to reduce the overall amount of water infiltrating through the upland soil/waste rock and exposed ore beds, this remedy would not effectively reduce infiltrating water and the resulting migration of constituents to groundwater and surface water. Also, constituents would continue to be mobilized by the runoff and transferred to media	*Administrative Feasibility:* ***High*** - ICs/LUCs would require preparation of an Institutional Control Implementation and Assurance Plan (ICIAP), and approval by the A/Ts. - Site grading and stormwater controls have few administrative requirements other than approval of a long-term O&M Plan and periodic inspection / maintenance so that these features continue to function as designed. *Technical Feasibility:* ***High*** - Grading and stormwater controls are relatively easy to construct with conventional excavation equipment, and are	***$6.7M***	***No*** – Alternative 2 would not reduce to the extent necessary upland soil/waste rock from continuing to contribute constituents to surface water and groundwater.

TABLE 2-1

INITIAL SCREENING OF ASSEMBLED ALTERNATIVES FOR UPLAND SOIL/WASTE ROCK
FEASIBILITY STUDY TECHNICAL MEMORANDUM #2
P4 Production LLC, Ballard Mine

Alternative Number/Name	Alternative Description	Effectiveness	Implementability	Cost	Retain for Detailed Analysis?
Alternative 2 – Upland Soil/Waste Rock Grading and Stormwater Controls, Institutional Controls (ICs)[2], Land Use Controls (LUCs)[3], and Operation and Maintenance (O&M)/Long Term Monitoring (LTM) (Continued)		downslope/downgradient of the upland soil/waste rock. As a result, Alternative 2 has limited long-term effectiveness. - Long-term effectiveness would rely to some extent on proper O&M of the Site grading and stormwater controls. - Climate change potentially could impact the long-term effectiveness of this grading/stormwater controls alternative. For example, increased precipitation or intensity of storms could result in increased runoff volumes that would need to be managed by the stormwater controls. Current climate change predictions for the Site indicate variable changes in precipitation (EPA, 2016). The design of the stormwater/erosion controls would need to consider both historical rainfall, temperature, and snowmelt patterns as well as climate change predictions. - ICs/LUCs would remain in place to limit site access and to prevent disturbance of the graded waste rock surfaces and permanent stormwater controls. *Compliance with ARARs:* ***Low*** - Alternative 2 would not comply with chemical-specific or non-degradation ARARs as it would not reduce the upland soil/waste rock from acting as a continuing source contamination to surface water and groundwater. - Some of the location- and action-specific ARARs likely would not be satisfied during implementation of Alternative 2.	relatively easy to inspect and maintain. - ICs/LUCs are relatively easy to implement and monitor.		
Alternative 3 – Upland Soil/Waste Rock Grading and Consolidation with Soil Cover, ICs, LUCs, and O&M/LTM	Alternatives 3, 4, and 5 are the same except for the type of cover system. Under each alternative, portions of the upland soil/waste rock dumps throughout the Site would be excavated and consolidated in the on-Site pits to cover any exposed ore beds (i.e., Meade Peak Member of the Phosphoria Formation), or graded/contoured in-place to create slopes that effectively shed stormwater and snowmelt. The new upland soil/waste rock surfaces then would be capped with a cover system that is unique to each alternative as follows: Alternative 3 - Soil Cover, Alternative 4 - Evapotranspiration (ET) Cover, and Alternative 5 - Multi-layer Cover. Important effectiveness considerations that are common for Alternatives 3, 4, and 5 include: • A key aspect of the covers is their ability to reduce infiltration of water that could cause leaching of constituents from the underlying soil/waste rock and migration to surface water and groundwater. A cover is considered to be protective if it effectively reduces infiltration such that	**Alternative 3 –Soil Cover** *Protective of Human Health and the Environment?* ***Low to Moderate*** - The simple soil cover over the graded/consolidated upland soil/waste rock and exposed ore beds would prevent direct contact by human and ecological receptors, and would limit uptake of constituents by the shallow-rooting vegetation planted and maintained on the cover system. In addition, preliminary modeling results indicate that the simple soil cover would reduce infiltration rates. However, the soil cover would not sufficiently reduce the migration of constituents from the upland soil/waste rock and exposed ore beds to surface water and groundwater. - ICs/LUCs would prevent activities that could disturb the soil cover. *Reduces Toxicity, Mobility, or Volume?* ***Low to Moderate*** - Grading/consolidation and covering of the upland soil/waste rock and exposed ore beds would reduce the mobility of constituents by limiting downslope movement of constituents to the adjacent stream channels. In addition, the simple soil cover would somewhat reduce the infiltration and resulting migration of constituents to surface water and groundwater. - The soil cover would limit plant uptake of constituents if vegetation on the soil cover is limited to shallow-rooting plants. - Although a simple soil cover system would isolate the waste rock to some degree, there is no reduction to toxicity or volume of constituents in the covered upland soil/waste rock or the ore beds. *Short-Term Effectiveness:* ***High*** - Risk of exposure to remediation workers to Site contaminants during remedial construction activities can be mitigated using standard health and safety protocols (i.e., use of PPE). - No increased risk to local communities during remedial construction unless soil cover materials are hauled from a distant off-Site source.	*Administrative Feasibility:* ***High*** - ICs/LUCs would require preparation of an ICIAP, and approval by the A/Ts. - Grading/consolidation and soil cover have relatively few administrative requirements other than approval of a long-term O&M Plan and periodic inspection/ evaluations. *Technical Feasibility:* ***Moderate to High*** - Grading/consolidation and a simple soil cover are relatively easy to construct with conventional excavation equipment, and are	***$37.5M***	***No –*** Alternative 3 would not reduce to the extent necessary upland soil/waste rock from continuing to contribute constituents to surface water and groundwater.

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FEASIBILITY STUDY TECHNICAL MEMORANDUM #2
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Alternative Number/Name	Alternative Description	Effectiveness	Implementability	Cost	Retain for Detailed Analysis?
Alternative 3 – Upland Soil/Waste Rock Grading and Consolidation with Soil Cover, ICs, LUCs, and O&M/LTM (Continued)	remedial goals are ultimately achieved in surface water and groundwater. • Removal of the upland soil/waste rock located outside of the pits for consolidation in the pits is protective only if the underlying ground surfaces are excavated until cleanup levels are achieved or the surfaces are covered. This is because the areas underlying the waste rock dumps may be contaminated by transfer of constituents contained in the waste rock dumps to the underlying soil. For this alternative evaluation, it is assumed that these underlying areas would be addressed with a cover. Excavation was not considered because the amount of material removal necessary to achieve the cleanup levels cannot be estimated with currently available data. • In most cases, the exposed ore beds in the pits are located in very steep areas (e.g., the pit wall). Covering of the ore beds would require waste rock to be built up from the pit bottom to cover the exposed ore, with the surface of the selected cover system sloped to transfer unimpacted water from the selected cover system into the Wells Formation. • Only the volume of upland soil/waste rock that is necessary to cover the exposed ore beds and create a 3:1 slope (that can accommodate a cover system) would be excavated from outside the pits and backfilled into the pits. Complete consolidation of the waste rock into the pits is described under Alternative 7. • Under any of these alternatives, it would be necessary to import clean fill to construct the final cover system either from on-Site or adjacent to the Site. However, the volume of the imported borrow material necessary varies widely among the cover systems. • Surfaces would be graded and the cover system would be placed as quickly as	- The simple soil cover would not sufficiently reduce infiltration of stormwater and snowmelt through the upland soil/waste rock or the exposed ore beds in the short term. - The surface area following excavation of the waste rock dumps to cover the exposed ore beds followed by regrading of waste rock dumps to a 3:1 slope is approximately 392 acres (assuming 294.1 acres exterior (100% of total exterior waste dump acres) and approximately 97.9 acres inside the pits would be regraded). It is anticipated that Alternative 3 would require 3 to 5 years to accomplish. *Long-Term Effectiveness:* ***Low to Moderate*** - A soil cover would prevent direct contact with the upland soil/waste rock and ore beds for as long as the cover is maintained; however, the simple soil cover would not sufficiently reduce infiltrating water and the resulting migration of constituents to groundwater and surface water. As a result, Alternative 3 has limited long-term effectiveness. - Long-term effectiveness would rely on proper O&M of the soil cover system to limit erosion and to maintain the appropriate cover vegetation. A soil cover would require maintaining reclamation vegetation that has shallow rooting systems that would not penetrate the underlying waste rock. - Climate change potentially could impact the long-term effectiveness of a soil cover. For example, increased precipitation could result in increased erosional forces acting on the cover, and temperature change could affect the viability of the reclamation vegetation. Current climate change predictions for the Site indicate an overall increase temperature, decrease in snowpack, and variable precipitation trends (EPA, 2016). The remedial design (e.g., stormwater/erosion controls, plant types) would need to consider both historical rainfall, temperature, and snowmelt patters as well as climate change predictions. - ICs/LUCs would remain in place during and following achievement of the remedial action objectives (RAOs) to prevent disturbance of the covered upland soil/waste rock and exposed ore beds. Under Alternative 3 RAOs likely would not be achieved *Compliance with ARARs:* ***Low to Moderate*** - Alternative 3 would not comply with chemical-specific or non-degradation ARARs as the simple soil cover would not effectively reduce the upland soil/waste rock and exposed ore beds from acting as a continuing source contamination to surface water and groundwater. - Some of the location- and action-specific ARARs likely would not be satisfied during implementation of Alternative 3.	relatively easy to inspect and maintain. - O&M requires maintaining shallow-rooting plants on the cover system over the long term. - ICs/LUCs are relatively easy to implement and monitor.		
Alternative 4 – Upland Soil/Waste Rock Grading and Consolidation with a Evapotranspiration (ET) Cover System, ICs, LUCs, and O&M/LTM		**Alternative 4: ET Cover** *Protective of Human Health and the Environment?* ***High*** - The ET cover over the graded/consolidated upland soil/waste rock and exposed ore beds would prevent direct contact by human and ecological receptors, and the cover thickness would limit uptake of constituents by vegetation planted to transpire water contained in the cover. The ET cover also is expected to substantially reduce infiltration of stormwater and snowmelt into the underlying upland soil/waste rock and ore beds, which would reduce the migration of constituents to surface water and groundwater. - ICs/LUCs would prevent activities that could disturb the ET cover. *Reduces Toxicity, Mobility, or Volume?* ***Low to Moderate*** - Grading/consolidation and covering of the upland soil/waste rock and exposed ore beds would reduce the mobility of constituents thus mitigating downgradient transport to groundwater and downslope movement of constituents in surface waters to adjacent stream channels. In addition, preliminary modeling results indicate that the ET cover would reduce infiltration rates, which should sufficiently	*Administrative Feasibility:* ***High*** - ICs/LUCs would require preparation of an ICIAP, and approval by the A/Ts - Grading /consolidation and ET covers have few administrative requirements other than approval of a long-term O&M Plan and periodic	***$50.7M***	***Yes -*** Alternative 4 (ET cover system) is protective of human health and the environment and effective with low costs when compared to other alternatives that also are

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Alternative Number/Name	Alternative Description	Effectiveness	Implementability	Cost	Retain for Detailed Analysis?
Alternative 4 – Upland Soil/Waste Rock Grading and Consolidation with a Evapotranspiration (ET) Cover System, ICs, LUCs, and O&M/LTM (Continued)	possible over exposed underlying surfaces (under the existing waste rock dumps) and in pit backfill areas to limit exposure of fresh waste rock surfaces to the environment. **Cover System Details:** ***Alternative 3 – Soil Cover***: The soil cover would be comprised of approximately 12" to 18" of topsoil/alluvial medium. The thickness of this cover would be sufficient to support plant growth and to limit uptake of constituents by vegetation selected to grow on the cover. Vegetation for the soil cover would be selected and maintained so roots do not penetrate to the underlying waste rock. ***Alternative 4 – Evapotranspiration (ET) Cover:*** The ET cover would be designed to shed and/or store infiltrating water, which then evaporates or is transpired by the vegetation planted on the surface of the cover system before the water can infiltrate into the underlying waste rock. Based on current information regarding nearby borrow material and a preliminary cover analysis, the ET cover would consist of (starting from the top of the cover): 1) 5-foot thickness of medium-grained, clean alluvial material, and 2) 6 inches to 1-foot thickness of high-permeability (coarse grained) clean fill material to act as a capillary break. The reclamation vegetation would be selected to form extensive root systems to effectively slow downward movement of stormwater and snowmelt, and to transpire water that infiltrates and accumulates in the upper layer of the cover system, but not into the underlying waste rock. ***Alternative 5 – Multi-Layered Cover:*** The multi-layer cover would be designed using materials that substantially reduce water infiltration into the underlying waste rock. The cap would contain at least one hydraulic barrier layer consisting of earthen materials of various gradations, a compacted clay layer, a	reduce the migration of constituents from the upland soil/waste rock and exposed ore beds to surface water and groundwater. - The ET cover design (thickness and coarse layer) would limit plant uptake of constituents. - Although an ET cover system would isolate the waste rock, there is no reduction to toxicity or volume of constituents in the covered upland soil/waste rock or the exposed ore beds. *Short-Term Effectiveness:* ***Moderate to High*** - Risk of exposure of remediation workers to Site contaminants during remedial construction activities can be mitigated using standard health and safety protocols (i.e., use of PPE). - No increased risk to local communities during remedial construction because it is anticipated that all the borrow materials necessary to build the ET cover are available at or adjacent to the Site. - The surface area following excavation of the waste rock dumps to cover the exposed ore beds followed by regrading of waste rock dumps to a 3:1 slope approximately 392 acres (assuming 294.1 acres exterior (100% of total exterior waste dump acres) and approximately 97.9 acres inside the pits would be regraded). It is anticipated that Alternative 4 would require 3 to 5 years to accomplish. *Long-Term Effectiveness:* ***High*** - The ET cover system would prevent direct human and ecological contact with the upland soil/waste rock and ore beds for as long as the cover is maintained. The ET cover also would substantially reduce infiltration of stormwater and snowmelt through these source materials, which would limit further contamination of surface water, groundwater, and riparian soil/sediment. - Long-term effectiveness is excellent because the cover is constructed of geologic materials that have an infinite life. Long-term effectiveness would rely on proper O&M of the ET cover system to limit erosion and to maintain the reclamation vegetation on the cover. O&M is somewhat simplified compared with thinner cover systems because more diverse reclamation vegetation is allowable (i.e., deeper rooting systems), resulting in less O&M and better erosion resistance. After cover construction, there are no risks to site workers during O&M and LTM activities, or risk to the environment. - Climate change predications were evaluated in the MWH memorandum included in Appendix B to determine if there would have to be changes in the ET cover design (e.g., increase in thickness to accommodate more storage). The evaluation concluded that, "*Due to the variability in precipitation trends and strong trends toward increasing temperature and decreasing snowpack, it is expected that total saturation and the total infiltration of precipitation through a cover system and into underlying waste rock may decrease under projected future climate scenarios. This is mainly attributable to the fact that snowmelt in this area is considered the dominant mechanism resulting in precipitation breakthrough of a cover system and snow is expected to decrease."* - ICs/LUCs would remain in place following achievement of the RAOs to prevent disturbance of the covered upland soil/waste rock/ore. *Compliance with ARARs:* ***High*** - Alternative 4 would comply with chemical-specific or non-degradation ARARs by isolating the source of surface water and groundwater contamination. - Location- and action-specific ARARs likely can be satisfied during implementation of Alternative 4.	inspection / evaluations. *Technical Feasibility:* ***High*** - Grading/consolidation and ET covers are relatively easy to construct with conventional excavation equipment, and are relatively easy to inspect and maintain. - O&M is simplified compared with thinner cover systems because a more diverse reclamation vegetation is acceptable (e.g., shrubs with deeper rooting systems).		protective (i.e., Alternatives 5, 6, and 7).

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Alternative Number/Name	Alternative Description	Effectiveness	Implementability	Cost	Retain for Detailed Analysis?
Alternative 5– Upland Soil/Waste Rock Grading and Consolidation with Multi-layered Cover System, ICs, LUCs, and O&M/LTM	geosynthetic clay layer, or a geomembrane layer. In addition to the hydraulic barrier layer, the cap would incorporate a drainage layer and be vegetated with native grass/forb species to control erosion. The appropriately sloped capped-surface and drainage layer would allow stormwater and snowmelt to run off or drain to the edge of the cover system. Based on similar multi-layer covers installed at nearby mine reclamation projects, the multi-layer cover likely would be approximately 4 feet thick and include from the ground surface 1) an alluvial material layer 3 feet thick to support plant growth, 2) a geocomposite material that drainage layer, 3) a geosynthetic clay laminate liner (GCLL) to act as the hydraulic barrier, and 4) a protective subgrade that varies in thickness from 6 to 12 inches placed over waste rock material. Vegetation for the soil cover would be selected so roots do not penetrate the hydraulic barrier layer or to the underlying waste rock. **ICs, LUCs, and O&M/LTM** All three alternatives would include ICs and LUCs to limit activities that could disturb the cover systems and the underlying waste rock. All three alternatives also would include O&M and LTM to maintain and monitor the integrity of the selected cover system and to prevent plants that are not compatible with the cover system (e.g., deep rooting and/or selenium hyperaccumulators on thinner cover systems.).	**Alternative 5: Multi-layer Cover** *Protective of Human Health and the Environment?* ***High*** - The multi-layer cover over the graded/consolidated upland soil/waste rock and ore beds would prevent direct contact by human and ecological receptors, and would limit uptake of constituents by the vegetation planted on the cover system. The multi-layer cover also is expected to substantially reduce infiltration of stormwater and snowmelt into the underlying upland soil/waste rock and exposed ore beds, which would limit further migration of constituents to surface water and groundwater. - ICs/LUCs would prevent activities that could disturb the multi-layer cover. *Reduces Toxicity, Mobility, or Volume?* ***Low to Moderate*** - Grading/consolidation and covering of the upland soil/waste rock and exposed ore beds would substantially reduce the mobility of constituents through downgradient transport to groundwater and downslope movement of constituents in surface waters to adjacent stream channels. In addition, the multi-layer cover would effectively reduce infiltration rates, which would limit migration of constituents from the upland soil/waste rock and exposed ore to surface water and groundwater. - The multi-layer cover would limit plant uptake of constituents if vegetation on the soil cover is limited to shallow-rooting plants. - Although a multi-layer cover system would isolate the waste rock, there is no reduction to toxicity or volume of constituents in the covered upland soil/waste rock/ore. *Short-Term Effectiveness:* ***Moderate to High*** - Risk of exposure of remediation workers to Site contaminants during remedial construction activities can be mitigated using standard health and safety protocols (i.e., use of PPE). - No increased risk to local communities during remedial construction, other than the transport of liner materials for the multi-layer cover system to the Site. - The surface area following excavation of the waste rock dumps to cover the exposed ore beds followed by regrading of these waste rock dumps to a 3:1 slope is approximately 392 acres (assuming 294.1 acres exterior (100% of total exterior waste dump acres) and approximately 97.9 acres inside the pits would be regraded). It is anticipated that Alternative 5 would require 3 to 5 years to accomplish. *Long-Term Effectiveness:* ***High*** - The multi-layer cover system would prevent direct human and ecological contact with the upland soil/waste rock and ore beds. The multi-layer cover also would effectively reduce infiltration of stormwater and snowmelt through these source materials, which limits further contamination of surface water, groundwater, and riparian soil/sediment. However, there is evidence that geosynthetic clay and geomembrane liners do not meet their design characteristics (i.e., they would leak to some degree) in real-world applications, even when properly designed and installed (EPA, 1992). - The long-term effectiveness of a multi-layer cover in reducing infiltration would be limited by the likelihood that the man-made geosynthetic clay or geomembrane liner components would degrade over time (e.g., over several hundred years assuming these materials are protected from surface erosion, freeze-thaw effects, biointrusion, and plant succession [i.e., grasses to shrubs to trees]). - Long-term effectiveness would rely on proper O&M of the multi-layer cover system to limit erosion and to maintain the vegetation on the cover. A multi-layer cover requires maintaining reclamation vegetation that has shallow rooting systems that would not penetrate the synthetic liner. After cover construction, there are no risks to site workers during O&M and LTM activities, or risk to the environment.	*Administrative Feasibility:* ***High*** - ICs/LUCs would require preparation of an ICIAP, and approval by the A/Ts. - Grading/consolidation and multi-layer covers have few administrative requirements other than approval of a long-term O&M Plan and periodic inspection / evaluations. *Technical Feasibility:* ***Moderate*** - Grading and waste rock consolidation are relatively easy to implement with conventional excavation equipment. - Multi-layer cover systems are more difficult to install than other covers offering similar performance (the hydraulic-barrier liner requires careful installation by a qualified contractor and a high level of construction quality assurance). - Experience has shown that over the long-term, multi-layer covers require more maintenance than other covers (offering similar performance) to maintain their initial performance (e.g., isolating and	***$122.2M***	***No –*** Alternative 5 (multi-layer cover system) offers similar human and environmental protection when compared to an ET system, but with additional long-term performance and O&M considerations and at twice the estimated cost of the ET cover under Alternative 4.

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Alternative Number/Name	Alternative Description	Effectiveness	Implementability	Cost	Retain for Detailed Analysis?
Alternative 5– Upland Soil/Waste Rock Grading and Consolidation with Multi-layered Cover System, ICs, LUCs, and O&M/LTM (Continued)		- ICs/LUCs would remain in place following achievement of the RAOs to prevent disturbance of the covered upland soil/waste rock and ore beds. *Compliance with ARARs:* ***High*** - Alternative 5 would comply with chemical-specific or non-degradation ARARs by isolating the source of surface water and groundwater contamination. - Location- and action-specific ARARs likely can be satisfied during implementation of Alternative 5.	repairing leaks in the hydraulic barrier). O&M requires maintaining shallow-rooting plants on the cover system over the long term. Long-term viability of the man-made components of the hydraulic barrier is uncertain. - O&M requires maintaining shallow-rooting plants on the cover system over the long term to prevent compromise of the manmade cover components.		
Alternative 6 - Upland Soil/Waste Rock Grading and Consolidation, Incidental Ore Recovery, ET Cover System[4], ICs, LUCs, and O&M/LTM.	Alternative 6 is similar to Alternatives 3, 4, and 5, except that incidental ore deposits would be recovered during the upland soil/waste rock grading and consolidation efforts. The cover system under this Alternative 6 would be an ET cover (as described in Alternative 4) Three ore bodies have been identified within the Site and as a result, remediation of the Site under this alternative would be implemented in three phases. Much of the remaining ore is located beneath existing waste rock that would be consolidated and capped as the remediation progresses, or beneath known sources of borrow material that would be used to construct the cover systems. Recovery of the incidental ore would result in a larger reclaimed area than Alternatives 3, 4, or 5. However, the additional disturbance within the mine-affected area would result in access to additional on-Site borrow material, which allows for more natural reclaimed surfaces (i.e., topography) across portions of the Site. These areas would be graded/contoured to drain effectively and blend with the surrounding native landscape. As with Alternatives 3, 4, and 5, this alternative would include ICs and LUCs to limit activities	*Protective of Human Health and the Environment?* ***High*** - The protectiveness of the grading, consolidation and cover system would be the same as described above in Alternatives 4 and 7. - Incidental ore recovery provides environmental protection in that it delays ore recovery activities at other P4 mines, while at the same time remediating the Site. *Reduces Toxicity, Mobility, or Volume?* ***Low to Moderate*** - The grading, consolidation and cover system would be the same as described above in Alternatives 4 and 7. *Short-Term Effectiveness:* ***High*** - The short-term effectiveness of the grading, consolidation and cover system would be the same as described above in Alternative 4, and 7. - Risk of exposure to Site contaminants during incidental ore removal can be mitigated using standard health and safety protocols (i.e., use of PPE). - Potential increased risk to local communities resulting from transport of the recovered ore to the plant for processing but volume similar to present-day haul trips. - The alternative results in a larger overall reclaimed footprint, however incidental ore recovery would produce additional clean overburden for the selected cover system and waste rock for use as backfill. The result is that more material is available which would allow for a more natural, thorough reclamation when compared to Alternatives 4 and 5 that blends into the adjacent native upland surfaces and effectively drains the cover system and Site. - The surface area following incidental ore recovery followed by regrading is approximately 538 acres following incidental ore recovery. It is anticipated that Alternative 6 would require 6 to 8 years to accomplish.	*Administrative Feasibility:* ***Moderate*** - ICs/LUCs would require preparation of an ICIAP, and approval by the A/Ts. - The administrative feasibility of the grading, consolidation and ET cover system would be similar as described above in Alternative 4. - Incidental ore recovery would require coordination of mineral extraction with BLM and is a hurdle that the other alternatives won't encounter. *Technical Feasibility:* ***High***	***$37.0M*** *(T*his cost is exclusively for remedial action activities and represents approx. 25% of the total cost to implement Alternative 6. As discussed in Section 3.0, the remaining 75% of the total cost for Alternative 6 is for ore recovery activities.)	***Yes –*** similar to Alternatives 4 and 7 and has additional benefits related to short- and long-term effectiveness.

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Alternative 6 - Upland Soil/Waste Rock Grading and Consolidation, Incidental Ore Recovery, ET Cover System[4], ICs, LUCs, and O&M/LTM. (Continued)	that could disturb the final cover system and the underlying waste rock; and O&M/LTM to confirm the integrity of the cover system and to prevent plants from growing on the capped surfaces that are incompatible with the possible cover systems (e.g., selenium hyper accumulators or trees).	*Long-Term Effectiveness:* ***High*** - The long term effectiveness of the grading, consolidation and cover system would be the same as described above in Alternative 4. - Incidental ore recovery addresses the CERCLA principal of incorporating reasonably anticipated future land use into the remedy (EPA, 2010) by implementing a reasonable land use (i.e., ore recovery) while attaining the CERCLA RAOs during the remedial action. This approach has several long-term effectiveness benefits including: o Recovers valuable resource that would become inaccessible after the remedy is implemented (unless the remedy is disturbed). o Removing existing ore for the overall mine footprint to be capped in a more comprehensive manner. o Produces a portion of the necessary borrow material on-Site that is necessary to construct the ET cover system. Under this alternative, less borrow material maybe imported from off-Site sources resulting in reductions in greenhouse gas emissions. o Ore recovery delays future ore recovery at other P4 mine areas. Proximity of the Ballard Site to the P4 processing facility (as opposed to obtaining ore from another more distant new mine) reduces greenhouse gas emissions during the transport of ore. *Compliance with ARARs:* ***High*** - Alternative 6 would comply with chemical-specific or non-degradation ARARs by isolating the source of surface water and groundwater contamination, and by removing a portion of the source materials (i.e., exposed ore beds). - Location- and action-specific ARARs likely can be satisfied during implementation of Alternative 6.	- The technical feasibility of the grading, consolidation and cover system would be the same as described above in Alternative 4. - Incidental ore recovery can be integrated into the remedial design and implementation.		
Alternative 7 - Complete Consolidation of Existing Upland Soil/Waste Rock into the Pits, ET Cover System[4], ICs, LUCs, and O&M/LTM.	Under this alternative, all upland soil/waste rock lying outside the existing pits would be excavated and consolidated in the existing pits in an attempt to backfill the existing pits and to cover any exposed Meade Peak ore beds then graded/contoured to create slopes that effectively shed stormwater and snowmelt. The graded upland soil/waste rock surfaces in the pits and the areas underlying the former upland soil/waste rock dumps would be capped with an ET cover (as described in Alternative 4). The volume of existing waste rock material is not sufficient to completely fill the existing pits to the pre-mining surface. The difference between the volume of materials that would be required to fill the pits to original contour and the volume of the existing upland soil/waste rock dumps is approximately 6.4 million cubic yards (cy). This difference is approximately equal to the volume of ore that was originally mined and removed	*Protective of Human Health and the Environment?* ***High*** - The protectiveness of the consolidation and cover system would be the same as described above in Alternatives 4 and 6. - Complete consolidation of the waste rock into the pits likely would not provide increased protectiveness over Alternatives 4, 5, and 6 because those alternatives also would effectively isolate the waste rock and the exposed ore beds. *Reduces Toxicity, Mobility, or Volume?* ***Low to Moderate*** - The volume of waste rock consolidation and size of the final cover is considerably larger (i.e., 546 acres) under this alternative than Alternatives 4 and 5 (i.e., 392 acres) and similar in size to the ore recovery Alternative 6 (i.e., 538 acres). However, ultimately Alternative 7 is most similar to Alternatives 4 and 6 because the waste rock is isolated to limit mobility of constituents using ET cover systems and complete backfilling of the waste rock under this alternative does not reduce the toxicity or volume of COCs/COECs and more than these other alternatives. *Short-Term Effectiveness:* ***High*** - The short-term effectiveness of the grading, consolidation and cover system are essentially the same as described above in Alternatives 4 and 6. - The surface area regrading interior and exterior to the existing mine pits under Alternative 7 is approximately 546 acres. This assumes that areas where waste rock is removed outside the pits would be covered (approximately 294 acres), as opposed to excavating these areas until cleanup levels are achieved. It also assumes that 220 acres of mine pits would be backfilled and covered. Assumes that	*Administrative Feasibility:* ***High*** - ICs/LUCs would require preparation of an ICIAP, and approval by the A/Ts. - The administrative feasibility of the grading, consolidation and cover system would be the same as described above in Alternative 4. *Technical Feasibility:* ***Moderate to High*** - The technical feasibility of the grading, consolidation and cover system would	***$113.1M***	***Yes-*** Alternative 7 has similar effectiveness and implement-ability to Alternatives 4 and 6, but has significantly higher costs than Alternative 4 with no discernable increased benefit. However, Alternative 7 is retained as requested by the A/Ts so that a wide range of alternatives is

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Alternative Number/Name	Alternative Description	Effectiveness	Implementability	Cost	Retain for Detailed Analysis?
Alternative 7 - Complete Consolidation of Existing Upland Soil/Waste Rock into the Pits, ET Cover System[4], ICs, LUCs, and O&M/LTM. (Continued)	from the Site. However, there is sufficient volume of waste rock in the waste rock dumps to contour the sides of the existing pits crest to crest, to cover the exposed ore beds, and to create 3:1 maximum slopes and topography that directs any stormwater out of the pits and away from the source area As with previous alternatives that include excavation and consolidation of portions of upland soil/waste rock into the pits, the underlying ground surfaces also must be excavated until cleanup levels are achieved or the surfaces are covered. This is because the areas underlying the upland soil/waste rock dumps likely are contaminated by transfer of constituents from the waste rock dumps to the underlying surface. For this alternative evaluation, it is assumed that these underlying areas would be addressed with a cover. Excavation was not considered because the amount of removed material necessary to achieve cleanup levels cannot be estimated with currently available data. As with Alternatives 3, 4, 5, and 6, this alternative would include ICs and LUCs to prevent activities that could disturb the cover systems and the underlying waste rock; and O&M/LTM to maintain the integrity of the cover system and to prevent plants that are incompatible with the selected cover system.	the 3D representation of the final reclaimed cover surface would be approximately 25% more for backfilling or approximately 162 acres. It is anticipated that Alternative 7 would require 5 to 7 years to accomplish. *Long-Term Effectiveness:* ***High*** The long term effectiveness of the consolidation and cover system would be the same as described above in Alternatives 4 and 6. - Complete consolidation of the waste rock into the pits under this alternative likely would not provide increased long-term effectiveness over Alternatives 4, 5, and 6 because those alternatives also would effectively isolate the waste rock and the exposed ore beds. *Compliance with ARARs:* ***High*** - Alternative 7 would comply with chemical-specific or non-degradation ARARs by isolating the sources of surface water and groundwater contamination. - Location- and action-specific ARARs likely can be satisfied during implementation of Alternative 7.	be the same as described above in Alternative 4.		evaluated in the detailed/ comparative analysis.

1) Section 121 of CERCLA, as amended by SARA, requires that remedial actions which result in any hazardous substances, pollutants, or contaminants remaining at the site be subject to a five-year review. The NCP further provides that remedial actions which result in any hazardous substances, pollutants, or contaminants remaining at the site above levels that allow for unlimited use and unrestricted exposure be reviewed every five years to ensure protection of human health and the environment.
2) Institutional controls (ICs) are non-engineered instruments, such as administrative and legal controls, that help to minimize the potential for exposure to contamination and/or protect the integrity of a response action (e.g., government controls, proprietary controls, enforcement tools, and informational tools).
3) Land Use Controls (LUCs) are engineering controls (e.g., fencing signage, and other physical barriers) that limit human and in some cases ecological exposures. Although EPA considers ICs to be a subset of LUCs, for clarity, this FS document distinguishes ICs to be non-engineered instruments and LUCs to be engineered controls.
4) The cover system for this alternative was selected following the screening of Alternative 3 (Soil Cover), Alternative 4 (ET Cover), and Alternative 5 (Multi-layer Cover). Based on the evaluation of key trade-offs between the three cover types, the recommended cover system for Alternative 6 and Alternative 7 is an ET Cover as discussed in Sections 2.0 and 3.0.

TABLE 2-2

INITIAL SCREENING OF ASSEMBLED ALTERNATIVES FOR SURFACE WATER
FEASIBILITY STUDY TECHNICAL MEMORANDUM #2
P4 Production LLC, Ballard Mine
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Alternative Number/Name	Alternative Description[1]	Effectiveness	Implementability	Relative Cost	Retain for Detailed Analysis?
Alternative 1 – No Action	The No Action alternative would leave the Site in its existing condition.	*Protective of Human Health and the Environment?* ***Low*** - No actions would occur to prevent human/wildlife contact with affected surface water. *Reduces Toxicity, Mobility, or Volume?* ***Low*** - With no source controls in the upland soils/waste rock, COCs/COECs would continue to migrate to Site surface water via stormwater runoff from or via mine-affected groundwater that discharges to the ground surface at seep/spring locations. *Short-Term Effectiveness:* ***Low*** *Long-Term Effectiveness:* ***Low*** *Compliance with ARARs:* ***Low*** - With no source controls in the upland soil/waste rock, COCs/COECs in surface water would continue to exceed the chemical-specific ARARs indefinitely.	*Administrative Feasibility:* ***High*** - No associated administrative requirements other than the CERCLA 5-year review[2]. *Technical Feasibility:* ***High*** - No remedial actions to implement.	***Low***	***Yes*** *- The No-Action alternative is not acceptable for the majority Site surface water areas because it is not protective, but is retained as required by the NCP.*
Alternative 2 –Institutional Controls (ICs)[3] and Land Use Controls (LUCs)[4], in conjunction with source controls in the upland soil/waste rock	ICs and LUCs would be implemented to restrict surface water use and access until cleanup levels are achieved at the perennial seeps/springs. Upon completion of source controls in the upland soil/waste rock, surface water runoff would be unimpacted and only residual flows from seeps/springs are expected to exceed cleanup levels for a period of time (i.e., until the regrading and cover systems significantly reduces the source of water that recharges through the upland soil/waste rock and ultimately discharges to the seeps/springs). In association with source controls, sediment basins and other construction related BMPs would be used to control ongoing sediment releases caused by stormwater.	*Protective of Human Health and the Environment?* ***Moderate to High*** - ICs and LUCs would limit human and some wildlife contact with the mine-affected surface water until cleanup levels are achieved following source controls. *Reduces Toxicity, Mobility, or Volume?* ***Low*** - ICs/LUCs on their own do not reduce the toxicity, mobility, or volume of mine-affected surface water. However, without an ongoing source of COCs/COECs, surface water runoff from the capped areas of the mined area would shed unimpacted to the downgradient drainages. The cover systems also would substantially reduce stormwater and snowmelt from infiltrating the waste rock. As a result, the mine-affected seeps/springs should dry up or meet surface water cleanup levels over time as residual water drains from the consolidated waste rock. *Short-Term Effectiveness:* ***Moderate*** - Surface water runoff would shed unimpacted water upon completion of the cover system in the upland soil/waste rock areas; however, consolidation and grading of the upland soil/waste rock and construction of the cover systems would take an estimated 5 to 10 years to complete. During that time, suspended sediment discharges would be controlled through the use of sediment berm/basins placed at the cover margins. It likely would take additional time before the mine-affected seeps/springs either dry up or meet cleanup levels. Suspended sediment releases from runoff would be controlled by sediment basins and other construction related BMPs. ICs/LUCs would be effective immediately to limit human and some wildlife contact and would remain in place until cleanup levels are achieved. - Site risks would remain for trespassers during remedy implementation. No additional risk to Site workers during remedial construction. *Long-Term Effectiveness:* ***High*** - Source controls in the mined area would minimize potential for contamination of the surface water. Long-term monitoring (LTM) would confirm effectiveness of the source controls. Long-term effectiveness of ICs and the overall remedy would be evaluated as part of the CERCLA 5-year review[2] process. *Compliance with ARARs:* ***Moderate to High*** - With source controls in the upland soil/waste rock, concentrations of COCs/COECs in surface water should eventually decrease to levels below the chemical-specific ARARs.	*Administrative Feasibility:* ***High*** - ICs/LUCs would require preparation of an Institutional Control Implementation and Assurance Plan (ICIAP), and approval by the A/Ts. ICs also may require cooperation from private landowners adjacent to the Site. *Technical Feasibility:* ***High*** - ICs/LUCs are relatively easy to implement and monitor.	***Low***	***Yes*** *– Although ICs on their own do not reduce the toxicity, mobility, or volume of mine-affected surface water, once source controls are in place, the volume of mine-affected surface water would significantly reduce and all surface water at the Site should eventually meet the cleanup levels within a reasonable time period (e.g., within 10 years).*

TABLE 2-2

INITIAL SCREENING OF ASSEMBLED ALTERNATIVES FOR SURFACE WATER
FEASIBILITY STUDY TECHNICAL MEMORANDUM #2
P4 Production LLC, Ballard Mine
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Alternative Number/Name	Alternative Description[1]	Effectiveness	Implementability	Relative Cost	Retain for Detailed Analysis?
Alternative 3 – In-Situ Biological (Wetlands) Treatment of Source Area Seepage, ICs, and LUCs, in conjunction with source controls in the upland soil/waste rock	ICs and LUCs (with source controls) would be implemented as in Alternative 2, and in-situ wetlands treatment would be implemented at mine-affected perennial seep/spring locations. The wetlands would treat the residual mine-affected water at the seeps/springs 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. Stormwater and snowmelt in the capped areas would shed unimpacted water from the cover systems upon completion of the source controls in the upland soil/waste rock.	*Protective of Human Health and the Environment?* ***High*** - ICs/LUCs would limit human and some wildlife contact with the affected surface water until cleanup levels are achieved. - This alternative would be protective of receptors downgradient of the in-situ wetlands as it is assumed they would achieve RAOs. *Reduces Toxicity, Mobility, or Volume?* ***High*** - ICs/LUCs on their own do not reduce the toxicity, mobility or volume of mine-affected surface water. However, without an ongoing source of COCs/COECs, surface water runoff on the capped areas of the mined area would shed unimpacted water to the downgradient drainages. The cover systems also would substantially reduce stormwater and snowmelt from infiltrating the waste rock. As a result, the mine-affected seeps/springs should dry up or meet surface water cleanup levels over time as residual water drains from the consolidated waste rock. The in-situ wetlands would treat the residual mine-affected surface water at the perennial seeps/springs, which would reduce downgradient migration of COCs/COECs at concentrations above the cleanup levels. As a whole, this alternative effectively reduces the toxicity, mobility, and volume of COCs/COECs in surface water. *Short-Term Effectiveness:* ***High*** - Surface water runoff would be unimpacted upon completion of the cover systems in the upland soil/waste rock areas; however, consolidation and grading of the upland soil/waste rock and construction of the cover systems would take an estimated 5 to 10 years to complete. During that time, suspended sediment discharges would be controlled through the use of sediment berm/basins placed upstream of the engineered wetlands. It likely would take additional time before residual flows at the mine-affected seeps/springs either dry up or meet the cleanup levels. In the interim, the seeps/springs would be treated via engineered wetlands to reduce downstream migration of COCs/COECs. Their effectiveness would be based on the time for maturation (i.e., several weeks to a year for biological growth) and may be reduced during cold weather unless the seeps/springs are from deeper groundwater sources. ICs/LUCs would be effective immediately to limit human and some wildlife contact and would remain in place until cleanup levels are achieved. - Site risks would remain at the wetlands for trespassers during remedy implementation, and potentially from wetland plants that uptake COECs. Any risk to site workers during remedial construction can be mitigated with standard health and safety procedures. *Long-Term Effectiveness:* ***High*** - Source controls in the mined area would minimize potential for re-contamination of the surface water. LTM would confirm effectiveness of the source controls, and wetlands would remain in place indefinitely to treat any rebound of COC/COEC concentrations at the seep/spring locations. Effectiveness of ICs/LUCs and the overall remedy would be evaluated as part of the CERCLA 5-year review[2] process. *Compliance with ARARs:* ***Moderate to High*** - Treating residual flow at the mine-affected seeps/springs should meet chemical-specific ARARs down gradient of wetlands. It is anticipated that the constructed wetlands component of this alternative can be designed and implemented to comply with location- and action-specific ARARs.	*Administrative Feasibility:* ***High*** - The administrative feasibility of ICs/LUCs is as described in Alternative 2. - Administrative feasibility of in-situ wetlands is relatively straightforward. *Technical Feasibility:* ***Moderate to High*** - ICs are relatively easy to implement and monitor. - Wetlands are easily constructed, but may have lower effectiveness in the colder winter months due to low seepage flows and reduced biological activity. The effectiveness of in-situ wetlands treatment has not been demonstrated for Site surface waters, and some amendments may be required to maintain conditions that successfully reduce COC/COEC concentrations to below cleanup levels.	***Low to Moderate***	***Yes –*** *This alternative includes in-situ wetlands treatment of residual seeps/springs at specific locations. Alternatives 4 and 5 below are the same as Alternative 3 except they treat these seep/spring flows using ex-situ treatment options that likely are no more effective than the wetland option included in this alternative.*

TABLE 2-2

INITIAL SCREENING OF ASSEMBLED ALTERNATIVES FOR SURFACE WATER
FEASIBILITY STUDY TECHNICAL MEMORANDUM #2
P4 Production LLC, Ballard Mine
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Alternative Number/Name	Alternative Description[1]	Effectiveness	Implementability	Relative Cost	Retain for Detailed Analysis?
Alternative 4 – Ex-Situ Bioreactor Treatment of Source Area Seepage, ICs, and LUCs, in conjunction with source controls in the upland soil/waste rock	ICs and LUCs (with source controls) would be implemented as in Alternative 2, and mine-affected seepage conveyed to a lined storage impoundment and then fed at a controlled rate to one or more bioreactors. The bioreactors would treat the residual mine-affected water at the perennial seeps/springs via biological reduction using anaerobic bacteria resulting in precipitation or sorption of the COC/COEC. The treated water would discharge from the bioreactor to the downstream drainages. Evaporation basins or infiltration would be used if discharge to surface water would be restricted because of the requirements of a Clean Water Act (NPDES) permit. The bioreactor systems would be operated until source controls have reduced mine-affected seep/spring discharge. Stormwater and snowmelt in the capped areas would shed unimpacted water from the cover systems upon completion of the source controls in the upland soil/waste rock.	*Protective of Human Health and the Environment?* ***High*** - ICs/LUCs would limit human contact with the mine-affected surface water until cleanup levels are achieved. - Conveying the mine-affected seep/spring flow to ex-situ treatment systems may be more protective of aquatic and wildlife receptors compared with the in-situ wetlands treatment option in Alternative 3. However, some risk to wildlife receptors may continue if the retention ponds attract waterfowl. *Reduces Toxicity, Mobility, or Volume?* ***High*** - ICs/LUCs on their own do not reduce the toxicity, mobility or volume of mine-affected surface water. However, without an ongoing source of COCs/COECs, surface water runoff on the capped areas of the mined area would shed unimpacted water to the downstream drainages. The cover systems also would substantially reduce stormwater and snowmelt from infiltrating the waste rock. As a result, the mine-affected seeps/springs should dry up or meet surface water cleanup levels over time as residual water drains from the consolidated waste rock. The ex-situ bioreactors would treat the mine-affected surface water at the perennial seeps/springs to reduce downstream migration of COCs/COECs pending achievement of the cleanup levels. As a whole, this alternative effectively reduces the toxicity, mobility, and volume of COCs/COECs in surface water *Short-Term Effectiveness:* ***Moderate to High*** - Surface water runoff would shed unimpacted water upon completion of the cover systems in the upland soil/waste rock areas; however, consolidation and grading of the upland soil/waste rock and construction of the cover systems would take an estimated 5 to 10 years to complete. During that time, suspended sediment discharges would be controlled through the use of sediment berm/basins placed upstream of any surface water collection points. An additional duration is likely before the mine-affected seeps/springs either dry up or meet the cleanup levels; however, these seep/spring flows would be treated via ex-situ bioreactors to reduce downgradient migration of COCs/COECs pending achievement of the cleanup levels. However, their effectiveness may be reduced during cold weather unless housed in a heated enclosure. ICs/LUCs would be effective immediately to limit human and some wildlife contact and would remain in place until cleanup levels are achieved. Conveying the seep/spring flow to ex-situ treatment systems would limit impacts to most aquatic and wildlife receptors while treatment is occurring. - Site risks would remain for trespassers during remedy implementation. Any risk to site workers during remedial construction can be mitigated with standard health and safety procedures. *Long-Term Effectiveness:* ***Moderate to High*** - Source controls in the mined area would minimize potential for re-contamination of the surface water. LTM would confirm effectiveness of the source controls and bioreactor treatment. Effectiveness of ICs/LUCs and the overall remedy would be evaluated as part of the CERCLA 5-year review[2] process. *Compliance with ARARs:* ***Moderate to High*** - Treating residual flow at the mine-affected seeps/springs should meet chemical-specific ARARs. However, consistently meeting the surface water for selenium (0.005 mg/L) using bioreactor technology can be difficult. - Discharge of treated water may require substantive compliance with Clean Water Act (i.e., NPDES) requirements and Idaho wastewater-discharge requirements.	*Administrative Feasibility:* ***Moderate*** - The administrative feasibility of ICs/LUCs is as described in Alternative 2. - Administrative feasibility of constructing and operating bioreactors is relatively straightforward. Some agreements for non-P4 properties may be required. *Technical Feasibility:* ***Moderate*** - ICs/LUCs are relatively easy to implement and monitor. - Bioreactors construction and operation is well established. P4 tested a bioreactor system for the treatment of mine-affected seep/spring water at the Site with favorable results for selenium, arsenic, cadmium and several other metals that would be a concern if the discharge was routed to surface water (P4, 2011). The test bioreactor consistently produced effluent that had selenium concentrations below the groundwater MCL (0.05 mg/L), but would need modifications to consistently meet the surface water discharge standard limit of 0.005 mg/L. - Bioreactors can be designed to operate under conditions of low-flow conditions effectively. - Bioreactors generate a sludge that requires management and disposal. - Would require system decommissioning when cleanup levels are achieved.	***Moderate to High***	***No*** – *Effectiveness and implementability is the same as Alternative 3 (in-situ wetlands), but the ex-situ bioreactor facilities would have more of an environmental "footprint", would lose effectiveness in cold weather if not in a heated building, would be more difficult to operate and maintain, and would require decommissioning after cleanup levels are achieved, whereas the wetlands in Alternative 3 likely would not.*

TABLE 2-2

INITIAL SCREENING OF ASSEMBLED ALTERNATIVES FOR SURFACE WATER
FEASIBILITY STUDY TECHNICAL MEMORANDUM #2
P4 Production LLC, Ballard Mine
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Alternative Number/Name	Alternative Description[1]	Effectiveness	Implementability	Relative Cost	Retain for Detailed Analysis?
Alternative 5 – Ex-Situ Chemical Treatment of Source Area Seepage, ICs, and LUCs, in conjunction with source controls in the upland soil/waste rock	This alternative is similar to Alternative 4 except that a physical/chemical treatment plant would be used to treat mine-affected seepage instead of a bioreactor. Treatment would consist of a combination of separation/filtration, chemical precipitation, and oxidation/reduction. (Membrane technology is a retained technology that could be considered during RD if judged more effective than a chemical process.) Stormwater and snowmelt in the capped areas would shed unimpacted water from the cover systems upon completion of the source controls in the upland soil/waste rock.	*Protective of Human Health and the Environment?* ***High*** - Same as Alternative 4. *Reduces Toxicity, Mobility, or Volume?* ***High*** - Same as Alternative 4 except that a physical/chemical treatment plant would be used to treat mine-affected seepage instead of a bioreactor. *Short-Term Effectiveness:* ***Moderate to High*** - Same as Alternative 4. *Long-Term Effectiveness:* ***Moderate to High*** - Same as Alternative 4 except that a physical/chemical treatment plant would be used to treat mine-affected seepage instead of a bioreactor. However, over the long term an ex-situ treatment system is difficult to adapt to changing water conditions (i.e., specifically the quantity of water produced by springs and their changing water quality). This could cause a redesign of the water treatment system. *Compliance with ARARs:* ***High*** - Same as Alternative 4, but achieving more stringent surface water cleanup levels should be more reliable.	*Administrative Feasibility:* ***Low to Moderate*** - The administrative feasibility of ICs/LUCs is as described in Alternative 2. - Administrative feasibility of designing, constructing and operating a physical/chemical treatment plant is relatively complex. *Technical Feasibility:* ***Moderate*** - ICs/LUCs are relatively easy to implement and monitor. - Treatment process likely would require a combination of separation/filtration, chemical precipitation, and oxidation/reduction to achieve cleanup levels for all COCs/COECs. However, the treatment technologies are well established. - Designing a system to treat flows that substantially would decrease in volume and concentration of COCs/COECs with time as is expected in this case, would be challenging and the system would not be cost effective at lower flow rates. - Chemical precipitation step would generate a sludge that requires management and disposal. - Would require system decommissioning when cleanup levels are achieved.	***High***	***No*** *–Seep/spring flows are expected to substantially decrease with time and improve in quality. A conventional chemical treatment plant has limited flexibility in dealing with changing influent quantities and concentrations. Therefore, because of the long-term O&M challenges, larger environmental footprint, decommissioning requirements, and higher costs this alternative is not retained.*

1 With the exception of the No-Action alternative, all assembled remedial alternatives for surface water rely on source controls for the upland soil/waste rock (i.e., a cover system to reduce infiltration of precipitation through these materials). The cover system would isolate the upland soils/waste rock thereby preventing or reducing the migration of COCs/COECs from these materials to surface water.

2 Section 121 of CERCLA, as amended by SARA, requires that remedial actions which result in any hazardous substances, pollutants, or contaminants remaining at the site be subject to a five-year review. The NCP further provides that remedial actions which result in any hazardous substances, pollutants, or contaminants remaining at the site above levels that allow for unlimited use and unrestricted exposure be reviewed every five years to ensure protection of human health and the environment.

3 Institutional controls (ICs) are non-engineered instruments, such as administrative and legal controls, that help to minimize the potential for exposure to contamination and/or protect the integrity of a response action (e.g., government controls, proprietary controls, enforcement tools, and informational tools).

4 Land Use Controls (LUCs) are engineering controls (e.g., fencing signage, and other physical barriers) that limit human and in some cases ecological exposures. Although USEPA considers ICs to be a subset of LUCs, for clarity, this FS document distinguishes ICs to be non-engineered instruments and LUCs to be engineered controls.

TABLE 2-3

INITIAL SCREENING OF ASSEMBLED ALTERNATIVES FOR SEDIMENT/RIPARIAN SOIL
FEASIBILITY STUDY TECHNICAL MEMORANDUM #2
P4 Production LLC, Ballard Mine
(Page 1 of 3)

Alternative Number/Name	Alternative Description[1]	Effectiveness	Implementability	Cost	Retain for Detailed Analysis?
Alternative 1 - No Action	The No-Action alternative will leave the Site in its existing condition.	*Protective of Human Health and the Environment?* ***Low*** - No actions will occur to prevent human/wildlife contact with affected media. *Reduces Toxicity, Mobility, or Volume?* ***Low*** - With no source controls in the upland soil/waste rock, COCs/COECs will continue to migrate to the sediment/riparian soil in downstream drainages. Therefore there is no reduction in toxicity mobility, or volume of COCs/COECs. Short Term Effectiveness: ***Low*** Long-Term Effectiveness: ***Low*** *Compliance with ARARs:* ***Low*** - With no source controls in the upland soil/waste rock, COCs/COECs in sediment/riparian would continue to exceed cleanup levels indefinitely.	*Administrative Feasibility:* ***High*** - No associated administrative requirements other than the CERCLA 5-year review[2]. *Technical Feasibility:* ***High*** - No remedial actions to implement.	***Low***	**Yes** - The No-Action alternative is not applicable to any of the sediment/ riparian soil remediation areas because it is not protective, but is retained as required by the NCP.
Alternative 2 – Monitored Natural Recovery (MNR), Institutional Controls (ICs)[3], and Land Use Controls (LUCs)[4], in conjunction with source controls in the upland soil/waste rock	This alternative includes MNR, which relies on natural processes (i.e., physical, chemical, and biological processes) to reduce COC/COEC concentrations in the affected media over time. In order for MNR to be successful, source controls will need to be implemented in the upland soil/waste rock to prevent or reduce migration of COCs/COECs to the downstream drainages. MNR also will require ICs and LUCs to restrict Site activities until the cleanup levels are achieved.	*Protective of Human Health and the Environment?* ***Moderate*** - ICs/LUCs will limit humans, livestock, and some wildlife from contacting the affected media. *Reduces Toxicity, Mobility, or Volume?* ***Moderate*** - Without an ongoing source of COCs/COECs from the upland soil/waste rock areas, the sediment/riparian soil in the downstream drainages will disperse/mix and be buried/isolated naturally over time, resulting in lower COC/COEC concentrations that likely will not pose unacceptable risks. *Short-Term Effectiveness:* ***Moderate*** - ICs and LUCs will be effective immediately, but MNR to reduce COC/COEC concentrations is a long-term process. - Site risks will remain for trespassers during remedy implementation. *Long-Term Effectiveness:* ***High*** - Source controls for the upland soil/waste rock will prevent or reduce potential for re-contamination of the sediment/riparian soil. Long-term monitoring (LTM) will confirm effectiveness of the source controls and MNR. Effectiveness of ICs will be evaluated as part of the CERCLA 5-year review[2] process. *Compliance with ARARs:* ***Moderate to High*** - Chemical-specific ARARs will be achieved over time (in the long term) by natural recovery processes.	*Administrative Feasibility:* ***Moderate to High*** - ICs/LUCs will require preparation of an Institutional Control Implementation and Assurance Plan (ICIAP), and approval by the A/Ts. ICs also may require cooperation from private landowners adjacent to the Site. MNR has few administrative requirements but may require predesign/design study, approval of the LTM plan and periodic data evaluations. *Technical Feasibility:* ***High*** - ICs/LUCs are relatively easy to implement and monitor. - Natural recovery is relatively easy to implement, monitor, and evaluate.	***Low***	***No –*** *Alternative 2 is similar to Alternative 3 (both using MNR) but is less protective than Alternative 3, because it doesn't retain contaminated sediment near the source areas which is a component of Alternative 3 (i.e., sediment traps).*

TABLE 2-3

INITIAL SCREENING OF ASSEMBLED ALTERNATIVES FOR SEDIMENT/RIPARIAN SOIL
FEASIBILITY STUDY TECHNICAL MEMORANDUM #2
P4 Production LLC, Ballard Mine
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Alternative Number/Name	Alternative Description[1]	Effectiveness	Implementability	Cost	Retain for Detailed Analysis?
Alternative 3 - Sediment Traps/Basins, MNR, ICs, and LUCs, in conjunction with source controls in the upland soil/waste rock	Sediment traps/basins would be installed in the upper reaches of the mine-affected drainages, where the highest concentrations of COCs/COECs are detected in sediment/riparian soil. The basins (installed at the lowest elevation of the upper reaches) will capture mine-affected sediment entrained in the intermittent stream flow. Sediment in these traps will be cleaned out periodically and disposed of with the other mine wastes under the upland soil/waste rock cover system during the RA or in an on-Site landfill post-RA. MNR will be implemented as described in Alternative 2 for the lower reaches of the mine-affected drainages where COC/COEC concentrations are lower. ICs and LUCs also will be implemented as described in Alternative 2 for all mine-affected reaches of the drainages until cleanup levels are achieved.	*Protective of Human Health and the Environment?* ***Moderate to High*** - ICs/LUCs will limit human and some wildlife from contacting the affected media. - Sediment trap/basins will prevent downslope migration of the most highly contaminated sediment located near the perimeter of the mined area. *Reduces Toxicity, Mobility, or Volume?* ***Moderate*** - The most contaminated sediment closer to the mined area will be captured by the installed traps during storm events and removed and disposed (volume and mobility is reduced). The downstream distribution of additional contaminated sediment/riparian soil from upland soil/waste rock also will be prevented or reduced by cover systems. Lesser contaminated sediment/riparian soil further from the mined area will naturally disperse/mix and be buried/isolated over time. *Short-Term Effectiveness:* ***Moderate*** - ICs and LUCs will be effective immediately, but sediment capture and removal via traps/basins, and MNR are long-term processes. - Site risks will remain for trespassers during remedy implementation. - Periodic removal and disposal of contaminated sediment in the traps/basins could present slight risks to Site workers. Risks can be mitigated using standard health and safety protocols (i.e., use of personal protective equipment). *Long-Term Effectiveness:* ***High*** - ICs and LUCs will remain in place until cleanup levels are achieved. Sediment traps typically are effective in capture of mine-affected sediment, but sediment capture success depends on the location of the traps and size and frequency of precipitation events. MNR will act to reduce COC/COEC concentrations over time. The cover system that isolates the upland soil/waste rock from the environment will prevent the source of contaminated sediment/riparian soil to the drainages and the potential for re-contamination of the downstream areas. *Compliance with ARARs:* ***High*** - Active remedial activities in the intermittent drainages may require substantive compliance requirements with location- and action-specific ARARs (e.g., Idaho stream channel alteration rules).	*Administrative Feasibility:* ***High*** - The administrative feasibility of ICs and MNR is as described in Alternative 2. Periodic handling and disposal of the accumulated sediment in the traps/basins may be administratively challenging because their disposal likely will require substantive compliance with permitting post-RA for disposal in an on-Site landfill (after the upland soil/waste rock is consolidated and covered). If this wasn't possible, off-Site disposal at an appropriate facility will be necessary. *Technical Feasibility:* ***High*** - Sediment traps/basins are relatively easy to construct with conventional excavation equipment, and are relatively easy to inspect and maintain. - ICs are relatively easy to implement and monitor. - Natural recovery is relatively easy to implement, monitor, and evaluate.	***Low***	***Yes*** *– Alternative 3 is more protective than Alternative 2 and presents minor additional administrative burden and capital costs to operate and maintain sediment traps/basins and to handle and dispose of accumulated sediment/ riparian soil either on- or off-Site over the long term.*
Alternative 4 - Removal and On-Site Disposal, MNR, ICs, and LUCs, in conjunction with source controls in the upland soil/waste rock	Sediment/riparian soil (and all associated vegetation) in the upper reaches of the mine-affected drainages, where the highest concentrations of COCs/COECs are detected, will be excavated, transported, and consolidated with the upland soil/waste rock, then covered. MNR, ICs, and LUCs will be implemented as described in Alternative 2 for sediment/riparian soil that is not removed in the lower reaches of the mine-affected drainages where	*Protective of Human Health and the Environment?* ***Moderate to High*** - Most highly contaminated media closer to the mined area will be removed; and ICs/LUCs will be established to limit human and some wildlife contact with lesser contaminated media left in place further from the mined area while MNR is occurring. *Reduces Toxicity, Mobility, or Volume?* ***Moderate to High*** - Most highly contaminated media closer to the mined area will be removed (volume and mobility is reduced). Lesser contaminated sediment/riparian soil further from the mined area will naturally disperse over time. The downstream distribution of additional contaminated sediment/riparian soil from the upland areas also will be eliminated by capping, thereby reducing the mobility and volume of additional sediment/riparian soil. *Short-Term Effectiveness:* ***Low to Moderate*** - Cleanup levels will be achieved relatively quickly where most highly contaminated media closer to the mined area is removed; ICs/LUCs for lesser contaminated media will be implemented over a relatively short time period. However, removal activities will significantly disturb the riparian corridors (and associated wetlands and wildlife/ecological habitat) until the vegetation and habitat can be reestablished.	*Administrative Feasibility:* ***Moderate to High*** - The administrative feasibility of ICs/LUCs and MNR is as described in Alternative 2. There will be little to no extra administrative requirements to transport and combine the excavated sediment/riparian soil with the upland soil/waste rock during the consolidation and capping activities in the mined area. There could be substantive compliance requirements for wetland mitigation associated with sediment/riparian soil	***High***	***Yes –*** *Alternative 4 is more costly than the other alternatives but mine affected sediment/ riparian soil are excavated and consolidated with the other mine wastes then covered which immediately*

TABLE 2-3

INITIAL SCREENING OF ASSEMBLED ALTERNATIVES FOR SEDIMENT/RIPARIAN SOIL
FEASIBILITY STUDY TECHNICAL MEMORANDUM #2
P4 Production LLC, Ballard Mine
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Alternative Number/Name	Alternative Description[1]	Effectiveness	Implementability	Cost	Retain for Detailed Analysis?
Alternative 4 - Removal and On-Site Disposal, MNR, ICs, and LUCs, in conjunction with source controls in the upland soil/waste rock (Continued)	COC/COEC concentrations are lower.	- Risk of exposure to remediation workers to site contaminants during removal and consolidation activities. Risks can be mitigated using standard health and safety protocols (i.e., use of personal protective equipment). - Site risks to trespassers will remain where lesser contaminated media is not excavated until MNR occurs. *Long-Term Effectiveness:* ***High*** - Removal of the most highly contaminated media closer to the mine is a permanent remedy especially with the cover system in place to prevent a continuing source of contaminated sediment/riparian soil. MNR will act to reduce COC/COEC concentrations over time. The cover system that isolates the upland soil/waste rock from the environment will prevent contaminated sediment/riparian soil to the drainages and the potential for re-contamination of the downstream areas. *Compliance with ARARs:* ***Moderate*** - Active remedial activities in the intermittent drainages may require substantive requirements with location- and action-specific ARARs (e.g., Idaho stream channel alteration rules).	removal in the upper reaches of some of the mine drainages. *Technical Feasibility:* ***High*** - Sediment/riparian soil excavation and reclamation of excavated areas are relatively easy to implement. - These areas will require O&M while vegetation is reestablished but the equipment and procedures are readily available well understood. - ICs/LUCs are relatively easy to implement and monitor. - Natural recovery is relatively easy to implement, monitor, and evaluate.		*removes them from direct contact with human and ecological receptors.*

1 With the exception of the No-Action alternative, all assembled remedial alternatives for sediment/riparian soil rely on source controls in the upland soil/waste rock (i.e., the mined area) to prevent or reduce migration of COCs/COECs from the upland soil/ waste rock to downstream sediment/riparian soil.

2 Section 121 of CERCLA, as amended by SARA, requires that remedial actions which result in any hazardous substances, pollutants, or contaminants remaining at the site be subject to a five-year review. The NCP further provides that remedial actions which result in any hazardous substances, pollutants, or contaminants remaining at the site above levels that allow for unlimited use and unrestricted exposure be reviewed every five years to ensure protection of human health and the environment.

3 Institutional controls (ICs) are non-engineered instruments, such as administrative and legal controls, that help to minimize the potential for exposure to contamination and/or protect the integrity of a response action (e.g., government controls, proprietary controls, enforcement tools, and informational tools).

4 Land Use Controls (LUCs) are engineering controls (e.g., fencing signage, and other physical barriers) that limit human and in some cases ecological exposures. Although EPA considers ICs to be a subset of LUCs, for clarity, this FS document distinguishes ICs to be non-engineered instruments and LUCs to be engineered controls.

TABLE 2-4

INITIAL SCREENING OF ASSEMBLED ALTERNATIVES FOR GROUNDWATER
FEASIBILITY STUDY TECHNICAL MEMORANDUM #2
P4 Production LLC, Ballard Mine
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Alternative Number/Name	Alternative Description[1]	Effectiveness	Implementability	Relative Cost	Retain for Detailed Analysis?
Alternative 1 - No Action	The No-Action alternative would leave the Site and its groundwater in its existing condition.	*Protective of Human Health and the Environment?* ***Low*** - No actions would occur to prevent human/wildlife contact with affected groundwater. *Reduces Toxicity, Mobility, or Volume?* ***Low*** - With no source controls in the upland soil/waste rock, COCs would continue to migrate to the alluvial and Wells Formation groundwater. Short-Term Effectiveness: ***Low*** Long-Term Effectiveness: ***Low*** *Compliance with ARARs:* ***Low*** - With no source controls in the upland soil/waste rock, COCs in groundwater would continue to exceed the chemical-specific ARARs indefinitely.	*Administrative Feasibility:* ***High*** - No associated administrative requirements other than the CERCLA 5-year review[2]. *Technical Feasibility:* ***High*** - No remedial actions to implement.	***Low***	***Yes*** *- The No-Action alternative is not applicable to any of the groundwater remediation areas, but is retained as required by the NCP.*
Alternative 2 – Monitored Natural Attenuation (MNA) and Institutional Controls (ICs)[3], in conjunction with source controls in the upland soil/waste rock	This alternative includes MNA, which relies on natural attenuation processes to reduce COC concentrations in the Site groundwater over time. In order for MNA to be successful in groundwater, source controls would be implemented in the upland soil/waste rock to prevent or reduce migration of COCs to groundwater. MNA also would require ICs to restrict groundwater use until the cleanup levels are achieved.	*Protective of Human Health and the Environment?* ***Moderate*** - ICs would restrict human contact with the mine-affected groundwater until cleanup levels are achieved. *Reduces Toxicity, Mobility, or Volume?* ***Moderate*** - Without an ongoing source of COCs, natural processes (e.g., sorption, chemical transformation) would cause the COCs in the groundwater to attenuate over time, ultimately resulting in COC concentrations that do not pose unacceptable risks. As a whole, this alternative effectively reduces the toxicity, mobility, and volume of COCs/COECs in groundwater over time. *Short-Term Effectiveness:* ***Low to Moderate*** - ICs would be effective immediately to restrict human contact and would remain in place until cleanup levels are achieved. Natural attenuation to reduce COC concentrations is a long-term process (e.g., potentially decades for complete plume remediation). The effectiveness of natural attenuation processes would need to be demonstrated per USEPA guidance (EPA, 2015). - Exposure risk would remain to trespassers where mine-affected groundwater discharges to ground surface at seeps/springs until cleanup levels are achieved. *Long-Term Effectiveness:* ***Moderate to High*** - Source controls in the mined area would reduce potential for re-contamination of the groundwater. Natural attenuation would reduce COC concentrations over time and long- term monitoring (LTM) would confirm MNA effectiveness. Effectiveness of ICs would be evaluated as part of the CERCLA 5-year review[2] process. *Compliance with ARARs:* ***Moderate to High*** - Chemical-specific ARARs would be achieved in the long term through source controls in the upland soil/waste rock and by the natural attenuation processes. MNA is a passive remedial action that does not trigger any location- or action-specific ARARs.	*Administrative Feasibility:* ***High*** - ICs would require preparation of an Institutional Control Implementation and Assurance Plan (ICIAP), and approval by the A/Ts. ICs also may require cooperation from private landowners adjacent to the Site. MNA has no administrative requirements other than approval of predesign/design studies, the LTM plan and periodic data evaluations. *Technical Feasibility:* ***High*** - ICs are relatively easy to implement and monitor. - Natural recovery (i.e., MNA) is proven and relatively easy to implement, monitor, and evaluate. - Treatability studies may be required to identify the Site-specific natural attenuation mechanisms and to estimate cleanup timeframes.	***Low***	***Yes*** *– Alternative 2 has moderate to high effectiveness and implementability. In addition, MNA and ICs do not provide the technical challenges of in-situ or ex-situ treatment and it has a low costs.*

TABLE 2-4

INITIAL SCREENING OF ASSEMBLED ALTERNATIVES FOR GROUNDWATER
FEASIBILITY STUDY TECHNICAL MEMORANDUM #2
P4 Production LLC, Ballard Mine
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Alternative Number/Name	Alternative Description[1]	Effectiveness	Implementability	Relative Cost	Retain for Detailed Analysis?
Alternative 3 – Limited Permeable Reactive Barrier (PRB) Treatment of Alluvial Groundwater, MNA, and ICs, in conjunction with source controls in the upland soil/waste rock	MNA (with source controls) and ICs would be implemented as in Alternative 2, and PRB treatment would be implemented upgradient of select perennial seeps/springs to treat alluvial groundwater before it discharges at the seep/spring. PRBs may be constructed utilizing inorganic, biological, or a combination of reactive reagents. In some cases, where the affected alluvial groundwater is excessively deep, extraction wells may supplement the system and would discharge to the PRB. The Wells Formation groundwater would be addressed by MNA alone as a PRB is not feasible for this area due to the depth to groundwater.	*Protective of Human Health and the Environment?* ***Moderate to High*** ICs would restrict human contact with the affected groundwater until cleanup levels are achieved. Mine-affected alluvial groundwater would be treated by PRBs before it discharges to the ground surface at the perennial seeps/springs where there are complete exposure pathways to human and ecological receptors. *Reduces Toxicity, Mobility, or Volume?* ***Moderate (MNA) to High (PRBs)*** - PRB treatment just upgradient of where alluvial groundwater discharges to the perennial seeps/springs would reduce COCs toxicity, mobility, and volume over time, and would reduce COC/COEC transport to surface water. - MNA should effectively reduce COC concentrations in other areas of the alluvial and Wells Formation groundwater plumes after source controls are implemented in the upland soil/waste rock (i.e., a cover system). - As a whole, this alternative effectively reduces the toxicity, mobility, and volume of COCs in groundwater. *Short-Term Effectiveness:* ***High*** - ICs would be effective immediately to restrict human contact; groundwater that passes through the PRBs would be treated relatively quickly (dependent on hydraulic conductivity and treatment efficiencies); MNA for untreated portions of the alluvial and Wells Formation groundwater plumes is a long-term processes (e.g., decades). - Installation of the PRBs could present short-term risks to site workers. Risks can be mitigated using standard health and safety protocols (i.e., use of personal protective equipment). *Long-Term Effectiveness:* ***Moderate to High*** - Capping of the upland soil/waste rock would reduce potential for re-contamination of the shallow and deep groundwater. LTM would confirm MNA and PRB effectiveness. Effectiveness of ICs would be evaluated as part of the CERCLA 5-year review[2] process. *Compliance with ARARs:* ***High*** - Chemical-specific ARARs would be achieved over time as a result of source controls in the upland soil/waste rock, PRB treatment up gradient of select seeps/springs, and MNA. It is anticipated that the PRB component of this alternative can be designed and implemented to substantively comply with location- and action-specific ARARs.	*Administrative Feasibility:* ***High*** - The administrative feasibility of ICs and MNA is as described in Alternative 2. - Administrative feasibility of PRBs is relatively straightforward. *Technical Feasibility:* ***Moderate to High*** - The technical feasibility of ICs and MNA is as described in Alternative 2. - PRBs for shallow alluvial groundwater remediation are relatively easy to install, monitor, operate, and maintain. However, PRBs are susceptible to long-term (i.e., over 5 to 10 years) fouling due to precipitation of minerals or biofouling. This becomes less of an issue assuming source controls and MNA are effective. - It is assumed that the PRB would be constructed with zero-valent iron; other media such as biological materials (hay, woodchips, and sand) could be evaluated during the RD. The treatment media placed in the PRBs would have permeability appropriate for the hydraulic conductivity of surrounding material and with an adequate retention time to treat the intended contaminants to acceptable standards.	***Moderate to High***	***Yes –*** *Alternative 3 is more protective than Alternative 2. It presents additional administrative and technical burden and capital costs associated with PRBs. However, it reduces the toxicity, mobility, and volume of high concentrations in groundwater near seeps/springs*

TABLE 2-4

INITIAL SCREENING OF ASSEMBLED ALTERNATIVES FOR GROUNDWATER
FEASIBILITY STUDY TECHNICAL MEMORANDUM #2
P4 Production LLC, Ballard Mine
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Alternative Number/Name	Alternative Description[1]	Effectiveness	Implementability	Relative Cost	Retain for Detailed Analysis?
Alternative 4 – In-Situ Treatment of Alluvial Plumes by Injection, MNA, and ICs, in conjunction with source controls in the upland soil/waste rock	Alluvial groundwater plumes on the eastern and western flanks of the former mined area would be treated via in-situ injection of chemical or biologic reagents. MNA would be implemented in the Wells Formation aquifer because monitoring reagent dispersion in the Wells Formation would be very difficult due to stratigraphic and structural complexity. ICs would be implemented for all mine-affected groundwater to restrict use until cleanup levels are achieved.	*Protective of Human Health and the Environment?* ***High*** - Mine-affected groundwater would be treated in the alluvial aquifer and allowed to naturally attenuate in the Wells Formation. ICs would restrict human contact with the affected groundwater until cleanup levels are achieved. *Reduces Toxicity, Mobility, or Volume?* ***Low to Moderate*** - Injected reagent would treat the COCs in alluvial groundwater it contacts to below cleanup levels in-situ thereby reducing the toxicity, mobility, and volume of contaminants in alluvial groundwater. However, treatment efficiency is highly dependent on the ability to disperse the reagent in the aquifer matrix. It may be difficult or impossible to achieve complete remediation of the COCs in zones of low hydraulic conductivity or low permeability (e.g., clay zones) as are encountered in the shallow alluvial aquifer surrounding the Site. After initial achievement of the cleanup levels, COC concentrations could rebound as COCs desorb from low-permeability silts and clays in the aquifer matrix. In addition, the potential re-release of retained contaminants without reinjection of reagents is a consideration. - MNA should effectively reduce COC concentrations in the Wells Formation groundwater after the cover system is constructed over the upland soil/waste rock. *Short-Term Effectiveness:* ***Moderate*** - ICs would be effective immediately and would remain in place until cleanup levels are achieved. - Short-term effectiveness would be dependent upon the ability of reagents to disperse in the alluvial aquifer. However, short-term effectiveness would be greater than MNA alone. - Multiple reagent injections may be required to adequately disperse the reagent in the alluvial aquifer matrix, and to address potential rebound of COC concentrations. - MNA for the untreated portions of the Wells Formation groundwater plumes is a long-term process (e.g., decades). - Risks to remedial action site workers can be mitigated using standard health and safety protocols (i.e., use of personal protective equipment). *Long-Term Effectiveness:* ***High*** - Source controls (i.e., cover system) in the mined area would minimize potential for re-contamination of the shallow and deep groundwater. After initial achievement of the cleanup levels in the alluvial aquifer following in-situ treatment, COC concentrations could rebound as COCs desorb from low-permeability silts and clays in the aquifer matrix. Ultimately, long-term effectiveness should be similar to MNA. *Compliance with ARARs:* ***High*** - Treating alluvial groundwater before it discharges to seeps/springs meets the Idaho non-degradation ARAR. It is anticipated that the GW recovery and treatment component of this alternative can be designed to substantively comply with location- and action-specific ARARs.	*Administrative Feasibility:* ***Moderate*** - The administrative feasibility of ICs and MNA is as described in Alternative 2. In-situ treatment is a relatively common remedial action for groundwater, but would require A/T approval. *Technical Feasibility:* ***Low to Moderate*** - The technical feasibility of ICs and MNA is as described in Alternative 2. - Injection of reagents into the shallow alluvial groundwater would be relatively easy to implement with little operation and maintenance requirements other than monitoring to evaluate effectiveness. - It is assumed that the reagent used to treat the alluvial groundwater would be calcium polysulfide, but treatability testing could indicate that another reagent or biological treatment is more effective and/or implementable. The reagent would be applied on a grid pattern using direct-push drilling and possibly permanent well installation. - In addition to identifying appropriate reagents, treatability studies may need to include extensive hydraulic conductivity testing to confirm reagents would effectively disperse into the alluvial aquifer. Alluvium at the Site are known to have clay beds where it would be difficult or impossible to disperse reagent. - Most significant technical challenge would be achieving adequate dispersion in the interbedded, lower permeability (heterogeneous) sediment encountered in the shallow aquifer surrounding the Site.	***Moderate***	***No –*** *Likely would not be effective at reducing the toxicity, mobility, and volume of contaminants other than in limited areas due to the relatively low permeability of the alluvial unit and the heterogeneity of the shallow alluvial aquifer.*
Alternative 5a – Groundwater Recovery and Treatment of Wells Formation Groundwater, MNA (Alluvial GW), and ICs, in conjunction with source controls in the upland soil/waste rock	Groundwater would be extracted from the Wells Formation in the vicinity of the West Ballard Pit, treated using a physical (including membrane technology), chemical, or biological treatment system (either alone or in combination), and then infiltrated back to the West Ballard Mine Pit. This in effect is aquifer flushing. If source controls (waste rock consolidation) result in the bottom of the pit not being accessible, then infiltration wells	*Protective of Human Health and the Environment?* ***Moderate to High*** - Mine-affected groundwater would be extracted and treated in the Wells Formation and allowed to naturally attenuate in the alluvial aquifer. The geologic complexity of the Wells Formation likely would result in low efficiency in extracting mine-affected groundwater. ICs would restrict human contact with the affected groundwater until cleanup levels are achieved. *Reduces Toxicity, Mobility, or Volume?* ***Moderate (MNA); Moderate (extraction and treatment)*** - COCs in the extracted groundwater would be treated to below the cleanup levels before being infiltrated back into the aquifer thereby reducing the toxicity and volume of contaminants.	*Administrative Feasibility:* ***Moderate*** - The administrative feasibility of ICs and MNA is as described in Alternative 2. Groundwater extraction and treatment is a relatively common remedial action for groundwater, but would require A/T approval. *Technical Feasibility:* ***Low***	***Very High***	***No –*** *Low/Moderate effectiveness and technical feasibility with High cost. Components of this alternative are retained in Alternative 5b.*

TABLE 2-4

INITIAL SCREENING OF ASSEMBLED ALTERNATIVES FOR GROUNDWATER
FEASIBILITY STUDY TECHNICAL MEMORANDUM #2
P4 Production LLC, Ballard Mine
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Alternative Number/Name	Alternative Description[1]	Effectiveness	Implementability	Relative Cost	Retain for Detailed Analysis?
Alternative 5a – Groundwater Recovery and Treatment of Wells Formation Groundwater, MNA (Alluvial GW), and ICs, in conjunction with source controls in the upland soil/waste rock (continued)	drilled through backfill into the bottom of the pit may be needed. MNA would be implemented for the mine-affected alluvial groundwater, and ICs would be implemented to restrict groundwater use until cleanup levels are achieved.	- Groundwater extraction would create a hydraulic cone-of-depression that would prevent or reduce downgradient migration of COCs. However, recovery of the entire volume of mine-affected groundwater is unlikely. - MNA should effectively reduce COC concentrations in the alluvial aquifer over time after the cover system is constructed over the upland soil/waste rock. *Short-Term Effectiveness:* ***Low to Moderate*** - ICs would be effective immediately and would remain in place until cleanup levels are achieved. - MNA for the untreated portions of the alluvial aquifer groundwater plumes and residual contamination in the Wells Formation is a long-term process (e.g., decades). - Installation of a recovery well system is likely to have low to moderate effectiveness because of the geologic complexity (i.e., structural and heterogeneity) and depth of the Wells Formation aquifer. - Installation of the extraction wells and construction of a water treatment plant (WTP) could present risks to site workers in the short term. Risks can be mitigated using standard health and safety protocols (i.e., use of personal protective equipment). *Long-Term Effectiveness:* ***Low to Moderate*** - Source controls (i.e., cover system) in the mined area would minimize potential for re-contamination of the shallow and deep groundwater. After initial achievement of the cleanup levels in the Wells Formation following extraction and treatment, COC concentrations could rebound as COCs diffuse from low-permeability zones in the aquifer matrix. Likely long term effectiveness would be similar to MNA. - Extracted groundwater from the Wells Formation would meet cleanup goals upon treatment. However, extraction and treatment of all mine-affected groundwater in the Wells Formation likely would take several years to decades and may not be practicable. Infiltrating the treated water to flush the aquifer could reduce the timeframe to reach the cleanup levels. Potential challenges to successfully reaching the cleanup levels include preferential conductivity in the aquifer matrix and rebound of COC concentrations as COCs diffuse from the aquifer matrix, which may result in asymptotic concentrations trends typical of pump-and-treat systems. The result is that achievement of cleanup levels may be longer than anticipated and ultimately only marginally faster than MNA. - However, over the long term an ex-situ treatment system is difficult to adapt to changing water conditions (i.e., specifically the quantity and quality). This could cause a redesign of the water treatment system. *Compliance with ARARs:* ***Moderate to High*** - Treating mine-affected groundwater complies with chemical-specific ARARs. However, complete recovery of groundwater containing concentrations exceeding ARARs likely is not practicable. It is anticipated that the GW recovery and treatment component of this alternative can be designed to substantively comply with location- and action-specific ARARs.	- The technical feasibility of ICs and MNA is as described in Alternative 2. - The extraction and treatment system would require design, construction, and O&M of pumping wells, the treatment system, and the infiltration gallery or wells. - Aquifer tests are required to design the extraction wells and infiltration gallery/wells, and treatability studies likely would be necessary to determine the optimal treatment technology for the extracted groundwater. - Designing a system to treat flows that may change in volume and concentration of COCs/COECs with time would be challenging. - A program for treatment residuals like sludge solids would be required. - Literature research and treatability studies would be required to optimize the design and operation of the water treatment process and facility. - Practicable recovery of all Wells Formation groundwater is not likely practicable or feasibly demonstrated.		*Ultimately unlikely to be more effective than MNA or PRB treatment at reducing risk and at a much higher costs because of the geologic complexity and depth of the Wells Formation aquifer.*

TABLE 2-4

INITIAL SCREENING OF ASSEMBLED ALTERNATIVES FOR GROUNDWATER
FEASIBILITY STUDY TECHNICAL MEMORANDUM #2
P4 Production LLC, Ballard Mine
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Alternative Number/Name	Alternative Description[1]	Effectiveness	Implementability	Relative Cost	Retain for Detailed Analysis?
Alternative 5b – Groundwater Recovery and Treatment of both Alluvial and Wells Formation Groundwater, and ICs, in conjunction with source controls in the upland soil/waste rock	Same as Alternative 5a, but includes extraction and treatment of all mine-affected groundwater including the alluvial in addition to the Wells Formation groundwater as under Alternative 5a. It is assumed that extraction trenches would be used to extract mine-affected alluvial groundwater both upgradient of the perennial seeps/springs and on the east and west sides of the Site in appropriate downgradient locations. Extraction wells would be used to remove groundwater from the Wells Formation. The extracted groundwater would be treated using a physical (including membrane technology), chemical, or biological treatment system (either alone or in combination). Extracted and treated water from the Wells Formation would be infiltrated back into the Wells Formation through a constructed pond in the West Ballard Pit (MMP035) or if source controls (waste rock consolidation) result in the bottom of the pit not being accessible, then infiltration wells drilled through the backfill into the bottom of the pit may be needed to return treated water to the Wells Fm. Extracted and treated water from the alluvial aquifer would be discharged to a constructed basin and allowed to infiltrate back into the alluvial aquifer.	Same as Alternative 5a, except complete recovery of groundwater for the alluvial system would be necessary under this alternative and difficult because of the relatively low permeability of the unit and the heterogeneity of the aquifer. A limited number of extraction wells could be needed in areas of deep alluvium.	Similar to Alternative 5a but additional administrative and technical feasibility considerations include: - More than 5,000 linear feet of extraction trenches would be required for capture and extraction of the alluvial groundwater near the source areas and a significantly higher number if complete recovery of the alluvial plumes is considered. - If locations where contaminated groundwater is deeper than common trench depth, then a limited number of extraction wells could be utilized. It is expected that any such areas would be very limited in extent. - Locations for evaporation and infiltration would have to be identified. If infiltrated to the Wells Formation in a backfilled mine pit, wells placed through the backfill may need to be utilized if the selected pit(s) have been backfilled.	***Very High***	***Yes*** *– Although this alternative has low effectiveness and technical feasibility (implementability) and has high cost, it is retained so that a full range of alternatives are included in the Detailed Analysis step of the FS as requested by the A/Ts. In addition, this alternative extracts and treats water from both the alluvial and Wells Formation groundwater systems so it could be viewed as more protective than Alternative 5a.*

1 With the exception of the No-Action alternative, all assembled remedial alternatives for groundwater rely on source controls in the upland soil/waste rock (i.e., the mined area) to prevent or reduce the migration of COCs from the upland soil/waste rock and exposed ore sections to groundwater.

2 Section 121 of CERCLA, as amended by SARA, requires that remedial actions which result in any hazardous substances, pollutants, or contaminants remaining at the site be subject to a five-year review. The NCP further provides that remedial actions which result in any hazardous substances, pollutants, or contaminants remaining at the site above levels that allow for unlimited use and unrestricted exposure be reviewed every five years to ensure protection of human health and the environment.

3 Institutional controls (ICs) are non-engineered instruments, such as administrative and legal controls, that help to minimize the potential for exposure to contamination and/or protect the integrity of a response action (e.g., government controls, proprietary controls, enforcement tools, and informational tools).

TABLE 3-1a
DETAILED AND COMPARATIVE ANALYSES - UPLAND SOIL/WASTE ROCK REMEDIAL ALTERNATIVES
FEASIBILITY STUDY TECHNICAL MEMORANDUM #2
P4 Production LLC, Ballard Mine

USEPA Evaluation Criteria	**Alternative 1 (see Figure 3-1)** **No Action** *The No Action alternative does not include any remedial action, long-term monitoring (LTM), or administrative or engineering controls.*	**Alternative 4 (see Figures 3-2a and 3-2b)** **Upland Soil/Waste Rock Grading and Consolidation with a Evapotranspiration (ET) Cover System, Institutional Controls (ICs)[1], Land Use Controls (LUCs)[2], and Operation and Maintenance (O&M)/ LTM** *Under this alternative portion of the upland soil/waste rock dumps throughout the Site would be excavated and consolidated in the on-Site pits to cover any exposed ore beds, or graded/contours in-place to at 3:1 slopes. The new upland soil/waste rock surface both inside and outside of the mine pits would be capped with an ET cover. LTM/O&M would be necessary to inspect the cover for plants that are incompatible with the selected cover system and to repair any stormwater erosion that might occur. ICs and LUCs would be implemented to restrict activities that could disturb the covered waste rock.*	**Alternative 6 (see Figures 3-3a through 3-3c)** **Upland Soil/Waste Rock Grading and Consolidation, Incidental Ore Recovery, ET Cover System, 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.*	**Alternative 7 (see Figure 3-4)** **Complete Consolidation of Existing Upland Soil/Waste Rock into the Pits, ET Cover System, ICs, LUCs, and O&M/LTM** *Under this alternative, all upland soil/waste rock lying outside the existing mine pits would be excavated and consolidated in the existing pits to backfill the existing pits and to cover any exposed ore beds, then graded/contoured to create 3:1 slopes. The upland soil/waste rock surfaces in the pits and the areas underlying the former upland soil/waste rock would be capped with the ET cover as described in Alternative 4 and graded to shed stormwater away from the source area.*
1) Overall Protection of Human Health and the Environment				
1A) Detailed Analysis	***Low***	***High***	***High***	***High***
How Alternative Provides Human Health and Environmental Protection	No remedial actions, ICs, or LUCs would be performed or implemented at the Site to reduce or prevent exposure pathways. As a result, the No Action alternative is not considered protective of human health and the environment.	Regrading, consolidation, and capping of the upland soil/waste rock areas both outside and in some cases inside the existing pits would: 1) prevent future human/wildlife contact with the upland soil/waste rock/exposed ore beds, and 2) isolate the waste rock so that it would substantially reduce the transfer of COCs/COECs to surface water, sediment/riparian soil, and groundwater. The Meade Peak Member of the Phosphoria Formation would be covered then capped under this alternative. The graded upland soil/waste rock surfaces in the pits and the areas underlying the former upland soil/waste rock would be graded as necessary and capped. The ET covers on waste rock areas inside and outside the pits would be constructed from uncontaminated earthen materials. The seed mixes and resulting vegetation types would be selected to form extensive root systems to limit erosion, to slow stormwater and snowmelt movement off the cap, to transpire water that infiltrates and accumulates in the upper layers of the cover system, and to penetrate the upper cap soil but not into the underlying waste rock. Remediation of mine-affected seeps/springs found in the upland soil/waste rock area are discussed under the surface water tables and not in this section. ICs/LUCs would restrict activities that could disturb the completed covered surfaces and LTM would ensure that the cover systems are in place and viable for the foreseeable future.	Same as Alternative 4 with regard to grading, consolidation, and capping of upland soil/waste rock and implementation of ICs/LUCs and LTM. Ore recovery prevents direct contact to exposed ore throughout the mined area. Alternative 6 allows for complete reworking of the mine affected area and results in a more comprehensive reclaimed landscape. Please note, remediation of mine-affected seeps/springs found in the upland soil/waste rock area are discussed under the surface water tables and not in this section.	All upland soil/waste rock lying outside the existing pits would be excavated and consolidated in the existing pits and the material would be placed to cover exposed ore beds. The graded upland soil/waste rock surfaces in the pits and the areas underlying the former upland soil/waste rock would be graded as necessary and capped with an ET cover system. The protectiveness of the consolidation and cover system would be the same as described above in Alternatives 4 and 6. Although the objective is to fill the existing pits, there is not sufficient volume in the existing waste rock dumps to completely backfill the mine pits to the pre-mine surface. However, there is sufficient volume of waste rock in the dumps to contour the sides of the existing pits crest to crest, to cover the exposed ore beds, and to create 3:1 maximum slopes and topography that directs any stormwater out of the pits and away from the source area
1B) Comparative Analysis	*Alternatives 4, 6, and 7 are all highly protective of human health and the environment as they prevent future human/wildlife contact with upland soil/waste rock/exposed ore beds and by isolating these materials under an ET Cover system and thereby preventing direct exposure and minimizing them as a source of COCs/COECs to downstream sediment/riparian soil, surface water, and groundwater. Although Alternative 7 results in all of the upland soil/waste rock being consolidated in the mine pits, the footprint of the cover system would be larger than Alternative 4 and similar to Alternative 6 because the areas underlying the upland soil/waste rock dumps are assumed to be impacted by migration of constituents from the waste rock dumps to the underlying soil and would have to be graded and covered after the waste rock is removed. The No Action alternative is not protective because it does not include any actions that would prevent human/wildlife contact with the waste rock, nor would it prevent the waste rock from contributing COCs/COECs to sediment/riparian soil, surface water and groundwater.*			

USEPA Evaluation Criteria	**Alternative 1 (see Figure 3-1)** **No Action** *The No Action alternative does not include any remedial action, long-term monitoring (LTM), or administrative or engineering controls.*	**Alternative 4 (see Figures 3-2a and 3-2b)** **Upland Soil/Waste Rock Grading and Consolidation with a Evapotranspiration (ET) Cover System, Institutional Controls (ICs)[1], Land Use Controls (LUCs)[2], and Operation and Maintenance (O&M)/ LTM** *Under this alternative portion of the upland soil/waste rock dumps throughout the Site would be excavated and consolidated in the on-Site pits to cover any exposed ore beds, or graded/contours in-place to at 3:1 slopes. The new upland soil/waste rock surface both inside and outside of the mine pits would be capped with an ET cover. LTM/O&M would be necessary to inspect the cover for plants that are incompatible with the selected cover system and to repair any stormwater erosion that might occur. ICs and LUCs would be implemented to restrict activities that could disturb the covered waste rock.*	**Alternative 6 (see Figures 3-3a through 3-3c)** **Upland Soil/Waste Rock Grading and Consolidation, Incidental Ore Recovery, ET Cover System, 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.*	**Alternative 7 (see Figure 3-4)** **Complete Consolidation of Existing Upland Soil/Waste Rock into the Pits, ET Cover System, ICs, LUCs, and O&M/LTM** *Under this alternative, all upland soil/waste rock lying outside the existing mine pits would be excavated and consolidated in the existing pits to backfill the existing pits and to cover any exposed ore beds, then graded/contoured to create 3:1 slopes. The upland soil/waste rock surfaces in the pits and the areas underlying the former upland soil/waste rock would be capped with the ET cover as described in Alternative 4 and graded to shed stormwater away from the source area.*
2) Compliance with ARARs				
2A) Detailed Analysis	***Low***	***High***	***High***	***High***
Chemical-Specific ARARs	Does not comply with chemical-specific ARARs	Complies with chemical-specific ARARs by isolating upland soil/waste rock and exposed ore under a cover system (direct exposure would be prevented and leaching would be reduced).	Same as Alternative 4.	Same as Alternatives 4 and 6.
Location- and Action- Specific ARARs	No Action would not trigger any location-or action-specific ARARs	It is anticipated that this alternative would be designed and implemented to comply with location-and action-specific ARARs. Compliance with ARARs intended to protect wetlands may be problematic depending on how existing ponds, seeps, and springs in the upland soil/waste rock areas are classified.	Same as Alternative 4. However, may be substantive compliance with mining regulations under CERCLA.	Same as Alternative 4.
2B) Comparative Analysis	*Alternatives 4, 6, and 7 comply with applicable ARARs and are effective in the long term so rank highly. The No Action alternative fails to comply with many of the ARARs.*			
3) Long-term Effectiveness and Permanence				
3A) Detailed Analysis	***Low***	***High***	***High***	***High***
Magnitude of residual risk	Existing Site risks would remain. 5-year reviews would be required in accordance with the NCP because COCs/COECs would remain at the site.	The ET cover systems are viable over the long term because they are made of earthen materials which are very durable and long lasting. Residual risks remain from the consolidated/capped upland soil/waste rock that would be left in-place. These risks would be mitigated by ICs/LUCs intended to protect the integrity of the ET covers. 5-year reviews would be necessary to verify that the remedy remains protective.	Same as Alternative 4, although recovery of the shallow exposed ore beds does to some extent reduce a potential long-term risk of COCs/COECs.	Under Alternative 7 all of the waste rock is consolidated in the pits, but a final cover will be necessary over the backfilled pits and in the areas outside of the existing pits where the waste rock was removed (because of potential leaching). As a result, the size of the covers for Alternatives 6 and 7 are similar and they have similar residual risks but those risks would be mitigated by ICs and LUCs similar to Alternative 4.
Adequacy and reliability of controls	No controls would be implemented. LTM would continue as required by the NCP.	Properly implemented ICs/LUCs should adequately restrict human activities that would compromise the integrity of the ET cover system. Long-term O&M/LTM would be required to determine if revegetation of the cover system has been successful, to inspect the cover for plants that are incompatible with the selected cover system (i.e., vegetation with roots that could penetrate the ET cover system) and to repair any areas on the cover where vegetation is inadequate or stormwater erosion has compromised the cover system. l.	Same as Alternative 4.	Same as Alternatives 4 and 6.

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3B) Comparative Analysis	*Alternatives 4, 6, and 7 have similar high long-term effectiveness and permanence rankings because of the use of ET covers with native, earthen materials, which have long-term viability and durability. If maintained, the covered surfaces should be very protective over the long-term. The No Action alternative does not address these evaluation criteria because it does not meet the response objectives or include controls. Please refer to the evaluation and selection of the appropriate cover system for all Site upland soil remedies in Appendix B.*			
4) Reduction of Toxicity, Mobility, or Volume Through Treatment				
4A) Detailed Analysis	***Low***	***Low to Moderate***	***Low to Moderate***	***Low to Moderate***
Treatment Process Used and Materials Treated	None.	None. This alternative relies on grading, consolidation, and capping of the upland soil/waste rock outside the mine pits, and the exposed Meade Peak Member (i.e., ore beds) inside the mine pits to: 1) prevent future direct contact of human/wildlife with these materials and 2) isolate these materials and reduce or prevent the transfer of COCs/COECs to surface water, sediment/riparian soil, and groundwater.	Same as Alternative 4, except that Meade Peak Member is removed through incidental ore recovery.	Same as Alternative 4.
Amount of Hazardous Materials Destroyed or Treated	None.	COCs/COECs would not be destroyed or treated.	Same as Alternative 4	Same as Alternative 4.
Degree of Expected Reductions in Toxicity, Mobility, and Volume	None.	The overall volume and toxicity of Site constituents would not be reduced. However, the mobility of COCs/COECs in upland soil/waste rock would be reduced through consolidation and capping.	Same as Alternative 4, except that Meade Peak Member is removed through incidental ore recovery.	Same as Alternative 4.
Degree to Which Treatment is Irreversible	No treatment is implemented.	COCs/COECs would not be treated. The isolation of the waste rock is irreversible to the extent that the completed ET cover systems are maintained.	Same as Alternative 4 except that the Meade Peak ore beds are removed and processed.	Same as Alternative 4.
Type and Quantity of Residuals Remaining After Treatment	No treatment is implemented.	COCs/COECs would not be treated - no treatment residuals would be generated.	Same as Alternative 4 except that additional waste rock would be generated during ore recovery that would be backfilled and covered.	Same as Alternative 4.
Statutory Preference for Treatment as a Principal Element	This alternative does not include treatment of COCs/COECs.	This alternative does not include treatment of COCs/COECs.	Same as Alternative 4.	Same as Alternative 4.
4B) Comparative Analysis	*Alternatives 4, 6, and 7 reduce the contaminant mobility in a similar way by isolating the waste rock and exposed ore beds to prevent direct contact and reduce migration of contaminants from the source area. However, none of the alternatives reduce the toxicity and volume of contamination through treatment because there is no treatment (low to moderate ranking). The No Action alternative would not treat the waste rock or otherwise reduce the volume or mobility of the COCs/COECs.*			

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5) Short-term Effectiveness				
5A) Detailed Analysis	***Low***	***Moderate to High***	***Moderate to High***	***Moderate to High***
Protection of Community During Remedial Actions	No remedial actions are implemented.	The community would be protected during the grading, consolidation, and capping of the upland soil/waste rock by employing industry-standard dust and stormwater best management practices (BMPs).	Same as Alternative 4 with additional considerations associated with transporting the extracted ore to the nearby P4 processing facility (e.g., dust control along the haul route, traffic plan).	Same as Alternative 4.
Protection of Workers During Remedial Actions	No remedial actions are implemented.	Workers would be protected during the grading, consolidation, and capping of the upland soil/waste rock by having HAZWOPER training, wearing appropriate PPE, and by following established health and safety procedures and protocols.	Same as Alternative 4 except that this alternative includes moving much more material during the RA.	Same as Alternative 6.
Environmental Impacts	Existing conditions not expected to change.	Potential adverse environmental impacts include dust generation and uncontrolled stormwater runoff during construction activities. These impacts would be mitigated using standard construction-related BMPs to control dust and stormwater. Surfaces would be graded and covers would be placed as quickly as possible over the exposed underlying surfaces and in pit backfill areas to limit exposure of fresh waste rock surfaces to the environment.	Potential adverse environmental impacts would be the same as Alternative 4. However, the positive environmental impacts associated with the incidental ore-recovery component of Alternative 6 include: • Recovering a resource before it becomes inaccessible after remediation • Removing existing ore would allow for the overall mine footprint to be capped in a more comprehensive manner. • Produces a portion of the necessary borrow material on-Site that is necessary to construct the ET cover system. Under this alternative, less borrow material maybe imported from off-Site sources resulting in reductions in greenhouse gas emissions. • Ore recovery at the Ballard Site delays future recovery of similar volumes of ore at other P4 mine areas. • Proximity of the Ballard Site to the P4 processing facility (as opposed to obtaining ore from another more distant	Same as Alternative 4.

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			new mine) reduces greenhouse gas emissions during the transport of ore.	
Time Until Remedial Objectives are Achieved	Remedial objectives would not be achieved.	Estimated duration to complete Alternative 4 is 3 to 5 years.	Estimated duration to complete Alternative 6 is 6 to 8 years.	Estimated duration to complete Alternative 7 is 5 to 7 years.
5B) Comparative Analysis	*Short-term Effectiveness. Short-term effectiveness is similar among Alternatives 4, 6, and 7, although Alternative 6 is slightly longer in duration and additional care would be necessary when transporting ore to Soda Springs for processing. However, over the short term, the environmental benefits of Alternative 6 are many including: 1) use of a resource before it becomes inaccessible and 2) ore recovery would produce, as a byproduct, a portion of the borrow material and additional waste rock that will be necessary to construct the cover system and backfill the Site. This would allow for a more comprehensive reclamation and would reduce greenhouse gas emissions because these materials are produced on-Site. Alternatives 4 and 7 would need to obtain clean borrow from other locations. Alternative 6 also delays future ore recovery in other areas mined by P4. The No Action alternative does not include any remedial activities that would have a short-term impact on the public or Site workers. However, the No Action alternative would not address the unacceptable risks over the short- or long-term.*			
6) Implementability				
6A) Detailed Analysis	***High***	***High***	***Moderate to High***	***Moderate to High***
Ability to Construct and Operate the Technology	No construction or operation and maintenance (O&M) activities are implemented.	Implementation of this alternative would require: • Additional geotechnical data is potentially necessary to support the remedial design components (e.g., borrow sources, cover design, etc.) • Remedial design of the earthworks activities (regrading, upland soil/waste rock consolidation, ET cover system, reclamation/revegetation plan). • Preparation of a RAWP containing LTM and O&M plans along with other plans to support the RA (e.g., the construction SWPPP). • Preparation of an Institutional Controls Implementation and Assurance Plan (ICIAP). • Phased earthworks construction (3 to 5 years). • Periodic O&M of the completed ET covers. The ET cover system can be easily constructed using readily available standard earthmoving equipment.	Same as Alternative 4 with additional design and construction activities related to the ore-recovery component of the remedy, including: • Likely designed in phases based on location of each ore body. • Traffic plan for hauling the recovered ore to the P4 processing plant in Soda Springs. • Phased earthworks construction (6 to 8 years).	Same as Alternative 4, but with additional excavation efforts to consolidate all upland soil/waste rock in the pits. • Phased earthworks construction (5 to 7 years).
Reliability of the Technology	No technology is implemented.	Properly designed and maintained ET caps are demonstrated to be reliable long term, particularly in semi-arid climates.	Same as Alternative 4.	Same as Alternatives 4 and 6.

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Ease of Undertaking Additional Remedial Action, if Necessary	No remedial action is implemented.	Although not anticipated, future remedial actions are feasible as the upland soil/waste rock would be consolidated and relatively accessible beneath the ET cap.	Same as Alternative 4.	Same as Alternatives 4 and 6.
Ability to Monitor Effectiveness of Remedy	No monitoring would occur.	Remedy effectiveness is easily demonstrated by downgradient surface water and groundwater monitoring to determine if COCs/COECs are reducing over time.	Same as Alternative 4.	Same as Alternatives 4 and 6.
Ability to Obtain Approvals From Other Agencies	Not applicable.	This alternative does not require approval from other agencies.	The ore-recovery component of this alternative may require approval from the BLM or a waiver of BLM requirements based on CERCLA's substantive compliance with NEPA process under BLM.	Same as Alternative 4.
Coordination with Other Agencies	Not applicable.	This alternative does not require coordination with other agencies.	The ore-recovery component of this alternative would require coordination with the BLM, at least in the short term to determine if the CERCLA regulations substantively comply with BLM NEPA requirements	Same as Alternative 4.
Availability of Treatment, Storage, and Disposal Services and Capacity	Not applicable.	The open pits at the Site have adequate capacity to store the consolidated upland soil/waste rock. No additional treatment or disposal services are needed with this remedy.	Same as Alternative 4.	Same as Alternatives 4 and 6.
Availability of Necessary Equipment and Specialists	None required.	Environmental construction contractors are readily available. Remedy construction would rely on readily available earthmoving equipment. P4 has trained staff and the necessary equipment to perform all aspects of upland soil/waste rock removal/consolidation and installation/maintenance of cover system.	Same as Alternative 4. P4 has trained staff and necessary equipment to perform all aspects of the remedial action including ore recovery and transportation and Site reclamation.	Same as Alternative 4.
Availability/Demonstrated Effectiveness of Prospective Technologies	None required.	Upland soil/waste rock consolidation and capping can be implemented relatively quickly and are known/reliable technologies/processes and are used widely in remediation project. ET covers are proven to be effective in semi-arid environments.	Ore recovery, upland soil/waste rock consolidation, and capping can be implemented relatively quickly and are known/reliable technologies/processes. ET covers are proven to be effective in semi-arid environments.	Same as Alternative 4.

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6B) Comparative Analysis	*Alternative 4 (ranking high) is easier to implement than Alternative 6 because the ore recovery component of Alternative 6 requires additional coordination with the BLM and other prominent A/T stakeholders. Alternative 4 also is easier to implement than Alternative 7 because the majority of the upland soil/waste rock would be graded and covered in place under Alternative 4, whereas all of the upland soil/waste rock would be excavated and consolidated in the mine pits under Alternative 7. Alternatives 6 and 7 likely would be similar to implement because of their large scale and are ranked moderately to highly implementable. The No Action alternative by its nature has high implementability, but is not protective of human health and the environment.*			
7) Cost				
7A) Detailed Analysis				
Total Present Worth Costs (30 year NPV)	**$108,000**	**$50,679,000**	**$147,897,000*25% = $36,974,000**[4]	**$113,121,000**
7B) Comparative Analysis	*Alternative 7 is by far the most expensive alternative with an estimated costs of $113.1M. Alternative 4 estimated cost is $50.7M, whereas the remediation portion of Alternative 6 under CERCLA is $37.0M. Alternative 6 is more cost effective than Alternative 4 because a certain portion of the work attributed to ore recovery in Alternative 6 also would contribute to the completion of the remedial action for the Site. Therefore, there is remedial cost benefit associated with integrating ore recovery in the RA. The No Action alternative has administrative costs and an estimated total cost of $108.0K.*			
8 and 9) State and Community Acceptance	To be evaluated after the public comment period.			

1 Institutional controls (ICs) are non-engineered instruments, such as administrative and legal controls, that help to minimize the potential for exposure to contamination and/or protect the integrity of a response action (e.g., government controls, proprietary controls, enforcement tools, and informational tools).

2 Land Use Controls (LUCs) are engineering controls (e.g., fencing signage, and other physical barriers) that limit human and in some cases ecological exposures. Although USEPA considers ICs to be a subset of LUCs, for clarity, this FS document distinguishes ICs to be non-engineered instruments and LUCs to be engineered controls.

3 Section 121 of CERCLA, as amended by SARA, requires that remedial actions which result in any hazardous substances, pollutants, or contaminants remaining at the site be subject to a five-year review. The National Oil and Hazardous Substances Pollution Contingency Plan (NCP) further provides that remedial actions which result in any hazardous substances, pollutants, or contaminants remaining at the site above levels that allow for unlimited use and unrestricted exposure be reviewed every five years to ensure protection of human health and the environment.

4 This cost is exclusively for remedial action activities and represents approx. 25% of the total cost to implement Alternative 6. As discussed in Section 3.0 and presented in Appendix A, the remaining 75% of the total cost for Alternative 6 is for ore recovery activities.

TABLE 3-1b
RECALCULATED WASTE ROCK DUMP AND PIT VOLUMES/AREAS
FEASIBILITY STUDY TECHNICAL MEMORANDUM #2
P4 Production LLC, Ballard Mine

	Revised 2016 Dump Volume	Revised 2016 Net Excavated Volume	Revised 2016 Areas Map Area	
	yd^3	yd^3	ft^2	acres
Dumps:				
MWD080	4,543,109		3,357,435	77.1
MWD081	4,050,346		2,095,206	48.1
MWD082	2,593,136		2,909,848	66.8
MWD083	494,795		605,839	13.9
MWD084	934,397		1,040,779	23.9
MWD093	4,848,902		2,802,900	64.3
				294.1
Pits:				
MMP035		12,931,583	3,910,465	89.8
MMP036		5,292,864	2,501,547	57.4
MMP037		2,877,580	1,052,193	24.2
MMP038		23,404	47,514	1.1
MMP039		1,386,239	1,148,760	26.4
MMP040		1,353,552	921,239	21.1
				220.0
MMP035 In-Pit	*NA*		*1,129,363*	*25.9*
MMP036 In-Pit	*NA*		*891,515*	*20.5*
TOTAL:	17,464,685	23,865,222	24,414,603	

NA = not available, the pit topography prior to waste rock deposition is not available, so a volume cannot be calculated.

Pit and mine waste pile volumes were calculated using the existing topography compared to the pre-mine topography

In-pit waste rock areas in italics were not recalculated

Map Area = is the area in a horizontal (flat) map view and does not account for topographic variation.

TABLE 3-2
DETAILED AND COMPARATIVE ANALYSES - SURFACE WATER REMEDIAL ALTERNATIVES
FEASIBILITY STUDY TECHNICAL MEMORANDUM #2
P4 Production LLC, Ballard Mine

USEPA Evaluation Criteria	**Alternative 1** **No Action (assumes no source controls are conducted in the upland soil/waste rock)** *The No Action alternative does not include any remedial action, long-term monitoring (LTM), or administrative or engineering controls for surface water.*	**Alternative 2** **Institutional Controls (ICs)[1] and Land Use Controls (LUCs)[2], in conjunction with source controls in the upland soil/waste rock[3]** *ICs and LUCs would be implemented to restrict surface water use and access until cleanup levels are achieved. Upon competition of source controls in the upland soil/waste rock, all surface water runoff would be unimpacted and only residual surface water 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).*	**Alternative 3** **In-Situ Biological (Wetlands) Treatment of Source Area Seepage, ICs, and LUCs, in conjunction with source controls in the upland soil/waste rock[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 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.*
1) Overall Protection of Human Health and the Environment			
1A) Detailed Analysis	***Low***	***Moderate to High***	***High***
How Alternative Provides Human Health and Environmental Protection	With no source controls in place in the upland soil/waste rock, COC/COEC concentrations in the surface water are not expected to significantly decrease without a cover system. ICs would not be implemented to limit surface water exposures. As a result, the No Action alternative is not considered protective of human health and the environment.	ICs and LUCs would limit human, livestock, and to some extent wildlife contact with the mine-affected surface water until cleanup levels are achieved following source controls in the upland soil/waste rock (i.e., grading and capping). Upon completion of source controls, all surface water runoff from the capped areas would be unimpacted and only residual flows from seeps/springs near the margins of the former mined area 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/springs).	ICs and LUCs would limit human, livestock, and to some extent wildlife contact with the mine-affected surface water until cleanup levels are achieved following source controls in the upland soil/waste rock (i.e., grading and capping). All surface water runoff from the capped areas would be unimpacted. This alternative is more protective of the human health and the environment because the in-situ wetlands would treat residual flows from seeps/springs that are expected to exceed cleanup levels for a period of time following source controls (i.e., until the regrading and cover systems substantially reduces the source of water that recharges through the upland soil/waste rock and ultimately discharges to the seeps/springs).
1B) Comparative Analysis	*Both Alternatives 2 and 3 are protective of human health and the environment as surface water running off the various cover systems would not be in contact with COCs/COECs once they are constructed. However, Alternative 3 is the most protective because it actively treats the only other source of mine-affected surface water (i.e., the seeps/springs) at the point of discharge and reduces potential exposures to this water. Alternative 2 has no provisions for treatment of mine-affected seeps/springs in the short term and only over time reduces human and ecological exposures so ranks lower (moderate to high ranking) than Alternative 3 (high ranking). The No Action alternative is not protective of human health and the environment because even if coupled with source controls, no ICs or LUCs would be implemented to prevent or reduce exposures at the mine-affected seeps in the interim before they go dry or meet the cleanup levels.*		
2) Compliance with ARARs			
2B) Detailed Analysis	***Low***	***Moderate to High***	***Moderate to High***
Chemical-Specific ARARs	No Action does not comply with chemical-specific ARARs because it assumes no source controls are implemented.	Upon completion of source controls, all surface water runoff from the capped areas would be unimpacted and only residual flows from seeps/springs near the margins of the former mined area are expected to exceed cleanup levels (i.e., chemical-specific ARARs) for a period of time.	Chemical-specific ARARs would be achieved in the short-term as a result of a combination of source controls in the upland soil/waste rock and wetlands treatment of mine-affected seeps/springs.

USEPA Evaluation Criteria	**Alternative 1** **No Action (assumes no source controls are conducted in the upland soil/waste rock)** *The No Action alternative does not include any remedial action, long-term monitoring (LTM), or administrative or engineering controls for surface water.*	**Alternative 2** **Institutional Controls (ICs)[1] and Land Use Controls (LUCs)[2], in conjunction with source controls in the upland soil/waste rock[3]** *ICs and LUCs would be implemented to restrict surface water use and access until cleanup levels are achieved. Upon competition of source controls in the upland soil/waste rock, all surface water runoff would be unimpacted and only residual surface water 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).*	**Alternative 3** **In-Situ Biological (Wetlands) Treatment of Source Area Seepage, ICs, and LUCs, in conjunction with source controls in the upland soil/waste rock[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 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.*
Location- and Action-Specific ARARs	No Action would not trigger any location- or action-specific ARARs.	ICs/LUCs require minimal field work and no land disturbance. As a result, no location- and action-specific ARARs are triggered	It is anticipated that the constructed wetlands component of this alternative can be designed and implemented to comply with location- and action-specific ARARs. Examples of location-specific ARARs that would need to be substantively complied with during remedial design and construction include those laws/regulations intended to protect wetlands, and natural streams and water bodies (e.g., substantive compliance with a 404 Permit for wetlands). Initial wetland delineations would be performed prior to the ROD based on Site-specific aerial photographs, photographs taken during the biannual surface water sampling events throughout the Ballard Site, and data from the National Wetlands Inventory. Additional wetland delineations would be completed during the pre-design phase in the spring season, as necessary. Examples of action-specific ARARs that would need to be substantively complied with during remedial design and construction include those laws/regulations intended to protect fish and wildlife during construction activities. This alternative has a positive impact with respect to some ARARs in that wetlands would be created.
2B) Comparative Analysis	*Both Alternatives 2 and 3 comply with applicable chemical-, location-, and action-specific ARARs immediately for the surface water shed from the capped surfaces. However, Alternative 3 shortens the timeframe for the mine-affected seeps/springs to meet chemical-specific ARARs with the creation of engineered wetlands. However the wetlands component of Alternative 3 has to substantively comply with location- and action-specific ARARs, which would not apply to Alternative 2. As a result, both rank similarly with respect to this criterion (moderate to high). The No Action alternative does not comply with chemical-specific ARARs.*		
3) Long-term Effectiveness and Permanence			
3A) Detailed Analysis	***Low***	***High***	***High***
Magnitude of residual risk	Existing risks would remain. 5-year reviews would be required in accordance with the NCP because COCs/COECs would remain at the Site[4].	Surface water emanating from the capped surfaces would be unimpacted as soon as the construction was completed. Because the seeps and springs are not actively treated under this alternative, residual risk remains from seep/spring discharge that is expected to exceed cleanup levels for a period of time (i.e., until the regrading and cover systems reduce the source of water that recharges through the upland soil/waste rock and ultimately discharges to the seeps/springs). These risks would be mitigated by ICs/LUCs until cleanup levels are achieved. CERCLA 5-year reviews would be necessary to verify that the remedy remains protective until COC/COEC concentrations are at levels that allow for unlimited use and unrestricted exposure.	Alternative 3 is similar to Alternative 2 with respect to unimpacted surface water /stormwater flowing from the capped surfaces upon completion of construction. Residual risks from perennial mine-affected seeps/springs would be reduced by the in-situ wetlands treatment. CERCLA 5-year reviews would be necessary to verify that the remedy remains protective.

USEPA Evaluation Criteria	**Alternative 1** **No Action (assumes no source controls are conducted in the upland soil/waste rock)** *The No Action alternative does not include any remedial action, long-term monitoring (LTM), or administrative or engineering controls for surface water.*	**Alternative 2** **Institutional Controls (ICs)[1] and Land Use Controls (LUCs)[2], in conjunction with source controls in the upland soil/waste rock[3]** *ICs and LUCs would be implemented to restrict surface water use and access until cleanup levels are achieved. Upon competition of source controls in the upland soil/waste rock, all surface water runoff would be unimpacted and only residual surface water 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).*	**Alternative 3** **In-Situ Biological (Wetlands) Treatment of Source Area Seepage, ICs, and LUCs, in conjunction with source controls in the upland soil/waste rock[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 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.*
Adequacy and reliability of controls	No controls would be implemented.	Properly implemented ICs/LUCs should be adequate to limit human, livestock, and some wildlife exposures to mine-affected surface water pending achievement of the cleanup levels at the seeps/springs. Reliability of ICs may be dependent on cooperation of adjacent landowners. LTM is required to evaluate COC/COEC-concentrations trends at the seeps/springs.	ICs/LUCs are similar to Alternative 2. Wetlands would require LTM to evaluate performance, and would require some O&M so that the wetlands continue to function properly as long as they are needed. For example, amendments may be required to maintain conditions that successfully reduce COC/COEC concentrations to below cleanup levels.
3B) Comparative Analysis	*The long-term effectiveness and permanence of Alternatives 2 and 3 are similar (high ranking) in that they both rely on source controls in the upland soil/waste rock to prevent or reduce the source of COCs/COECs to both stormwater runoff from the capped areas and the mine-affected seeps/springs discharging from the margins of the waste rock dumps. Alternative 3 is effective as soon as the wetlands are constructed and continues to be effective over the long term. Alternative 2 is effective in the long term, but relies on the cover systems to reduce the COCs/COECs in the seeps/springs over time and ICs/LUCs to prevent or reduce exposures. Alternative 2, over the long term, is effective similar to Alternative 3 and both rank high. No Action provides the least long-term effectiveness/permanence because it does not include controls to prevent or reduce exposures to the residual risks. All surface water alternatives would be subject to CERCLA 5-year review.*		
4) Reduction of Toxicity, Mobility, or Volume Through Treatment			
4A) Detailed Analysis	***Low***	***Low***	***Moderate to High***
Treatment Process Used and Materials Treated	None	None. This alternative relies on site grading and cover systems in the upland soil/waste rock to shed unimpacted surface water and to hydraulically isolate the consolidated waste rock such that the mine-affected seeps/springs either go dry or no longer are recharged by water that infiltrates through the mine waste rock.	Similar to Alternative 2, unimpacted surface water sheds from the constructed cover system. COCs/COECs in surface water that discharges from the perennial mine-affected seeps/springs would be treated in constructed in-situ wetlands where both biotic and abiotic processes would reduce COC/COEC concentrations. Biotic processes include biodegradation and plant uptake. Abiotic processes include settling, sedimentation, sorption, oxidation and hydrolysis, formation of carbonates, formation of insoluble mineral phases, and binding to iron and manganese oxides.
Amount of Hazardous Materials Destroyed or Treated	None	None. This alternative relies on site grading and cover systems over the upland soil/waste rock to shed unimpacted stormwater and to hydraulically isolate the consolidated waste rock such that the mine-affected seeps/springs either go dry or no longer are recharged by water that infiltrates through the waste rock. .	This alternative relies on cover systems over the upland soil/waste rock to result in unimpacted stormwater and hydraulically isolate the consolidated waste rock as described under Alternative 2. In addition, in-situ wetlands would be constructed at the perennial seeps/springs to treat the residual flows until cleanup levels are achieved. Wetlands are recognized as an effective treatment process for the Site COCs/COECs (DWTTC, 1999, Stillings and Amacher, 2004, Lamothe and Herring, 2004, Mackowiak, et. al., 2004), although, the effectiveness of wetlands treatment has not been demonstrated for Site surface waters. However, a pilot test using external tanks demonstrated that biological and chemical processes (similar to those expected to occur in the wetlands) would work to reduce Site COC/COECs.

USEPA Evaluation Criteria	**Alternative 1** **No Action (assumes no source controls are conducted in the upland soil/waste rock)** *The No Action alternative does not include any remedial action, long-term monitoring (LTM), or administrative or engineering controls for surface water.*	**Alternative 2** **Institutional Controls (ICs)[1] and Land Use Controls (LUCs)[2], in conjunction with source controls in the upland soil/waste rock[3]** *ICs and LUCs would be implemented to restrict surface water use and access until cleanup levels are achieved. Upon competition of source controls in the upland soil/waste rock, all surface water runoff would be unimpacted and only residual surface water 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).*	**Alternative 3** **In-Situ Biological (Wetlands) Treatment of Source Area Seepage, ICs, and LUCs, in conjunction with source controls in the upland soil/waste rock[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 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.*
Degree of Expected Reductions in Toxicity, Mobility, and Volume	None	This alternative relies on source controls in the upland soil/waste rock to reduce the mobility and volume of COCs/COECs immediately in surface water from snowmelt and stormwater running off the cover system, and in the longer term, in seeps/springs at the capped source area margin.	Similar to Alternative 2, surface water that runs off the cover system in the upland soil/waste rock would be unimpacted (i.e., below cleanup levels). However, under this alternative, reduction in toxicity, mobility and volume would begin at the perennial mine-affected seeps as soon as the wetlands are installed during the RA. It is likely that a properly constructed and maintained wetlands would reduce COCs/COECs concentrations to below surface water cleanup levels.
Degree to Which Treatment is Irreversible	No treatment implemented.	This is a passive approach. No surface water treatment is implemented, however, long-term maintenance would be necessary to maintain cover system integrity and reduce resumed leaching of COCs/COECs from the covered waste rock.	COCs/COECs that are retained or immobilized in the constructed wetlands have the potential to be released or remobilized. Typically, inorganic constituents remain immobilized as long as the wetland substrate/vegetation remains intact, and the environmental conditions of the wetland remains stable (e.g., pH, Eh). Mitigation measures would include proper design and O&M to limit erosion of the cover system and in the wetlands, to maintain proper environmental conditions, or removal/disposal of the wetland substrate and vegetation after cleanup levels are reliably achieved.
Type and Quantity of Residuals Remaining After Treatment	No treatment implemented.	No treatment implemented.	COCs/COECs would be retained/immobilized in the wetlands substrate/vegetation (see above).
Statutory Preference for Treatment as a Principal Element	This alternative does not include treatment of COCs/COECs.	This alternative does not include treatment of COCs/COECs.	The wetlands component of this alternative satisfies the statutory preference for treatment.
4B) Comparative Analysis	*Alternative 3 ranks moderate to high for reducing the toxicity, mobility, and volume of COCs/COECs by treating the surface water from the mine-affected seep/springs as it passes through the constructed wetlands and disposing of the COC/COEC precipitate contained in the wetlands either with the other waste rock during the RA or post-RA in an on-Site landfill when they are decommissioned. Alternatives 1 and 2 rank low because they do not actively reduce the toxicity, mobility, and volume of COCs/COECs in the mine-affected seep flows; any reductions would be attributable to the effective implementation of the upland soil/waste rock remedy.*		
5) Short-term Effectiveness			
5A) Detailed Analysis	***Low***	***Moderate***	***High***
Protection of Community During Remedial Actions	No remedial actions implemented.	ICs/LUCs would protect public from risks posed by the mine-affected surface water pending achievement of the cleanup levels.	Similar to Alternative 2, ICs/LUCs would protect public from risks posed by the mine-affected surface water pending achievement of the cleanup levels. The community would be protected during the wetland construction activities by employing industry-standard dust and stormwater best management practices (BMPs) and construction health and safety procedures (especially as it relates to access to the Site during construction). Constructed wetlands are a passive remedial action that would not affect the public after they are constructed.

USEPA Evaluation Criteria	**Alternative 1** **No Action (assumes no source controls are conducted in the upland soil/waste rock)** *The No Action alternative does not include any remedial action, long-term monitoring (LTM), or administrative or engineering controls for surface water.*	**Alternative 2** **Institutional Controls (ICs)[1] and Land Use Controls (LUCs)[2], in conjunction with source controls in the upland soil/waste rock[3]** *ICs and LUCs would be implemented to restrict surface water use and access until cleanup levels are achieved. Upon competition of source controls in the upland soil/waste rock, all surface water runoff would be unimpacted and only residual surface water 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).*	**Alternative 3** **In-Situ Biological (Wetlands) Treatment of Source Area Seepage, ICs, and LUCs, in conjunction with source controls in the upland soil/waste rock[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 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.*
Protection of Workers During Remedial Actions	No remedial actions implemented.	The only worker activity required for this alternative is periodic LTM to evaluate COC/COEC concentrations in surface water running off the covered surfaces and at seeps/springs. LTM (i.e., sampling) is a low-risk activity and would be mitigated using standard personal protective equipment (PPE), and routine health and safety procedures and protocols.	Workers would be protected while performing LTM as described in Alternative 2. Workers involved with wetland construction and O&M would be protected by having HAZWOPER training, wearing appropriate PPE, and by following established health and safety procedures and protocols.
Environmental Impacts	Existing conditions not expected to change.	Following source controls in the upland soil/waste rock, snowmelt and stormwater runoff from the cover system would be unimpacted. Residual mine-affected surface water would continue to discharge from the seeps/springs until they go dry or until the seep discharge meets the cleanup levels. This is expected because the source controls would reduce precipitation/snowmelt infiltration through the capped waste rock before discharging to the seeps/springs. The potential impacts of residual mine-affected seep flow would be evaluated via LTM and data evaluation.	Wetlands constructed at mine-affected seeps/springs would reduce COCs/COECs in surface water emanating from these areas immediately following their construction and so should have a positive effect in plants and animals downstream of the constructed wetlands. Potential environmental impacts associated with constructed wetlands are associated with accumulation of COCs/COECs in the wetland substrate or COC/COEC uptake by wetland plants. These impacts would be managed through proper design and O&M to limit erosion and to maintain proper anaerobic/aerobic conditions. LTM would evaluate COC/COEC accumulation in substrate and plants, and possible removal/disposal of the wetland substrate and vegetation prior to and/or after cleanup levels are achieved. This would require rejuvenation of the wetlands and possible excavation and disposal of the substrate material and vegetation in a designated on-Site disposal area. ICs/LUCs would limit exposures until cleanup levels are achieved.
Time Until Remedial Objectives are Achieved	Remedial objectives not achieved.	Upon completion of the regrading, waste rock consolidation, and capping in the upland soil/waste rock, COC/COEC concentrations in the surface water that sheds off these areas is expected to be below the cleanup levels (because that water would no longer come into contact with waste rock). After the upland soil/mine waste is capped and water infiltrating through the waste rock is substantially reduced, the time until the mine-affected seeps/springs go dry or meet surface water cleanup levels is based on unknowns that include: 1) volumes of residual mine-affected groundwater that would discharge to the seeps/springs, 2) the hydraulic conductivities of waste rock and alluvium where the mine-affected GW would travel before discharging to the seeps/springs and 3) if the seeps are from deeper (e.g., bedrock) or shallow sources of water.	Surface water runoff would be unimpacted as discussed under Alternative 2. At the residual seeps/springs, the constructed wetlands would treat the mine-affected surface water at the rate that the water passes through the wetlands. The design of the wetlands would consider the necessary retention time, necessary pond depth, and other construction details to allow the various biotic and abiotic processes to reduce the COC/COEC concentrations. For practical purposes, the water discharging from the wetlands is expected to meet the cleanup levels in a short timeframe following construction (e.g., in less than a year).

USEPA Evaluation Criteria	**Alternative 1** **No Action (assumes no source controls are conducted in the upland soil/waste rock)** *The No Action alternative does not include any remedial action, long-term monitoring (LTM), or administrative or engineering controls for surface water.*	**Alternative 2** **Institutional Controls (ICs)[1] and Land Use Controls (LUCs)[2], in conjunction with source controls in the upland soil/waste rock[3]** *ICs and LUCs would be implemented to restrict surface water use and access until cleanup levels are achieved. Upon competition of source controls in the upland soil/waste rock, all surface water runoff would be unimpacted and only residual surface water 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).*	**Alternative 3** **In-Situ Biological (Wetlands) Treatment of Source Area Seepage, ICs, and LUCs, in conjunction with source controls in the upland soil/waste rock[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 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.*
5B) Comparative Analysis	For short-term effectiveness, Alternative 2 does not require construction or O&M activities that could pose risks to the community or workers; however, it is not as effective in the short term as Alternative 3 because it does not treat the mine-affected seeps and includes only IC/LUCs to prevent or reduce exposure so ranks moderately. Alternative 3 includes construction of the wetlands, but that construction poses little risks to the community and workers and it is effective in the short term so ranks highly. In addition, Alternative 3 reduces the time until RAOs are achieved because it actively treats residual mine-affected seep flows. The No Action alternative provides the least short-term effectiveness because it provides no controls to prevent or reduce exposures to the community or any measures to address environmental impacts.		
6) Implementability			
6A) Detailed Analysis	***High***	***High***	***Moderate to High***
Ability to Construct and Operate the Technology	No construction or O&M.	This alternative requires no construction or maintenance. Implementation would require preparation of a LTM plan for the residual seeps/springs and an Institutional Controls Implementation and Assurance Plan (ICIAP). LTM is required at the residual seeps/springs to evaluate flow rates and COC/COEC concentration trends. The adequacy of the ICs/LUCs require periodic evaluation during the CERCLA 5-year review process to confirm they remain adequate in relation to the nature and extent of COCs/COECs at the perennial seeps, and that they are being enforced and maintained.	Wetlands construction at mine-affected seeps/springs would be conducted using readily available excavation and/or trenching equipment and readily available substrate and wetland vegetation. Wetland O&M is relatively routine (e.g., periodic inspections to confirm surface water retention in the wetland and possibly monitoring environmental parameters to confirm conditions are favorable for retaining/immobilizing COCs/COECs). Implementation would require preparation of a RD/RAWP, LTM and maintenance plan for the wetlands and an ICIAP. The RD/RAWP would include the wetland design information, design of temporary roads and engineered access restrictions, site restoration plan, HASP, and stormwater management plan. LTM would be required at the wetlands to evaluate COC/COEC concentration trends and other performance parameters and to support CERCLA 5-year reviews.
Reliability of the Technology	No technology is implemented.	No technology is implemented. ICs and LUCs are USEPA-recognized components of an overall remedial strategy.	ICs and LUCs are USEPA-recognized components of an overall remedial action strategy and are similar to Alternative 2. In-situ wetlands treatment is an USEPA-recognized remedial alternative for surface water with the COCs/COECs that are present at the Site. However, passive treatment systems can have some inherent reliability issues (e.g., winter temperatures can reduce treatment efficiency) that would have to be monitored and may have to be mitigated.
Ease of Undertaking Additional Remedial Action, if Necessary	No remedial action is implemented.	ICs/LUCs do not preclude or affect additional remedial actions if deemed necessary.	Wetlands and ICs/LUCs do not preclude or affect additional remedial actions if deemed necessary.
Ability to Monitor Effectiveness of Remedy	No monitoring would occur.	Flow rates and COC/COEC concentration trends at the residual seeps/springs are easily monitored by standard monitoring techniques, laboratory analyses, and data evaluation processes.	The effectiveness the constructed wetlands at reducing COC/COEC concentrations to below the cleanup levels at the outfall is easily monitored by standard monitoring techniques, laboratory analyses, and data evaluation processes.
Ability to Obtain Approvals and Coordinate with Other Agencies	Not applicable.	This alternative does not require approval or coordination from other agencies.	The wetlands component of this alternative likely would require substantive compliance with applicable ARARs (see Criterion #2).

USEPA Evaluation Criteria	**Alternative 1** **No Action (assumes no source controls are conducted in the upland soil/waste rock)** *The No Action alternative does not include any remedial action, long-term monitoring (LTM), or administrative or engineering controls for surface water.*	**Alternative 2** **Institutional Controls (ICs)[1] and Land Use Controls (LUCs)[2], in conjunction with source controls in the upland soil/waste rock[3]** *ICs and LUCs would be implemented to restrict surface water use and access until cleanup levels are achieved. Upon competition of source controls in the upland soil/waste rock, all surface water runoff would be unimpacted and only residual surface water 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).*	**Alternative 3** **In-Situ Biological (Wetlands) Treatment of Source Area Seepage, ICs, and LUCs, in conjunction with source controls in the upland soil/waste rock[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 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.*
Availability of Treatment, Storage, and Disposal Services and Capacity	Not applicable.	This alternative does not require treatment, storage, or disposal capacity or services.	This alternative does not require treatment, storage, or disposal capacity or services unless the residuals in the wetlands require on- or off-site disposal at some point in the future when seeps/spring reach the cleanup levels.
Availability of Necessary Equipment and Specialists	None required.	LTM would require field technicians/environmental scientists to periodically collect and evaluate environmental data. ICs/LUCs would require legal support to prepare and implement an ICIAP. These resources are readily available.	Wetlands would require field technicians to periodically perform O&M activities and to collect environmental data, and environmental scientists to evaluate the wetlands treatment performance. These resources are readily available. ICs/LUCs would require legal support to prepare and implement an ICIAP. These resources are readily available.
Availability/Demonstrated Effectiveness of Prospective Technologies	None required.	ICs and LUCs are USEPA-recognized remedial alternatives. The primary uncertainty associated with this alternative is the duration before residual flows in the mine-affected seeps/springs dry up or meet the surface water cleanup levels as a result of source controls.	Effectiveness of wetlands treatment has not been demonstrated for Site surface waters and may require pilot testing (although there was an ex-situ pilot study for biological water treatment). Wetlands treatment is recognized to be effective for the Site COCs/COECs (DWTTC, 1999, Stillings and Amacher, 2004, Lamothe and Herring, 2004, Mackowiak, et. al., 2004).
6B) Comparative Analysis	*Alternative 2 is easier to implement than Alternative 3 because there is no construction. As a result, it ranks higher with regard to implementability than Alternative 3 (ranks moderate to high), which involves construction and substantive compliance with action- and location- specific ARARs (e.g., construction in a wetlands area).*		
7) Cost			
7A) Detailed Analysis			
30-year Present Worth Total Cost	**$108,000**	**$850,000**	**$1,432,000**
7B) Comparative Analysis	*Alternatives 2 and 3 have similar costs for implementation of ICs and LUCs; however, Alternative 3 requires construction of wetlands and is more costly than Alternative 2 so ranks lower than Alternative 2 with respect to the cost criterion.*		
8 and 9) State and Community Acceptance	To be evaluated after the public comment period.		

1 Institutional controls (ICs) are non-engineered instruments, such as administrative and legal controls, that help to minimize the potential for exposure to contamination and/or protect the integrity of a response action (e.g., government controls, proprietary controls, enforcement tools, and informational tools).

2 Land Use Controls (LUCs) are engineering controls (e.g., fencing signage, and other physical barriers) that limit human and in some cases ecological exposures. Although USEPA considers ICs to be a subset of LUCs, for clarity, this FS document distinguishes ICs to be non-engineered instruments and LUCs to be engineered controls.

3 With the exception of the No-Action alternative, all retained remedial alternatives for surface water rely on source controls in the upland soil/waste rock (i.e., the mined area) to prevent or reduce migration of COCs/COECs from the waste rock to downstream surface water.

4 Section 121 of CERCLA, as amended by SARA, requires that remedial actions which result in any hazardous substances, pollutants, or contaminants remaining at the site be subject to a 5-year review. The National Oil and Hazardous Substances Pollution Contingency Plan (NCP) further provides that remedial actions which result in any hazardous substances, pollutants, or contaminants remaining at the site above levels that allow for unlimited use and unrestricted exposure be reviewed every five years to ensure protection of human health and the environment.

TABLE 3-3
DETAILED AND COMPARATIVE ANALYSES - SEDIMENT/RIPARIAN SOIL REMEDIAL ALTERNATIVES
FEASIBILITY STUDY TECHNICAL MEMORANDUM #2
P4 Production LLC, Ballard Mine

USEPA Evaluation Criteria	**Alternative 1** **No Action (assumes no source controls are conducted in the upland soil/waste rock)** *The No Action alternative does not include any remedial action, long-term monitoring (LTM), or administrative or engineering controls.*	**Alternative 3** **Sediment Traps/Basins, Monitored Natural Recovery (MNR), Institutional Controls (ICs)[1], and Land Use Controls (LUCs)[2], in conjunction with source control in upland soil/waste rock[3]** *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 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 or reduce migration of COCs/COECs to the downstream drainages. MNR also requires ICs and LUCs to restrict Site activities until the cleanup levels are achieved.*	**Alternative 4** **Removal and On-Site Disposal, MNR, ICs[1], and LUCs[2], in conjunction with source control in upland soil/waste rock[3]** *Sediment/riparian soil (and all associated riparian vegetation) in the upper reaches of the mine-affected drainages, where the highest concentrations of COCs/COECs are detected, would be excavated, transported, and consolidated with the upland soil/waste rock, then capped. The excavated areas would be reclaimed and revegetated. MNR, ICs, and LUCs would be implemented for sediment/riparian soil that is not removed in the lower reaches of the mine-affected drainages where the concentrations of COC/COEC are substantially lower.*
1) Overall Protection of Human Health and the Environment			
1A) Detailed Analysis	***Low***	***Moderate to High***	***Moderate to High***
How Alternative Provides Human Health and Environmental Protection	With no source controls in place in the upland soil/waste rock, COC/COEC concentrations in the sediment/riparian soil are not expected to decrease. ICs/LUCs would not be implemented to prevent access and exposures to affected media. As a result, the No Action alternative is not considered protective of human health and the environment.	With source controls in place in the upland soil/waste rock and after the installation of sediment control traps, natural recovery processes (i.e., physical, chemical, and biological) would reduce COC/COEC concentrations in the sediment/riparian soil over time to levels that do not pose unacceptable human health and environmental risk. In the interim, ICs/LUCs would limit humans, livestock, and some wildlife from contacting the affected media while MNR is occurring. However, until MNR is successful, ICs/LUCs would not prevent COC/COEC exposures to plants and small animals currently living in the affected drainages.	Following source controls in the upland soil/waste rock, the most highly contaminated sediment/riparian soil (and associated vegetation) adjacent to the mined area would be removed. Although sediment/riparian soil removal is protective of human health and the environment in the long-term, these actions would significantly disturb the riparian corridors (and associated wetlands and wildlife/ecological habitat) in the short-term. This loss of habitat would reduce the ecological productiveness of these riparian areas until the vegetation and habitat can be reestablished. MNR would be implemented for the lesser contaminated media in the lower reaches of the intermittent drainages much like Alternative 2. ICs/LUCs would be established to limit human and some wildlife contact with lesser contaminated media left in place while MNR is occurring but cannot prevent exposure to plants and small animals in the interim (i.e., prior the MNR success).
1B) Comparative Analysis	*Both Alternatives 3 and 4 rely on ICs and LUCs to limit human and ecological (including livestock) contact with the mine-affected media in the interim before unacceptable risks are reduced by natural recovery processes. Alternative 4 might be considered more protective than Alternative 3 in the short-term because the sediment/riparian soil with the highest COC/COEC concentrations in the drainages associated with the mined area would be removed and consolidated along with the upland soil/waste rock. However, Alternative 4 would have significant negative short-term impacts on the riparian corridors where approximately 3 ½ miles of sediment/riparian soil (and associated habitat) would be removed/destroyed. These negative short-term impacts to ecological/wildlife habitat likely outweigh the benefits associated with the sediment/riparian-soil-removal component of Alternative 4 especially when considering that the sediment traps installed under Alternative 3 would limit the movement of the most contaminated sediment/riparian soil in the headwater locations. Alternative 3 does not have negative construction-related impacts to ecological/wildlife habitat, and ultimately would be as protective as Alternative 4 after natural recovery processes reduce COC/COEC concentrations to acceptable levels. As a result, Alternative 3 is considered slightly more protective of human health and the environment considering short- and long-term tradeoffs. Under the No Action alternative, natural recovery would occur to some extent, but it would take substantially longer because it assumes no upland soil/waste rock area source controls (i.e., cover systems). The No Action alternative also is the least protective because it does not include ICs or LUCs to limit human/livestock contact with the mine-affected media while natural recovery is occurring.*		
2) Compliance with ARARs			
2A) Detailed Analysis	***Low***	***Moderate to High***	***Moderate***
Chemical-Specific ARARs	No Action does not comply with chemical-specific ARARs.	Chemical-specific ARARs would be achieved over time (in the long term) by capture of any sediment in the upstream drainages and the natural recovery processes.	Chemical-specific ARARs would be achieved by a combination of removal of mine-affected sediment/riparian soil (short term) in the upper drainages and by natural recovery processes in the lower drainage areas (long term).

USEPA Evaluation Criteria	**Alternative 1** **No Action (assumes no source controls are conducted in the upland soil/waste rock)** *The No Action alternative does not include any remedial action, long-term monitoring (LTM), or administrative or engineering controls.*	**Alternative 3** **Sediment Traps/Basins, Monitored Natural Recovery (MNR), Institutional Controls (ICs)[1], and Land Use Controls (LUCs)[2], in conjunction with source control in upland soil/waste rock[3]** *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 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 or reduce migration of COCs/COECs to the downstream drainages. MNR also requires ICs and LUCs to restrict Site activities until the cleanup levels are achieved.*	**Alternative 4** **Removal and On-Site Disposal, MNR, ICs[1], and LUCs[2], in conjunction with source control in upland soil/waste rock[3]** *Sediment/riparian soil (and all associated riparian vegetation) in the upper reaches of the mine-affected drainages, where the highest concentrations of COCs/COECs are detected, would be excavated, transported, and consolidated with the upland soil/waste rock, then capped. The excavated areas would be reclaimed and revegetated. MNR, ICs, and LUCs would be implemented for sediment/riparian soil that is not removed in the lower reaches of the mine-affected drainages where the concentrations of COC/COEC are substantially lower.*
Location- and Action-Specific ARARs	No Action would not trigger any location- or action-specific ARARs.	MNR is a passive remedial action that does not trigger any location- or action-specific ARARs. Installation of sediment traps/basins likely would be accomplished as a best management practice (BMP) under the stormwater control program implemented during the remedial action (RA). Substantive compliance with stormwater regulations under the Clean Water Act would be required for placement of the sediment traps/basins because they are stormwater/sediment controls.	It is anticipated that the sediment/riparian soil removal component of this alternative can be designed and implemented to comply with location-specific ARARs. Examples of location-specific ARARs that would need to be substantively complied with during the RA include those laws/regulations intended to protect wetlands, and natural streams and water bodies. In addition, action-specific ARARs that would need to be substantively complied with during the RA include those laws/regulations intended to protect fish and wildlife. Substantive compliance with these ARARs likely would be difficult due to the disruptive effect that sediment/riparian soil removal would have on the riparian corridors and associated habitat. The MNR component of this alternative is a passive remedial action that does not trigger any location- or action-specific ARARs.
2B) Comparative Analysis	*Alternative 3 complies with chemical-specific ARARs in the long term and does not trigger any location- or action-specific ARARs due to the passive nature of MNR and ranks moderate to high. Installation of sediment traps/basins likely would be accomplished at least initially as a BMP under a construction stormwater pollution prevention plan. Alternative 4 also complies with chemical-specific ARARs in the upper drainages following the RA and the lower portions of these same drainages rely on MNR like Alternative 3. In addition, because of the excavation and reclamation activities associated with the upper drainages, Alternative 4 would require substantive compliance with location- and action-specific ARARs that likely would be difficult so overall Alternative 4 ranks moderate with respect to compliance with ARARs. The No Action alternative does not comply with chemical-specific ARARs.*		
3) Long-term Effectiveness and Permanence			
3A) Detailed Analysis	***Low***	***High***	***High***
Magnitude of residual risk	Existing risks would remain. CERCLA 5-year reviews would be required in accordance with the NCP because COCs/ COECs would remain at the Site[4].	MNR in the intermittent drainages relies on erosional forces to disperse and mix/bury and isolate the mine-affected sediment/riparian soil in addition to burial by riparian vegetation decay and windblown dust. Residual risks could be associated with buried COCs/COECs that are eroded and exposed over time, except that the sediment traps in the upper reaches should control the most contaminated sediment. Following installation of source controls (cover system) and the installation of sediment traps, the magnitude of any residual risks is expected to be much lower than current Site conditions and within background levels. CERCLA 5-year reviews would be necessary to verify that the remedy remains protective until COC/COEC concentrations are at levels that allow for unlimited use and unrestricted access.	Same as Alternative 3 except most highly contaminated media near the waste rock (i.e., source area) would be removed (instead of its movement being restricted by the sediment traps). This would result in lower residual risks where the mine-affected sediment/riparian soil is removed, and could reduce the natural recovery timeframe for other mine-affected sediment/riparian soil lower in the drainages but this is dependent on the climatic conditions during recovery. CERCLA 5-year reviews would be necessary to verify that the remedy remains protective until COC/COEC concentrations are at levels that allow for unlimited use and unrestricted access.

USEPA Evaluation Criteria	**Alternative 1** **No Action (assumes no source controls are conducted in the upland soil/waste rock)** *The No Action alternative does not include any remedial action, long-term monitoring (LTM), or administrative or engineering controls.*	**Alternative 3** **Sediment Traps/Basins, Monitored Natural Recovery (MNR), Institutional Controls (ICs)[1], and Land Use Controls (LUCs)[2], in conjunction with source control in upland soil/waste rock[3]** *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 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 or reduce migration of COCs/COECs to the downstream drainages. MNR also requires ICs and LUCs to restrict Site activities until the cleanup levels are achieved.*	**Alternative 4** **Removal and On-Site Disposal, MNR, ICs[1], and LUCs[2], in conjunction with source control in upland soil/waste rock[3]** *Sediment/riparian soil (and all associated riparian vegetation) in the upper reaches of the mine-affected drainages, where the highest concentrations of COCs/COECs are detected, would be excavated, transported, and consolidated with the upland soil/waste rock, then capped. The excavated areas would be reclaimed and revegetated. MNR, ICs, and LUCs would be implemented for sediment/riparian soil that is not removed in the lower reaches of the mine-affected drainages where the concentrations of COC/COEC are substantially lower.*
Adequacy and reliability of controls	No controls would be implemented.	Development of performance standards and LTM is required to evaluate the progress of natural recovery. Properly constructed sediment traps/basins should control downstream migration of the most affected sediment/riparian soil. ICs/LUCs should be adequate to limit human, livestock, and some wildlife exposures while natural recovery is occurring (e.g., signage and fencing). Reliability of ICs/LUCs may be dependent on cooperation of adjacent landowners and long-term O&M activities. They likely would be decommissioned post-RA (i.e., post establishment of vegetated covers) because any sediment coming off the covered surfaces would be unimpacted, and other clean sediment from adjacent native areas throughout the drainages would aid MNR processes lower in the drainages.	O&M activities would be required for some period following sediment/riparian soil removal to ensure that reclamation and re-vegetation is successful in the areas that have undergone sediment/riparian soil removal. No long-term management is needed in the areas where mine-affected sediment/riparian soil are removed after the cleanup levels are met and Site reclamation is successful. Adequacy and reliability of controls for MNR and ICs/LUCs is as described in Alternative 2.
3B) Comparative Analysis	*The long-term effectiveness and permanence (i.e., risks remaining after the RAOs have been met) is addressed in Alternative 4 by removal of the sediment/riparian soil with the highest COC/COEC concentrations in the upper drainages and in Alternative 3 by properly installed sediment traps that would restrict the movement of the sediment with the highest COCs/COECs from downstream movement. Over the long term, these alternatives should be similar (i.e., once the MNR process has reduced the COC/COEC concentrations throughout the length of the affected drainages) and they both rank high for this criterion. The ICs and LUCs are equally effective under both Alternatives 3 and 4; however, the footprint where ICs/LUCs would be applied is smaller under Alternative 4 after the sediment/riparian soil with the highest COC/COEC concentrations are removed and the disturbed areas are reclaimed. The No Action alternative does not address these evaluation criteria because it does not meet the response objectives or include controls. All sediment/riparian soil alternatives would be subject to CERCLA 5-year reviews.*		
4) Reduction of Toxicity, Mobility, or Volume Through Treatment			
4A) Detailed Analysis	***Low***	***Moderate***	***Moderate to High***
Treatment Process Used and Materials Treated	None.	There is no treatment under this alternative. This alternative relies on sediment traps/basin to control downstream migration of the most affected sediment and natural recovery processes to reduce COC/COEC concentrations in the sediment/riparian soil over the long term. MNR processes may include physical, biological, and chemical mechanisms that act together to reduce the risk posed by the contaminants. It is anticipated that dispersion and burial would be the primary natural recovery mechanism in the intermittent drainages at the Site. USEPA considers dispersion to be the least preferable basis for MNR remedy selection because it may result in unacceptable risks to downstream areas or other receiving water bodies (USEPA, 2005). However, when coupled with source controls in the Site's upland soil/waste rock and the sediment control basins/traps, the mechanisms are considered acceptable, particularly because COC/COEC concentrations in the Blackfoot River (i.e., the receiving water body where dispersed COCs/COECs may ultimately discharge) are generally low in the current pre-remedial-action Site configuration where upstream sources of COCs/COECs are	There is no treatment under this alternative. This alternative relies on removal and disposal of the most contaminated sediment/riparian soil and associated vegetation in the upper reaches of the drainages associated with the mined area, coupled with MNR for sediment/riparian soil lower in the drainages (see Alternative 3). The removal and disposal activities would require conventional excavation equipment and haul trucks. Excavated areas would require reclamation by importing clean fill and re-seeding the disturbed riparian habitat to establish vegetation. No materials are treated per se as they would be placed with upland soil/waste rock, graded, and then covered.

USEPA Evaluation Criteria	**Alternative 1** **No Action (assumes no source controls are conducted in the upland soil/waste rock)** *The No Action alternative does not include any remedial action, long-term monitoring (LTM), or administrative or engineering controls.*	**Alternative 3** **Sediment Traps/Basins, Monitored Natural Recovery (MNR), Institutional Controls (ICs)[1], and Land Use Controls (LUCs)[2], in conjunction with source control in upland soil/waste rock[3]** *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 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 or reduce migration of COCs/COECs to the downstream drainages. MNR also requires ICs and LUCs to restrict Site activities until the cleanup levels are achieved.*	**Alternative 4** **Removal and On-Site Disposal, MNR, ICs[1], and LUCs[2], in conjunction with source control in upland soil/waste rock[3]** *Sediment/riparian soil (and all associated riparian vegetation) in the upper reaches of the mine-affected drainages, where the highest concentrations of COCs/COECs are detected, would be excavated, transported, and consolidated with the upland soil/waste rock, then capped. The excavated areas would be reclaimed and revegetated. MNR, ICs, and LUCs would be implemented for sediment/riparian soil that is not removed in the lower reaches of the mine-affected drainages where the concentrations of COC/COEC are substantially lower.*
		uncontrolled. Moreover, studies conducted in southeast Idaho indicate that selenium becomes less bioavailable as soil weathers (Mackowiak and Amacher, 2003).	
Amount of Hazardous Materials Destroyed or Treated	None.	COCs/COECs would not be destroyed or treated, but contained should they erode in headwater sediment traps/basins. This alternative relies on natural recovery processes to disperse, mix, and bury the COCs/COECs in the sediment/riparian soil, ultimately resulting in COC/COEC concentrations that do not present unacceptable risks.	COCs/COECs would not be destroyed or treated. The approximate volume of mine-affected sediment/riparian soil to be removed is 7,800 cubic yards (cy) in the upper reach Wooley Valley Creek and 13,000 cy in the upper reach of Ballard Creek.
Degree of Expected Reductions in Toxicity, Mobility, and Volume	None.	The mobility in the upper reaches of the intermittent drainages would be reduced through the installation of sediment traps/basins. It is anticipated that the predominant natural recovery process throughout the length of the intermittent drainages would be dispersion/burial of the COCs/COECs by erosional forces. This natural recovery process would redistribute, mix, and bury the COCs/COECs, and ultimately reduce the toxicity and mobility of the COCs/COECs by reducing concentrations through mixing, burying the COCs/COECs so they are less bio-available, etc. Under the alternative, volume of COCs/COECs is not significantly reduced (although some bio-transformation may occur); rather the COCs/COECs would be dispersed such that COC/COEC concentrations are below cleanup levels.	There would be reduction of toxicity and mobility of COCs/COECs in the upper reaches of the intermittent drainages where the mine-affected sediment/riparian soil is removed. Although the volume of COCs/COECs in the upper reaches of the intermittent drainages would be transferred to the upland soil/mine waste so it can be consolidated and capped (i.e., volume is moved and isolated rather than reduced). The expected reductions in toxicity, mobility, and volume of COCs/COECs in the lower reaches of the drainages which would rely on MNR is similar to Alternative 2.
Degree to Which Treatment is Irreversible	No treatment implemented.	It is likely that the reduction in COCs/COECs would be permanent due to the dynamic nature (ongoing erosional and depositional forces) of the intermittent streams that are present at the Site, mixing that would occur with unaffected sediment/riparian soil (e.g., from native rock/soil sources), and the lack of new contributions of COCs/COECs following source controls. There is potential that the dispersed COCs/COECs could concentrate in locations further downstream; however, the potential for this occurring is low for the reasons listed above.	Removal of the mine-affected sediment/riparian soil in the upper reaches of the intermittent drainages adjacent to the mine footprint (and the resulting reduction in COC/COEC concentrations) would be irreversible assuming source controls are effective and clean fill is used to reclaim the disturbed areas. However, as stated above, there is no treatment of the COC/COECs and the toxicity is not changed, but rather the contaminated sediment/riparian soil would be placed under the covered upland soil/waste rock. The degree to which natural recovery is irreversible is discussed in Alternative 2.
Type and Quantity of Residuals Remaining After Treatment	No treatment implemented.	None. MNR and installation of sediment traps would not generate any treatment residuals. Disposal of any contaminated sediment retained in sediment traps over the long term should be relatively easy to combine with other waste rock and place under the upland soil/waste rock soil cover during the RA and in an on-Site landfill post-RA.	There is no “treatment” per se and so no residuals, the excavated mine-affected sediment/riparian soil would be consolidated and capped along with the upland soil/waste rock.
Statutory Preference for Treatment as a Principal Element	This alternative does not include treatment of COCs/COECs.	This alternative does not include treatment of COCs/COECs.	Similar to Alternative 2, this alternative does not include treatment of COCs/COECs.

USEPA Evaluation Criteria	**Alternative 1** **No Action (assumes no source controls are conducted in the upland soil/waste rock)** *The No Action alternative does not include any remedial action, long-term monitoring (LTM), or administrative or engineering controls.*	**Alternative 3** **Sediment Traps/Basins, Monitored Natural Recovery (MNR), Institutional Controls (ICs)[1], and Land Use Controls (LUCs)[2], in conjunction with source control in upland soil/waste rock[3]** *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 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 or reduce migration of COCs/COECs to the downstream drainages. MNR also requires ICs and LUCs to restrict Site activities until the cleanup levels are achieved.*	**Alternative 4** **Removal and On-Site Disposal, MNR, ICs[1], and LUCs[2], in conjunction with source control in upland soil/waste rock[3]** *Sediment/riparian soil (and all associated riparian vegetation) in the upper reaches of the mine-affected drainages, where the highest concentrations of COCs/COECs are detected, would be excavated, transported, and consolidated with the upland soil/waste rock, then capped. The excavated areas would be reclaimed and revegetated. MNR, ICs, and LUCs would be implemented for sediment/riparian soil that is not removed in the lower reaches of the mine-affected drainages where the concentrations of COC/COEC are substantially lower.*
4B) Comparative Analysis	*Alternative 3 does not result in treatment of COCs/COECs or reduction in volume of COCs/COECs so it would rank moderate with regard to reducing the toxicity and volume of COCs/COECs. However, Alternative 4 ranks moderate to high with respect to this criterion because it would result in the greatest reduction of mobility of COCs/COECs (and the greatest degree to which the remedy is irreversible) because it removes the sediment/riparian soil with the highest COC/COEC concentrations in the upper drainages adjacent to the mined area and places them under a cover system. The sediment traps installed under Alternative 3 would restrict the movement of the headwater sediment/riparian soil with the highest COC/COECs from downstream movement and so to some extent reduces mobility. Alternatives 3 and 4 both rely on natural recovery of sediment/riparian soil, although Alternative 4 would have the shortest reaches of drainages that rely on natural recovery as the remedy.*		
5) Short-term Effectiveness			
5A) Detailed Analysis	***Low***	***Moderate***	***Low to Moderate***
Protection of Community During Remedial Actions	No remedial actions implemented.	The community would be protected during the construction of the sediment traps in the upper drainages by employing industry-standard dust and stormwater BMPs. MNR is a passive remedial action. ICs/LUCs would protect public from risks posed by the mine-affected sediment/riparian soil while natural recovery is occurring as long as O&M activities are ongoing.	The community would be protected during the excavation/disposal activities in the upper drainages by employing industry-standard dust and stormwater BMPs. The community would be protected while natural recovery is occurring as described in Alternative 3.
Protection of Workers During Remedial Actions	No remedial actions implemented.	Limited exposures to workers. Following construction of the sediment traps, the only worker activity required for this alternative is periodic monitoring to evaluate sediment retention in the traps and the natural recovery progress. Sediment/riparian soil sampling in the intermittent drainages and removal of sediment from the traps is a low-risk activity and would be mitigated for Site workers by having HAZWOPER training, wearing appropriate PPE, and by following established health and safety procedures and protocols.	Workers would be protected while excavating affected sediment/riparian soil and during the natural recovery is occurring as described in Alternative 3.
Environmental Impacts	Existing conditions not expected to change.	Following installation of source controls (i.e., cover system) and sediment traps, COC/COEC concentrations in the sediment/riparian soil are expected to decrease as erosional forces act to disperse, mix, and bury the COCs/COECs in the mine-affected sediment/riparian soil. There is a potential for impact to the environment from mobilization of COCs/COECs higher in the drainages to downstream areas including the Blackfoot River. However, the likelihood is low because presently the highest COC/COEC concentrations in the sediment/riparian soil are located adjacent to the former mine site (i.e., the greatest distance from the Blackfoot River) where the sediment traps are located. From the sediment traps downstream, the concentrations generally decrease in the downstream direction. This distribution of COCs/COECs allows the greatest potential for dispersion and mixing prior to the sediment/riparian soil discharging to the Blackfoot River. In addition, once the cover systems and sediment traps are in place in the former mined area, there would be no additional sources of contamination and the natural recovery process in sediment/riparian soil should take place progressively throughout all reaches of the affected intermittent channels.	Potential environmental impacts associated with removal and disposal of the mine-affected sediment/riparian soil include dust generation and uncontrolled stormwater runoff during construction activities. These impacts would be mitigated using standard construction-related BMPs to control dust and stormwater. The primary environmental impact that needs to be considered with the sediment/riparian soil removal in the upper drainages is the resulting destruction of approximately 3 ½ miles of ecological/wildlife habitat until the disturbed areas are reclaimed, revegetated, and the habitat is restored

USEPA Evaluation Criteria	**Alternative 1** **No Action (assumes no source controls are conducted in the upland soil/waste rock)** *The No Action alternative does not include any remedial action, long-term monitoring (LTM), or administrative or engineering controls.*	**Alternative 3** **Sediment Traps/Basins, Monitored Natural Recovery (MNR), Institutional Controls (ICs)[1], and Land Use Controls (LUCs)[2], in conjunction with source control in upland soil/waste rock[3]** *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 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 or reduce migration of COCs/COECs to the downstream drainages. MNR also requires ICs and LUCs to restrict Site activities until the cleanup levels are achieved.*	**Alternative 4** **Removal and On-Site Disposal, MNR, ICs[1], and LUCs[2], in conjunction with source control in upland soil/waste rock[3]** *Sediment/riparian soil (and all associated riparian vegetation) in the upper reaches of the mine-affected drainages, where the highest concentrations of COCs/COECs are detected, would be excavated, transported, and consolidated with the upland soil/waste rock, then capped. The excavated areas would be reclaimed and revegetated. MNR, ICs, and LUCs would be implemented for sediment/riparian soil that is not removed in the lower reaches of the mine-affected drainages where the concentrations of COC/COEC are substantially lower.*
Time Until Remedial Objectives are Achieved	Remedial objectives not achieved.	Installation of the sediment traps protects the downstream locations from the transfer of the highest level mine-affected sediment/riparian soil to locations lower in these intermittent drainages, but does not shorten the time for natural recovery process. Natural recovery in the intermittent drainages is expected to be a long-term remedy (i.e., potentially a decade or more to reduce COCs/COECs and achieve concentrations that do not pose unacceptable risks in sediment/riparian soil and the associated vegetation). ICs/LUCs would limit human health, livestock, and some wildlife exposures while natural recovery is occurring.	In the upper drainages where sediment/riparian soil would be removed, the time until the remedial objectives are achieved is equal to the duration of the excavation. However, reclamation activities to restore the disturbed areas would start immediately after removal, but full recovery of the riparian areas could be on the order of a decade or more depending on the riparian area. In the lower reaches of the drainages where MNR is the remedy, the time until the remedial objectives are met may be reduced compared with the expected duration for Alternative 3. This is because the most highly contaminated sediment/riparian soil in the upper reaches would be removed, which would prevent higher concentration sediment/riparian soil from being physically transported downstream during spring runoff in the short- term. Thus, Alternative 4 would reduce the overall timeframe for COCs/COECs in the lower drainages to disperse to concentrations that do not pose unacceptable risks.
5B) Comparative Analysis	*Alternative 3 provides the greatest protection of the community and workers during remedial actions and causes minimal disturbance of the riparian corridor because it includes only minor invasive construction activities and ranks moderate. Alternatives 3 and 4 present some environmental risk in that natural recovery processes may not occur under either of these alternatives (e.g., COCs/COECs would disperse but potentially at concentrations that continue to present unacceptable risks). Alternative 4 likely has the shortest time until RAOs are achieved because the sediment/riparian soil with the highest COC/COEC concentrations in the upper drainages adjacent to the mined area would be removed and capped with the upland soil/waste rock. However, that benefit is offset by the damage that the sediment/riparian-soil-removal component of Alternative 4 would have on the riparian corridors and associated ecological/wildlife habitat so Alternative 4 ranks low to moderate in relationship to the short term effectiveness criterion considering the tradeoffs of invasive construction. The No Action alternative does not meet these criteria because it does not meet the remedial objectives.*		
6) Implementability			
6A) Detailed Analysis	***Low***	***High***	***Moderate to High***

USEPA Evaluation Criteria	**Alternative 1** **No Action (assumes no source controls are conducted in the upland soil/waste rock)** *The No Action alternative does not include any remedial action, long-term monitoring (LTM), or administrative or engineering controls.*	**Alternative 3** **Sediment Traps/Basins, Monitored Natural Recovery (MNR), Institutional Controls (ICs)[1], and Land Use Controls (LUCs)[2], in conjunction with source control in upland soil/waste rock[3]** *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 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 or reduce migration of COCs/COECs to the downstream drainages. MNR also requires ICs and LUCs to restrict Site activities until the cleanup levels are achieved.*	**Alternative 4** **Removal and On-Site Disposal, MNR, ICs[1], and LUCs[2], in conjunction with source control in upland soil/waste rock[3]** *Sediment/riparian soil (and all associated riparian vegetation) in the upper reaches of the mine-affected drainages, where the highest concentrations of COCs/COECs are detected, would be excavated, transported, and consolidated with the upland soil/waste rock, then capped. The excavated areas would be reclaimed and revegetated. MNR, ICs, and LUCs would be implemented for sediment/riparian soil that is not removed in the lower reaches of the mine-affected drainages where the concentrations of COC/COEC are substantially lower.*
Ability to Construct and Operate the Technology	No construction or operation and maintenance (O&M).	MNR requires no construction or O&M. Proper implementation of MNR might require predesign/design study to demonstrate the effectiveness of the MNR processes. Implementation of MNR during the RA would require preparation of a LTM Sampling and Analysis Plan (SAP), routine monitoring of sediment/riparian soil and vegetation at known locations over a designated time frame, and periodic data evaluations to track the progress of natural recovery and to support CERCLA 5-year reviews. Sediment control basins are relatively easy to construct. Installation of sediment traps/basins in upper intermittent drainages would be conducted using readily available excavation, hauling, and grading equipment. O&M of these structures would require some long-term planning, but is similar to standard construction stormwater BMPs. Disposal of any contaminated sediment retained in these structures over the long term should be relatively easy to place in an on-Site landfill or under the adjacent cover implemented over the Site upland soil/waste rock. Sediment traps/basins would require appropriate planning during the RD and monitoring and periodic evaluations following construction. Construction of the sediment traps would require development of a RAWP. The RD/RAWP for this alternative would include the sediment trap/basin design information, design of temporary roads and engineered access restrictions, site restoration plan, LTM, O&M, and HASPs, and stormwater management plan. Periodic monitoring and data evaluations would be necessary to track evaluate the effectiveness of the RA and to support CERCLA 5-year reviews.	The ability to construct and operate the MNR portion of this alternative is as described in Alternative 3. Removal and disposal of the sediment/riparian soil in the upper drainages would be conducted using readily available excavation, hauling, and grading equipment. An unimpacted source of suitable fill and native plant species that are not selenium hyperaccumulators would need to be identified and selected for Site reclamation. Alternative 4 would require a RD/RAWP with similar components as described in Alternative 3. The RD/RAWP would include a confirmation SAP for verifying removal of the mine-affected sediment/riparian soil near the waste rock dumps. The confirmation sampling plan would identify the performance criteria that would guide the extents of the excavations. The implementability of Alternative 4 is complicated by the fact that additional background data (inclusive of all geologic formations including the Phosphoria Formation) may be necessary for sediment/riparian soil to refine the preliminary cleanup levels because as presented in *Ballard Mine FS Memo #1* the PCLs are very low and might be unattainable. Periodic monitoring and data evaluations would be necessary following remediation to track the reclamation and recovery of the areas where sediment/riparian soil were removed and progress towards achieving the MNR goals in the lower segment of the affected drainages. This information would be used to support CERCLA 5-year reviews.
Reliability of the Technology	No technology is implemented.	As it is anticipated that dispersion would be the predominant natural recovery mechanism in the intermittent Site drainages. The reliability of MNR is dependent on the frequency and magnitude of precipitation and snowmelt events that cause erosion, quantities of windblown dust accumulation and plant decay material, and sediment/riparian soil transport and mixing. These processes are considered reliable; however the timing and magnitude of these events cannot be predicted over the long term. Construction, monitoring and maintenance of sediment control basins is standard for all types of construction including remedial actions where USEPA approved plans would be followed.	The reliability of the MNR portion of this alternative is as described in Alternative 3. The potential limitations to the reliability of removal and disposal of mine-affected sediment/riparian soil include the ability to: 1) confirm that all mine-affected sediment/riparian soil is removed, 2) safely transport the excavated materials to the Site waste rock dumps without spillage, and 3) successfully restore the disturbed riparian corridors where the ecological/wildlife habitat is damaged. These potential limitations would be mitigated through proper planning (e.g., USEPA-approved RD).

USEPA Evaluation Criteria	**Alternative 1** **No Action (assumes no source controls are conducted in the upland soil/waste rock)** *The No Action alternative does not include any remedial action, long-term monitoring (LTM), or administrative or engineering controls.*	**Alternative 3** **Sediment Traps/Basins, Monitored Natural Recovery (MNR), Institutional Controls (ICs)[1], and Land Use Controls (LUCs)[2], in conjunction with source control in upland soil/waste rock[3]** *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 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 or reduce migration of COCs/COECs to the downstream drainages. MNR also requires ICs and LUCs to restrict Site activities until the cleanup levels are achieved.*	**Alternative 4** **Removal and On-Site Disposal, MNR, ICs[1], and LUCs[2], in conjunction with source control in upland soil/waste rock[3]** *Sediment/riparian soil (and all associated riparian vegetation) in the upper reaches of the mine-affected drainages, where the highest concentrations of COCs/COECs are detected, would be excavated, transported, and consolidated with the upland soil/waste rock, then capped. The excavated areas would be reclaimed and revegetated. MNR, ICs, and LUCs would be implemented for sediment/riparian soil that is not removed in the lower reaches of the mine-affected drainages where the concentrations of COC/COEC are substantially lower.*
Ease of Undertaking Additional Remedial Action, if Necessary	No remedial action is implemented.	Installation of sediment traps/basins, MNR and ICs/LUCs do not preclude or affect additional remedial actions if deemed necessary.	Removal and disposal and MNR do not preclude or affect additional remedial actions if deemed necessary.
Ability to Monitor Effectiveness of Remedy	No monitoring would occur.	The effectiveness of the sediment traps is easily monitored by standard operation, monitoring and maintenance plans. The natural recovery component of the remedy is easily monitored by standard sediment/riparian soil sampling techniques, laboratory analyses, and data evaluation processes and would be conducted throughout the length of the mine-affected intermittent drainages. Vegetation analyses if deemed necessary by the A/Ts would need to be defined and implemented.	Similar to Alternative 3, the effectiveness of natural recovery is easily monitored by standard sediment/riparian soil sampling techniques, laboratory analyses, and data evaluation processes. LTM would not be necessary in the upper reaches of the drainages where mine-affected sediment/riparian soil is removed (and confirmation sampling indicates cleanup levels are achieved).
Ability to Obtain Approvals and Coordinate with Other Agencies	Not applicable.	This alternative likely does not require formal approval or coordination with other agencies for implementation of standard stormwater type BMPs under a CERCLA action (i.e., the sediment control traps/ basins), but substantive compliance would be required for all stormwater and stormwater BMPs.	This alternative would require substantive compliance with various state and federal ARARs for the excavation activities in potential wetlands, and potentially coordination with and approval from other agencies.
Availability of Treatment, Storage, and Disposal Services and Capacity	Not applicable.	This alternative and MNR in general, which this alternative relies on, does not require treatment, storage, or disposal capacity or services. Ample storage capacity is available at the Site where accumulated sediment could be disposed under the cover system installed over the upland soil/waste rock during the RA or in an on-Site landfill post-RA.	The MNR component of this alternative does not require treatment, storage, or disposal capacity or services. Ample storage capacity is available at the Site where the excavated sediment/riparian soil would be consolidated and capped along with the upland soil/waste rock.
Availability of Necessary Equipment and Specialists	None required.	Construction of the sediment traps/basins would require construction workers with applicable HAZWOPER training. These resources are readily available. MNR would require field technicians to periodically collect environmental data and environmental scientists to evaluate the progress of the natural recovery process. ICs/LUCs would require legal support to prepare and implement an Institutional Controls ICIAP. These resources are readily available.	The MNR and ICs/LUCs requirements are as described in Alternative 3. The removal and disposal activities would require construction workers with applicable HAZWOPER training. These resources are readily available.

USEPA Evaluation Criteria	**Alternative 1** **No Action (assumes no source controls are conducted in the upland soil/waste rock)** *The No Action alternative does not include any remedial action, long-term monitoring (LTM), or administrative or engineering controls.*	**Alternative 3** **Sediment Traps/Basins, Monitored Natural Recovery (MNR), Institutional Controls (ICs)[1], and Land Use Controls (LUCs)[2], in conjunction with source control in upland soil/waste rock[3]** *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 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 or reduce migration of COCs/COECs to the downstream drainages. MNR also requires ICs and LUCs to restrict Site activities until the cleanup levels are achieved.*	**Alternative 4** **Removal and On-Site Disposal, MNR, ICs[1], and LUCs[2], in conjunction with source control in upland soil/waste rock[3]** *Sediment/riparian soil (and all associated riparian vegetation) in the upper reaches of the mine-affected drainages, where the highest concentrations of COCs/COECs are detected, would be excavated, transported, and consolidated with the upland soil/waste rock, then capped. The excavated areas would be reclaimed and revegetated. MNR, ICs, and LUCs would be implemented for sediment/riparian soil that is not removed in the lower reaches of the mine-affected drainages where the concentrations of COC/COEC are substantially lower.*
Availability/Demonstrated Effectiveness of Prospective Technologies	None required.	Sediment traps/basins are standard BMPs installed for construction projects including remedial actions. MNR, ICs and LUCs are USEPA-recognized remedial alternatives. Uncertainties related to implementing MNR at the Site include the presumption that dispersion would be the dominant natural recovery processes (e.g., as opposed to burial), plant uptake of the COCs/COECs as natural recovery is progressing, and a low potential COC/COEC loading to the Blackfoot River. It is unlikely that these uncertainties can be completely eliminated (i.e., modeling and contaminant loading calculations may not eliminate or even reduce uncertainties). However, there would be no continuing source of COCs/COECs once the cover system is in place in the former mined area, which greatly reduces any risks to the Blackfoot River. Other uncertainties are related to the available characterization data in the intermittent drainages (i.e., the nature and extent of COCs/COECs in sediment/riparian soil and associated vegetation are based on relatively few widely spaced sampling locations). Additional site characterization data may be necessary to provide a baseline for monitoring natural recovery.	MNR, ICs, and LUCs are USEPA-recognized remedial alternatives. Uncertainties related to MNR are as discussed in Alternative 3. The primary uncertainties related to removal/disposal alternative are the distribution of available site characterization data, lack of appropriate background data which drives the cleanup goals, and the indistinct and/or non-existent stream channels in the upper drainages near the mined area. These limitations may present design and implementation challenges to identify areas and the size of areas that are designated for excavation. Additional background data may be necessary to refine the cleanup levels because as presented in *Ballard Mine FS Memo #1* the cleanup levels are very low and might be unattainable. Site characterization data may be necessary to inform the design of sediment/riparian soil removal, refine volume estimates, and guide initial excavations during the RA.
6B) Comparative Analysis	*Alternative 3 would be the simplest to implement as it only involves installing sediment traps/basins in the upper drainages and implementing ICs/LUCs and monitoring the natural recovery processes and is highly implementable. Alternative 4 is difficult to implement because in addition to implementing ICs/LUCs and monitoring the MNR processes, it would require construction activities to remove the sediment/riparian soil in the drainages adjacent to the mined areas, transportation of the removed materials to the mined area, confirmation sampling, site restoration, and O&M of the disturbed areas until the riparian corridors, vegetation, and associated ecological/wildlife habitat is restored. The implementability of Alternative 4 is further complicated by the additional uncertainty related to the limits of the removal activities, and the potential difficulties presented by targeting excavation areas in the indistinct stream channels in the upper drainages near the mined area. The implementability of both Alternatives 3 and 4 also is complicated by the fact that additional background data (inclusive of all geologic formations including the Phosphoria Formation) may be necessary for sediment/riparian soil to refine the preliminary cleanup levels because as presented in Ballard FS Memo #1 the PCLs are very low and might be unattainable. This uncertainty would need to be addressed during the RD for Alternative 4 (prior to excavation activities). The uncertainties associated with MNR over the long term are equal between Alternatives 3 and 4. Based on this evaluation, Alternative 3 is easier to implement and ranks higher than Alternative 4 (moderate to high). The No Action alternative is easy to implement, but does not meet the criteria because it does not assist in achieving the RAOs for protection of human health and the environment.*		
7) Cost			
7A) Detailed Analysis			
30-year Present Worth Total Cost	**$108,000**	**$736,000**	**$1,591,000**
7B) Comparative Analysis	*As one would expect, the no action alternative is the least expensive, but does not meet the RAO for protection of human health and the environment and fails all the criteria including this one. Alternative 3 (MNR) is approximately one half of the cost of Alternative 4 which includes excavation, consolidation and capping of the most contaminated sediment/riparian soil in the upper drainages in addition to MNR. As a result, Alternative 3 ranks more highly than Alternative 4 with respect to the cost criterion.*		
8 and 9) State and Community Acceptance	To be evaluated after the public comment period.		

1 Institutional controls (ICs) are non-engineered instruments, such as administrative and legal controls, that help to minimize the potential for exposure to contamination and/or protect the integrity of a response action (e.g., government controls, proprietary controls, enforcement tools, and informational tools).

2 Land Use Controls (LUCs) are engineering controls (e.g., fencing signage, and other physical barriers) that limit human and in some cases ecological exposures. Although USEPA considers ICs to be a subset of LUCs, for clarity, this FS document distinguishes ICs to be non-engineered instruments and LUCs to be engineered controls.

3 With the exception of the No-Action alternative, all retained remedial alternatives for sediment/riparian soil rely on source controls in the upland soil/waste rock to restrict migration of COCs/COECs from the waste rock to downstream sediment/riparian soil. Following source controls in the upland soil/waste rock, the consolidated and covered waste rock will no longer be exposed at the ground surface, and therefore no longer available to be transported via erosional forces to the downstream drainages.

4 Section 121 of CERCLA, as amended by SARA, requires that remedial actions which result in any hazardous substances, pollutants, or contaminants remaining at the Site be subject to a 5-year review. The National Oil and Hazardous Substances Pollution Contingency Plan (NCP) further provides that remedial actions which result in any hazardous substances, pollutants, or contaminants remaining at the site above levels that allow for unlimited use and unrestricted exposure be reviewed every five years to ensure protection of human health and the environment.

TABLE 3-4
DETAILED AND COMPARATIVE ANALYSES - GROUNDWATER REMEDIAL ALTERNATIVES
FEASIBILITY STUDY TECHNICAL MEMORANDUM #2
P4 Production LLC, Ballard Mine

USEPA Evaluation Criteria	Alternative 1 **No Action (assumes no source controls are conducted in the upland soil/waste rock)** *The No Action alternative does not include any remedial action (RA), long-term monitoring (LTM), or administrative or engineering controls.*	Alternative 2 **Monitored Natural Attenuation (MNA) and Institutional Controls (ICs)[1] in conjunction with source control of upland soil/waste rock[2]** *MNA would be implemented for both shallow alluvial and Wells Formation groundwater, and ICs would be implemented to restrict groundwater use until cleanup levels are achieved.*	Alternative 3 **Limited Permeable Reactive Barrier (PRB) Treatment of Alluvial Groundwater, MNA, and ICs[1] in conjunction with source control of upland soil/waste rock[2]** *MNA and ICs would be implemented as in Alternative 2, and PRBs would be installed upgradient of select perennial seeps near the margins of the waste rock dumps at the Site to treat shallow alluvial groundwater before it discharges at seeps/springs.*	Alternative 5b **Groundwater Recovery and Treatment of both Alluvial and Wells Formation Groundwater followed by reinjection using impoundment or wells, and ICs in conjunction with source control of upland soil/waste rock[2]** *This alternative includes groundwater extraction via trenches in the alluvial aquifer and wells for the Wells Formation (Wells Fm) aquifer, then ex-situ treatment of all mine-affected groundwater using membrane technology[3]. Treated water would be discharged to a basin and allowed to infiltrate back into the alluvial aquifer and infiltrated back to the Wells Formation.*
1) Overall Protection of Human Health and the Environment				
1A) Detailed Analysis	***Low***	***Moderate***	***Moderate to High***	***High***
How Alternative Provides Human Health and Environmental Protection	With no source controls in place in the upland soil/waste rock, COC concentrations in the groundwater (GW) are not expected to decrease. ICs would not be implemented to restrict GW exposures. As a result, the No Action alternative is not considered protective of human health and the environment.	Source controls in the upland soil/waste rock area would substantially reduce ongoing contributions of COCs to GW over the long term. With source controls (e.g., a cover system) in place in the upland soil/waste rock, natural attenuation processes would reduce COC concentrations in the GW to cleanup levels over time. In the interim, ICs would restrict human and livestock contact with the mine-affected GW.	In addition to MNA and ICs as described in Alternative 2, this alternative uses PRB treatment of shallow alluvial GW upgradient of select perennial seeps/springs to treat alluvial GW before it discharges near the margins of the waste rock dumps. The PRB treatment at these locations should significantly reduce the potential for COC/COEC transfer to surface water where there are complete exposure pathways to human and ecological receptors.	ICs would be implemented as described in Alternative 2 to restrict use of the GW by humans and limit livestock contact with the mine-affected GW while extraction and treatment is ongoing. This alternative includes extraction and treatment of mine-affected GW from both the shallow alluvial aquifer and the deeper Wells Fm. Extracted GW would be treated to meet cleanup levels at an on-Site water treatment plant (WTP). Extracted and treated water from the Wells Fm would be infiltrated back into the Wells Fm. Extracted and treated water from the alluvial aquifer would be discharged to an infiltration basin for reintroduction to the alluvial aquifer.
1B) Comparative Analysis	*A key factor in evaluating the protectiveness of the GW alternatives is that there are no current or anticipated future users of the mine-affected GW. Because the only complete exposure pathway is where mine-affected GW discharges and becomes surface water (i.e., at the seeps/springs located near the margins of the waste rock dumps), Alternatives 3 and 5b are the most protective because they treat mine-affected groundwater before it discharges to the seeps/springs where exposures can occur. However Alternative 3 does not treat Wells Formation groundwater or the eastern and western alluvial plumes on the flanks of the Site so ranks slightly lower (moderate to high) than Alternative 5b which treats all mine affected groundwater and ranks high. Because Alternative 2 does not actively treat groundwater it is ranked as moderate because it relies on source controls and MNA to remediate alluvial and Wells Formation groundwater over the long term. The No Action alternative is not protective of human health and the environment because no ICs would be implemented to prevent or reduce exposure to mine-affected groundwater.*			
2) Compliance with ARARs				
2A) Detailed Analysis	***Low***	***Moderate to High***	***High***	***Moderate to High***
Chemical-Specific ARARs	No Action does not comply with chemical-specific ARARs because it assumes no source controls are implemented.	Chemical-specific ARARs would be achieved in the long term through source controls in the upland soil/waste rock and by the natural attenuation processes.	Chemical-specific ARARs would be achieved over time as a result of source controls in the upland soil/waste rock, PRB treatment up gradient of select seeps/springs, and MNA.	Chemical-specific ARARs would be achieved over time as a result of source controls in the upland soil/waste rock and treatment of extracted alluvial and Wells Fm GW.
Location- and Action-Specific ARARs	No Action would not trigger any location- or action-specific ARARs.	MNA is a passive RA that does not trigger any location- or action-specific ARARs.	It is anticipated that the PRB component of this alternative can be designed and implemented to substantively comply with location- and action-specific ARARs. Examples of location-specific ARARs that would need to be substantively complied with during remedial design and construction include those laws/regulations intended to protect wetlands, natural streams and water bodies (near where the PRBs would be located). Examples of action-specific ARARs where substantive compliance would be necessary	It is anticipated that the GW recovery and treatment component of this alternative can be designed to substantively comply with location- and action-specific ARARs. Although this GW remedy requires by far the most construction for extraction and infiltration wells/trenches (or infiltration ponds), piping, and construction of a WTP. Examples of location-specific ARARs that would need to be substantively complied with during remedial design and construction include those laws/regulations related to discharge of treated water (e.g., USEPA underground injection control regulations). Substantive compliance with these ARARs likely would be difficult due to relatively strict discharge requirements. Examples of action-specific ARARs that would need to be substantively complied with during remedial design and construction

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			include those laws/regulations intended to protect fish and wildlife. Substantive compliance with these ARARs is expected to be straightforward as the PRBs would be constructed in areas where there is already disturbance related to the past mining operation and because the construction itself would not create significantly additional impacts to any existing streams or wetlands. The MNA component of this alternative is a passive RA that does not trigger any location-specific ARARs.	include those laws/regulations intended to protect fish and wildlife during construction of extraction wells/trenches, infiltration ponds, and WTP.
2B) Comparative Analysis	*Alternative 2 complies with chemical-specific ARARs in the long term and does not trigger any location- or action-specific ARARs because it does not involve construction. Alternative 3 includes installation of PRBs, but in the mine disturbed area, so in addition to compliance with chemical ARARs, it should easily substantively comply with action- and location-specific ARARs. Alternative 5b also complies with chemical-specific ARARs, but substantive compliance with location- and action-specific ARARs would be required and are difficult as it relates to disposal of treatment wastes (e.g., sludges) and treated groundwater. As a result, Alternatives 2 and 5b are similar as to compliance to these ARAR types with moderate to high ranking, while Alternative 3 ranks highest. The No Action alternative does not comply with chemical-specific ARARs so ranks lowest.*			
3) Long-term Effectiveness and Permanence				
3A) Detailed Analysis	***Low***	***Moderate***	***Moderate to High***	***Moderate to High***
Magnitude of residual risk	Existing risks would remain.	Residual risk is associated with GW concentrations of COCs above cleanup levels until the concentrations are reduced by natural attenuation processes. This risk is mitigated as long as ICs are maintained to restrict contact with mine-affected GW during the remediation process.	Residual risk is associated with concentrations of COCs above cleanup levels in GW until COC concentrations are reduced by natural attenuation processes and PRB treatment of the affected seeps/springs near the margins of the former mined area. This risk is mitigated as long as ICs are maintained to restrict contact with mine-affected GW during the remediation process.	Residual risk is associated with concentrations of COCs above cleanup levels in GW; they are reduced by GW extraction and treatment. This risk is mitigated as long as ICs are maintained to restrict contact with mine-affected GW during the remediation process.
Adequacy and reliability of controls	No controls would be implemented.	Properly implemented ICs should be adequate to restrict human exposures to mine-affected GW while natural attenuation (MNA) is occurring. Reliability of ICs may be dependent on cooperation of adjacent landowners. Long-term monitoring (LTM) is required to evaluate the progress of natural attenuation.	Adequacy and reliability of controls for MNA and ICs are as described in Alternative 2. PRBs used under this alternative are adequate, reliable, and would require a relatively moderate degree of O&M and LTM to evaluate performance. The permeable reactive material may periodically require replacement to restore treatment effectiveness.	The adequacy and reliability of ICs is as described in Alternative 2. GW extraction and injection wells, trenches, and/or infiltration ponds, along with WTP operations would require a high degree of O&M to maintain consistent operation of this complex treatment process. The WTP would require frequent monitoring/adjustment, and equipment is expected to need periodic maintenance/ replacement. LTM would be required to evaluate effectiveness of extraction wells/trenches at hydraulic capture, status of injection systems, and to monitor progress toward achieving cleanup levels in both the alluvial and Wells Fm aquifers.

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3B) Comparative Analysis	*Long-term effectiveness and permanence (i.e., risk remaining after the RAOs have been met) is similarly addressed by Alternatives 3 and 5b ranking moderate to high and slightly lower for Alternative 2 ranking moderate. Although Alternative 5b has the greatest potential to reduce the mass of COCs/COECs in groundwater in a relatively short timeframe, over the long term, it may offer no advantage because of aquifer heterogeneity in both the alluvial and Wells Formation aquifers. Alternative 5b groundwater withdrawal and reinjection also does not completely prevent contaminant rebound in the groundwater following initial cleanup. In addition, the extraction, treatment and reinjection processes and equipment is much more difficult to operate and maintain over the long term, and ultimately may be no more effective or faster than Alternative 3 in achievement of the groundwater cleanup levels in both the alluvial and Wells Formation aquifers. With source control in place over the long term, Alternative 2 (MNA) should be effective and permanent for meeting cleanup levels within these aquifers, but likely in the short term the speed with which RAOs are achieved is accelerated by using the treatment technologies in Alternatives 3 or 5b. The No Action alternative provides no long-term effectiveness/ permanence.*			
4) Reduction in Toxicity, Mobility, or Volume Through Treatment				
4A) Detailed Analysis	***Low***	***Moderate***	***Moderate to High***	***High***
Treatment Process Used and Materials Treated	None	This alternative relies on natural attenuation processes to reduce COC/COEC concentrations in the alluvial and Wells Fm GW. These processes may include physical, biological, and chemical mechanisms that act together to reduce the risk posed by the COCs. It is anticipated that sorption would be the primary natural attenuation mechanism for the inorganic COCs. Proper implementation of MNA would require a predesign/design study to demonstrate the effectiveness of MNA processes. In addition, unimpacted surface water coming off of the capped surfaces would serve to flush and dilute the contaminants in GW downgradient of the Site.	COCs in GW would be treated in-situ by allowing mine-affected GW to passively flow through reactive treatment media (e.g., zero-valent iron, organic material, etc.) installed in trenches positioned perpendicular to the GW flow direction immediately upgradient of selected mine-affected seeps/springs. The media placed in the PRBs will have permeabilities appropriate for the hydraulic conductivities of surrounding materials and with adequate retention times to treat the intended contaminants to acceptable standards. It is likely that these PRBs would be based on those designed and tested at P4's South Rasmussen Mine since 2012 (Newfields, 2016a, b, c). The remainder of the mine-affected alluvial GW (away from the seeps/springs) and the mine-affected Wells Fm GW would be treated by MNA as described in Alternative 2.	COCs in the GW would be extracted from both the alluvial and Wells Fm aquifers would be treated by a membrane technology. Membrane technologies include reverse osmosis (RO), nanofiltration and electrodialysis/ electrodialysis reversal. However, RO was selected for this evaluation, because it should be effective for treating the Site COCs without pretreatment and is widely used in similar situations.
Amount of Hazardous Materials Destroyed or Treated	None	COC mass in GW would be reduced by biological or chemical transformation, although it is anticipated that the primary attenuation mechanism for the inorganic COCs would be sorption to the aquifer matrix.	The amount of hazardous materials destroyed or treated for MNA is as described in Alternative 2. The PRBs would treat the same amount of contaminants but more rapidly. PRBs are demonstrated effective at treating the Site COCs to the anticipated cleanup levels. COCs are either immobilized or sorbed by the reactive media.	RO is demonstrated effective at treating all Site COCs to the anticipated cleanup levels. The contaminants are retained in a brine that would require handling and disposal.
Degree of Expected Reductions in Toxicity, Mobility, and Volume	None	The predominant natural attenuation process in GW likely would be sorption of the inorganic COCs to the aquifer matrix, which would result in an overall reduction of toxicity, mobility, and volume of COCs in GW. Although COCs would be	Properly designed, constructed, and maintained PRBs are expected to reduce COCs/COECs concentrations to below cleanup levels at the selected perennial seeps/springs.	The ex-situ membrane treatment system is expected to reduce COC concentrations in the extracted GW to below cleanup levels. COCs would be transferred to the brine. GW extraction would create a hydraulic cone-of-depression that should prevent downgradient migration of COCs. However, complete recovery of the

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		transferred to the aquifer matrix under this scenario, they likely would remain immobile – and there is no complete exposure pathway to the immobilized constituents. Other natural attenuation processes might mobilize COCs in GW (e.g., dispersion, diffusion), but the ultimate result is lower COC concentrations.	The expected reductions in toxicity, mobility, and volume of COCs/ in other areas of mine-affected GW where MNA is occurring is as discussed in Alternative 2.	entire volume of mine-affected GW may not be possible due to heterogeneities within the aquifer matrices. Potential challenges to successfully reaching the cleanup levels include preferential conductivity in the aquifer matrix and rebound of COC concentrations as COCs diffuse from low-permeability materials in the aquifer matrix. As a result, asymptotic COC concentrations trends may occur, which are typical of pump-and-treat systems.
Degree to Which Treatment is Irreversible	No treatment implemented.	It is anticipated that the dominant natural attenuation mechanism for the inorganic COCs in GW would be sorption to the aquifer matrix. As a result, there is a low potential that the COCs that initially sorb to the aquifer matrix could desorb at a later date. However, with source controls in place, the overall COC-concentration trends should be downward over the long term.	The degree to which natural attenuation is irreversible is as discussed in Alternative 2. PRB treatment is not reversible so long as the inflow chemistry does not drastically change. PRBs would be removed and placed either along with the mine wastes during the RA, or in an on-Site landfill post-RA, once cleanup levels are reliably achieved, to avoid re-mobilization of COCs and potential releases to the environment.	Treatment by membrane technology removes COCs from the water and so is not reversible. However, COC concentrations in the aquifers may rebound when concentration gradients are reversed and COCs slowly diffuse out of low-permeability zones in the aquifer matrix.
Type and Quantity of Residuals Remaining After Treatment	None. No treatment implemented.	None. MNA would not generate any treatment residuals.	The MNA portion of the remedy would not generate any treatment residuals. PRB followed by wetlands treatment of the mine-affected GW would not result in residuals in the treated GW. The need to remove and dispose of the permeable reactive material may need to be addressed after cleanup levels are achieved, if it becomes fouled, or it reaches its effective capacity. If necessary, these materials likely can be disposed of during the RA along with the other mine wastes, or post-RA at an on-Site landfill created for the waste or at an offsite disposal facility (e.g., Subtitle C landfill).	Membrane treatment would generate a brine that would require further treatment (e.g., thermal concentrator) prior to off-site or on-Site landfill disposal.
Statutory Preference for Treatment as a Principal Element	This alternative does not include treatment of COCs.	This alternative does not include active treatment of COCs.	The PRB component of this alternative satisfies the statutory preference for treatment of Site COCs.	This alternative satisfies the statutory preference for treatment of Site COCs by using RO for removal of Site contaminants.
4B) Comparative Analysis	*Alternative 5b best addresses this criterion because it includes extraction and treatment of mine-affected groundwater in both the alluvial and Wells Formation aquifers (ranks high). Whereas, Alternative 3 only treats portions of the alluvial groundwater so ranks moderate to high. Alternative 2 does not treat any portion of the Site groundwater actively, but MNA processes passively reduce COCs in groundwater through physical, biological, and chemical mechanisms so ranks moderately. Alternative 5b further reduces the mobility of COCs in groundwater because the extraction wells and trenches would provide some hydraulic capture to reduce downgradient migration of COCs. Alternative 3 would reduce the mobility of COCs/COECs upgradient of contaminated seeps/springs where transfer of COCs/COECs to surface waters occurs. An advantage to Alternative 3 over Alternative 5b is that PRBs do not generate residuals (unless they are fouled and require disposal which may or may not be necessary), whereas the ex-situ treatment under Alternative 5b would generate material (e.g., a brine or solid waste) that would require handling and disposal. The No Action alternative does not address this criterion.*			

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5) Short-term Effectiveness				
5A) Detailed Analysis	***Low***	***Low to Moderate***	***High***	***Moderate to High***
Protection of Community During RAs	No RAs implemented.	MNA is a passive RA. ICs would protect public from risks posed by the mine-affected GW while natural attenuation is occurring.	MNA is a passive RA and PRBs are in-situ treatment that does not expose the community to any risk except during PRB construction. The community would be protected during the construction activities by employing industry-standard dust and stormwater best management practices (BMPs). ICs would protect public from risks posed by the mine-affected GW while natural attenuation is occurring.	Installation of the infrastructure associated with this GW remedy would require significantly more time to complete than the other alternatives. The community would be protected during the extraction well/trench installation, WTP, and injection well/infiltration pond construction activities by employing industry-standard dust and stormwater BMPs. Treatment byproducts (brine) that require disposal would be properly stored and transported according to Department of Transportation regulations, and disposed of at an appropriate permitted facility either on- or off-Site.
Protection of Workers During RAs	No RAs implemented.	The only worker activity required for this alternative is LTM to evaluate the natural attenuation progress. GW sampling is a low-risk activity and would be mitigated using standard personal protective equipment (PPE), and routine health and safety procedures and protocols.	Periodic monitoring to evaluate the natural attenuation progress would be the same as Alternative 2. Workers involved with PRB construction and O&M activities would be protected by having OSHA and HAZWOPER training, wearing appropriate PPE, and by following established health and safety procedures and protocols. Workers would be protected while natural attenuation is occurring as described in Alternative 2.	Workers involved with construction and O&M activities would be protected by having OSHA and HAZWOPER training, wearing appropriate PPE, and by following established health and safety procedures and protocols.
Environmental Impacts	Existing conditions not expected to change.	Following source controls, COC concentrations in the GW are expected to decrease as natural attenuation occurs but over the long-term. In the short term little COC reduction is likely to occur. The potential impacts to the environment associated with natural attenuation include mobilization of COCs (dispersion, diffusion) and media transfer of COCs (sorption of COCs to the aquifer matrix). Dispersion and diffusion ultimately would result in lower COC concentrations, and there are no complete exposure pathways associated with transfer of COCs from GW to the aquifer matrix. These potential impacts would be evaluated via LTM and data evaluation.	The environmental impacts associated with the MNA portion of this remedy are as described in the Alternative 2 column. Potential environmental impacts associated with PRBs include altering the natural GW flow regime. For example, if a PRB becomes fouled, permeability would be reduced and untreated GW would back-up on the upgradient side and flow over or around the PRB. These environmental impacts would be addressed by proper O&M and contingency planning to address fouling. The PRB component of this alternative also has an “environmental footprint” associated with the selected reactive materials and PRB installation (e.g., greenhouse gas emissions related to generating zero-valent iron and construction activities)	Environmental impacts associated with this alternative are associated with producing the required materials used to construct the remedy, construction of the remedy, O&M; and the environmental footprint associated with the handling, transport, and disposal of residual wastes generated by the treatment processes.

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Time Until Remedial Objectives are Achieved	Remedial objectives not achieved.	Natural attenuation is expected to be a long-term remedy (i.e., potentially a decade or more to reduce COC concentrations to below cleanup levels) following completion of source controls. However, without an ongoing source of COCs, the overall size of the mine-affected plumes likely would shrink considerably during the initial 10-year timeframe. ICs would restrict human exposures to GW while natural attenuation is occurring.	The cleanup timeframes for MNA is as described in Alternative 2. The PRBs would treat the mine-affected GW as it passes through the permeable reactive materials and would reduce COC concentrations immediately down-gradient of the PRB relatively quickly (i.e., likely in months). However, the time to achieve overall Site cleanup levels is likely to take considerable time because it would not be equal to the GW flow velocity due to heterogeneities in the aquifer matrices (i.e., zones of high and low hydraulic conductivity) and slow rates of COC diffusion from low-permeability materials. The cleanup timeframes for MNA is as described in Alternative 2.	The treatment system would treat GW at the rate it can be extracted and processed. However, overall achievement of the cleanup levels, much like Alternative 3 would be controlled by heterogeneities in the aquifer matrices and the degree that COCs are sorbed to low-permeability aquifer materials. For example, the volumes of extracted GW may be dominated by flow from high-permeability zones, whereas COC concentrations in the aquifer may be controlled by the slow diffusion of sorbed COCs from low-permeability zones. As a result, while GW recovery and treatment may rapidly reduce COC mass in the aquifers (within years), the time until remedial objectives are completely achieved is expected to be on the order of a decade or more with active treatment.
5B) Comparative Analysis	*Groundwater Alternative 2 would be effective in the short term (i.e., during the construction and implementation phase until the remedial response objectives are met) in terms of protection of the public and construction workers because it does not require construction or O&M activities. However, Alternative 2 would not be as effective in the short term as Alternatives 3 and 5b that involve treatment because it is slower in achieving RAOs (i.e., reduction of the GW COC levels in the alluvial and Wells Fm aquifers to cleanup levels) so ranks low to moderate. The construction and O&M of the PRBs included in Alternative 3 presents little risk to the community and workers and treats shallow alluvial GW before it discharges to seeps/springs where exposures can occur and this alternative ranks the highest for short term effectiveness. Alternative 5b ranks moderate to high falling between Alternatives 2 and 3 as it is the least protective of the community and workers because the required construction, infrastructure, and O&M are relatively complicated. In addition, the residuals from the treatment process would require handling and disposal. Alternative 5b also has the largest environmental footprint, followed by Alternative 3, with Alternative 2 having the smallest environmental footprint. Although Alternative 5b would reduce the mass of COCs the fastest, the time to complete achievement of the cleanup levels in GW is likely to be similar among Alternatives 2, 3, and 5b because of the many factors discussed in criteria 3, 4, and this criterion (5) herein. The No Action alternative does not meet these criteria, because it does not meet the response objectives.*			
6) Implementability				
6A) Detailed Analysis	***Low***	***High***	***Moderate to High***	***Low***
Ability to Construct and Operate the Technology	No construction or operation and maintenance (O&M).	This alternative requires no construction or maintenance so it is easy to implement. Implementation would require preparation of a LTM plan and Sampling and Analysis Plan (SAP) for MNA, an Institutional Controls Implementation and Assurance Plan (ICIAP), and potentially installing additional monitoring points (i.e., monitoring wells). MNA would require periodic GW sampling and data evaluation to assess the progress of natural attenuation and to support CERCLA 5-year reviews. .	The MNA and ICs portion of this alternative has the same planning, monitoring, and evaluation requirements as described in Groundwater Alternative 2. Installation of the PRBs would require remedial design (RD) and a Remedial Action Work Plan (RAWP). The RD/RAWP would include necessary design elements including PRB installation procedures, depths, and materials; design of temporary roads, site restoration plan, HASP, and a stormwater management plan. The PRBs also would require periodic O&M and LTM to evaluate performance. The performance monitoring planning can be a component of the RAWP or included in a SAP.	Construction and operation of extraction systems for the alluvial and Wells Fm aquifers, WTP, and an infiltration pond and Wells Fm injection system (either pond, with an infiltration gallery, or injection wells) would be a complex undertaking, and operation of the system would be difficult. Implementation of this alternative would require: • Predesign testing of RO membranes and other possible pilot testing • Extraction well and extraction trench designs • Treatment system designs • Injection well and infiltration basin designs • RD/RAWP • Preparation of a Performance Standard Verification Plan • Trained O&M staff • Handling and disposal of RO treatment residuals.

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			PRB construction would be conducted using readily available excavation and/or trenching equipment and readily available permeable reactive materials. PRB O&M is relatively routine (e.g., periodic water level measurements to confirm flow directions and hydraulic gradients). Should locations with excessively deep contamination be encountered, a limited number of extraction wells could be constructed to bring water into or upstream of the PRB. Such locations are not expected, but are possible.	
Reliability of the Technology	No technology is implemented.	MNA is an USEPA-recognized remedial alternative and is considered reliable under the right conditions (e.g., source controls, stable plume).	The reliability of the MNA portion of this alternative is as described in Alternative 2. PRB treatment is an USEPA-recognized remedial alternative for GW with the COCs that are present at the Site.	Membrane technology is considered by USEPA to be best available technology (BAT) for the treatment of Site COCs and is reliable, but can be difficult to operate. Also, the extraction trenches and wells are not difficult to construct, but are subject to fouling, as are the disposal components of this remedy (infiltration pond for the alluvial aquifer and injection wells for Wells Fm recharge). Therefore, these remedy components may not be reliable over the longer term. In addition, pump-and-treat systems are notorious for asymptotic concentration trends (or concentration rebound after cleanup levels are initially achieved) as a result of COC diffusion from low permeability materials in the aquifer matrix. Often these treatment systems don't respond well to changing constituents or changes in quantity of water that can be extracted. The geology of the Wells Fm is complex further exacerbating construction of an effective groundwater recovery system, and historically, production well construction in the Wells Fm has proven problematic because of the soft sand units which transmit most of the groundwater.
Ease of Undertaking Additional RA, if Necessary	No RA is implemented.	MNA and ICs do not preclude or affect additional RAs if deemed necessary.	PRBs and MNA do not preclude or affect additional RAs if deemed necessary.	GW recovery and treatment does not preclude or affect additional RAs if deemed necessary.
Ability to Monitor Effectiveness of Remedy	No monitoring would occur.	The effectiveness of natural attenuation is easily monitored by standard GW sampling techniques, laboratory analyses, and data evaluation processes.	The effectiveness of both PRBs and natural attenuation is easily monitored by standard GW monitoring techniques, laboratory analyses, and data evaluation processes.	The effectiveness of GW treatment and recovery is easily monitored by standard GW monitoring techniques, laboratory analyses, and data evaluation processes. However, because of the depth of potential contamination in the Wells Fm, effective monitoring of all portions of the plume may not be possible. The treatment influent and effluent would be monitored throughout the treatment process and upon discharge to insure that the WTP is operating properly and that the cleanup goals are being reached prior to discharge for infiltration or injection.
Ability to Obtain Approvals from Other Agencies	Not applicable.	This alternative does not require approval from other agencies, however substantive compliance of	This alternative does not require approval from other agencies, however substantive compliance of all applicable laws and regulations are necessary on any CERCLA site. The PRBs may disturb wetlands and	This alternative does not require approval from other agencies, however substantive compliance of all applicable laws and regulations are necessary on any CERCLA site and this remedy includes the most construction that would require substantive compliances for these activities. Should any portion of the

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		all applicable laws and regulations are necessary on the CERCLA site.	as a result substantive compliance with applicable laws/regulations would be necessary.	remedy be off the CERCLA site (e.g., brine disposal), compliance with the appropriate regulatory agency would be necessary.
Coordination with Other Agencies	Not applicable.	This alternative does not require coordination with other agencies. However, substantive compliance of all applicable laws and regulations would be necessary on the CERCLA site.	This alternative does not require coordination with other agencies. However, substantive compliance of all applicable laws and regulations are necessary on the CERCLA site and there likely would be some coordination with other agencies depending on construction activity.	This alternative does require substantive compliance of all applicable laws and regulations are necessary on the CERCLA site and there likely would be some coordination with other agencies depending on construction activity (e.g., removal and disposal (i.e., reinjection or infiltration) of water into the alluvial and Wells Fm aquifers would require coordination with and approval from other agencies).
Availability of Treatment, Storage, and Disposal Services and Capacity	Not applicable.	This alternative does not require treatment, storage, or disposal capacity or services.	This alternative does not require treatment, storage, or disposal capacity or services. There is a remote possibility that the reactive materials in the PRBs would have to be removed and disposed. If so, there are numerous Subtitle C landfills in Idaho and Utah and these spent materials possibly could be landfilled on-Site.	There are residual brine wastes generated by the membrane technologies. These materials could be landfilled on Site or disposed at one of the numerous Subtitle C landfills in Idaho and Utah.
Availability of Necessary Equipment and Specialists	None required.	MNA would require field technicians to periodically collect environmental data and environmental scientists to evaluate the progress of the natural recovery process. ICs would require legal support to prepare and implement an ICIAP. These resources are readily available.	The MNA requirements are as described in Alternative 2. Construction of the PRBs would require skilled workers but they are readily available as are the components of the PRBs. PRB operation would require field technicians to periodically perform O&M activities and to collect environmental data, and environmental scientists to evaluate the PRB treatment performance. These resources are readily available.	The RO technology is mature and proven, and is often used for treatment of mine/industrial wastewater. As a result, the equipment for the WTP is readily available, as are the construction staff necessary to install the equipment necessary for this alternative. Operation of the treatment system would require trained O&M staff, environmental technicians to collect environmental data, and environmental scientists to evaluate the treatment-system operation and performance. These resources are readily available, with the possible exception of full-time trained O&M staff.
Availability/Demonstrated Effectiveness of Prospective Technologies	None required.	MNA is often used at CERCLA sites where source control is established and GW use can be restricted until cleanup goals are achieved. Treatability studies may be required to identify the Site-specific natural attenuation mechanisms and to better estimate cleanup timeframes for both the alluvial and Wells Fm aquifers.	PRBs installed at P4's South Rasmussen Mine utilize limestone gravel, alfalfa, and wood chips to promote bacterial action have been very effective in reducing multiple constituents in GW, including the Ballard Site COCs.	RO is an USEPA BAT. Aquifer testing might be necessary to confirm the suitability/effectiveness of GW extraction/injection options (e.g., wells vs ponds) in the Wells Fm and alluvial aquifers. Bench scale or pilot treatability studies likely would be necessary to inform the RO design.
6B) Comparative Analysis	*Alternative 2 is the most implementable because MNA does not require any construction or O&M (ranking high). Alternative 3 is the next most implementable ranking moderate to high because construction and O&M of PRBs is much less difficult than construction, substantive compliance with regulations related to groundwater extraction, treatment, and disposal facilities and O&M requirements associated with Alternative 5b (which ranks low). In addition, the PRBs associated with Alternative 3 would effectively treat the mine-affected groundwater in-situ without a large environmental footprint (disturbance area), while ex-situ treatment under Alternative 5b would require extensive infrastructure and O&M. The No Action alternative does not meet this criteria because it does not meet the remedial objectives.*			

USEPA Evaluation Criteria	Alternative 1 **No Action (assumes no source controls are conducted in the upland soil/waste rock)** *The No Action alternative does not include any remedial action (RA), long-term monitoring (LTM), or administrative or engineering controls.*	Alternative 2 **Monitored Natural Attenuation (MNA) and Institutional Controls (ICs)[1] in conjunction with source control of upland soil/waste rock[2]** *MNA would be implemented for both shallow alluvial and Wells Formation groundwater, and ICs would be implemented to restrict groundwater use until cleanup levels are achieved.*	Alternative 3 **Limited Permeable Reactive Barrier (PRB) Treatment of Alluvial Groundwater, MNA, and ICs[1] in conjunction with source control of upland soil/waste rock[2]** *MNA and ICs would be implemented as in Alternative 2, and PRBs would be installed upgradient of select perennial seeps near the margins of the waste rock dumps at the Site to treat shallow alluvial groundwater before it discharges at seeps/springs.*	Alternative 5b **Groundwater Recovery and Treatment of both Alluvial and Wells Formation Groundwater followed by reinjection using impoundment or wells, and ICs in conjunction with source control of upland soil/waste rock[2]** *This alternative includes groundwater extraction via trenches in the alluvial aquifer and wells for the Wells Formation (Wells Fm) aquifer, then ex-situ treatment of all mine-affected groundwater using membrane technology[3]. Treated water would be discharged to a basin and allowed to infiltrate back into the alluvial aquifer and infiltrated back to the Wells Formation.*
7) Cost				
7A) Detailed Analysis				
30-year Present Worth Total Cost	**$108,000**	**$1,389,000**	**$2,073,000**	**$24,219,000**
7B) Comparative Analysis	*Alternative 2 uses MNA and ICs as a long-term remediation strategy and is the most inexpensive of the remedial alternatives for groundwater. Alternative 3 includes active treatment (PRBs) of the most contaminated alluvial groundwater at the waste rock margins before it discharges to the surface at seeps/springs. It is more costly, but in the range of Alternative 2. Alternative 5b is the most expensive of the viable alternatives for the Site groundwater and is more than ten times the cost of Alternative 3. The No Action alternative is the cheapest by far, but it does not satisfy many of the detailed analysis criterion listed above (e.g., it is not protective) and therefore fails the criterion.*			
8 and 9) State and Community Acceptance	To be evaluated after the public comment period.			

1 Institutional controls (ICs) are non-engineered instruments, such as administrative and legal controls, that help to minimize the potential for exposure to contamination and/or protect the integrity of a response action (e.g., government controls, proprietary controls, enforcement tools, and informational tools).

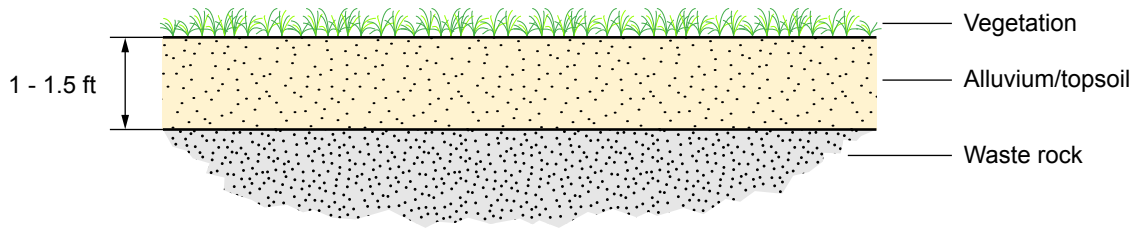
2 With the exception of the No-Action alternative, all retained remedial alternatives for groundwater rely on source controls in the upland soil/waste rock (i.e., the mined area) to prevent or reduce migration of COCs from the waste rock and exposed ore beds to downgradient groundwater. The source controls (i.e., waste rock consolidation, surface grading, and capping) would substantially reduce precipitation and snowmelt from infiltrating through the consolidated and capped wastes, thereby reducing the source of mine-affected groundwater to both the shallow (alluvial) and the deep (Wells Formation) aquifers.

3 Membrane technology (in this case RO) was assumed as the treatment process in these detailed and comparative analyses because it is best suited to address Site COCs/COECs (refer to Appendix B of *Ballard Mine FS Memo #1*. There are other suitable treatment technologies (e.g., chemical precipitation, biological treatment) and one (or a combination) may be selected during RD phase of project.

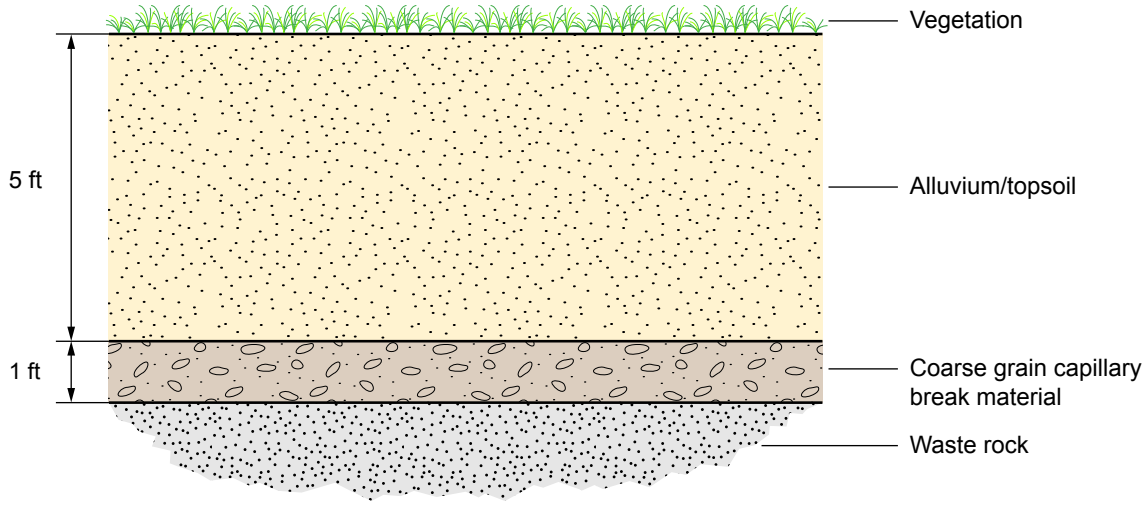
FIGURES

DRAWN BY D. Severson
10 Feb 2017
C:\Data\MWH\P4 Monsanto\P4_Ballard_FS_Jan2015\Ballard_FS_MEMO_2\FIGURES_11Sep2015\Fig 2-1_ET Cover Conceptual Design_10Feb2017.ai

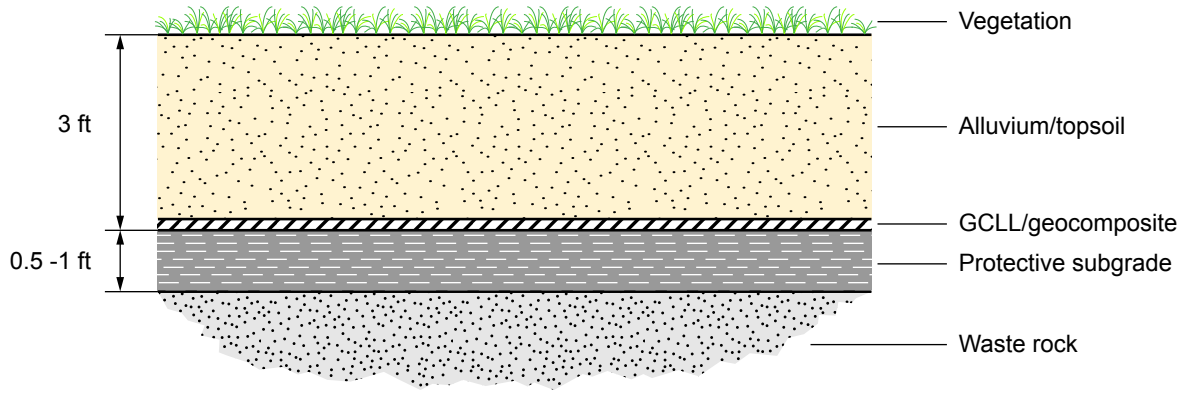
SOIL COVER



MONOLITHIC ET COVER



MULTI-LAYER COVER



NO SCALE

NOTE

Cover vegetation will be selected to remove water from the soil horizon, with roots that will not penetrate through the soil and make contact with waste materials. Depending on the cover soil thickness, the appropriate plant selection and seed mix will change.

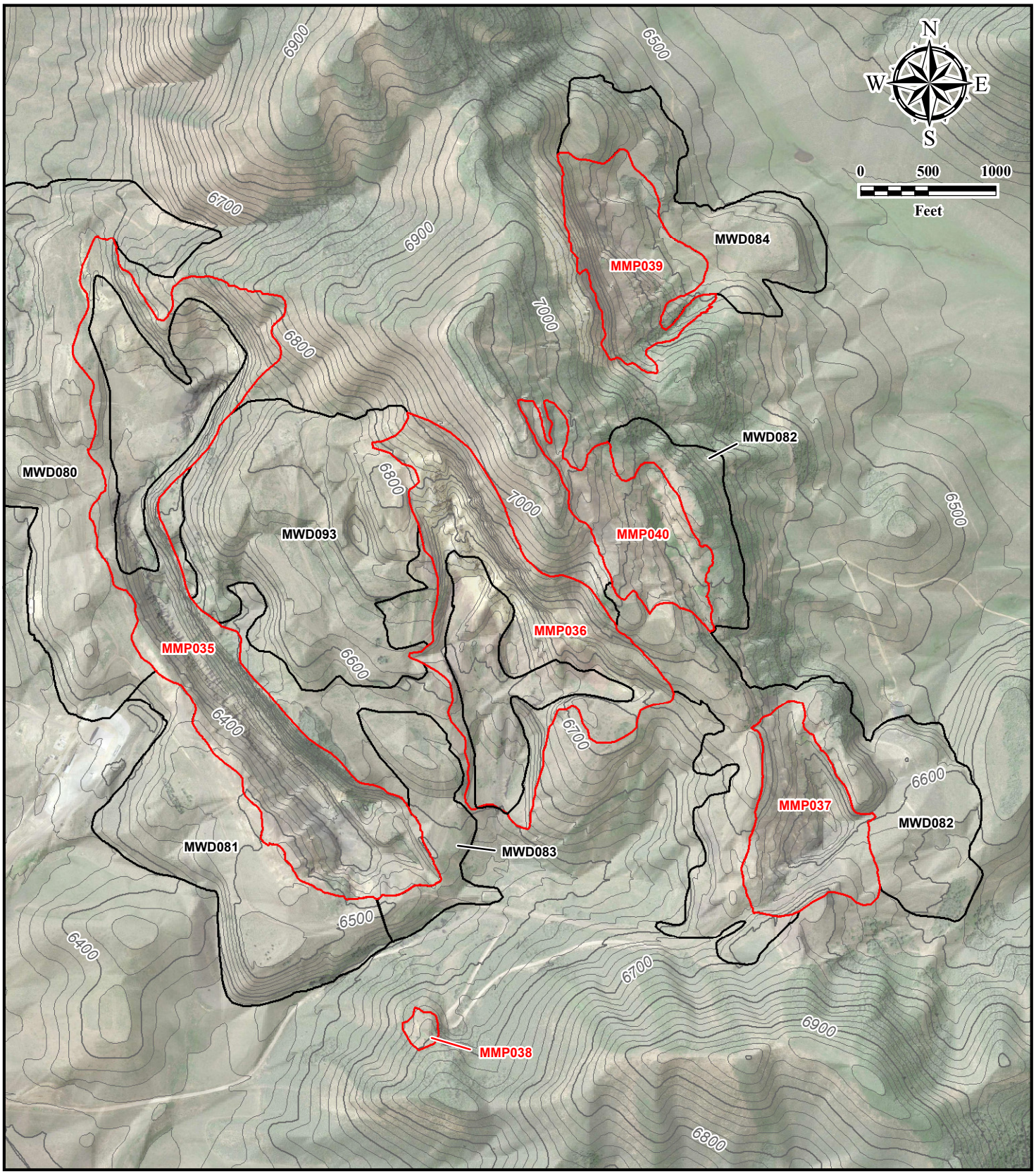
MWH

P_4 Production, LLC

BALLARD FS MEMO 2

ET COVER CONCEPTUAL DESIGN

Figure 2-1



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

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

P_4 Production, LLC

BALLARD FEASIBILITY STUDY
MEMO #2

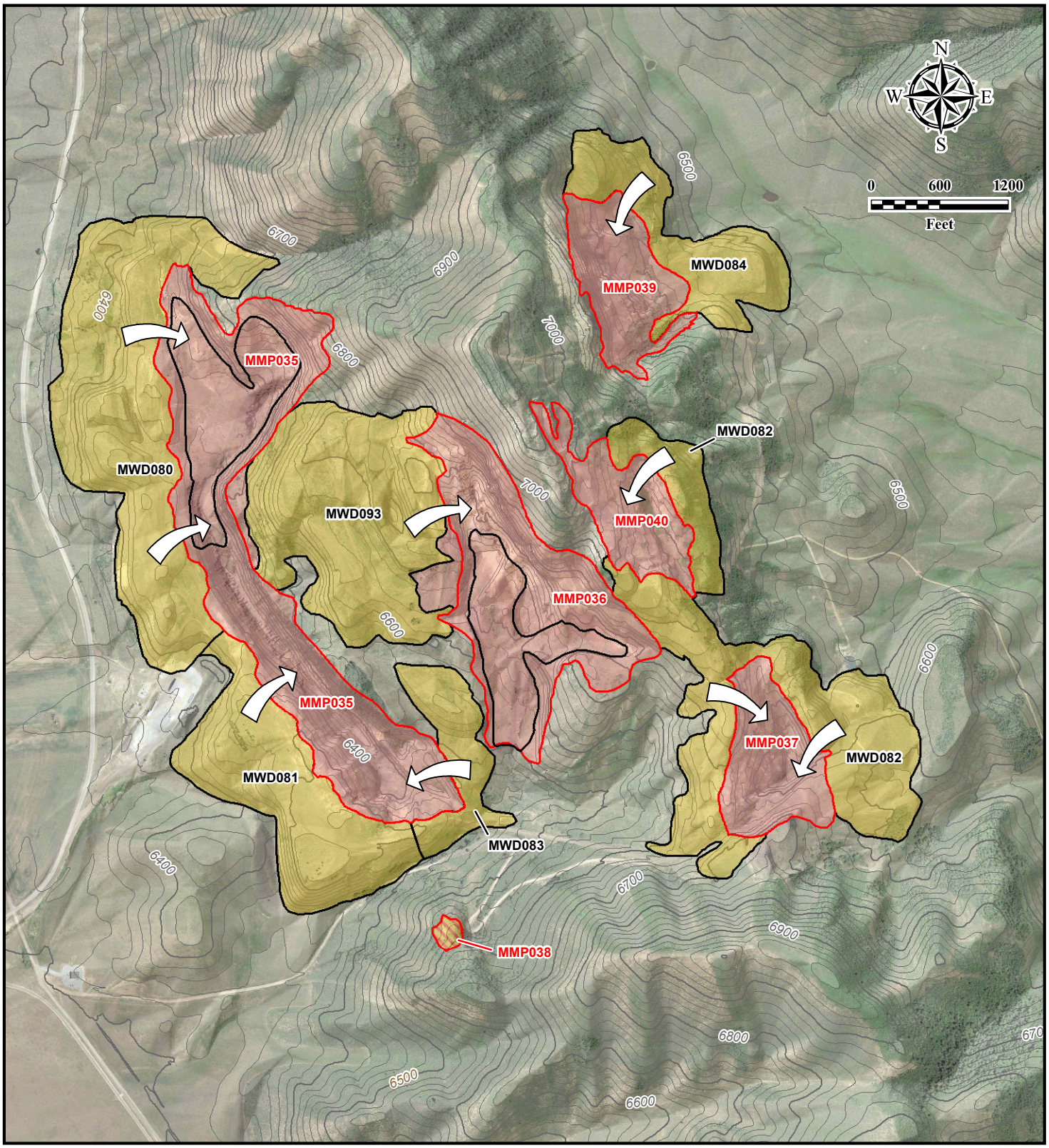
EXISTING SITE CONDITIONS PRIOR TO REMEDIATION

Figure 3-1

DRAWN BY D. Severson

15 Sep 2015

D:\MWH\P4 Monsanto\P4_Ballard_FS_Jan2015\Ballard_FS_MEMO_2\FIGURES_11Sep2015\Fig 3-1_Ballard Reuse_Existing Site Conditions Prior to Remediation_12Sep2015.mxd



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

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

Approximate cut

Approximate fill

Approximate fill and grade

Arrows show where cut materials will be consolidated in fill locations

P_4 Production, LLC

BALLARD FEASIBILITY STUDY MEMO #2

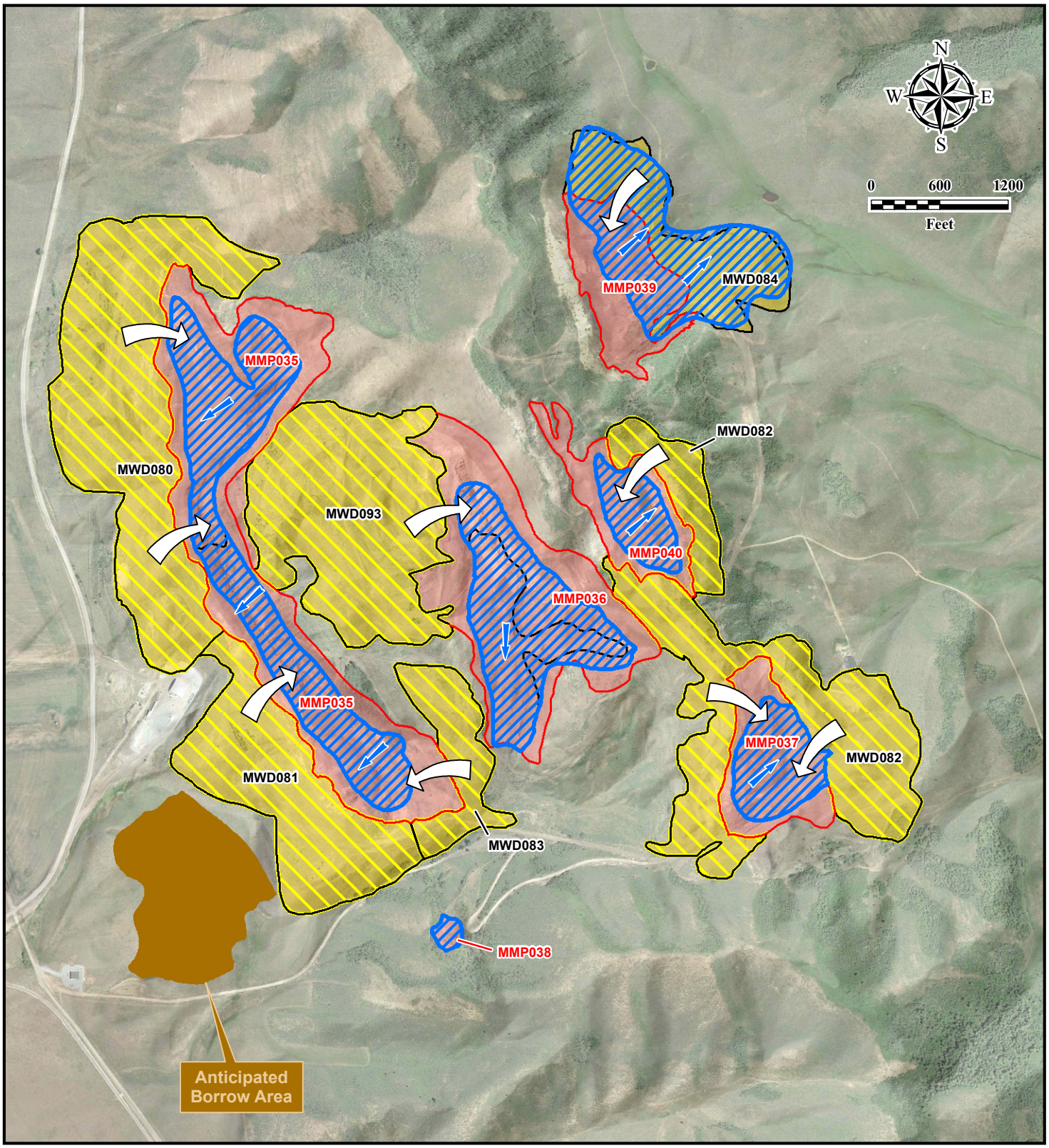
UPLAND SOIL/WASTE ROCK ALTERNATIVE 4: WASTE ROCK REMOVAL/CONSOLIDATION AND/OR GRADING WITH ET COVER SYSTEM, ICs, AND LUCs

Figure 3-2a

DRAWN BY D. Severson

27 Sep 2015

D:\MWH\P4 Monsanto\P4_Ballard_FS_Jan2015\Ballard_FS_MEMO_2\FIGURES_11Sep2015\Fig 3-2a_Ballard_Waste Rock_ALT3B_27Sep2015.mxd



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

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

Existing waste rock dump area (graded and covered)

Approximate fill area (graded and covered)

Arrows show where cut materials will be consolidated in fill locations

General stormwater flow direction

P_4 Production, LLC

BALLARD FEASIBILITY STUDY MEMO #2

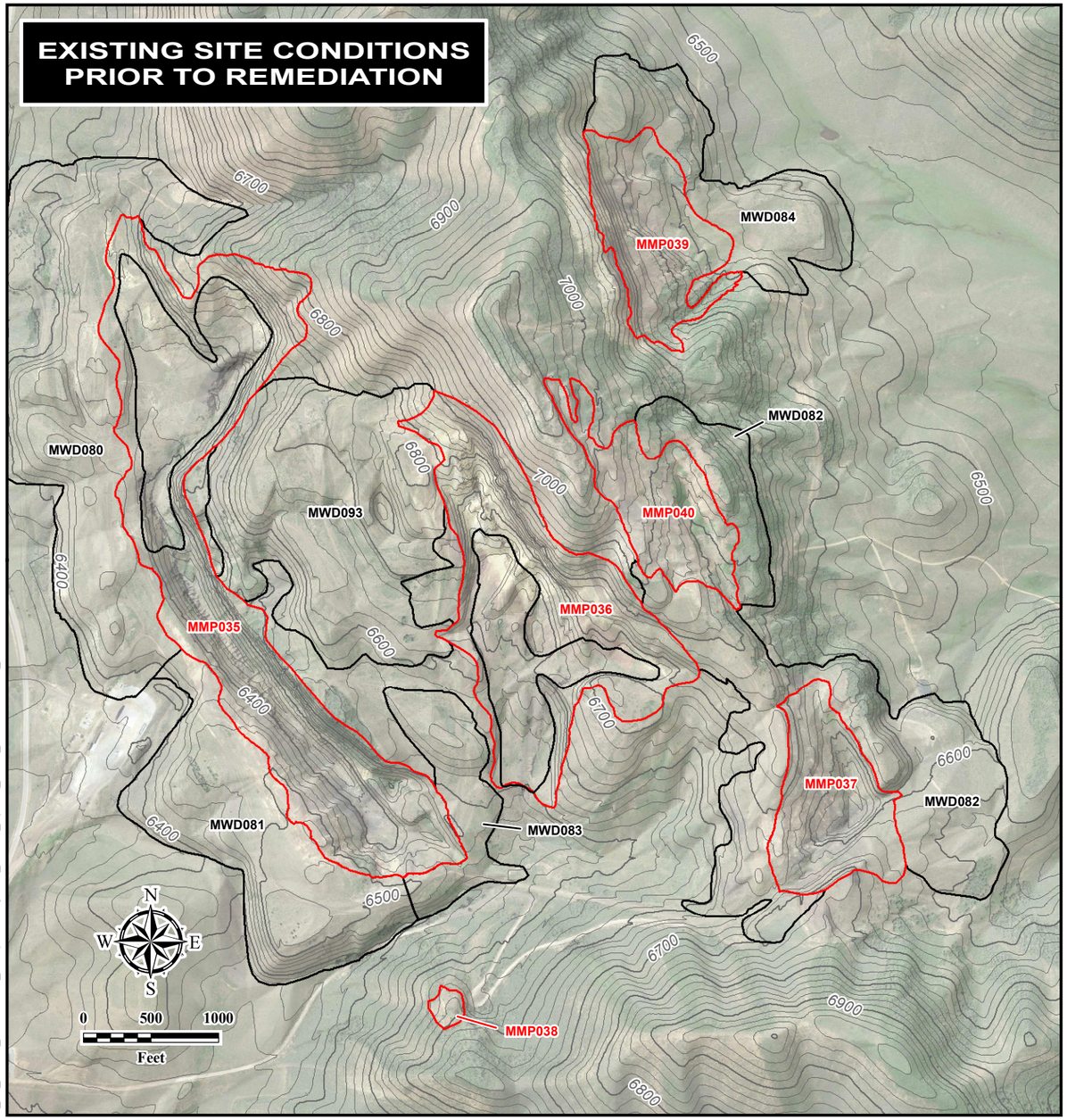
UPLAND SOIL/WASTE ROCK ALTERNATIVE 4: WASTE ROCK REMOVAL/CONSOLIDATION AND/OR GRADING WITH ET COVER SYSTEM, ICs, AND LUCs

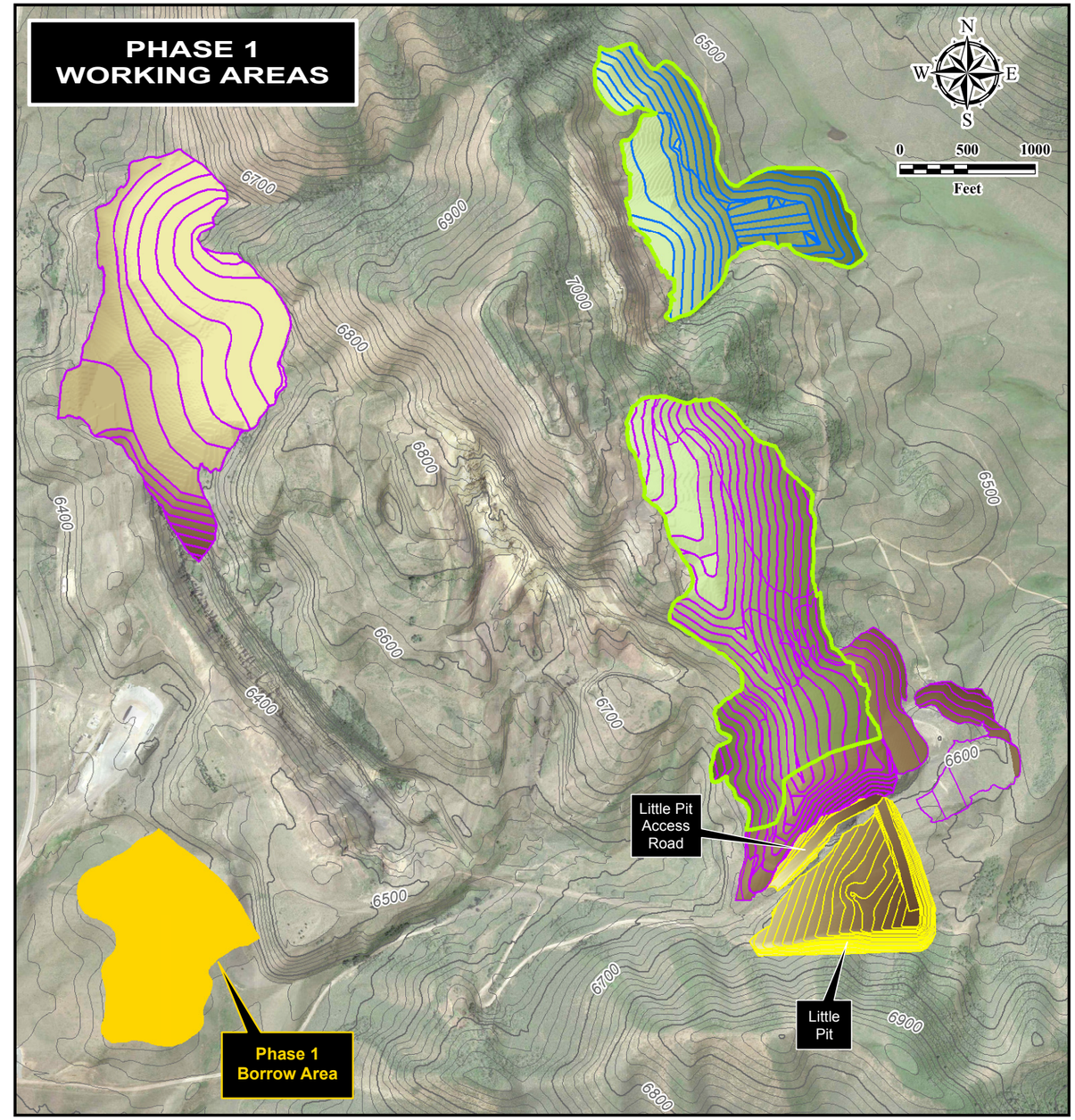
Figure 3-2b

DRAWN BY D. Severson

16 Jun 2016

C:\Data\MWH\P4 Monsanto\P4_Ballard_FS_Jan2015\Ballard_FS_MEMO_2\FIGURES_11Sep2015\Fig 3-2b_Ballard_Waste Rock_ALT4_16Jun2016.mxd





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

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

PHASE 1 WORK ACTIVITIES

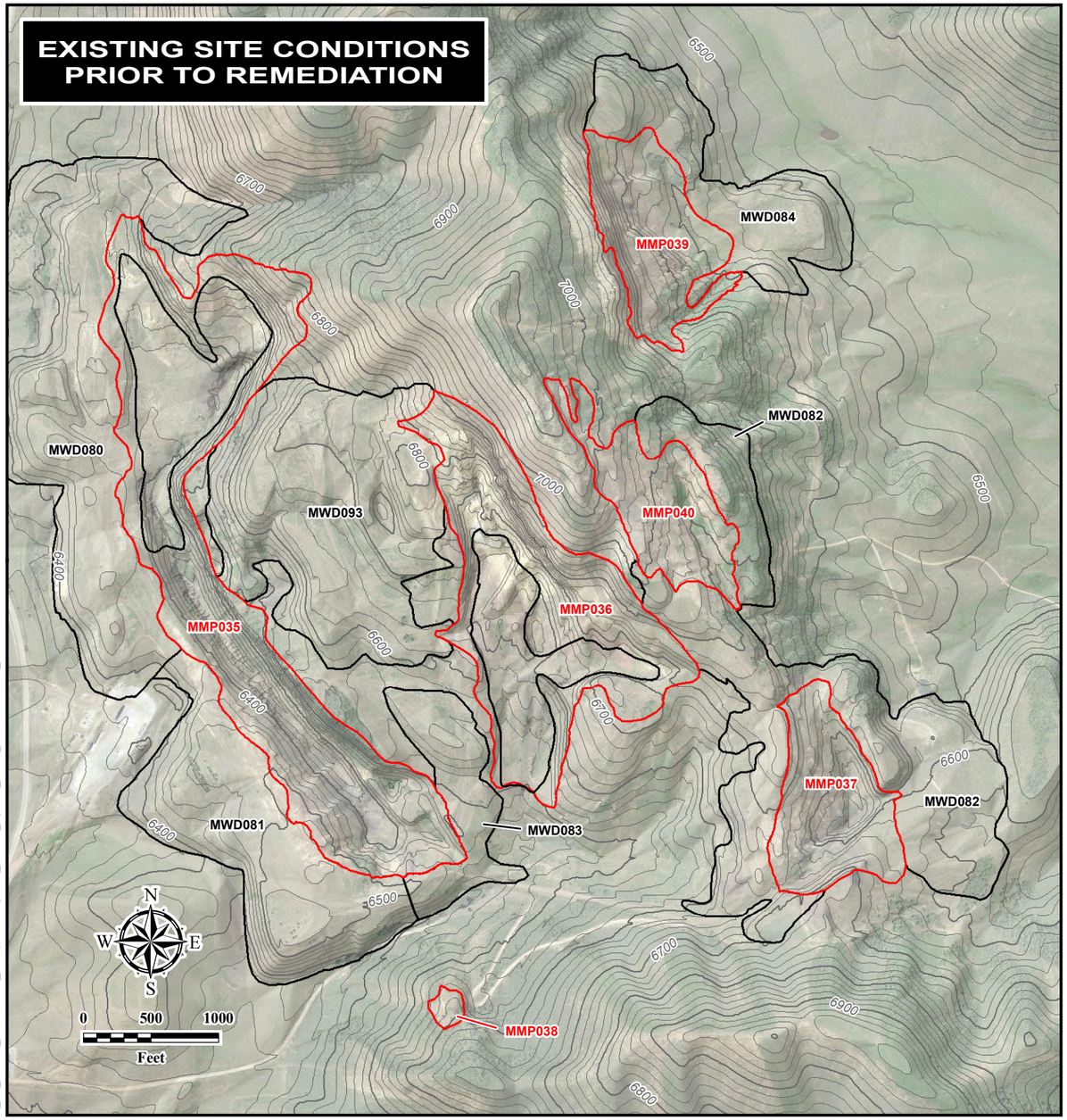
- Completed reclamation area
- Active regrading/consolidation area
- Active mining area

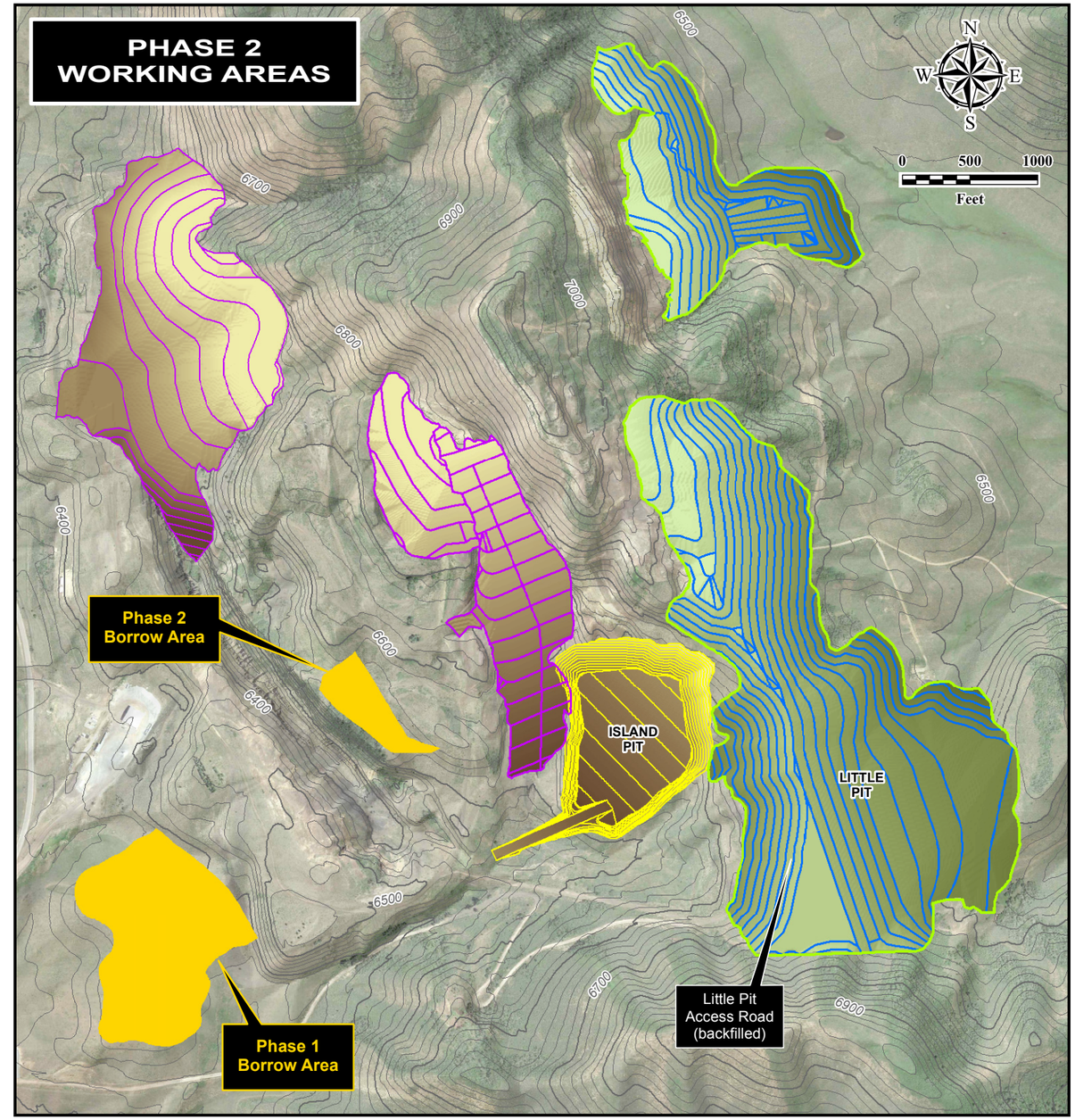
1. *Regrade mine dumps MWD082 and MWD084. Consolidate material into open mine pits MMP040 and MMP039.*
2. *Regrade MMP035 in-pit mine dump.*
3. *Mine Little Pit and Little Pit Access Road. Consolidate material in open mine pits MMP035 and MMP040.*

P_4 Production, LLC

BALLARD FEASIBILITY STUDY MEMO #2
UPLAND SOIL/WASTE ROCK ALTERNATIVE 6: ORE RECOVERY/WASTE ROCK GRADING AND CONSOLIDATION WITH ET COVER SYSTEM, ICs, AND LUCs END OF PHASE 1
Figure 3-3a

DRAWN BY D. Severson
8 Jun 2016
C:\Data\MWH\P4 Monsanto\P4_Ballard_FS_Jan2015\Ballard_FS_MEMO_2\FIGURES_11Sep2015\Fig 3-3a_Ballard_Up Soil_ALT 6_End of Phase 1_8Jun2016.mxd





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

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

PHASE 2 WORK ACTIVITIES

Completed reclamation area

Active regrading/consolidation area

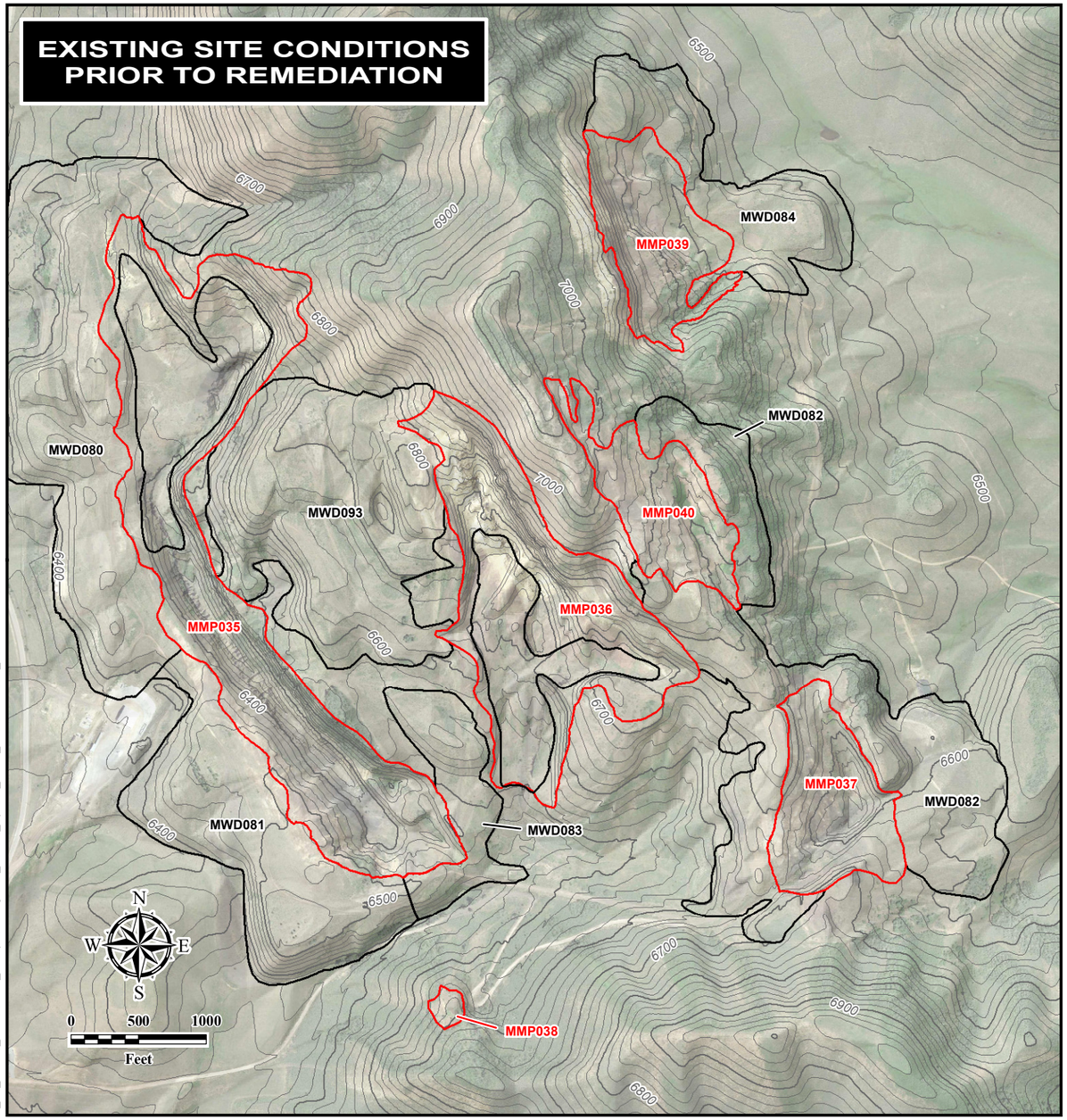
Active mining area

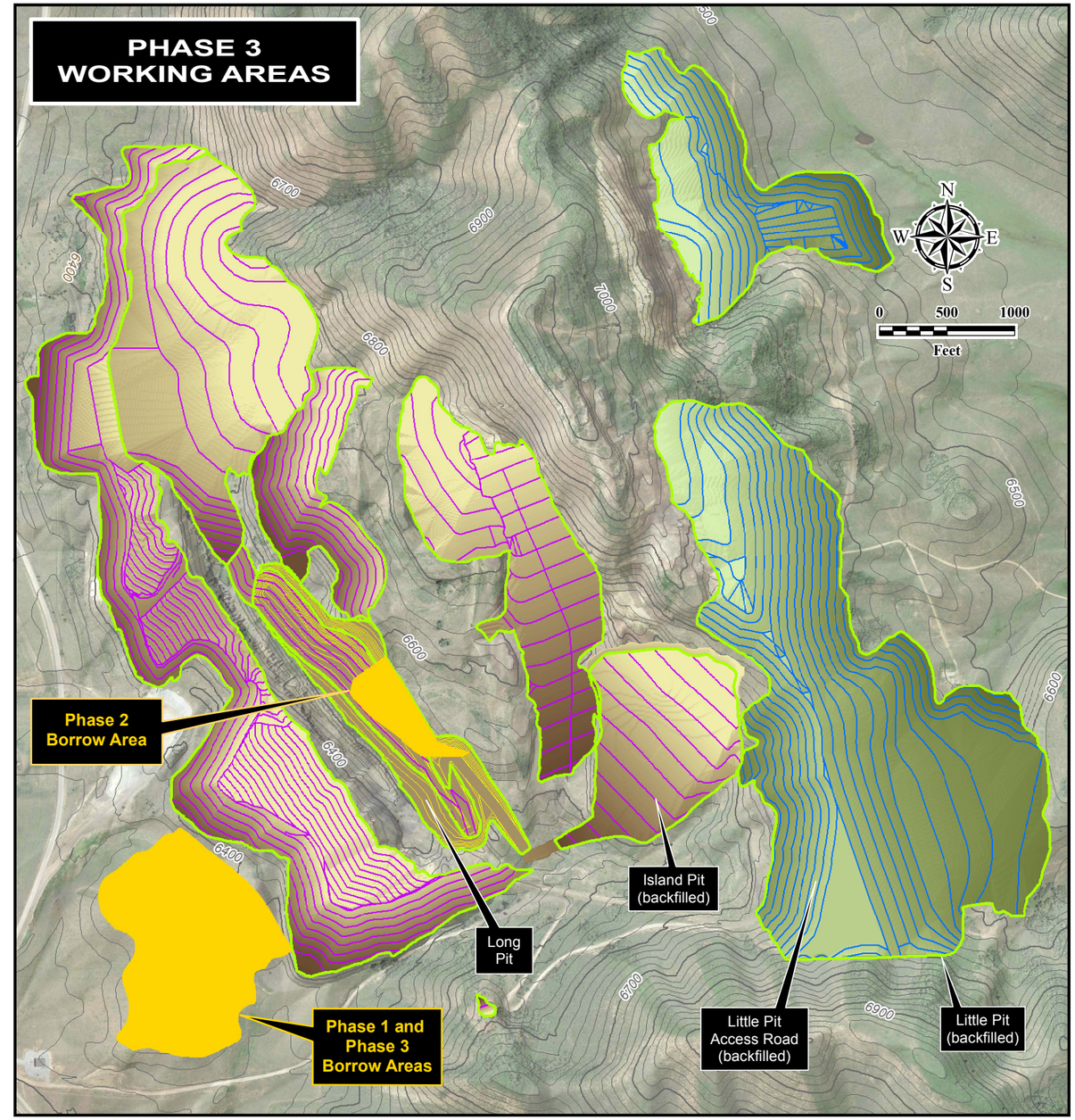
1. *Regrade mine dump MWD093. Consolidate material into open mine pit MMP036.*
2. *Mine Island Pit. Consolidate material in Little Pit (Phase 1) and open mine pit MMP036.*

P_4 Production, LLC

BALLARD FEASIBILITY STUDY MEMO #2
UPLAND SOIL/WASTE ROCK ALTERNATIVE 6: ORE RECOVERY/WASTE ROCK GRADING AND CONSOLIDATION WITH ET COVER SYSTEM, ICs, AND LUCs
END OF PHASE 2
Figure 3-3b

DRAWN BY D. Severson
8 Jun 2016
C:\Data\MWH\P4 Monsanto\P4_Ballard_FS_Jan2015\Ballard_FS_MEMO_2\FIGURES_11Sep2015\Fig 3-3b_Ballard_Up Soil_ALT 6_End of Phase 2_8Jun2016.mxd





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

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

PHASE 3 WORK ACTIVITIES

- Completed reclamation area
- Active regrading/consolidation area
- Active mining area

1. *Mine Long Pit. Consolidate overburden into Island Pit and open mine pit MMP036.*
2. *Regrade mine dumps MWD080, MWD081, and MWD083 and consolidate material into open mine pits MMP035 and MMP036.*
3. *Regrade open mine pit MMP038.*

P_4 Production, LLC

BALLARD FEASIBILITY STUDY MEMO #2

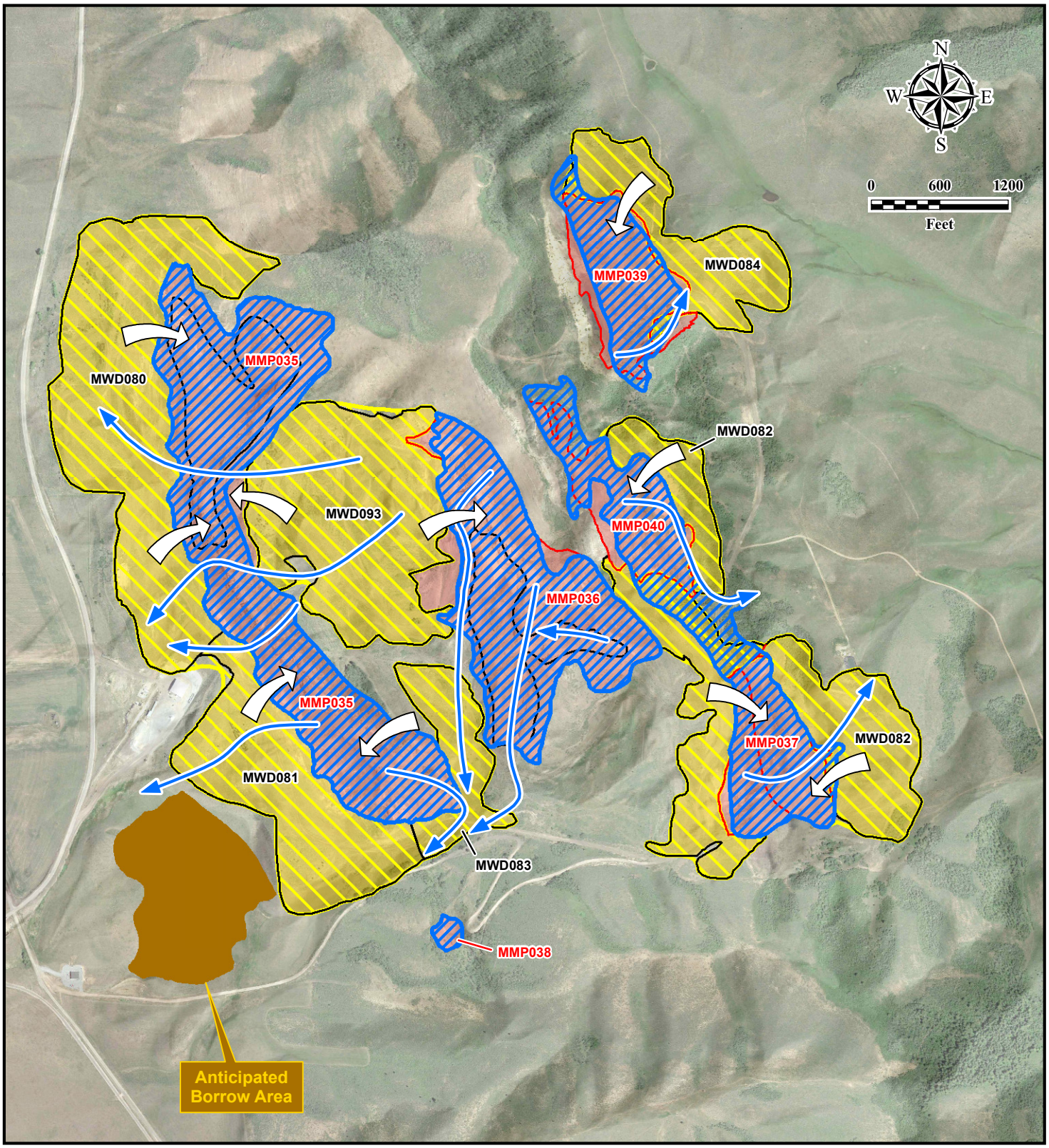
UPLAND SOIL/WASTE ROCK ALTERNATIVE 6: ORE RECOVERY/WASTE ROCK GRADING AND CONSOLIDATION WITH ET COVER SYSTEM, ICs, AND LUCs END OF PHASE 3

Figure 3-3c

DRAWN BY D. Severson

8 Jun 2016

C:\Data\MWH\P4 Monsanto\P4_Ballard_FS_Jan2015\Ballard_FS_MEMO_2\FIGURES_11Sep2015\Fig 3-3c_Ballard_Up Soil_ALT 6_End of Phase 3_8Jun2016.mxd



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

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

Excavated existing waste rock dump area (graded and covered)

Approximate remaining pit high wall area

Approximate fill area (graded and covered)

Arrows show where cut materials will be consolidated in fill (pit) locations

Approximate stormwater flow direction off reclaimed surfaces

P_4 Production, LLC

BALLARD FEASIBILITY STUDY MEMO #2

UPLAND SOIL/WASTE ROCK ALTERNATIVE 7: COMPLETE CONSOLIDATION OF EXISTING WASTE ROCK INTO THE PITS, ET COVER INTERIOR/ EXTERIOR, ICs, LUCs, AND OM&M/LUCs

Figure 3-4

DRAWN BY D. Severson

6 Jul 2016

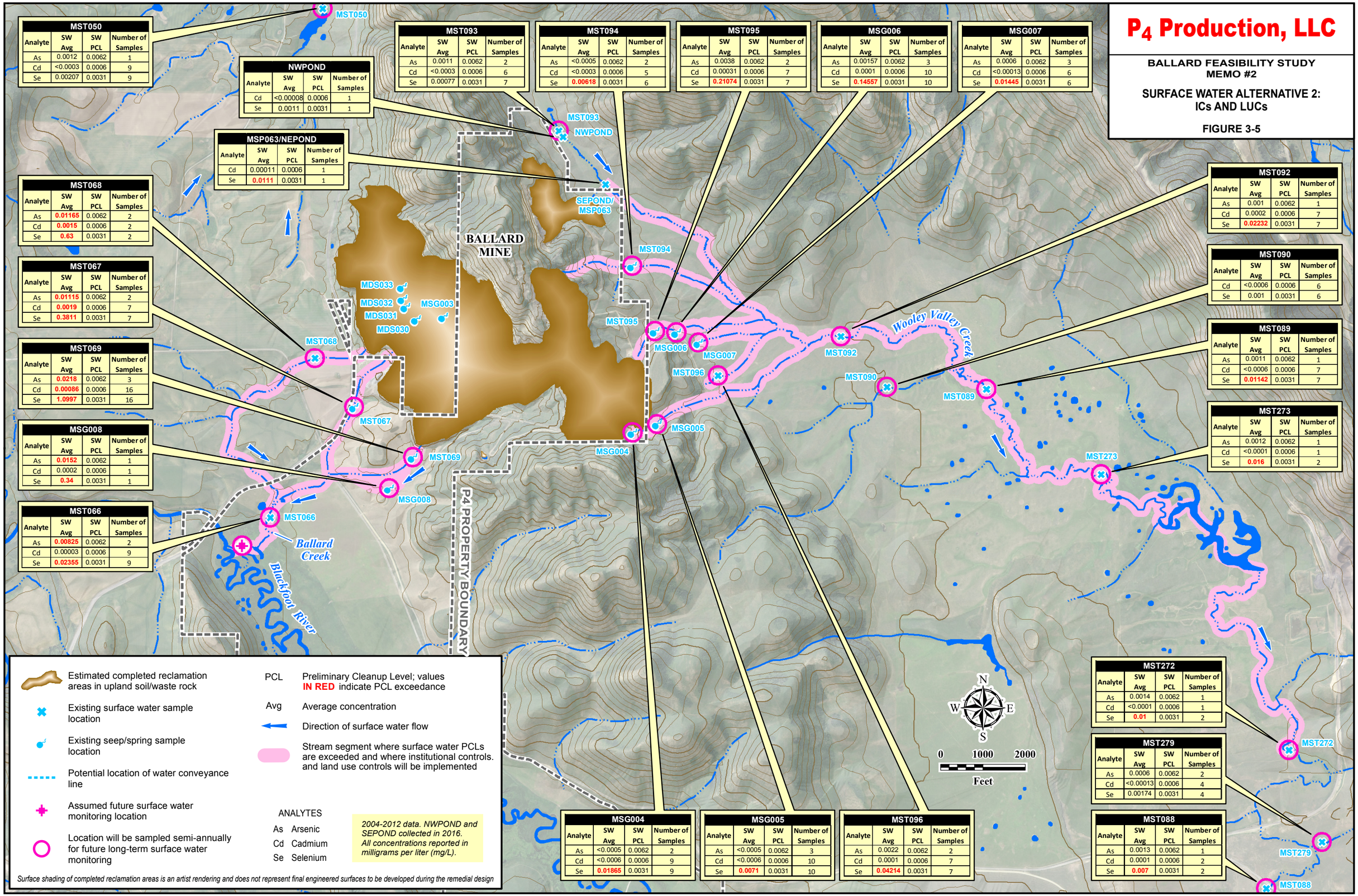
C:\Data\MWH\P4 Monsanto\P4_Ballard_FS_Jan2015\Ballard_FS_MEMO_2\FIGURES_11Sep2015\Fig 3-4_Ballard_Waste Rock_ALT7_6Jul2016.mxd

P_4 Production, LLC

BALLARD FEASIBILITY STUDY
MEMO #2

SURFACE WATER ALTERNATIVE 2:
ICs AND LUCs

FIGURE 3-5



MST050			
Analyte	SW Avg	SW PCL	Number of Samples
As	0.0012	0.0062	1
Cd	<0.0003	0.0006	9
Se	0.00207	0.0031	9

NWPOND			
Analyte	SW Avg	SW PCL	Number of Samples
Cd	<0.00008	0.0006	1
Se	0.0011	0.0031	1

MST093			
Analyte	SW Avg	SW PCL	Number of Samples
As	0.0011	0.0062	2
Cd	<0.0003	0.0006	6
Se	0.00077	0.0031	7

MST094			
Analyte	SW Avg	SW PCL	Number of Samples
As	<0.0005	0.0062	2
Cd	<0.0003	0.0006	5
Se	**0.00618**	0.0031	6

MST095			
Analyte	SW Avg	SW PCL	Number of Samples
As	0.0038	0.0062	2
Cd	0.00031	0.0006	7
Se	**0.21074**	0.0031	7

MSG006			
Analyte	SW Avg	SW PCL	Number of Samples
As	0.00157	0.0062	3
Cd	0.0001	0.0006	10
Se	**0.14557**	0.0031	10

MSG007			
Analyte	SW Avg	SW PCL	Number of Samples
As	0.0006	0.0062	3
Cd	<0.00013	0.0006	6
Se	**0.01445**	0.0031	6

MSP063/NEPOND			
Analyte	SW Avg	SW PCL	Number of Samples
Cd	0.00011	0.0006	1
Se	**0.0111**	0.0031	1

MST068			
Analyte	SW Avg	SW PCL	Number of Samples
As	**0.01165**	0.0062	2
Cd	**0.0015**	0.0006	2
Se	**0.63**	0.0031	2

MST067			
Analyte	SW Avg	SW PCL	Number of Samples
As	**0.01115**	0.0062	2
Cd	**0.0019**	0.0006	7
Se	**0.3811**	0.0031	7

MST069			
Analyte	SW Avg	SW PCL	Number of Samples
As	**0.0218**	0.0062	3
Cd	**0.00086**	0.0006	16
Se	**1.0997**	0.0031	16

MSG008			
Analyte	SW Avg	SW PCL	Number of Samples
As	**0.0152**	0.0062	1
Cd	0.0002	0.0006	1
Se	**0.34**	0.0031	1

MST066			
Analyte	SW Avg	SW PCL	Number of Samples
As	**0.00825**	0.0062	2
Cd	0.00003	0.0006	9
Se	**0.02355**	0.0031	9

MST092			
Analyte	SW Avg	SW PCL	Number of Samples
As	0.001	0.0062	1
Cd	0.0002	0.0006	7
Se	**0.02232**	0.0031	7

MST090			
Analyte	SW Avg	SW PCL	Number of Samples
Cd	<0.0006	0.0006	6
Se	0.001	0.0031	6

MST089			
Analyte	SW Avg	SW PCL	Number of Samples
As	0.0011	0.0062	1
Cd	<0.0006	0.0006	7
Se	**0.01142**	0.0031	7

MST273			
Analyte	SW Avg	SW PCL	Number of Samples
As	0.0012	0.0062	1
Cd	<0.0001	0.0006	1
Se	**0.016**	0.0031	2

MST272			
Analyte	SW Avg	SW PCL	Number of Samples
As	0.0014	0.0062	1
Cd	<0.0001	0.0006	1
Se	**0.01**	0.0031	2

MST279			
Analyte	SW Avg	SW PCL	Number of Samples
As	0.0006	0.0062	2
Cd	<0.00013	0.0006	4
Se	0.00174	0.0031	4

MST088			
Analyte	SW Avg	SW PCL	Number of Samples
As	0.0013	0.0062	1
Cd	0.0001	0.0006	2
Se	**0.007**	0.0031	2

MSG004			
Analyte	SW Avg	SW PCL	Number of Samples
As	<0.0005	0.0062	2
Cd	<0.0006	0.0006	9
Se	**0.01865**	0.0031	9

MSG005			
Analyte	SW Avg	SW PCL	Number of Samples
As	<0.0005	0.0062	3
Cd	<0.0006	0.0006	10
Se	**0.0071**	0.0031	10

MST096			
Analyte	SW Avg	SW PCL	Number of Samples
As	0.0022	0.0062	2
Cd	0.0001	0.0006	7
Se	**0.04214**	0.0031	7

Estimated completed reclamation areas in upland soil/waste rock

Existing surface water sample location

Existing seep/spring sample location

Potential location of water conveyance line

Assumed future surface water monitoring location

Location will be sampled semi-annually for future long-term surface water monitoring

PCL Preliminary Cleanup Level; values **IN RED** indicate PCL exceedance

Avg Average concentration

Direction of surface water flow

Stream segment where surface water PCLs are exceeded and where institutional controls. and land use controls will be implemented

ANALYTES

As Arsenic
Cd Cadmium
Se Selenium

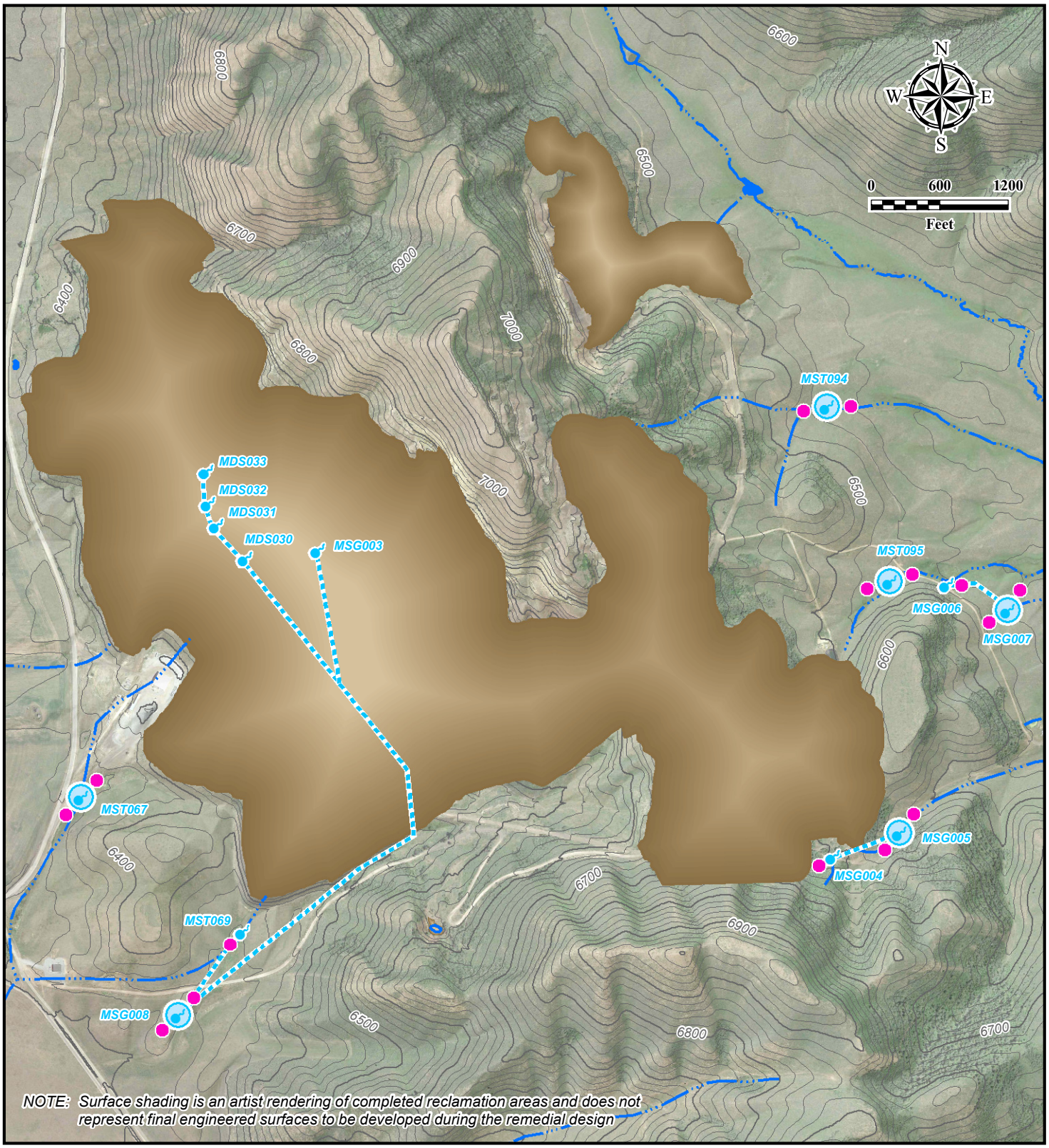
2004-2012 data. NWPOND and SEPOND collected in 2016. All concentrations reported in milligrams per liter (mg/L).

Surface shading of completed reclamation areas is an artist rendering and does not represent final engineered surfaces to be developed during the remedial design

DRAWN BY D. Severson

12 Feb 2017

C:\Data\MWH\P4 Monsanto\P4_Ballard_FS_Jan2015\Ballard_FS_MEMO_2\FIGURES_11Sep2015\Fig 3-5_Ballard_SW_Remed Alt 2_12Feb2017.mxd



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 fooprint 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.

P_4 Production, LLC

BALLARD FEASIBILITY STUDY MEMO #2

SURFACE WATER ALTERNATIVE 3: IN-SITU (WETLANDS) TREATMENT OF SOURCE AREA SEEPAGE, ICs, AND LUCs

Figure 3-6

DRAWN BY D. Severson

9 Jun 2016

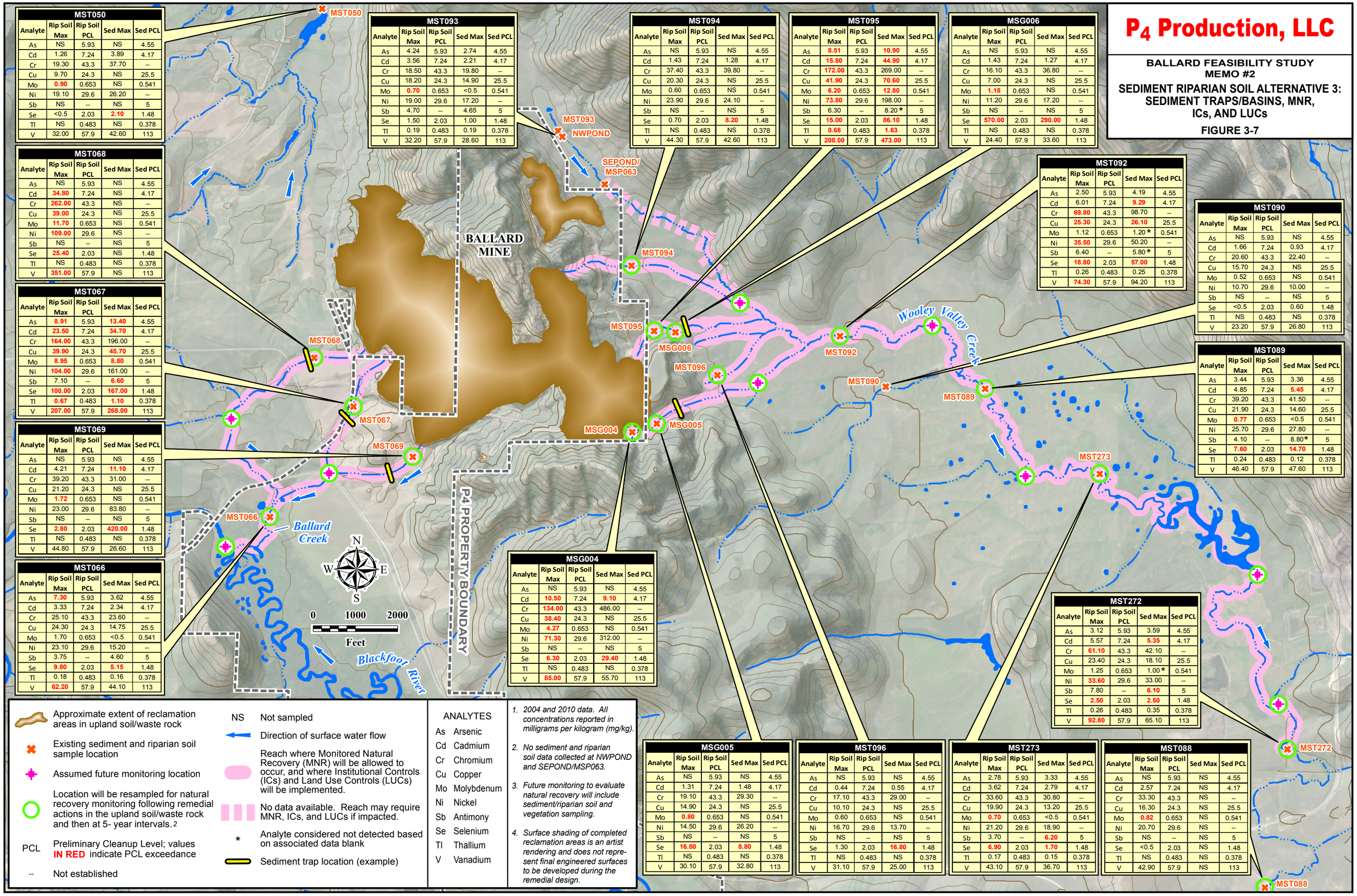
C:\Data\MWH\P4 Monsanto\P4_Ballard_FS_Jan2015\Ballard_FS_MEMO_2\FIGURES_11Sep2015\Fig 3-6_Ballard_Surf Water Alt 3 In-Situ Wetlands_9Jun2016.mxd

P4 Production, LLC

BALLARD FEASIBILITY STUDY
MEMO #2

SEDIMENT RIPARIAN SOIL ALTERNATIVE 3: SEDIMENT TRAPS/BASINS, MNR, ICs, AND LUCs

FIGURE 3-7



MST050				
Analyte	Rip Soil Max	Rip Soil PCL	Sed Max	Sed PCL
As	NS	5.93	NS	4.55
Cd	1.26	7.24	3.89	4.17
Cr	19.30	43.3	37.70	--
Cu	9.70	24.3	NS	25.5
Mo	0.90	0.653	NS	0.541
Ni	19.10	29.6	26.20	--
Sb	NS	--	NS	5
Se	<0.5	2.03	2.10	1.48
Tl	NS	0.483	NS	0.378
V	32.00	57.9	42.60	113

MST068				
Analyte	Rip Soil Max	Rip Soil PCL	Sed Max	Sed PCL
As	NS	5.93	NS	4.55
Cd	34.80	7.24	NS	4.17
Cr	262.00	43.3	NS	--
Cu	39.00	24.3	NS	25.5
Mo	11.70	0.653	NS	0.541
Ni	109.00	29.6	NS	--
Sb	NS	--	NS	5
Se	25.40	2.03	NS	1.48
Tl	NS	0.483	NS	0.378
V	351.00	57.9	NS	113

MST067				
Analyte	Rip Soil Max	Rip Soil PCL	Sed Max	Sed PCL
As	8.91	5.93	13.40	4.55
Cd	23.50	7.24	34.70	4.17
Cr	164.00	43.3	196.00	--
Cu	39.90	24.3	45.70	25.5
Mo	8.95	0.653	8.80	0.541
Ni	104.00	29.6	161.00	--
Sb	7.10	--	6.60	5
Se	100.00	2.03	167.00	1.48
Tl	0.67	0.483	1.10	0.378
V	207.00	57.9	268.00	113

MST069				
Analyte	Rip Soil Max	Rip Soil PCL	Sed Max	Sed PCL
As	NS	5.93	NS	4.55
Cd	4.21	7.24	11.10	4.17
Cr	39.20	43.3	31.00	--
Cu	21.20	24.3	NS	25.5
Mo	1.72	0.653	NS	0.541
Ni	23.00	29.6	83.80	--
Sb	NS	--	NS	5
Se	2.80	2.03	420.00	1.48
Tl	NS	0.483	NS	0.378
V	44.80	57.9	26.60	113

MST066				
Analyte	Rip Soil Max	Rip Soil PCL	Sed Max	Sed PCL
As	7.30	5.93	3.62	4.55
Cd	3.33	7.24	2.34	4.17
Cr	25.10	43.3	23.60	--
Cu	24.30	24.3	14.75	25.5
Mo	1.70	0.653	<0.5	0.541
Ni	23.10	29.6	15.20	--
Sb	3.75	--	4.60	5
Se	9.80	2.03	5.15	1.48
Tl	0.18	0.483	0.16	0.378
V	62.20	57.9	44.10	113

MST093				
Analyte	Rip Soil Max	Rip Soil PCL	Sed Max	Sed PCL
As	4.24	5.93	2.74	4.55
Cd	3.56	7.24	2.21	4.17
Cr	18.50	43.3	19.80	--
Cu	18.20	24.3	14.90	25.5
Mo	0.70	0.653	<0.5	0.541
Ni	19.00	29.6	17.20	--
Sb	4.70	--	4.65	5
Se	1.50	2.03	1.00	1.48
Tl	0.19	0.483	0.19	0.378
V	32.20	57.9	28.60	113

MST094				
Analyte	Rip Soil Max	Rip Soil PCL	Sed Max	Sed PCL
As	NS	5.93	NS	4.55
Cd	1.43	7.24	1.28	4.17
Cr	37.40	43.3	39.80	--
Cu	20.30	24.3	NS	25.5
Mo	0.60	0.653	NS	0.541
Ni	23.90	29.6	24.10	--
Sb	NS	--	NS	5
Se	0.70	2.03	8.20	1.48
Tl	NS	0.483	NS	0.378
V	44.30	57.9	42.60	113

MST095				
Analyte	Rip Soil Max	Rip Soil PCL	Sed Max	Sed PCL
As	8.51	5.93	10.90	4.55
Cd	15.80	7.24	44.90	4.17
Cr	172.00	43.3	269.00	--
Cu	41.90	24.3	70.60	25.5
Mo	6.20	0.653	12.80	0.541
Ni	73.80	29.6	198.00	--
Sb	6.30	--	8.20*	5
Se	15.00	2.03	86.10	1.48
Tl	0.68	0.483	1.63	0.378
V	208.00	57.9	473.00	113

MSG006				
Analyte	Rip Soil Max	Rip Soil PCL	Sed Max	Sed PCL
As	NS	5.93	NS	4.55
Cd	1.43	7.24	1.27	4.17
Cr	16.10	43.3	36.80	--
Cu	7.00	24.3	NS	25.5
Mo	1.18	0.653	NS	0.541
Ni	11.20	29.6	17.20	--
Sb	NS	--	NS	5
Se	570.00	2.03	290.00	1.48
Tl	NS	0.483	NS	0.378
V	24.40	57.9	33.60	113

MST092				
Analyte	Rip Soil Max	Rip Soil PCL	Sed Max	Sed PCL
As	2.50	5.93	4.19	4.55
Cd	6.01	7.24	9.29	4.17
Cr	69.80	43.3	98.70	--
Cu	25.30	24.3	26.10	25.5
Mo	1.12	0.653	1.20*	0.541
Ni	35.50	29.6	50.20	--
Sb	6.40	--	5.80*	5
Se	18.80	2.03	57.00	1.48
Tl	0.26	0.483	0.25	0.378
V	74.30	57.9	94.20	113

MST090				
Analyte	Rip Soil Max	Rip Soil PCL	Sed Max	Sed PCL
As	NS	5.93	NS	4.55
Cd	1.66	7.24	0.93	4.17
Cr	20.60	43.3	22.40	--
Cu	15.70	24.3	NS	25.5
Mo	0.52	0.653	NS	0.541
Ni	10.70	29.6	10.00	--
Sb	NS	--	NS	5
Se	<0.5	2.03	0.60	1.48
Tl	NS	0.483	NS	0.378
V	23.20	57.9	26.80	113

MST089				
Analyte	Rip Soil Max	Rip Soil PCL	Sed Max	Sed PCL
As	3.44	5.93	3.36	4.55
Cd	4.85	7.24	5.45	4.17
Cr	39.20	43.3	41.50	--
Cu	21.90	24.3	14.60	25.5
Mo	0.77	0.653	<0.5	0.541
Ni	25.70	29.6	27.80	--
Sb	4.10	--	8.80*	5
Se	7.60	2.03	14.70	1.48
Tl	0.24	0.483	0.12	0.378
V	46.40	57.9	47.60	113

MSG004				
Analyte	Rip Soil Max	Rip Soil PCL	Sed Max	Sed PCL
As	NS	5.93	NS	4.55
Cd	10.50	7.24	9.10	4.17
Cr	134.00	43.3	486.00	--
Cu	38.40	24.3	NS	25.5
Mo	4.27	0.653	NS	0.541
Ni	71.30	29.6	312.00	--
Sb	NS	--	NS	5
Se	6.30	2.03	29.40	1.48
Tl	NS	0.483	NS	0.378
V	85.00	57.9	55.70	113

MST272				
Analyte	Rip Soil Max	Rip Soil PCL	Sed Max	Sed PCL
As	3.12	5.93	3.59	4.55
Cd	5.57	7.24	5.35	4.17
Cr	61.10	43.3	42.10	--
Cu	23.40	24.3	18.10	25.5
Mo	1.25	0.653	1.00*	0.541
Ni	33.60	29.6	33.00	--
Sb	7.80	--	6.10	5
Se	2.50	2.03	2.50	1.48
Tl	0.26	0.483	0.35	0.378
V	92.80	57.9	65.10	113

MSG005				
Analyte	Rip Soil Max	Rip Soil PCL	Sed Max	Sed PCL
As	NS	5.93	NS	4.55
Cd	1.31	7.24	1.48	4.17
Cr	19.10	43.3	29.30	--
Cu	14.90	24.3	NS	25.5
Mo	0.80	0.653	NS	0.541
Ni	14.50	29.6	26.20	--
Sb	NS	--	NS	5
Se	16.80	2.03	8.80	1.48
Tl	NS	0.483	NS	0.378
V	30.10	57.9	32.80	113

MST096				
Analyte	Rip Soil Max	Rip Soil PCL	Sed Max	Sed PCL
As	NS	5.93	NS	4.55
Cd	0.44	7.24	0.55	4.17
Cr	17.10	43.3	29.00	--
Cu	10.10	24.3	NS	25.5
Mo	0.60	0.653	NS	0.541
Ni	16.70	29.6	13.70	--
Sb	NS	--	NS	5
Se	1.30	2.03	16.80	1.48
Tl	NS	0.483	NS	0.378
V	31.10	57.9	25.00	113

MST273				
Analyte	Rip Soil Max	Rip Soil PCL	Sed Max	Sed PCL
As	2.78	5.93	3.33	4.55
Cd	3.62	7.24	2.79	4.17
Cr	33.60	43.3	30.80	--
Cu	19.90	24.3	13.20	25.5
Mo	0.70	0.653	<0.5	0.541
Ni	21.20	29.6	18.90	--
Sb	3.70	--	6.20	5
Se	6.90	2.03	1.70	1.48
Tl	0.17	0.483	0.15	0.378
V	43.10	57.9	36.70	113

MST088				
Analyte	Rip Soil Max	Rip Soil PCL	Sed Max	Sed PCL
As	NS	5.93	NS	4.55
Cd	2.57	7.24	NS	4.17
Cr	33.30	43.3	NS	--
Cu	16.30	24.3	NS	25.5
Mo	0.82	0.653	NS	0.541
Ni	20.70	29.6	NS	--
Sb	NS	--	NS	5
Se	<0.5	2.03	NS	1.48
Tl	NS	0.483	NS	0.378
V	42.90	57.9	NS	113

Approximate extent of reclamation areas in upland soil/waste rock

Existing sediment and riparian soil sample location

Assumed future monitoring location

Location will be resampled for natural recovery monitoring following remedial actions in the upland soil/waste rock and then at 5- year intervals.[2]

PCL Preliminary Cleanup Level; values **IN RED** indicate PCL exceedance

-- Not established

NS Not sampled

Direction of surface water flow

Reach where Monitored Natural Recovery (MNR) will be allowed to occur, and where Institutional Controls (ICs) and Land Use Controls (LUCs) will be implemented.

No data available. Reach may require MNR, ICs, and LUCs if impacted.

* Analyte considered not detected based on associated data blank

Sediment trap location (example)

ANALYTES

- As Arsenic
- Cd Cadmium
- Cr Chromium
- Cu Copper
- Mo Molybdenum
- Ni Nickel
- Sb Antimony
- Se Selenium
- Tl Thallium
- V Vanadium

1. *2004 and 2010 data. All concentrations reported in milligrams per kilogram (mg/kg).*
2. *No sediment and riparian soil data collected at NWPOND and SEPOND/MSP063.*
3. *Future monitoring to evaluate natural recovery will include sediment/riparian soil and vegetation sampling.*
4. *Surface shading of completed reclamation areas is an artist rendering and does not represent final engineered surfaces to be developed during the remedial design.*

DRAWN BY D. Severson

3 Apr 2017

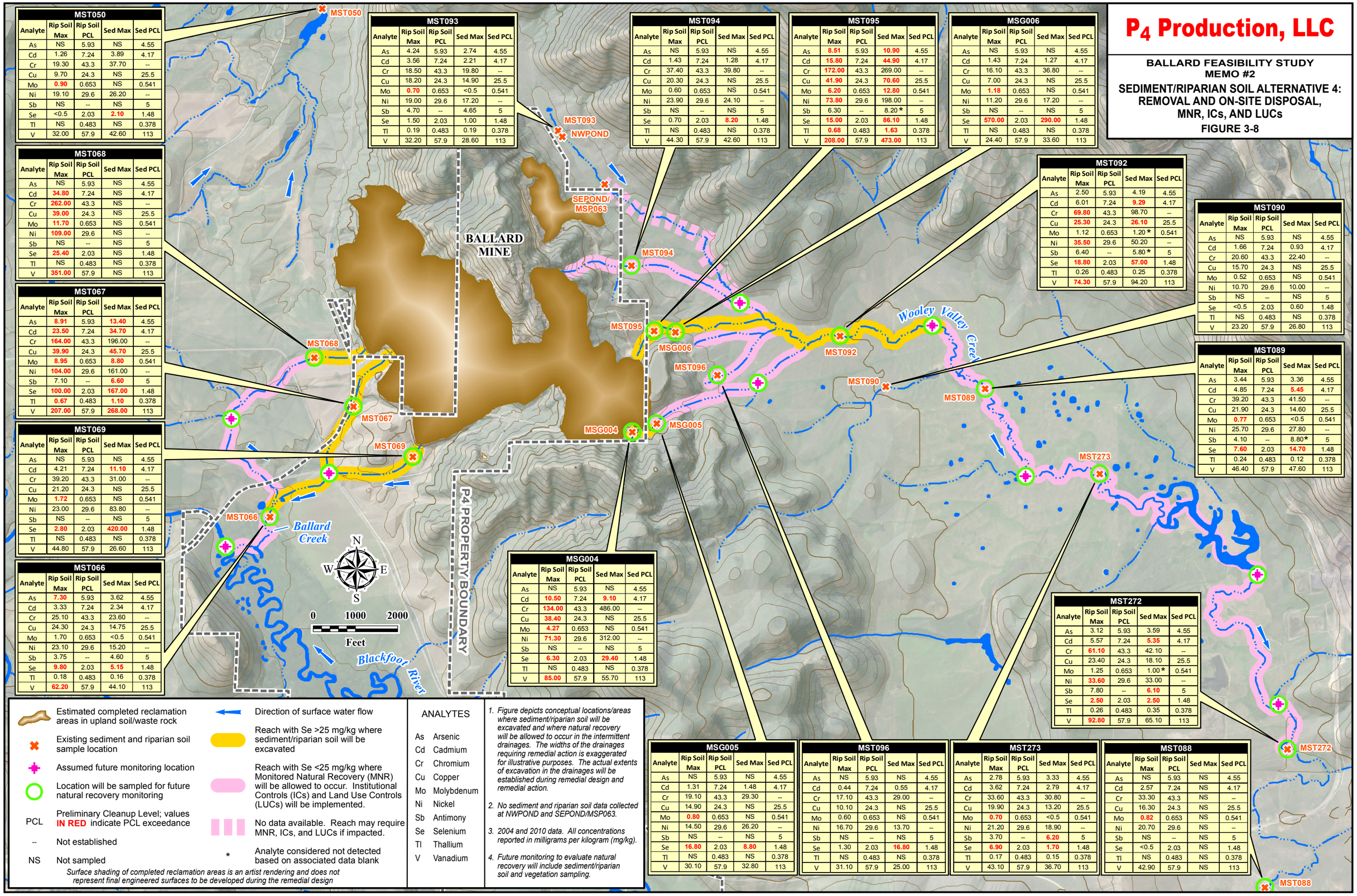
C:\Data\MWH\P4 Monsanto\P4_Ballard_FS_Jan2015\Ballard_FS_MEMO_2\FIGURES_11Sep2015\Fig 3-7_Ballard_Sed_Traps_Basins_3Apr2017.mxd

P_4 Production, LLC

BALLARD FEASIBILITY STUDY
MEMO #2

SEDIMENT/RIPARIAN SOIL ALTERNATIVE 4: REMOVAL AND ON-SITE DISPOSAL, MNR, ICs, AND LUCs

FIGURE 3-8



MST050				
Analyte	Rip Soil Max	Rip Soil PCL	Sed Max	Sed PCL
As	NS	5.93	NS	4.55
Cd	1.26	7.24	3.89	4.17
Cr	19.30	43.3	37.70	--
Cu	9.70	24.3	NS	25.5
Mo	0.90	0.653	NS	0.541
Ni	19.10	29.6	26.20	--
Sb	NS	--	NS	5
Se	<0.5	2.03	2.10	1.48
Tl	NS	0.483	NS	0.378
V	32.00	57.9	42.60	113

MST068				
Analyte	Rip Soil Max	Rip Soil PCL	Sed Max	Sed PCL
As	NS	5.93	NS	4.55
Cd	34.80	7.24	NS	4.17
Cr	262.00	43.3	NS	--
Cu	39.00	24.3	NS	25.5
Mo	11.70	0.653	NS	0.541
Ni	109.00	29.6	NS	--
Sb	NS	--	NS	5
Se	25.40	2.03	NS	1.48
Tl	NS	0.483	NS	0.378
V	351.00	57.9	NS	113

MST067				
Analyte	Rip Soil Max	Rip Soil PCL	Sed Max	Sed PCL
As	8.91	5.93	13.40	4.55
Cd	23.50	7.24	34.70	4.17
Cr	164.00	43.3	196.00	--
Cu	39.90	24.3	45.70	25.5
Mo	8.95	0.653	8.80	0.541
Ni	104.00	29.6	161.00	--
Sb	7.10	--	6.60	5
Se	100.00	2.03	167.00	1.48
Tl	0.67	0.483	1.10	0.378
V	207.00	57.9	268.00	113

MST069				
Analyte	Rip Soil Max	Rip Soil PCL	Sed Max	Sed PCL
As	NS	5.93	NS	4.55
Cd	4.21	7.24	11.10	4.17
Cr	39.20	43.3	31.00	--
Cu	21.20	24.3	NS	25.5
Mo	1.72	0.653	NS	0.541
Ni	23.00	29.6	83.80	--
Sb	NS	--	NS	5
Se	2.80	2.03	420.00	1.48
Tl	NS	0.483	NS	0.378
V	44.80	57.9	26.60	113

MST066				
Analyte	Rip Soil Max	Rip Soil PCL	Sed Max	Sed PCL
As	7.30	5.93	3.62	4.55
Cd	3.33	7.24	2.34	4.17
Cr	25.10	43.3	23.60	--
Cu	24.30	24.3	14.75	25.5
Mo	1.70	0.653	<0.5	0.541
Ni	23.10	29.6	15.20	--
Sb	3.75	--	4.60	5
Se	9.80	2.03	5.15	1.48
Tl	0.18	0.483	0.16	0.378
V	62.20	57.9	44.10	113

MST093				
Analyte	Rip Soil Max	Rip Soil PCL	Sed Max	Sed PCL
As	4.24	5.93	2.74	4.55
Cd	3.56	7.24	2.21	4.17
Cr	18.50	43.3	19.80	--
Cu	18.20	24.3	14.90	25.5
Mo	0.70	0.653	<0.5	0.541
Ni	19.00	29.6	17.20	--
Sb	4.70	--	4.65	5
Se	1.50	2.03	1.00	1.48
Tl	0.19	0.483	0.19	0.378
V	32.20	57.9	28.60	113

MST094				
Analyte	Rip Soil Max	Rip Soil PCL	Sed Max	Sed PCL
As	NS	5.93	NS	4.55
Cd	1.43	7.24	1.28	4.17
Cr	37.40	43.3	39.80	--
Cu	20.30	24.3	NS	25.5
Mo	0.60	0.653	NS	0.541
Ni	23.90	29.6	24.10	--
Sb	NS	--	NS	5
Se	0.70	2.03	8.20	1.48
Tl	NS	0.483	NS	0.378
V	44.30	57.9	42.60	113

MST095				
Analyte	Rip Soil Max	Rip Soil PCL	Sed Max	Sed PCL
As	8.51	5.93	10.90	4.55
Cd	15.80	7.24	44.90	4.17
Cr	172.00	43.3	269.00	--
Cu	41.90	24.3	70.60	25.5
Mo	6.20	0.653	12.80	0.541
Ni	73.80	29.6	198.00	--
Sb	6.30	--	8.20 *	5
Se	15.00	2.03	86.10	1.48
Tl	0.68	0.483	1.63	0.378
V	208.00	57.9	473.00	113

MSG006				
Analyte	Rip Soil Max	Rip Soil PCL	Sed Max	Sed PCL
As	NS	5.93	NS	4.55
Cd	1.43	7.24	1.27	4.17
Cr	16.10	43.3	36.80	--
Cu	7.00	24.3	NS	25.5
Mo	1.18	0.653	NS	0.541
Ni	11.20	29.6	17.20	--
Sb	NS	--	NS	5
Se	570.00	2.03	290.00	1.48
Tl	NS	0.483	NS	0.378
V	24.40	57.9	33.60	113

MST092				
Analyte	Rip Soil Max	Rip Soil PCL	Sed Max	Sed PCL
As	2.50	5.93	4.19	4.55
Cd	6.01	7.24	9.29	4.17
Cr	69.80	43.3	98.70	--
Cu	25.30	24.3	26.10	25.5
Mo	1.12	0.653	1.20 *	0.541
Ni	35.50	29.6	50.20	--
Sb	6.40	--	5.80 *	5
Se	18.80	2.03	57.00	1.48
Tl	0.26	0.483	0.25	0.378
V	74.30	57.9	94.20	113

MST090				
Analyte	Rip Soil Max	Rip Soil PCL	Sed Max	Sed PCL
As	NS	5.93	NS	4.55
Cd	1.66	7.24	0.93	4.17
Cr	20.60	43.3	22.40	--
Cu	15.70	24.3	NS	25.5
Mo	0.52	0.653	NS	0.541
Ni	10.70	29.6	10.00	--
Sb	NS	--	NS	5
Se	<0.5	2.03	0.60	1.48
Tl	NS	0.483	NS	0.378
V	23.20	57.9	26.80	113

MST089				
Analyte	Rip Soil Max	Rip Soil PCL	Sed Max	Sed PCL
As	3.44	5.93	3.36	4.55
Cd	4.85	7.24	5.45	4.17
Cr	39.20	43.3	41.50	--
Cu	21.90	24.3	14.60	25.5
Mo	0.77	0.653	<0.5	0.541
Ni	25.70	29.6	27.80	--
Sb	4.10	--	8.80*	5
Se	7.60	2.03	14.70	1.48
Tl	0.24	0.483	0.12	0.378
V	46.40	57.9	47.60	113

MSG004				
Analyte	Rip Soil Max	Rip Soil PCL	Sed Max	Sed PCL
As	NS	5.93	NS	4.55
Cd	10.50	7.24	9.10	4.17
Cr	134.00	43.3	486.00	--
Cu	38.40	24.3	NS	25.5
Mo	4.27	0.653	NS	0.541
Ni	71.30	29.6	312.00	--
Sb	NS	--	NS	5
Se	6.30	2.03	29.40	1.48
Tl	NS	0.483	NS	0.378
V	85.00	57.9	55.70	113

MST272				
Analyte	Rip Soil Max	Rip Soil PCL	Sed Max	Sed PCL
As	3.12	5.93	3.59	4.55
Cd	5.57	7.24	5.35	4.17
Cr	61.10	43.3	42.10	--
Cu	23.40	24.3	18.10	25.5
Mo	1.25	0.653	1.00 *	0.541
Ni	33.60	29.6	33.00	--
Sb	7.80	--	6.10	5
Se	2.50	2.03	2.50	1.48
Tl	0.26	0.483	0.35	0.378
V	92.80	57.9	65.10	113

MSG005				
Analyte	Rip Soil Max	Rip Soil PCL	Sed Max	Sed PCL
As	NS	5.93	NS	4.55
Cd	1.31	7.24	1.48	4.17
Cr	19.10	43.3	29.30	--
Cu	14.90	24.3	NS	25.5
Mo	0.80	0.653	NS	0.541
Ni	14.50	29.6	26.20	--
Sb	NS	--	NS	5
Se	16.80	2.03	8.80	1.48
Tl	NS	0.483	NS	0.378
V	30.10	57.9	32.80	113

MST096				
Analyte	Rip Soil Max	Rip Soil PCL	Sed Max	Sed PCL
As	NS	5.93	NS	4.55
Cd	0.44	7.24	0.55	4.17
Cr	17.10	43.3	29.00	--
Cu	10.10	24.3	NS	25.5
Mo	0.60	0.653	NS	0.541
Ni	16.70	29.6	13.70	--
Sb	NS	--	NS	5
Se	1.30	2.03	16.80	1.48
Tl	NS	0.483	NS	0.378
V	31.10	57.9	25.00	113

MST273				
Analyte	Rip Soil Max	Rip Soil PCL	Sed Max	Sed PCL
As	2.78	5.93	3.33	4.55
Cd	3.62	7.24	2.79	4.17
Cr	33.60	43.3	30.80	--
Cu	19.90	24.3	13.20	25.5
Mo	0.70	0.653	<0.5	0.541
Ni	21.20	29.6	18.90	--
Sb	3.70	--	6.20	5
Se	6.90	2.03	1.70	1.48
Tl	0.17	0.483	0.15	0.378
V	43.10	57.9	36.70	113

MST088				
Analyte	Rip Soil Max	Rip Soil PCL	Sed Max	Sed PCL
As	NS	5.93	NS	4.55
Cd	2.57	7.24	NS	4.17
Cr	33.30	43.3	NS	--
Cu	16.30	24.3	NS	25.5
Mo	0.82	0.653	NS	0.541
Ni	20.70	29.6	NS	--
Sb	NS	--	NS	5
Se	<0.5	2.03	NS	1.48
Tl	NS	0.483	NS	0.378
V	42.90	57.9	NS	113

Estimated completed reclamation areas in upland soil/waste rock

Existing sediment and riparian soil sample location

Assumed future monitoring location

Location will be sampled for future natural recovery monitoring

PCL — Preliminary Cleanup Level; values **IN RED** indicate PCL exceedance

-- Not established

NS Not sampled

Direction of surface water flow

Reach with Se >25 mg/kg where sediment/riparian soil will be excavated

Reach with Se <25 mg/kg where Monitored Natural Recovery (MNR) will be allowed to occur. Institutional Controls (ICs) and Land Use Controls (LUCs) will be implemented.

No data available. Reach may require MNR, ICs, and LUCs if impacted.

* Analyte considered not detected based on associated data blank

Surface shading of completed reclamation areas is an artist rendering and does not represent final engineered surfaces to be developed during the remedial design

ANALYTES

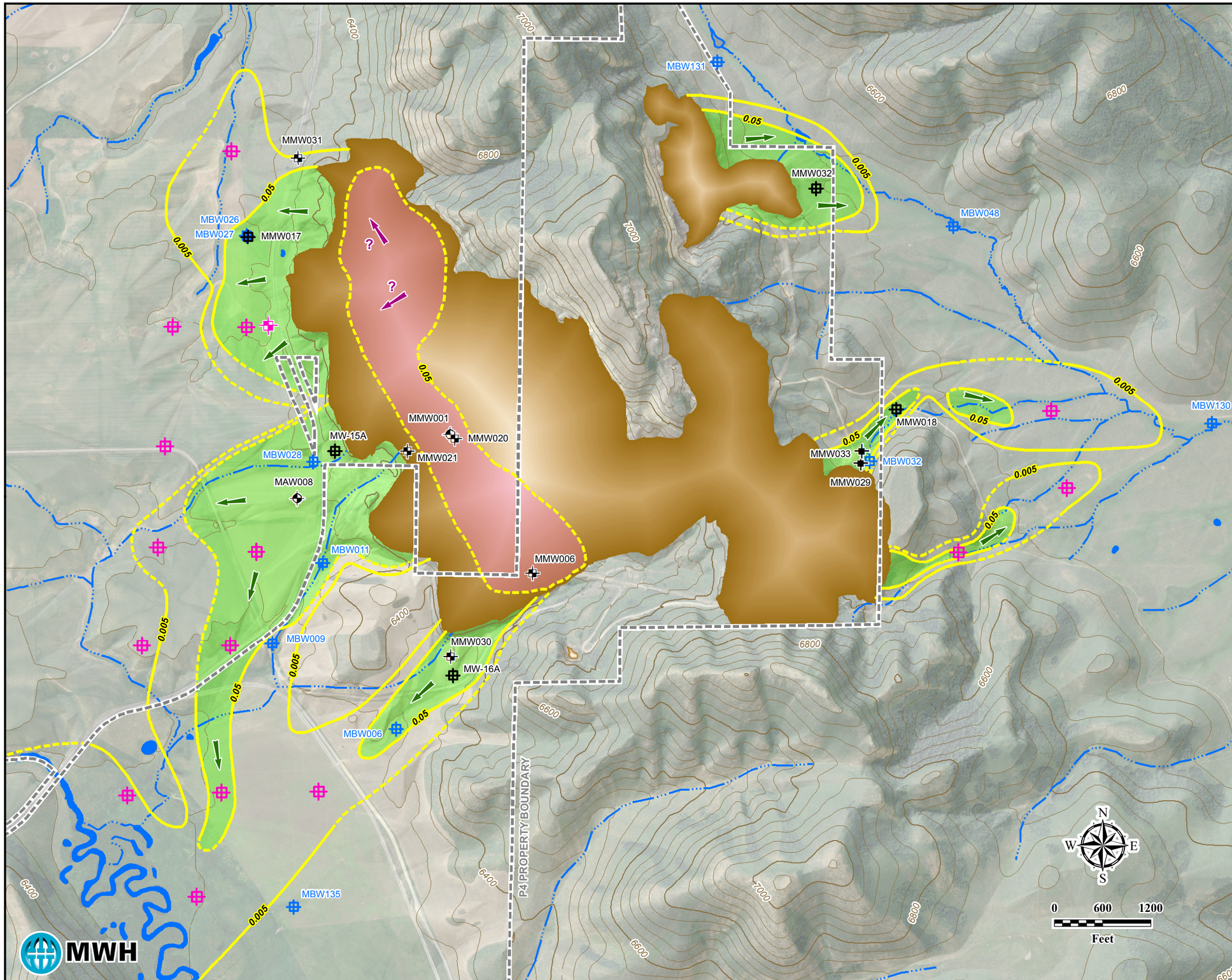
As Arsenic
Cd Cadmium
Cr Chromium
Cu Copper
Mo Molybdenum
Ni Nickel
Sb Antimony
Se Selenium
Tl Thallium
V Vanadium

1. *Figure depicts conceptual locations/areas where sediment/riparian soil will be excavated and where natural recovery will be allowed to occur in the intermittent drainages. The widths of the drainages requiring remedial action is exaggerated for illustrative purposes. The actual extents of excavation in the drainages will be established during remedial design and remedial action.*
2. *No sediment and riparian soil data collected at NWPOND and SEPOND/MSP063.*
3. *2004 and 2010 data. All concentrations reported in milligrams per kilogram (mg/kg).*
4. *Future monitoring to evaluate natural recovery will include sediment/riparian soil and vegetation sampling.*

DRAWN BY D. Severson

3 Apr 2017

C:\Data\MWH\P4 Monsanto\P4_Ballard_FS_Jan2015\Ballard_FS_MEMO_2\FIGURES_11Sep2015\Fig 3-8_Ballard_Sed_Rip Soil_Remed Alt 4_3Apr2017.mxd



EXPLANATION

PROPOSED NATURAL ATTENUATION MONITORING NETWORK

- Existing direct push alluvial aquifer well
- Existing agricultural, domestic or production well
- Existing local aquifer monitoring well (generally alluvial system)
- Existing intermediate aquifer monitoring well (generally Dinwoody Formation)
- Existing regional aquifer monitoring well (Wells Formation)
- Proposed new alluvial monitoring well
- Proposed new Wells Formation monitoring well
- Estimated completed reclamation areas in upland soil/waste rock.
- Approximate alluvial groundwater plume >selenium MCL. (→ indicates approximate direction of groundwater flow.)
- Approximate Wells Formation groundwater plume >selenium MCL. (→ indicates approximate direction of groundwater flow.)
- Total selenium isoconcentration contour (mg/L)
- Inferred total selenium concentration contour (mg/L)

mg/L Milligrams per liter

MCL Maximum Concentration Level

NOTES

1. *Groundwater Institutional Controls (ICs) will be implemented in all areas where MCLs are exceeded.*
2. *Approximate plume delineations are based on groundwater monitoring well sampling results and other direct-push sampling locations not shown on this figure. (Refer to Drawing 2-3 in the Ballard FS Memo #1).*
3. *Surface shading of completed reclamation areas is an artist rendering and does not represent final engineered surfaces to be developed during the remedial design.*

P_4 Production, LLC

BALLARD FEASIBILITY STUDY
MEMO #2
GROUNDWATER ALTERNATIVE 2:
MNA AND ICs
FIGURE 3-9

DRAWN BY D. Severson

9 Jun 2016

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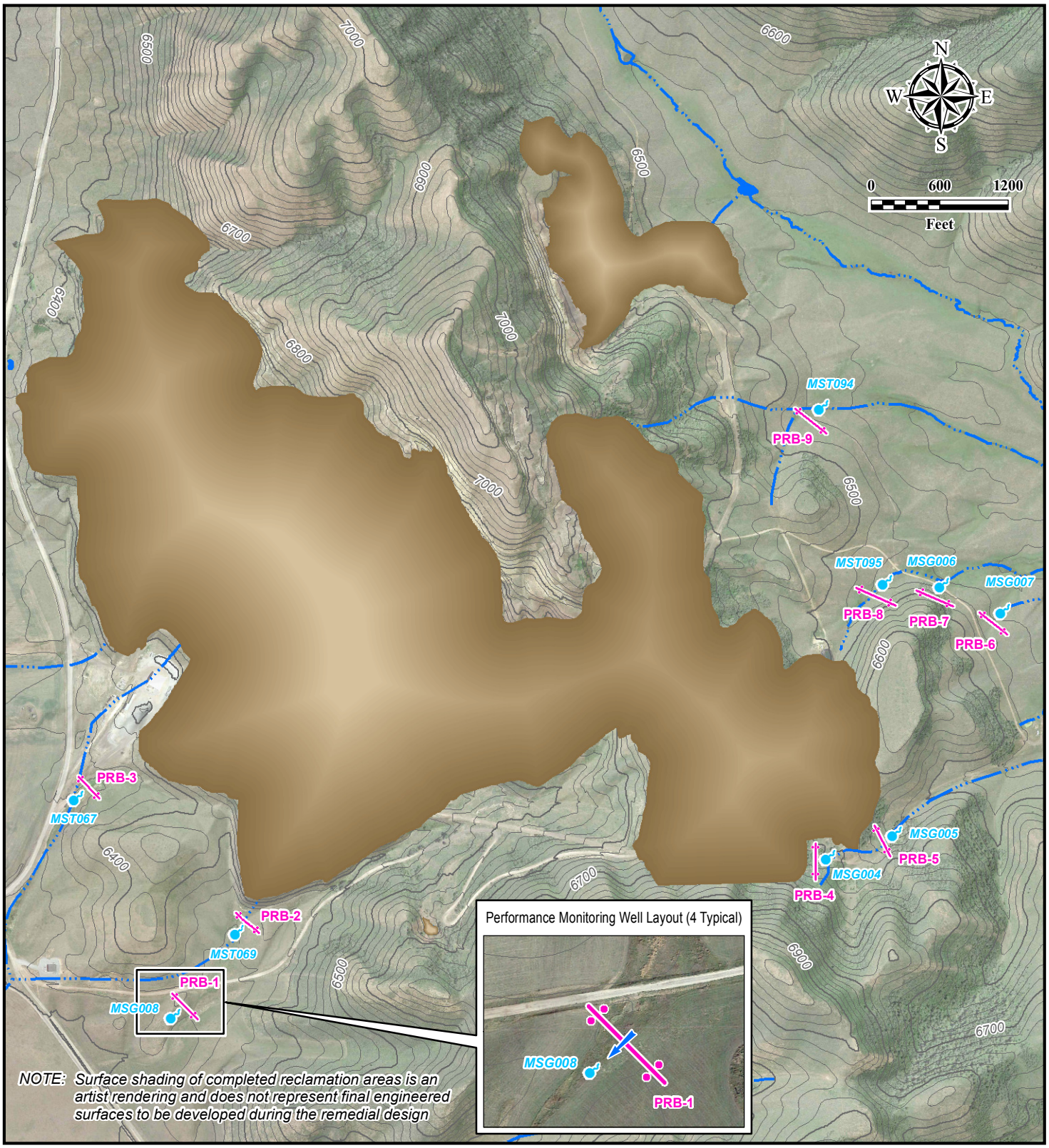

Estimated completed reclamation areas in upland soil/waste rock

Mine-affected seep/spring

Proposed Permeable Reactive Barrier (PRB)

Performance monitoring well (approximately 25 feet from PRB)

Approximate direction of groundwater flow

Figure depicts conceptual locations of permeable reactive barriers and associated performance monitoring wells. Actual locations and associated design details will be determined during remedial design and is dependant on fooprint 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 3-8.

P_4 Production, LLC

BALLARD FEASIBILITY STUDY MEMO #2

GROUNDWATER ALTERNATIVE 3: LIMITED PRB TREATMENT OF ALLUVIAL GROUNDWATER, MNA, AND ICS

Figure 3-10

DRAWN BY D. Severson

10 Feb 2017

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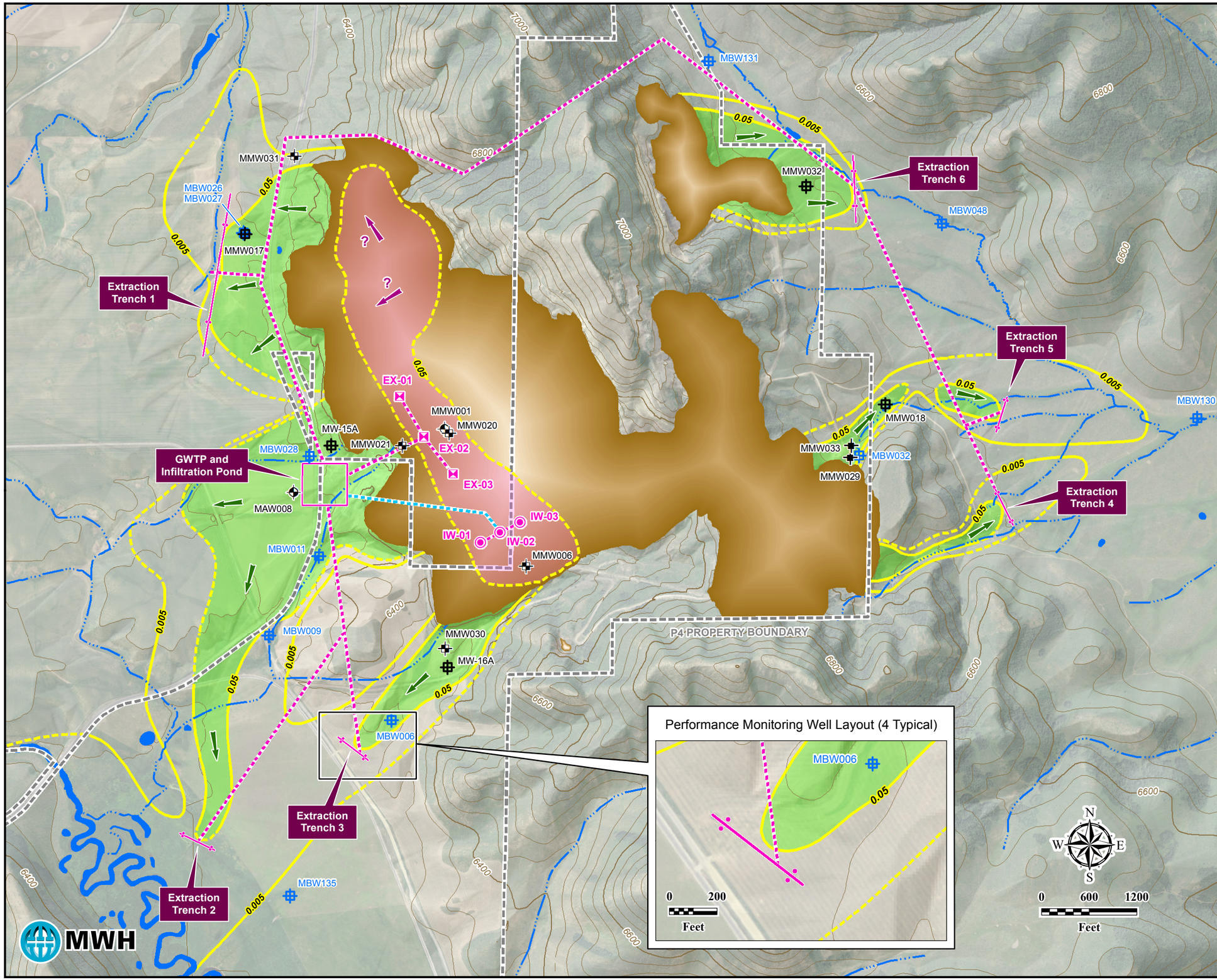


EXPLANATION

PROPOSED INFRASTRUCTURE

Actual location will be determined during Remedial Design

- Extraction trench
- Untreated water conveyance line
- Treated water conveyance line
- Extraction well
- Injection well
- Performance monitoring well (Approximately 25 feet from trench)

EXISTING WELLS

- Direct push alluvial aquifer well
- Agricultural, domestic or production well
- Local aquifer monitoring well (generally alluvial system)
- Intermediate aquifer monitoring well (generally Dinwoody Formation)
- Regional aquifer monitoring well (Wells Formation)

- Estimated completed reclamation areas in upland soil/waste rock.
- Approximate alluvial groundwater plume >selenium MCL. (→ indicates approximate direction of groundwater flow.)
- Approximate Wells Formation groundwater plume >selenium MCL. (→ indicates approximate direction of groundwater flow.)
- Total selenium isoconcentration contour (mg/L)
- Inferred total selenium concentration contour (mg/L)

mg/L Milligrams per liter

MCL Maximum Concentration Level

Surface shading of completed reclamation areas is an artist rendering and does not represent final engineered surfaces to be developed during the remedial design.

P_4 Production, LLC

BALLARD FEASIBILITY STUDY MEMO #2

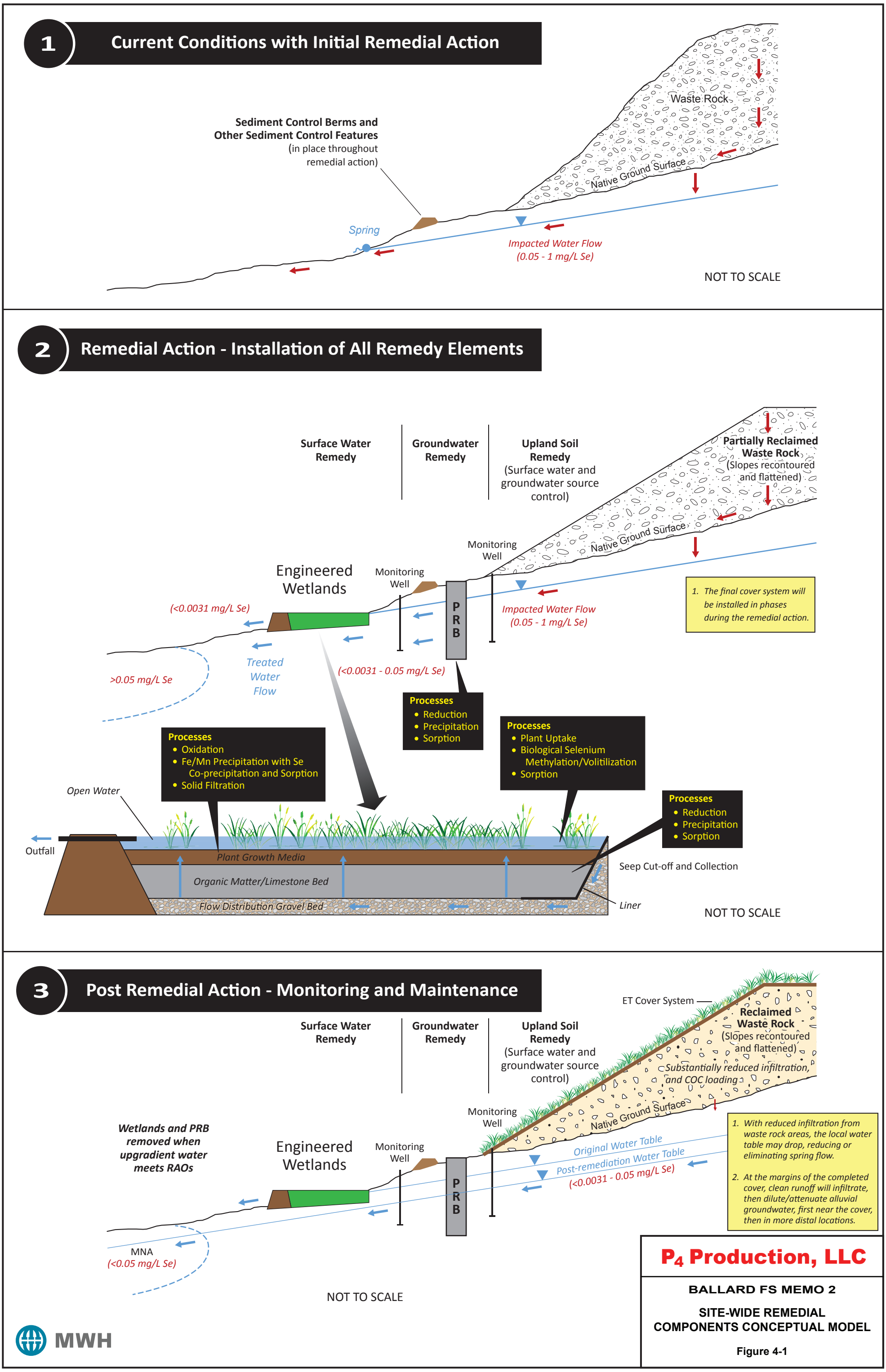
GROUNDWATER ALTERNATIVE 5B: GROUNDWATER RECOVERY AND TREATMENT OF BOTH ALLUVIAL AND WELLS FORMATION GROUNDWATER, AND ICS

FIGURE 3-11

DRAWN BY D. Severson

9 Jun 2016

C:\Data\MWH\P4 Monsanto\P4_Ballard_FS_Jan2015\Ballard_FS_MEMO_2\FIGURES_11Sep2015\Fig 3-11_Ballard_GW Alt 5B_GW Alluv and Wells FM_ICs_9Jun2016.mxd



P_4 Production, LLC

BALLARD FS MEMO 2

SITE-WIDE REMEDIAL COMPONENTS CONCEPTUAL MODEL

Figure 4-1

APPENDIX A

FS COST ESTIMATE FOR VIABLE ALTERNATIVES BY MEDIUM

Upland Soil / Waste Rock Alternatives

Table A-1 Summary of Cost Estimates for Remaining Upland Soil / Waste Rock Alternatives

Table A-1a Upland Soil Alternative 1: No Action

Table A-1b Upland Soil Alternative 4: Waste Rock Removal and Consolidation / ET Cover System

Table A-1c Upland Soil Alternative 6: Ore Recovery and Reclamation

Table A-1d Upland Soil Alternative 7: Complete Waste Rock Removal and Consolidation / ET Cover System

TABLE A-1
SUMMARY OF COST ESTIMATES FOR REMAINING UPLAND SOIL/WASTE ROCK ALTERNATIVES
FEASIBILITY STUDY TECHNICAL MEMORANDUM #2
P4 Production LLC, Ballard Mine

BALLARD MINE REMAINING ALTERNATIVES				
	Alternative 1 - No Action	**Alternative 4 - Upland Soil/Waste Rock Consolidation and/or Grading with an Evapotranspiration (ET) Cover System, ICs, and LUCs, and LTM**	**Alternative 6 - Upland Soil/Waste Rock Consolidation and/or Grading, Incidental Ore Recovery, ET Cover System, ICs, LUCs, and LTM[2]**	**Alternative 7 - Complete Consolidation of Existing Waste Rock into the Pits, ET Cover System, ICs, LUCs, and LTM**
Cost Item Description				
Total Direct Costs	$0	$50,099,136	$147,292,914	$112,540,985
Institutional Controls	$0	$25,000	$50,000	$25,000
5 Year Summary Reports (30-Year Present Worth)	$107,885	$215,770	$215,770	$215,770
Annual O&M Costs (30-Year Present Worth)[1]	$0	$338,294	$338,294	$338,294
30-Year Total Present Worth	**$108,000**	**$50,679,000**	**$36,974,250**	**$113,121,000**

[1] The annual O&M costs include the costs of O&M of treatment system, if applicable, annual monitoring and the annual operation reports.

[2]Alternative 6 costs for the CERCLA remediation are presented at 25% of the overall ore recovery and CERCLA costs. Please look at individual tab for total costs

Note: 2016 Rev includes latest volumes for the waste piles and the 2016 RS Means values

TABLE A-1a
UPLAND SOIL ALTERNATIVE 1: NO ACTION
FEASIBILITY STUDY TECHNICAL MEMORANDUM #2
P4 Production LLC, Ballard Mine

Description: Alternative 1 - No Action. The No Action alternative does not include any remedial action, long-term monitoring (LTM), or administrative or engineering controls.

Item No.	Item	Description	Quantity	Unit	Unit Cost ($)	Item Cost ($)	Comments / Assumptions
1	DIRECT CAPITAL COSTS						
					Subtotal Capital Costs	**$0**	
	Project Management		10%	Capital Costs	$0	$0	Project management below a $100K capital cost is 10 percent (Table 5-8, EPA 540-R-00-002).
	Remedial Design		0%	Capital Costs	$0	$0	There would be no remedial design under this alternative
	Construction Management and Oversight		0%	Capital Costs	$0	$0	There would be no construction or construction management under this alternative.
	Contingency Costs		10%	Capital Costs	$0	$0	See Note 1
					Other Direct Costs	**$0**	
	TOTAL DIRECT COSTS					**$0**	Does not include subcontractor mark-up or profit
2	**ANNUAL COSTS**						
	30-YEAR PRESENT WORTH **(i=7%;n=30,P/A=12.4090)**					**$0**	
3	**SUMMARY REPORT (Every 5 Years)**		1	/5 Yrs	$50,000	$50,000	
	30-YEAR PRESENT WORTH **(i=7%; P/F=0.7130+0.5083+0.3624+0.2584+0.1842+0.1314=2.1577)**					**$107,885**	
4	**INSTITUTIONAL CONTROLS**		0	EA	$5,000	**$0**	See Note 2
5	**ALTERNATIVE 1: 30 Year Present Worth Cost** **(Items 1+2+3+4)**					**$108,000**	See Note 3

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.

QA/QC quality assurance / quality control

TABLE A-1b
UPLAND SOIL ALTERNATIVE 4: WASTE ROCK REMOVAL AND CONSOLIDATION/ET COVER SYSTEM
FEASIBILITY STUDY TECHNICAL MEMORANDUM #2
P4 Production LLC, Ballard Mine

Description: Alternative 4 - Waste Rock Removal/Consolidation in Pit and/or Grading with ET Cover System, ICs, LUCs, and O&M/LTM: this alternative portion of the upland soil/waste rock piles throughout the Site would be excavated and consolidated in the on-Site pits to cover any exposed ore sections, or graded/contours in-place to at 3:1 slopes. The new upland soil/waste rock surface both inside and outside of the mine pits would be capped with an ET cover. LTM/O&M would be necessary to inspect the cover for plants that are incompatible with the selected cover system and to repair any stormwater erosion that might occur. ICs and LUCs would be implemented to prevent activities that could disturb the covered waste rock. See Figures 3-2a and 3-2b for general depiction of grading and capping areas. Additional details regarding Alternative 4 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	30	ea	Site mobilization, over 75 ton, + 10% per addn'l 5 mi mob dist. 01 54 36.50 0100/2500	$530.00	$25,440	Assumed 10 dozers,10 loaders, and 10 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. 2016 Means 01 54 36.50 0100/2500
	Construction Field Offices	60	ea	Field office, 32'x8', rent per month 01 52 13 13.20 0350	$270.00	$16,200	Assumed 3 - 32'x8' office trailers rented for 60 month term. 2016 Means 01 52 13 13.20 0350
	Portable Toilets	7,200	ea	Blue rooms, /day 01 54 33 6410	$21.50	$154,800	Assumed 4 rental units. 2016 Means 01 54 33 6410
	Temporary Utilities						
	Power	180	ea	Power/HVAC combined, /month 01 51 13.80 0430	$176.00	$31,680	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
	Site Preparation						
	Clearing and Grubbing	392	ac	Selective clearing, with dozer and brush rake, light 31 11 13.10 0500	$262.00	$102,704	Assume dozer and brush rake, average brush diameter less than 4-inches, total area is 392 acres. 2016 Means 31 11 13.10 0500. Crew = 1 operator and 1 laborer.
	Waste Rock Removal,On-Site Consolidation, and Regrading						
	1. Regrade Mine Waste Dump MWD084 and Place Material into Open Mine Pit MMP039						
	Load, Haul, Dump and Slope (grade to 3:1) mine waste rock from MWD084 to fill areas in pit prior to cover placement	311,466	bcy	P4 Unit Rate for ROM LHD, Graded 3:1	$3.71	$1,155,538	Total volume of MWD084 934,397 cy. Assumed new waste rock dump in the pit will be regraded (1/3 of total volume) to provide drainage and to provide a minimum 20 feet of cover for Phosphoria Formation previously exposed in bottom of open mine pit MMP039. Equipment and task costs based on recent (2014) P4 competitive bid for similar work at active mine site
	Use dozer to grade MWD084 to 3:1 slope - following excavation and pit fill waste rock removal	18	acres	P4 Unit Rate for Grading Only, slope max 3:1	$7,068.44	$126,702	Assume 75% of the existing mine dump will have to be graded and sloped following waste rock removal. Assume 4 total-combination of D9 and D10 dozers based on recent (2014) P4 competitive bid for similar work at active mine site.
	2. Regrade Mine Waste Dump MWD082 and Place Material into Open Mine Pits MMP040 and MMP037						
	Load, Haul, Dump and Slope (grade to 3:1) mine waste rock from MWD082 to fill areas in pit prior to cover placement	864,379	bcy	P4 Unit Rate for ROM LHD, Graded 3:1	$3.71	$3,206,845	Total volume of MWD082 2,593,136 cy. Assumed new waste rock dump in the pits will be regraded (1/3 of total volume) to provide drainage and to provide a minimum of 20 feet of cover for the Phosphoria Formation exposed in the bottom of open mine pit MMP037. Equipment and task costs based on recent (2014) P4 competitive bid for similar work at active mine site
	Use dozer to grade MWD082 to 3:1 slope - following excavation and pit fill waste rock removal.	50	acres	P4 Unit Rate for Grading Only, slope max 3:1	$7,068.44	$354,129	Assume 75% of the existing mine dump will have to be graded and sloped following waste rock removal. Assumed 4 total-combination of D9 and D10 dozers based on recent (2014) P4 competitive bid for similar work at active mine site.
	3. Regrade Mine Waste Dump MWD093 and Place Material into Open Mine Pit MMP036						
	Load, Haul, Dump and Slope (grade to 3:1) mine waste rock from MWD093 to fill areas in pit prior to cover placement	1,616,301	bcy	P4 Unit Rate for ROM LHD, Graded 3:1	$3.71	$5,996,475	Total volume of MWD093 4,848,902 cy. Assumed waste rock will be regraded (1/3 of total volume) to provide drainage. Equipment and task costs based on recent (2014) P4 competitive bid for similar work at active mine site
	Use dozer to grade MWD093 to 3:1 slope - following excavation and pit fill waste rock removal;	48	acres	P4 Unit Rate for Grading Only, slope max 3:1	$7,068.44	$340,876	Assume 75% of the existing mine dump will have to be graded and sloped following waste rock removal. Assumed 4 total-combination of D9 and D10 dozers based on recent (2014) P4 competitive bid for similar work at active mine site.
	4. Regrade Mine Waste Dumps MWD080, MWD081, and MWD083 and Place Material into Open Mine Pits MMP035, MMP037, and MMP040						
	Load, Haul, Dump and Slope (grade to 3:1) mine waste rock from the 3 listed above to fill areas in pit prior to cover placement	3,029,417	bcy	P4 Unit Rate for ROM LHD, Graded 3:1	$3.71	$11,239,136	Total volume of MWD080 4,543,109 cy, MWD081 4,050,346 cy, and MWD083 494,795 cy. Assumed waste rock will be regraded (1/3 of total volume) to provide drainage and to provide fill material to cover the Wells formation exposed in the bottom of open mine pit MMP035, 037 and 040. Equipment and task costs based on recent (2014) P4 competitive bid for similar work at active mine site
	Use dozer to grade MWD080, 081, and 083 to 3:1 slope - following excavation and pit fill waste rock removal.	104	acres	P4 Unit Rate for Grading Only, slope max 3:1	$7,068.44	$737,415	Assume 75% of the existing mine dumps (surface area) will have to be graded and sloped following waste rock removal. Assume 4 total-combination of D9 and D10 dozers based on recent (2014) P4 competitive bid for similar work at active mine site.
		221					17,078,000 square feet for capping
	Confirmation Sampling						
	Sample Collection		LS		$0.00	$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 (Graded Mine Waste Dumps and Backfilled Mine Pits)						
	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 1 foot of coarse material)	3,794,560	bcy	P4 Unit Rate for ET Cover, LHD, Graded 3:1	$3.95	$14,988,512	This is the borrow material necessary to cover the interior (97.9 acres) and exterior (294.1 acres or 100% of existing mine dumps regraded) waste rock piles or 392 acres total. Assume ET cover material willl consist of: 1) 5-foot thickness of medium-grained, clean alluvial material, and 2) underlain by a least 1-foot thickness of high-permeability (coarse grained) clean fill material to act as a capillary break and that this material will come from a new borrow pit immediately south of the Site. Equipment and task costs based on recent (2014) P4 competitive bid for similar work at active mine site
	Revegetation of graded interior and exterior waste rock dumps	17,076	msf	Revegetation, hydro or air seeding, with mulch and fertilizer 32 92 19.14 5400	$44.50	$759,861	A total of 392 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	**$39,448,138**	
	Project Management	5%	Capital Costs		$39,448,138	$1,972,407	Project management costs when the capital costs are greater than $10M is estimated at 5 percent (Table 5-8, EPA 540-R-00-002).
	Remedial Design	6%	Capital Costs		$39,448,138	$2,366,888	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		$39,448,138	$2,366,888	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		$39,448,138	$3,944,814	See Note 1
					Other Direct Costs	**$10,650,997**	
	TOTAL DIRECT COSTS					**$50,099,136**	Does not include subcontractor mark-up or profit
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**	1	EA		$25,000	**$25,000**	See Note 2. Assumed deed restriction will need to be exeed with one property owner (original mine property)
5	**ALTERNATIVE 4: 30 Year Present Worth Cost (Items 1+2+3+4)**					**$50,679,000**	

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

TABLE A-1c
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 GCLL 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 31 11 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

TABLE A-1c (continued)
UPLAND SOIL ALTERNATIVE 6: ORE RECOVERY AND RECLAMATION
FEASIBILITY STUDY TECHNICAL MEMORANDUM #2
P4 Production LLC, Ballard Mine
(Page 5 of 6)

Description : Alternative 6 - Ore Recovery/Waste Rock Grading and Consolidation with GCLL 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

TABLE A-1d
UPLAND SOIL ALTERNATIVE 7: COMPLETE WASTE ROCK REMOVAL AND CONSOLIDATION/ET COVER SYSTEM
FEASIBILITY STUDY TECHNICAL MEMORANDUM #2
P4 Production LLC, Ballard Mine

Description: Alternative 7 - Complete Consolidation of Existing Upland Soil/Waste Rock into the Pits, Recommended Cover System, ICs, LUCs, and OM&M/LTM : Under this alternative, all upland soil/waste rock lying outside the existing mine pits would be excavated and consolidated in the existing pits in an attempt to backfill the existing pits and to cover any exposed ore sections, then graded/contoured to create 3:1 slopes. The graded upland soil/waste rock surfaces in the pits and the areas underlying the former upland soil/waste piles would be capped with the ET cover as described in Alternative 4. See Figure 3-4 for general depiction of grading and capping areas. Additional details regarding Alternative 7 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	30	ea	Site mobilization, over 75 ton, + 10% per addn'l 5 mi mob dist. 01 54 36.50 0100/2500	$530.00	$15,900	Assumed 10 dozers,10 loaders, and 10 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. 2016 Means 01 54 36.50 0100/2500
		Construction Field Offices	60	ea	Field office, 32'x8', rent per month 01 52 13 13.20 0350	$270.00	$16,200	Assumed 3 - 32'x8' office trailers rented for 60 month term. 2016 Means 01 52 13 13.20 0350
		Portable Toilets	7,200	ea	Blue rooms, /day 01 54 33 6410	$21.50	$154,800	Assumed 4 rental units. 2016 Means 01 54 33 6410
		Temporary Utilities						
		Power	180	ea	Power/HVAC combined, /month 01 51 13.80 0430	$176.00	$31,680	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 projects.
	Site Preparation							
		Clearing and Grubbing	546	ac	Selective clearing, with dozer and brush rake, light 31 11 13.10 0500	$262.00	$143,052	Assume dozer and brush rake, 546 ac, average brush diameter less than 4-inches. 2016 Means 31 11 13.10 0500. Crew = 1 operator and 1 laborer.
	Waste Rock Removal,On-Site Consolidation, and Regrading							
	1. Fill Mine Pit MMP035 with waste rock from MWD080, MWH081, MWH083 and a portion of MMD093 (i.e., 737K bcy) to fill this pit to drain stormwater (SW) generally west							
		Load, Haul, Dump and Slope (grade to 3:1) mine waste rock from dumps listed above prior to cover placement	9,824,878	bcy	P4 Unit Rate for ROM LHD, Graded 3:1	$3.71	$36,450,297	Equipment and task costs based on recent (2014) P4 competitive bid for similar work at active mine site. This backfilling allows the water to flow generally west off the backfilled surface.
	2. Partially fill Mine Pit MMP036 (4.8M cy) with remaining waste rock from MWD093 (i.e., 4.1M bcy) and a portion of MWD082 (690K bcy) and to drain SW generally south							
		Load, Haul, Dump and Slope (grade to 3:1) mine waste rock from dumps listed above prior to cover placement	4,798,493	bcy	P4 Unit Rate for ROM LHD, Graded 3:1	$3.71	$17,802,409	Equipment and task costs based on recent (2014) P4 competitive bid for similar work at active mine site.
	3. Partially fill Mine Pit MMP037 (1.6M cy) and MMP040 (0.8M cy) with the remaining waste rock from MWD082 (1.9M bcy) and a portion of MWD084 (i.e., 513K bcy) to drain SW generally to the east							
		Load, Haul, Dump and Slope (grade to 3:1) mine waste rock from dumps listed above prior to cover placement	2,420,050	bcy	P4 Unit Rate for ROM LHD, Graded 3:1	$3.71	$8,978,386	Equipment and task costs based on recent (2014) P4 competitive bid for similar work at active mine site.
	4. Partially fill Mine Pit MMP039 (750K cy) with waste rock remaining in MWD084 (i.e., 421K bcy) plus 330K bcy of imported clean fill to drain SW to the east							
		Load, Haul, Dump and Slope (grade to 3:1) mine waste rock from dumps listed above prior to cover placement	751,573	bcy	P4 Unit Rate for ROM LHD, Graded 3:1	$3.71	$2,788,336	Equipment and task costs based on recent (2014) P4 competitive bid for similar work at active mine site.
	5. Fill Mine Pit MMP038 (23K cy) with with clean fill from borrow area to drain SW generally west							
		Load, Haul, Dump and Slope (grade to 3:1) clean fill prior to cover placement	23,404	bcy	P4 Unit Rate for ROM LHD, Graded 3:1	$3.71	$86,829	Equipment and task costs based on recent (2014) P4 competitive bid for similar work at active mine site.
			17,818,398					
	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 (Excavated, Graded Mine Waste Dumps and Backfilled Mine Pits)							
		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 1 foot of coarse material)	5,285,280	bcy	P4 Unit Rate for ET Cover, LHD, Graded 3:1	$3.95	$20,876,856	Assume that each of the former mine dump locations (294 acres) plus backfilled pits MMP035 (90 acres) and MMP038 (1 acre) will be covered using a typical 3:1 surface. Assume the undulating 3:1 backfilled surfaces in mine pits MMP036 (57.4 acres) , 037 (24.2 acres), 039 (26.4 acres) , 040 (21.1 acres) will increase their 2D acreage by 25%, which is approximately 161.4 acres inside these partially backfilled pits. The total acreage then for the ET cover placement is 546 acres. Assume ET cover material willl consist of: 1) 5-foot thickness of medium-grained, clean alluvial material, and 2) underlain by a least 1-foot thickness of high-permeability (coarse grained) clean fill material to act as a capillary break and that this material will come from a new borrow pit immediately south of the Site.
		Revegetation of total acreage	23,784	msf	Revegetation, hydro or air seeding, with mulch and fertilizer 32 92 19.14 5400	$44.50	$1,058,377	Assumed 546 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	**$88,614,949**	
	Project Management		5%	Capital Costs		$88,614,949	$4,430,747	Project Management cost, when the capital costs are greater than $10M, are esitmated at 5 percent (Table 5-8, EPA 540-R-00-002).
	Remedial Design		6%	Capital Costs		$88,614,949	$5,316,897	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		$88,614,949	$5,316,897	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		$88,614,949	$8,861,495	See Note 1
						Other Direct Costs	**$23,926,036**	
	TOTAL DIRECT COSTS						**$112,540,985**	Does not include subcontractor mark-up or profit
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**		1	EA		$25,000	**$25,000**	See Note 2. Assumed deed restriction will need to be exeed with one property owner (original mine property)
5	**ALTERNATIVE 7: 30 Year Present Worth Cost (Items 1+2+3+4)**						**$113,121,000**	

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

Surface Water Alternatives

Table A-2 Summary of Cost Estimates for Remaining Surface Water Alternatives

Table A-2a Surface Water Alternative 1: No Action

Table A-2b Surface Water Alternative 2: ICs and LUCs

Table A-2c Surface Water Alternative 3: In-Situ Treatment, ICs, and LUCs

TABLE A-2
SUMMARY OF COST ESTIMATES FOR REMAINING SURFACE WATER ALTERNATIVES
FEASIBILITY STUDY TECHNICAL MEMORANDUM #2
P4 Production LLC, Ballard Mine

	Alternative 1 - No Action	Alternative 2 - ICs and LUCs	Alternative 3 - In-Situ Treatment, ICs and LUCs
Cost Item Description			
Total Direct Costs	$0	$86,112	$576,835
Institutional Controls	$0	$50,000	$50,000
5 Year CERCLA Summary Reports (30-Year Present Worth)	$107,885	$215,770	$215,770
Annual O&M Costs (30-Year Present Worth) [1]	$0	$497,924	$589,254
30-Year Total Present Worth	**$108,000**	**$850,000**	**$1,432,000**

[1] The annual O&M costs include the costs of O&M of treatment system, if applicable, annual monitoring and the annual operation reports.

TABLE A-2a
SURFACE WATER ALTERNATIVE 1: NO ACTION
FEASIBILITY STUDY TECHNICAL MEMORANDUM #2
P4 Production LLC, Ballard Mine
(Page 2 of 5)

Description: Alternative 1 - No Action. The No Action alternative does not include any remedial action, long-term monitoring (LTM), or administrative or engineering controls for surface water.

Item No.	Item	Description	Quantity	Unit	Unit Cost ($)	Item Cost ($)	Comments / Assumptions
1	DIRECT CAPITAL COSTS						
					Subtotal Capital Costs	**$0**	
	Project Management		10%	Capital Costs	$0	$0	Project management below a $100K capital cost is 10 percent (Table 5-8, EPA 540-R-00-002).
	Remedial Design		0%	Capital Costs	$0	$0	There would be no remedial design under this alternative
	Construction Management and Oversight		0%	Capital Costs	$0	$0	There would be no construction or construction management under this alternative.
	Contingency Costs		10%	Capital Costs	$0	$0	See Note 1
					Other Direct Costs	**$0**	
	TOTAL DIRECT COSTS					**$0**	Does not include subcontractor mark-up or profit
2	**ANNUAL COSTS**						
	30-YEAR PRESENT WORTH (i=7%;n=30,P/A=12.4090)					**$0**	
3	**SUMMARY REPORT (Every 5 Years)**		1	/5 Yrs	$50,000	$50,000	
	30-YEAR PRESENT WORTH (i=7%; P/F=0.7130+0.5083+0.3624+0.2584+0.1842+0.1314=2.1577)					**$107,885**	
4	**INSTITUTIONAL CONTROLS**		0	EA	$25,000	**$0**	See Note 2
5	**ALTERNATIVE 1: 30 Year Present Worth Cost** (Items 1+2+3+4)					**$108,000**	

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.

QA/QC quality assurance / quality control

TABLE A-2b
SURFACE WATER ALTERNATIVE 2: ICs AND LUCs
FEASIBILITY STUDY TECHNICAL MEMORANDUM #2
P4 Production LLC, Ballard Mine

Description: Alternative 2 - ICs and LUCs would be implemented to restrict surface water use and access until cleanup levels are achieved. Upon competition of source controls in the upland soil/waste rock, all surface water runoff would be unimpacted and only residual surface water 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/springs). See Figure 3-5 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**						
	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.
					Subtotal Capital Costs	**$71,760**	
	Project Management		10%	Capital Costs	$71,760	$7,176	Project Management typically is estimated at 10% of capital costs (EPA 540-R-00-002)
	Remedial Design		0%	Capital Costs	$71,760	$0	There would be no remedial design under this alternative
	Construction Management and Oversight		0%	Capital Costs	$71,760	$0	There would be no construction and no construction management necessary under this alternative.
	Contingency Costs		10%	Capital Costs	$71,760	$7,176	See Note 1
					Other Direct Costs	**$14,352**	
	TOTAL DIRECT COSTS					**$86,112**	Does not include subcontractor mark-up or profit
2	**ANNUAL COSTS**						
	Long-term surface water monitoring		1	ls	$40,126	$40,126	Sampling will be conducted by a 2-person field crew over a 5-day period. Assumed 22 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.
	30-YEAR PRESENT WORTH (i=7%;n=30,P/A=12.4090)					**$497,924**	
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 2: 30 Year Present Worth Cost (Items 1+2+3+4)**					**$850,000**	

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.

EA each
ls lump sum
ICs Institutional Controls
LUCs Land Use Controls
ICIAP Institutional Controls Implementation and Assurance Plan
LTM Long-term Monitoring
QA/QC quality assurance / quality control
Yrs years

TABLE A-2c
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

TABLE A-2c (continued)
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

Sediment / Riparian Soil Alternatives

Table A-3 Summary of Cost Estimates for Remaining Sediment / Riparian Soil Alternatives

Table A-3a Sediment and Riparian Soils Alternative 1: No Action

Table A-3b Sediment and Riparian Soils Alternative 3: Sediment Traps / Basins, MNR, ICs, and LUCs

Table A-3c Sediment and Riparian Soils Alternative 4: On-Site Disposal, MNR, ICs, and LUCs

TABLE A-3

SUMMARY OF COST ESTIMATES FOR REMAINING SEDIMENT/RIPARIAN SOIL ALTERNATIVES
FEASIBILITY STUDY TECHNICAL MEMORANDUM #2
P4 Production LLC, Ballard Mine

	Alternative 1 - No Action	Alternative 3 - Sediment Traps/Basins, MNR, ICs and LUCs	Alternative 4 - Removal/On-site Disposal, MNR, ICs, and LUCs
Cost Item Description			
Total Direct Costs	$0	$240,433	$1,219,988
Institutional Controls	$0	$75,000	$75,000
5 Year Summary Reports (30-Year Present Worth)	$107,885	$215,770	$215,770
Annual O&M Costs (30-Year Present Worth) [1]	$0	$204,216	$80,126
30-Year Total Present Worth	**$108,000**	**$736,000**	**$1,591,000**

[1] The annual O&M costs include the costs of O&M of treatment system, if applicable, annual monitoring and the annual operation reports.

TABLE A-3a
SEDIMENT AND RIPARIAN SOILS ALTERNATIVE 1: NO ACTION
FEASIBILITY STUDY TECHNICAL MEMORANDUM #2
P4 Production LLC, Ballard Mine

Description: Alternative 1 - No Action. The no action alternative will leave the Site in its existing condition. The No Action alternative does not include any remedial action, long-term monitoring (LTM), or administrative or engineering controls.

Item No.	Item	Description	Quantity	Unit	Unit Cost ($)	Item Cost ($)	Comment
1	**DIRECT CAPITAL COSTS**						
					Subtotal Capital Costs	**$0**	
	Project Management		8%	Capital Costs	$0	$0	Project management below a $100K capital cost is 10 percent (Table 5-8, EPA 540-R-00-002).
	Remedial Design		0%	Capital Costs	$0	$0	There would be no remedial design under this alternative
	Construction Management and Oversight		0%	Capital Costs	$0	$0	There would be no construction or construction management under this alternative.
	Contingency Costs		10%	Capital Costs	$0	$0	See Note 1
					Other Direct Costs	**$0**	
	TOTAL DIRECT COSTS					**$0**	Does not include subcontractor mark-up or profit
2	**ANNUAL COSTS**						
	30-YEAR PRESENT WORTH (i=7%;n=30,P/A=12.4090)					**$0**	
3	**SUMMARY REPORT (Every 5 Years)**		1	/5 Yrs	$50,000	$50,000	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)					**$107,885**	
4	**INSTITUTIONAL CONTROLS**		0	EA	$25,000	**$0**	See Note 2
5	**ALTERNATIVE 1: 30 Year Present Worth Cost (Items 1+2+3+4)**					**$108,000**	

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.

QA/QC quality assurance / quality control

TABLE A-3b
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

TABLE A-3c
SEDIMENT AND RIPARIAN SOILS ALTERNATIVE 4: REMOVAL, ON-SITE DISPOSAL, MNR, ICs, AND LUCs
FEASIBILITY STUDY TECHNICAL MEMORANDUM #2
P4 Production LLC, Ballard Mine

Description: Alternative 4 - Removal and On-site Disposal, MNR, ICs, and LUCs. Sediment/riparian soil (and all associated riparian vegetation) in the upper reaches of the mine-affected drainages, where the highest concentrations of COCs/COECs are detected, would be excavated, transported, and consolidated with the upland soil/waste rock, then capped. The excavated areas would be reclaimed and revegetated. MNR, ICs, and LUCs would be implemented for sediment/riparian soil that is not removed in the lower reaches of the mine-affected drainages where the concentrations of COC/COEC are substantially lower. See Figure 3-8 for general depiction of alternative. Additional details regarding Alternative 4 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 Equipment	6	each	$816	$4,896	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	3	month	$223	$669	Assumed 1 - 32'x8' office trailer rented for monthly term. 2014 Means 01 52 13 13.20 0350
		Portable Toilets	104	day	$13	$1,388	Assumed 2 rental units for 52 days each. 2014 Means 01 54 33 6410
		Temporary Utilities					
		Power	3	month	$2	$5	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
	Excavate Impacted Sediment for On-Site Consolidation (refer to figure 3-7)						
		Area "A" - Excavation area that includes existing monitoring location MST068	2,444	bcy	$2.45	$5,989	Assumed track mounted hydraulic excavator, 1-CY bucket. 2014 Means 31 23 16.42 0200. Crew = 1 operator and one laborer. Area A in Ballard Creek headwater. Assume excavation is 12" deep and 30 feet wide
		Area "B" - Excavation area that includes existing monitoring locations MST066, MST067, and MST069	10,556	bcy	$5.60	$59,111	Assumed track mounted hydraulic excavator, 1-CY bucket. 2014 Means 31 23 16.42 0200. Crew = 1 operator and one laborer. Area B in Ballard Creek headwater.
		Area "C" - Excavation area that includes existing monitoring locations MST095 and MSG006	4,333	bcy	$5.60	$24,267	Assumed track mounted hydraulic excavator, 1-CY bucket. 2014 Means 31 23 16.42 0200. Crew = 1 operator and one laborer. Area C in Wooley Valley Creek headwater.
		Area "D" - Excavation area that includes existing monitoring location MST092	3,444	bcy	$5.60	$19,289	Assumed track mounted hydraulic excavator, 1-CY bucket. 2014 Means 31 23 16.42 0200. Crew = 1 operator and one laborer. Area D in Wooley Valley Creek headwater.
	Consolidate Excavated Sediments in Pits						
		Haul excavated sediment and dump in open mine pits	20,778	lcy	$3	$63,372	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	27,011	lcy	$5	$126,952	Assumed 30% fluffing of material, 300 hp dozer, max 300 ft push. 2014 Means 31 23 23.17 0190. Crew = 1 operator and 1 laborer.
	Confirmation Sampling during Sediment/Riparian Removal						
		Sample Collection and Analysis	1	ls	$103,893	$103,893	Assumed one sample for every 900 sf of excavation for a total of 623 primary comfirmation samples. Total number of samples increased by 15% to account for QA/QC. Samples collected by one-person field crew requiring 1 hour per sample.
		Confirmation Sampling Summary Report	1	ls	$25,000	$25,000	Cost basis is engineering judgement based on similar projects. Report to be prepared following completion of all confirmation sampling. Report to include summary text of sampling efforts, figure illustrating sample locations, tabulation of data, and comparison of sampling results to the cleanup standards.
	Restoration of Excavated Areas						
		Borrow Development	20,973	bcy	$0.73	$15,311	Volume based on excavated area of 13 acres and 1-ft thickness. Assumed backhoe with 7 cy bucket and 95% fill factor. 2014 Means 31 23 16.43 4430. Crew = 1 operator and 1 laborer.
		Haul fill materials to backfill excavations	27,265	lcy	$3.05	$83,159	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	27,265	cy	$4.70	$128,147	Assumed 300 hp dozer, max 300 ft push. 2014 Means 31 23 23.17 0190. Crew = 1 operator and 1 laborer.
		Revegetation	566	MSF	$67	$37,941	Assumed 13 acres revegetated using a Utility Mix, 7 lbs/MSF, hydroseed application. 2014 Means - Site Work & Landscaping 32 92 19.14 5400. Crew = 1 laborer, 1 operator, and 1 truck driver.
	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.
		Baseline Monitoring 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
		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	**$897,050**	
	Project Management		6%	Capital Costs	$897,050	$53,823	Project Management costs when the capital costs are between $500K and $2M are estimated at 6 percent (Table 5-8, EPA 540-R-00-002).
	Remedial Design		12%	Capital Costs	$897,050	$107,646	Remedial Design costs when the capital costs are between $500K and $2M are estimated at 12 percent (Table 5-8, EPA 540-R-00-002).
	Construction Management and Oversight		8%	Capital Costs	$897,050	$71,764	Construction management costs, including construction QA/QC, when the capital costs are between $500K and $2M are estimated at 8 percent (Table 5-8, EPA 540-R-00-002).
	Contingency Costs		10%	Capital Costs	$897,050	$89,705	See Note 1
					Other Direct Costs	**$322,938**	
	TOTAL DIRECT COSTS					**$1,219,988**	Does not include subcontractor mark-up or profit
2	**ANNUAL COSTS**						
		Long-term MNR sampling	1	/5 Yrs	$37,135.00	$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**	
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-
	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 2. 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 4: 30 Year Present Worth Cost (Items 1+2+3+4)**					**$1,591,000**	

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.

bcy bank cubic yard
COC constituent of concern
CSF Flr 100 square feet of floor
EA each
lcy loose cubic yard
LF linear feet
ls lump sum
MSF thousand square feet
MNR monitored natural recovery
PCL preliminary cleanup level
QA/QC quality assurance / quality control
Yrs years

Groundwater Alternatives

Table A-4 Summary of Cost Estimates for Remaining Groundwater Alternatives

Table A-4a Groundwater Alternative 1: No Action

Table A-4b Groundwater Alternative 2: MNA and ICs

Table A-4c Groundwater Alternative 3: Limited PRB Treatment, MNA, and ICs

Table A-4d Groundwater Alternative 5b: GW Recovery and Treatment, and ICs

TABLE A-4
SUMMARY OF COST ESTIMATES FOR REMAINING GROUNDWATER ALTRNATIVES
FEASIBILITY STUDY TECHNICAL MEMORANDUM #2
P4 Production LLC, Ballard Mine

	Alternative 1 - No Action	Alternative 2 - MNA and ICs	Alternative 3 - PRB Treatment, MNA, and ICs	Alternative 5b - Pump and Treat, and ICs
Cost Item Description				
Total Direct Costs	$0	$166,222	$727,004	$15,271,969
Institutional Controls	$0	$125,000	$125,000	$100,000
5 Year Summary Reports (30-Year Present Worth)	$107,885	$215,770	$215,770	$215,770
Annual O&M Costs (30-Year Present Worth) [1]	$0	$881,076	$1,004,968	$8,631,241
30-Year Total Present Worth	**$108,000**	**$1,389,000**	**$2,073,000**	**$24,219,000**

[1] The annual O&M costs include the costs of O&M of treatment system, if applicable, annual monitoring and the annual operation reports.

TABLE A-4a
GROUNDWATER ALTERNATIVE 1: NO ACTION
FEASIBILITY STUDY TECHNICAL MEMORANDUM #2
P4 Production LLC, Ballard Mine

Description: Alternative 1 - No Action. The no action alternative will leave the Site in its existing condition. The No Action alternative does not include any remedial action (RA), long-term monitoring (LTM), or administrative or engineering controls.

Item No.	Item	Description	Quantity	Unit	Unit Cost ($)	Item Cost ($)	Comment
1	DIRECT CAPITAL COSTS						
					Subtotal Capital Costs	$0	
	Project Management		10%	Capital Costs	$0	$0	Project management below a $100K capital cost is 10 percent (Table 5-8, EPA 540-R-00-002).
	Remedial Design		0%	Capital Costs	$0	$0	There would be no remedial design under this alternative
	Construction Management and Oversight		0%	Capital Costs	$0	$0	There would be no construction or construction management under this alternative.
	Contingency Costs		10%	Capital Costs	$0	$0	See Note 1
					Other Direct Costs	$0	
	TOTAL DIRECT COSTS					$0	Does not include subcontractor mark-up or profit
2	ANNUAL COSTS						
	30-YEAR PRESENT WORTH (i=7%;n=30,P/A=12.4090)					$0	
3	SUMMARY REPORT (Every 5 Years)		1	/5 Yrs	$50,000	$50,000	
	30-YEAR PRESENT WORTH (i=7%; P/F=0.7130+0.5083+0.3624+0.2584+0.1842+0.1314=2.1577)					$107,885	
4	INSTITUTIONAL CONTROLS		0	EA	$25,000	$0	See Note 2
5	ALTERNATIVE 1: 30 Year Present Worth Cost (Items 1+2+3+4)					$108,000	

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.

EA each
QA/QC quality assurance / quality control
Yrs years

TABLE A-4b
GROUNDWATER ALTERNATIVE 2: MNA AND ICs
FEASIBILITY STUDY TECHNICAL MEMORANDUM #2
P4 Production LLC, Ballard Mine

Description: Alternative 2 - MNA and ICs. This alternative includes MNA, which relies on natural attenuation processes to reduce COC concentrations in the Site groundwater over time. In order for MNA to be successful in groundwater, source controls will implemented in the upland soil/waste rock to limit migration of COCs to groundwater. MNA also will require ICs to restrict groundwater use until the cleanup levels are achieved. See Figure 3-9 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**						
		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 MNA monitoring program.
		Installation of six additional monitoring wells	120	LF	$77	$9,240	Assumed six monitoring wells provide additional GW sampling locations in the alluvial aquifer. 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 wells	6	ea	$500	$3,000	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	**$107,240**	
	Project Management		10%	Capital Costs	$107,240	$10,724	Project Management costs, when the capital costs are less than 100K, are estimated at 10 percent (Table 5-8, EPA 540-R-00-002).
	Remedial Design		20%	Capital Costs	$107,240	$21,448	Remedial Design costs, when the capital costs are less than 100K, are estimated at 20 percent (Table 5-8, EPA 540-R-00-002).
	Construction Management and Oversight		15%	Capital Costs	$107,240	$16,086	Construction management costs, including construction QA/QC, when capital costs are less than $100K, are estimated at 15 percent (Table 5-8, EPA 540-R-00-002).
	Contingency Costs		10%	Capital Costs	$107,240	$10,724	See Note 1
					Other Direct Costs	**$58,982**	
	TOTAL DIRECT COSTS					**$166,222**	Does not include subcontractor mark-up or profit
2	**ANNUAL COSTS**						
		Long-term MNA Groundwater Monitoring and Reporting	1	ls	$71,003	$71,003	Sampling will be conducted yearly by a 2-person field crew over a 10-day period. Assumed 42 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)					**$881,076**	
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 five property owners (Tucker Torgeson Farms, Hunsaker Ranching, Nu West Industries, Mark & Beth Carter Trust, Clair Holmgren)
5	**ALTERNATIVE 2: 30 Year Present Worth Cost (Items 1+2+3+4)**					**$1,389,000**	

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.

EA each
ls lump sum
QA/QC quality assurance / quality control
Yrs years

TABLE A-4c
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

TABLE A-4c (continued)
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

TABLE A-4d
GROUNDWATER ALTERNATIVE 5b: GW RECOVERY AND TREATMENT, AND ICs
FEASIBILITY STUDY TECHNICAL MEMORANDUM #2
P4 Production LLC, Ballard Mine

Description: Alternative 5b - Groundwater Recovery and Treatment of Both Alluvial and Wells Formation Groundwater, and ICs. This alternative includes groundwater extraction via trenches in the alluvial aquifer and wells for the Wells Formation (Wells Fm) aquifer, then ex-situ treatment of all mine-affected groundwater using membrane technology. Treated water would be discharged to a basin and allowed to infiltrate back into the alluvial aquifer and discharged to a basin or injected back into the Wells Fm. See Figure 3-11 for general depiction of alternative. Additional details regarding Alternative 5b 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 Equipment for Extraction Trench Installatic	6	each	$816	$4,896	Assumed 3 trackhoes and 3 frontloaders. 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
		Mobilization/Demobilization of Drill Rig	1	LS	$10,000	$10,000	Based on driller estimate for a similar site in SE Idaho
		Construction Field Offices	24	month	$223	$5,352	Assumed 2 - 32'x8' office trailers rented for a 12 month term. 2014 Means 01 52 13 13.20 0350
		Portable Toilets	1,460	each	$13	$19,491	Assumed 4 rental units for 12 months each. 2014 Means 01 54 33 6410
		Temporary Utilities					
		Power	48	month	$2	$87	2014 Means 01 51 13.80 0430
		Heat	31	CSF Flr	$69	$2,104	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	1	ls	$21,760	$21,760	Existing groundwater monitoring plan will be updated to conform with post RA monitoring program.
	Site Preparation						
		Drill Pad Preparation	2,222	bcy	$2	$5,444	Assume a 100ft x 50ft pad will need to be prepared at each extraction well and piezometer location. Assumed average excavation depth of 1 foot. 2014 Means 31 23 16.42 0200
	Wells Formation Groundwater Extraction Wells						
		Installation of 3 Extraction Wells (6-inch, 300 feet deep)	900	LF	$123.00	$110,700	Includes drilling and installation, 6-inch PVC casing and continuously wrapped stainless stell well screen, with 1-inch PVC drop tude on otside of well for pressure transducer installation.
		Extraction Well Development	3	ea	$1,500.00	$4,500	Assumes swab and surge initially followed by overpumping. Cost includes
		Extraction Well Testing	3	ea	$6,950.00	$20,850	Perform 72-hour pump test on each well, cost includes temporary pump, transducers, and water handling/disposal. Based on driller estimate from a similar site in SE Idaho
		Surface Completions for Extraction Wells	3	ea	$950.00	$2,850	8-inch steel protective casing, four steel concrete filled bollards, and concrete pad. Based on driller estimate from a similar site in SE Idaho
		Drilling and installation of piezometers (2-inch, 300 feet deep)	2,700	LF	$77.00	$207,900	Assumed three piezometers per extraction well to monitor hydraulic response during pump testing. Assumes 2-inch SCH 40 PVC casing and well screen
		Piezometer Development	9	ea	$750.00	$6,750	Based on driller estimate from a similar site in SE Idaho
		Surface Completions for Piezometers	9	ea	$500.00	$4,500	4-inch steel protective casing, four steel concrete filled bollards, and concrete pad. Based on driller estimate from a similar site in SE Idaho
		Submersible Pump for Extraction Well	3	ea	$3,500.00	$10,500	Assumed submersible pump (Grundfos Type) flow rate of 50 gpm at 300 ft of head, 5 hp. 2015 Means Mechanical Data - 33 21 13.10 2000
		Flow Meters for Extraction wells	3	ea	$4,480.00	$13,440	2-inch Thermo Polysonics Model 65908 magmeter
		Pressure Transducers for wells and Piezometers	12	ea	$1,771.00	$21,252	Global Water Model WL450-500 level Transmitter
	Alluvial Aquifer Groundwater Extraction Trenches						
		Extraction Trench Excavation (6 trenches various lengths, 25 feet deep)	13,611	bcy	$6	$76,903	Assumed 4,900 feet of excavation. 2014 Means Heavy Construction Cost Data 31 23 16.13 1387
		Pea Gravel Backfill	13,611	cy	$133	$1,810,278	2014 Means Heavy Construction Cost Data 32 91 13.16 1600
		Extraction Sump	150	LF	$98.00	$14,700	Includes drilling and installation, 6-inch PVC casing and PVC well screen, with 1-inch PVC drop tude on otside of well for pressure transducer installation. Based on driller estimate from a similar site in SE Idaho
		Surface Completions for Extraction Sumps	6	ea	$950.00	$5,700	8-inch steel protective casing, four steel concrete filled bollards, and concrete pad. Based on driller estimate from a similar site in SE Idaho
		Monitoring Wells	900	LF	$77.00	$69,300	Assumed six piezometers per extraction trench to monitor hydraulic response and provided 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
		Monitoring Well Development	36	ea	$750.00	$27,000	Based on driller estimate from a similar site in SE Idaho
		Surface Completions for Monitoring Wells	36	ea	$500.00	$18,000	4-inch steel protective casing, four steel concrete filled bollards, and concrete pad. Based on driller estimate from a similar site in SE Idaho
		Submersible Pump for Extraction Sump	6	ea	$2,425.00	$14,550	Assumed submersible pump (Grundfos Type) flow rate of 50 gpm at 40 ft of head, 2 hp. 2015 Means Mechanical Data - 33 21 13.10 1800
		Flow Meters for Extraction Sumps	6	ea	$4,480.00	$26,880	2-inch Thermo Polysonics Model 65908 magmeter
		Pressure Transducers for Sumps and Monitoring Wells	42	ea	$1,771.00	$74,382	Global Water Model WL450-500 level Transmitter
	Yard Piping						
		Trenching	2,989	bcy	$7	$22,267	Assumed manifolded discharge piping from each extraction facility into center of GWTP compound. 26,900 linear feet of trenching, 3 feet deep and 1 foot wide. 2014 Means Heavy Construction Cost Data 31 23 16.13 0060
		4-inch HDPE pipiing	26,900	LF	$11	$299,935	Assumed 4-inch HDPE piping, fusion welded. 2015 Means Mechanical Data - 33 11 13.35 0100
		Backfill Trench Excavations	3,886	lcy	$3	$11,113	Assumed 30% fluffing of excavated material. 2014 Means Heavy Construction Cost Data 31 23 16.13 3020
	Groundwater Treatment Plant						
		Reverse Osmosis Treatment Plant (Max 450 gpm capacity)	1	ls	$9,000,000	$9,000,000	Engineering judgement based on similar systems on other projects. Assumed RO system complete, metal building, all ancillary process equipment, and evaporation pond for brine management.
	Water Disposal						
		Installation of 3 Injection Wells (8-inch, 150 feet deep-to Wells Fm in bottom of West Ballard Pit)	450	LF	$57.50	$25,875	Includes drilling and installation, 8-inch steel casing. 2015 Means Mechanical Data - 33 21 13.10 0200
		Surface Completions for Injection Wells	3	ea	$950.00	$2,850	8-inch steel protective casing, four steel concrete filled bollards, and concrete pad. Based on driller estimate from a similar site in SE Idaho
		Infiltration Basin for Treated Alluvial water	1,250	bcy	$2.45	$3,063	Assume 75 ft x 75 ft x 6 ft basin. 2014 Means Heavy Construction Data 31 23 16.42 0200
					Subtotal Capital Costs	**$12,025,172**	
	Project Management		5%	Capital Costs	$12,025,172	$601,259	Project Management cost, when the capital costs are greater than $10M, are esitmated at 5 percent (Table 5-8, EPA 540-R-00-002).
	Remedial Design		6%	Capital Costs	$12,025,172	$721,510	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	$12,025,172	$721,510	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	$12,025,172	$1,202,517	See Note 1
					Other Direct Costs	**$3,246,796**	
	TOTAL DIRECT COSTS					**$15,271,969**	Does not include subcontractor mark-up or profit

TABLE A-4d (continued)
GROUNDWATER ALTERNATIVE 5b: GW RECOVERY AND TREATMENT, AND ICs
FEASIBILITY STUDY TECHNICAL MEMORANDUM #2
P4 Production LLC, Ballard Mine

Description: Alternative 5b - Groundwater Recovery and Treatment of Both Alluvial and Wells Formation Groundwater, and ICs. This alternative includes groundwater extraction via trenches in the alluvial aquifer and wells for the Wells Formation (Wells Fm) aquifer, then ex-situ treatment of all mine-affected groundwater using membrane technology. Treated water would be discharged to a basin and allowed to infiltrate back into the alluvial aquifer and discharged to a basin or injected back into the Wells Fm. See Figure 3-11 for general depiction of alternative. Additional details regarding Alternative 5b can be found in Section 3.

Item No.	Item	Description	Quantity	Unit	Unit Cost ($)	Item Cost ($)	Comment
2	**ANNUAL COSTS**						
		Operation and Maintenance of RO Plant	1	ls	$624,560	$624,560	Assumed full time plant operator, part time technican, and PM and admin. Also includes field vehicle and fuel, monthly influent and effluent sampling, and an allowance for spare parts.
		Long-term MNA Groundwater Monitoring and Reporting	1	ls	$71,003	$71,003	Sampling will be conducted by a 2-person field crew over a 10-day period. Assumed 42 groundwater locations to be monitored on an annual basis as presented in Alternative 2. 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.
				Subtotal Annual Costs		**$695,563**	
	30-YEAR PRESENT WORTH (i=7%;n=30,P/A=12.4090)					**$8,631,241**	
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**		4	EA	$25,000	**$100,000**	See Note 2. Assumed property easement and deed restriction will need to be executed with four property owner (Tucker Torgeson Farms, Hunsaker Ranching, Nu West Industries, Mark & Beth Carter Trust)
5	**ALTERNATIVE 5b: 30 Year Present Worth Cost (Items 1+2+3+4)**					**$24,219,000**	

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
Yrs years

APPENDIX B

COVER SYSTEM EVALUATION MEMORANDUM

FOR THE BALLARD MINE SITE

COVER SYSTEM EVALUATION MEMORANDUM
FOR
THE BALLARD MINE SITE

FINAL REVISION 2

APRIL 2017

Prepared by:

MWH, AMERICAS, INC

For:

P4 PRODUCTION, LLC

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ATTACHMENTS

Attachment 1 – Golder Cover Design Evaluation

Attachment 2 – USGS - National Climate Change Viewer Summary of Caribou County Idaho

1 INTRODUCTION AND PROJECT BACKGROUND

As part of the Feasibility Study (FS) for the Ballard Mine Site (the Site), MWH has prepared this technical memorandum (memo) with the primary goal of evaluating and selecting possible cover designs that will limit infiltration through the existing Site waste rock dumps and leaching of contaminants of concern (COCs) and contaminants of ecological concern (COECs) into surface water and underlying groundwater based on typical CERCLA cover performance requirements. Golder Associates (Golder) was contracted to perform the modeling of various cover types for the Ballard Mine Site and prepared a report entitled *Ballard Mine Reclamation Cover Design Evaluation (Golder Cover Design Evaluation, 2015)*. MWH has reviewed the inputs to the Golder cover design modeling effort to determine if they are reasonable/defendable and to select the most appropriate cover for the Site. These inputs include: the climate data (and how climate change might affect it), material properties, and vegetative cover selection that were used by Golder. Attachment 1 includes the *Golder Cover Design Evaluation*.

The Site is located approximately 13 miles north-northeast of Soda Springs, Idaho in Caribou County. The Site is comprised of six external waste rock dumps, six open pits, an abandoned haul road, and the Ballard Shop Area which accounts for approximately 534 acres of disturbance.

The transport of contaminants within and away from the Site is dominated by the movement of water that comes into contact with the six exposed mine waste rock dumps – MWD080, MWD081, MWD082, MWD083, MWD084, and MWD093 – that are shown in Figure 1. The primary contaminant transport pathways include 1) stormwater that has come into direct contact with the waste rock dumps, then travels offsite, and 2) the leaching of contaminants as water from precipitation percolates through the waste rock dumps. Leached contaminants discharge at the surface in the form of localized and ephemeral springs, seeps, or river recharge (Figure 2).

As part of the remediation efforts at the Site, it is likely that the waste rock dumps and other contaminated upland soil will be graded then covered to promote drainage/discharge of clean surface water and to reduce infiltration of precipitation into the waste rock dumps. An effective cover design reduces total contaminant transport by preventing direct contact of stormwater with contaminants and reducing the total volumetric flux of water through the waste rock dump. As the volumetric flux of water through the waste rock dump decreases, the total leached contaminant mass also decreases. Reducing the contaminant transport to the groundwater systems is critical for any proposed remediation strategy at the Site.

In the absence of a performance standard for the Site cover system (that will be defined in the Record of Decision [ROD]), MWH uses in this document, as it has on other CERCLA sites at the FS stage, the typical infiltration rate through a RCRA Subtitle C, 2-foot compacted clay liner (CCL). The hydraulic conductivity of a RCRA Subtitle C CCL is $1x10^{-7}$ cm/sec or approximately 1.24 in/year. This number is used for comparison purposes with the proposed cover systems modeled by Golder to determine if a cover system passes this minimum threshold.

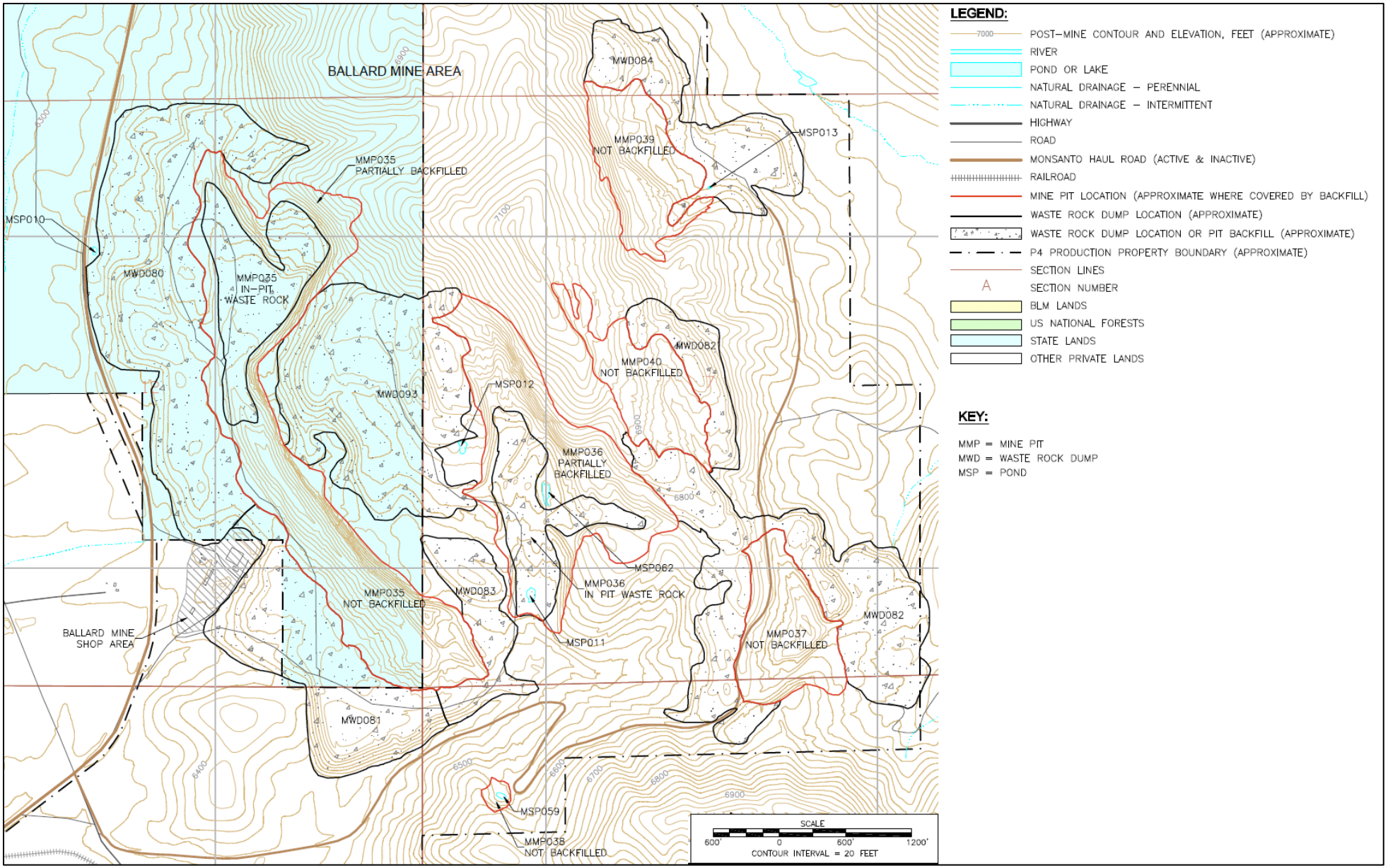
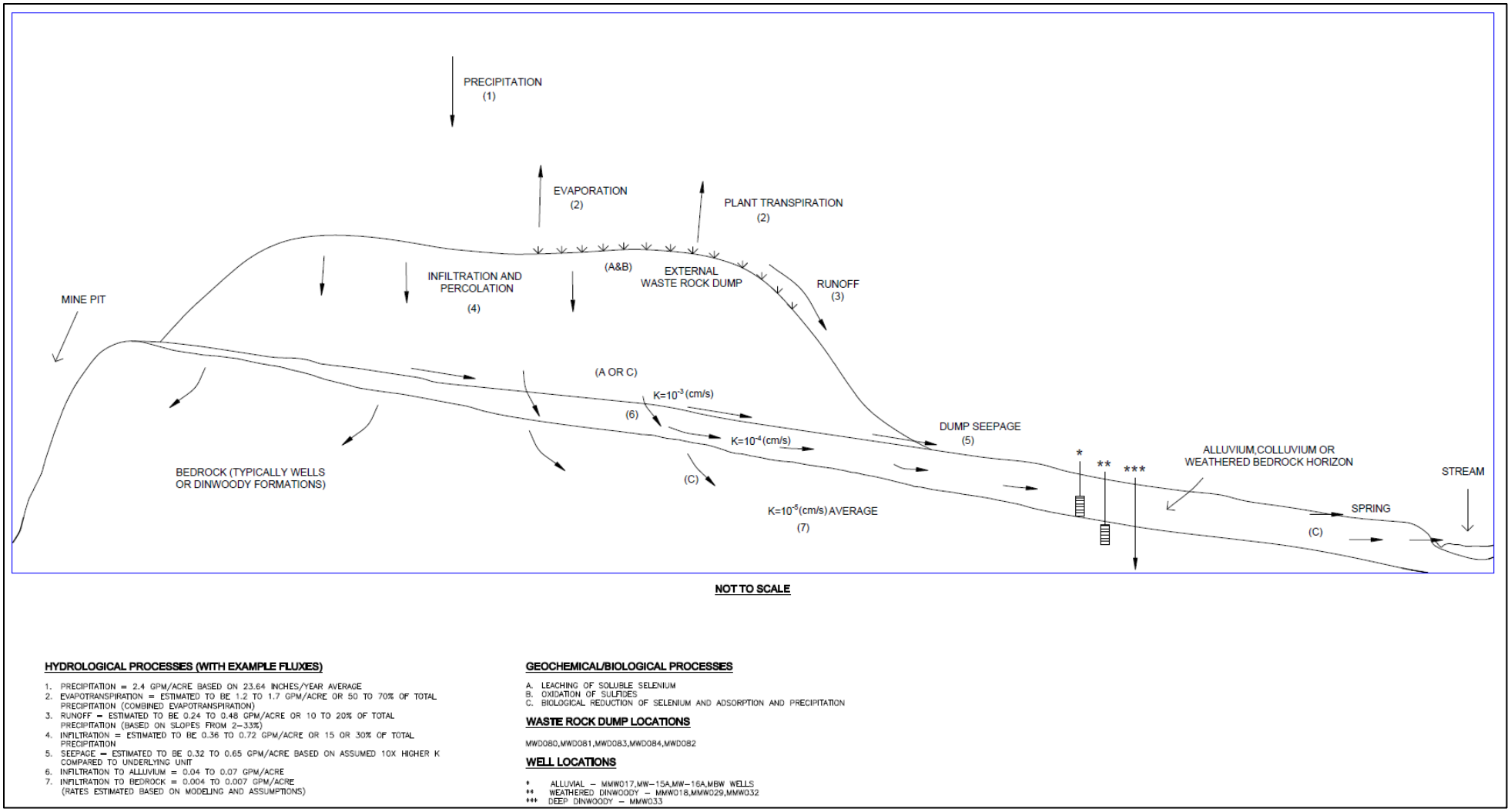


Figure 1: Mine Waste Rock Dumps and Mine Pits at the Ballard Mine



HYDROLOGICAL PROCESSES (WITH EXAMPLE FLUXES)

1. PRECIPITATION = 2.4 GPM/ACRE BASED ON 23.64 INCHES/YEAR AVERAGE
2. EVAPOTRANSPIRATION = ESTIMATED TO BE 1.2 TO 1.7 GPM/ACRE OR 50 TO 70% OF TOTAL PRECIPITATION (COMBINED EVAPOTRANSPIRATION)
3. RUNOFF – ESTIMATED TO BE 0.24 TO 0.48 GPM/ACRE OR 10 TO 20% OF TOTAL PRECIPITATION (BASED ON SLOPES FROM 2–33%)
4. INFILTRATION = ESTIMATED TO BE 0.36 TO 0.72 GPM/ACRE OR 15 OR 30% OF TOTAL PRECIPITATION
5. SEEPAGE – ESTIMATED TO BE 0.32 TO 0.65 GPM/ACRE BASED ON ASSUMED 10X HIGHER K COMPARED TO UNDERLYING UNIT
6. INFILTRATION TO ALLUVIUM = 0.04 TO 0.07 GPM/ACRE
7. INFILTRATION TO BEDROCK = 0.004 TO 0.007 GPM/ACRE (RATES ESTIMATED BASED ON MODELING AND ASSUMPTIONS)

GEOCHEMICAL/BIOLOGICAL PROCESSES

A. LEACHING OF SOLUBLE SELENIUM
B. OXIDATION OF SULFIDES
C. BIOLOGICAL REDUCTION OF SELENIUM AND ADSORPTION AND PRECIPITATION

WASTE ROCK DUMP LOCATIONS

MWD080,MWD081,MWD083,MWD084,MWD082

WELL LOCATIONS

* ALLUVIAL – MMW017,MW–15A,MW–16A,MBW WELLS
** WEATHERED DINWOODY – MMW018,MMW029,MMW032
*** DEEP DINWOODY – MMW033

Figure 2: Conceptual Surface Water and Groundwater Flow Diagram at the External Waste Rock Dumps with Example Fluxes (MWH, 2014)

2 GOLDER COVER MODEL EVALUATION

In support of the Ballard FS, as discussed above, Golder performed infiltration modeling for thirteen different soil cover systems on slopes facing north, south, east, or west. Seven unique cover systems were used to model these thirteen soil conditions (refer to Figure 3). Those seven cover systems consist of the following:

1. Base: no cover is provided and water is allowed to percolate through 10 feet of waste material. This analysis represents approximate percolation rates through exposed waste rock at the Ballard Site.
2. Topsoil-only cover: 1.5 feet of topsoil is placed over shale or chert waste rock.
3. Geosynthetic Clay Laminated Liner (GCLL) cover: 1.5 feet of topsoil, 1.5 feet of medium-textured alluvium, a GCLL and drainage layer, and a two-foot lift of chert. The GCLL consists of a geosynthetic clay (GCL) made of granular sodium bentonite clay placed between two geotextile layers with the top layer laminated to a polyethylene geomembrane layer (O'Kane, 2009a). No underlying waste rock was modeled for this system.
4. ET Cover 1 and ET Cover 5 (ET 1/5): 2 feet of topsoil, 3 feet of fine-textured alluvium, 2 feet of chert over existing shale (ET 1) or chert (ET 5) waste rock.
5. ET Cover 2 and ET Cover 6 (ET 2/6): 1.5 feet of topsoil, 1.5 feet of medium-textured alluvium, 2 feet of chert over existing shale (ET 2) or chert (ET 6) waste rock.
6. ET Cover 3 and ET Cover 7 (ET 3/7): 5 feet of medium-textured alluvium over existing shale (ET 3) or chert (ET 7) waste rock.
7. ET Cover 4 and ET Cover 8 (ET 4/8): 5 feet of coarse-textured alluvium over existing shale (ET 3) or chert (ET 7) waste rock.

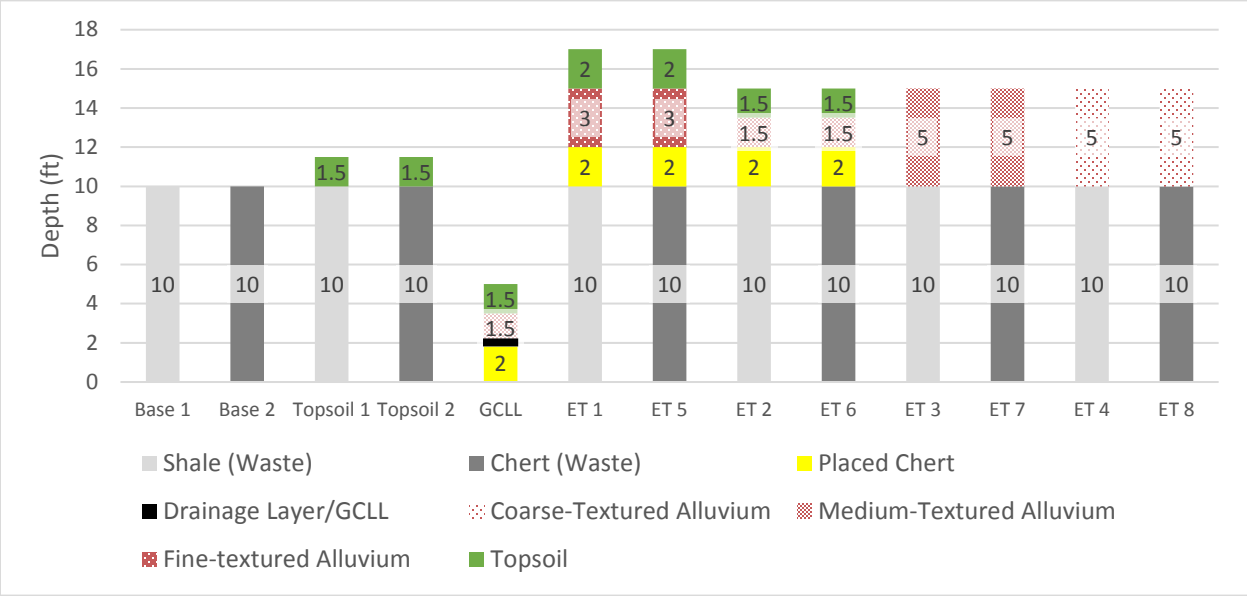


Figure 3: Simulated Cover Designs by Golder (2015)

The selection of an appropriate cover is dependent upon the following model inputs:

- Climate of the Site (i.e., climate record),
- Material properties of the cover system, and
- Site-specific vegetation requirements

Each of these topics is discussed below, with a focus on the climate conditions simulated by O'Kane (2009b).

2.1 Climate Record Review

With regard to climate inputs, Albright et al. (2010) notes that for cover designs it is important to obtain the following climate data directly from the site of interest (in order of importance to cover design): precipitation, relative humidity, wind speed, temperature, global solar radiation (solar radiation), and cloud cover. Additionally, Albright et al. (2010) recommends that data should be used from nearby weather stations when not available at the point of interest. Typically, older stations with longer records contain temperature and precipitation data, but rarely include wind speed, solar radiation, or relative humidity. Newer stations may contain these values, but may not provide a sufficient length of record to be statistically significant. Therefore, using multiple weather stations within a similar climatic region is justifiable, and often necessary, to build a complete a weather record.

Given the absence of site-specific climate data at the Ballard Site, Golder in its evaluation of covers for the Site utilized a previous dataset developed by O'Kane (2009b) for the design of cover systems at the Blackfoot Bridge (BFB) Mine. The BFB mine is owned by P4 and located approximately 3 miles south of the Site just across the Blackfoot River which bounds the southern margin of the Site. In keeping with the recommendations of Albright et al. (2010), the climate dataset utilized site-specific data and datasets from other nearby weather stations.

MWH evaluated the O'Kane climate data for use in the Golder model. This review focused on O'Kane's precipitation dataset because it is the most important aspect for cover design modeling. To determine the appropriateness of the O'Kane data, MWH performed the following:

1. Reviewed the synthetic 100-year record produced by O'Kane,
2. Compared this dataset with regional climate data, and
3. Reviewed potential climate change impacts using projected climate change data made available by the United States Geological Survey (USGS). Each of these items is discussed in more detail below.

2.1.1 Review of O'Kane's 100-year Synthetic Precipitation Record

The O'Kane dataset utilized climate data from the following sources and locations:

1. Site-specific data from the BFB Mine weather station for precipitation, temperature, and average wind speed located 3 miles southwest of the Ballard Mine
2. The Soda Springs AP (station ID: USC00108535) for precipitation and temperature, located 13 miles southwest of the Ballard Mine,
3. Grace Idaho (station ID: USR0000IGRA) for precipitation and temperature, located 21 miles southwest of the Ballard Mine, and
4. Pocatello Idaho (station ID: USW00024156) for relative humidity, located 55 miles west of the Ballard Mine.

Due to the relatively short period of record of climate data (2004-present) at the BFB Mine, it was necessary for O'Kane to lengthened the climate records for maximum temperature, minimum temperature, and precipitation by comparing and adjusting trends at the BFB Mine with the Soda Springs weather station and then with the Grace Idaho weather station (O'Kane, 2009b). The O'Kane synthetic records preserve the precipitation and temperature

magnitudes from the BFB weather station, but utilize the climate variability from the Grace and Soda Springs weather stations.

The annual total precipitation and the 20-year cumulative precipitation data for the weather stations analyzed by O'Kane, and for the produced synthetic 100-year record, are shown in **Figure** 4. The 20-year cumulative precipitation values are the total precipitation that has fallen for the 20 years prior to the shown date. For example, a 20-year cumulative record for 2000, adds up the data from 1981 to year 2000 and reports the total precipitation over that period. Using 20-year cumulative values is another way to look at the multi-year variability.

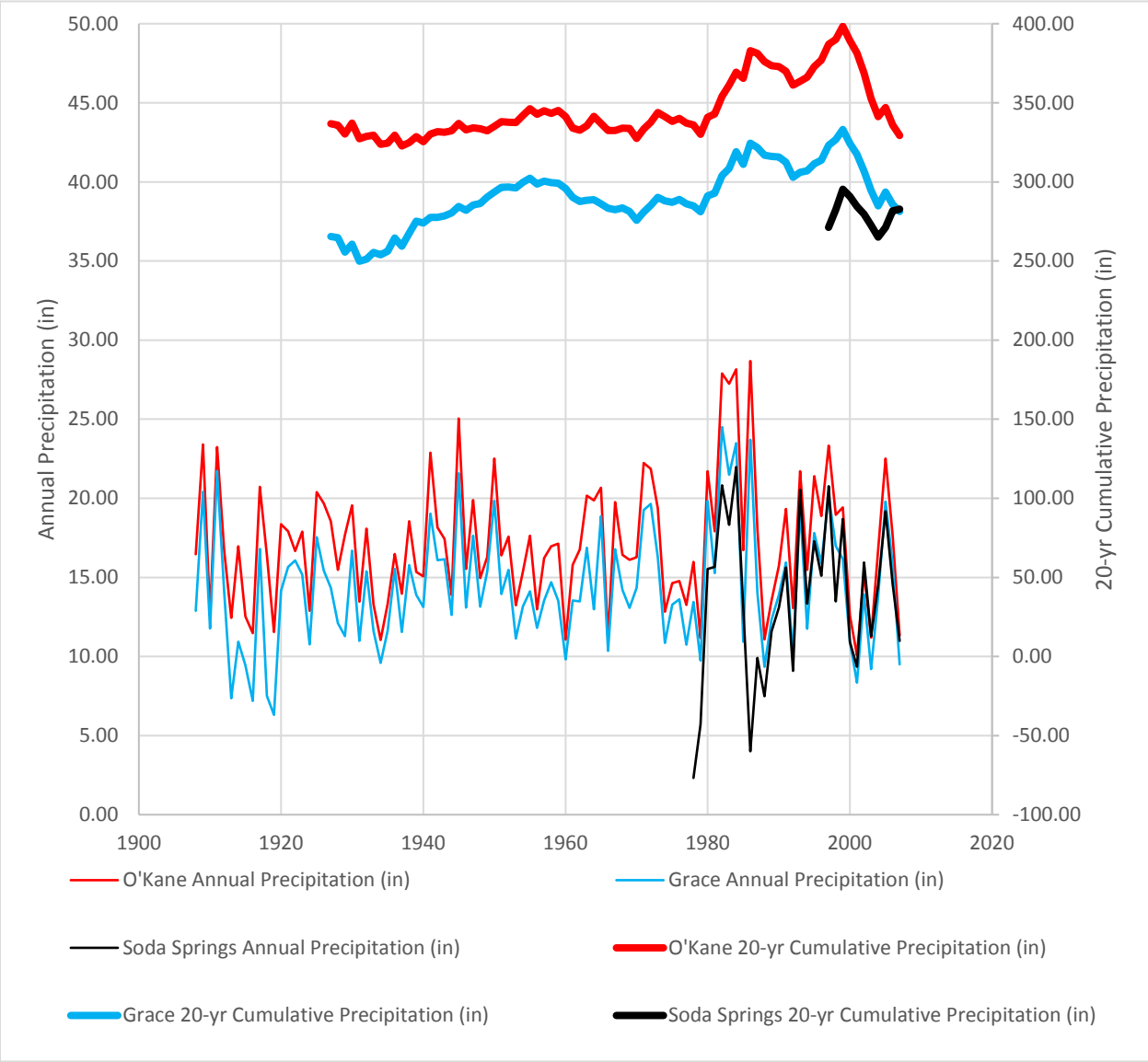


Figure 4: Annual Total Precipitation and 20-Year Cumulative Precipitation Used / Developed by O'Kane

The O'Kane record closely approximates the precipitation trends from the Grace weather station including the annual variability shown by the annual precipitation values. The synthesized data also reflects wet and dry conditions that were used in the Golder cover simulations. Capturing this variability is important to assessing the overall performance of a cover design. Due to the limited number of weather stations referenced by the O'Kane report, MWH evaluated a number of additional stations for comparison as described in the following section.

2.1.2 Comparison of O'Kane's 100-year Synthetic Precipitation Record to Regional Data

The O'Kane precipitation records extend from October 1, 1907 through September 30, 2007 using a combination of the Grace and Soda Springs weather stations. In addition to these weather stations used by O'Kane, MWH collected precipitation records for 12 additional weather stations surrounding the Ballard Mine (Figure 5) for the same period. Metadata for these weather stations are provided in

Although the stations are spread out over the region surrounding the Ballard Site and are positioned at varied elevations, the dataset provides an understanding of potential precipitation that could be experienced at the Site. These trends are presented by the 20-year cumulative precipitation lines shown in Figure 6. For example, the Somsen Ranch weather station contains 29 years of data and is located 10.6 miles away from the Ballard Mine (see Table 1). Given the elevations are similar and the distance to the weather station is less than Soda Springs and Grace stations, it is reasonable to assume that the available data for Somsen Ranch may provide an upper bound for the cover design at the Ballard Mine. Additionally, although the Slug Creek Divide weather station is located at a higher elevation, and therefore is likely to experience more snowfall than the Site, it also provides an extreme upper bound for the region.

For the 12 additional weather stations selected, the precipitation data developed by O'Kane is slightly above average for weather stations data since 1980, while cumulative trends prior to 1980 suggest the station provides an upper bound for historic information. Therefore, the current O'Kane weather record provides a reasonable estimate for average to slightly above average historic climate conditions at the Ballard Site.

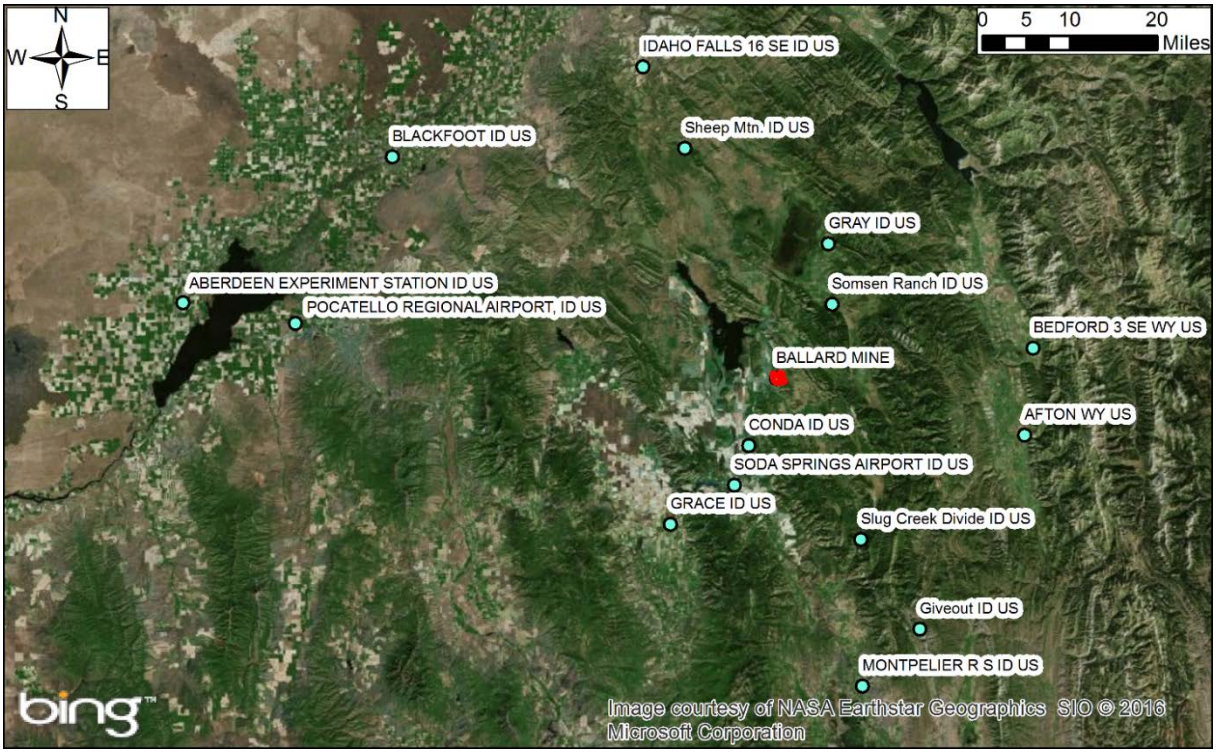


Figure 5: Weather Stations Surrounding the Ballard Mine

Table 1: Metadata of Weather Stations Near Ballard Mine Compared to the 100-Year Record Developed by O'Kane

Station Name	Network: Station ID	Latitude	Longitude	Years Recorded (10/1/1907 to 09/30/2007)	Distance from Ballard Mine (miles)	Elevation (ft amsl)	Maximum Annual Precipitation Depth (inches)	Maximum 20-Year Cumulative Precipitation Depth (inches)
Ballard Mine	-	42.8277	-111.4867	0	-	~6650		
Blackfoot Bridge Mine[1]	-	42.7922	-111.5229	100	3	~6400	28.7	398.3
Conda ID US	COOP:102071	42.7167	-111.55	39	8.3	6204	26.1	384.2
Somsen Ranch ID US	GHCND:USS0011G01S	42.95	-111.36	29	10.6	6800	38.9	529.2
Soda Springs Airport ID US	GHCND:USC00108535	42.6513	-111.5833	20	13.1	5842	22.0	295.4
Gray ID US	COOP:103825	43.05	-111.3667	38	16.5	6450	23.8	347.6
Grace ID US	GHCND:USC00103732	42.5872	-111.7275	100	20.6	5550	24.5	333.2
Slug Creek Divide ID US	GHCND:USS0011G05S	42.56	-111.3	29	20.8	7225	49.8	652.1
Sheep Mtn. ID US	GHCND:USS0011F11S	43.21	-111.69	29	28.3	6570	39.7	496.3
Afton WY US	GHCND:USC00480027	42.7291	-110.9297	50	29.1	6245	28.7	365.0
Bedford 3 SE WY US	GHCND:USC00480603	42.8733	-110.9075	32	29.6	6425	36.5	476.9
Giveout ID US	GHCND:USS0011G33S	42.41	-111.17	26	33.0	6930	31.4	415.3
Montpelier R S ID US	COOP:106053	42.3167	-111.3	76	36.5	5960	20.6	304.6
Idaho Falls 16 SE ID US	GHCND:USC00104456	43.3455	-111.7847	52	38.8	5828	23.6	329.2
Blackfoot ID US	COOP:100915	43.1969	-112.353	91	50.7	4536	21.4	246.1
Pocatello Regional Airport, ID US	GHCND:USW00024156	42.9202	-112.5711	69	55.4	4452	19.8	263.1
Aberdeen Experiment Station ID US	COOP:100010	42.9536	-112.8253	91	68.5	4405	15.1	199.3

NOTES:
1. Summary of the data produced by O'Kane for the Blackfoot Bridge Mine.

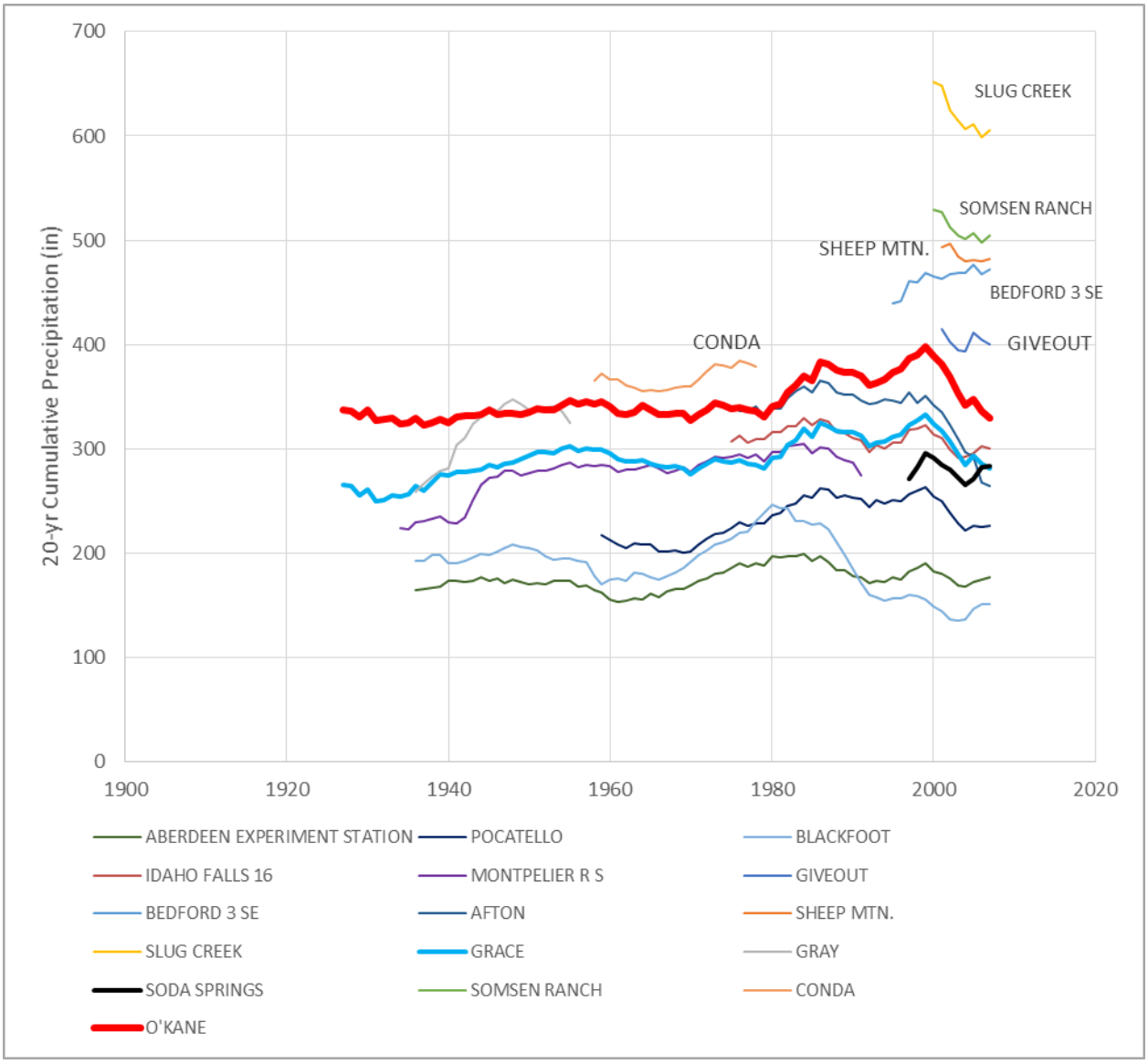


Figure 6: Comparison of 20-Year Cumulative Precipitation Values for Weather Stations near the Ballard Mine

2.1.3 Climate Change Considerations for Cover Design

MWH reviewed climate change impacts for Caribou County using the USGS's National Climate Change Viewer (NCCV) (2014). Thirty independently produced climate models and an average projection (called the ensemble projection) are distributed into four time periods: 1950-2005, 2025-2049, 2050-2074, and 2075-2099. The time periods represent the average condition across the reported years. Data for each model and time period is given at annual or monthly time scales. To simplify potential climate impacts for the Site, Table 2 shows the annual average projections of the ensemble climate records. Two emissions scenarios are available from the USGS. Run RCP4.5 is for curbed emissions and RCP8.5 is for aggressive, un-checked emissions.

Table 2: Annual Average Climate Change Projections for Caribou County, Idaho using the 30 Model Ensemble

Emission Scenario	Variable	Units	Historic average for 1950-2005	Change from 1950-2005 to 2025-2049	Change from 1950-2005 to 2050-2074	Change from 1950-2005 to 2075-2099
RCP4.5 (less emissions)	Max Temperature	°F	52.9	+3.8	+5.2	+5.9
	Min Temperature	°F	27.5	+4.0	+5.4	+6.1
	Precipitation	inches/day	0.059	0.0	+0.004	+0.004
	Runoff	inches/month	0.6	0.0	0.0	0.0
	Snow	inches	2.7	-0.7	-1.1	-1.2
	Soil Storage	inches	3.0	-0.2	-0.1	-0.2
	Evaporation Deficit	inches/month	0.3	0.1	0.2	0.2
RCP8.5 (more emissions)	Max Temperature	°F	52.9	+4.1	+6.1	+10.4
	Min Temperature	°F	27.5	+4.5	+7.6	+11.0
	Precipitation	inches/day	0.059	+0.004	+0.004	+0.008
	Runoff	inches/month	0.6	0.0	0.0	0.0
	Snow	inches	2.7	-0.8	-1.4	-2.0
	Soil Storage	inches	3.0	-0.1	-0.3	-0.3
	Evaporation Deficit	inches/month	0.3	0.1	0.3	0.5

From the results presented in Table 2, increased maximum temperature, increased minimum temperature, decreased snowpack, decreased soil storage, and increased evaporation deficit all indicate that less water would be available for infiltration into the cover. Annual average precipitation is currently projected to increase by the end of the century between 1.46 inches/year and 2.92 inches/year (0.008 in/day) on average. However, projected precipitation trends are highly variable as shown Attachment 1.

Due to the variability in precipitation trends and strong trends toward increasing temperature and decreasing snowpack, it is expected that total saturation and the total infiltration of precipitation through a cover system and into underlying waste rock may decrease under projected future climate scenarios. This is mainly attributable to the fact that snowmelt in this area is considered the dominant mechanism resulting in precipitation breakthrough of a cover system. This is because snowmelt occurs while the plants in the cover are still dormant and therefore moisture is not being removed through evapotranspiration during this time. Therefore, as the winter snowfall and snowpack decreases in the future, so does total volume of water available for infiltration and the chance for the ground to saturate during spring snowmelt periods.

2.2 Review of Material Properties

The soil water characteristic curve (SWCC) and saturated hydraulic conductivity are used to evaluate the unsaturated flow conditions of the modeled cover designs. Golder reported that these material properties were obtained by O'Kane (2009b) at the Blackfoot Bridge Site and MWH (2014) immediately south of the Ballard Site at a potential borrow area. Based on a review of available site-specific material properties, cover systems incorporating topsoil simulated by Golder are deemed not feasible at the Ballard Site due to the limited quantities of appropriate top soil materials in the local area. Of the modeled designs, only ET 3/7 and ET 4/8 do not include a topsoil layer and are applicable.

2.3 Review of Vegetative Parameters

P4 provided Golder with a reclamation seed mix for the cover design analysis (Table 3). The seed mix used during the implementation of the remedy will be evaluated during the Remedial Design (RD) and documented in a Vegetation Plan that is developed with input from the A/Ts.

Table 3: Monsanto Reclamation Seed Mix (from Golder - 2015)

Common Name	Scientific Name	Variety	Root Depth	Percent of Mix (% seeds/lb)
Grasses				
Mountain Bromegrass	*Bromus marginatus*	Bromar	10"-16"	7.47
Orchardgrass	*Dactylis glomerata*	Paiute	12"-16"	4.75
Great Basin Wildrye	*Leymus cinereus*	Magnar	18"-24"	8.67
Western Wheatgrass	*Pascopyrum smithii*	Rosanna	10"-14"	7.34
Timothy	*Phleum pratense*	Climax	8"-14"	3.61
Kentucky Bluegrass	*Poa pratensis*	Ginger	6"-8"	7.26
Big Bluegrass	*Poa secunda ssp ampla*	Sherman	8"-12"	4.90
Bluebunch Wheatgrass	*Pseudoroegneria spicata ssp spicata*	Goldar	12"-18"	7.78
Pubescent Wheatgrass	*Thinopyrum intermedium ssp barbulatum*	Greenleaf	10"-14"	6.67
Forbs				
Arrowleaf Balsomroot	*Balsamorhiza sagittata*		12"-16"	1.07
Blanket flower	*Gaillardia aristata*		6"-8"	3.67
Lewis Blue Flax	*Linum lewisii*	Appar	4"-6"	5.70
Alfalfa	*Medicago sativa*	Ladak	36"-72"	5.25
Sainfoin	*Onobrychis viciaefolia*	Eski	24"-60"	3.50
Rocky Mtn Penstemon	*Penstemon strictus*	Bandera	6"-8"	6.58
Small Burnet	*Sanguisorba minor*	Delar	6"-8"	5.50
Strawberry Clover	*Trifolium fragiferum*	Palestine	12"-16"	1.67
Mule's Ears	*Wyethia amplexicaulis*		18"-22"	1.17
Shrubs				
Antelope Bitterbrush	*Purshia tridentata*		18"-22"	2.00
Wax Currant	*Ribes cereum*		16"-24"	2.72
Other				
Quickguard	*Sterile Triticale Cover Crop*	CMS 154E	6"-8"	2.71

3 BENEFITS AND LIMITATIONS OF VARIOUS COVER DESIGNS

The primary performance criteria for the selected cover design at the Site will be to reduce surface water infiltration into regraded waste rock material. With this goal in mind, a more in-depth technical evaluation of the benefits and limitations of the two main cover systems is provided below (i.e., ET and GCLL) to determine the most suitable cover system that will provide the best long-term performance for the Site.

3.1 GCLL Covers

If installed properly, a cover design including a synthetic material may significantly reduce infiltration into underlying waste. A survey by Giroud and Bonaparte (1989) and U.S. EPA (2002) found that properly installed membrane liners had 1 hole of 2 mm diameter per acre. Nosko et al. (1996, 2000) and Rollin (1999) have shown that covered liners receive the most damage (greater than 70%) during placement of the cover soil. Additionally, freeze-thaw patterns, drying and wetting patterns, penetration of plant roots, seam separation, and burrowing animals can all potentially cause punctures of synthetic systems (Albright et al., 2010). Lastly, the relatively shallow depth of the GCLL would likely reduce the cover vegetation community to plants and shrubs with less extensive root systems. The field tests

from the previous sources indicate that while geosynthetic systems do reduce percolation and can function well, they are prone to various forms of damage that can significantly increase the hydraulic conductivity of the barrier system. With increases in hydraulic conductivity, the actual percolation rates through a GCLL cover system will likely be much higher over the long term due to the fact that the GCLL is the main barrier against percolation. It should be noted that the infiltration modeling performed by Golder assumed a completely intact GCLL, which explains the lower infiltration rates for this cover system as compared to an ET cover system.

3.2 ET Covers

The performance of an ET cover is highly dependent on executing a robust construction quality control and assurance procedures to ensure proper placement of the cover soil and then ongoing maintenance especially as the vegetative cover is being established in the first few years after installation. If designed, constructed, and maintained properly, ET covers provide a robust system as they do not rely on a single hydraulic barrier to prevent percolation. Other advantages of ET Covers include reduced complexity during construction, reduced construction costs, and having a potentially infinite life cycle because they are constructed of geologic materials. Although the vegetative community on an ET cover cannot completely represent the native plant community because deeply rooting plants would have to be eliminated (e.g., aspen or evergreen trees), the lack of physical obstruction from an impermeable layer at 3 feet below ground surface means a more diverse community can be developed on the cover. This increases the ability to more fully restore the ecosystem functions of the impacted land to a more natural state. Lastly, several ET cover designs modeled by Golder are estimated to perform better than the RCRA Subtitle C CCL rate of 1.24 in/year of infiltration.

4 RESULTS AND RECOMMENDATIONS

Golder's results showed that north-facing slopes and covers placed over chert waste rock base typically produced the most infiltration when compared to a shale base (Figure 7). As expected, model results varied significantly among the various cover systems with 100-year average annual net infiltration rates ranging from the low of <0.001 inches per year (in/yr) for a GCLL system to a high of 11.1 in/yr for exposed chert waste rock. ET covers had average infiltration rates ranging from 3.1 in/year to 0.78 in/year. Golder's analysis showed the GCLL, ET 1/5, ET 3/7, and ET 4/8 cover systems reduced infiltration below 1.24 in/year on average (Figure 7). Please note that Section 2 discusses the Golder naming convention for the cover system evaluation. For example, ET 3/7 is 5 feet of medium-textured alluvium over existing shale (ET 3) or chert (ET 7) waste rock. Refer to Section 2 for additional detail.

Although average annual conditions are important to the selection of cover designs, repeating wet years should also be evaluated for potential extreme infiltration loading conditions. For the wettest 5-year period of the 100-year record, only the GCLL reduced percolation rates to below 1.24 in/year on north-facing slopes (Table 4). However, the model results for south-, west-, and east-facing slopes showed consistent results of GCLL, ET1/5, ET 3/7, and ET 4/8 all reducing infiltration below 1.24 in/year (Golder, 2015). (Note that only shale waste rock was evaluated for east- and west-facing slopes; however, due to the similar performance of shale and chert waste rock from other analyses, these results should also apply for chert waste rock).

From these results, MWH proposes that ET cover system "ET 3/7" be used going forward in the FS evaluations. ET cover 3/7 consists of a 5-foot thick monolithic medium-textured alluvium overlying waste rock of either chert or shale. This cover produced the best modeled results for average infiltration rates and the medium-textured alluvial material is available near the Site in large enough quantities to supply the construction requirements of the cover system. Although the cover does not perform as well as the GCLL in modeling results, the cover materials are native and have a potentially infinite life cycle, whereas GCLL performance may falter over the longer term. The proposed system is estimated to produce annual average infiltration rates of 0.78 in/year or less (an approximately of 13 fold reduction in contaminant transport compared to the current conditions with exposed waste rock) and perform 1.5 times better than a typical RCRA Subtitle C CCL cover system.

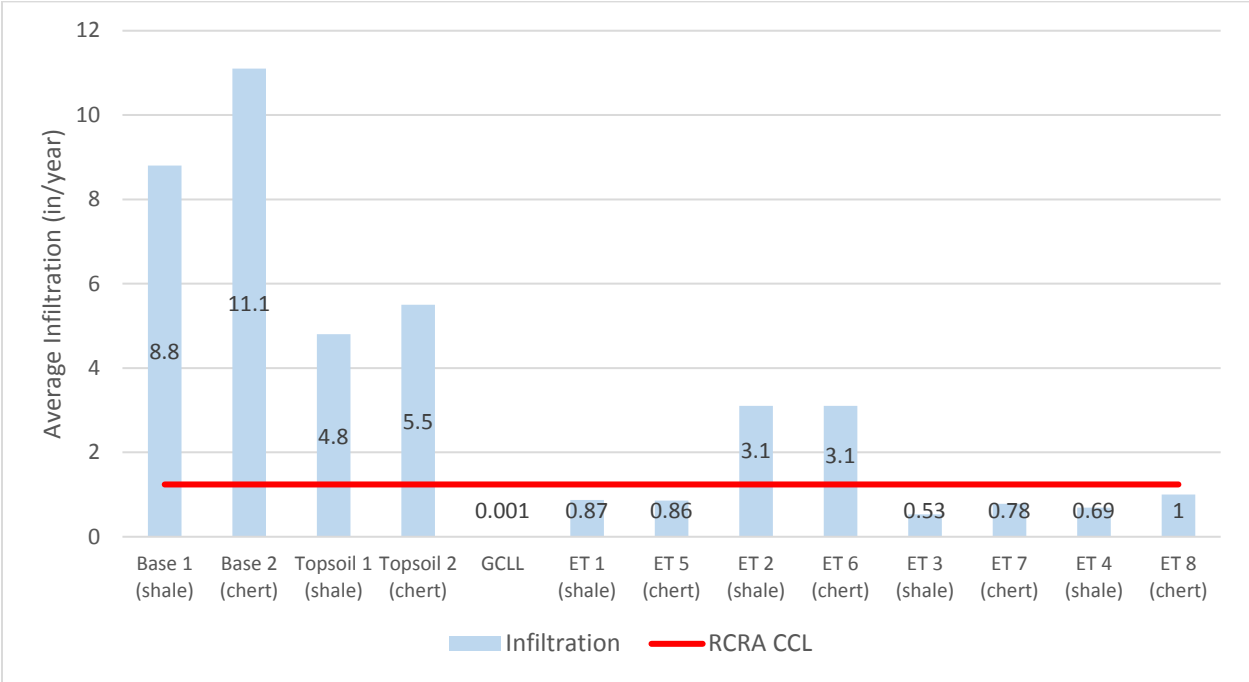


Figure 7: Average 100-Year Infiltration Rates for the Simulated Covers Shown in Figure 3

Table 4: Soil-Atmosphere Model Results – Predicted net Infiltration – Chert Waste Rock (Table 6 from Golder, 2015)

Simulation ID	100-Year Average		Average 5-Year Period		Wettest Year		Wettest 5-Year Period		Driest Year		Driest 5-Year Period	
	inches	%	inches	%	inches	%	inches	%	inches	%	inches	%
Base 2N	11.1	59	11.3	59	19.4	61	17.8	63	6.0	55	7.2	50
Base 2S	7.2	42	7.4	43	13.2	46	12.9	50	2.6	26	3.7	28
TS 2N	5.5	29	5.8	30	13.0	40	11.5	41	2.2	20	2.1	15
TS 2S	0.99	6	1.6	9	4.8	17	5.1	20	0.28	3	0.19	1
GCLL N	<0.001	<0.01	<0.001	<0.01	<0.001	<0.01	<0.001	<0.01	<0.001	<0.01	<0.001	<0.01
GCLL S	<0.001	<0.01	<0.001	<0.01	<0.001	<0.01	<0.001	<0.01	<0.001	<0.01	<0.001	<0.01
ET 5N	0.86	5	1.1	6	5.4	17	5.6	20	0.50	4	0.50	3
ET 5S	0.02	0.10	0.007	0.04	0.004	0.01	0.004	0.02	0.03	0.3	0.03	0.2
ET 6N	3.1	16	3.6	19	10.3	32	9.1	32	0.54	5	0.55	4
ET 6S	0.24	1	0.15	0.9	1.7	6	2.5	10	0.09	0.9	0.08	0.6
ET 7N	0.78	4	0.98	5	5.4	17	5.4	17	0.39	4	0.35	2
ET 7S	0.01	0.07	0.005	0.03	0.003	0.003	0.003	0.01	0.03	0.3	0.02	0.2
ET 8N	1.0	5	1.3	7	6.1	19	5.9	21	0.40	4	0.41	3
ET 8S	0.03	0.1	0.005	0.03	0.36	1	0.14	0.5	0.03	0.3	0.03	0.2

Notes:
N denotes the North facing slope climate simulation and S denotes the South facing slope climate simulations.
Values shown for the 5-year periods are the 5-year average
% net infiltration is based on the period average annual precipitation
GCLL model results are from the HELP model. All other simulation results are from HYDRUS.

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Attachment 1
Golder Cover Design Evaluation

REPORT

BALLARD MINE

Reclamation Cover Design Evaluation

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1.0 INTRODUCTION

Monsanto Company's (Monsanto) Ballard Mine is a former phosphate mine located in Caribou County, Idaho approximately 13.5 miles northeast of Soda Springs, Idaho. Monsanto's wholly owned subsidiary, P4 Production LLC, owns the Ballard Mine. Ballard Mine was in operation from 1951 to 1969. Monsanto conducted some reclamation activities in the late 1960s and early 1970s using introduced grasses. The site consists of multiple pits and waste rock dumps with slopes at angle of repose. In addition to the reclaimed areas, some areas of the mine have volunteer vegetation. Monsanto is responsible for reclamation and closure of the Ballard Mine under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) program administered by the US Environmental Protection Agency (EPA) with coordination from the Idaho Department of Environmental Quality, the Idaho Department of Lands, the Bureau of Indian Affairs, the Shoban Tribe, and the US Fish and Wildlife Service. Monsanto is preparing a Feasibility Study (FS) as part of the CERCLA process. In order to support the FS, Monsanto requires an understanding of cover performance and wishes to evaluate multiple cover scenarios for reclamation at the Ballard Mine.

There are no formal cover performance criteria for cover designs under CERCLA. The constituent of concern for the phosphate district is primarily selenium. Monsanto is committed to assessing impacts to surface water and groundwater quality. Consequently, the purpose of this study was to predict net infiltration for a variety of covers to support the alternatives analysis for the FS.

Monsanto expects to complete the FS in July 2015. The schedule does not allow for data collection and analysis of site specific materials for this project. Therefore, Golder Associates Inc. (Golder) completed a comparative study of alternative cover design systems using materials characterization data from the Blackfoot Bridge Mine or analog materials, where applicable.

1.1 Objectives

The goal of this study is to evaluate the efficacy of the alternative cover designs to limit net infiltration into the mine waste materials. The net infiltration for each cover system was estimated to evaluate the relative effectiveness of each cover system to limit drainage. The assumption for this approach is that reduced net infiltration will be associated with greater protection of groundwater and surface water quality. Final reclamation designs of the mine will influence surface water drainage (i.e., regraded slope profiles, lengths, and conveyance channels) and affect any estimated erosion and runoff rates. Therefore, refined predictions of net infiltration through the covers may be required once Monsanto and the stakeholders approve the final reclamation designs for the Ballard Mine.

A numerical one dimensional soil-atmosphere model was used to predict net infiltration through the various cover designs. This type of modeling is appropriate to evaluate cover performance for alternative

cover designs. In addition, a semi-analytical, quasi two dimensional model was used to estimate net infiltration for a cover system with hydraulic barrier.

The current objectives of the cover system are:

- To establish a vegetation community appropriate for the climate, environment, and post mining land use (grazing) through revegetation of native plant species,
- To minimize erosion, and
- To protect groundwater and surface water quality through the reduction of net infiltration.

Thus, the key design criteria related to the cover system are its ability to store and release water, support vegetation, and resist wind and water erosion to the extent practicable. Golder believes that the appropriate cover design system needs to balance these objectives.

1.2 Scope of Work

Golder performed this work in accordance with the scope of work outlined in our proposal submitted to Monsanto on March 20, 2015 and accepted on April 3, 2015. Additional modifications to the scope of work were included in the analysis at the request of Monsanto.

2.0 COVER DESIGN ALTERNATIVES

Monsanto is evaluating the following cover scenarios as part of the FS (MWH 2015):

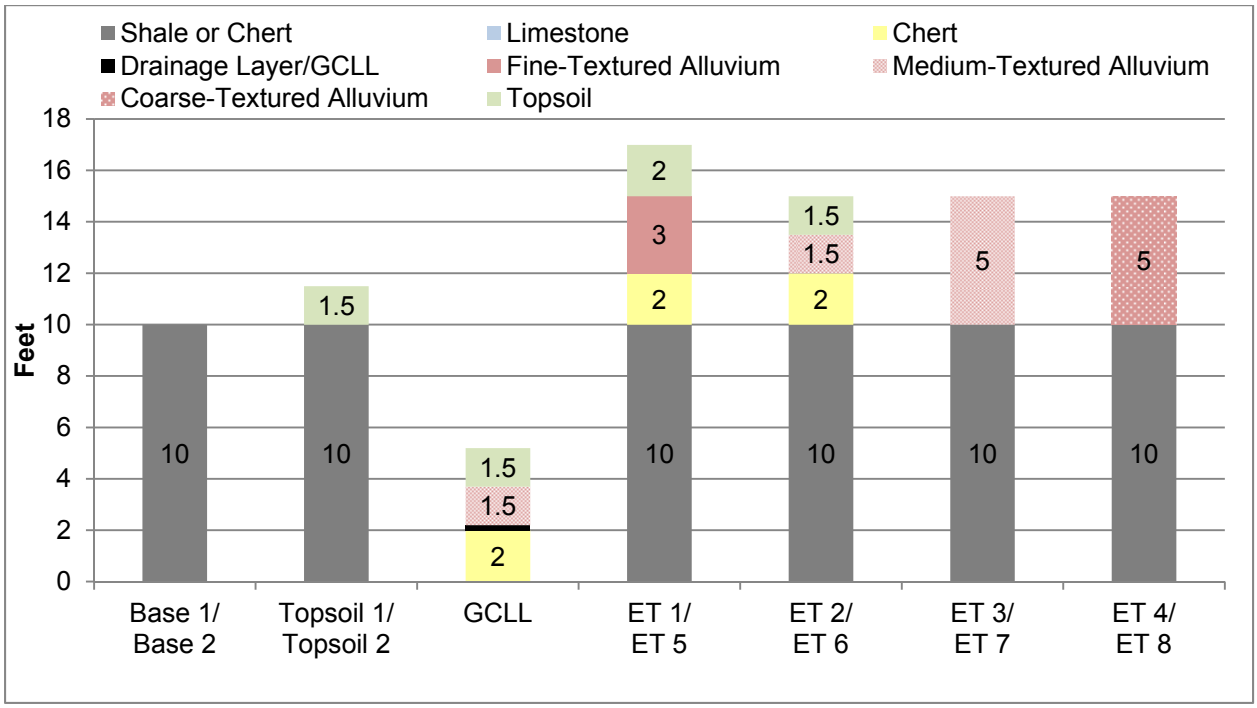
- Baseline scenario (no cover, No Action Alternative)
- 18-inch soil cover (Alternative 2)
- Multi-layered cover system with hydraulic barrier (GCLL, Alternative 3a and 4a)
- Evapotranspirative (ET) Cover (Alternative 3b and 4b)

In addition to the alternatives evaluated in the FS, the following additional cover scenarios were also evaluated:

- Modification to the FS ET Cover (thinner soil layers)
- 5-foot Monolithic ET Cover (two sensitivities)

Figure 1 illustrates the model configuration used in the soil-atmosphere model for each cover design.

Figure 1: Simulated Cover Designs



Because the site-wide composition of the waste materials (chert and shale) at Ballard is unknown, simulations included each cover design over the shale and chert independently. Each simulation used 10 feet of waste rock (either chert or shale). Monsanto assumes a homogenous mixture of shale and chert of varying particle size distributions will compose the waste material to be covered, but there are no physical data available for such a mixture.

Site-specific data for the reclamation and waste materials are limited. The FS identifies material types, but does not identify sources for the reclamation materials. Thus, Golder compiled the available data (provided by Monsanto) and developed the best fit model scenarios using the available data. The primary sources of material data are the O'Kane Consultants Inc. (O'Kane) modeling report for Blackfoot Bridge Mine (O'Kane 2009a) and the MWH Americas, Inc. (MWH) borrow materials characterization for Ballard Mine (MWH 2014). The borrow materials characterization is site specific, but there are no characterization studies for the waste materials at the Ballard Mine. O'Kane characterized the topsoil, limestone, chert, and shale from Monsanto's Enoch Valley Backfilled Panel about 7 miles northwest of the Ballard Mine. O'Kane's work was part of the Blackfoot Bridge project's Final Environmental Impact Statement ([FEIS] BLM, 2011). Section 3 includes a detailed discussion of the material properties.

The following sections describe the model simulations for each cover design.

2.1 Baseline – No Cover

The baseline scenarios consist of 10 feet of waste rock. Base 1 simulates the center waste shale (CWS) as the waste and Base 2 simulates the chert as the waste rock. Base 1 and Base 2 simulate the No Action Alternative in the FS.

2.2 Topsoil Cover

The topsoil cover design is a revegetation cover system designed to establish vegetation. The topsoil cover design presented in the FS consists of 12- to 18-inch topsoil over the waste rock. An 18-inch cover over 10 feet of waste rock was simulated given the constructability of an 18-inch cover is more practical than a 12-inch cover. Topsoil 1 simulates the center waste shale as the waste rock and Topsoil 2 simulates the chert as the waste rock.

2.3 Multi-layered Cover System with Hydraulic Barrier – GCLL

The function of the multi-layered cover system with hydraulic barrier or GCLL cover system is to significantly reduce net infiltration into the underlying waste rock. The hydraulic barrier is a low hydraulic conductivity layer that impedes downward flux of water. Based on the FS, the proposed hydraulic barrier is a geosynthetic clay laminate liner (GCLL) which consists of geosynthetic clay made of a powdered sodium bentonite clay layer sandwiched between two geotextile layers. The top geotextile layer for the GCLL is laminated to a polyethylene geomembrane layer for added protection. To reduce significant perching above the hydraulic barrier, the FS proposes to install a drainage layer immediately above the GCLL to drain excess soil water that might otherwise lead to instability of the overlying materials during periods of high snow melt or elevated runoff.

The entire cover system is about 5 feet thick (Figure 1); however, only 3 feet of material is above the GCLL: 18 inches of topsoil and 18 inches of alluvium. The drainage layer is immediately above the GCLL

at an assumed thickness of 3 inches. The model was terminated at the GCLL because upward flux of water that has infiltrated past the GCLL is highly unlikely. The GCLL interrupts the mechanisms that would move water upward in the profile (capillary rise and transpiration). Any water moving past the GCLL is therefore net infiltration. Consequently, there was not a need to simulate the model with the underlying materials. The GCLL simulation represents both scenarios of waste rock.

GCLL cover system model geometry (from surface to base) is as follows:

- 18 inches of topsoil;
- 18 inches of alluvium;
- 3 inches of drainage material; and
- GCLL

The medium textured alluvium was used for this model scenario.

2.4 Evapotranspirative Covers

ET covers are store-and-release systems intended to store precipitation during wet periods and release the moisture back to the atmosphere via evapotranspiration during dry periods. The net effect is a significant reduction of net infiltration into the deeper waste rock profile.

2.4.1 Feasibility Study ET Cover

The ET cover design presented in the FS includes the following sequence (from surface to base):

- 24 inches of topsoil;
- 36 inches of fine-textured soil; and
- 24 inches of coarse-textured soil

The ET cover was simulated over 10 feet of shale (ET 1) and 10 feet of chert (ET 5) in which the finest and coarsest textured alluvium samples available from the Ballard borrow materials characterization report were selected for the fine- and coarse-textured soils. The function of the fine-textured soil is to store water while the underlying coarse-textured material provides a hydraulic discontinuity to reduce net infiltration into the waste rock.

Additionally, a modification to the ET cover proposed in the FS was evaluated. The modified ET cover sequence is as follows:

- 18 inches of topsoil;
- 18 inches of fine-textured soil; and
- 24 inches of coarse-textured soil

The modified ET cover was simulated over 10 feet of shale (ET 2) and 10 feet of chert (ET 6).

2.4.2 Monolithic ET Covers

In addition to the layered ET covers, two monolithic ET covers were simulated using a medium- and coarse-textured alluvium. A monolithic cover is generally easier and less expensive to construct than a multi-layered system. The function of a monolithic cover is the same as a multi-layered ET cover; to store water during the wet periods and release water during the dry periods.

Golder simulated 5 feet of medium-textured alluvium over 10 feet of shale (ET 3) and 10 feet of chert (ET 7) and 5 feet of coarse-textured alluvium over 10 feet of shale (ET 4) and 10 feet of chert (ET 8).

3.0 MODEL INPUTS

Golder constructed a long-term soil-atmosphere model (e.g., 100-year modeling period) for the proposed feasibility level cover designs using the unsaturated flow model HYDRUS-1D (Simunek et al., 2008). The HYDRUS-1D software solves a modified Richard's equation for liquid flow and a one-dimensional advection-dispersion equation for heat and solute transport. The model solves the governing equations numerically using Galerkin-type linear finite element schemes.

One of the proposed cover designs is a multi-layer cover system with hydraulic barrier consisting of a geosynthetic clay laminate liner (GCLL). A 1D model would not simulate natural lateral flow (drainage) away from the GCLL due to natural topography and gravity. Hence, a 1D model would over-estimate predicted net infiltration. Golder used the Hydrologic Evaluation of Landfill Performance (HELP) quasi-two-dimensional model to predict net infiltration through the mulit-layer cover system with hydraulic barrier. HELP can simulate various combinations of vegetation, cover soils, waste cells, lateral drain layers, low hydraulic conductivity barrier soils, and synthetic geomembrane liners. The model uses solution techniques that can account for the effects of lateral subsurface drainage and leakage through a synthetic geomembrane or composite liners. HELP computes leakage through the geomembranes by a series of equations based on the compilations of Giroud and Bonaparte (1989) as a result of vapor diffusion, manufacturing flaws (pinholes) and installation defects (punctures, cracks, tears and bad seams). The simulations were constructed in HELP on a per unit area (1-acre) basis.

For the purposes of this study, net infiltration is the portion of precipitation that infiltrates into the cover and waste material and is not subsequently lost to evaporation or transpiration. Infiltration is water that may enter the groundwater and surface water systems.

The lower boundary for both models was specified as a unit gradient (i.e., free-draining) boundary. The unit gradient boundary condition is often the most appropriate to use when there is a thick unsaturated zone between the base of the cover and the underlying water table (McCord 1991). Assuming a unit gradient as the lower boundary condition, any moisture that propagates to the base of the model domain will drain freely out of the system.

The long-term models are in water years, October 1 to September 30 of the subsequent year. This applies all the precipitation occurring during the winter months to the spring melt of the same year and is consistent with modeling efforts performed for the Blackfoot Bridge Mine (O'Kane 2009a and 2009b).

3.1 HYDRUS-1D

HYDRUS-1D is a one-dimensional soil water and heat flux model that simulates the dynamic processes of infiltration, drainage (or net infiltration), redistribution, evaporation, transpiration, and runoff. HYDRUS uses soil, meteorological, and vegetation input data to simulate fluxes of moisture and energy. The

required soil material properties include saturated hydraulic conductivity and soil water characteristic functions. Required daily weather inputs include precipitation and potential evapotranspiration (PET). Vegetation inputs required include average percent ground coverage, critical suction limits, root distribution with depth, total root depth, and leaf area index (LAI) distribution for the reclamation plant community.

3.2 HELP

The HELP model is a quasi-two dimensional hydrologic model of water movement across, into, through, and out of landfills. The US Army Corps of Engineers developed the model for landfills, although the model is effective at evaluating performance for other facilities using a drainage layer and synthetic geomembrane liners with vegetated cover soils. The HELP model requires the following three types of input data:

- Climate data – precipitation, temperature, parameters related to evapotranspiration, and solar radiation;
- Surface condition – vegetation type and density, slope, and Natural Resource Conservation Service runoff curve number; and
- Soil layer data – material texture, thickness, porosity, field capacity, wilting point, initial soil water content, and saturated hydraulic conductivity.

3.3 Material Properties

The required material physical properties for the soil-atmosphere model include the soil water characteristic curve (SWCC) and the saturated hydraulic conductivity. The SWCC describes the functional relationship between soil water content and matric potential under equilibrium conditions. The SWCC is the primary hydraulic property used to predict water behavior in unsaturated media. Paired measurements of matric potential and soil water content are fit to the van Genuchten (van Genuchten 1980) parametric retention model to generate the SWCC.

Material properties were obtained from O'Kane (2009a) and MWH (2014). O'Kane collected samples from open pits excavated in the reclaimed Enoch Valley Panel Backfill for laboratory hydraulic analysis. These material properties were used assuming the materials sampled at the Enoch Valley mine are similar (e.g., same lithology) to those found at the Ballard Mine. MWH sampled and analyzed alluvium samples from seven boreholes located at three potential borrow areas at the Ballard Mine. Three of the alluvium samples were selected for use in the soil-atmosphere models. The alluvium has a limited range of material properties; the three materials selected were the coarsest, finest and middle range textured materials.

O'Kane provided the laboratory data for one sample of each material (topsoil, limestone, chert, and shale). O'Kane's laboratory data included: soil water retention data (paired measurements of suction and

water content), particle size distribution, and saturated hydraulic conductivity. The paired retention data were fit to the van Genuchten parametric retention model to generate the SWCCs. MWH laboratory data also included paired retention data, particle size distribution, and saturated hydraulic conductivity.

Table 1 lists the material properties used in the soil-atmosphere model and the sample source.

Table 1: Material Properties used in the Soil-Atmosphere Model

Sample ID	Source	Material	van Genuchten Parameters				K_{sat} cm/s
			θ_r cm^3/cm^3	θ_s cm^3/cm^3	α cm^{-1}	n	
BSA-1 (0-25ft)	MWH 2014	Medium-Textured Alluvium	0.030	0.331	0.0012	1.260	3.0E-04
BSA-2 (0-25ft)		Coarse-Textured Alluvium	0.020	0.244	0.0004	1.350	5.2E-04
BSA-1 (25-39ft)		Fine-Textured Alluvium	0.030	0.401	0.0007	1.330	1.5E-04
Topsoil	O'Kane 2009a	Topsoil	0.020	0.285	0.0012	1.345	1.0E-04
Limestone		Limestone	0.010	0.287	0.0108	1.330	1.3E-03
TRInCHT		Chert	0.001	0.200	0.3923	1.120	3.4E-03
CWS		Shale	0.010	0.381	0.1079	1.210	5.6E-04
N/A	Roesler et al 2002	Gravel	0.050	0.410	0.2463	3.000	7.1E-01

Notes: Gravel is an analog for the drainage layer in the GCLL cover system
θ_r = residual water content; θ_s = saturated water content; α = fitted parameter related to air entry pressure;
n = pore-distribution parameter; Ksat = saturated hydraulic conductivity; N/A = not applicable

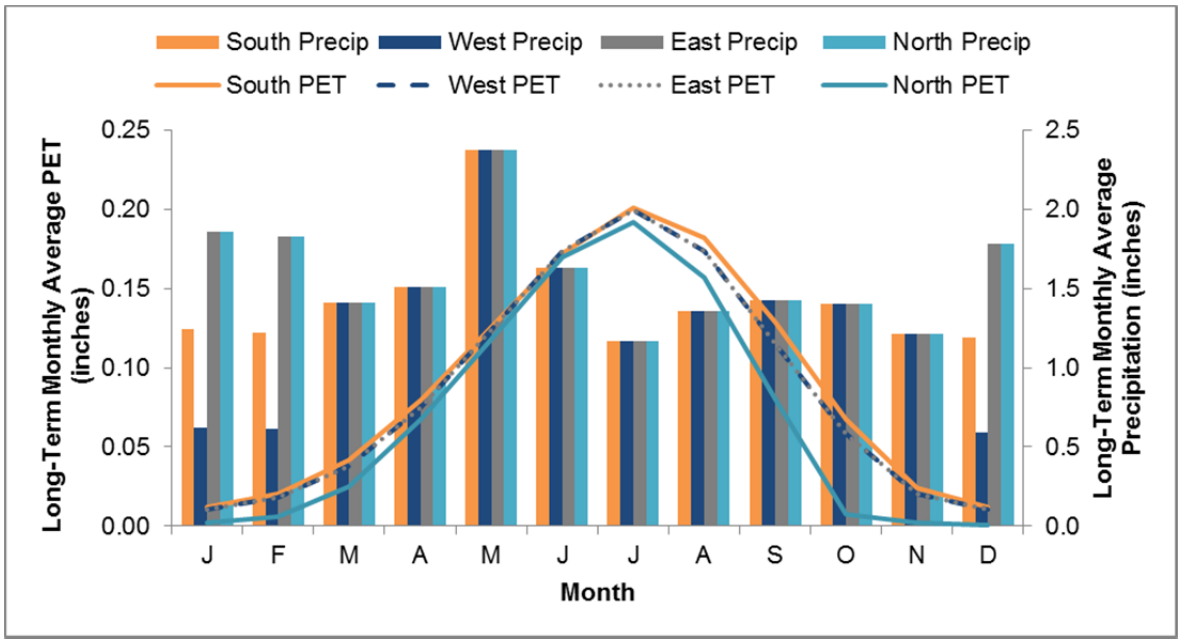
The HELP model requires slightly different input parameters. The inputs for HELP include porosity, field capacity, wilting point, and saturated hydraulic conductivity. Porosity was assumed equal to the saturated water content. Field capacity is the water content at which internal drainage (after redistribution) becomes essentially negligible. However, contemporary soil physicists recognize the field capacity concept as somewhat arbitrary since it lacks a universal physical basis (Hillel 2004). The redistribution and drainage process is continuous and highly dependent on depth of wetting and the antecedent water content, plus the presence of impeding layers and/or a water table would affect the rate and extent of redistribution. Similarly, the wilting point pressure is defined simply as the water content at which plants can no longer extract water where wilting varies by plant species. Wilting point is more dependent on the soils ability to transmit water rather than the plant's ability to withstand drought. Nonetheless, these upper and the lower retention limits are commonly defined at static pressures (1/10 or 1/3 bar for field capacity and 15 bar for wilting point) regardless of the dynamic nature of soil moisture. The SWCC curves from Table 1 were used to determine the field capacity (1/10 bar) and wilting point (15 bar) water contents for the topsoil and medium-textured alluvium.

3.4 Climate

O'Kane developed a 100-year climate data set for the Blackfoot Bridge water balance modeling (O'Kane 2009a). The Blackfoot Bridge site is at a similar elevation and location to Ballard; therefore, the O'Kane climate dataset is appropriate for Ballard. Although the Blackfoot Bridge site has an on-site weather station, the period of record is short. Thus, O'Kane used the Soda Springs (Utah Climate Center), Grace, Idaho (National Climate Data Center), and Pocatello, Idaho (National Climate Center) stations to generate a 100-year climate data set. They compared the measured Blackfoot Bridge climate data (short period of record) to the Soda Springs station to correlate climate patterns and developed an offset for temperature and precipitation. The Soda Springs station only has a period of record of 28 years (1979 to 2008); consequently O'Kane adapted the Grace station (100-year record) to configure with the adjusted Soda Springs data. Neither the Soda Springs nor the Grace station have long-term precipitation frequency and duration data so O'Kane used data obtained from Pocatello, Idaho (National Climate Data Center) to estimate time and duration of precipitation events in the climate database. The average annual maximum temperature is 52.2°F and the average annual minimum temperature is 32.8°F. The highest monthly precipitation occurs in May.

O'Kane developed a 100-year climate dataset for four slope aspects: North, South, East, and West. The electronic datasets include: daily precipitation, daily minimum and maximum temperature, daily minimum and maximum relative humidity, average wind speed, and average daily net radiation. HYDRUS requires daily PET which was calculated using the Food and Agriculture Organization (FAO) Penman-Monteith method, which is a modification of the Penman-Monteith method developed by the FAO of the United Nations (Allen et al., 2000). The north and south climate represent the two end members of the climate scenarios for sensitivity analysis. However, areas to be covered at the Ballard Mine will have predominantly east and west facing slopes. Thus, additional model scenarios simulating east and west facing slopes were evaluated for comparison.

Figure 2: Long-Term Climate Aspect Comparison of Precipitation and PET



The climate data were preprocessed to account for snow processes and frozen soil conditions. Kustas et al. (1994) provide an equation for snowmelt:

$$M = a_r \times T_d \pm m_Q \times R_n$$

Where M is snowmelt in cm/day; a_r is the restricted degree-day factor in cm/°C; T_d is the difference between the average daily air temperature and the temperature of the snowpack, assumed to be 0°C; m_Q is the conversion factor for energy flux density to snowmelt depth in (cm/day)*(m^2/W) and is approximately 0.026; and R_n is net radiation in W/m^2. For this study, recorded precipitation was assumed to fall as snow if the daily temperature was below 36°F. As described by Martinec (1989), the factor a_r varies from 0.20 to 0.25 and depends on average daily wind speed and average daily relative humidity, with smaller values of a_r corresponding to lower wind speeds and lower relative humidity. The deficit between the amount of snowfall and potential snowmelt is the snowpack. Precipitation used in the long-term soil-atmosphere model is the combined rainfall and snowmelt on a daily basis. Table 2 presents the precipitation summary for the 100-year climate period. Precipitation for the north and east facing slopes have the same distribution.

Table 2: Precipitation Summary of the 100-year Climate Period

Climate Period	Climate for North/East Facing Slopes		Climate for South Facing Slopes		Climate for West Facing Slopes	
	Annual Precipitation (inches)	Average Annual (inches)	Annual Precipitation (inches)	Average Annual (inches)	Annual Precipitation (inches)	Average Annual (inches)
Average Annual	19	-	17.1	-	15.3	-
Average 5-Years	25.1	19.1	22.5	17	12.0	15.4
	18.4		16.4		17.1	
	20		17.6		14.0	
	15.3		13.2		12.8	
	16.7		15.4		20.9	
Wettest Year	32	-	28.7	-	25.9	-
Wettest 5-Years	31.3	28.2	27.9	25.7	24.4	23.3
	28.6		27.2		25.9	
	31.3		28.2		25.1	
	17.8		16.7		15.6	
	32		28.7		25.4	
Driest Year	11.1	-	10.1	-	9.0	-
Driest 5-Years	14.5	14.5	12.6	13.2	11.4	11.6
	11.1		10.1		9.0	
	16.4		15.3		12.1	
	11.9		11.2		13.6	
	18.6		16.8		12.0	

Notes: Source: (O'Kane 2009a). All data reported in water years (October 1 to September 30)

3.5 Vegetation

The undisturbed areas around the Ballard Mine area include non-forested and forested uplands (personal communication M. Vice 2015). The plant communities in the non-forested uplands include Mountain Big sagebrush (*Artemesia tridentata ssp vaseyana*), Antelope bitterbrush (*Purshia tridentata*), and snowberry (*Symphoricarpos albus*). The forested upland plant communities include quaking aspen (*Populus tremuloides*), Lodgepole pine (*Pinus contorta*), and Douglas fir (*Pseudotsuga menziesii*). The reclamation goals are to establish vegetation; however, the resulting species composition and community structure are different than pre-disturbance conditions. The edaphic conditions and the species established at the

time of reclamation can have lasting effects on successional trajectories and ecosystem function of the reclaimed landscape (MacMahon 1987, Chambers et al. 1992). Thus, it is imperative that reclamation planning incorporate to the extent practical, the native plant community. Since reclamation success is typically determined by comparing the reclamation area to an undisturbed native reference area.

Monsanto provided a typical reclamation seed mix for their mines located within the phosphate district (Table 3). One species not included in the seed mix, but prevalent in the Ballard Mine area is Mountain Big sagebrush. Mountain Big sagebrush is a deep rooted perennial shrub that contributes to the redistribution of soil water from deep within the soil profile (Ryel et al. 2002). The vegetation inputs are based on the seed mix and the Mountain Big sagebrush vegetation community. Monsanto requested a sensitivity analysis for a grass dominated and shallower root distribution reclamation vegetation community. The alternative reclamation seed mix was provided by Monsanto (Table 4). With the exception of Great Basin Wildrye (*Leymus cinereus*), Northern sweetvetch (*Hedysarum boreale),* and Scarlet Globemallow (*Sphaeralcea coccinea*), the alternative seed mix is comprised of shallow rooted species (<18 inches).

Table 3: Typical Reclamation Seed Mix

Common Name	Scientific Name	Variety	Root Depth	Percent of Mix (% seeds/lb)
Grasses				
Mountain Bromegrass	*Bromus marginatus*	Bromar	10"-16"	7.47
Orchardgrass	*Dactylis glomerata*	Paiute	12"-16"	4.75
Great Basin Wildrye	*Leymus cinereus*	Magnar	18"-24"	8.67
Western Wheatgrass	*Pascopyrum smithii*	Rosanna	10"-14"	7.34
Timothy	*Phleum pratense*	Climax	8"-14"	3.61
Kentucky Bluegrass	*Poa pratensis*	Ginger	6"-8"	7.26
Big Bluegrass	*Poa secunda ssp ampla*	Sherman	8"-12"	4.90
Bluebunch Wheatgrass	*Pseudoroegneria spicata ssp spicata*	Goldar	12"-18"	7.78
Pubescent Wheatgrass	*Thinopyrum intermedium ssp barbulatum*	Greenleaf	10"-14"	6.67
Forbs				
Arrowleaf Balsomroot	*Balsamorhiza sagittata*		12"-16"	1.07
Blanket flower	*Gaillardia aristata*		6"-8"	3.67
Lewis Blue Flax	*Linum lewisii*	Appar	4"-6"	5.70
Alfalfa	*Medicago sativa*	Ladak	36"-72"	5.25
Sainfoin	*Onobrychis viciaefolia*	Eski	24"-60"	3.50
Rocky Mtn Penstemon	*Penstemon strictus*	Bandera	6"-8"	6.58
Small Burnet	*Sanguisorba minor*	Delar	6"-8"	5.50
Strawberry Clover	*Trifolium fragiferum*	Palestine	12"-16"	1.67
Mule's Ears	*Wyethia amplexicaulis*		18"-22"	1.17
Shrubs				
Antelope Bitterbrush	*Purshia tridentata*		18"-22"	2.00
Wax Currant	*Ribes cereum*		16"-24"	2.72
Other				
Quickguard	*Sterile Triticale Cover Crop*	CMS 154E	6"-8"	2.71

Inputs for the soil-atmosphere model to simulate vegetation include: critical suction limits, root distribution with depth, total root depth, vegetative cover percentage, and LAI, which is the ratio of leaf area to ground area. The Mountain Big sagebrush root density function and critical suction limits (Ryel et al 2002), LAI, and canopy cover (Clark and Seyfried 2001) were used for model inputs for the typical reclamation scenario. The root distribution for the alternative reclamation seed mix was modified for a grass dominated community and truncated to 18 inches. The LAI was also modified for a grass dominated reclamation plant community.

Table 4: Alternative Reclamation Seed Mix

Common Name	Scientific Name	Variety	Root Depth	Percent of Mix (% seeds/lb)
Grasses				
Mountain Bromegrass	*Bromus marginatus*	Garnet	10"-16"	9.66
Orchardgrass	*Dactylis glomerata*	Paiute	12"-16"	6.27
Thickspike Wheatgrass	*Elymus lanceolatus ssp lanceolatus*	Bannock	4"-12"	7.75
Idaho Fescue	*Festuca idahoensis*	Winchester	12"-16"	7.55
Sheep Fescue	*Festuca ovina*	Covar	12"-16"	7.13
Great Basin Wildrye	*Leymus cinereus*	Magnar	30"-63"	7.63
Western Wheatgrass	*Pascopyrum smithii*	Rosanna	10"-14"	5.17
Kentucky Bluegrass	*Poa pratensis*	Ginger	6"-8"	6.39
Big Bluegrass	*Poa secunda ssp ampla*	Sherman	8"-12"	7.40
Bluebunch Wheatgrass	*Pseudoroegneria spicata ssp spicata*	Goldar	12"-18"	8.81
Pubescent Wheatgrass	*Thinopyrum intermedium ssp barbulatum*	Greenleaf	10"-14"	6.71
Forbs				
Western Yarrow	*Achillea millefolium var. occidentalis*	VNS*	5"-8"	1.16
Blanket Flower	*Gaillardia aristata*	VNS*	6"-8"	1.38
Northern Sweetvetch	*Hedysarum boreale*	Timp	16"-79"	2.72
Lewis Blue Flax	*Linum lewisii*	Appar	4"-6"	2.46
Fernleaf Biscuitroot	*Lomatium dissectum*	VNS*	12"	1.70
Rocky Mtn Penstemon	*Penstemon strictus*	Bandera	6"-8"	3.48
Scarlet Globemallow	*Sphaeralcea coccinea*	VNS*	6"-36"	2.10
Small Burnet	*Sanguisorba minor*	Delar	6"-8"	2.26
Other				
Quickguard	*Triticum aestivum x Secale cereale*		6"-8"	2.99

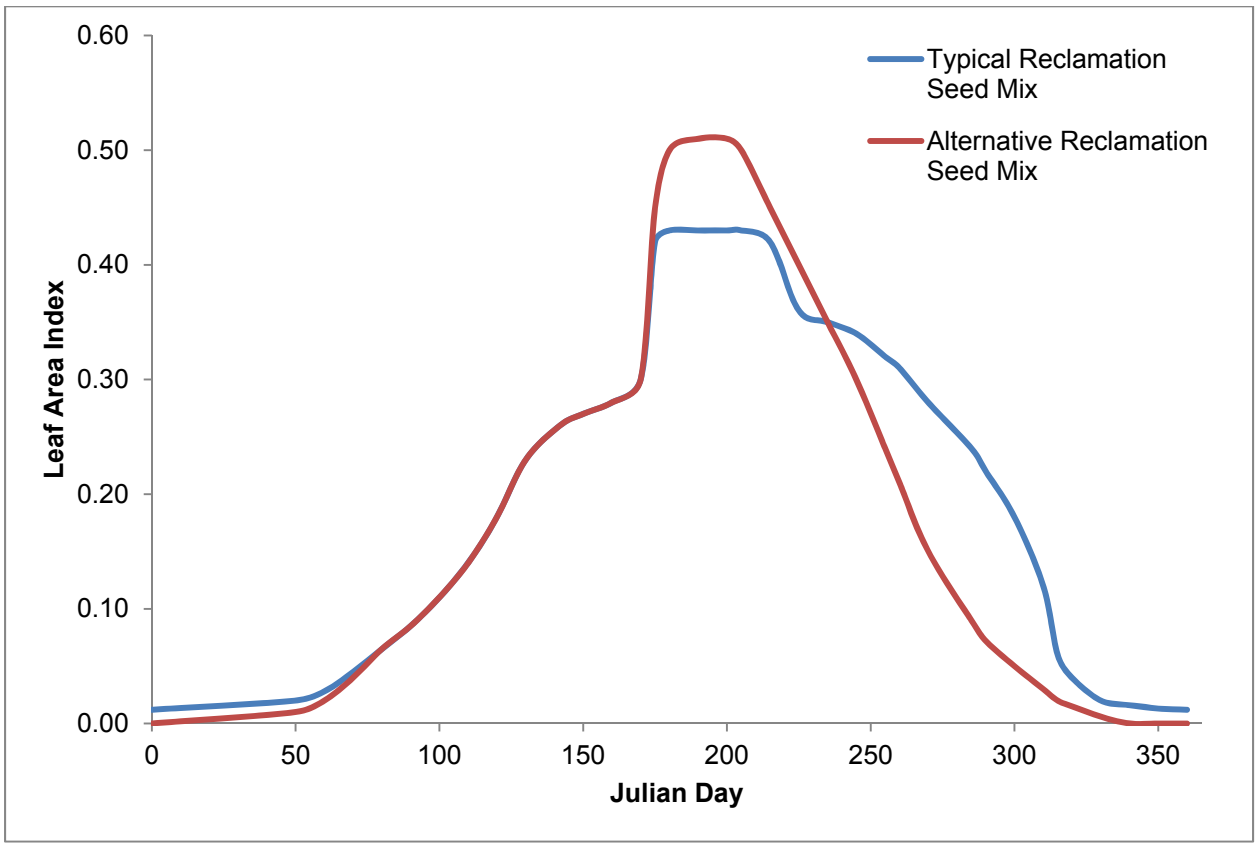
While plants are actively growing, transpiration is the dominant mode of water loss from the soil profile, even with sparse vegetation (Hillel, 2004). The root density function allocates water removal from the model domain. The maximum rooting depth for the typical reclamation was set at 160 cm (63 inches; Ryel et al. 2002) and with a cumulative distribution having 50% of the roots above 50 cm (19.7 inches). The rooting depth for the alternative reclamation was set at 45 cm (18 inches) and with a cumulative distribution having 50% of the roots above 10 cm (4 inches).

The critical suction head limits include wilting point, initial transpiration, decreased transpiration, and transpiration rate. Wilting point is typically about 15 bars for crop plants; 25 to 30 for prairie grasses; and may exceed 60 bars for some desert shrubs. The critical suction head limits selected for the model

included 30,000 cm (30 bars) for wilting point and 10 cm (0.01 bars) as the point where transpiration starts. The decreased transpiration was set at 500 cm and 1,000 cm for the upper and lower transpiration rates 0.10 to 0.96 cm/day (Ryel et al. 2002).

The LAI distribution describes the ratio of leaf surface area to the soil surface area. Figure 3 shows the annual distribution of LAI used in the soil-atmosphere model. The range in total LAI for Mountain Big sagebrush according to Clark and Seyfried (2002) is 0.43 to 1.10. These ranges are for established native Mountain Big sagebrush communities, thus the low value, 0.43, was chosen as the peak LAI since the reclamation community establishment will lag behind the native vegetation communities and is conservative. The annual LAI distribution selected for Ballard assumes an LAI distribution that ranges from nearly 0 in the winter to 0.43 during the peak growing season. The LAI increases rapidly in May when the average prevailing air temperatures climb over 40°F (biological zero) and decreases abruptly in late September when the average daily air temperatures fall below 40°F. Cool season grasses are effective in the spring and fall, whereas shrubs above the snow line are effective in the winter. Maximum LAI for the alternative reclamation of a grass dominated community was increased to 0.50 and winter values were reduced to zero.

Figure 3: Annual Leaf Area Distribution for Ballard Mine



After defining the yearly distribution of LAI, potential transpiration was calculated using potential evapotranspiration and the Ritchie equation (Ritchie and Burnett 1971).

3.6 Initial Conditions

Water flow in unsaturated conditions is dependent on the antecedent water content of the soil, as unsaturated hydraulic conductivity is a non-linear function of soil moisture (typically expressed in terms of the volumetric water content or suction). As a soil dries, the unsaturated hydraulic conductivity decreases. The extent and rate at which the unsaturated hydraulic conductivity decreases depends on the soil type, stratification, and initial conditions. Initial pressure heads were set to 100 cm, representing the relatively wet conditions expected immediately following mine operations. Additionally, a 20-year equilibrium period was used prior to the 100-year model period to allow the soil profile to equilibrate to the applied climate.

4.0 MODEL RESULTS

Table 5 and 6 summarize the results of the model simulations in terms of water years. Table 5 summarizes the simulations using the shale waste rock and Table 6 summarizes the chert waste rock scenarios. The east and west facing slopes climate simulations with the shale waste rock are summarized in Table 7. The alternative reclamation vegetation for a grass dominated community with a shallow root distribution simulations are summarized in Table 8. The long-term average annual predicted net infiltration is shown in Figures 4, 5, 6, and 7.

4.1 Baseline

Results of the baseline simulations indicate that without cover, the waste rock piles comprised of shale have less predicted net infiltration than waste rock piles comprised of chert (Tables 5 and 6). The 100-year average annual predicted net infiltration for the shale is 4.2 (Base 1S) to 8.8 inches (Base 1N) or 25 to 46 percent of annual average precipitation. The long-term average annual predicted net infiltration for the chert is 7.2 inches (Base 2S) to 11.1 inches (Base 2N), or 42 to 59 percent of annual average precipitation. Both the shale and chert waste rock model scenarios show higher predicted net infiltration for the North climate than the South climate, as expected. For the North climate, predicted net infiltration for the wettest 5-year period is 14.9 inches (53% of average precipitation) for the shale and 17.8 inches (63% of average precipitation) for the chert. For the South climate, predicted net infiltration for the wettest 5-year period is 9.1 inches (35% of average precipitation) for the shale and 12.9 inches (50% of average precipitation) for the chert.

The 100-year average annual predicted net infiltration for the east and west facing slopes climate range between 2.9 inches (Base 1W) and 6.2 inches (Base 1E) for shale waste rock. Predicted net infiltration for the baseline cover was largest for north facing slopes, moderate for east and south facing slopes, and lowest for west facing slopes (Table 5 and Table 7). The alternative reclamation vegetation simulations indicate increased predicted net infiltration for both the east and west climate compared to the typical reclamation vegetation (Table 7 and Table 8).

4.2 Topsoil Cover

The 100-year average annual predicted net infiltration for the 18-inch topsoil cover over shale is 0.57 inches (TS 1S) to 4.8 inches (TS 1N) or 3 to 25 percent of annual average precipitation. The long-term average annual predicted net infiltration for the topsoil over chert is 0.99 inches (TS 2S) to 5.5 inches (TS 2N), or 6 to 29 percent of annual average precipitation. The 18-inch topsoil cover simulations show marginally less predicted net infiltration for the shale waste rock compared to the chert waste rock. Predicted net infiltration in the wettest 5-year period ranges from 3.7 inches (TS 1S) to 11.5 inches (TS 2N). Predicted net infiltration in the driest 5-year period ranges from 0.19 inches (TS 2S) to 2.1 inches (TS 2N).

Table 5: Soil-Atmosphere Model Results – Predicted Net Infiltration – Shale Waste Rock

Simulation ID	100-Year Average		Average 5-Year Period		Wettest Year		Wettest 5-Year Period		Driest Year		Driest 5-Year Period	
	inches	%	inches	%	inches	%	inches	%	inches	%	inches	%
Base 1N	8.8	46	9.2	48	15.9	50	14.9	53	4.8	43	5.1	35
Base 1S	4.2	25	4.9	29	9.1	32	9.1	35	1.7	17	1.5	12
TS 1N	4.8	25	5.3	28	12.0	38	10.8	38	2.0	19	1.9	13
TS 1S	0.57	3	0.89	5	2.0	7	3.7	14	0.39	4	0.33	2
GCLL N	<0.001	<0.01	<0.001	<0.01	<0.001	<0.01	<0.001	<0.01	<0.001	<0.01	<0.001	<0.01
GCLL S	<0.001	<0.01	<0.001	<0.01	<0.001	<0.01	<0.001	<0.01	<0.001	<0.01	<0.001	<0.01
ET 1N	0.87	5	1.1	6	3.5	11	5.1	18	0.96	9	0.71	5
ET 1S	0.03	0.2	0.02	0.1	0.01	0.04	0.01	0.05	0.03	0.3	0.03	0.2
ET 2N	3.1	16	3.8	20	9.9	31	9.2	32	1.3	12	1.4	9
ET 2S	0.24	1	0.03	0.2	1.2	4	1.8	7	0.17	1	0.16	1
ET 3N	0.53	3	0.59	3	2.9	9	4.1	15	0.35	3	0.30	2
ET 3S	0.01	0.08	0.01	0.06	0.01	0.02	0.01	0.02	0.01	0.05	0.01	0.04
ET 4N	0.69	4	0.80	4	3.5	11	4.8	17	0.56	5	0.45	3
ET 4S	0.01	0.09	0.01	0.06	0.01	0.02	0.01	0.02	0.01	0.07	0.01	0.06

Notes:
N denotes the North facing slope climate simulation and S denotes the South facing slope climate simulations.
Values shown for the 5-year periods are the 5-year average
% net infiltration is based on the period average annual precipitation
GCLL model results are from the HELP model. All other simulation results are from HYDRUS.

Table 6: Soil-Atmosphere Model Results – Predicted Net Infiltration – Chert Waste Rock

Simulation ID	100-Year Average		Average 5-Year Period		Wettest Year		Wettest 5-Year Period		Driest Year		Driest 5-Year Period	
	inches	%	inches	%	inches	%	inches	%	inches	%	inches	%
Base 2N	11.1	59	11.3	59	19.4	61	17.8	63	6.0	55	7.2	50
Base 2S	7.2	42	7.4	43	13.2	46	12.9	50	2.6	26	3.7	28
TS 2N	5.5	29	5.8	30	13.0	40	11.5	41	2.2	20	2.1	15
TS 2S	0.99	6	1.6	9	4.8	17	5.1	20	0.28	3	0.19	1
GCLL N	<0.001	<0.01	<0.001	<0.01	<0.001	<0.01	<0.001	<0.01	<0.001	<0.01	<0.001	<0.01
GCLL S	<0.001	<0.01	<0.001	<0.01	<0.001	<0.01	<0.001	<0.01	<0.001	<0.01	<0.001	<0.01
ET 5N	0.86	5	1.1	6	5.4	17	5.6	20	0.50	4	0.50	3
ET 5S	0.02	0.10	0.007	0.04	0.004	0.01	0.004	0.02	0.03	0.3	0.03	0.2
ET 6N	3.1	16	3.6	19	10.3	32	9.1	32	0.54	5	0.55	4
ET 6S	0.24	1	0.15	0.9	1.7	6	2.5	10	0.09	0.9	0.08	0.6
ET 7N	0.78	4	0.98	5	5.4	17	5.4	17	0.39	4	0.35	2
ET 7S	0.01	0.07	0.005	0.03	0.003	0.003	0.003	0.01	0.03	0.3	0.02	0.2
ET 8N	1.0	5	1.3	7	6.1	19	5.9	21	0.40	4	0.41	3
ET 8S	0.03	0.1	0.005	0.03	0.36	1	0.14	0.5	0.03	0.3	0.03	0.2

Notes:
N denotes the North facing slope climate simulation and S denotes the South facing slope climate simulations.
Values shown for the 5-year periods are the 5-year average
% net infiltration is based on the period average annual precipitation
GCLL model results are from the HELP model. All other simulation results are from HYDRUS.

Table 7: Soil-Atmosphere Model Results – Predicted Net Infiltration – East and West Climate, Shale Waste Rock

Simulation ID	100-Year Average		Average 5-Year Period		Wettest Year		Wettest 5-Year Period		Driest Year		Driest 5-Year Period	
	inches	%	inches	%	inches	%	inches	%	inches	%	inches	%
Base 1E	6.2	33	6.9	36	12.9	40	12.0	42	2.3	21	2.7	19
Base 1W	2.9	19	2.4	16	6.0	23	7.1	31	1.4	15	1.4	12
TS 1E	2.1	11	2.9	15	7.1	22	7.4	26	1.1	10	0.95	7
TS 1W	0.10	0.6	0.01	0.1	0.93	4	0.69	3	0.02	0.2	0.09	0.8
ET 1E	0.19	1.0	0.03	0.2	1.2	4	1.4	5	0.12	1	0.06	0.4
ET 1W	0.02	0.2	0.03	0.2	0.01	0.04	0.01	0.05	0.03	0.3	0.03	0.2
ET 2E	1.1	6	1.4	7	3.8	12	5.4	19	0.61	6	0.54	4
ET 2W	0.04	0.3	0.02	0.2	0.009	0.04	0.010	0.04	0.03	0.3	0.03	0.2
ET 3E	0.09	0.5	0.02	0.09	0.97	3	0.48	2	0.08	0.7	0.07	0.5
ET 3W	0.01	0.09	0.02	0.1	0.006	0.02	0.006	0.03	0.02	0.2	0.02	0.1
ET 4E	0.14	0.7	0.02	0.1	0.99	3	0.95	3	0.08	0.8	0.08	0.5
ET 4W	0.01	0.09	0.02	0.1	0.006	0.02	0.006	0.03	0.02	0.2	0.02	0.1

Notes:
E denotes the East facing slope climate simulation and W denotes the West facing slope climate simulations.
Values shown for the 5-year periods are the 5-year average
% net infiltration is based on the period average annual precipitation

Table 8: Soil-Atmosphere Model Results – Predicted Net Infiltration – Alternative Reclamation Vegetation, East and West Climate, Shale Waste Rock

Simulation ID	100-Year Average		Average 5-Year Period		Wettest Year		Wettest 5-Year Period		Driest Year		Driest 5-Year Period	
	inches	%	inches	%	inches	%	inches	%	inches	%	inches	%
Base 1Ev	6.8	36	7.5	39	13.5	42	12.5	44	2.9	26	3.4	24
Base 1Wv	3.5	23	3.1	20	6.7	26	7.7	33	1.9	21	1.9	17
TS 1Ev	1.0	5	1.4	7	3.5	11	5.0	18	0.59	5	0.47	3
TS 1Wv	0.23	1	0.05	0.3	0.96	4	1.9	8	0.06	0.7	0.06	0.5
ET 1Ev	0.19	1	0.03	0.2	1.2	4	1.4	5	0.12	1	0.11	0.8
ET 1Wv	0.02	0.2	0.03	0.2	0.01	0.04	0.01	0.05	0.03	0.3	0.03	0.3
ET 2Ev	1.2	6	1.5	8	4.0	13	5.5	20	0.66	6	0.56	4
ET 2Wv	0.06	0.4	0.03	0.2	0.06	0.3	0.03	0.1	0.03	0.4	0.03	0.3
ET 3Ev	0.09	0.5	0.02	0.09	0.98	3	0.52	2	0.08	0.7	0.07	0.5
ET 3Wv	0.01	0.09	0.02	0.1	0.006	0.02	0.006	0.03	0.02	0.2	0.02	0.1
ET 4Ev	0.14	0.7	0.02	0.1	0.99	3	0.95	3	0.08	0.8	0.08	0.5
ET 4Wv	0.01	0.09	0.02	0.1	0.006	0.02	0.006	0.03	0.02	0.2	0.02	0.1

Notes:
E denotes the East facing slope climate simulation and W denotes the West facing slope climate simulations.
Values shown for the 5-year periods are the 5-year average
% net infiltration is based on the period average annual precipitation

Predicted net infiltration for the topsoil cover was largest for north facing slopes, moderate for east and south facing slopes, and lowest for west facing slopes (Table 5 and Table 7). The long-term averages range from 0.10 (TS 1W) to 2.1 (TS 1E) inches. Predicted net infiltration for the west climate is lower than the east climate. Predicted net infiltration for the alternative reclamation vegetation simulation for the topsoil cover ranged from 0.59 inches in the driest year to 5.0 in the wettest year for the east climate (TS 2E) and 0.05 inches in the average 5-yr period to 1.9 inches in the wettest year (TS 2W) for the west climate.

4.3 Multi-layered Cover System with Hydraulic Barrier – GCLL

The GCLL model simulations are from the HELP model. Since the model did not simulate the underlying materials (truncated at the GCLL), the GCLL simulation results represents both waste rock scenarios.

Predicted net infiltration from the GCLL is negligible (less than 0.001 inches) for all climate periods. For comparison, the Base 1N and Base 1S cover systems were simulated in HELP to evaluate the differences in the two models. The HELP model tends to under predict net infiltration by a factor of 1.5. O'Kane predicted 0.002 to 0.005 (2009b) inches of annual net infiltration on the 100-year average annual basis for a similar GCLL using the North climate in VADOSE/W. The cover system (from surface to base) simulated by O'Kane included: 18-inches of topsoil, 12-inches of alluvium, 6-inches of drainage layer, and the GCLL. The material properties for the alluvium, drainage layer, and GCLL were different from the current modeling effort.

4.4 Evapotranspirative Covers

4.4.1 Feasibility Study ET Cover Designs

Model runs ET 1N, ET 1S, ET 5N, ET 5S, ET 1E, ET 1W, ET 1Ev, and ET 1Wv simulate the ET cover design presented in the FS. The predicted 100-year average annual net infiltration for the FS ET cover design is 0.87 inches (5% of average annual precipitation) for the North climate/shale waste rock (ET 1N) and 0.03 inches (0.2% of average annual precipitation) for the South climate/shale waste rock (ET 1S). The chert simulations show slightly less predicted net infiltration for the North climate (0.86 inches; ET 5N) and the South climate (0.02 inches; ET 5S) compared to the shale. In the wettest 5-year period, the predicted net infiltration for the FS ET cover design ranges from 0.004 inches (ET 5S) to 5.4 inches (ET 5N).

Similar to the baseline and topsoil covers, predicted net infiltration for the FS ET cover was largest for north facing slopes, moderate for east and south facing slopes, and lowest for west facing slopes (Table 5 and Table 7). Predicted net infiltration for the FS ET cover ranged from 0.02 inches (ET 1W) to 0.19 inches (ET 1E) for the long-term average. The simulated alternative reclamation vegetation did not affect predicted net infiltration for the FS ET cover except in the driest years (Table 7 and Table 8).

Model runs ET 2N, ET 2S, ET 6N, ET 6S, ET 2E, ET 2W, ET 2Ev and ET 2Wv simulate the modified FS ET cover design. This cover design uses the same material sequence, but with thinner layers. Predicted net infiltration for these simulations is generally greater than the FS cover design. The long-term average annual predicted net infiltration ranges from 0.24 inches (ET 2S) to 3.1 inches (ET 2N) for the shale waste rock simulations and 0.24 inches (ET 2S) to 3.1 inches (ET 2N) for the chert simulations. The shale and chert waste rock simulations predict similar net infiltration for all climate periods except the driest years. The chert waste rock simulations have lower predicted net infiltration in the driest years. This is likely due to the decrease in unsaturated hydraulic conductivity under dry conditions in coarser material. The chert is a coarser material compared to the shale and as such has larger pore sizes that lose connectivity under dry conditions, resulting in less downward flux. In the dry years the modified FS ET cover and the FS ET cover design predicted similar performance.

Long-term average annual predicted net infiltration for the east and west climate ranges from 0.04 inches (ET 2W) to 1.1 inches (ET 2E; Table 7). Model simulations of the shallow rooted vegetation indicated slightly increased long-term average annual predicted net infiltration (0.06 inches for ET 2Wv and 1.2 inches for ET 2Ev).

4.4.2 Monolithic ET Cover Designs

Model runs ET 3N, ET 3S, ET 7N, ET 7S, ET 3E, ET 3W, ET 3Ev, and ET 3Wv simulate the 5-foot medium-textured alluvium cover design. The predicted 100-year average annual net infiltration for the 5-foot medium-textured alluvium cover design is 0.53 inches (3% of average annual precipitation) for the North climate/shale waste rock (ET 3N) and 0.01 inches (0.08% of average annual precipitation) for the South climate/shale waste rock (ET 3S). The chert simulations show slightly higher predicted long-term net infiltration for the North climate (0.78 inches; ET 7N) and the South climate (0.01 inches; ET 7S) compared to the shale.

Long-term annual average predicted net infiltration for the medium-textured ET cover ranges from 0.01 inches (ET 3W) to 0.09 inches (ET 3E; Table 7). The alternative reclamation vegetation only slightly affects predicted net infiltration for the medium-textured ET cover (Table 7 and Table 8).

Model runs ET 4N, ET 4S, ET 8N, ET 8S, ET 4E, ET 4W, ET 4Ev, and ET 4Wv simulate the 5-foot coarse-textured alluvium cover design. In general, the predicted net infiltration for this monolithic cover is slightly greater than the medium-textured alluvium cover. The long-term average annual predicted net infiltration ranges from 0.01 inches (ET 4S) to 0.69 inches (ET 4N) for the shale waste rock simulations and 0.03 inches (ET 8S) to 1.0 inches (ET 8N) for the chert simulations.

Figure 4: Shale Waste Rock Simulation Results for the Long-Term Annual Average Predicted Net Infiltration

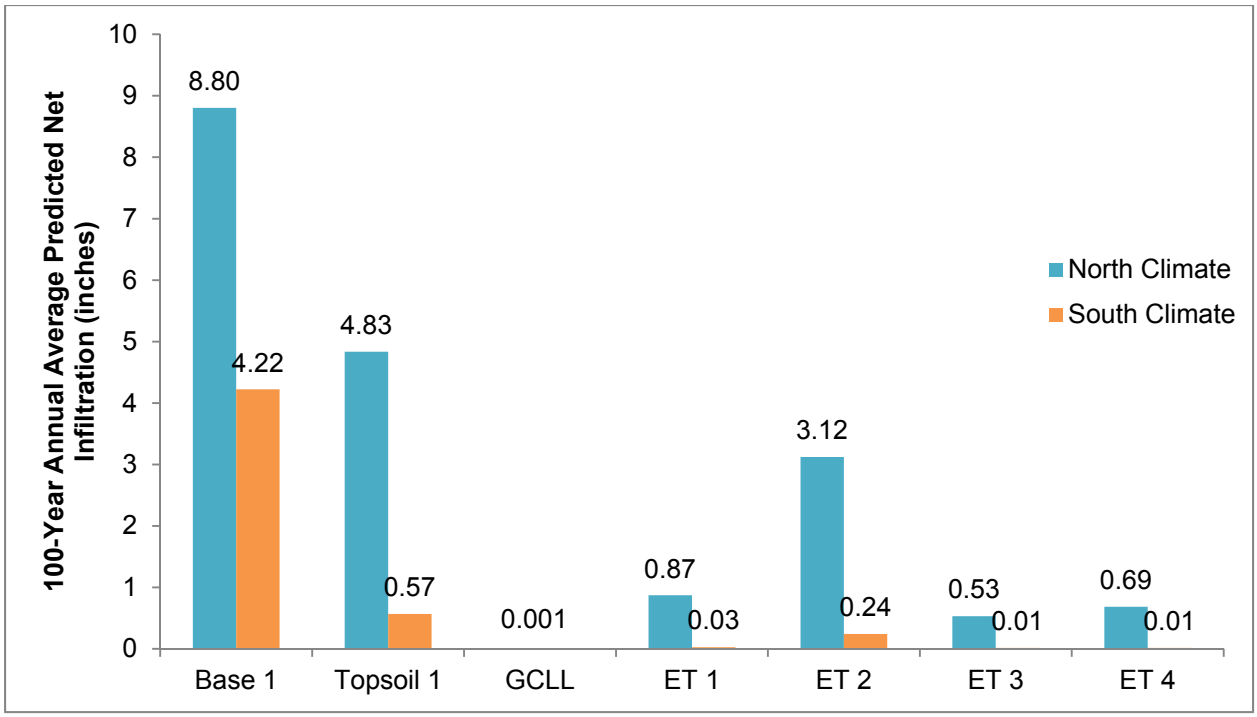


Figure 5: Chert Waste Rock Simulation Results for the Long-Term Annual Average Predicted Net Infiltration

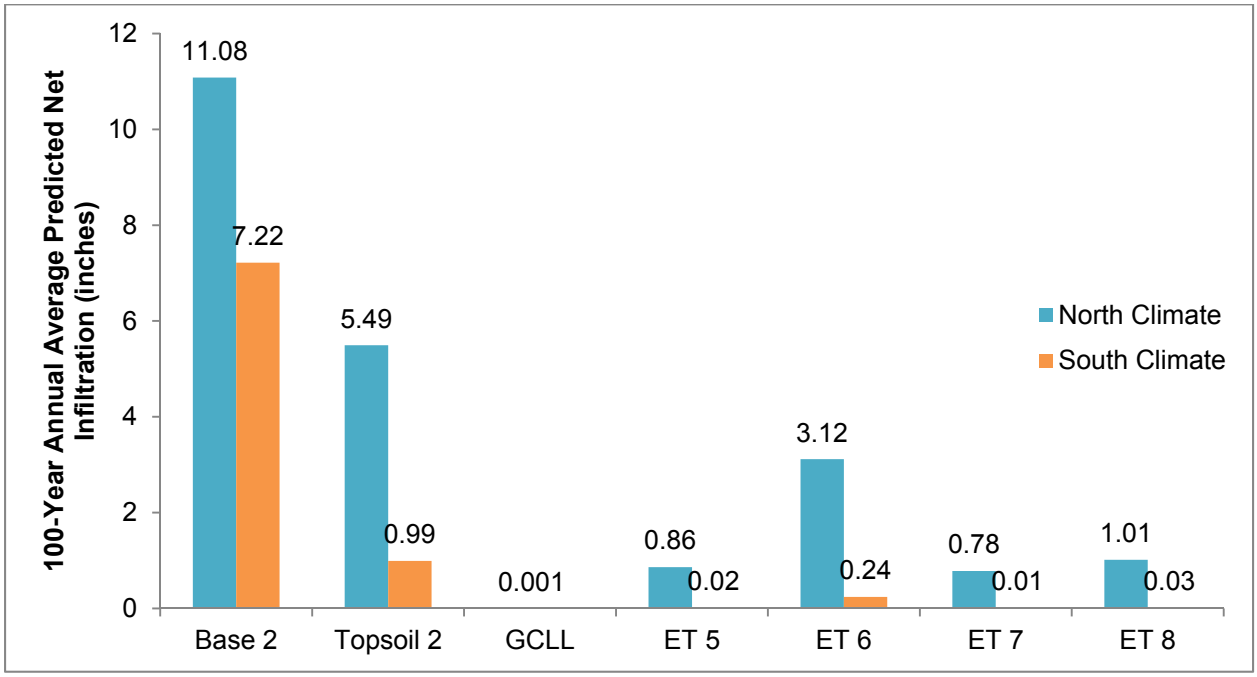


Figure 6: All Climates, Shale Waste Rock Simulation Results for the Long-Term Annual Average Predicted Net Infiltration

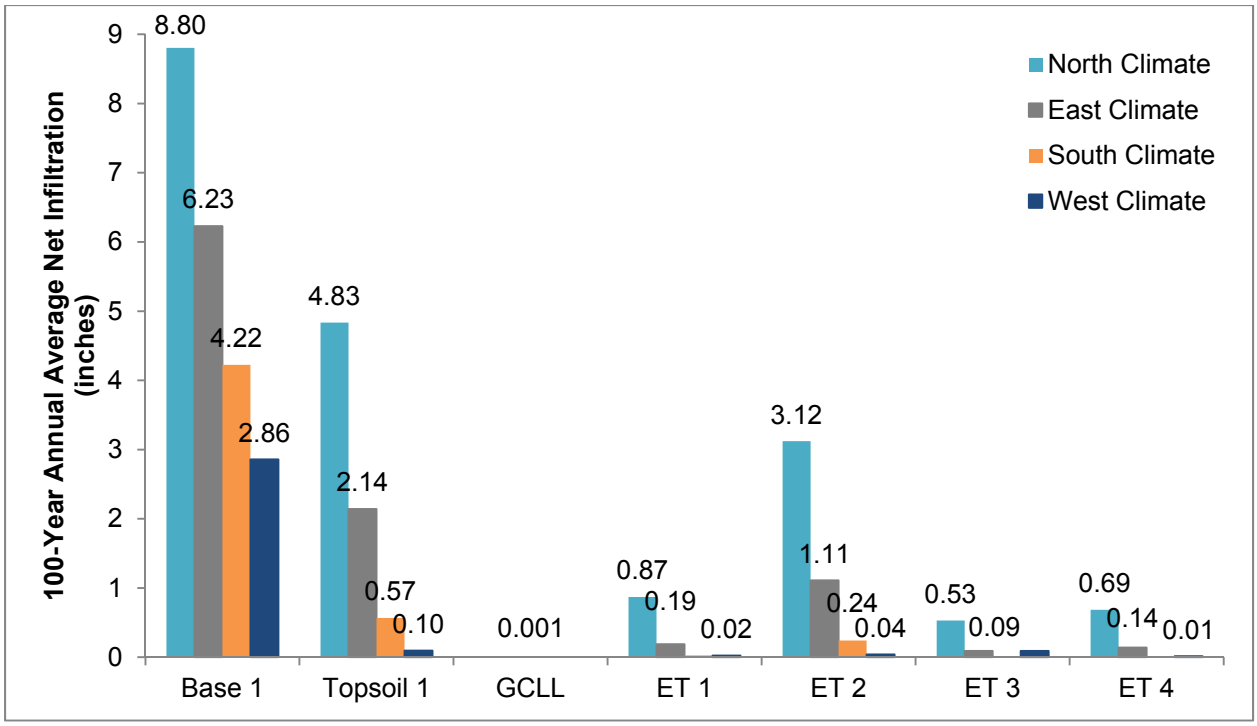
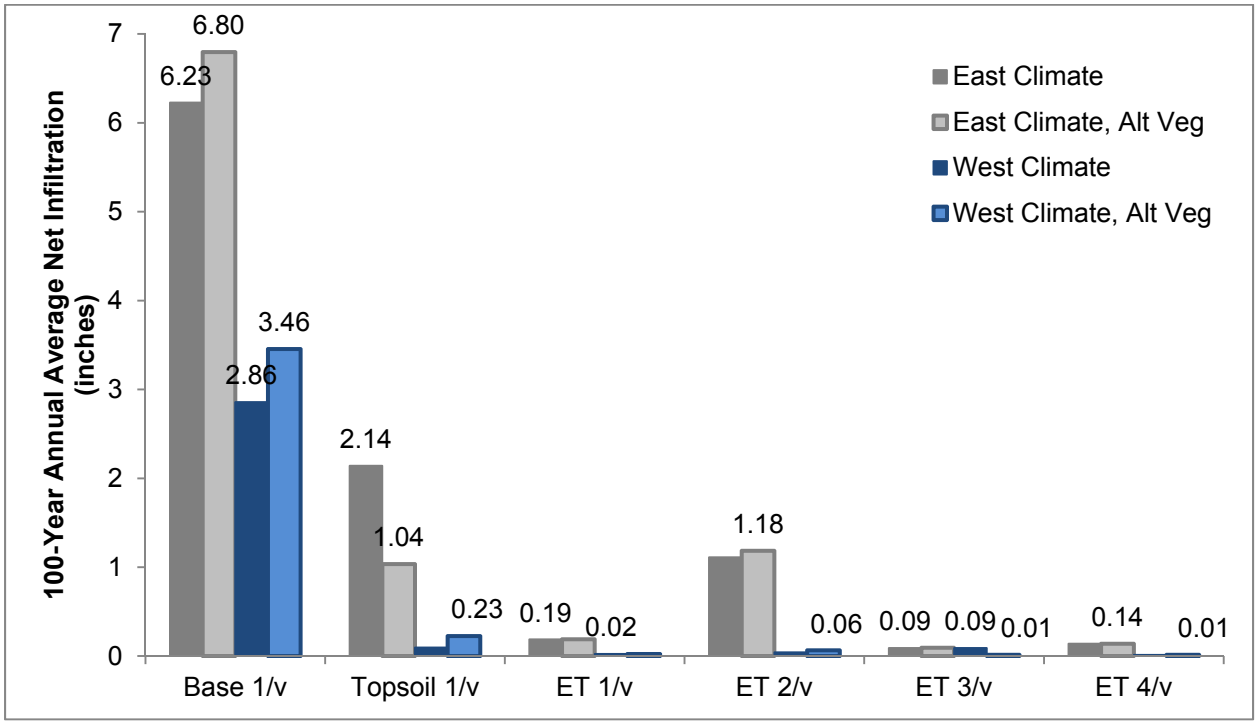


Figure 7: East and West Climate with Baseline and Alternative Vegetation, Shale Waste Rock Simulation Results for the Long-Term Annual Average Predicted Net Infiltration



Long-term average annual predicted net infiltration for the east and west facing slope climate ranges from 0.01 inches (ET 4W) to 0.14 inches (ET 4E). The simulated alternative reclamation vegetation did not affect predicted net infiltration for the coarse-textured ET cover (Table 7 and Table 8).

5.0 DISCUSSION

In general, the model results indicate that the ET covers are effective at limiting net infiltration through the shale and chert waste rock. The model results show that there will be periods of higher net infiltration (wet years) and periods with very little net infiltration (dry periods), while the long-term (100-year) average annual predicted net infiltration for these covers is less than or equal to 5% of mean annual precipitation, with the exception of the modified FS ET cover (ET 2/6).

The modified FS ET cover demonstrated lower performance than the other ET cover simulations (ET 1/5, ET 3/7, and ET 4/8). The remaining ET cover scenarios demonstrated similar predicted net infiltration. The shale and chert waste rock model scenarios generally show similar same results for the ET covers while the predicted net infiltration was higher for the chert compared to the shale for the Base and Topsoil covers. Covers on North-facing slopes demonstrated higher predicted net infiltration followed by East-, South-facing slopes with West-facing slopes demonstrating generally the lowest predicted net infiltration. This is expected given the scouring of snow from West-facing slopes and deposition on North- and East-facing slopes while ET is highest on South-facing slopes, moderate on East- and West-facing slopes and lowest on North-facing slopes. The predominant slopes to be covered at the Ballard Mine are East- and West-facing. For ET covers 1, 3, and 5 (excludes the modified FS ET cover), the predicted long-term average net infiltration was 1% of mean annual precipitation or less.

The GCLL cover is the most effective at limiting net infiltration; however, the construction costs to install a GCLL cover are greater than soil covers and vegetation diversity is compromised due to shallower rooting depths. Depending on the level of acceptable net infiltration that will protect surface water and groundwater quality, the ET cover designs are likely more feasible for construction, lower in cost, and tend to support a more robust vegetation community.

Reclamation suitability and performance depends on the cover material's ability to provide erosion control, sustain vegetation, and reduce infiltration of precipitation through the underlying materials. Thus, it is imperative that the reclamation cover system has physical properties that will enable the cover to meet all three performance objectives: reduce erosion, establish vegetation, and limit drainage. The ability of the cover system to meet these cover performance objectives depends on the physical properties of the soil, specifically the surface texture and rock fragment content, and the cover thickness. Having a moderately coarse-textured surface with adequate rock fragments will help reduced erosion especially in the early vegetation establishment period. The coarser materials will also have high infiltration rates, reducing runoff, but can still adequately store and redistribute water through evapotranspiration. Additionally, a more diverse vegetation community may be more feasible to establish with a deeper ET cover that will support deeper rooted native shrub species.

The alternative reclamation of a grass dominated community with shallow root distribution simulation results suggest lower performance (higher predicted net infiltration) for the baseline and topsoil cover designs. The ET cover designs are not as sensitive to the alternative reclamation vegetation as simulated although the predicted net infiltration is generally slightly higher compared to the typical reclamation vegetation.

The model results provide a comparative analysis of relative cover performance. Because there are limited site-specific data for the waste rock and some of the cover materials, the results do not provide a definitive prediction of net infiltration. Therefore, subsequent modeling is required prior to design and construction.

The proposed cover designs in the FS specify materials that may or may not be available at Ballard Mine at the time of reclamation. Specifically, the coarse-textured material specified as a capillary break in the FS Alternatives should have a target hydraulic conductivity of 10^{-3} cm/s (personal communication M. Prickett 2015); however, the coarsest cover material available among the alluvium samples has a hydraulic conductivity of 5.2×10^{-4} cm/s. Thus, the chert was used to simulate the capillary break material specified in the FS cover designs. The physical data for the chert is from the Enoch Valley Backfill Panel. The chert at the Ballard Mine may not be suitable to use as part of the cover if the geochemical characterization indicates that it is unsuitable. Secondly, the fine-textured material specified in the FS Alternatives should have a target hydraulic conductivity of 10^{-4} to 10^{-5} cm/s. An alluvium hydraulic conductivity of 1.2×10^{-4} cm/s was used to simulate this material. Overall the alluvium materials sampled and analyzed at Ballard Mine have very little variation of saturated hydraulic conductivity. Additional samples would need to be sampled and analyzed to determine if a wider range of hydraulic conductivity materials are available at the site.

The available data for the study indicates that the alluvium materials found at the Ballard Mine do not have a large range in hydraulic conductivity. However, the model results indicate these materials will function well as an ET cover. Golder recommends collecting site-specific physical data for the waste materials and topsoil once a cover design has been selected to validate these model results.

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Established in 1960, Golder Associates is a global, employee-owned organization that helps clients find sustainable solutions to the challenges of finite resources, energy and water supply and management, waste management, urbanization, and climate change. We provide a wide range of independent consulting, design, and construction services in our specialist areas of earth, environment, and energy. By building strong relationships and meeting the needs of clients, our people have created one of the most trusted professional services organizations in the world.

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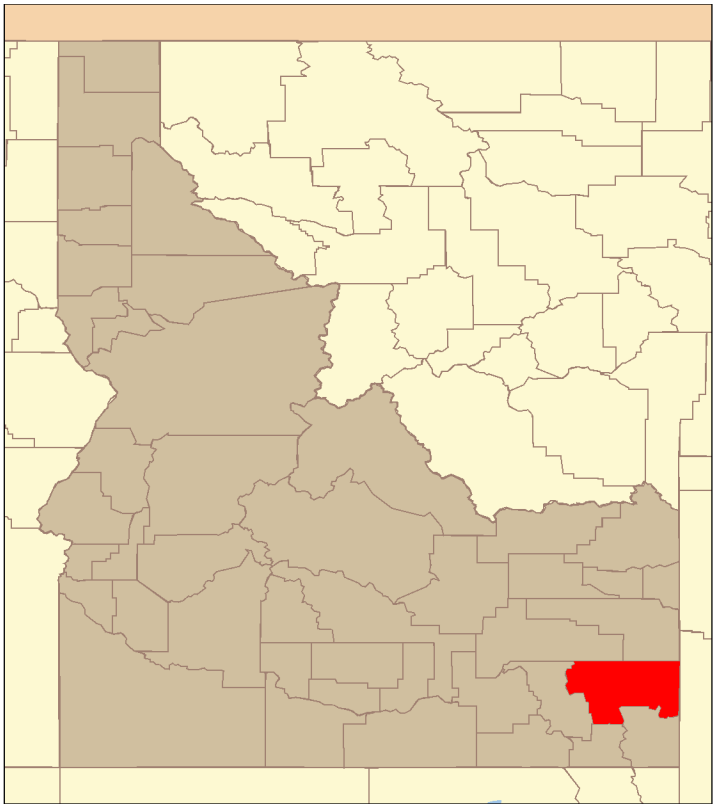
Attachment 2
U.S.G.S. – National Climate Change Viewer
Summary of Caribou County Idaho

U.S. Geological Survey - National Climate Change Viewer

Summary of Caribou County, Idaho



May 13, 2014

1 Maximum 2-m Air Temperature

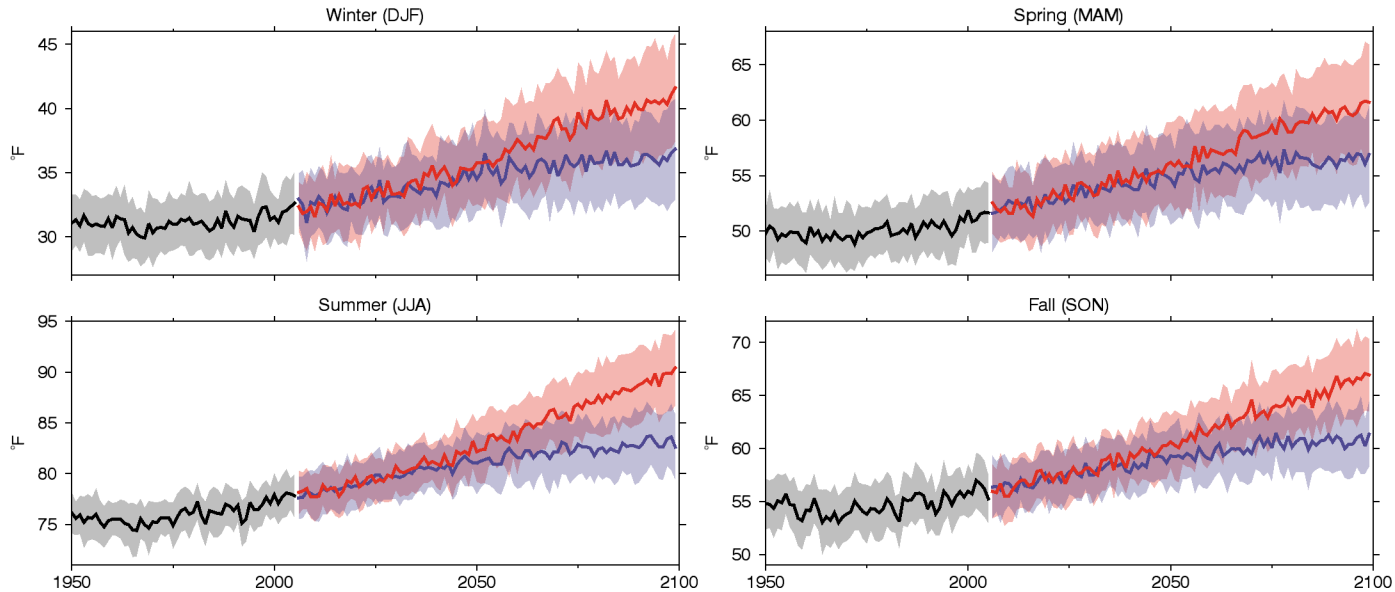


Figure 1: Seasonal average time series of maximum 2-m air temperature for historical (black), RCP4.5 (blue) and RCP8.5 (red). The historical period ends in 2005 and the future periods begin in 2006. The average of 30 CMIP5 models is indicated by the solid lines and their standard deviations are indicated by the respective shaded envelopes.

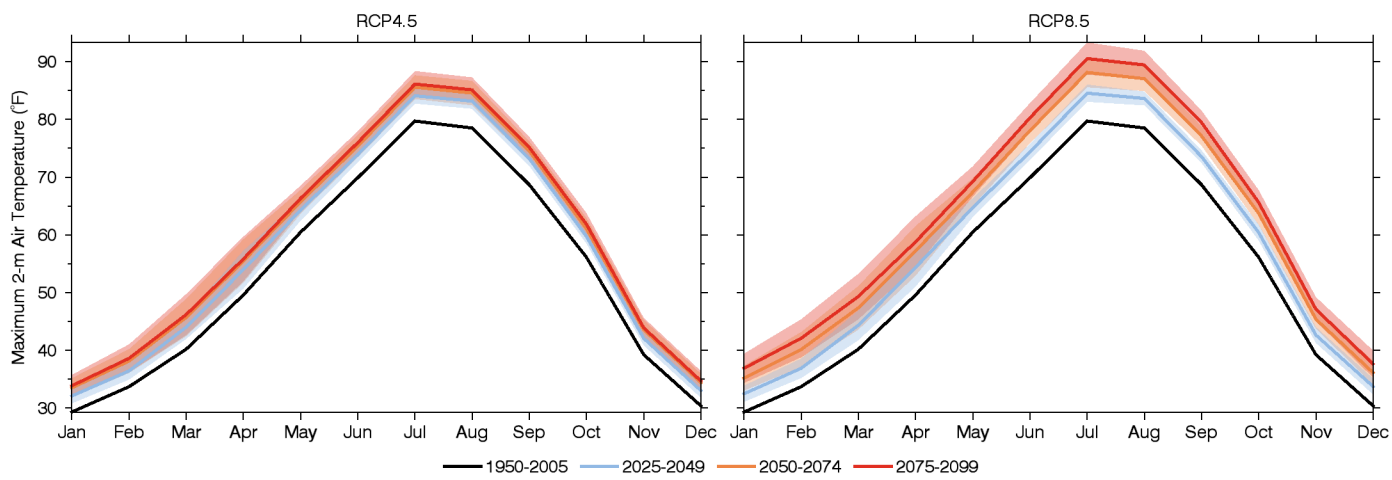


Figure 2: Monthly averages of maximum 2-m air temperature for four time periods for the RCP4.5 (left) and RCP8.5 (right) simulations. The average of 30 CMIP5 models is indicated by the solid lines and their standard deviations are indicated by the respective shaded envelopes.

2 Minimum 2-m Air Temperature

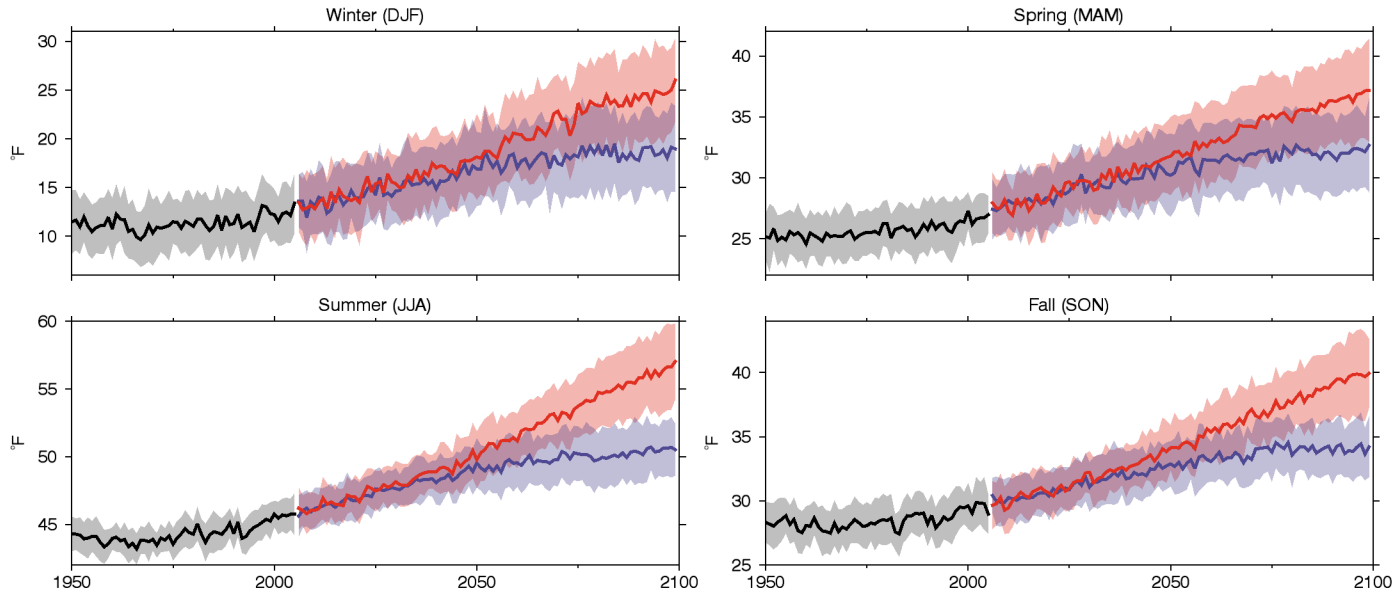


Figure 3: Seasonal average time series of minimum 2-m air temperature for historical (black), RCP4.5 (blue) and RCP8.5 (red). The historical period ends in 2005 and the future periods begin in 2006. The average of 30 CMIP5 models is indicated by the solid lines and their standard deviations are indicated by the respective shaded envelopes.

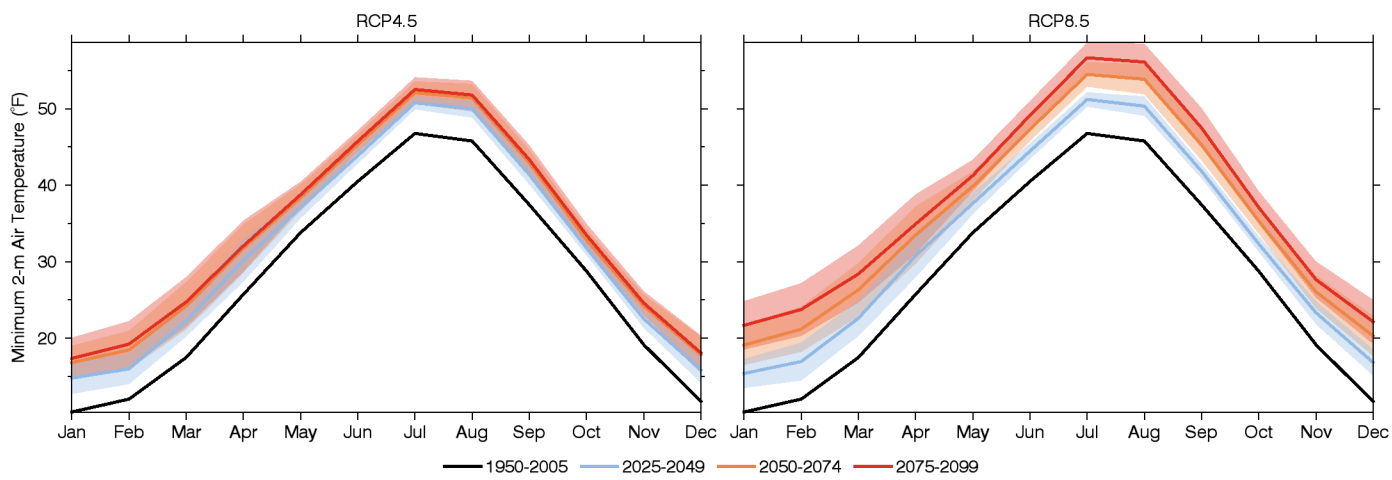


Figure 4: Monthly averages of minimum 2-m air temperature for four time periods for the RCP4.5 (left) and RCP8.5 (right) simulations. The average of 30 CMIP5 models is indicated by the solid lines and their standard deviations are indicated by the respective shaded envelopes.

3 Precipitation

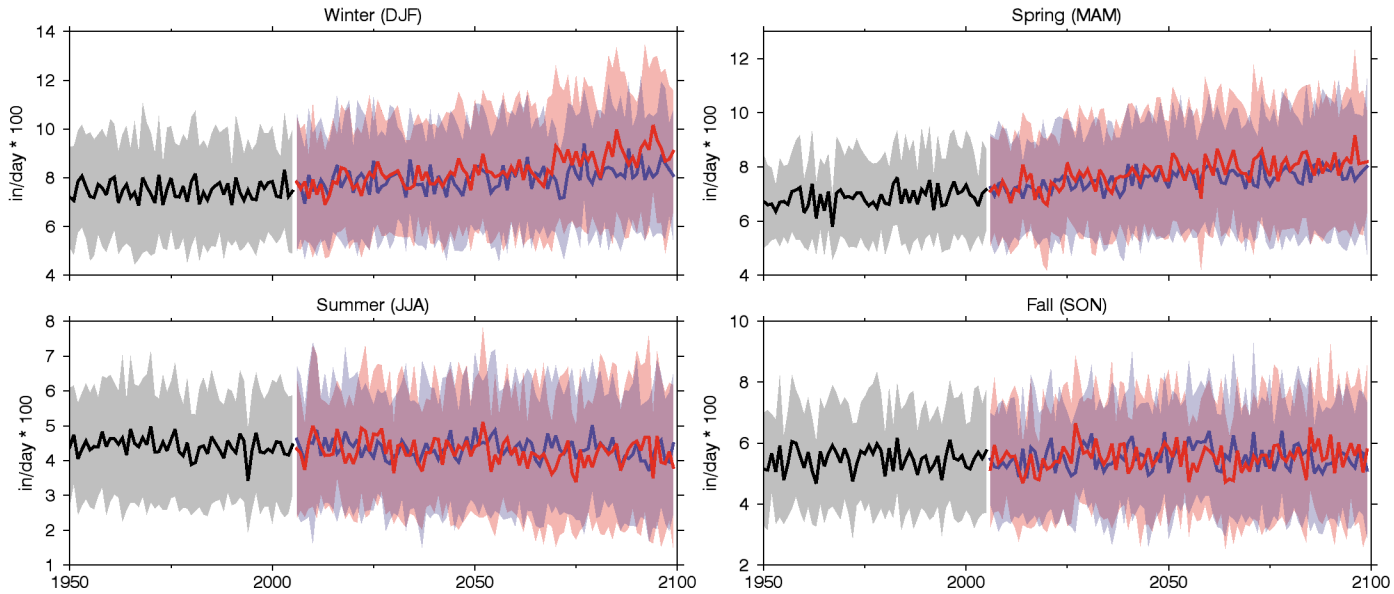


Figure 5: Seasonal average time series of precipitation for historical (black), RCP4.5 (blue) and RCP8.5 (red). The historical period ends in 2005 and the future periods begin in 2006. The average of 30 CMIP5 models is indicated by the solid lines and their standard deviations are indicated by the respective shaded envelopes.

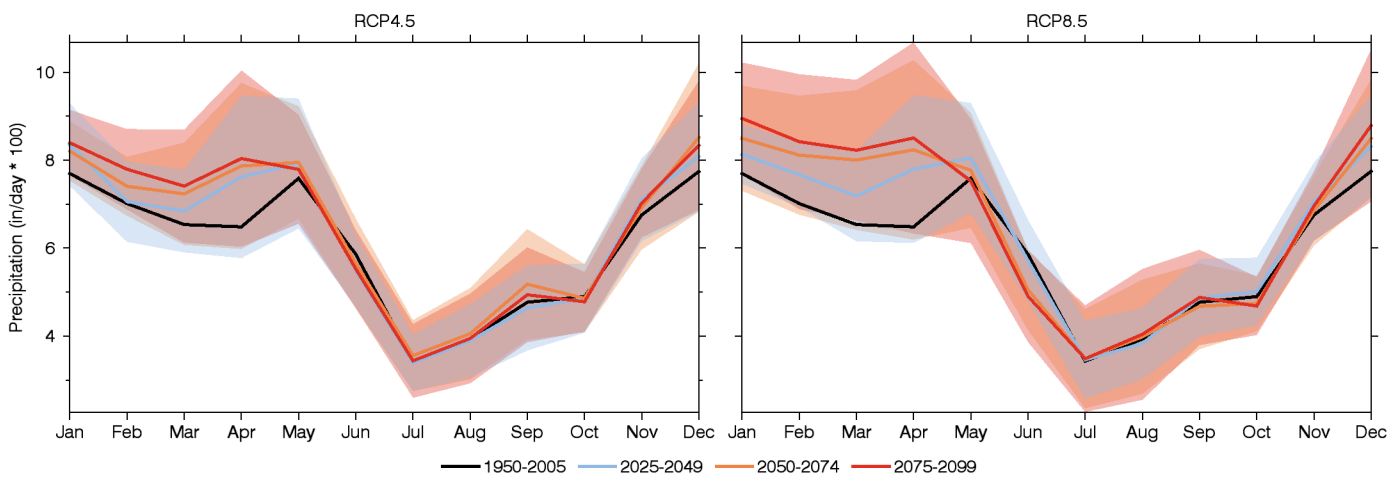


Figure 6: Monthly averages of precipitation for four time periods for the RCP4.5 (left) and RCP8.5 (right) simulations. The average of 30 CMIP5 models is indicated by the solid lines and their standard deviations are indicated by the respective shaded envelopes.

4 Snow Water Equivalent

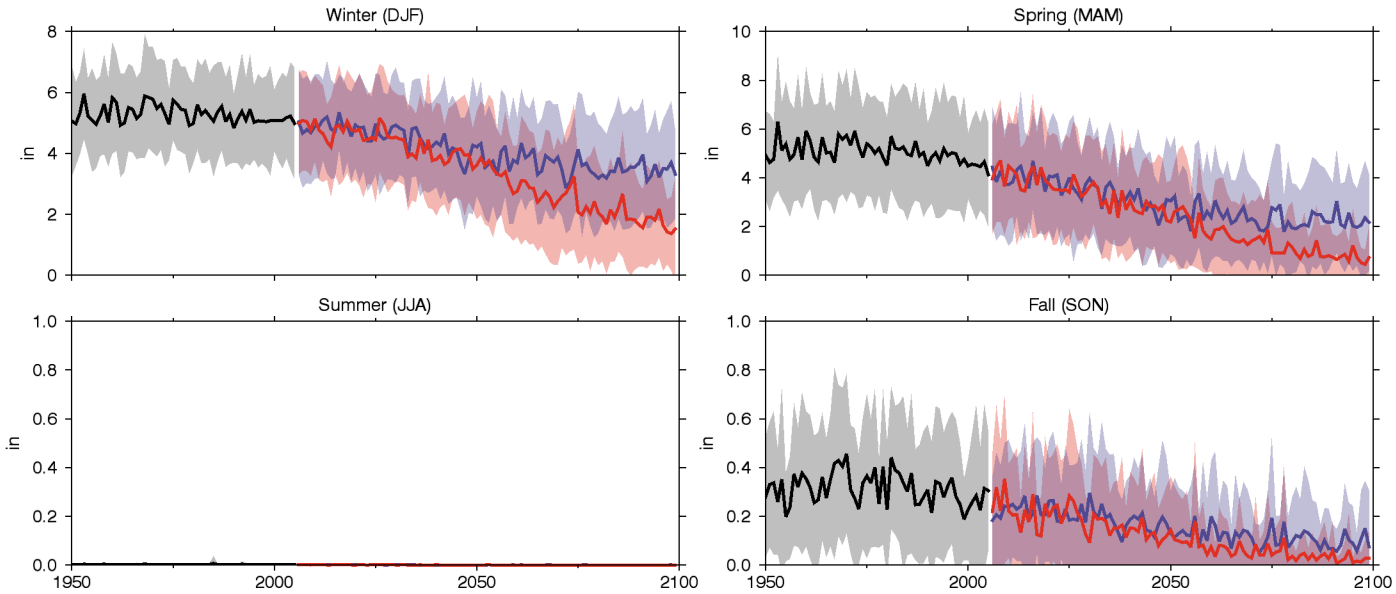


Figure 7: Seasonal average time series of snow water equivalent for historical (black), RCP4.5 (blue) and RCP8.5 (red). The historical period ends in 2005 and the future periods begin in 2006. The average of 30 CMIP5 models is indicated by the solid lines and their standard deviations are indicated by the respective shaded envelopes.

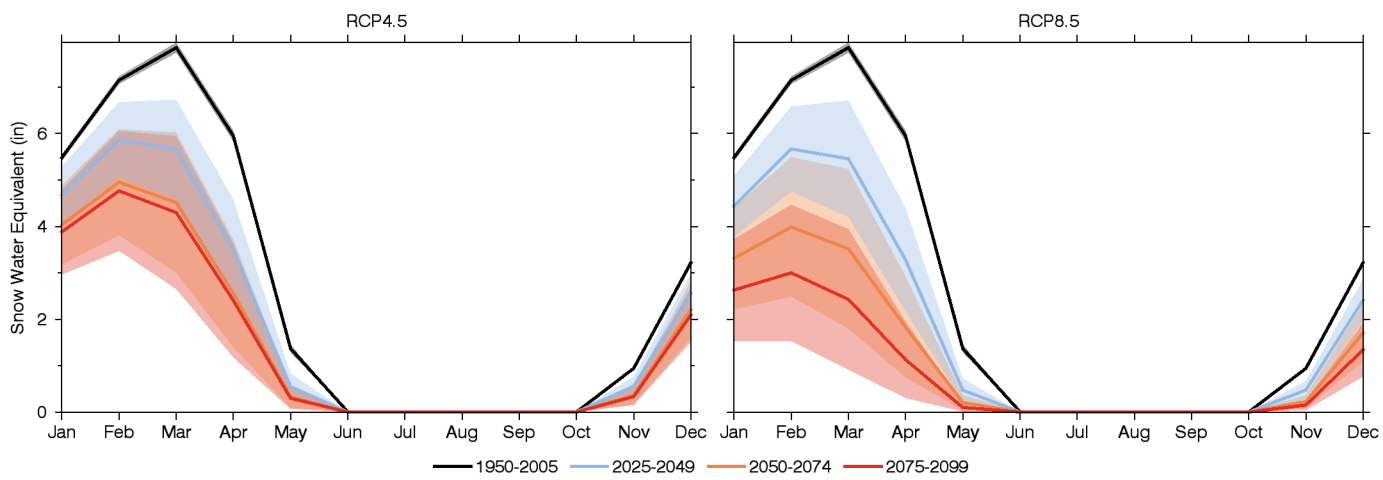


Figure 8: Monthly averages of snow water equivalent for four time periods for the RCP4.5 (left) and RCP8.5 (right) simulations. The average of 30 CMIP5 models is indicated by the solid lines and their standard deviations are indicated by the respective shaded envelopes.

5 Runoff

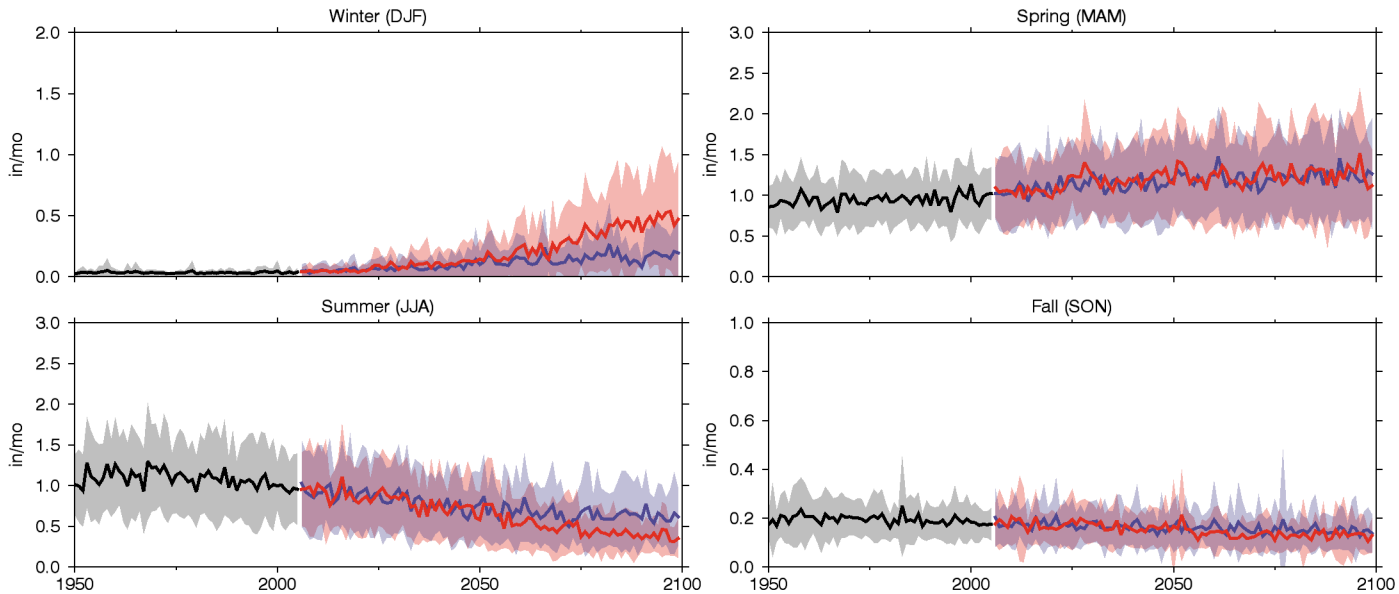


Figure 9: Seasonal average time series of runoff for historical (black), RCP4.5 (blue) and RCP8.5 (red). The historical period ends in 2005 and the future periods begin in 2006. The average of 30 CMIP5 models is indicated by the solid lines and their standard deviations are indicated by the respective shaded envelopes.

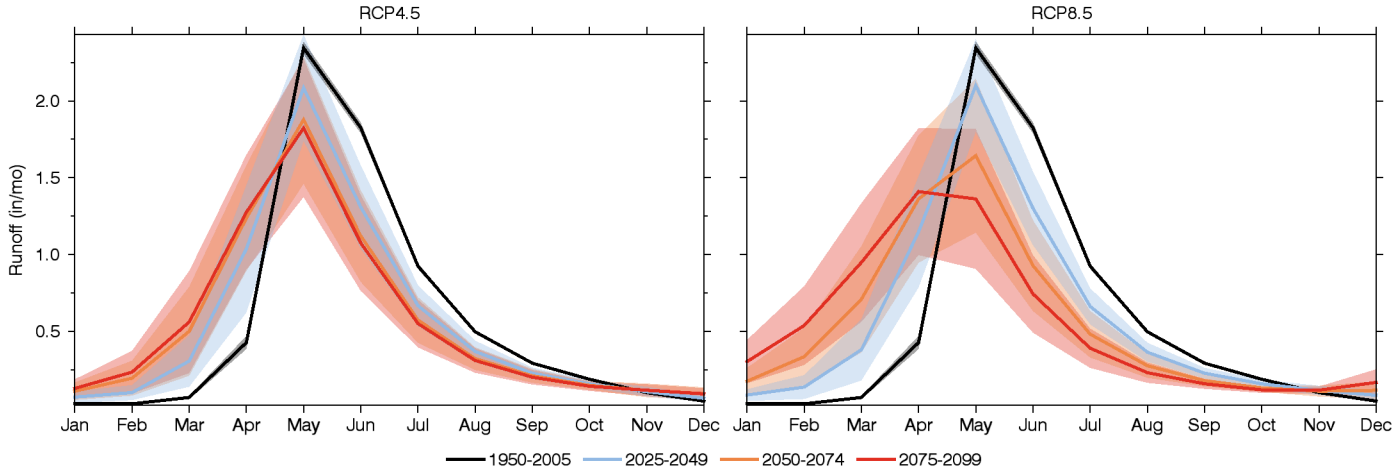


Figure 10: Monthly averages of runoff for four time periods for the RCP4.5 (left) and RCP8.5 (right) simulations. The average of 30 CMIP5 models is indicated by the solid lines and their standard deviations are indicated by the respective shaded envelopes.

6 Soil Water Storage

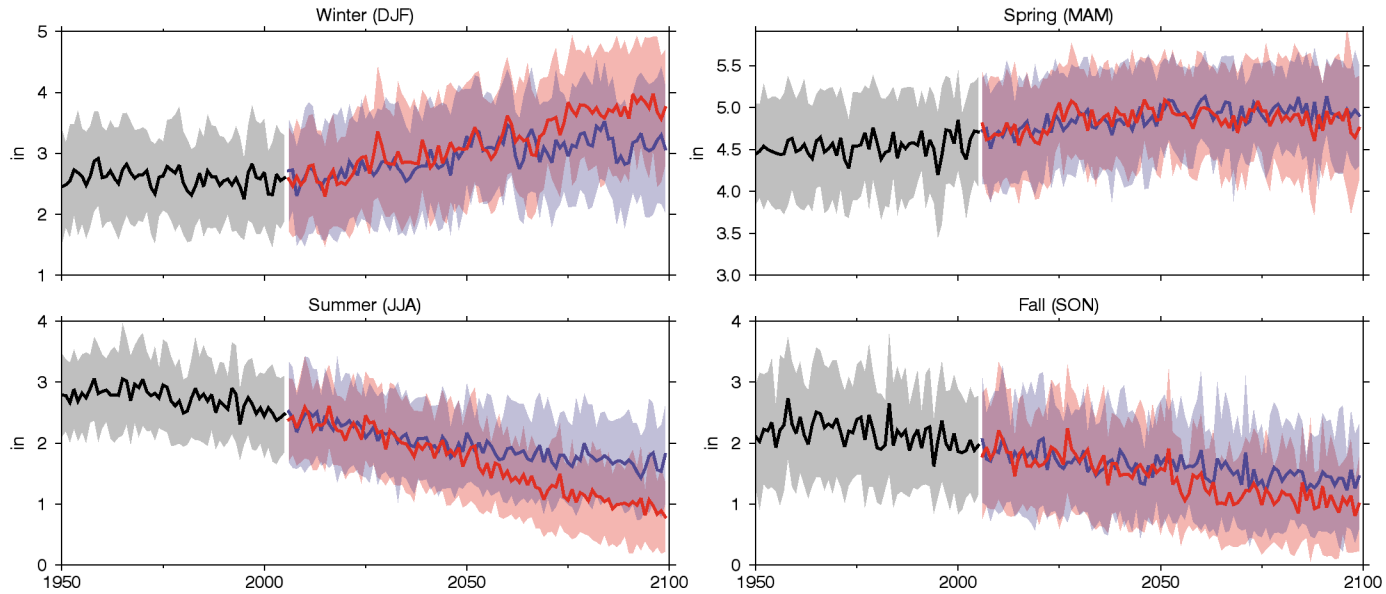


Figure 11: Seasonal average time series of soil water storage for historical (black), RCP4.5 (blue) and RCP8.5 (red). The historical period ends in 2005 and the future periods begin in 2006. The average of 30 CMIP5 models is indicated by the solid lines and their standard deviations are indicated by the respective shaded envelopes.

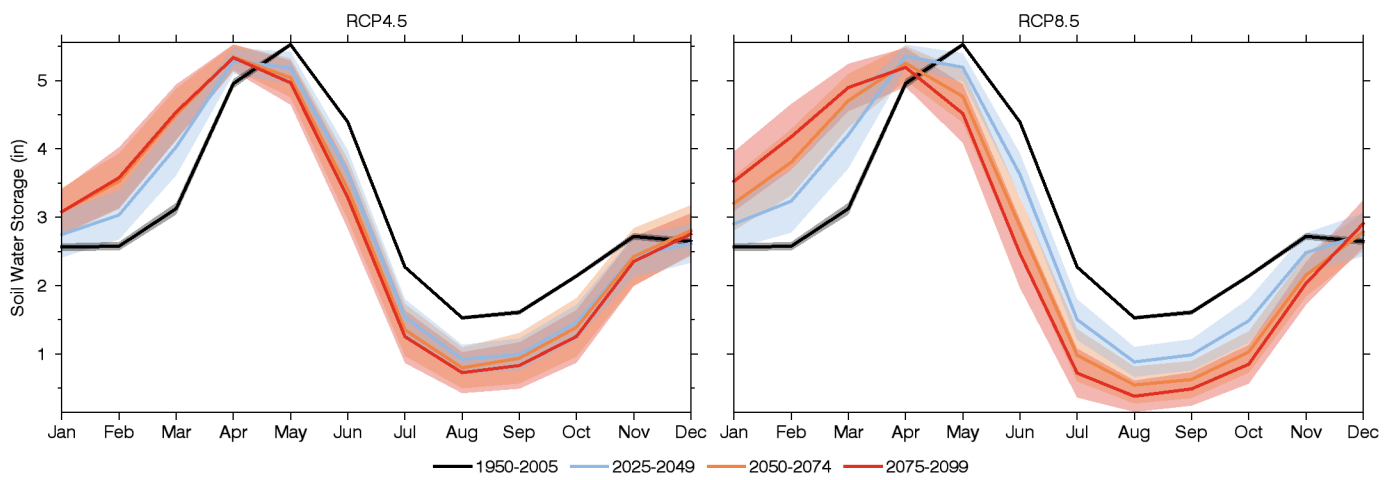


Figure 12: Monthly averages of soil water storage for four time periods for the RCP4.5 (left) and RCP8.5 (right) simulations. The average of 30 CMIP5 models is indicated by the solid lines and their standard deviations are indicated by the respective shaded envelopes.

7 Evaporative Deficit

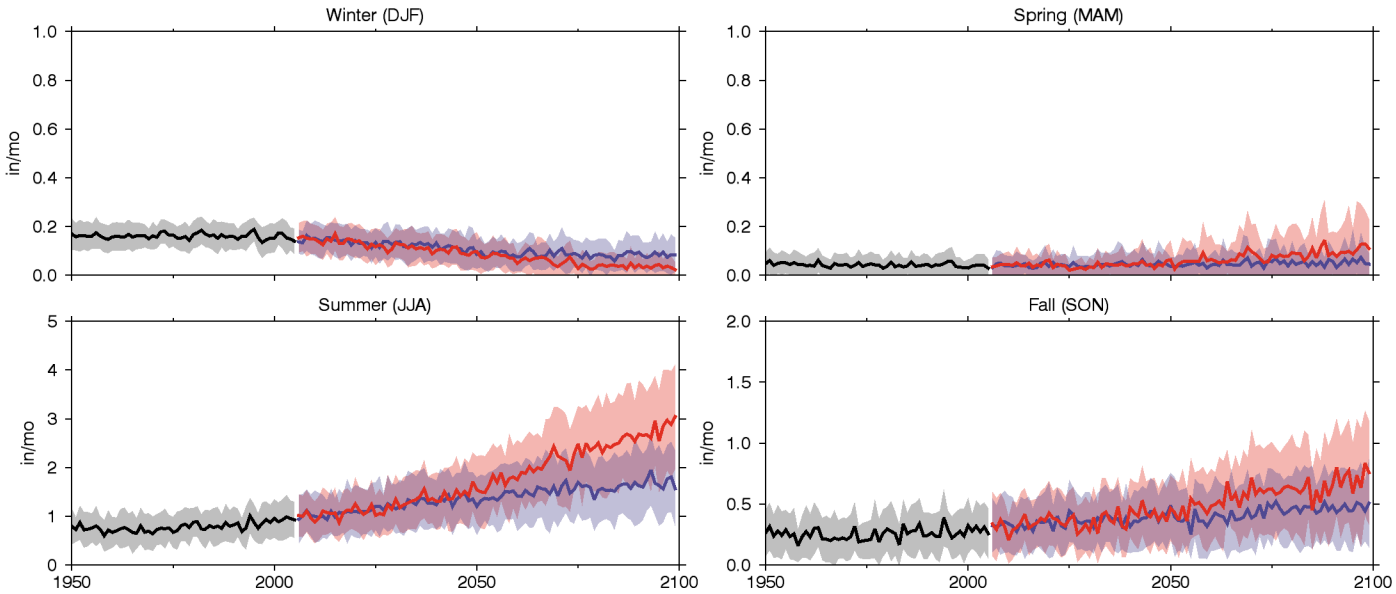


Figure 13: Seasonal average time series of evaporative deficit for historical (black), RCP4.5 (blue) and RCP8.5 (red). The historical period ends in 2005 and the future periods begin in 2006. The average of 30 CMIP5 models is indicated by the solid lines and their standard deviations are indicated by the respective shaded envelopes.

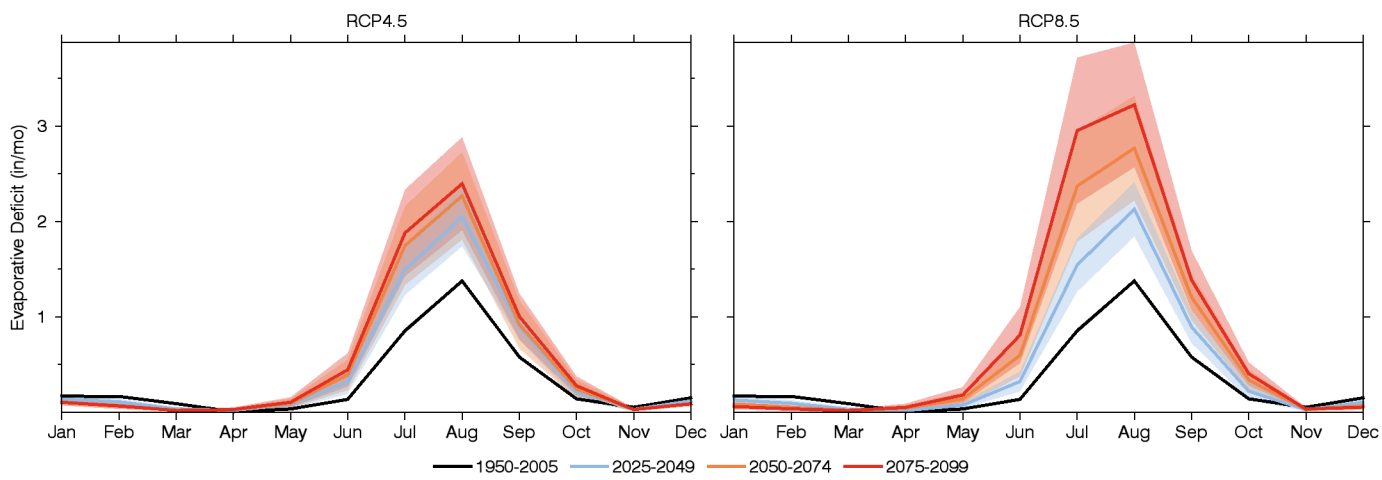


Figure 14: Monthly averages of evaporative deficit for four time periods for the RCP4.5 (left) and RCP8.5 (right) simulations. The average of 30 CMIP5 models is indicated by the solid lines and their standard deviations are indicated by the respective shaded envelopes.

8 Data

The temperature and precipitation summaries are created by spatially averaging the NASA NEX-DCP30 data set (Thrasher et al., 2013). The water-balance variables snow water equivalent, runoff, soil water storage and evaporative deficit are simulated by using the NEX-DCP30 temperature and precipitation as input to a simple model (McCabe and Wolock, 2011). The water-balance model accounts for the partitioning of water through the various components of the hydrologic system, but does not account for groundwater, diversions or regulation by impoundments.

9 Models

ACCESS1-0	bcc-csm1-1	bcc-csm1-1-m	BNU-ESM	CanESM2	CCSM4
CESM1-BGC	CMCC-CM	CNRM-CM5	CSIRO-Mk3-6-0	FGOALS-g2	FIO-ESM
GFDL-CM3	GFDL-ESM2G	GFDL-ESM2M	GISS-E2-R	HadGEM2-AO	HadGEM2-CC
HadGEM2-ES	inmcm4	IPSL-CM5A-LR	IPSL-CM5A-MR	IPSL-CM5B-LR	MIROC5
MIROC-ESM	MIROC-ESM-CHEM	MPI-ESM-LR	MPI-ESM-MR	MRI-CGCM3	NorESM1-M

10 Citation Information

Alder, J. R. and S. W. Hostetler, 2013. USGS National Climate Change Viewer. US Geological Survey `http://www.usgs.gov/climate_landuse/clu_rd/nccv.asp` doi:10.5066/F7W9575T

McCabe, G. J., and D. M. Wolock, 2011. Independent effects of temperature and precipitation on modeled runoff in the conterminous United States, Water Resour. Res., 47, W11522, doi:10.1029/2011WR010630

Thrasher, B., J. Xiong, W. Wang, F. Melton, A. Michaelis, and R. Nemani, 2013. New downscaled climate projections suitable for resource management in the U.S. Eos, Transactions American Geophysical Union 94, 321-323, doi:10.1002/2013EO370002

11 Disclaimer

These freely available, derived data sets were produced by J. Alder and S. Hostetler, US Geological Survey (USGS). The original climate data are from the NEX-DCP30 dataset, which was prepared by the Climate Analytics Group and NASA Ames Research Center using the NASA Earth Exchange, and is distributed by the NASA Center for Climate Simulation. No warranty expressed or implied is made by the USGS regarding the display or utility of the derived data on any other system, or for general or scientific purposes, nor shall the act of distribution constitute any such warranty. The USGS shall not be held liable for improper or incorrect use of the data described and/or contained herein.

APPENDIX C

COMMENTS AND COMMENT RESPONSES

APPENDIX C-1

A/T Comments on *P4's Ballard Mine Feasibility Study Report Memorandum 2 – Screening, Detailed, and Comparative Analysis of Assembled Remedial Alternatives, Draft Rev 0, July 2016*

Transmitted to P4 on September 23, 2016

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 10
IDAHO OPERATIONS OFFICE
950 West Bannock, Suite 900
Boise, Idaho 83702

September 23, 2016

Molly R. Prickett
Environmental Engineer
Monsanto Company
Soda Springs Operations
1853 Highway 34
Soda Springs, Idaho 83276

Re: A/T Comments on Ballard Mine FS Report Memorandum 2 – July 2016

Dear Ms. Prickett,

The Agencies and Tribes (A/T) have reviewed the above referenced deliverable, submitted pursuant to the 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 (or 2009 AOC). This letter transmits preliminary comments on the draft deliverable. There may be additional comments provided on this deliverable as other specialists and peer reviewers are consulted and engaged in review of the project and selection of a preferred alternative to be presented in the proposed plan.

Please review the comments and provide a response to comments document. We will be available to discuss these comments in the coming weeks. Please contact me if you have questions. I can be reached at 208-378-5763 or electronically at tomten.dave@epa.gov.

Sincerely,

//s//

Dave Tomten
Remedial Project Manager

Enclosure

cc: Mike Rowe, IDEQ - Pocatello
Sandi Fisher, US FWS - Chubbuck
Kelly Wright, Shoshone Bannock Tribes
Susan Hanson (for the tribes)
Sherri Stumbo, Forest Service - Pocatello

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Colleen O'Hara-Epperly, BLM - Pocatello
Vance Drain, MWH (electronic version only)
Cary Faulk, Integrated-Geosolutions (electronic version only)
Shannon Ansley, Shoshone Bannock Tribes (electronic version only)
Dennis Smith, CH2MHill (electronic version only)
Gary Billman, IDL – Pocatello (electronic version only)
Jeremy Moore, US FWS – Chubbuck (electronic version only)

Attachment

A/T Comments on Ballard Mine Feasibility Study Report Memorandum #2, Screening, Detailed, and Comparative Analysis of Assembled Remedial Alternatives, Revision 0, July 2016

General

A. FS Memorandum #2 seems generally well written, and faithfully follows Comprehensive Environmental Response Compensation and Liability Act (CERCLA) Remedial Investigation (RI)/Feasibility Study (FS) guidance.

B. The presentation of upland soils and waste rock alternatives should acknowledge and discuss generally how construction of the proposed remedial components would be sequenced to avoid or minimize extended exposure of fresh soil and waste rock surfaces to climatic factors that would likely stimulate accelerated mobilization of chemicals of concern (COCs) and chemicals of ecological concern (COECs) into surface and groundwater.

C. The screening of surface water alternatives (Section 2) appears to assume that all seep flows are the result of precipitation and runoff migrating through dump material and can be reduced or eliminated through source control. Experience at other mine sites indicates that seeps are commonly surface expressions of groundwater and may not be significantly influenced by installation of covers. Please describe the implications of this condition relative to the remedial options proposed.

D. Given the proposed mining option and associated remedial action alternatives for the site, it is anticipated that site conditions may change as remedial options are implemented. For instance, modifying the extent of the remedial cover proposed for excavated dump areas based on relevant post Record of decision (ROD) sample results. Please describe P4's strategy with respect to (1) adapting remedial actions to changing site conditions and (2) applying lessons learned to subsequent design activities to optimize the success of a proposed preferred alternative (adaptive management).

E. Please state, where appropriate, that media placed in the permeable reactive barriers (PRBs) or extraction trenches will have suitable permeability to match hydraulic conductivity of surrounding material and adequate retention time to treat the intended contaminants to acceptable standards.

F. As would be expected, an FS-level design is more conceptual than the remedial design and carries a cost range of +50 to –30%. Please include some text in FS Memorandum #2 stating that the depiction and location of remedial features (such as sediment traps, constructed wetlands, and PRBs) are based on current knowledge of contaminated media, its potential mobility, current site conditions, and professional judgement, to facilitate comparison and detailed analysis of alternatives. Specific location and numbers of such features, if selected, shall be determined during remedial design, along with construction specifications and a refined range of costs (+15 to -10% for budgeting purposes).

G. Section 3 and accompanying tables present the detailed analyses of alternatives, including information on compliance with ARARs. There are a number of areas where this ARARs analysis should be expanded and supported with additional information or analyses, in particular compliance with the Clean Water Act Section 402 and 404. For example, with respect to Section 402, the document should provide information and/or rationale supporting the conclusion that discharges from constructed wetlands will achieve cleanup targets. With respect to section 404, the EPA must issue a 404 compliance memo prior to issuance of a ROD. Information must be available and presented for this compliance determination to be made, either in the FS or

perhaps in a separate deliverable. Information necessary includes, but is not limited to, information on the location and extent of waters of the US that are included in the site, the approximate number, location, and extent of fills necessary to implement the recommended actions (including road crossings, constructed wetlands, sediment control structures and the like). It is acknowledged that the initial 404b1 compliance determination at the ROD stage may be general, and that additional information and refinements would be made during the remedy design stage, with reissuance of the 404 compliance memo.

H. In recent months, there have been two water quality standards developments that may have implications for cleanup levels and that may affect the evaluation of ARARs compliance. These include issuance by EPA of a revised criteria recommendation for Se, and EPA's recent disapproval of the State of Idaho's criterion for As for protection of human health. These are issues where additional information and direction are forthcoming.

I. As discussed previously, the Ballard Shop closure plan or focused FS should be submitted for A/T review so that cleanup measures can be presented in the proposed plan.

Specific Comments

Report

1. Section 2.1.4, Page 2-5, Revegetation – Please provide references regarding determination of plant species that do not accumulate selenium.
2. Section 2.3.1, Page 2-8, first paragraph under Alternative 4 heading – For clarification, it would be helpful to include a cross section of the evapotranspiration (ET) cover intended to illustrate the sequence of layers comprising the proposed cover.
3. Section 2.3.1, Page 2-10, second paragraph from top of page – For clarification, it would be helpful to include a cross section of the multi-layer cover system intended to illustrate the sequence of layers comprising the proposed cover.
4. Section 2.3.1, Page 2-11, third paragraph – Provide clarification on whether the high carbon ore is currently exposed from historical mining operations or is in undisturbed portions of the mine.
5. Section 2.3.1, Page 2-11; third paragraph from top – Delete ")" from "...incompatible with the selected cover system)."
6. Section 2.3.1, Page 2-11, fourth paragraph – If the ore recovery is from areas not previously mined, it will add to the total area to be reclaimed, and any additional topsoil stripped in the process will be needed to reclaim the newly impacted area; therefore, it would not appear to produce "…additional unimpacted overburden in the selected cover system…" as stated.
7. Section 2.3.2, Page 2-4, Surface Water, Alternatives 3 and 4 – Please clarify how P4 is differentiating "in situ biological (wetlands) treatment" (Alternative 3 – retained) versus "ex situ bioreactor treatment" (Alternative 4 – not retained). True anaerobic wetlands are outdated technology and their ability to effectively treat all the surface water COCs and COECs (i.e., arsenic, cadmium, or selenium) is questionable. Most modern passive treatment systems for mining-influenced water include one or more anaerobic (sulfate-reducing) biochemical reactors (BCRs), along with aerobic ponds or wetlands for polishing. Although these are often constructed as in-ground basins, they are not truly "in situ." From the discussion in FS Memorandum #1, it appears that the term "ex situ bioreactor" (Alternative 4) is intended to mean an aboveground, active treatment system like the ABMet process. Please clarify where a passive or semi-passive BCR-based system would fit in these alternatives. This is important because a passive BCR-based system could be a good process option for surface water treatment – more effective than a simple wetland, and less expensive and labor-

intensive than an active bioreactor system. Please acknowledge that the selection of any of these treatment systems carries some uncertainty, which would be resolved through pilot testing to demonstrate effective treatment for all of the COCs and COECs and to develop design criteria, or cite local or related documented pilot studies as backup.

8. Section 2.3.2, Page 2-4, Surface Water, Alternatives 3 and 4 – Alternatives using passive as well as active systems should include costs for decommissioning or removal and residuals disposal at the end of the treatment period, to remove the precipitated contaminants from the environment and avoid possible re-solubilization and release of contaminants in the future. Please clarify whether this is included in the cost estimate for Alterative 3.

9. Section 2.3.2, Page 2-14, second paragraph under Alternative 3 bullet – Please qualify the description of the benefits of the wetlands treatment. As it stands, the paragraph describes water treatment benefits likely to come from established, mature wetlands, rather than newly "constructed" wetlands. Please include the likely maturation process and timetable of a constructed wetland that would eventually yield the desired results. Please cite local or related documented pilot studies as backup.

10. Section 2.3.3, Pages 2-15 through 2-17, Sediment/Riparian Soil, Alternatives 2 through 4 – It is questionable whether monitored natural recovery (MNR), as used in Alternative 2 (not retained), is consistent with United States Environmental Protection Agency (EPA) policy, which indicates a strong preference for natural attenuation mechanisms that degrade or (more importantly for inorganics) immobilize contaminants, rather than simply allowing them to disperse over time (see excerpt below). The use of MNR in Alternative 3 (retained) seems somewhat more consistent with EPA policy because it includes sediment traps to collect and allow proper disposal of contaminated sediment. Alternative 4 (retained) seems even more consistent with EPA policy because it includes both excavation and removal of the most-contaminated sediment and MNR for final polishing after concerted efforts at source control or removal.

    > ***However, dilution and dispersion generally are not appropriate as primary MNA mechanisms because they reduce concentrations through dispersal of contaminant mass rather than destruction or immobilization of contaminant mass.*** Dilution and dispersion may be appropriate as a "polishing step" for distal portions of a plume when an active remedy is being used at a site, source control is complete and appropriate land use and groundwater use controls are in place.[1] [emphasis in original document]

11. Section 2.3.3, Page 2-15, Sediment/Riparian Soil, Alternative 2 – Please define the term "natural processes" to clarify for the reader what specific processes contribute to MNR.

12. Section 2.3.3, Page 2-16, paragraph associated with Alternative 3 – Please describe what the likely fate of water impounded by the sediment traps or basins would be (initially it may be contaminated), and whether the impounding of this water would have any effect on the "natural processes" that contribute to the success of the MNR further downstream.

13. Section 2.3.3, Page 2-16, second paragraph – Sediments cleaned from the traps are described as being disposed of in designated areas under the soil/waste rock cover. The sediments will need to be cleaned from the traps and disposed of over a longer period of time than it takes to cover the exposed rock; therefore, the TM should describe accomplishing this after the cover is installed.

14. Page 2-18, paragraph associated with Alternative 3 – Please include documentation (as an attachment) that permeable reactive barriers will work in this environment with these

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[1] EPA. 2015. *Use of Monitored Natural Attenuation for Inorganic Contaminants in Groundwater at Superfund Sites*. OSWER Directive 9283.1-36, August 2015. (p. 14)

contaminants. This is generally demonstrated by site-specific pilot study results or reference to local studies at other mine sites with similar climatic conditions and contaminants (e.g., South Rasmusson Mine).

15. Section 2.3.4, Page 2-18, Groundwater, Alternative 3 (retained) – This alternative employs MNA for polishing after PRBs and as the sole remedial approach in the Wells formation groundwater. While the former might be considered consistent with EPA policy, the latter seems questionable (see Comment 10); please clarify. PRB treatment would likely require pilot testing to demonstrate effective treatment for all of the COCs and COECs and to develop design criteria. In addition, this alternative should include costs for decommissioning or removal of the PRB at the end of the treatment period and for residuals disposal, to remove the precipitated contaminants from the environment and avoid possible re-solubilization and release of contaminants in the future.
16. Section 2.3.4, Page 2-18, Groundwater, Alternative 4 (not retained) – Although this approach has been proposed elsewhere, there is a potential critical flaw with the technology involving injection of reagents for treatment of inorganics in soil and groundwater. Most often, this approach involves injection of organic substrate or chemical reducing agent to create anaerobic conditions and precipitation of metals as reduced species (often as sulfides). The potential problem with this approach is if the deeply reducing conditions are not maintained indefinitely by reagent addition, the groundwater can revert to more oxidizing conditions and the immobilization reactions can be reversed, resulting in re-solubilization of the contaminants.
17. Section 2.3.4, Page 2-18 to 2-19, Groundwater, Alternative 5a (not retained) – This alternative used MNA as the primary remediation mechanism for alluvial groundwater. Is this use consistent with EPA policy? Alternative 5a was reportedly not retained because "the component associated with the Wells Formation is judged to have low/moderate effectiveness and technical feasibility, with high cost." Agree with high cost, but it is not clear why the effectiveness and technical feasibility of Wells formation groundwater extraction and treatment is considered low; please explain. Table 2-4 ranks effectiveness as moderate to high. While it ranks technical feasibility low, it is not clear why.
18. Section 3.1.2, Page 3-3, sixth paragraph, Cost – 30 years is used as the net present value period. The cited reference, *A Guide to Developing and Documenting Cost Estimates During the Feasibility Study* (EPA, 2000) includes the guidance "…the blanket use of a 30-year period of analysis is not recommended." Provide justification for the use of a 30-year period in the cost analysis.
19. Section 3.2, Page 3-5, Last sentence in the first paragraph – Remove the second "… the screening."
20. Section 3.2.2, Page 3-8, first complete sentence – Please correct "The estimates…" to "The estimated…."
21. Section 3.2.4, Page 3-11, second paragraph – The bulleted list of volume descriptions uses loose yards for quantities of material available in the dumps and quantities required in the backfill of the pits. The material in the dumps should be considered bank fill and (when placed in the pits, assuming some compaction requirement in the remedial design) compacted fill. Therefore, the cubic yards of material available and material required would not have a one-to-one correlation. Volumes should be adjusted to reflect this or an explanation of why it is not required should be added.
22. Section 3.3, Page 3-14, number second paragraph – The assumption that all seeps will disappear following source control implies that the seeps are surface water-related rather than groundwater-related. This is unsubstantiated unless there is flow data that shows a strong correlation between seep flows and wet weather or runoff seasons.
23. Section 3.3.3, Page 3-16, first paragraph – This paragraph refers to "perennial seeps" that would seem to imply groundwater-fed seeps as opposed to surface water-seeps, as was assumed in

Section 3.3 (see previous comment). In order to compare these alternatives, a common assumption on the nature of these seeps and springs is required.

24. Section 3.5.3, Page 3-25, Groundwater, Alternative 3, Bullet 2 – Cost assumption of 1.5-foot-wide PRB filled with iron "fillings" (please correct – should be "filings") may be overly simplistic and may lead to underestimation of cost.

25. Section 3.6.1, Page 3-30, first paragraph (Short-Term Effectiveness) – This approach combines a CERCLA action with a mining operation. Some discussion should be given to how this affects worker safety, because CERCLA action would be covered by Occupational Safety and Health Administration (OSHA) safety requirements and include Hazardous Waste Operations and Emergency Response (HAZWOPER) training for workers, whereas mining operations would be covered under the Mine Safety and Health Administration (MSHA) and have no HAZWOPER requirements. Design requirements for things like haul roads are also different under the two operations and may have short- or long-term impacts on the total operation.

26. Section 3.6.3, Page 3-35, third paragraph (Long-Term Effectiveness) – The first sentence states that Alternative 4 would best address long-term effectiveness in the short term. This language is confusing in the context of the subject. Short-term effectiveness is addressed in its own separate paragraph. Please clarify.

27. Table 3-1a, Upland Soil/Waste Rock Alternative 4, Short Term Effectiveness Criteria, 5A Detailed Analysis Ranking – It is recommended that this ranking be changed from "High" to "Moderate to High." Although unique positive attributes are called out under Environmental Impacts, these are offset by needing a longer haul route to deliver the ore (best management practices needed over a longer distance), and a significantly longer construction duration (6 to 8 years), resulting in more truck traffic (potential for safety and haul related issues). Longer construction periods translate into potential for more worker protection issues as well.

28. Table 3-1a, Upland Soil/Waste Rock Alternative 4, Short Term Effectiveness Criteria, 5A Detailed Analysis Ranking – *Time until Remedial Objectives are Achieved Criteria* column lists Alternative 7 with a construction duration of 5 to 7 years. This is shorter than the 6 to 8 years called out in the text (page 3-13; second paragraph). Please make consistent.

29. Section 3, Page 3-16 etc., surface and groundwater alternatives under various *Detailed Analysis Summaries* – Please describe the method used to establish a cleanup timeframe cited for each surface water and groundwater alternative.

30. Section 3.3.3, Page 3-16, Surface Water, Alternative 3 – Has an inventory of wetlands been conducted on the Ballard Mine Site? If not, when will such an inventory be performed? If an established wetland is found along a stream reach proposed for installation of a remedial wetlands, will the existing wetlands be retained as a remedial feature? What criteria will be used to dictate the size of a remedial wetlands to promote adequate water retention and treatment time (which affects cost)? Please expand the discussion under this alternative to address these items, or specifically state that such information will be deferred to remedial design for development.

31. Table 3-2, Surface Water Alternative 3, 3B) Comparative Analysis Criteria, last sentence – Please change "…CERCLA 4-year review" to "…CERCLA 5-year review."

32. Table 3-2, Surface Water Alternative 3, 4) Reduction of Toxicity, Mobility, or Volume through Treatment Criteria, 4A) *Detailed Analyses* – Consider changing the ranking from High to Moderate because (1) the beneficial treatment processes described in the table are more reflective of "mature functioning" wetlands rather than newly constructed wetlands and (2) "…the effectiveness of wetlands treatment has not been demonstrated for site surface waters." Both conditions are inconsistent with a High rating.

33. Table 3-2, Surface Water Alternative 3, 5) Short-term Effectiveness, *Time until Remedial Objectives are Achieved* – Last sentence under Alternative 3 states "For practical purposes, the water discharging from the wetlands is expected to meet the cleanup levels *in a very short time frame* following construction (e.g., within weeks)." Please clarify, or describe more completely, the basis for determining this functional timeframe. The text under Alternative 6, Implementability and *Availability/Demonstrated Effectiveness of Prospective Technologies Criteria* states "…the effectiveness of wetlands treatment has not been demonstrated for site surface waters."

34. Table 3-3, Sediment/Riparian Soil Remedial Alternatives, 2) Compliance with ARARs – It seems that Alternative 3 (Sediment Traps and MNR) are a less robust means of achieving chemical-, location-, or action-specific ARARs than is Alternative 4, where contaminated sediment is actively removed and MNR is left as a polishing technology. Yes, this alternative would result in effects to several seep and stream reaches, but no wetlands have been identified, excavated areas can be quickly replanted, and work can be coordinated when the cover is being installed in the area. Recommend changing the 2A) *Detail Analysis* rating for Alternative 3 to "Moderate" and Alternative 4 to "High."

35. Table 3-3, Sediment/Riparian Soil Remedial Alternatives, 6) Implementability, 6A) *Detailed Analysis* – Under Alternative 4, change "The ability to implementability of Alternative 4…" to "The implementability of Alternative 4…"

36. Section 3.4, Paged 3-18, second paragraph – Aren't there three mechanisms for COCs/COECs migrating to sediment/riparian soil? Material transport via erosional forces, surface water runoff, and infiltrated water that surfaces via seeps/springs. Revise accordingly.

37. Section 3.4.2, Page 3-19, second paragraph – It states "Disposal of any contaminated sediment retained in these structures over the long term should be relatively easy to place under an adjacent upland soil/waste rock soil cover." Wouldn't this entail digging up the cover, placing the contaminated sediment, replacing the cover, recontouring as needed, and reseeding? That doesn't necessarily sound relatively easy. Revise accordingly.

38. Section 3.5.2, Page 3-24, third paragraph – Sampling may have to be done twice a year depending on when the highest COC/COEC concentrations are observed. Revise accordingly.

39. Section 3.5.3, Page 3-25, Bullet 2 – As it doesn't sound like there has been a decision made as to what material would be used for the PRB, change "an iron-filings-filled" to something like "a treatment media-filled."

40. Section 3.6.1, Page 3-29, Bullet 1 – It states "because the areas underlying the upland soil/waste rock dumps are assumed to be impacted by migration of constituents from the waste rock dumps to the underlying soil and would have to be graded and covered after the waste rock is removed." Intuitively this might make sense, but provide data to support this. Although not directly comparable (ore vs ROM or center waste shale), removal of phosphate ore at the Georgetown Canyon Industrial Complex Area did not require a cap on the daylighted native soil. A cap was placed on the area because of the buried elemental phosphorus.

41. Section 3.6.2, Page 3-31 – The assumption is that the sole source of water to the upland soil/waste rock is meteoric. Are there any upland soil/waste rock areas where the source of seeps/springs might be spring water located at the natural ground-waste rock interface? If so, reducing/eliminating meteoric water may or may not result in "the mine-affected seeps/springs near the margins of the former mined area to eventually go dry or otherwise meet the surface water cleanup levels over time through substantial reduction of precipitation infiltrating into upland soil/waste rock." Revise as needed.

42. Section 3.6.2, Page 3-42, Groundwater, bullet list of advantages of Groundwater, Alternative 3 (including PRBs), Bullet 3 – Suggest that treatment residuals should include used PRB materials at

project end, at a minimum, and that an allowance be included for possible replacement of fouled or spent PRB media during the treatment period (and that these factors be included in the cost estimate). For Bullet 2, suggest that decommissioning should include removal of used PRB media at the end of the treatment period (and possibly some extra width of soil downgradient of the PRB), to remove immobilized contaminants and avoid the potential for re-mobilization.

43. Section 3.6.3, Page 3-37, Bullet 1 (Partial) – It says "The implementability of Alternative 4 also is complicated by the fact that additional background data (inclusive of all geologic formations including the Phosphoria Formation) may be necessary for sediment/riparian soil to refine the preliminary cleanup levels because as presented in Ballard FS Memo #1 the cleanup levels are very low and might be unattainable." This makes it sound like additional background work may be needed to help establish preliminary clean-up levels for sediment/riparian soil for Alternative 4 only. However, preliminary cleanup levels (PCLs) would apply for all alternatives. They would just have to be addressed sooner with actual excavation versus monitored natural recovery. Revise accordingly.
44. Section 3.6.4, Page 3-39, Bullet 2 (Long-term Effectiveness and Permanence) – According to Table 3-4, Alternative 2 ranks "Moderate" with Alternatives 3 and 5b being "Moderate and High(?)" or "Moderate to High." Reconcile.
45. Section 3.6.4, Page 3-40, Bullet 2 (Short-term Effectiveness) – Alternative 4 was eliminated and not discussed. Revise.
46. Table 3-2, Page 5, Row Environmental Impacts, Column Alternative 3, second paragraph – Is there potential for the wetlands to reach the point of COC/COEC saturation prior to cleanup levels being achieved, which in turn would require removal/disposal of the wetland substrate and vegetation? If so, this needs to be mentioned. Revise accordingly.
47. Table 3-3, Page 3, Row Treatment Process Used and Materials Treated, Column Alternative 3, line 1 – Change to "This alternative relies on sediment traps/basins."
48. Table 3-3, Page 3, Row Treatment Process Used and Materials Treated, Column Alternative 3 – Explain how COC/COEC concentrations in the Blackfoot River are generally low, yet the river is on the 303(d) list for selenium.
49. Table 3-3, Page 3, Row Treatment Process Used and Materials Treated Column Alternative 4 – It seems like some of the removal of more highly contaminated sediment/riparian soil could be coordinated with the construction of the engineered wetland, thereby reducing the cost. Discuss.
50. Table 3-3, Page 6, Row Time Until Remedial Objectives are Achieved Column Alternative 4, second paragraph, sentence 1 – Reword, perhaps to "In the lower reaches of the drainages where MNR is the remedy, the time until the remedial objectives are met would be reduced compared with the expected duration for Alternative 3."
51. Table 3-3, Page 6, Row Time Until Remedial Objectives are Achieved Column Alternative 4, second paragraph, sentence 2 – Confirm that this would assume that COC/COECs are being transported via the water column and chemical sorption is taking place in sediment and/or riparian soil in the lower reaches. Otherwise, why would there be a reduction in the overall timeframe for meeting remedial objectives in the lower reaches for Alternative 4 vs Alternative 3, as contribution of sediment/riparian soil to the lower reaches is eliminated either right away (excavated) or over time (capture in sediment traps/basins)?
52. Table 3-4, Page 1, Row EPA Evaluation Criteria, Column Alternative 5b, second paragraph, sentence 2 – Other places (later in table, text) do not present discharge to a basin as an option for discharge treated Wells Fm water. Revise accordingly.

53. Table 3-4, Page 2, Row 2B) Comparative Analysis, Column Alternatives 1, 2, 3, 5b, sentence 4 – This sentence reads awkwardly. Change perhaps to "… Alternatives 2 and 5b are similar as to compliance to these ARAR types ..."

54. Table 3-4, Page 2, Row 3A) Detailed Analysis Column Alternative 3 – Should it be "Moderate to High"? Revise accordingly.

55. Table 3-4, Page 2, Row Adequacy and reliability of controls, Column Alternative 5b, second paragraph, Sentence 2 – Change to "The WTP would require frequent monitoring/adjustment, and equipment is expected to need periodic maintenance/replacement."

56. Table 3-4, Page 2, Row Adequacy and reliability of controls, Column Alternative 5b, second paragraph, line 8 (last) – Change "shallow" to "alluvial" for consistency.

57. Table 3-4, Page 4, Row Degree to Which Treatment is Irreversible, Column Alternative 5b, sentence 2 – This seems to be the opposite of what was said under Alternative 2. Reconcile.

58. Section 4.0 Combined Remedy, Page 4-1.

The reach of the N. Fork of Wooley Valley Creek adjacent to, and NE of, waste rock dump MWD084 has been identified as an area of focus where additional information is necessary (see illustrations below).

This reach includes several ponds at the upper end and is bracketed by surface water stations MST093 (North) and MST092 (South). There appears to be intermittent seep from the dump (MWD084) feeding the main stem (see illustration below). Moving further south downgradient of this reach section, additional seeps flowing east from waste rock dump MWD082 form approximately three tributaries to the main stem before encountering surface water station MST092.

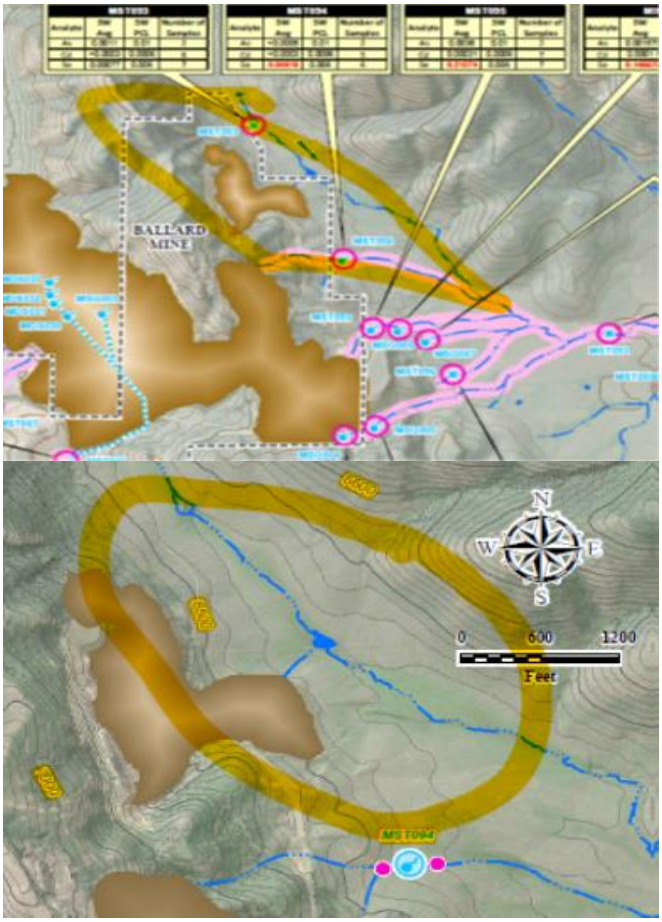
Based on both FS memoranda, characterization data (media and average Se concentrations) along the North Fork of Wooley Valley Creek from SW station MST093 south to its confluence with the first seep tributary from dump MWD082 (area of concern) include the following:

- Surface water and riparian monitoring station (MST093) **(Ref. TM#2 Fig 3-5)**
  - Surface water [7 samples; Se ave., 0.00077 mg/L]
  - Riparian soil [1 sample; Se max, 1.5 mg/kg]
  - Sediment [1 sample; Se max, 1.0 mg/kg]
- Direct push alluvial aquifer wells (MBW131 and MBW048) **(Ref. TM#1 Fig 2-3)**
  - MBW131 [2 samples; Se ave., 0.0038 mg/L]
  - MBW048 [4 samples; Se ave., 0.0019 mg/L]
- Local aquifer monitoring well MMW032 **(Ref. TM#1 Figs 2-3 and 2-6)**
  - MMW032 [3 samples; Se ave., 0.0005 mg/L]
- Approximately 6 direct push boreholes (2008 and 2009) **(Ref. TM#1 Fig 2-7)**
  - BH054; Se 0.43 mg/L (Exceed Se PCL)
  - BH132; Se 0.006 mg/L (Exceed Se PCL)
  - BH052; Se 0.27 mg/L (Exceed Se PCL)
  - BH053; Se 1.25 mg/L (Exceed Se PCL)
  - BH133; Se <0.0005 mg/L
  - BH050; Se 0.003 mg/L
  - BH049A; Dry
  - BH049B; Dry

Using Google Earth, the reach of concern is approximately 0.8 to 1 mile in length. This reach is not proposed for any remedial action (including installation of sediment ponds or PRBs for a groundwater plume). Please clarify why. The existing data through this area is sparse and, by itself, does not appear to support the conclusion that no remedial activities are necessary. It is recommended that additional

sampling of riparian soils, sediment, and surface water (where it is present) be performed to confirm the proposed status of this area. If P4 has additional sampling results or additional information that would support that supplemental data collection is not needed for this area, then please provide it to the A/T. This issue will not delay advancement of the FS; however, it will need to be addressed in the Remedial Design/Remedial Action process, if not sooner.

P4 may want to consider additional surface water sampling this fall of any ponds along this reach retaining water, or consider adding a couple of sampling stations in the spring to help bracket MWD084 to confirm that it is not contaminated or contributing to offsite migration of contaminated surface water or sediment.



59. Section 4.1.1, Page 4-2 – Explain how long-term monitoring of the performance of the wetlands helps to determine if the remedial action objectives for groundwater are met.

60. Section 4.1.2, Page 4-3, Second paragraph, Sentence 5 (last) – It seems possible that the accompanying wetlands could be eliminated if the PRB at a particular site is treating surfacing groundwater to below the surface water standard. However, it appears that the wetlands will be built first "during the waste rock consolidation and cover system construction activities" (see earlier in paragraph). Explain how one or the other might be eliminated.

61. Section 4, Recommended Combined Remedy, Page 4-1 – There is considerable uncertainty about how effective the two water treatment methods—in situ wetland (depending on how this is defined – see previous comment) for surface water, and PRBs for groundwater—will be for all COC/COECs. While it may be possible to achieve effective treatment using these technologies, it is not clear what the correct sizing is or what combination of treatment units might be required. Ideally, treatability (pilot) testing would be conducted as part of the FS process to address key questions about

effectiveness, design, operations, and maintenance to allow more accurate cost estimation and support preferred remedy selection and preparation of the proposed plan.

62. Sections 4.2 and 4.2.1, Ballard Shop, Page 4-7 – It is understood that remedial action for the Ballard Shop is proposed for after the area is no longer actively used. However, a proposed schedule for when P4 would be submitting a "…brief FS-level closure plan for the Ballard Shop so that it can be included in the remedy" and performing associated investigative studies would be helpful for advancing the entire project to a proposed plan and Record of Decision. Please include this information in this section.

Appendix A – FS Cost Estimate

Appendix A – FS Cost Estimate

General Comment:

EPA guidance recommends that estimates for professional services be presented in specific categories with level of effort percentages based on the relative size of the remedial project capital costs, as illustrated in Exhibit 5-8.

Exhibit 5-8

Capital Cost Element	< $100K (%)	$100K-$500K (%)	$500K-$2M (%)	$2M-$10M (%)	> $10M (%)
Project Management	10	8	6	5	5
Remedial Design	20	15	12	8	6
Construction Management	15	10	8	6	6

Source: *A Guide to Developing and Documenting Cost Estimates During the Feasibility Study* (EPA, 2000)

The Ballard Mine FS cost estimate presents the following professional services categories at a consistent rate for each medium, as indicated.

- Engineering (8 percent)
- Construction Management and Oversight (14 percent)
- Contingency (10 percent)

For clarification, it is recommended that professional service categories and estimated percentage of construction costs be revised to be more consistent with EPA guidance for estimating FS costs.

Specific Comments

<u>Table A-1: Upland Soil/Waste Rock Alternatives</u>

Alternative 1 – No Action

- No comments

Alternative 4 – Upland Soil/Waste Rock Consolidation and/or Grading with an Evapotranspiration (ET) Cover System, ICs, and LUCs, and LTM

- Direct Capital Cost
  - Mobilization/Demobilization

        - Where is site preparation and laydown area development captured?
        - Regarding clearing and grubbing, how much cleared material will be generated and how and where is that material being handled?
    - Waste Rock Removal, Onsite Consolidation and Regrading
        - Do any haul roads need to be constructed or will existing haul roads be used?
        - Are costs captured for periodic road maintenance and dust control?
        - Do erosion control measures need to be installed and maintained during construction?
        - Is there any potential for variation in excavation unit rates because of haul distance or production issues?
        - Surveying for layout, volume surveys and as-builts should be included.
        - Noted that engineered land use controls (LUCs) will be required in the alternative description (fence, signage, gates). Where is this cost captured?
    - Total Direct Costs
        - Noted that total does not include subcontractor markup or profit. Where is this captured in the summary?
- Annual Costs
    - Is a yearly Long-term Monitoring (LTM) Report required to document the semi-annual inspections or are reports required every 5 years?
    - Are any periodic costs, such as erosion repair, vegetation maintenance or fence repair anticipated during the out years?

Alternative 6 – Upland Soil/Waste Rock Consolidation and/or Grading, Incidental Ore Recovery, ET Cover System, ICs, LUCs, and LTM

- Same comments as noted above in Alternative 4.

Alternative 7 – Complete Consolidation of Existing Waste Rock into the Pits, ET Cover System, ICs, LUCs, and LTM

- Same comments as noted above in Alternative 4.
- Additional Comments:
    - Direct Capital Costs
        - Import material for MMP039 and MMP038 – Is any material being imported from offsite or is all this from an onsite source? May impact unit rates.

<u>Table A-2: Remaining Surface Water Alternatives</u>

Alternative 1 – No Action

- No comments

Alternative 2 – ICs and LUCs

- Annual Costs
    - Is a yearly LTM Report required to document the semi-annual inspections or are reports required every 5 years?

Alternative 3 – In Situ Treatment, ICs and LUCs

- Direct Capital Cost
  - Mobilization/Demobilization
    - Where is site preparation and laydown area development captured?
    - Clearing and grubbing – how much cleared material will be generated, and how and where is that material being handled?
  - Surface Water Remedial Components
    - Costs for constructing collection basins appears low based on the conceptual scope.
    - Will the excavated spoils for the wetland basins be left locally or hauled to a common stockpile area? Is this cost captured?
    - Surveying should be included for layout and as-builts.
- Annual Costs
  - Same comment regarding LTM Report.

<u>Table A-3: Remaining Sediment/Riparian Soil Alternatives</u>

Alternative 1 – No Action

- No comments

Alternative 3 – Sediment Traps/Basins, MNR, ICs and LUCs

- Annual Costs
  - Same comment regarding LTM Report.

Alternative 4 – Removal/On-site Disposal, MNR, ICs, and LUCs

- LTM
  - Are periodic erosion or vegetation replacement costs captured during the 30-year LTM?

<u>Table A-4: Remaining Groundwater Alternatives</u>

Alternative 1 – No Action

- No comments

Alternative 2 – Sediment Traps/Basins, MNR, ICs and LUCs

- Is well abandonment required upon completion of the 30-year LTM period?

Alternative 3 – Removal/On-site Disposal, MNR, ICs, and LUCs

- Direct Capital Cost
  - Mobilization/Demobilization
    - Where is site preparation and laydown area development captured?
    - Clearing and grubbing – how much cleared material will be generated and how and where is that material being handled?
    - Single-pass mobilization appears low based on recent budgetary quotes from DeWind on similar projects.

- Groundwater Remedial Components
  - Include transportation costs for iron filings.
  - Is any site preparation or grading required prior to constructing the PRB wall?
  - Should include move and set-up per seep location for PRB equipment.
  - How are the trench spoils being handled?
  - Should include well development and investigation-derived waste costs for monitoring well installation.
  - Zero-valent iron PRB Installation cost appears low.
  - Surveying should be included.

- Annual Costs
  - Same comment regarding LTM Report.
  - Any routine maintenance required during the 30-year LTM?

Alternative 5b – Pump and Treat, and ICs

- Direct Capital Cost
  - Wells Formation Groundwater Extraction Wells
    - Containerizing and disposal of extraction well and piezometer development water should be included.
    - Surveying should be included.
    - What is the power source and electrical distribution for the extraction well pumps?

Appendix B – Cover System Evaluation

1. As a cross-check of the estimations of necessary cover thickness that will effectively limit infiltration of precipitation through cap materials into Se-bearing waste rock, it is recommended that technical personnel from P4 and associated subcontractors consider the attached reference documents by W. Albright and C. Benson. Albright and Benson have and are currently working in the SE Idaho phosphate patch helping design and test cover designs. Their findings may be helpful for evaluating the conceptual cover design for the Ballard site and planning the future remedial cover design.

2. The final cover design should be based on the upper bound of measured precipitation (or the 100-year event or maximum recorded precipitation), rather than on average annual precipitation. Precipitation amounts from the highest elevation of the project area should be the data used in cover design (i.e., 30 inches per year). Please confirm this will be done during remedial design.

3. Appendix B, Attachment 1 (Golder Report), Page 16, Table 3, Typical Reclamation Seed Mix – The seed mix includes alfalfa as a component of “Monsanto Reclamation Seed Mix.” Given the potential for a deep root (36 to 72 inches), it is suggested the plant list be reviewed to identify and potentially eliminate deep-rooted plants from the mix, if these are intended as cover vegetation in an ET-containment system.

4. No substantive comments for change. However, there were a number of editorial changes we recommend. (All page numbers refer to the PDF page)

- Page 178, third paragraph, third line – Fix figure reference.
- Page 183, second paragraph, second line – Typographic error “Figure,” and need to fix figure reference.
- Page 184, second paragraph, third line – Fix figure reference.
- Page 184, second paragraph, fourth line – Fix table reference.
- Page 184, second paragraph, eighth line – Fix table reference.
- Page 187, first paragraph, first line – Fix table reference.
- Page 187, fourth paragraph, first line – Fix table reference.
- Page 189, third paragraph, second line – Fix figure reference.
- Page 189, third paragraph, sixth line – Fix figure reference.
- Page 189, fourth paragraph, third line – Fix table reference.

Ballard Mine Feasibility Study Report
Memorandum 2 – Screening, Detailed, and Comparative Analysis of Assembled Remedial Alternatives (August 2016)

Editorial Comments

Item No.	Section; Table; Figure	Page	Paragraph	Line (if not obvious)	Agency/Tribe Comments
	1.1	1-1	1	1	Insert “into” to read “… entered into an …”
	1.1	1-1	1	6	Change “tribes” to “Tribes.”
	1.3	1-3	Section 3.0	1	Insert “Action” to read “Remedial Action Alternatives” for consi
	2	2-1	1	3	Change “on” to “in” to read “… detailed in Tables 2-1 through 2-
	2	2-1	2	1	Change “on” to “in” to read “… screened in Tables 2-1 through 2
	2.3.1	2-9	1 (partial)	3	Change “are” to “is” for subject-verb agreement.
	2.3.1	2-10	1 (partial)	3	Change “are” to “is” for subject-verb agreement.
	2.3.1	2-11	2	3	Change to “Henry Mine.”
	2.3.2	2-13	Bullet 2 (Alternative 1 – No Action)	3	Delete the second “would not.”
	2.3.2	2-15	Bullet 2 (Alternative 5 – Ex-Situ Treatment …)	11	Change to “… and 5) overall higher costs.”
	2.3.4	2-18	Bullet 2 (Alternative 4 – In-Situ Treatment …)	9	Delete “it” to read “… because in-situ treatment …”
	3	3-1	Bullet 2	3	Change “on” to “in” to read “… presented in tables …”
	3.2	3-5	1	9	Insert a comma to read “… (soil cover), Alternative 4 …)
	3.2	3-5	1	10	Delete the second “the screening.”
	3.2.4	3-12	2	4	Change to “alternatives.”
	3.2.4	3-12	2	5	Change to “assumed.”
	3.2.4	3-13	2	3	Change to “weather-related.”
	3.3	3-13	4	3	Change “on” to “in” to read “… presented in Table 3-2 …”
	3.3.2	3-15	1	4	Change “contacts” to “contact” for subject-verb agreement.

Editorial Comments

Item No.	Section; Table; Figure	Page	Paragraph	Line (if not obvious)	Agency/Tribe Comments
	3.3.2	3-15	1	13	Sampling may have to be done twice a year depending on when COC/COEC concentrations are observed. Revise accordingly.
	3.4	3-17	4	3	Change "on" to "in" to read "… presented in **Table 3-3** …"
	3.4.2	3-20	1 (partial)		Insert "and" to read "… track and evaluate the effectiveness …"
	3.4.3	3-22	1	1	Insert "an" to read "… would require an RD and …"
	3.4.3	3-22	2 (Detailed Analysis Summary)	10	Change "costs" to "cost."
	3.5.1	3-23	5 (Detailed Analysis Summary) (last)	6 (last)	Change "is" to "are" for subject-verb agreement.
	3.5.2	3-25	1 (Detailed Analysis Summary)	14 (last)	Change "is" to "are" for subject-verb agreement.
	3.5.3	3-26	2 (Detailed Analysis Summary)	9	Delete the space to read "long-term."
	3.5.3	3-26	2 (Detailed Analysis Summary)	13	Change "is" to "are" for subject-verb agreement.
	3.6.1	3-31	Bullet 3 (Aesthetics)		The phrase "it would result in a reclaimed surface that would co and more naturally blends into with the surrounding native landscape/landforms" reads awkwardly. Revise.
	3.6.2	3-32	Bullet 1 (Overall Protection of Human Health and the Environment)	10	Delete the semi-colon to read "…because even if coupled with s controls, no ICs or LUCs would be implemented …"
	3.6.2	3-33	Bullet 3 (Short-term Effectiveness)	2	Insert a semi-colon and comma to read "… or workers; however
	3.6.2	3-33	Bullet 5 (Cost)	1	Insert a semi-colon and comma to read "… LUCs; however, Alter
	3.6.3	3-36	Bullet 1 (Reduction in Toxicity, Mobility, and Volume through Treatment)	2	Change "ranks" to "rank."
	3.6.3	3-36	Bullet 2 (Short-term Effectiveness)	10	Delete the first hyphen to read "sediment/riparian soil-removal
	3.6.3	3-37	Bullet 2 (Cost)	2	Change "and" to "of" to read "… for protection of human health environment …"
	4.1.4	4-4	Bullet 2	Sentence 2	Add a period at the end of the sentence.
	Table 2-4	1	Row Alternative 2	Column Alternative Description	Insert "be" to read "would be implemented."
	Table 3-2	3	Row 3B) Comparative Analysis	Columns Alternatives 1, 2, & 3	Line 5, change "4-year review" to "5-year review."
	Table 3-2	3	Row Treatment Process Used and Materials Treated	Column Alternative 3	Line 1, change "surfaces" to "surface."

Editorial Comments

Item No.	Section; Table; Figure	Page	Paragraph	Line (if not obvious)	Agency/Tribe Comments
	Table 3-3	5	Row Environmental Impacts	Column Alternative 4	Second paragraph, line 1, change "need" to "needs" for subject- agreement.
	Table 3-3	6	Row Time Until Remedial Objectives are Achieved	Column Alternative 4	Paragraph 1, line 2, add a comma after "However."
	Table 3-3	7	Row Ability to Construct and Operate the Technology	Column Alternative 4	Third paragraph, sentence 4, change to "The ability to impleme 4 …"
	Table 3-3	9	Row Availability/Demonstrated Effectiveness of Prospective Technologies	Column Alternative 4	Second paragraph, sentence 4, change to "Site characterization necessary to inform the design of sediment/riparian soil remova volume estimates, and guide initial excavations during the RA."
	Table 3-4	1	Row EPA Evaluation Criteria	Column Alternative 3	Second paragraph, line 2, change to "upgradient" for consistenc
	Table 3-4	1	Row Location- and Action-Specific ARARs	Column Alternative 5b	Line 4, change "injected" to "injection."
	Table 3-4	2	Row Magnitude of residual risk	Column Alternative 2	Line 5, change to "… maintained to restrict contact …"
	Table 3-4	2	Row Magnitude of residual risk	Column Alternative 5b	Insert a semi-colon to read "… cleanup levels in GW; they are re
	Table 3-4	5	Row Protection of Community During RAs	Column Alternative 5b	Line 2, change "that" to "than" to read "… more time to comple other alternatives."
	Table 3-4	5	Row Environmental Impacts	Column Alternative 3	Paragraph 1, line 1, change "MNR" to "MNA."
	Table 3-4	6	Row Time Until Remedial Objectives are Achieved	Column Alternative 3	Second paragraph, line 8, delete the second "in."
	Table 3-4	6	Row Time Until Remedial Objectives are Achieved	Column Alternative 5b	Paragraph 1, line 3, delete the second "in."
	Table 3-4	6	Row 5B) Comparative Analysis	Column Alternatives 1, 2, 3, 5b	Line 5, change "is" to "are" to read "… construction, infrastructu are relatively complicated."
	Table 3-4	6	Row Ability to Construct and Operate the Technology	Column Alternative 3	Second paragraph, line 2, change to "Remedial Action Work Pla

Editorial Comments

Item No.	Section; Table; Figure	Page	Paragraph	Line (if not obvious)	Agency/Tribe Comments
	Table 3-4	7	Row Reliability of the Technology	Column Alternative 5b	Line 14, change “wells” to “well” to read “… production well cor
	Table 3-4	8	Row Availability of Necessary Equipment and Specialists	Column Alternative 5b	Line 1, change “are” to “is” for subject-verb agreement.
	Table 3-4	8	Row Availability/Demonstrated Effectiveness of Prospective Technologies	Column Alternative 5b	Line 3, change “FM” to “Fm” for consistency.

APPENDIX C-2

P4 Responses to A/T Comments (dated September 23, 2016) on *P4's Ballard Mine Feasibility Study Report Memorandum 2 – Screening, Detailed, and Comparative Analysis of Assembled Remedial Alternatives, Draft Rev 0, July 2016*

Submitted to A/Ts on October 26, 2016

From: Vance Drain
Sent: Wednesday, October 26, 2016 4:19 PM
To: Tomten.Dave@epamail.epa.gov
Cc: MOLLY PRICKETT [AG/1850] <molly.prickett@monsanto.com>; COOPER, RANDALL LEE [AG/1000] <randall.lee.cooper@monsanto.com>; LEATHERMAN, CHRIS R [AG/1850] <chris.r.leatherman@monsanto.com>; VRANES, RANDY K (AG/1850) <randy.k.vranes@monsanto.com>
Subject: P4's Response to A/T comments on the Ballard Feasibility Study Report - Memorandum #2

Dave,
Attached to the message, both as a pdf file and as a Word file, are P4's responses to the A/T's comments on the *Ballard Feasibility Study Memorandum #2* that were received on September 23, 2016. Please forward this email and its attachments to the appropriate A/T members for review.
We are ready to revise the memorandum upon your approval of our responses, or provide additional clarification in writing or on a conference call, if that is necessary.
Best Regards,

Vance Drain

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MWH. now part of Stantec
Send very large files to me via this link:
https://ft.mwhglobal.com/Desktop/Dropbox/Create/?toemail=vance.k.drain@mwhglobal.com

A/T Comments on Ballard Mine Feasibility Study Report Memorandum #2, Screening, Detailed, and Comparative Analysis of Assembled Remedial Alternatives, Revision 0, July 2016

and

P4's Responses

General

A. FS Memorandum #2 seems generally well written, and faithfully follows Comprehensive Environmental Response Compensation and Liability Act (CERCLA) Remedial Investigation (RI)/Feasibility Study (FS) guidance.

P4 Response (GC-A)*: Thank you.*

B. The presentation of upland soils and waste rock alternatives should acknowledge and discuss generally how construction of the proposed remedial components would be sequenced to avoid or minimize extended exposure of fresh soil and waste rock surfaces to climatic factors that would likely stimulate accelerated mobilization of chemicals of concern (COCs) and chemicals of ecological concern (COECs) into surface and groundwater.

P4 Response (GC-B)*: P4 and its contractors operate the Blackfoot Bridge and South Rasmussen mines to concurrently remove ore and encapsulate the waste rock material under a cover system as soon as possible once the ore is removed. During the remedial action (RA), P4 will operate similarly so that waste rock from the ore recovery operation, or from excavation of the existing waste rock, will not exposed to the environment for an extended period. In addition and perhaps even more important than time of exposure, is the grading, drainage and positioning of the exposed waste rock materials such that surface runoff through and over this material is minimized. These practices are also standard operating practices at the active Blackfoot Bridge Mine. In areas where existing waste rock is found, prior to its removal or regrading, its final location will be designed (i.e., in the remedial design [RD] or mine plan), then these materials will be excavated, transported, backfilled, regraded and quickly covered. This discussion will be included in Section 2.3.1 and Section 3.2, as appropriate. In addition, as currently presented in the tables, standard stormwater controls in the form of best management practices (BMPs) will be installed as part of the CERCLA RA construction (and necessary construction documents) to retain airborne (dust) and water-related COCs/COECs on-Site to the extent possible during the remedial actions.*

C. The screening of surface water alternatives (Section 2) appears to assume that all seep flows are the result of precipitation and runoff migrating through dump material and can be reduced or eliminated through source control. Experience at other mine sites indicates that seeps are commonly surface expressions of groundwater and may not be significantly influenced by installation of covers. Please describe the implications of this condition relative to the remedial options proposed.

P4 Response (GC-C)*: The Ballard Site has a somewhat unique configuration because of the structural (faulting and folding) complexity of the Site as presented and discussed in the Ballard RI Report. The Site is located on both flanks of a low ridge with multiple mine pits and waste rock covering much of the ridge surface. Because of this configuration and location, the Site includes the upper portion of the watershed (i.e., most all of significant the recharge zone), which feed the springs and (dump) seeps located along the perimeter and interior of the Site.*

Both interflow and groundwater seeps and springs are present on the Site. Seeps that are dominantly runoff interflow are present at the Site (e.g., MSG004 and MST095). These will be very directly remediated by the source control. Other seeps and springs within and on the west side of the Site appears to be fed by varying portions of interflow and groundwater. The

groundwater is recharged locally and flows through shallow bedrock, colluvium and/or the bottom of the waste rock deposits. The springs on the east side of the Site may have a component of Site water, as well as deeper, upwelling, unimpacted groundwater from the Dinwoody Formation. The conceptual model for shallow groundwater discharge, therefore, consists of two pathways for COCs/COECs-affected water that daylights in springs or seeps at the Site.

The first pathway is where the shallow groundwater is recharged in the upland areas of the Site and flows to the perimeter where a portion of the flow discharges as seeps or springs and the remainder of that water results in the observed groundwater plumes. Both the waste rock dump and possibly some mine pits are areas of enhanced infiltration and recharge. The recharge through a coarse waste rock dump may be four times that of the native ground surface. The resulting shallow groundwater may flow through the shallow bedrock, underlying colluvium or in the waste rock with the flow focused along drainage channels covered by the waste rock deposits. Seeps/springs at MST067 and MST069 are examples of this. Spring MSG003 appears to be receiving discharge from shallow bedrock, because of the position of mine pits, and must be largely recharged from nearby waste rock and mine pit sources. Because the recharge areas are largely within the Site, a significant portion of the recharge is waste rock percolation with elevated COCs/COECs or through the higher elevation mine pits. Source control through cover placement over the exposed waste rock will result in significant reduction of: infiltration through the waste rock, percolation to groundwater, and discharge volume/contaminants in the associated seep/springs.

The second groundwater discharge pathway at the Site is where unimpacted groundwater is upwelling beneath an area on the east side of the Site. In this case, it appears that the upwelling water results in an upward hydraulic gradient that forces the impacted shallow groundwater plumes to the surface. There may be some mixing, but there is no evidence that unimpacted groundwater is upwelling into the waste rock and becoming directly impacted. It is notable that the springs on the east side of the Site are offset and downgradient of the waste rock area. If there was a spring directly upwelling beneath the waste rock, the discharge would be expected at the toe of the waste rock, which we do not observe.

In summary, because the location of the Site is in a groundwater recharge area, it is expected that percolation through the waste rock is the dominant COC/COEC loading mechanism and source to the shallow groundwater, which results in discharges at seeps and springs. It is believed that source control, consisting of a cover system (e.g., ET cover that is designed as detailed in FS Memo #2 to shed or otherwise store and evapotranspire water) and the corresponding reduction in waste rock infiltration, will result in a signification reduction in COC/COEC loading to groundwater. Over time, it believed that source control will reduce contaminant concentrations currently detected at seeps/springs. There is no evidence at the Site of unimpacted groundwater contacting waste rock and discharging as impacted water. It is therefore expected that all of the proposed remedial actions for upland soils/waste rock which reduce percolation through this source material will reduce COCs/COECs in both seeps and springs as well as shallow groundwater over time, as presented in the document.

D. Given the proposed mining option and associated remedial action alternatives for the site, it is anticipated that site conditions may change as remedial options are implemented. For instance, modifying the extent of the remedial cover proposed for excavated dump areas based on relevant post Record of decision (ROD) sample results. Please describe P4's strategy with respect to (1) adapting remedial actions to changing site conditions and (2) applying lessons

learned to subsequent design activities to optimize the success of a proposed preferred alternative (adaptive management).

***P4 Response (GC-D)**: As pointed out in this comment, there undoubtedly will be numerous instances of changed Site conditions, or design assumptions, during the implementation of the Site remedy and methods for addressing these changes or adaptations will be included the RA Work Plan, which is prepared just prior to construction of the Selected Remedy. Adaptive management is an interactive process by which certain aspects of the remedy (RD elements) will be measured and/or monitored during the RA construction to determine if additional designs or design modifications are necessary during the next phase of work (as this work is proposed). Adaptive management also includes corrective actions that may be necessary on previously constructed remedy elements that are not functioning properly. If design modifications are necessary during the next phase of construction, or if corrective actions are necessary on earlier components of the design, they will be implemented as needed so that the overall, in-place remedy continues to fulfill the remedial action objectives (RAOs, e.g., reduction in COCs/COECs in shallow groundwater). Because the upland soil/waste rock remediation will occur in phases, each phase in concert with the removal of remnant ore at the Site, there will be opportunities to install cover, seep treatment, and other systems and refine their designs through ongoing monitoring and maintenance during each successive phase of the RA.*

E. Please state, where appropriate, that media placed in the permeable reactive barriers (PRBs) or extraction trenches will have suitable permeability to match hydraulic conductivity of surrounding material and adequate retention time to treat the intended contaminants to acceptable standards.

***P4 Response (GC-E)**: In Section 2.3.4, Alternative 3, the text has been revised to say, "PRBs may be constructed utilizing inorganic, biological, or a combination of reactive reagents. <u>The media placed in the PRBs will have permeability appropriate for the hydraulic conductivity of surrounding material and with an adequate retention time to treat the intended contaminants to acceptable standards. …….</u>" This language also has been incorporated into Section 3.5.3. Specific details will be included in the RD and RA Work Plan.*

F. As would be expected, an FS-level design is more conceptual than the remedial design and carries a cost range of +50 to –30%. Please include some text in FS Memorandum #2 stating that the depiction and location of remedial features (such as sediment traps, constructed wetlands, and PRBs) are based on current knowledge of contaminated media, its potential mobility, current site conditions, and professional judgement, to facilitate comparison and detailed analysis of alternatives. Specific location and numbers of such features, if selected, shall be determined during remedial design, along with construction specifications and a refined range of costs (+15 to -10% for budgeting purposes).

***P4 Response (GC-F)**: Much of the text above has been added to Section 3.1.2 of the revised FS Memo #2 to note that these are preliminary/conceptual RA construction elements that will be designed following the ROD and refined as the project phases are implemented.*

G. Section 3 and accompanying tables present the detailed analyses of alternatives, including information on compliance with ARARs. There are a number of areas where this ARARs analysis should be expanded and supported with additional information or analyses, in particular compliance with the Clean Water Act Section 402 and 404. For example, with respect to Section 402, the document should provide information and/or rationale supporting the conclusion that discharges from constructed wetlands will achieve cleanup targets. With respect to section 404, the EPA must issue a 404 compliance memo prior to issuance of a ROD. Information must be

available and presented for this compliance determination to be made, either in the FS or perhaps in a separate deliverable. Information necessary includes, but is not limited to, information on the location and extent of waters of the US that are included in the site, the approximate number, location, and extent of fills necessary to implement the recommended actions (including road crossings, constructed wetlands, sediment control structures and the like). It is acknowledged that the initial 404b1 compliance determination at the ROD stage may be general, and that additional information and refinements would be made during the remedy design stage, with reissuance of the 404 compliance memo.

P4 Response (GC-G)*: We agree that additional ARAR analysis will be necessary, including information regarding CWA Section 402 and 404 compliance, but in most cases it should be conducted after selection of the Site remedy components and areas of disturbance are better understood. At this point, we know that e.g., PRBs followed by wetlands for polishing, likely will remove Site COCs/COECs to target cleanup levels based on similar systems installed at P4's South Rasmussen Mine (see response to SC-14). However, the configuration of the wetlands will be location specific and the attainment of cleanup goals largely will depend on the system design and operation. This information has been added to the revised FS Memo #2 where necessary.*

In many cases, a wetlands delineation is performed during the pre-design phase of the project after the Site remedy has been selected and data gaps are identified that need to be filled before the design can be completed. P4 will perform an initial "paper" study based on Site-specific aerial photographs, photographs taken during the biannual surface water sampling events throughout the Ballard Site, and data from the National Wetlands Inventory. P4 will consider a preliminary survey to identify "waters of the US" in the spring, which is the best time to perform wetlands delineations, if it is deemed necessary.

At this point, we know there are wetlands at a few existing perennial seeps/springs/ponds and that there are no perennial streams at the Site. The drainages at the Site are small, ephemeral headwater drainages that carry surface water only in the spring during periods of snowmelt or prolonged rain (refer to Section 2.4 and Table 2-2 in the Ballard Mine RI Report (MWH, 2014)).

H. In recent months, there have been two water quality standards developments that may have implications for cleanup levels and that may affect the evaluation of ARARs compliance. These include issuance by EPA of a revised criteria recommendation for Se, and EPA's recent disapproval of the State of Idaho's criterion for As for protection of human health. These are issues where additional information and direction are forthcoming.

P4 Response (GC-H)*: As shown on Figure 2-5 of Ballard FS Memo #1, maximum Site surface water selenium concentrations are either well above the surface water standard of 0.005 mg/L or well below that standard. A reduction of the standard to 0.0031 mg/L would not impact the stream reaches considered under the evaluated alternatives. Nor should it affect the remedial alternative technologies considered in both Ballard FS memorandums.*

I. As discussed previously, the Ballard Shop closure plan or focused FS should be submitted for A/T review so that cleanup measures can be presented in the proposed plan.

P4 Response (GC-I)*: As discussed during finalization of Ballard FS Memorandum #1, P4 proposes that a separate simple closure plan be developed for the Ballard Shop Area that includes: 1) the Ballard Shop background, i.e., the nature and extent of contamination and technologies suitable for remediation of the Shop constituents, 2) plans for control of risks to industrial workers during future industrial use of the area during the implementation of the RA (i.e., the construction phase) prior to final closure, 3) plans for control of any ongoing contamination from source area(s) identified at the Shop and 4) plans for final closure of the Ballard Shop when the Shop is*

no longer used. Reference to this closure plan will be included in Section 4.2 and 4.2.1 and a draft will be transmitted to the A/Ts following submittal of the next revision of FS Memo #2.

Specific Comments

Report

1. Section 2.1.4, Page 2-5, Revegetation – Please provide references regarding determination of plant species that do not accumulate selenium.

   ***P4 Response (SC-1)**: The reference to NRC, 1983 listed below has been inserted in Section 2.1.4 and in Section 5.0 References to refer to selenium hyperaccumulator species.*

   National Academy of Science-National Research Council. 1983. Selenium in nutrition. Rev. ed. Board on Agric. NAS-NRC, Washington, DC.

2. Section 2.3.1, Page 2-8, first paragraph under Alternative 4 heading – For clarification, it would be helpful to include a cross section of the evapotranspiration (ET) cover intended to illustrate the sequence of layers comprising the proposed cover.

   ***P4 Response (SC-2)**: A new Figure 2-1, which depicts the three (3) cover systems discussed in Section 2.0, has been referenced and is included in the revised version of FS Memo #2.*

3. Section 2.3.1, Page 2-10, second paragraph from top of page – For clarification, it would be helpful to include a cross section of the multi-layer cover system intended to illustrate the sequence of layers comprising the proposed cover.

   ***P4 Response (SC-3)**: Please refer to P4's response to SC-2 above.*

4. Section 2.3.1, Page 2-11, third paragraph – Provide clarification on whether the high carbon ore is currently exposed from historical mining operations or is in undisturbed portions of the mine.

   ***P4 Response (SC-4)**: Text has been inserted into the referenced paragraph to indicate that high carbon ore from the Meade Peak Formation remains at the Site both exposed at the surface in the mine pit bottoms, in the pit walls, and underlies Rex Chert and/or Dinwoody Formation bedrock in flanks of current mine pits.*

5. Section 2.3.1, Page 2-11; third paragraph from top – Delete ")" from "...incompatible with the selected cover system)."

   ***P4 Response (SC-5)**: This comment has been addressed in the revised FS Memo #2.*

6. Section 2.3.1, Page 2-11, fourth paragraph – If the ore recovery is from areas not previously mined, it will add to the total area to be reclaimed, and any additional topsoil stripped in the process will be needed to reclaim the newly impacted area; therefore, it would not appear to produce "…additional unimpacted overburden in the selected cover system…" as stated.

   ***P4 Response (SC-6)**: In most cases, ore recovery will not significantly add to the total area reclaimed (or remediated) because the existing waste rock piles are on the flanks of the pits and these areas would require either capping in place or excavation of existing waste rock and backfilling into the existing pits (as presented in Table 2-1, Alternatives 3, 4, 5, and 7). Those same pit flanks are, in some cases, underlain by the Meade Peak ore at depth. During the ore recovery, uncontaminated Rex Chert and Dinwoody formation materials many tens of feet in thickness will be removed and used in the final selected ET cover system that is estimated at 5.5 to 6 feet thick. A comparison in total acreage remediated between Alternative 6 – Ore Recovery during Remediation and Alternative 7 – Complete Consolidation of Existing Waste Rock shows they are nearly the same at an estimated 538 acres for Alternative 6 and 546 acres for Alternative 7. Alternatives 3, 4, and 5 are less at 392*

acres because the existing pits are only partially backfilled with exterior waste rock to cover the exposed Meade Peak Formation where necessary.

7. Section 2.3.2, Page 2-*(1)*4, Surface Water, Alternatives 3 and 4 – Please clarify how P4 is differentiating "in situ biological (wetlands) treatment" (Alternative 3 – retained) versus "ex situ bioreactor treatment" (Alternative 4 – not retained). True anaerobic wetlands are outdated technology and their ability to effectively treat all the surface water COCs and COECs (i.e., arsenic, cadmium, or selenium) is questionable. Most modern passive treatment systems for mining-influenced water include one or more anaerobic (sulfate-reducing) biochemical reactors (BCRs), along with aerobic ponds or wetlands for polishing. Although these are often constructed as in-ground basins, they are not truly "in situ." From the discussion in FS Memorandum #1, it appears that the term "ex situ bioreactor" (Alternative 4) is intended to mean an aboveground, active treatment system like the ABMet process. Please clarify where a passive or semi-passive BCR-based system would fit in these alternatives. This is important because a passive BCR-based system could be a good process option for surface water treatment – more effective than a simple wetland, and less expensive and labor-intensive than an active bioreactor system. Please acknowledge that the selection of any of these treatment systems carries some uncertainty, which would be resolved through pilot testing to demonstrate effective treatment for all of the COCs and COECs and to develop design criteria, or cite local or related documented pilot studies as backup.

   ***P4 Response (SC-7)**: The system described in the comment is intermediate between Alternatives 3 and 4, but is possibly more comparable to an in-ground modification of Alternative 4. A BCR with active dosing was pilot tested at the Ballard Site, and if it were constructed in the ground opposed to tanks (+/- dosing) and had polishing wetlands, it would have resembled the system described in the comment. Not every potential modification to treatment systems were carried through FS Memo #1, and the above ground, ex-situ bioreactor treatment generally represents the system described for the FS evaluations.*

   We disagree with the statement that anaerobic wetlands are an outdated technology. Like all technologies, applicability depends on site characteristic and conditions. There are a number of conditions at the Site that make this technology favorable. These include: (1) relatively low flows, (2) treating upwelling unoxygenated water, and (3) the treatment process should be temporary until source control becomes effective. More importantly, in the recommended combined remedy as described in Section 4 (but not mentioned specifically in Section 2 where individual media alternatives are evaluated), this would be a secondary treatment (polishing) step with upgradient PRBs acting as the primary system to remediate groundwater before it is discharged at the surface. However, even without the primary PRB step, a more robust wetlands would still be effective with the anaerobic bed essentially being a horizontal PRB for the upwelling groundwater. The lower tech passive character of the wetlands is appropriate and desirable based on a number of criteria as listed above, but if once installed, the wetlands are not performing as anticipated (not attaining cleanup goals); in-ground basins as described in the comment would be considered for polishing.

   In summary, we stress that any biological treatment system involves some uncertainty and often requires fine-tuning. Please see the response to SC-14 regarding PRB pilot testing.

8. Section 2.3.2, Page 2-14, Surface Water, Alternatives 3 and 4 – Alternatives using passive as well as active systems should include costs for decommissioning or removal and residuals disposal at the end of the treatment period, to remove the precipitated contaminants from the environment and avoid possible re-solubilization and release of contaminants in the future. Please clarify whether this is included in the cost estimate for Alterative 3.

***P4 Response (SC-8)**: The decommissioning costs are not specifically included in Alternatives 3 and 4 for surface water. Only Alternative 3 was carried forward into the detailed analysis in Section 3 and we believe that transportation of these material to an on-Site disposal area easily are captured in the alternative contingency cost in Appendix A. In addition, we recognize that a long-term disposal area will be needed on-Site that can receive and contain the materials described above, but also contaminated sediments from the sediment traps associated with the cleanup of the intermittent mine drainages and spent materials from the PRBs. Costs for development of this relatively small landfill (an estimated 10,000 cy) have been added to the upland soils alternatives cost estimated in Appendix A because it will be sited within the covered area.*

9. Section 2.3.2, Page 2-14, second paragraph under Alternative 3 bullet – Please qualify the description of the benefits of the wetlands treatment. As it stands, the paragraph describes water treatment benefits likely to come from established, mature wetlands, rather than newly "constructed" wetlands. Please include the likely maturation process and timetable of a constructed wetland that would eventually yield the desired results. Please cite local or related documented pilot studies as backup.

   ***P4 Response (SC-9)**: Please see comment response SC-14 regarding pilot testing. The maturation of the wetlands will be dependent upon a number of design items including time of year of construction (temperature), any seeding with bacteria, and type of organic matter used as substrate or introduced to kick start biological growth. These factors will be considered during the RD stage based on the design criteria and the overall sequencing of the RA. Because there are many design factors that can affect (accelerate or slow) the maturation, this detail is not necessary at the FS level, and the discussion of the maturation is not appropriate for the presentation in Section 2. However, a statement to the effect that the wetlands will not be immediately effective (e.g., may take several weeks to a year) because of the need for biological growth has been added to the "Short-term Effectiveness" item in Tables 2-2 and 3-2 for Alternative 3.*

10. Section 2.3.3, Pages 2-15 through 2-17, Sediment/Riparian Soil, Alternatives 2 through 4 – It is questionable whether monitored natural recovery (MNR), as used in Alternative 2 (not retained), is consistent with United States Environmental Protection Agency (EPA) policy, which indicates a strong preference for natural attenuation mechanisms that degrade or (more importantly for inorganics) immobilize contaminants, rather than simply allowing them to disperse over time (see excerpt below). The use of MNR in Alternative 3 (retained) seems somewhat more consistent with EPA policy because it includes sediment traps to collect and allow proper disposal of contaminated sediment. Alternative 4 (retained) seems even more consistent with EPA policy because it includes both excavation and removal of the most-contaminated sediment and MNR for final polishing after concerted efforts at source control or removal.

    > ***However, dilution and dispersion generally are not appropriate as primary MNA mechanisms because they reduce concentrations through dispersal of contaminant mass rather than destruction or immobilization of contaminant mass.*** Dilution and dispersion may be appropriate as a "polishing step" for distal portions of a plume when an active remedy is being used at a site, source control is complete and appropriate land use and groundwater use controls are in place.[1] [emphasis in original document]

    ***P4 Response (SC-10)**: The use of MNR following source control and in conjunction with institutional and land use controls (ICs/LUC) as outlined in Alternative 2 should meet USEPA policy as it is believed*

[1] EPA. 2015. *Use of Monitored Natural Attenuation for Inorganic Contaminants in Groundwater at Superfund Sites*. OSWER Directive 9283.1-36, August 2015. (p. 14)

that isolation and dispersion would all take place following source control. However, P4 recognizes the benefits that sediment traps offer and as result, did not retain Alternative 2 for detailed and comparative analysis. The criteria in the initial analysis Table 3-2 and Section 2.3.3 has been reviewed and additional information on MNR processes has been included as discussed in response to SC-11.

11. Section 2.3.3, Page 2-15, Sediment/Riparian Soil, Alternative 2 – Please define the term "natural processes" to clarify for the reader what specific processes contribute to MNR.

    ***P4 Response (SC-11)**: Section 2.3.3, Page 2-15 Sediment/Riparian Soil, Alternative 2, has been revised to state "natural processes (i.e., physical, chemical, and biological). Section 3.4.2 also has been revised to clarify the specific natural processes that contribute to MNR.*

12. Section 2.3.3, Page 2-16, paragraph associated with Alternative 3 – Please describe what the likely fate of water impounded by the sediment traps or basins would be (initially it may be contaminated), and whether the impounding of this water would have any effect on the "natural processes" that contribute to the success of the MNR further downstream.

    ***P4 Response (SC-12)**: In several instances, the sediment traps (refer to Figures 3-6) would be installed in drainages downstream of a proposed wetland (Surface Water, Alternative 3, Figure 3-7). In this scenario, the surface water coming from the seeps will be isolated and treated by the wetland before comingling with other water in the drainage and continuing downstream. Other surface waters entering the drainage will be uncontaminated because they will be coming off the clean cover system or other native unimpacted surfaces. Initially, in all drainages whether they have wetlands or not, any impacted water will continue downstream much like it does today until such time as the upland soil/waste rock source control is completed (i.e., the cover system is installed) and unimpacted water is shed from the cover system. It is not believed that impounding of the water behind the sediment traps will do anything other than retain the turbid water primarily during spring runoff so that sediment can settle out before it continues downstream. Following spring runoff, we believe these structures will not contain any water.*

13. Section 2.3.3, Page 2-16, second paragraph – Sediments cleaned from the traps are described as being disposed of in designated areas under the soil/waste rock cover. The sediments will need to be cleaned from the traps and disposed of over a longer period of time than it takes to cover the exposed rock; therefore, the TM should describe accomplishing this after the cover is installed.

    ***P4 Response (SC-13)**: As depicted on Figure 3-7, sediment traps would be installed on the major intermittent drainages (at the lowest elevation of their upper reaches) during remediation. However, they would be decommissioned at some point post-remediation because the sediments coming off the cover surface will be unimpacted (and verified through sampling as unimpacted or "clean"). If the sediment traps were left in place once the cover system is completed, they could slow the MNR processes lower in these drainages (as discussed in SC-12 above). An area for disposal of any contaminated sediments, and possibly sediments from the decommissioning of the temporary wetland or contents of the PRBs, will have to be selected, designed, and constructed in the covered area for disposal of these types of waste throughout the life of the RA. Section 2.3.3 and Section 3.4.2 have been revised to include the description of a designated area for long-term sediment disposal and the costs for this small disposal area are included in the revised cost estimate for upland soils alternatives.*

14. Page 2-18, paragraph associated with Alternative 3 – Please include documentation (as an attachment) that permeable reactive barriers will work in this environment with these contaminants. This is generally demonstrated by site-specific pilot study results or reference to local

studies at other mine sites with similar climatic conditions and contaminants (e.g., South Rasmussen Mine).

P4 Response (SC-14)*: P4 currently is collecting data from first and second generation PRBs that were installed at the South Rasmussen Mine in 2009 and 2012, respectively. The 2012 2nd generation system in particular has exhibited excellent contaminant removal. The last South Rasmussen Annual Report that includes performance data for these PRBs was submitted to IDEQ in August 2016. A third expansion of the PRB system at South Rasmussen was completed in October 2016. Data from these systems will be utilized as a starting point for design of the Ballard PRBs. The climate and contaminants are similar enough that the South Rasmussen PRBs can be considered a pilot test for the Ballard Site. Due to the size of the reports and that they have been submitted to the IDEQ, we have not attached them. Text has been added to the referenced paragraph as follows (underlined): "PRBs may be constructed utilizing inorganic, biological, or a combination of reactive reagents. <u>It is likely that these PRBs will be based on designs tested at P4's South Rasmussen Mine since 2009 (Newfields, 2016)</u>."*

Newfields, 2016. 2015 Annual Report: South Rasmussen Mine and Horseshoe Overburden Area, Caribou County, Idaho. Prepared for P4 Production LLC, August 2016.

15. Section 2.3.4, Page 2-18, Groundwater, Alternative 3 (retained) – This alternative employs MNA for polishing after PRBs and as the sole remedial approach in the Wells formation groundwater. While the former might be considered consistent with EPA policy, the latter seems questionable (see Comment 10); please clarify. PRB treatment would likely require pilot testing to demonstrate effective treatment for all of the COCs and COECs and to develop design criteria. In addition, this alternative should include costs for decommissioning or removal of the PRB at the end of the treatment period and for residuals disposal, to remove the precipitated contaminants from the environment and avoid possible re-solubilization and release of contaminants in the future.

P4 Response (SC-15)*: The use of MNA for both the alluvial and Wells Formation aquifers is predicated on the implementation of source controls (i.e., the capping and grading of waste rock). For the Wells Formation, this alternative also includes the elimination of contaminated spring discharge into mine pit MMP035 (West Ballard Pit). This discharge is the primary source of contaminants to the Wells Formation.*

As stated in the EPA, 2015 MNA guidance, page 8: "Control of source materials is the most effective means of ensuring the timely attainment of remediation objectives. EPA, therefore, expects that source control measures will be evaluated for all contaminated sites and that source control measures will be taken at most sites where practicable."

EPA's 1999 MNA guidance (OSWER Directive 9200.4-17P, pg. 3, 1999) states, "..... EPA expects that ***source control and long-term performance monitoring will be fundamental components of any MNA remedy****."*

Therefore, we conclude that MNA with the source controls is consistent with EPA policy.

Please see the previous comment response (SC-14) for the discussion of pilot testing. Note that in the preferred combined remedy, source controls are a significant consideration and requirement for the use of MNA and to some extent PRBs, which likely will have a limited life. Presumably, when the source controls have reduced contaminant concentration to acceptable levels, the PRB would be removed. The costs for removal and transport of this material have are not included in the cost estimate in Appendix A. Please review the response to SC-8 above for further details of where the majority of those costs are captured.

16. Section 2.3.4, Page 2-18, Groundwater, Alternative 4 (not retained) – Although this approach has been proposed elsewhere, there is a potential critical flaw with the technology involving injection of reagents for treatment of inorganics in soil and groundwater. Most often, this approach involves injection of organic substrate or chemical reducing agent to create anaerobic conditions and precipitation of metals as reduced species (often as sulfides). The potential problem with this approach is if the deeply reducing conditions are not maintained indefinitely by reagent addition, the groundwater can revert to more oxidizing conditions and the immobilization reactions can be reversed, resulting in re-solubilization of the contaminants.

    P4 Response (SC-16)*: We agree that if the groundwater reverts to more oxidizing conditions, contaminant re-release can occur. However, once the anaerobic bacteria are present, they may create self-sustaining anaerobic conditions. Nonetheless, the potential release of retained contaminants is a condition that requires consideration. The following sentence has been added at the end of the paragraph and at the appropriate location in Table 2-4 – "In addition, the potential re-release of retained contaminants without reinjection of reagents is a consideration in not retaining the alternative". It should be noted that programs with similar chemical species have shown limited remobilization. That can be in part due to a general change in aquifer chemistry with the introduction of anaerobic biological communities.*

17. Section 2.3.4, Page 2-18 to 2-19, Groundwater, Alternative 5a (not retained) – This alternative used MNA as the primary remediation mechanism for alluvial groundwater. Is this use consistent with EPA policy? Alternative 5a was reportedly not retained because "the component associated with the Wells Formation is judged to have low/moderate effectiveness and technical feasibility, with high cost." Agree with high cost, but it is not clear why the effectiveness and technical feasibility of Wells formation groundwater extraction and treatment is considered low; please explain. Table 2-4 ranks effectiveness as moderate to high. While it ranks technical feasibility low, it is not clear why.

    P4 Response (SC-17): *Under Alternative 5a, alluvial groundwater is "MNA for Alluvial Groundwater and ICs in conjunction with source controls in the upland soil/waste rock". In effect, source controls are the primary remedial mechanism for alluvial groundwater with MNA utilized for the residual contamination in the aquifer. It is our understanding that coupling MNA with source controls is consistent with EPA policy as stated in the response to SC-15. Furthermore, MNA at the Site will primarily rely on the attenuation capacity of the aquifer matrix to reduce the soluble chemical mass (primarily through adsorption). This is also consistent with EPA policy on use of the MNA alternative. As stated in the EPA, 2015 MNA guidance, page 8:*

    "MNA may, under certain conditions (e.g., through sorption or oxidation-reduction reactions), effectively reduce the dissolved concentrations and/or toxic forms of inorganic contaminants in groundwater and soil. Both metals and non-metals (including radionuclides) may be attenuated by sorption[14] reactions such as precipitation, adsorption on the surfaces of soil minerals, absorption into the matrix of soil minerals, or partitioning into organic matter."

    The complexity, due primarily to faulting, and depth of the Wells Formation aquifer beneath the Site are the reason for the low effectiveness and technical feasibility for the Wells Formation portion of the alternative. The sentence in the paragraph that reads – "…. is judged to have low/moderate effectiveness and technical feasibility, with high cost", has been modified by addition – "….because of the geologic complexity and depth of the aquifer….". In addition, Table 2-4 has been modified to be consistent with the Section 2.3.4 text.

18. Section 3.1.2, Page 3-3, sixth paragraph, Cost – 30 years is used as the net present value period. The cited reference, A Guide to Developing and Documenting Cost Estimates During the Feasibility Study

(EPA, 2000) includes the guidance "…the blanket use of a 30-year period of analysis is not recommended." Provide justification for the use of a 30-year period in the cost analysis.

***P4 Response (SC-18)**: As discussed in the EPA cost guidance document mentioned above, the 30-year time period for estimating present value costs initially was the standard time frame provided in the original EPA guidance document (EPA, 1988). The current document (EPA, 2000) says that, "Site-specific justification should be provided for the period of analysis selected, especially when the project duration (i.e., the time required for design, construction, O&M and closeout) exceeds the selected time period." In the case of the Ballard Site, active remediation for upland soils/waste rock will be completed in 5 to a maximum of an estimated 8 years depending on the selected remedy, and long-term monitoring and maintenance of the MNA alternatives in groundwater/ surface water and MNR alternative in sediment should be nearing an end in the 30-year time frame if source controls are effective. As a result, in our judgment the 30-year time frame is acceptable for this feasibility study (FS) cost estimate because most of the project construction and monitoring elements should be nearing completion within the 30-year period.*

19. Section 3.2, Page 3-5, Last sentence in the first paragraph – Remove the second "… the screening."

    ***P4 Response (SC-19)**: The sentence has been revised as requested.*

20. Section 3.2.2, Page 3-8, first complete sentence – Please correct "The estimates…" to "The estimated…."

    ***P4 Response (SC-20)**: The sentence has been revised as requested.*

21. Section 3.2.4, Page 3-11, second paragraph – The bulleted list of volume descriptions uses loose yards for quantities of material available in the dumps and quantities required in the backfill of the pits. The material in the dumps should be considered bank fill and (when placed in the pits, assuming some compaction requirement in the remedial design) compacted fill. Therefore, the cubic yards of material available and material required would not have a one-to-one correlation. Volumes should be adjusted to reflect this or an explanation of why it is not required should be added.

    ***P4 Response (SC-21)**: We agree that the use of the term loose cubic yards is confusing and will modify the text to refer to "bank cubic yards (bcy)" when referring to the volumes of material removed from the existing external waste rock dumps. We will also modify the text to refer to volumes of material that has been placed as pit backfill as "placed cubic yards (pcy)." It is our experience on other sites where material was excavated from older waste rock dumps and placed as backfill with moderate compaction (i.e. in 3 to 10-foot-thick horizontal lifts with compaction from construction equipment traffic), a shrink-swell factor (the ratio of pcy/bcy) of unity was appropriate. Based on this experience, it is our opinion that assume a shrink/swell factor of 1.0 is a reasonable estimate at this stage in the project. The actual shrink swell factor achieved during construction will depend, to a large extent, on the placement procedures and equipment used in the backfilling operation. This assumption of a shrink/swell factor of 1.0 will be evaluated as construction progresses using as-built surveying of the excavation and fill sites and necessary adjustments will be made during later phases to accommodate variations in this shrink/swell factor.*

22. Section 3.3, Page 3-14, number second paragraph – The assumption that all seeps will disappear following source control implies that the seeps are surface water-related rather than groundwater-related. This is unsubstantiated unless there is flow data that shows a strong correlation between seep flows and wet weather or runoff seasons.

    ***P4 Response (SC-22)**: The text in question reads that the seeps/springs will go dry or will meet surface water cleanup goals as the result of the source control actions. That is, it is not assumed that all seeps will disappear. A revision to the text is not necessary.*

In addition, as discussed in the response to GC-C, there are interflow dominated seeps. It is reasonable that they will go dry. For the more groundwater dominated seeps/springs, most of the higher recharge areas for these features areas are within the Site and will be covered (e.g., ET cover system) as the result of the RA. In particular, the areas with poor vegetation that account for a disproportionally large part of the infiltration to the shallow groundwater system will be covered (e.g., the waste rock dumps). This will substantially reduce, and in some cases may eliminate, much of the seep/spring flow. Where it does not, removal of the contaminant load from the waste rock should result in substantial improvement in water quality. As part of the annual LTM reporting and CERCLA 5-year reviews, any adjustment (e.g., additional treatment at seeps and springs) will be evaluated as necessary.

23. Section 3.3.3, Page 3-16, first paragraph – This paragraph refers to "perennial seeps" that would seem to imply groundwater-fed seeps as opposed to surface water-seeps, as was assumed in Section 3.3 (see previous comment). In order to compare these alternatives, a common assumption on the nature of these seeps and springs is required.

    ***P4 Response (SC-23)**: Please refer to GC-C and SC-22 response above. There are a variety of sources for the seeps and springs at the Site. The Site conceptual model is that the source of all water contamination is infiltration of precipitation that percolates through the waste rock as interflow entering the shallow groundwater system that feeds the seeps and springs. Perennial groundwater discharge that is directly leaching contaminants from source materials is not a likely source of contaminant loading at the Site as discussed in response to GC-C.*

24. Section 3.5.3, Page 3-25, Groundwater, Alternative 3, Bullet 2 – Cost assumption of 1.5-foot-wide PRB filled with iron "fillings" (please correct – should be "filings") may be overly simplistic and may lead to underestimation of cost.

    ***P4 Response (SC-24)**: The text edit has been made. The paragraph explains that the media could be other materials (which would be based on testing, see SC-14). It is felt that iron filings are an appropriate surrogate for this level of analysis. A mixture of organic material and other media could be more or less expensive than the iron filings depending on the actual formula and source, and the costs assumed here are appropriate for an FS-level cost estimate. These costs will be refined as the design is progressed in the next phase of the CERCLA process.*

25. Section 3.6.1, Page 3-30, first paragraph (Short-Term Effectiveness) – This approach combines a CERCLA action with a mining operation. Some discussion should be given to how this affects worker safety, because CERCLA action would be covered by Occupational Safety and Health Administration (OSHA) safety requirements and include Hazardous Waste Operations and Emergency Response (HAZWOPER) training for workers, whereas mining operations would be covered under the Mine Safety and Health Administration (MSHA) and have no HAZWOPER requirements. Design requirements for things like haul roads are also different under the two operations and may have short- or long-term impacts on the total operation.

    ***P4 Response (SC-25)**: You are correct that the mining operations typically are covered under MSHA regulations. P4 intends to meet all applicable OSHA and MSHA safety requirements, and RA work will be conducted under an EPA-approved Health and Safety Plan (part of the RA Work Plan).*

26. Section 3.6.3, Page 3-35, third paragraph (Long-Term Effectiveness) – The first sentence states that Alternative 4 would best address long-term effectiveness in the short term. This language is confusing in the context of the subject. Short-term effectiveness is addressed in its own separate paragraph. Please clarify.

***P4 Response (SC-26)**: The first two sentences in the third paragraph (Long-Term Effectiveness) have been removed and the following sentence added: "The long-term effectiveness and permanence (i.e., risks remaining after the RAOs have been met) is addressed in Alternative 4 by removal of the sediment/riparian soil with the highest COC/COEC concentrations in the upper drainages and in Alternative 3 by properly installed sediment traps that would restrict the movement of the sediment with the highest COCs/COECs from downstream movement."*

27. Table 3-1a, Upland Soil/Waste Rock Alternative 4, Short Term Effectiveness Criteria, 5A Detailed Analysis Ranking – It is recommended that this ranking be changed from "High" to "Moderate to High." Although unique positive attributes are called out under Environmental Impacts, these are offset by needing a longer haul route to deliver the ore (best management practices needed over a longer distance), and a significantly longer construction duration (6 to 8 years), resulting in more truck traffic (potential for safety and haul related issues). Longer construction periods translate into potential for more worker protection issues as well.

    ***P4 Response (SC-27)**: P4 agrees that short-term effectiveness is similar among the three primary upland soil/waste rock alternatives (Alts 4, 6, and 7) because of various tradeoffs among the subcategories listed in Table 3-1a. As you suggest, Alternative 6 environmental benefits might be offset because this alternative does require a slightly longer construction duration of when compared to Alternatives 4 and 7, which also translates to worker protection for a slightly longer time. As a result, P4 has the ranking of Alternative 6 from "High" to "Moderate to High" similar to Alternatives 4 and 7 in Table 3-1a and made other changes in the subcategories and to the 5B Comparative Analysis discussion to reflect the concerns expressed in the comments. We do believe that the environmental benefits listed in the table represent a large net benefit when compared to the other upland soil/ waste rock alternatives that do not include ore recovery.*

28. Table 3-1a, Upland Soil/Waste Rock Alternative 4, Short Term Effectiveness Criteria, 5A Detailed Analysis Ranking – *Time until Remedial Objectives are Achieved Criteria* column lists Alternative 7 with a construction duration of 5 to 7 years. This is shorter than the 6 to 8 years called out in the text (page 3-13; second paragraph). Please make consistent.

    ***P4 Response (SC-28)**: The text on page 3-13 indicates that construction duration of Alternative 7 is 4 to 6 years while Table 3-1a lists 5 to 7 years. Table 3-1a duration of 5 to 7 years is correct and Page 3-13 has been revised to make it consistent.*

29. Section 3, Page 3-16 etc., surface and groundwater alternatives under various *Detailed Analysis Summaries* – Please describe the method used to establish a cleanup timeframe cited for each surface water and groundwater alternative.

    ***P4 Response (SC-29)**: The broadly stated cleanup timeframes are based on professional judgement and familiarity with the technologies and the rate at which they can be implemented.*

30. Section 3.3.3, Page 3-16, Surface Water, Alternative 3 – Has an inventory of wetlands been conducted on the Ballard Mine Site? If not, when will such an inventory be performed? If an established wetland is found along a stream reach proposed for installation of a remedial wetlands, will the existing wetlands be retained as a remedial feature? What criteria will be used to dictate the size of a remedial wetlands to promote adequate water retention and treatment time (which affects cost)? Please expand the discussion under this alternative to address these items, or specifically state that such information will be deferred to remedial design for development.

    ***P4 Response (SC-30)**: A wetland delineation has not been conducted at the Ballard Site. Typically, a wetlands delineation is completed after the Site remedy has been selected and it is relatively well known where the disturbances will occur during the RA. However, P4 may complete an initial*

wetlands work as discussed in response to GC-G. Information regarding the size of engineered wetlands, use of existing wetlands during the RA, and potential impacts to any identified wetlands will be evaluated during the RD process.

31. Table 3-2, Surface Water Alternative 3, 3B) Comparative Analysis Criteria, last sentence – Please change "…CERCLA 4-year review" to "…CERCLA 5-year review."

    ***P4 Response (SC-31)**: This revision has been made to the revised FS Memo #2.*

32. Table 3-2, Surface Water Alternative 3, 4) Reduction of Toxicity, Mobility, or Volume through Treatment Criteria, 4A) *Detailed Analyses* – Consider changing the ranking from High to Moderate because (1) the beneficial treatment processes described in the table are more reflective of "mature functioning" wetlands rather than newly constructed wetlands and (2) "…the effectiveness of wetlands treatment has not been demonstrated for site surface waters." Both conditions are inconsistent with a High rating.

    ***P4 Response (SC-32)**: The ranking in Table 3-2 has been revised from "High" to "Moderate to High". As discussed in response to SC-7, although the effectiveness has not been demonstrated, Site conditions are such that make wetland technology favorable, especially as a polishing step. In addition, this criterion does not rely on time criteria so it is assumed that benefits of the treatment process are reflective of a functioning (mature) wetland that has operated for a few months.*

33. Table 3-2, Surface Water Alternative 3, 5) Short-term Effectiveness, *Time until Remedial Objectives are Achieved* – Last sentence under Alternative 3 states "For practical purposes, the water discharging from the wetlands is expected to meet the cleanup levels *in a very short time frame* following construction (e.g., within weeks)." Please clarify, or describe more completely, the basis for determining this functional timeframe. The text under Alternative 6, Implementability and *Availability/Demonstrated Effectiveness of Prospective Technologies Criteria* states "…the effectiveness of wetlands treatment has not been demonstrated for site surface waters."

    ***P4 Response (SC-33)**: Please see response SC-9. The time until the wetlands if fully mature will vary depending on in part design factors; weeks to a year may be the best way to bracket it. However, a constructed wetland does not need to be fully mature to be effective. Weeks may be overly optimistic. The phase will be modified to say: ..... levels in a ~~very~~ short time frame following construction (e.g., ~~within weeks~~ in less than a year)".*

34. Table 3-3, Sediment/Riparian Soil Remedial Alternatives, 2) Compliance with ARARs – It seems that Alternative 3 (Sediment Traps and MNR) are a less robust means of achieving chemical-, location-, or action-specific ARARs than is Alternative 4, where contaminated sediment is actively removed and MNR is left as a polishing technology. Yes, this alternative would result in effects to several seep and stream reaches, but no wetlands have been identified, excavated areas can be quickly replanted, and work can be coordinated when the cover is being installed in the area. Recommend changing the 2A) *Detail Analysis* rating for Alternative 3 to "Moderate" and Alternative 4 to "High."

    ***P4 Response (SC-34)**: As described in Table 3-3 both alternatives can comply with the chemical-specific ARARs. As detailed in the table, compliance with action-specific ARRARs under Alternative 4 would be difficult due to the disruptive effective that excavation and removal will have on the riparian corridors and habitat. For this reason, Alternative 4 was given a "Moderate" ranking. In addition, wetlands delineation has not yet occurred. P4 proposes to leave Alternative 4 as a "Moderate" ranking and reduce the Alterative 3 ranking to from High to "Moderate to High."*

35. Table 3-3, Sediment/Riparian Soil Remedial Alternatives, 6) Implementability, 6A) *Detailed Analysis* – Under Alternative 4, change "The ability to implementability of Alternative 4…" to "The implementability of Alternative 4…"

***P4 Response (SC-35)**: This revision has been made to Table 3-3 in the revised FS Memo #2.*

36. Section 3.4, Paged 3-18, second paragraph – Aren't there three mechanisms for COCs/COECs migrating to sediment/riparian soil? Material transport via erosional forces, surface water runoff, and infiltrated water that surfaces via seeps/springs. Revise accordingly.

    ***P4 Response (SC-36)**: Agreed. The section has been revised to list the three mechanisms for COCs/COECs migrating to sediment/riparian soil. A third bullet has been added that states the following:*

    3) Following source controls in the upland soil/ waste rock, precipitation infiltration would be significantly reduced through the waste rock that could surface as seeps/springs. Therefore, the source of impacted surface water from seeps/springs would be reduced or eliminated and would no longer contact sediment/riparian soil.

37. Section 3.4.2, Page 3-19, second paragraph – It states "Disposal of any contaminated sediment retained in these structures over the long term should be relatively easy to place under an adjacent upland soil/waste rock soil cover." Wouldn't this entail digging up the cover, placing the contaminated sediment, replacing the cover, recontouring as needed, and reseeding? That doesn't necessarily sound relatively easy. Revise accordingly.

    ***P4 Response (SC-37)**: Following source control, any sediment shed from the caps should be unimpacted (and verified through sampling as unimpacted or "clean"). However, an area for disposal of these sediments collected in the sediment control structures prior to capping, and possibly sediments from the decommissioning of the temporary wetland or contents of the PRBs, will have to be selected, designed, and constructed in the covered area for disposal of these types of waste throughout the life of the RA. This text has been added to Section 3.4.2, Section 4.1.3, and Table 3-3.*

38. Section 3.5.2, Page 3-24, third paragraph – Sampling may have to be done twice a year depending on when the highest COC/COEC concentrations are observed. Revise accordingly.

    ***P4 Response (SC-38)**: Based on evaluations of historical data as documented in the 2009 and 2010 Groundwater Monitoring Sampling and Analysis Plans (SAPs), it has been shown that groundwater concentrations of selenium and the indicator parameter sulfate are higher in the spring than in the fall and as such fall groundwater sampling is not part of the Long-Term Monitoring (LTM) SAP since 2012. It is not anticipated that semi-annual LTM monitoring will be necessary during or following the RA. However, the text has been revised to state that semi-annual sampling may be evaluated, but the FS-level cost estimate will continue to assume that groundwater samples only will be collected annually.*

39. Section 3.5.3, Page 3-25, Bullet 2 – As it doesn't sound like there has been a decision made as to what material would be used for the PRB, change "an iron-filings-filled" to something like "a treatment media-filled."

    ***P4 Response (SC-39)**: This edit has been made to Section 2.3.4, Section 3.5.3, Table 2-4, and Table 3-4. It has been stated that the costs assume iron filings where appropriate.*

40. Section 3.6.1, Page 3-29, Bullet 1 – It states "because the areas underlying the upland soil/waste rock dumps are assumed to be impacted by migration of constituents from the waste rock dumps to the underlying soil and would have to be graded and covered after the waste rock is removed." Intuitively this might make sense, but provide data to support this. Although not directly comparable (ore vs ROM or center waste shale), removal of phosphate ore at the Georgetown

Canyon Industrial Complex Area did not require a cap on the daylighted native soil. A cap was placed on the area because of the buried elemental phosphorus.

***P4 Response (SC-40)**: This is prudent assumption for the FS. The converse assumption would be to assume that no cover or growth media would be needed in removal areas, which could lead to a significant underestimation of costs if some cover (or growth media) is needed in these areas.*

41. Section 3.6.2, Page 3-31 – The assumption is that the sole source of water to the upland soil/waste rock is meteoric. Are there any upland soil/waste rock areas where the source of seeps/springs might be spring water located at the natural ground-waste rock interface? If so, reducing/eliminating meteoric water may or may not result in "the mine-affected seeps/springs near the margins of the former mined area to eventually go dry or otherwise meet the surface water cleanup levels over time through substantial reduction of precipitation infiltrating into upland soil/waste rock." Revise as needed.

    ***P4 Response (SC-41)**: Please see P4 response to GC-C. Springs upwelling and flowing through the waste rock are not thought to be a significant source at the Site. The shallow groundwater system within the Site beneath the waste rock is complex. However, the entirety of the shallow groundwater system is contained in the Site including the recharge areas. Reduction of infiltration within the Site will not only reduce the loading from the waste rock, but should also significantly reduce the recharge to any perennial seeps/springs and the concentrations of COCs/COECs in the discharged water. As discussed in GC-C, an exception may be on the east side of the Site where there is a Dinwoody Formation component contributing to the shallow groundwater system. However, the springs associated with this system generally daylight downstream of the waste rock.*

42. Section 3.6.2, Page 3-42, Groundwater, bullet list of advantages of Groundwater, Alternative 3 (including PRBs), Bullet 3 – Suggest that treatment residuals should include used PRB materials at project end, at a minimum, and that an allowance be included for possible replacement of fouled or spent PRB media during the treatment period (and that these factors be included in the cost estimate). For Bullet 2, suggest that decommissioning should include removal of used PRB media at the end of the treatment period (and possibly some extra width of soil downgradient of the PRB), to remove immobilized contaminants and avoid the potential for re-mobilization.

    ***P4 Response (SC-42)**: The text edit has been made as suggested. Refer to P4's response to SC-8 for removal and disposal of Site wastes during the RA. Removal and disposal of the fouled or spent PRB media during the operation of the PRBs and at the close out, should be relatively minor (approximately 150 tons) and will be placed within the on-Site landfill within the covered area that will be necessary for the Site. Cost for construction of the disposal area can be found in Table A-1 for upland soils/waste rock. Costs for replacement and disposal of fouled PRB media are accounted for indirectly in the 10% contingency costs for Alternative 3 because they should be relatively minor.*

43. Section 3.6.3, Page 3-37, Bullet 1 (Partial) – It says "The implementability of Alternative 4 also is complicated by the fact that additional background data (inclusive of all geologic formations including the Phosphoria Formation) may be necessary for sediment/riparian soil to refine the preliminary cleanup levels because as presented in Ballard FS Memo #1 the cleanup levels are very low and might be unattainable." This makes it sound like additional background work may be needed to help establish preliminary clean-up levels for sediment/riparian soil for Alternative 4 only. However, preliminary cleanup levels (PCLs) would apply for all alternatives. They would just have to be addressed sooner with actual excavation versus monitored natural recovery. Revise accordingly.

    ***P4 Response (SC-43)**: Agreed. The sentence in Section 3.6.3 has been revised to state that the implementability of both Alternatives 3 and 4 are complicated by potentially low background/PCLs,*

but that it would be need to be addressed sooner under Alternative 4. This revision also has been made in Table 3-3 in the revised FS Memo #2.

44. Section 3.6.4, Page 3-39, Bullet 2 (Long-term Effectiveness and Permanence) – According to Table 3-4, Alternative 2 ranks "Moderate" with Alternatives 3 and 5b being "Moderate and High(?)" or "Moderate to High." Reconcile.

    ***P4 Response (SC-44)**: The text in Section 3.6.4, Page 3-39, Bullet 2 is correct. Table 3-4 has been revised to change Alternative 3 ranking from "Moderate and High" to "Moderate to High".*

45. Section 3.6.4, Page 3-40, Bullet 2 (Short-term Effectiveness) – Alternative 4 was eliminated and not discussed. Revise.

    ***P4 Response (SC-45)**: Yes, we agree that Groundwater, Alternative 4 was eliminated during the initial screening in Section 2.3.4 and Table 2-4; thus, it was not carried forward into Section 3.0, more specifically into the detailed and comparative analyses found in Sections 3.5 and 3.6. (including subsection 3.6.4). No further revisions to Section 3.6.4 are required.*

46. Table 3-2, Page 5, Row Environmental Impacts, Column Alternative 3, second paragraph – Is there potential for the wetlands to reach the point of COC/COEC saturation prior to cleanup levels being achieved, which in turn would require removal/disposal of the wetland substrate and vegetation? If so, this needs to be mentioned. Revise accordingly.

    ***P4 Response (SC-46)**: Yes, there is a potential for the wetlands to be exhausted and require rejuvenation before water quality cleanup goals are achieved. The phrase relating to this issue has been modified as follows: "….., LTM to evaluate COC/COEC accumulation in substrate and plants, and possible removal/disposal of the wetland substrate and vegetation <u>prior to and/or</u> after cleanup levels are achieved. <u>The possibility exists that the wetlands substrate will be exhausted prior to cleanup levels being achieved, which would require rejuvenation of the wetlands and possible excavation and disposal of the substrate material and vegetation in a designated On-Site disposal area</u>."*

47. Table 3-3, Page 3, Row Treatment Process Used and Materials Treated, Column Alternative 3, line 1 – Change to "This alternative relies on sediment traps/basins."

    ***P4 Response (SC-47)**: This revision has been made to Table 3-3 in the revised FS Memo #2.*

48. Table 3-3, Page 3, Row Treatment Process Used and Materials Treated, Column Alternative 3 – Explain how COC/COEC concentrations in the Blackfoot River are generally low, yet the river is on the 303(d) list for selenium.

    ***P4 Response (SC-48)**: Generally, low concentrations are observed in the Blackfoot River adjacent to the Ballard Site. Only in May 2006 was the selenium surface water standard slightly exceeded with a maximum concentration of 0.008 mg/L (refer to Figure 4-3 in the Ballard RI Report).*

49. Table 3-3, Page 3, Row Treatment Process Used and Materials Treated Column Alternative 4 – It seems like some of the removal of more highly contaminated sediment/riparian soil could be coordinated with the construction of the engineered wetland, thereby reducing the cost. Discuss.

    ***P4 Response (SC-49)**: The configuration of engineered wetlands (currently estimated to be six wetlands in headwater locations) will be based on the Selected Remedy and located during the RD. These locations may (or possibly may not) correspond with reaches identified for excavation and removal of sediment/riparian soil identified in Figure 3-8. In some cases, existing wetlands (based on future delineations) may be used or further engineered. Therefore, the volume of material excavated for the wetlands would likely be small percentage of the excavated volume identified in Alternative 4*

and would not significantly impact the cost of Alternative 4. No revisions to the memorandum or cost estimate are proposed.

50. Table 3-3, Page 6, Row Time Until Remedial Objectives are Achieved Column Alternative 4, second paragraph, sentence 1 – Reword, perhaps to "In the lower reaches of the drainages where MNR is the remedy, the time until the remedial objectives are met would be reduced compared with the expected duration for Alternative 3."

    ***P4 Response (SC-50)**: This revision has been made to Table 3-3 in the revised FS Memo #2.*

51. Table 3-3, Page 6, Row Time Until Remedial Objectives are Achieved Column Alternative 4, second paragraph, sentence 2 – Confirm that this would assume that COC/COECs are being transported via the water column and chemical sorption is taking place in sediment and/or riparian soil in the lower reaches. Otherwise, why would there be a reduction in the overall timeframe for meeting remedial objectives in the lower reaches for Alternative 4 vs Alternative 3, as contribution of sediment/riparian soil to the lower reaches is eliminated either right away (excavated) or over time (capture in sediment traps/basins)?

    ***P4 Response (SC-51)**: P4 agrees that transport via the water column and chemical sorption is one possible transport mechanism for impacting sediment/riparian soil in both the upper and lower reaches. Both Alternatives 3 and 4 assume that this transport mechanism would be significantly reduced due to source controls, use of wetlands, and PRBs. As you suggest, the time frame for remediation of the sediments lower in these drainages might be similar. However, the thought is that under Alternative 4, excavation and removal of sediment/riparian soil with the highest concentrations would prevent this higher concentration material from physically being transported downstream during spring runoff in the short-term, thus reducing the timeframe to meet RAOs in the lower reaches. This has been clarified in Table 3-3.*

52. Table 3-4, Page 1, Row EPA Evaluation Criteria, Column Alternative 5b, second paragraph, sentence 2 – Other places (later in table, text) do not present discharge to a basin as an option for discharge treated Wells Fm water. Revise accordingly.

    ***P4 Response (SC-52)**: The text in Sections 2.3.4 and 3.5.4 and Table 3-4 has been modified to indicate more generally that the treated water would be infiltrated back into the Wells Formation. This could occur through an infiltration basin or infiltration gallery.*

53. Table 3-4, Page 2, Row 2B) Comparative Analysis, Column Alternatives 1, 2, 3, 5b, sentence 4 – This sentence reads awkwardly. Change perhaps to "… Alternatives 2 and 5b are similar as to compliance to these ARAR types ..."

    ***P4 Response (SC-53)**: The edit has been made as suggested.*

54. Table 3-4, Page 2, Row 3A) Detailed Analysis Column Alternative 3 – Should it be "Moderate to High"? Revise accordingly.

    ***P4 Response (SC-54)**: Table 3-4 has been revised to change Alternative 3 ranking from "Moderate and High" to "Moderate to High".*

55. Table 3-4, Page 2, Row Adequacy and reliability of controls, Column Alternative 5b, second paragraph, Sentence 2 – Change to "The WTP would require frequent monitoring/adjustment, and equipment is expected to need periodic maintenance/replacement."

    ***P4 Response (SC-55)**: This revision has been made to Table 3-4 in the revised FS Memo #2.*

56. Table 3-4, Page 2, Row Adequacy and reliability of controls, Column Alternative 5b, second paragraph, line 8 (last) – Change "shallow" to "alluvial" for consistency.

***P4 Response (SC-56)**: A global search and replace of text and tables has been performed to use "alluvial" or "shallow alluvial" within the revised FS Memo #2.*

57. Table 3-4, Page 4, Row Degree to Which Treatment is Irreversible, Column Alternative 5b, sentence 2 – This seems to be the opposite of what was said under Alternative 2. Reconcile.

    ***P4 Response (SC-57)**: The two items are discussing different processes. Alternative 2 is discussing sorption/desorption, whereas, Alternative 5b is discussing diffusion. Diffusion rebound is a common issue where groundwater extraction is implemented. With groundwater extraction, it is primarily the water from the high permeability zones that is recovered and treated. Monitoring wells that by their nature primarily monitor water from the higher-permeability zones may show clean and the extraction systems shut down. However, diffusion from more stagnant lower permeability zone results in a rebound in concentrations and extraction needs to be restarted. This cycle may repeat many times. With MNA, desorption and diffusion also are processes that occur. However, with MNA the processes are more gradual and inherent to the overall process.*

58. Section 4.0 Combined Remedy, Page 4-1.

    The reach of the N. Fork of Wooley Valley Creek adjacent to, and NE of, waste rock dump MWD084 has been identified as an area of focus where additional information is necessary (see illustrations below).

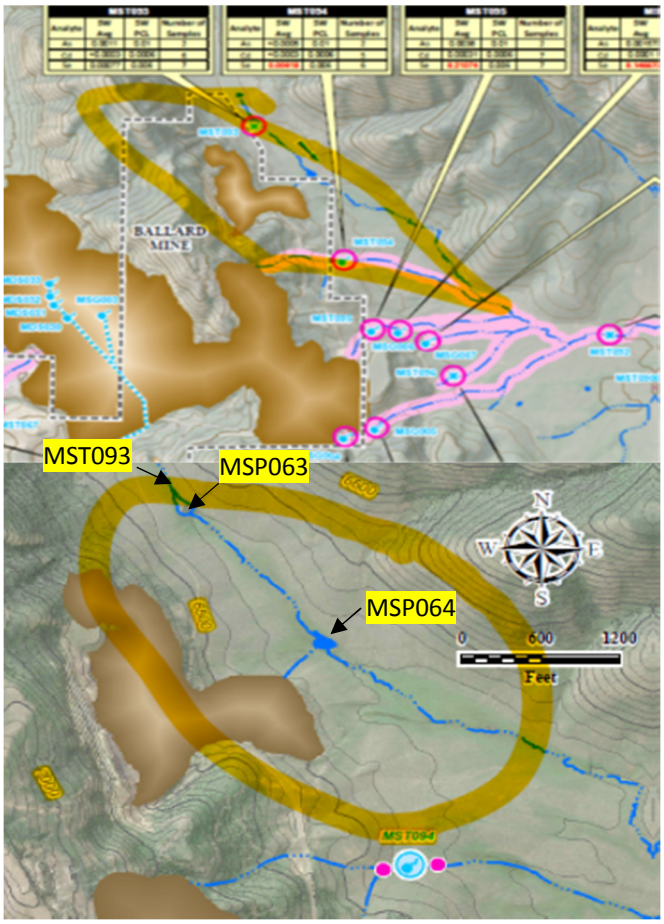
    This reach includes several ponds at the upper end and is bracketed by surface water stations MST093 (North) and MST092 (South). There appears to be intermittent seep from the dump (MWD084) feeding the main stem (see illustration below). Moving further south downgradient of this reach section, additional seeps flowing east from waste rock dump MWD082 form approximately three tributaries to the main stem before encountering surface water station MST092.

    Based on both FS memoranda, characterization data (media and average Se concentrations) along the North Fork of Wooley Valley Creek from SW station MST093 south to its confluence with the first seep tributary from dump MWD082 (area of concern) include the following:

- Surface water and riparian monitoring station (MST093) **(Ref. TM#2 Fig 3-5)**
  - Surface water [7 samples; Se ave., 0.00077 mg/L]
  - Riparian soil [1 sample; Se max, 1.5 mg/kg]
  - Sediment [1 sample; Se max, 1.0 mg/kg]
- Direct push alluvial aquifer wells (MBW131 and MBW048) **(Ref. TM#1 Fig 2-3)**
  - MBW131 [2 samples; Se ave., 0.0038 mg/L]
  - MBW048 [4 samples; Se ave., 0.0019 mg/L]
- Local aquifer monitoring well MMW032 **(Ref. TM#1 Figs 2-3 and 2-6)**
  - MMW032 [3 samples; Se ave., 0.0005 mg/L]
- Approximately 6 direct push boreholes (2008 and 2009) **(Ref. TM#1 Fig 2-7)**
  - BH054; Se 0.43 mg/L (Exceed Se PCL)
  - BH132; Se 0.006 mg/L (Exceed Se PCL)
  - BH052; Se 0.27 mg/L (Exceed Se PCL)
  - BH053; Se 1.25 mg/L (Exceed Se PCL)
  - BH133; Se <0.0005 mg/L
  - BH050; Se 0.003 mg/L
  - BH049A; Dry
  - BH049B; Dry

Using Google Earth, the reach of concern is approximately 0.8 to 1 mile in length. This reach is not proposed for any remedial action (including installation of sediment ponds or PRBs for a groundwater plume). Please clarify why. The existing data through this area is sparse and, by itself, does not appear to support the conclusion that no remedial activities are necessary. It is recommended that additional sampling of riparian soils, sediment, and surface water (where it is present) be performed to confirm the proposed status of this area. If P4 has additional sampling results or additional information that would support that supplemental data collection is not needed for this area, then please provide it to the A/T. This issue will not delay advancement of the FS; however, it will need to be addressed in the Remedial Design/Remedial Action process, if not sooner.

P4 may want to consider additional surface water sampling this fall of any ponds along this reach retaining water, or consider adding a couple of sampling stations in the spring to help bracket MWD084 to confirm that it is not contaminated or contributing to offsite migration of contaminated surface water or sediment.



***P4 Response (SC-58)**: P4 understands that the data gap detailed in this comment exists. As we discussed during the bi-weekly call on September 19, 2016, reconnaissance of this reach would be performed during the Fall 2016 LTM sampling event. During that event, conducted the week of September 26th, the MWH-led field team identified two ponds containing water. The Wooley Valley Creek channel was dry. Two pond surface water samples were collected (labeled MSP063 and MSP064) as shown on the figure above. Pond MSP063 is connected to upgradient background*

locations MST093, which historically has been unimpacted. The results of both samples will be evaluated and additional sampling will be performed in Spring 2016, as needed.

59. Section 4.1.1, Page 4-2 – Explain how long-term monitoring of the performance of the wetlands helps to determine if the remedial action objectives for groundwater are met.

    ***P4 Response (SC-59)**: The sentence in question is in the middle of the final paragraph of Section 4.1.1. This sentence seems misplaced in this discussion of upland soil/waste rock. It is the groundwater upgradient of the treatment systems that would be the primary performance monitoring data as alluded to in the preceding sentence. The sentence in question has been modified as follows: "These LTM data would be used to ~~continually~~ evaluate the performance of the ~~wetlands and PRBs~~ upland soil/waste rock remedial actions and to determine when RAOs are achieved (e.g., meeting the MCLs in groundwater)."*

60. Section 4.1.2, Page 4-3, Second paragraph, Sentence 5 (last) – It seems possible that the accompanying wetlands could be eliminated if the PRB at a particular site is treating surfacing groundwater to below the surface water standard. However, it appears that the wetlands will be built first "during the waste rock consolidation and cover system construction activities" (see earlier in paragraph). Explain how one or the other might be eliminated.

    ***P4 Response (SC-60)**: The sequencing of construction of groundwater and surface water remedial actions with upland soils/waste rock actions is only generally defined at this stage and will vary across the Site depending on the location. It is unlikely that the PRBs would be eliminated as they are being utilized broadly to treat groundwater, not just the seeps and springs. As further defined in the RD stage, the wetlands will likely be built as a polishing stage for seep/spring discharge that passes through the PRBs. Conceivably, if the groundwater downgradient of the PRBs is meeting surface water standards, the engineered wetland would not be constructed. However, unless there is a compelling reason for elimination, leaving the wetlands in place as backup is a reasonable assumption.*

    Because it is unlikely that the PRBs would be eliminated upstream of a seep/spring location, the sentence in question has been revised as follows: "In some locations, it may be possible to eliminate ~~either a PRB or~~ wetlands if surface water standards are being met after the groundwater has passed through the PRB located upgradient of specific seep or spring locations." This edit will be carried through to appropriate places in Section 3 and associated tables.

61. Section 4, Recommended Combined Remedy, Page 4-1 – There is considerable uncertainty about how effective the two water treatment methods—in situ wetland (depending on how this is defined – see previous comment) for surface water, and PRBs for groundwater—will be for all COC/COECs. While it may be possible to achieve effective treatment using these technologies, it is not clear what the correct sizing is or what combination of treatment units might be required. Ideally, treatability (pilot) testing would be conducted as part of the FS process to address key questions about effectiveness, design, operations, and maintenance to allow more accurate cost estimation and support preferred remedy selection and preparation of the proposed plan.

    ***P4 Response (SC-61)**: Treatment using PRBs is underway at the nearby South Rasmussen Mine (see Response to SC-14). The data from these PRBs are functionally the pilot testing data for PRBs that would be installed at the Ballard Site. The PRBs would be the primary treatment system for groundwater discharging to the surface. The wetlands are viewed as a downstream polishing step to provide further treatment to meet surface water standards, if needed. Any further pilot testing could be conducted prior to and/or during the RD stage, if it is not available from the ongoing treatment programs at South Rasmussen. However, because the preferred ore recovery alternative is phased as discussed in response to GC-D, "There will be opportunities to install the cover, seep treatment,*

and other systems and refine the designs of these remedy components through ongoing monitoring and maintenance during each phase of the RA." The current cost estimate falls well within the FS range of +50/-30% of the actual cost as a conceptual layout and design has been assumed for individual seep locations (refer to Table A-2c in Appendix A and Figures 3-6 and 3-10). At the FS stage, we feel that the costs are sufficiently defined for comparison amongst the alternatives. Please see response to comments GC-D, GC-G, and SC-14 for further clarification.

62. Sections 4.2 and 4.2.1, Ballard Shop, Page 4-7 – It is understood that remedial action for the Ballard Shop is proposed for after the area is no longer actively used. However, a proposed schedule for when P4 would be submitting a "…brief FS-level closure plan for the Ballard Shop so that it can be included in the remedy" and performing associated investigative studies would be helpful for advancing the entire project to a proposed plan and Record of Decision. Please include this information in this section.

    ***P4 Response (SC-62)**: See P4's response to GC-I. This information will be included in Section 4.2 and 4.2.1 in the revised FS Memo #2.*

Appendix A – FS Cost Estimate

Appendix A – FS Cost Estimate

General Comment:

EPA guidance recommends that estimates for professional services be presented in specific categories with level of effort percentages based on the relative size of the remedial project capital costs, as illustrated in Exhibit 5-8.

Exhibit 5-8

Capital Cost Element	< $100K (%)	$100K-$500K (%)	$500K-$2M (%)	$2M-$10M (%)	> $10M (%)
Project Management	10	8	6	5	5
Remedial Design	20	15	12	8	6
Construction Management	15	10	8	6	6

Source: *A Guide to Developing and Documenting Cost Estimates During the Feasibility Study* (EPA, 2000)

The Ballard Mine FS cost estimate presents the following professional services categories at a consistent rate for each medium, as indicated.

- Engineering (8 percent)
- Construction Management and Oversight (14 percent)
- Contingency (10 percent)

For clarification, it is recommended that professional service categories and estimated percentage of construction costs be revised to be more consistent with EPA guidance for estimating FS costs.

***P4 Response (GCA-1)**: Tables A-1 through A-4 in Appendix A –FS Cost Estimate have been revised to break down the professional services categories as shown in Exhibit 5-8 of the EPA guidance, "A Guide to Developing and Documenting Cost Estimates During the Feasibility Study" (July 2000) as*

depicted above. The EPA 2000 cost guidance shows a rule-of-thumb scope contingency of 10%-30% and 10% was applied uniformly to all the FS cost estimates.

Specific Comments

<u>Table A-1: Upland Soil/Waste Rock Alternatives</u>

Alternative 1 – No Action

- No comments

Alternative 4 – Upland Soil/Waste Rock Consolidation and/or Grading with an Evapotranspiration (ET) Cover System, ICs, and LUCs, and LTM

- Direct Capital Cost
  - Mobilization/Demobilization
    - Where is site preparation and laydown area development captured?

      Site preparation is broken out just below the Mobilization/ Demobilization entries in Table A-1. The clearing and grubbing costs cover site preparation prior to load out. The laydown area for the Ballard Mine likely will be the shop area and because it is already constructed there is no additional cost assumed for preparation of a laydown area (also where the Site trailers will be for construction personnel).

    - Regarding clearing and grubbing, how much cleared material will be generated and how and where is that material being handled?

      Clearing and grubbing is assumed for the entire area that will be covered during this upland soil/waste rock remedial alternative. The amount of material generated from the activity will be highly variable depending on if you are at the old existing waste rock piles with trees and shrubs or if you are in the mine pits where there might be no or very little vegetation. Compared to cost of the overall remedial action transport of the cleared material will be negligible and is presently accounted for indirectly in the alternative contingency. These materials will be backfilled with the waste rock and covered.

  - Waste Rock Removal, Onsite Consolidation and Regrading
    - Do any haul roads need to be constructed or will existing haul roads be used?

      Yes, new haul routes and roads undoubtedly will be necessary during the partial backfilling of the pits under Alternative 4; the costs of which are included in the unit rates (e.g., bcy) provided in the cost estimate.

    - Are costs captured for periodic road maintenance and dust control?

      Yes, road maintenance and dust control are included in the units rates (e.g. bcy) used in the cost estimate.

    - Do erosion control measures need to be installed and maintained during construction?

      Yes, a master stormwater plan will be prepared during the design stage that describes the overall processes including methods and procedures that will be used during the remedial action to control erosion (including best management practices), and a construction stormwater management and pollution prevention plan (SWPPP) will be prepared to starting individual work activities during the RA. The plans mentioned above have been prepared in the past. However, please note that the EPA's multi-sector general permit requirements are

evolving and there may be other or slightly different stormwater plans prepared in the future for this Site.

- Is there any potential for variation in excavation unit rates because of haul distance or production issues?

  While there will be some variation in haul distances and production rates, these differences are accounted for in the unit rates, which considers these variations and presents an average unit rate cost for these services.

- Surveying for layout, volume surveys and as-builts should be included.

  These costs will be minor and are captured in the engineering costs.

- Noted that engineered land use controls (LUCs) will be required in the alternative description (fence, signage, gates). Where is this cost captured?

  These costs will be minor and are captured in the contingency for this alternative as well as the others in the 10% contingency cost.

– Total Direct Costs

  - Noted that total does not include subcontractor markup or profit. Where is this captured in the summary?

    The per cubic yard costs for each activity include the contractor's assumed profit.

- Annual Costs

  – Is a yearly Long-term Monitoring (LTM) Report required to document the semi-annual inspections or are reports required every 5 years?

    For this upland soil/waste rock alternative annual cover inspections are included in the costs. Typically, they are summarized every 5 years for the CERCLA 5-year review meeting. Other parts of the remedy, including LTM of groundwater and surface water are assumed to have annual reports. In these FS estimates because they are presented by individual medium, we captured these LTM cost for each medium so annual and/or 5-year reports are included for surface water, groundwater, and sediment/riparian soil. As a result, we may have overestimated the costs for LTM reporting and therefore any LTM reporting for the soil/waste rock alternative is captured through LTM reporting for the other media.

  – Are any periodic costs, such as erosion repair, vegetation maintenance or fence repair anticipated during the out years?

    Yes, there would be some maintenance costs, but it is assumed these costs will be minor and are captured in two places in these estimates. Note there is a 25% increase in the baseline cost of the revegetation price "to cover additional erosional controls" this is during the out years. In addition, the 10% contingency for this alternative, which is approximately $4M could be used for periodic maintenance of all types (including the cover system).

***P4 Response (SCA-1)**: Please refer to the P4's responses to individual comments above. In most cases, the comments pertain to information that will be determined as the selected remedy is designed and the cost estimated is refined. The relatively minor costs mentioned above are currently*

captured in the unit rates, engineering costs, or in the contingency on estimated capital expenditures.

Alternative 6 – Upland Soil/Waste Rock Consolidation and/or Grading, Incidental Ore Recovery, ET Cover System, ICs, LUCs, and LTM

- Same comments as noted above in Alternative 4.

  ***P4 Response (SCA-2)**: Please refer to P4's responses above under SCA-1 – because they are similar for Alternative 6.*

Alternative 7 – Complete Consolidation of Existing Waste Rock into the Pits, ET Cover System, ICs, LUCs, and LTM

- Same comments as noted above in Alternative 4.

  ***P4 Response (SCA-3):** Please refer to P4's responses above under SCA – 1 because they are similar for Alternative 7.*

- Additional Comments:
  - Direct Capital Costs
    - Import material for MMP039 and MMP038 – Is any material being imported from offsite or is all this from an onsite source? May impact unit rates.

  ***P4 Response (SCA-4):** It is assumed that the material for MMP038 backfill would come from the borrow area depicted on Figure 3-4. It is assumed that the material used to backfill MMP039 would be the waste rock remaining in mine waste dump MWD084 (Refer to Alt 7 in Table A-1) and some clean material approximately 330K bank cubic yards from the borrow area to the south (shown on Figure 3-4).*

<u>Table A-2: Remaining Surface Water Alternatives</u>

Alternative 1 – No Action

- No comments

Alternative 2 – ICs and LUCs

- Annual Costs
  - Is a yearly LTM Report required to document the semi-annual inspections or are reports required every 5 years?

  ***P4 Response (SCA-5):** For this surface water alternative, the field labor for annual long-term monitoring are included in the cost estimate, as are costs for laboratory analyses, data validation and a yearly data summary report. Typically, these data then are summarized every 5 years for the CERCLA 5-year review meeting in either reports for each media or an overall report of LTM at the Site. In these FS estimates because they are presented by individual medium, we tried to capture the cost for each medium independently and may have overestimated the costs for LTM reporting.*

Alternative 3 – In Situ Treatment, ICs and LUCs

- Direct Capital Cost
  - Mobilization/Demobilization
    - Where is site preparation and laydown area development captured?

The laydown area for the Ballard Mine RA likely will be the shop area and because it is already constructed there is no additional cost assumed for site preparation or preparation of a laydown area (also where the Site trailers will be for construction personnel).

- Clearing and grubbing – how much cleared material will be generated, and how and where is that material being handled?

  The engineered wetlands are in relatively small areas because the seeps are minor (< 50 gpm max in spring) and as such there will not be a lot of material generated during the clearing and grubbing operation. Costs for clearing, grubbing and disposal of the material generated should be negligible and are accounted for indirectly in the alternative contingency of 10% of total capital costs.

– Surface Water Remedial Components

- Costs for constructing collection basins appears low based on the conceptual scope.

  We have included all the major components of the remedy and have the most current pricing. As noted in several responses above, these FS-level cost estimates will be refined during the RD, after the data are reviewed, necessary data gaps are filled and if necessary pilot tests are conducted, and the construction elements for engineered wetlands are refined/designed.

- Will the excavated spoils for the wetland basins be left locally or hauled to a common stockpile area?

  Left locally to create berms and other important elements of the engineered wetlands.

  Is this cost captured?

  Yes, it is captured in the excavation costs for the wetlands.

- Surveying should be included for layout and as-builts.

  Surveying costs will be minor and are captured in the engineering costs.

- Annual Costs

  – Same comment regarding LTM Report.

  Refer to P4's response to SCA-5 above regarding LTM.

  P4 Response (SCA-6): *Please refer to the P4's responses to individual comments above.*

<u>Table A-3: Remaining Sediment/Riparian Soil Alternatives</u>

Alternative 1 – No Action

- No comments

Alternative 3 – Sediment Traps/Basins, MNR, ICs and LUCs

- Annual Costs

  – Same comment regarding LTM Report.

  P4 Response (SCA-7): *Refer to P4's response to SCA-5 above regarding LTM.*

Alternative 4 – Removal/On-site Disposal, MNR, ICs, and LUCs

- LTM

- Are periodic erosion or vegetation replacement costs captured during the 30-year LTM?

P4 Response (SCA-8): *Not specifically, but those costs would be better estimated when the sections of stream needing remediation are refined during the RD process. Those costs currently are accounted for in the contingency costs for this alternative.*

<u>Table A-4: Remaining Groundwater Alternatives</u>

Alternative 1 – No Action

- No comments

Alternative 2 – Sediment Traps/Basins, MNR, ICs and LUCs

Is well abandonment required upon completion of the 30-year LTM period?

P4 Response (SCA-9): *The Alternative 2 groundwater remedy calls for MNA and ICs, not the items listed in the comment (i.e., Sediment traps, etc). Under Alternative 2 for groundwater (if that is the correct reference), monitoring wells would be needed during the RA MNA activities. At this point, we have assumed the existing monitoring wells would be used, but undoubtedly that there would be some augmentation to the current monitoring wells system. A line item for 6 additional shallow monitoring wells has been added to the capital costs in the estimate. In regards to your question, it is likely well abandonment would be necessary under this alternative, but when and in what locations is unknown. Monitoring well abandonment is not a difficult or an expensive activity and these costs are accounted for both in the per-foot cost of the new monitoring wells, as well as the alternative contingency costs.*

Alternative 3 – Removal/On-site Disposal, MNR, ICs, and LUCs

The Alternative 3 groundwater remedy includes: Limited Permeable Reactive Barrier (PRB) Treatment of Alluvial Groundwater, MNA for Wells Formation and alluvial groundwater downgradient of the seeps, and ICs, not the items listed in the comment (Removal/On-Site Disposal, etc.).

- Direct Capital Cost
  - Mobilization/Demobilization
    - Where is site preparation and laydown area development captured?

      Site preparation for the PRBs should be minimal and is accounted for in the contingency cost. The laydown area is at the Ballard shop so laydown area development will not be needed at the Ballard Site.

    - Clearing and grubbing – how much cleared material will be generated and how and where is that material being handled?

      Similar to Site preparation, clearing and grubbing prior to installing the PRBs should be minimal and this cost is accounted for the alternative contingency cost.

    - Single-pass mobilization appears low based on recent budgetary quotes from DeWind on similar projects.

      We received this verbal quote over the phone from this contractor.

  - Groundwater Remedial Components
    - Include transportation costs for iron filings.

      Those costs are included in the per ton cost of the iron filings (refer to note on iron filings row in cost estimate)

- Is any site preparation or grading required prior to constructing the PRB wall?

  Some site preparation might be necessary, but it depends on the specific location and in most cases, should be minimal as noted above.

- Should include move and set-up per seep location for PRB equipment.

  The time between locations should be minimal and are considered in the per linear foot ZVI PRB installation costs.

- How are the trench spoils being handled?

  We anticipated the spoils from the PRB trench construction would be used for the wetlands construction downhill from the PRBs. If impacted, this material would be placed as backfill within the existing mine pits.

- Should include well development and investigation-derived waste costs for monitoring well installation.

  These costs are minimal when considering the overall well installation costs and are accounted for in the per-foot drilling costs and in contingency.

- Zero-valent iron PRB Installation cost appears low.

  This is based on a vendor quote.

- Surveying should be included.

Similar to many of the items listed above, this cost is minor and is accounted for in the engineering costs.

- Annual Costs
  - Same comment regarding LTM Report.

    We are not sure what comment you are referring to. It is regarding the report itself, the monitoring, or well abandonment?

  - Any routine maintenance required during the 30-year LTM?

    There could be some but it is accounted for in the contingency costs estimated for this alternative.

P4 Response (SCA-10): *Please refer to the P4's responses to individual comments above. In most cases, the comments pertain to information that will be determined as the selected remedy is designed and the cost estimated is refined. The majority of these relatively minor costs mentioned above are captured in the engineering costs or contingency on estimated capital expenditures.*

Alternative 5b – Pump and Treat, and ICs

- Direct Capital Cost
  - Wells Formation Groundwater Extraction Wells

    - Containerizing and disposal of extraction well and piezometer development water should be included.

      Water removed from these wells during development will be containerized on Site and treated by passing it through the completed groundwater treatment plant. The cost for temporary storage tanks is relatively minimal when compared to the other capital costs and

is accounted for in the over $1M of contingency costs set aside for this groundwater alternative.

- Surveying should be included.

  This cost is minor and is accounted for in the engineering cost for this alternative.

- What is the power source and electrical distribution for the extraction well pumps?

  Rocky Mountain Power, a regional electricity provider, would supply the electrical power for extraction wells and RO plant operations. The costs for the electrical distribution system including pumps, power poles, transformers, electrical line, etc. is assumed in the $9M RO plant cost provided in the cost estimate

P4 Response (SCA-11): *Please refer to the P4's responses to individual comments above.*

Appendix B – Cover System Evaluation

1. As a cross-check of the estimations of necessary cover thickness that will effectively limit infiltration of precipitation through cap materials into Se-bearing waste rock, it is recommended that technical personnel from P4 and associated subcontractors consider the attached reference documents by W. Albright and C. Benson. Albright and Benson have and are currently working in the SE Idaho phosphate patch helping design and test cover designs. Their findings may be helpful for evaluating the conceptual cover design for the Ballard site and planning the future remedial cover design.

   P4 Response (SCB-1): *In previous cover designs, MWH has typically followed best practices as provided by Benson, Albright, and others. MWH also will review specific cover studies in SE Idaho during future design efforts and will use the information from these previous studies to ensure the development of an appropriate cover design for the Ballard Site.*

2. The final cover design should be based on the upper bound of measured precipitation (or the 100-year event or maximum recorded precipitation), rather than on average annual precipitation. Precipitation amounts from the highest elevation of the project area should be the data used in cover design (i.e., 30 inches per year). Please confirm this will be done during remedial design.

   P4 Response (SCB-2): *P4 and others will use a Site-appropriate upper bound precipitation record to evaluate the cover design as requested. It is likely that the precipitation that will control the cover design will be a long wet period of record as measured by historic data within the vicinity of the Ballard Mine.*

3. Appendix B, Attachment 1 (Golder Report), Page 16, Table 3, Typical Reclamation Seed Mix – The seed mix includes alfalfa as a component of "Monsanto Reclamation Seed Mix." Given the potential for a deep root (36 to 72 inches), it is suggested the plant list be reviewed to identify and potentially eliminate deep-rooted plants from the mix, if these are intended as cover vegetation in an ET-containment system.

   P4 Response (SCB-3): *P4 and others will review the seed mix in order to ensure plant-rooting depths are appropriate for the selected cover design.*

4. No substantive comments for change. However, there were a number of editorial changes we recommend. (All page numbers refer to the PDF page)

- Page 178, third paragraph, third line – Fix figure reference.
- Page 183, second paragraph, second line – Typographic error "Figure," and need to fix figure reference.

- Page 184, second paragraph, third line – Fix figure reference.
- Page 184, second paragraph, fourth line – Fix table reference.
- Page 184, second paragraph, eighth line – Fix table reference.
- Page 187, first paragraph, first line – Fix table reference.
- Page 187, fourth paragraph, first line – Fix table reference.
- Page 189, third paragraph, second line – Fix figure reference.
- Page 189, third paragraph, sixth line – Fix figure reference.
- Page 189, fourth paragraph, third line – Fix table reference.

P4 Response (SCB-4): *These revisions have been made in the revised document.*

Editorial Comments

Item No.	Section; Table; Figure	Page	Paragraph	Line (if not obvious)	Agency/Tribe Comments	Did P4 Respond to Comment
	1.1	1-1	1	1	Insert "into" to read "… entered into an …"	
	1.1	1-1	1	6	Change "tribes" to "Tribes."	
	1.3	1-3	Section 3.0	1	Insert "Action" to read "Remedial Action Alternatives" for consistency.	
	2	2-1	1	3	Change "on" to "in" to read "… detailed in Tables 2-1 through 2-4."	
	2	2-1	2	1	Change "on" to "in" to read "… screened in Tables 2-1 through 2-4 …"	
	2.3.1	2-9	1 (partial)	3	Change "are" to "is" for subject-verb agreement.	
	2.3.1	2-10	1 (partial)	3	Change "are" to "is" for subject-verb agreement.	
	2.3.1	2-11	2	3	Change to "Henry Mine."	
	2.3.2	2-13	Bullet 2 (Alternative 1 – No Action)	3	Delete the second "would not."	
	2.3.2	2-15	Bullet 2 (Alternative 5 – Ex-Situ Treatment …)	11	Change to "… and 5) overall higher costs."	
	2.3.4	2-18	Bullet 2 (Alternative 4 – In-Situ Treatment …)	9	Delete "it" to read "… because in-situ treatment …"	
	3	3-1	Bullet 2	3	Change "on" to "in" to read "… presented in tables …"	
	3.2	3-5	1	9	Insert a comma to read "… (soil cover), Alternative 4 …)	
	3.2	3-5	1	10	Delete the second "the screening."	
	3.2.4	3-12	2	4	Change to "alternatives."	
	3.2.4	3-12	2	5	Change to "assumed."	
	3.2.4	3-13	2	3	Change to "weather-related."	
	3.3	3-13	4	3	Change "on" to "in" to read "… presented in Table 3-2 …"	
	3.3.2	3-15	1	4	Change "contacts" to "contact" for subject-verb agreement.	
	3.3.2	3-15	1	13	Sampling may have to be done twice a year depending on when highest COC/COEC concentrations are observed. Revise accordingly.	
	3.4	3-17	4	3	Change "on" to "in" to read "… presented in **Table 3-3** …"	
	3.4.2	3-20	1 (partial)		Insert "and" to read "… track and evaluate the effectiveness …"	
	3.4.3	3-22	1	1	Insert "an" to read "… would require an RD and …"	
	3.4.3	3-22	2 (Detailed Analysis Summary)	10	Change "costs" to "cost."	
	3.5.1	3-23	5 (Detailed Analysis Summary) (last)	6 (last)	Change "is" to "are" for subject-verb agreement.	
	3.5.2	3-25	1 (Detailed Analysis Summary)	14 (last)	Change "is" to "are" for subject-verb agreement.	
	3.5.3	3-26	2 (Detailed Analysis Summary)	9	Delete the space to read "long-term."	
	3.5.3	3-26	2 (Detailed Analysis Summary)	13	Change "is" to "are" for subject-verb agreement.	
	3.6.1	3-31	Bullet 3 (Aesthetics)		The phrase "it would result in a reclaimed surface that would comprehensive and more naturally blends into with the surrounding native landscape/landforms" reads awkwardly. Revise.	
	3.6.2	3-32	Bullet 1 (Overall Protection of Human Health and the Environment)	10	Delete the semi-colon to read "…because even if coupled with source controls, no ICs or LUCs would be implemented …"	

Ballard Mine Feasibility Study Report
Memorandum 2 – Screening, Detailed, and Comparative Analysis of Assembled Remedial Alternatives
(August 2016)

Editorial Comments

Item No.	Section; Table; Figure	Page	Paragraph	Line (if not obvious)	Agency/Tribe Comments	Did P4 Respond to Comment
	3.6.2	3-33	Bullet 3 (Short-term Effectiveness)	2	Insert a semi-colon and comma to read "… or workers; however, it is not …"	
	3.6.2	3-33	Bullet 5 (Cost)	1	Insert a semi-colon and comma to read "… LUCs; however, Alternative 3 …"	
	3.6.3	3-36	Bullet 1 (Reduction in Toxicity, Mobility, and Volume through Treatment)	2	Change "ranks" to "rank."	
	3.6.3	3-36	Bullet 2 (Short-term Effectiveness)	10	Delete the first hyphen to read "sediment/riparian soil-removal component."	
	3.6.3	3-37	Bullet 2 (Cost)	2	Change "and" to "of" to read "… for protection of human health and the environment …"	
	4.1.4	4-4	Bullet 2	Sentence 2	Add a period at the end of the sentence.	
	Table 2-4	1	Row Alternative 2	Column Alternative Description	Insert "be" to read "would be implemented."	
	Table 3-2	3	Row 3B) Comparative Analysis	Columns Alternatives 1, 2, & 3	Line 5, change "4-year review" to "5-year review."	
	Table 3-2	3	Row Treatment Process Used and Materials Treated	Column Alternative 3	Line 1, change "surfaces" to "surface."	
	Table 3-3	5	Row Environmental Impacts	Column Alternative 4	Second paragraph, line 1, change "need" to "needs" for subject-verb agreement.	
	Table 3-3	6	Row Time Until Remedial Objectives are Achieved	Column Alternative 4	Paragraph 1, line 2, add a comma after "However."	
	Table 3-3	7	Row Ability to Construct and Operate the Technology	Column Alternative 4	Third paragraph, sentence 4, change to "The ability to implement Alternative 4 …"	
	Table 3-3	9	Row Availability/Demonstrated Effectiveness of Prospective Technologies	Column Alternative 4	Second paragraph, sentence 4, change to "Site characterization data may be necessary to inform the design of sediment/riparian soil removal, refine volume estimates, and guide initial excavations during the RA."	
	Table 3-4	1	Row EPA Evaluation Criteria	Column Alternative 3	Second paragraph, line 2, change to "upgradient" for consistency.	
	Table 3-4	1	Row Location- and Action-Specific ARARs	Column Alternative 5b	Line 4, change "injected" to "injection."	
	Table 3-4	2	Row Magnitude of residual risk	Column Alternative 2	Line 5, change to "… maintained to restrict contact …"	
	Table 3-4	2	Row Magnitude of residual risk	Column Alternative 5b	Insert a semi-colon to read "… cleanup levels in GW; they are reduced …"	
	Table 3-4	5	Row Protection of Community During RAs	Column Alternative 5b	Line 2, change "that" to "than" to read "… more time to complete than the other alternatives."	
	Table 3-4	5	Row Environmental Impacts	Column Alternative 3	Paragraph 1, line 1, change "MNR" to "MNA."	
	Table 3-4	6	Row Time Until Remedial Objectives are Achieved	Column Alternative 3	Second paragraph, line 8, delete the second "in."	
	Table 3-4	6	Row Time Until Remedial Objectives are Achieved	Column Alternative 5b	Paragraph 1, line 3, delete the second "in."	

Ballard Mine Feasibility Study Report
Memorandum 2 – Screening, Detailed, and Comparative Analysis of Assembled Remedial Alternatives
(August 2016)

Editorial Comments

Item No.	Section; Table; Figure	Page	Paragraph	Line (if not obvious)	Agency/Tribe Comments	Did P4 Respond to Comment
	Table 3-4	6	Row 5B) Comparative Analysis	Column Alternatives 1, 2, 3, 5b	Line 5, change "is" to "are" to read "… construction, infrastructure, and O&M are relatively complicated."	
	Table 3-4	6	Row Ability to Construct and Operate the Technology	Column Alternative 3	Second paragraph, line 2, change to "Remedial Action Work Plan (RAWP)."	
	Table 3-4	7	Row Reliability of the Technology	Column Alternative 5b	Line 14, change "wells" to "well" to read "… production well construction …"	
	Table 3-4	8	Row Availability of Necessary Equipment and Specialists	Column Alternative 5b	Line 1, change "are" to "is" for subject-verb agreement.	
	Table 3-4	8	Row Availability/Demonstrated Effectiveness of Prospective Technologies	Column Alternative 5b	Line 3, change "FM" to "Fm" for consistency.	

P4 Response (Editorial): *These revisions have been made in the revised FS Memo #2.*

APPENDIX C-3

A/T Comments on P4's Response to Comments (dated October 26, 2016) on *P4's Ballard Mine Feasibility Study Report Memorandum 2 – Screening, Detailed, and Comparative Analysis of Assembled Remedial Alternatives, Draft Rev 0, July 2016*

Transmitted to P4 on December 5, 2016

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 10
IDAHO OPERATIONS OFFICE
950 West Bannock, Suite 900
Boise, Idaho 83702

December 5, 2016

Molly R. Prickett
Environmental Engineer
Monsanto Company
Soda Springs Operations
1853 Highway 34
Soda Springs, Idaho 83276

Re: A/T Additional Comments on Ballard Mine FS Report Memorandum 2

Dear Ms. Prickett,

The Agencies and Tribes (A/T) have reviewed the above referenced deliverable, and related responses to comments, submitted pursuant to the 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 (or 2009 AOC). This letter transmits additional comments.

Please review the comments and provide responses. We will be available to discuss these comments in the coming weeks. Please contact me if you have questions. I can be reached at 208-378-5763 or electronically at tomten.dave@epa.gov.

Sincerely,

//s//

Dave Tomten
Remedial Project Manager

Enclosure

cc: Mike Rowe, IDEQ - Pocatello
Sandi Fisher, US FWS - Chubbuck
Kelly Wright, Shoshone Bannock Tribes
Susan Hanson (for the tribes)
Sherri Stumbo, Forest Service – Pocatello (electronic version only)
Colleen O'Hara-Epperly, BLM – Pocatello (electronic version only)
Vance Drain, MWH (electronic version only)

Printed on Recycled Paper

Cary Faulk, Integrated-Geosolutions (electronic version only)
Shannon Ansley, Shoshone Bannock Tribes (electronic version only)
Dennis Smith, CH2MHill (electronic version only)
Gary Billman, IDL – Pocatello (electronic version only)
Jeremy Moore, US FWS – Chubbuck (electronic version only)

Enclosure

Ballard Mine FS TM#2
Additional Comments and Responses to Comments Regarding TM #2.

Additional Comments:

In recent weeks, the proposed strategy for remediating the Ballard Mine was presented to internal EPA Region 10 peer reviewers. Reviewers were generally supportive of the overall remedial strategy presented in the FS, including consideration of ore recovery, use of ET covers and other key elements. There were, however, a number of questions raised about the effectiveness and reliability of some elements of the recommended combined remedy. Generally, there were questions about:

- The basis for concluding that the polishing ponds/cells for treating seepage would have removal efficiency necessary to achieve PCLs for surface water.
- The basis for concluding that the PRBs for treating shallow groundwater would be effective at removing selenium.
- The length of time anticipated to meet PCLs in GW, SW and sediment, and the basis for those estimates. Related to that, how will different portions of GW plumes respond over time to engineering controls and MNA?
- How the elements of the combined remedy worked together; that is, the placement and sequencing of the elements.

Additional information and/or analyses are necessary to address these comments. For example:

1. Include a more thorough description, perhaps in section 4, of how the elements of the combined remedy work together to achieve PCLs for SW, GW and sediment. This text should discuss <u>why</u> the preferred combined alternative, as proposed, will succeed as a remedy. Much like in the risk assessment, lines of evidence for each remedial media alternative and their integration into a comprehensive long term remedy should be described in light of the specific setting, elevation, topography, geology, climate, water chemistry, etc. of the Ballard Mine. A figure may also be useful to emphasize that the separate elements must be considered as an integrated system.
2. Provide more and specific information describing the technical basis for concluding that the PCLs (for GW, SW and sediment) will be achieved through use of the preferred technologies. The <u>technical basis for the choice</u> of each media alternative should be clearly summarized for the reader (citing specific relevant remediation practices or results of pilot studies as backup would be helpful). For instance:
    - What is it about constructed wetlands that make them the most effective treatment choice for polishing surface water runoff contaminated with residual selenium and other COCs and best choice to meet regulatory standards?
    - What criteria will be used to decide if the treatment effectiveness of engineered wetlands down gradient of mine seeps would be enhanced by upstream construction of a permeable reactive barrier?
    - Suggest that the classes of media envisioned for use in treatment unit processes, including wetlands and PRBs, be described, as well as the intended mechanisms of contaminant treatment/removal. Details like the exact materials and amounts are appropriately left until the remedial design.

- What is it about selenium and the chemistry of the Dinwoody and Wells Formation groundwater, or the location, size or setting of the contaminant plume, that make Monitored Natural Attenuation (MNA) the best choice to restore water quality in these aquifers?
- What is it about monitored natural recovery (MNR) that makes it the best choice for remediating contaminated riparian soils and sediment in local drainages? (On a technical basis, could the physical removal of more highly contaminated sediment and riparian soil close to the fringes of the mine dumps, in combination with MNR applied in downstream reaches that extend on to private property, be a more effective choice?)

3. Provide a summary statement describing the anticipated timeline for the comprehensive remedy to meet RAOs, and the basis for the time estimate.

Responses to Earlier General and Specific Comments

H. In recent months, there have been two water quality standards developments that may have implications for cleanup levels and that may affect the evaluation of ARARs compliance. These include issuance by EPA of a revised criteria recommendation for Se, and EPA's recent disapproval of the State of Idaho's criterion for As for protection of human health. These are issues where additional information and direction are forthcoming.

P4 Response (GC-H)*: As shown on Figure 2-5 of Ballard FS Memo #1, maximum Site surface water selenium concentrations are either well above the surface water standard of 0.005 mg/L or well below that standard. A reduction of the standard to 0.0031 mg/L would not impact the stream reaches considered under the evaluated alternatives. Nor should it affect the remedial alternative technologies considered in both Ballard FS memorandums.*

<u>EPA Comment:</u> Does EPA's recent disapproval of the State's criterion for Arsenic for the protection of human health have any cleanup implications or effect on the preferred alternative's ability to comply with ARARS as a result of this change? Based on our preliminary analysis, it appears that the recent disapproval will require revision of the PCL for As in surface water from 10 to 6.2 ug/l in the intermittent streams in the vicinity of Ballard.

Specific Comments

9. Section 2.3.2, Page 2-14, second paragraph under Alternative 3 bullet – Please qualify the description of the benefits of the wetlands treatment. As it stands, the paragraph describes water treatment benefits likely to come from established, mature wetlands, rather than newly "constructed" wetlands. Please include the likely maturation process and timetable of a constructed wetland that would eventually yield the desired results. Please cite local or related documented pilot studies as backup.

   P4 Response (SC-9)*: Please see comment response SC-14 regarding pilot testing. The maturation of the wetlands will be dependent upon a number of design items including time of year of construction (temperature), any seeding with bacteria, and type of organic matter used as substrate or introduced to kick start biological growth. These factors will be considered during the RD stage based on the design criteria and the overall sequencing of the RA. Because there are many design factors that can affect (accelerate or slow) the maturation, this detail is not necessary at the FS level,*

and the discussion of the maturation is not appropriate for the presentation in Section 2. However, a statement to the effect that the wetlands will not be immediately effective (e.g., may take several weeks to a year) because of the need for biological growth has been added to the "Short-term Effectiveness" item in Tables 2-2 and 3-2 for Alternative 3.

EPA Comment: Add a statement into the text that if wetlands treatment is not adequate to achieve required water quality standards at an approved compliance point within a reasonable time period, the remedy will be adapted to include another viable remedial technology to treat discharge, such as a passive bioreactor, runoff collection and conveyance to an infiltration gallery up gradient of a permeable reactive barrier, etc..

11. Section 3, Page 3-16 etc., surface and groundwater alternatives under various *Detailed Analysis Summaries* – Please describe the method used to establish a cleanup timeframe cited for each surface water and groundwater alternative.

    ***P4 Response (SC-29)**: The broadly stated cleanup timeframes are based on professional judgement and familiarity with the technologies and the rate at which they can be implemented.*

    EPA Comment: Please cite, in the FS, relevant studies or technical publications that concur and substantiate the cleanup timeframes.

40. Section 3.6.1, Page 3-29, Bullet 1 – It states "because the areas underlying the upland soil/waste rock dumps are assumed to be impacted by migration of constituents from the waste rock dumps to the underlying soil and would have to be graded and covered after the waste rock is removed." Intuitively this might make sense, but provide data to support this. Although not directly comparable (ore vs ROM or center waste shale), removal of phosphate ore at the Georgetown Canyon Industrial Complex Area did not require a cap on the daylighted native soil. A cap was placed on the area because of the buried elemental phosphorus.

    ***P4 Response (SC-40)**: This is prudent assumption for the FS. The converse assumption would be to assume that no cover or growth media would be needed in removal areas, which could lead to a significant underestimation of costs if some cover (or growth media) is needed in these areas.*

    EPA Comment: We agree this is the conservative approach, but this assumption has ramifications on the final, overall footprint of waste rock needing cover. We believe it would be prudent, and in the best interest of the remedy, to reduce the ultimate foot print of the waste rock and associated cover through consolidation (into pits, etc.) without compromising the final grading to facilitate drainage.

    Please provide available data that shows possible contamination of native ground under waste rock piles and justifies extending the cover in these areas? If there is no need to cover the native ground, it may be economically and environmentally prudent, to focus on consolidating all the waste rock into the pits and other areas and reduce the overall waste rock/cover footprint. This also begs the follow-on question: Is it more cost effective to consolidate the waste rock (into mine pits, etc.) or cover them in place?

APPENDIX C-4

P4's Response to Additional A/T Comments (dated December 5, 2016) on *P4's Ballard Mine Feasibility Study Report Memorandum 2 – Screening, Detailed, and Comparative Analysis of Assembled Remedial Alternatives, Draft Rev 0, July 2016*

(Second set of P4 responses. Responses to A/T comments on original P4 response to A/T comments.)

Submitted to A/T on January 13, 2017

From: Vance Drain <Vance.K.Drain@mwhglobal.com>
Sent: Friday, January 13, 2017 1:19 PM
To: Tomten.Dave@epamail.epa.gov
Cc: Bruce Narloch; bruce.olenick@deq.idaho.gov; Colleen O'Hara-Epperly (cepperly@blm.gov); eldine.stevens@bia.gov; gbillman@idl.idaho.gov; jcundick@blm.gov; Jeff Schut; jeffrey.fromm@deq.idaho.gov; Kelly Wright (kwright@shoshonebannocktribes.com); Edmond.Lorraine@epamail.epa.gov; VRANES, RANDY K (AG/1850); robert.blaesing@bia.gov; sherriaclark@fs.fed.us; susanh@ida.net; michael.rowe@deq.idaho.gov; Jeff Schut; Sandi_Fisher@fws.gov; Trina Burgin; Marc Stifelman ; Cary Foulk (cfoulk@integrated-geosolutions.com); Leah Wolf-Martin (leah@wolfmartininc.com); COOPER, RANDALL LEE [AG/1000]; Dennis Smith (dennis.smith2@ch2m.com); LEATHERMAN, CHRIS R [AG/1850]; MOLLY PRICKETT [AG/1850]; Paula Weyen-Gellner; Anthony Magliocchino; Barry Myers (bmyers@blm.gov); Shannon Leigh Ansley (sansley@sbtribes.com); Jeremy Moore (jeremy_n_moore@fws.gov); Stumbo, Sherri A -FS; Norka Paden (Norka.Paden@deq.idaho.gov)
Subject: P4's responses to additional A/T comments on the Ballard Site FS Memo #2
Attachments: FSMemo2_Rspns_Additional_A_TCommnts_01-13-17_toA_T.pdf; Fig 1_Site Wide Rem Components Conceptual Model_10Jan2017.pdf; FSMemo2 _Rspns_Additional_A_TCommnts_01-13-17_toA_T.docx

Dave,
Attached to the message, both as a pdf file and as a Word file, are P4's responses to the A/T's additional comments on the *Ballard Feasibility Study Memorandum #2* that were received on December 5, 2016. Please forward this email and its attachments to anyone that I may have inadvertently omitted for review.

We are ready to revise the memorandum upon your approval of our responses, or provide additional clarification in writing or on a conference call, if that is necessary.
Best Regards,

Vance Drain

Ballard Mine FS TM#2
Additional A/T Comments and P4 Responses to Comments Regarding TM #2.

In response to the A/Ts' additional comments on the combined Ballard Site preferred remedy discussed in the Ballard Mine FS TM #2, the following written materials and figure have been prepared and are provided below.

Additional A/T Comments:

GC-1: In recent weeks, the proposed strategy for remediating the Ballard Mine was presented to internal EPA Region 10 peer reviewers. Reviewers were generally supportive of the overall remedial strategy presented in the FS, including consideration of ore recovery, use of ET covers and other key elements. There were, however, a number of questions raised about the effectiveness and reliability of some elements of the recommended combined remedy. Generally, there were questions about:

- The basis for concluding that the polishing ponds/cells for treating seepage would have removal efficiency necessary to achieve PCLs for surface water.
- The basis for concluding that the PRBs for treating shallow groundwater would be effective C-2: at removing selenium.
- The length of time anticipated to meet PCLs in GW, SW and sediment, and the basis for those estimates. Related to that, how will different portions of GW plumes respond over time to engineering controls and MNA?
- How the elements of the combined remedy worked together; that is, the placement and sequencing of the elements.

P4 Response GC-1:

How will the elements of the combined remedy work together to remediate the Site?

The combined Ballard Site preferred remedy addresses four primary media: upland soil/waste rock, sediment/riparian soil, groundwater, and surface water. The remedy for upland soil/waste rock is the key component in the discussions of Site restoration because it addresses the source of contaminants of concern and contaminants of ecological concern (COCs/COECs) detected in all Site media. Completion of the upland soil/waste rock cover system and full site restoration will take several years to implement. Therefore, there are other components of the Site remedy that in the shorter-term substantially reduce or eliminate the transport of COCs/COECs in concentrations that exceed preliminary cleanup levels (PCLs). Concurrently with the active remediation, human and ecological receptors will be protected through institutional controls (ICs) and land use restrictions (LUCs) as other remedy elements are implemented. The major components of the remedy in the approximate sequence of implementation are as follows:

- ***Upland Soil/Waste Rock*** *- The upland soil/waste rock grading, consolidation, and partial mine pit backfill, incidental ore recovery, and ET cover system over the life of site restoration will prevent human/environmental exposure (i.e., contact) with upland soil/waste rock and vegetation. The ET cover will prevent contact with COC/COEC-impacted material allowing clean surface water and sediment to be shed from the Site. More importantly, the ET cover will substantially reduce infiltration into the waste rock and thereby control the release of COCs/COECs to groundwater and associated surface water seeps and springs. The regrading and ET cover also may facilitate increased selenium attenuation within the underlying waste rock as a result of decreased oxygen levels (Hay, et. al., 2016).*

The construction of upland soil/waste rock remedy will begin early during the remedy implementation and will likely will take six to eight years to complete. The remedy elements below will address the other contaminated media in the short-term, until the positive effects of the upland soil/waste rock remediation on these media are realized.

- ***Sediment/Riparian Soil*** *- Sediment traps or basins will address contaminated sediment associated with overland flow from upland soil/waste rock by capturing this sediment and reducing potential sediment loading further downstream in the intermittent drainages during RA (construction). These features will be constructed at the beginning of the remedy implementation and will be maintained/modified as needed throughout the remedial construction of the ET cover. Once the cover system is in place, the sediment basins could be removed to allow clean sediments from throughout the headwaters to migrate into the lower portion of these channels. The response to comment SC-2e provides additional details regarding the sediment remedy component including monitored natural recovery (MNR).*
- ***Groundwater*** *- PRBs will be installed upgradient of locations where impacted groundwater is discharging to surface water (i.e., seeps and springs), often at the edge of the existing waste rock sources. The PRBs will be constructed early during remedy implementation and will help treat the cores of several alluvial groundwater plumes near the waste rock source areas. MNA is proposed for treatment of the remaining alluvial plumes and the Wells Formation as discussed in response to SC-2d. PRBs are shown to be effective for treating alluvial groundwater COCs/COECs to surface water PCLs in the regional phosphate mine area (Newfields, 2015, 2016a, b, and c).*
- ***Surface Water*** *- Engineered wetlands will be constructed to polish groundwater discharging to the surface as seeps/springs after treatment through the PRBs (as described in the wetland discussion below). The wetlands will address any variability in the PRB effectiveness and possible secondary issues like suspended solids. Individual wetlands will be constructed early during the remedy implementation, but at some locations wetlands construction may be delayed until after the upgradient PRB effectiveness is evaluated (which could affect design and sizing of the wetlands at the individual locations).*
- ***LUCs, ICs, and LTM*** *- These important administrative and monitoring elements to the combined remedy will be necessary to protect human and environmental receptors in the short/intermediate term and monitor the success of various remedy elements.*

Figure 1 illustrates conceptual cross-sections of the combined remedy components (or elements). The first frame depicts the current Site condition and shows the initial implementation of sediment controls to prevent COC/COEC-affected sediment transport from the Site. Frame 2 illustrates the upgradient groundwater and surface water remedies implemented during the RA – PRB and engineered wetlands-- and depicts details of the remediation processes. Frame 3 illustrates the on-going monitoring and maintenance following completion of the remedy with the ET cover emplaced over the waste rock. With large reductions in COC/COEC loading from the upland soil/waste rock, surface water that meets PCLs will flow from the cover systems. Seeps/springs, as well as alluvial groundwater near the cover margin and Wells Formation groundwater, should meet (or be close to meeting) PCLs after construction of the cover system and after the existing contaminated interstitial groundwater drains out of the system. Eventually, it is thought that the PRBs and wetlands will be decommissioned (based on site monitoring and comparison to PCLs). Over the longer term, with the sources of contamination removed and the constant influx of clean water off the cover system, MNA in the alluvial and Wells Formation aquifers should be effective in addressing the remaining areas of groundwater

contamination, and MNR will reduce sediment/riparian soil concentrations in the downstream drainages.

Permeable Reactive Barriers (PRBs) – Placement and Effectiveness for Selenium removal in alluvial groundwater

Selenium is the primary COC/COEC considered during the remediation of Site water, and its removal is a key consideration during the treatment of alluvial groundwater and surface water. P4 currently has three PRBs installed below the Horseshoe Overburden Area at the South Rasmussen Mine (i.e., in 2009, 2012, 2016) that are used to treat selenium/other COC contamination (e.g., nickel, cadmium, zinc) in alluvial groundwater. The Ballard Site is approximately six miles to the west-southwest of the South Rasmussen Mine, and the geology, hydrogeology, source waste rock, and COCs are very similar to the Ballard Site. The mines are similar enough that the South Rasmussen Mine PRB testing can be considered pilot testing for the Ballard Site.

These PRBs were installed at South Rasmussen Mine during 2009/2010 and 2012, with a larger expansion added in 2016. For the purpose of this response, we discuss only the 2012 and 2016 PRB construction and groundwater sampling results. Additional detail on the performance of both PRBs can be found in Newfields (2015, 2016a, 2016c).

The 2012 PRB is 137 feet long, 10 feet wide and 17 feet deep and was constructed in the alluvial aquifer with a residence time of 24 hours. The PRB is organic-based consisting of quartzite sand (50%), chopped alfalfa hay (25%), and wood chips (25%) (Newfields, 2016b). Injection laterals were installed should liquid carbon amendments be needed in the future to extend the PRB life. The 2016 PRB construction at South Rasmussen included PRBs based on the 2012 design and are approximately 17 feet deep, 10 – 20 feet wide, and 1,150 feet long extending of both ends of the 2012 PRB. The 2016 construction included most of the same design features but has a higher percentage of wood chips (50% sand, 12.5% alfalfa hay, and 37.5% woodchips) to increase longevity (currently assumed to be about 10 years) (Newfields, 2016c).

The 2012 PRB has reliably decreased selenium concentrations to less than 0.005 mg/L and is also effective for cadmium removal. Early data from the 2016 PRB is also favorable but indicated that some portions need further maturation. The performance of the 2012 PRB is monitored by four pairs of monitoring wells. Each pair consists of an upgradient and a downgradient monitoring wells where selenium concentrations throughout the alluvial aquifer (shallow to deep) are monitored.

The measured selenium concentrations upgradient of the 2012 PRB range from approximately 0.05 to 0.65 mg/L between 2012 and 2016 (with a few lower exceptions). These concentrations are similar to what is seen at the Ballard Site (0.05 to just above 1 mg/L). Immediately after PRB construction beginning in 2013, of 22 downgradient groundwater samples collected, only five sample results exceeded 0.0031 mg/L total selenium (the SW PCL). The five selenium concentrations above 0.0031 mg/L ranged from 0.0044 to 0.006 mg/L (Newfields, 2016a), approximately twice the SW PCL. The Ballard PRBs will utilize the designs and lessons learned at the South Rasmussen Mine and combine the Site PRBs with engineered wetlands for enhanced treatment of the surface water discharge, as discussed below.

Engineered Wetlands – Placement and Effectiveness for Selenium removal to Surface Water PCL (as a tertiary treatment step)

Engineered wetlands were chosen for the combined Site remedy because they have proven to be effective at selenium removal, are simple to construct, and are relatively low cost. When these wetlands are combined with upgradient PRBs, compliance with surface water PCLs should be attainable.

The effectiveness of the upgradient PRBs needs to be considered when evaluating the selenium concentrations expected to be treated by the wetlands. As discussed above, the South Rasmussen Mine PRBs are consistently capable of treating groundwater to below the surface water standard (0.0031 mg/L; Newfields, 2016a). However, for the Ballard Site it was assumed the engineered wetlands will have to treat selenium concentrations up to 0.05 mg/L (post-PRB treatment) if the expected PRB performance is not achieved. In any seep/spring location, should the upgradient PRB remove selenium to below the surface water standard there will be no need for an engineered wetlands. It is anticipated that initially each individual locations will have a PRB installed followed by groundwater monitoring downgradient of the PRB and sampling of the discharging water at the seep/spring location. If the results indicate there is no need for a wetlands they will not be installed.

It should be noted that industry, including power generation plants, agriculture, and mining (in particular coal), all have used engineered and natural wetlands for selenium removal. They are shown to be effective at treating concentrations of selenium and obtaining greater than 90 percent removal which is more than sufficient to reduce e.g., 0.05 mg/L to less than 0.005 mg/L (e.g., Bland, et. al., 2013; Bays, et. al., 2012, DWTTC, 1999). If other COCs/COECs are present, they also can be reduced by engineered wetland systems using the same mechanisms as for selenium.

The conceptual engineered wetlands design for the Site, as depicted in Frame 2 of Figure 1, is an upflow anaerobic/aerobic wetlands system. This conceptual system 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). Any of these components could be modified or eliminated during the remedial design phase to optimize the location-specific systems. Even after initial construction of these systems (e.g., following the RA phase of the project) they could be modified to optimize their performance and efficiency. During the design phase, site-specific design variables such as residence time, peak and low flow requirements, material needs, etc. will be evaluated and specified for construction of these wetlands.

The conceptual system will intercept the treated groundwater (from the PRB) in the subsurface prior to any atmospheric oxygenation. The water upwelling into the wetlands will be reduced and organic-rich. Filtration will occur as the water from the PRB is captured and enters the gravel then passes up through the various layers in the engineered wetlands (refer to Figure 1, Frame 2 flow arrows). The filtration component of the system could be important for any total suspended solids (TSS) downgradient of the PRB.

The anaerobic bed portion of the wetlands is somewhat redundant with the PRB. However, this component potentially could be beneficial because it would provide redundant selenium removal

through enhanced precipitation or adsorption or if there is any short-circuiting/ bypassing of the PRB by contaminated alluvial groundwater.

The aerobic portion of the wetlands (i.e., plant growth media, plants, and open water) affect selenium removal by several additional processes not replicated in the anaerobic removal processes. These include:

- *Oxidation and hydrolysis of iron and manganese and subsequent selenium sorption or co-precipitation*
- *Plant uptake and subsequent sequestration in the dead organic matter of the wetlands*
- *Biological methylation and volatilization of selenium (DWTTC, 1999)*
- *Filtration of any selenium binding solids*

Most of these aerobic processes have been documented in wetlands, including at the nearby Wooley Valley Phosphate Mine (WVM), which effectively reduces selenium concentrations in waste rock seepage mine to below the surface water standard (Stillings and Amacher, 2004, sequestration by precipitants/sediments; Lamothe and Herring, 2004, volatilization; and Mackowiak, et. al., 2004, plant uptake). Selenium in the Wooley Valley wetlands was observed to drop from a range of 0.011 – 0.52 mg/L at the main seep to the wetland down to <0.005 mg/L within the wetland (Stillings and Amacher, 2004).

Oxidation in the aerobic portion of the wetlands will result in the precipitation of some solids, notably iron. The wetlands will sequester these solids, some of which may have selenium, and other COCs/COECs sorbed to them. The iron-oxyhydroxide precipitants are particularly important as it is these precipitants that were found to be the primary method of selenium attenuation in the WVM wetlands (Stilling and Amacher, 2004). Increasing the dissolved iron content of the seepage flow into the wetlands could be a design element considered (e.g., with the addition of zero-valent iron).

The primary limitation of the wetlands is their reduced effectiveness during winter conditions that are experienced at the Site, specifically the effectiveness of the plant and open water treatment components of the wetlands (i.e., aerobic portion). This concern is offset by the seasonality of many of the seeps/springs during the winter months, which is often a low-flow or no-flow time period.

Timeframe to Achieve PCLs

Timeframes for achieving PCLs are discussed for individual media below:

Upland Soil/Waste Rock *– Control of the source of contamination by regrading, consolidation and capping is the most important of the remedy components because it directly affects the other media of concern at the Site. Source control will be accomplished on the upland soil/waste rock in phases over six to eight years of remedy construction, and as a result, direct human health and ecological exposure pathways will be eliminated in stages as the cover systems are systematically installed throughout the Site. Any transfer of COCs/COECs to other media including sediment/riparian soil, surface water and groundwater either will be completely eliminated or substantially reduced as covers are completed in each of the Site's upland areas.*

Sediment/Riparian Soil *– The completed cover system on upland soil/waste rock substantially reduces precipitation infiltrating into the waste rock. This in turn eliminates COCs/COECs in the waste rock from dissolving into this water and the transport of contaminated sediment as particulates in runoff from the Site. These results will be achieved immediately in each area of the cover as the upland soil/waste rock areas are successively graded, covered and revegetated. Sediment control basins installed early in the RA, will allow for a reduction in transport of contaminated sediments prior to completion of the cover system. Once the cover system is in place, the sediment basins could be removed to allow clean sediments throughout the headwaters area to migrate into the lower portion of these channels and assist with the MNR. PCLs will be monitored in the lower reaches of the intermittent drainages and will be achieved via natural recovery over time following completion of the Site-wide remedy as further discussed in response to SC-2e.*

Surface Water *– Surface water includes seeps and springs at the margin of the cover system and snow melt/stormwater that is running off the cover system. Implementation of the preferred remedy will result in runoff immediately attaining the surface water PCLs. Seeps and springs will be treated by a combination of PRBs and wetlands as discussed above and should within a matter of months attain the surface water PCLs.*

Groundwater *– Groundwater includes the groundwater that directly discharges to the seeps and springs and is available to human and ecological receptors, alluvial groundwater that is distal from the source area, and the Wells Formation groundwater. Shallow groundwater, which emanates from seeps/springs, will be treated immediately upon installation the PRBs upgradient of seeps/springs and should attain, at a minimum, the groundwater MCLs immediately. The timeframe to achieve PCLs in distal portions of the alluvial aquifer as well as in the deeper Wells Formation aquifer cannot be well estimated using existing data due to the complexity of the Site. (Additional data collection is discussed below.)*

USEPA guidance for MNA provides context for allowing MNA where exposure pathways are not complete:

Per the USEPA MNA inorganic guidance (2015) "While remediation timeframes for organic plumes may be on the order of a few tens of years to more than a hundred years, remediation timeframes for inorganic plumes may be substantially longer. Ultimately, the timeframe for remediation will be based on site-specific conditions and chemical characteristics. The longer timeframes for inorganic plumes may be reasonable if the source term has already been addressed, the plume is stable or shrinking, the exposure risks for the source term and daughter products are acceptable, and when active measures have similar timeframes. Multiple lines of evidence are recommended for demonstrating "reasonable timeframe" considering the above factors in conjunction with the following: source control or removal is complete; there is high confidence in the attenuation mechanisms, rates and capacity identified; and contingency plans are included for both the monitoring program and containment or treatment approaches."

In evaluating whether PCLs in groundwater at the Site can be achieved in a reasonable timeframe, P4 has considered the factors discussed in the guidance document above.

- *The source of contamination (the source term mentioned above) will be graded and covered to substantially reduce or eliminate precipitation from moving through this medium, thereby eliminating it as a continuing source of contaminants to surface water, sediments, and groundwater.*

- *Based on relatively static groundwater concentrations in most monitoring wells provided by LTM data, the groundwater plumes appear to be stable. As discussed in response to SC-2d, there are lines of evidence that MNA can assist in achievement of PCLs.*
- *Human health and ecological exposure pathways and resulting risks will be controlled and largely eliminated through the implementation of ICs and LUCs. The majority of the impacted alluvial and Wells Formation groundwater is located on P4 property and where it is not, P4 will pursue land purchase, land exchanges, or agreements with property owners to implement appropriate ICs in order to control the beneficial use in these areas. As a result, there would be no current or anticipated future users of the mine-affected groundwater (no complete pathway of exposure), so there is not a significant driver for a potentially faster, but more costly treatment alternative. POC well locations will monitor compliance with RAOs in the alluvial and Wells Formation aquifers.*
- *The complex geology and heterogeneity of the aquifers is such that groundwater withdrawal, treatment and discharge to wells/ponds is not feasible, possibly has similar cleanup time frames as MNA, and contaminant rebound in the alluvial and Wells Formation aquifers could occur when MCLs are achieved and pumping is discontinued.*

Additional data collection and monitoring likely are necessary to evaluate the performance and timeframes involved with MNA of the alluvial and Wells Formation aquifers. P4 is proposing that additional monitoring and evaluations be performed through collection of groundwater and aquifer solids data from existing and new monitoring points. The Ballard Site MNA evaluation will follow the USEPA tiered analysis approach and recommended analyses per the USEPA 2015 guidance document (e.g., groundwater chemistry, subsurface mineralogy, chemical speciation).

Further MNA evaluations and long-term performance monitoring (LTM) ultimately will provide the data as to whether the proposed remedies and factors mentioned immediately above can achieve PCLs in a reasonable timeframe. CERCLA five-year reviews will evaluate the LTM data and determine the performance/ effectiveness of the combined Site remedy. Contingency options will be explored if the data presented at the five-year reviews do not provide evidence that PCLs are being achieved in a reasonable amount of time.

Groundwater Plumes responses – Alluvial and Wells Formation Aquifers

Regarding how different portions of the groundwater plumes will respond over time to as the combined remedy including MNA in the alluvial and Wells Formation aquifers is implemented, the following points are offered.

Alluvial Aquifer

- *Source control (in this case the cover system) will result in a reduction in flows and ultimately drying up of most of the existing seeps/springs at the waste rock margin, as any residual water in the waste rock and underlying alluvial groundwater drains through the hydrologic system.*
- *PRBs will treat impacted the alluvial groundwater upgradient of contaminated seeps/spring locations that then will have tertiary treatment through engineered wetlands during and following the RA. This cleanup near the cover margin, when combined with the infiltration of clean stormwater/snow melt runoff from the covered surfaces, will reduce concentrations of COCs/COECs in the shallow alluvial aquifer to*

below the MCLs. Cleanup will occur first near the margins of the cover and then expanding in a downgradient direction through infiltration of this water and dilution and natural attenuation. POC locations, established near P4's property line, will monitor compliance with RAOs. And ICs will be implemented on all P4-owned lands, and as necessary, on private land adjacent to the Site through legally binding agreements to restrict withdrawal and use of alluvial groundwater until ARARs are achieved.

- *Groundwater plumes emanating from the southwest side of the Site toward the Blackfoot River encounter wetland areas near the river. Data from the RI suggest that there is possible attenuation through anaerobic processes occurring near the river where more favorable conditions might occur in these marshy wetland areas. This possibility will be further explored as part of the MNA evaluation mentioned above.*

Wells Formation Aquifer

- *Source control will result in the substantial reduction and/or elimination of the primary sources of contamination to the Wells Formation. In the case of the contaminated perennial springs which are a source of contamination to the Wells Formation aquifer, the reduced COC/COEC flux from the waste rock would result in improved water quality. This is especially true in the West Ballard Pit area (MWP035) where elimination of flow through the waste rock and diversion of contaminated surface water from the West Pit will greatly reduce or completely eliminate COC loading to the Wells Formation. In this area, any contaminated surface water will be rerouted as ore recovery is conducted and upland soil/waste rock concurrently are regraded and covered to reduce infiltration of precipitation.*
- *Residual impacts to the Wells Formation once the source of contamination is eliminated will be remedied by MNA as further discussed in response to SC-2e. Similar to alluvial groundwater, POC locations on the Ballard Site will be used to monitor compliance with RAOs in the Wells Formation. ICs will be established to eliminate groundwater removal from the Wells Formation until monitoring indicates groundwater has achieved necessary MCLs.*

References:

Bays, J., Thomas, B.T., Harrison, T., and Evans, D., (CH2M Hill) 2012. *Advances in the use of passive wetlands systems for selenium treatment of mine-impacted water*. 9th INTCOL Internationals Wetlands Conference, Conference Abstract and Presentation, June, Orlando, Florida, pp. 272.

Bland, K.A., Snider, C.J., Morrison, J., and Von Hertsenburg, P., 2013. *Upcoming effluent guidelines, challenges: using constructed wetlands treatment systems to your advantage*. Proceedings of 74th Annual International Water Conference 2013, Orlando, Florida, November, IWC 13-58, vol. 2, pp. 926 – 945.

Drainage Water Treatment Technical Committee (DWTTC), 1999. *Task 2, Drainage Water Treatment, Final Report*. The San Joaquin Valley Drainage Implementation Program and the University of California Salinity/Drainage Program. 45p.

Hay, M.B., Leone, G., Partey, F., and Wilking, B., 2016. *Selenium attenuation via reductive precipitation in unsaturated waste rock as a control on groundwater impacts in the Idaho phosphate patch*. Applied Geochemistry, vol. 74, pp. 176-193.

Lamothe, P.J., and Herring, J.R., 2004. *Chapter 15 – Gaseous selenium and other elements in near-surface atmospheric samples, Southeast Idaho*. In J.R. Hein ed.*, Life Cycle of the Phosphoria Formation: From Deposition to Post-Mining Environment.* Handbook of Exploration and Environmental Geochemistry, Vol. 8, Elsevier B.V., pp. 427 – 435.

Mackowiak, C.L., Amacher, M.C., Hall, J.O., and Herring, J.R., 2004*. Chapter 19 - Uptake of selenium and other contaminants into plants and implications for grazing animals in Southeast Idaho*. In J.R. Hein ed.*, Life Cycle of the Phosphoria Formation: From Deposition to Post-Mining Environment.* Handbook of Exploration and Environmental Geochemistry, Vol. 8, Elsevier B.V., pp. 527 – 555.

Newfields, 2015. Final 2014 Annual Report, South Rasmussen Mine and Horseshoe Overburden Area, Caribou County, Idaho. Prepared for P4 Production, July.

Newfields, 2016a. Final 2015 Annual Report, South Rasmussen Mine and Horseshoe Overburden Area, Caribou County, Idaho. Prepared for P4 Production, August.

Newfields, 2016b. Remedial Design and Implementation Plan, Horseshoe Overburden Area, South Rasmussen Mine, Caribou County, Idaho. Prepared for P4 Production, January.

Newfields, 2016c. Construction Completion Report, Horseshoe Overburden Area, South Rasmussen Mine, Caribou County, Idaho. Prepared for P4 Production, December.

Stillings, L.L. and Amacher, M.C., 2004. *Chapter 17 - Selenium attenuation in a wetland formed from mine drainage in the Phosphoria Formation, Southeast Idaho*. In J.R. Hein ed.*, Life Cycle of the Phosphoria Formation: From Deposition to Post-Mining Environment.* Handbook of Exploration and Environmental Geochemistry, Vol. 8, Elsevier B.V., pp. 467 – 482.

Additional information and/or analyses are necessary to address these comments. For example:

1. Include a more thorough description, perhaps in section 4, of how the elements of the combined remedy work together to achieve PCLs for SW, GW and sediment. This text should discuss why the preferred combined alternative, as proposed, will succeed as a remedy. Much like in the risk assessment, lines of evidence for each remedial media alternative and their integration into a comprehensive long term remedy should be described in light of the specific setting, elevation, topography, geology, climate, water chemistry, etc. of the Ballard Mine. A figure may also be useful to emphasize that the separate elements must be considered as an integrated system.

   P4 Response SC-1: *Section 4.0 will be revised to incorporate pertinent sections of GC-1 response.*

2. Provide more and specific information describing the technical basis for concluding that the PCLs (for GW, SW and sediment) will be achieved through use of the preferred technologies. The technical basis for the choice of each media alternative should be clearly summarized for the reader (citing specific relevant remediation practices or results of pilot studies as backup would be helpful). For instance:

   - SC-2a: What is it about constructed wetlands that make them the most effective treatment choice for polishing surface water runoff contaminated with residual selenium and other COCs and best choice to meet regulatory standards?

     P4 Response SC-2a: *See response to GC-1 above.*

- SC-2b: What criteria will be used to decide if the treatment effectiveness of engineered wetlands down gradient of mine seeps would be enhanced by upstream construction of a permeable reactive barrier?

  P4 Response SC-2b: *See response to GC-1 above.*

- SC-2c: Suggest that the classes of media envisioned for use in treatment unit processes, including wetlands and PRBs, be described, as well as the intended mechanisms of contaminant treatment/removal. Details like the exact materials and amounts are appropriately left until the remedial design.

  P4 Response SC-2c: *See response to GC-1 above.*

- SC-2d: What is it about selenium and the chemistry of the Dinwoody and Wells Formation groundwater, or the location, size or setting of the contaminant plume, that make Monitored Natural Attenuation (MNA) the best choice to restore water quality in these aquifers?

  P4 Response SC-2d: *As presented in the RI Report (MWH, 2014), the Dinwoody Formation is not impacted at the Ballard Site, and in fact, where groundwater has been encountered in the Dinwoody Formation, it is a source of clean upwelling groundwater. The Wells Formation is impacted beneath and around the West Ballard Pit, which receives seep and spring water with elevated COCs.*

  When considering the Wells Formation, the physical configuration of the aquifer is an important aspect of its attenuation characteristics. The unit consists of alternating beds of limestone and calcareous sandstone beds and only locally one or two beds may be impacted by selenium concentrations that exceed MCLs. Locating these thin discontinuous interstitial layers can be a challenge for well installation. At the Ballard Site, these beds also are fractured and displaced by faulting and folding. In addition, the top of the Wells Formation is often located at considerable depth beneath the Site. These factors isolate and compartmentalize the Wells Formation and makes investigation (and remediation) difficult and costly. It is likely that segmentation of the Wells Formation keeps the groundwater contamination mostly local. Based on the current monitoring network at the Ballard Site, this appears to be the case, but because of the geologic complexity, it is not possible to know this with certainty.

  No industrial, domestic or agricultural wells are known to be installed in the Wells Formation in the vicinity of the Ballard Site often because of the depth and difficulty of drilling to and locating permeable beds within the formation. As presented in the RI Report, the nearest location for Wells Formation groundwater discharge are regional aquifer springs located 5.5 miles from the Ballard Site. Discharge from these springs has been dated to between 10,000 and 20,000 years old. Currently, COCs in the Wells Formation at the Ballard Site are unlikely to reach any receptors.

  These factors are considerations in deciding why MNA in the Wells Formation is the preferred remedy. Any active remediation would be difficult, complex and costly. The chemical conditions of the Wells Formation also are a consideration for MNA.

  Chemically, the selenium attenuation capacity of the Wells Formation has not been evaluated at the Ballard Site. However, it has been evaluated for several new mine

permitting studies in surrounding areas. Data as presented in the table below are summarized in the Smoky Canyon Mine, Panel F & G FEIS (BLM/USFS, 2007) and are compilation of literature values, data developed from laboratory batch attenuation tests, and evaluation of field data.

SELENIUM ATTENUATION SUMMARY

ATTENUATION EVIDENCE	EFFECTIVENESS (%)
Literature	11 - 46
Smoky Canyon Mine – Pole Canyon to Hoopes Spring	50
Smoky Canyon Mine – Panel A to Culinary Well	30 - 60
Smoky Canyon Mine – Batch Tests (1:4 to 1:10 rock:water ratio)	21 - 26
Dry Valley Mine – Batch Tests (1:4 rock:water ratio)	64

The data summarized above generally show that the Wells Formation rock in areas surrounding the Ballard Site have low to moderate attenuation capacity, primarily attributed to adsorption onto carbonate minerals. Generally, the Wells Formation rock at these sites in SE Idaho and the Ballard Site do not differ significantly and so these finding should apply at the Site.

Anoxic conditions are more favorable for selenium attenuation, and once the source of oxygenated selenium-impacted water is cut off with source controls, then anoxia may develop and be maintained in the Wells formation which would enhance attenuation. MNA with implementation of ICs should be an acceptable remedy for the Wells aquifer given the physical characteristics of the Site (such as the long flow paths and lengthy residence time), the lack of receptors, and an suitable attenuation capacity.

References:

U.S. Bureau of Land Management and U.S. Forest Service (BLM/USFS), 2007. *Smoky Canyon Mine, Panels F & G, Final Environmental Impact Statement*. October 2007. http://www.fs.usda.gov/Internet/FSE_DOCUMENTS/fsm8_047445.pdf

BLM, 2011. *Final* Environmental *Impact Statement, Blackfoot Bridge Mine, Caribou County, Idaho.* March 2011

- SC-2e: What is it about monitored natural recovery (MNR) that makes it the best choice for remediating contaminated riparian soils and sediment in local drainages? (On a technical basis, could the physical removal of more highly contaminated sediment and riparian soil close to the fringes of the mine dumps, in combination with MNR applied in downstream reaches that extend on to private property, be a more effective choice?)

P4 Response SC-2e: *MNR is a passive RA that would reduce risks in the long term. Comparison of alternatives in the detailed analysis show that MNR ranks high for effectiveness, implementability, and cost as well as several other criteria as discussed in Section 3.6.3 and Table 3.2 in FS Memo #2. The preferred alternative for sediment/riparian soil (Alterative 3) does not rely on MNR alone, but also includes source*

control, sediment traps, and ICs/LUCs. Alternative 4, which includes sediment removal in the upper drainages in addition to MNR and ICs/LUCs was evaluated in FS Memo #2 and was not proposed for the preferred remedy for several reasons as described in the memo and summarized below.

There are several reasons why MNR (with sediment traps near the sources) was selected as the preferred remedy. MNR, under Alternative 3, is a passive remedial approach that prevents the destruction of approximately 3½ miles of established natural riparian corridor and associated habitat near the source areas (Alternative 4). The loss of this habitat through excavation could affect wetland areas downstream and negatively impact aquatic and terrestrial wildlife until well after reclamation of the excavated area is complete, and the riparian plant communities have time to partially re-establish themselves.

MNR processes may include physical, biological, and chemical mechanisms that act together to reduce the risk posed by the contaminants. It is anticipated that dispersion and burial would be the primary natural recovery mechanism in the intermittent drainages at the Site. When coupled with source controls in the Site's upland soil/waste rock (eliminate impacted sediment load), surface water remedies (clean runoff and reduced seep/spring flows and concentrations), as well as sediment control basins/traps during implementation of the RA, the combined Alternative 3 MNR mechanisms/ remedies are considered reasonable.

Additionally, COC/COEC concentrations decrease generally by an order of magnitude away from the Site and most COCs/COECs approach background levels in the furthest downstream stations in the current pre- remedial-action Site configuration where upstream sources of COCs/COECs are uncontrolled. Moreover, studies conducted in southeast Idaho indicate that selenium becomes less bioavailable as soil weathers (Mackowiak and Amacher, 2003).

Also of note is that as part of the upland soil/waste rock remedy (i.e., ore recovery, consolidation, and grading), it is likely that portions of impacted sediment in the upper intermittent drainages will be removed and/or ultimately covered. Also, sediment in some drainage sections will be excavated and removed as a result of installation of sediment traps, engineered wetlands, and PRB installations. All these mentioned remedy components will in reality either remove or isolate under an ET cover some of the more highly contaminated sediment/riparian soil at the margins of the existing mine dumps. However, what will occur in those locations will only be understood once the design of the remedy is completed.

3. Provide a summary statement describing the anticipated timeline for the comprehensive remedy to meet RAOs, and the basis for the time estimate.

   P4 Response SC-3: *See response to GC-1 above.*

Responses to Earlier General and Specific Comments

H. In recent months, there have been two water quality standards developments that may have implications for cleanup levels and that may affect the evaluation of ARARs compliance. These include issuance by EPA of a revised criteria recommendation for Se, and EPA's recent disapproval of

the State of Idaho's criterion for As for protection of human health. These are issues where additional information and direction are forthcoming.

***P4 Response (GC-H)**: As shown on Figure 2-5 of Ballard FS Memo #1, maximum Site surface water selenium concentrations are either well above the surface water standard of 0.005 mg/L or well below that standard. A reduction of the standard to 0.0031 mg/L would not impact the stream reaches considered under the evaluated alternatives. Nor should it affect the remedial alternative technologies considered in both Ballard FS memorandums.*

EPA Comment: Does EPA's recent disapproval of the State's criterion for Arsenic for the protection of human health have any cleanup implications or effect on the preferred alternative's ability to comply with ARARS as a result of this change? Based on our preliminary analysis, it appears that the recent disapproval will require revision of the PCL for As in surface water from 10 to 6.2 ug/l in the intermittent streams in the vicinity of Ballard.

***P4 Supplemental Response (GC-H)**: Based on Drawing 4-14 from the Ballard RI Report (November 2014), a change in the PCL for arsenic in surface water to 6.2 ug/l would only add MSP012 and MST095 to the list of stations that exceed the PCL based on maximum detected concentrations. MSP012 is an interior pond, which will be removed as part of the upland soil remedy. MST095 is located in a headwater drainage on the east side of the Site. It is currently anticipated that a PRB and engineered wetland will be installed upgradient of this location as a result of elevated selenium concentrations. As discussed in response to GC-1, these treatment components (PRBs followed by wetlands polishing) can effectively be designed to treat a wide range of COCs/COECs including arsenic and selenium and comply with cleanup goals.*

Specific Comments

9. Section 2.3.2, Page 2-14, second paragraph under Alternative 3 bullet – Please qualify the description of the benefits of the wetlands treatment. As it stands, the paragraph describes water treatment benefits likely to come from established, mature wetlands, rather than newly "constructed" wetlands. Please include the likely maturation process and timetable of a constructed wetland that would eventually yield the desired results. Please cite local or related documented pilot studies as backup.

   ***P4 Response (SC-9)**: Please see comment response SC-14 regarding pilot testing. The maturation of the wetlands will be dependent upon a number of design items including time of year of construction (temperature), any seeding with bacteria, and type of organic matter used as substrate or introduced to kick start biological growth. These factors will be considered during the RD stage based on the design criteria and the overall sequencing of the RA. Because there are many design factors that can affect (accelerate or slow) the maturation, this detail is not necessary at the FS level, and the discussion of the maturation is not appropriate for the presentation in Section 2. However, a statement to the effect that the wetlands will not be immediately effective (e.g., may take several weeks to a year) because of the need for biological growth has been added to the "Short-term Effectiveness" item in Tables 2-2 and 3-2 for Alternative 3.*

   EPA Comment: Add a statement into the text that if wetlands treatment is not adequate to achieve required water quality standards at an approved compliance point within a reasonable time period, the remedy will be adapted to include another viable remedial technology to treat

discharge, such as a passive bioreactor, runoff collection and conveyance to an infiltration gallery up gradient of a permeable reactive barrier, etc..

P4 Supplemental Response (SC-9)*: Text will be added to Sections 4.1.2 and 4.1.4 as follows: "If proposed remedies for surface water and groundwater do not achieve RAOs at an approved compliance point within a reasonable time frame as established by USEPA in consultation with P4, the remedy will be evaluated and if necessary, adapted to include other viable remedial technologies for treating discharge. The LTM data, and possible alternative changes will be evaluated, discussed among stakeholders, and as necessary, implemented as part of the CERCLA 5-year review process."*

11. Section 3, Page 3-16 etc., surface and groundwater alternatives under various *Detailed Analysis Summaries* – Please describe the method used to establish a cleanup timeframe cited for each surface water and groundwater alternative.

    P4 Response (SC-11)*: The broadly stated cleanup timeframes are based on professional judgment and familiarity with the technologies and the rate at which they can be implemented.*

    EPA Comment: Please cite, in the FS, relevant studies or technical publications that concur and substantiate the cleanup timeframes.

    P4 Supplemental Response (SC-11)*: See response to GC-1 above.*

40. Section 3.6.1, Page 3-29, Bullet 1 – It states "because the areas underlying the upland soil/waste rock dumps are assumed to be impacted by migration of constituents from the waste rock dumps to the underlying soil and would have to be graded and covered after the waste rock is removed." Intuitively this might make sense, but provide data to support this. Although not directly comparable (ore vs ROM or center waste shale), removal of phosphate ore at the Georgetown Canyon Industrial Complex Area did not require a cap on the daylighted native soil. A cap was placed on the area because of the buried elemental phosphorus.

    P4 Response (SC-40)*: This is prudent assumption for the FS. The converse assumption would be to assume that no cover or growth media would be needed in removal areas, which could lead to a significant underestimation of costs if some cover (or growth media) is needed in these areas.*

    EPA Comment: We agree this is the conservative approach, but this assumption has ramifications on the final, overall footprint of waste rock needing cover. We believe it would be prudent, and in the best interest of the remedy, to reduce the ultimate foot print of the waste rock and associated cover through consolidation (into pits, etc.) without compromising the final grading to facilitate drainage.

    Please provide available data that shows possible contamination of native ground under waste rock piles and justifies extending the cover in these areas? If there is no need to cover the native ground, it may be economically and environmentally prudent, to focus on consolidating all the waste rock into the pits and other areas and reduce the overall waste rock/cover footprint. This also begs the follow-on question: Is it more cost effective to consolidate the waste rock (into mine pits, etc.) or cover them in place?

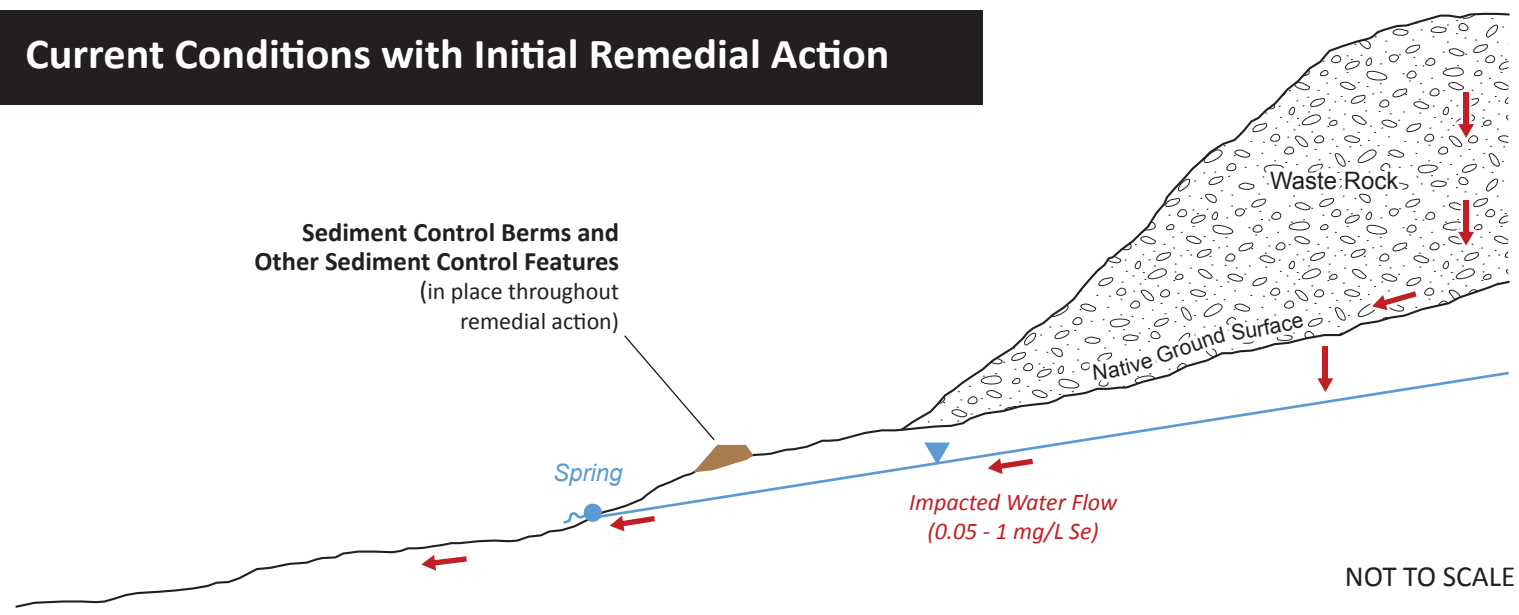
    P4 Supplemental Response (SC-40)*: Representative data are not available for waste rock dump subsoils at the Ballard Site. The substantive dumps have not been drilled and sub-dump soil samples analyzed. A limited number of soil samples currently are being analyzed as part of the 2016 Ballard Exploration field program. However, this small number of samples will not be representative of*

potential leaching impacts underlying the mine waste rock dumps across the Site. There are soil data from other P4 Sites (for example, underlying the more recent, reclaimed Enoch Valley Mine dumps). However, these data are not likely analogous due to the older and unreclaimed nature of the Ballard Site. In addition, based on elevated concentrations in sediment/riparian soil near the Ballard Site waste rock dumps, it is reasonable to assume that COCs/COECs have been leached from the waste rock into the underlying colluvial/alluvial soil.

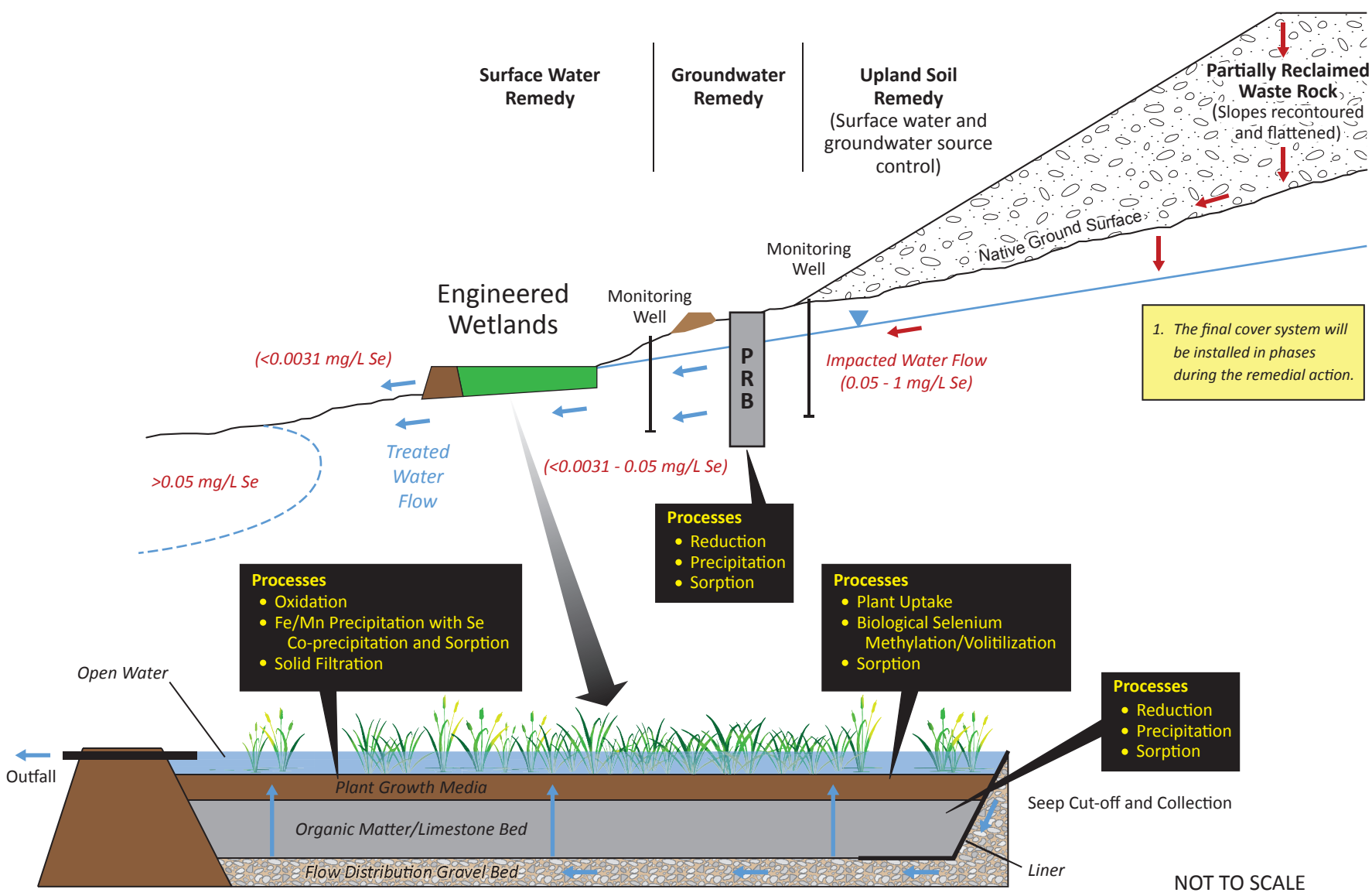
If necessary, sampling could be conducted during the RA to identify those areas that can remain uncovered (not impacted by leaching) at some cost, although the size of these areas left uncovered is likely minimal compared to the total covered area and shrinking the covered footprint would not result in reduced risks. Because of the unknowns and reasons stated above, assuming a cover for the FS costs are justified and prudent. In addition, waste rock pile removal will leave behind highly disturbed and potentially infertile soil (after up to 60 years of burial). At a minimum, regrading would be necessary, as would placement of some minimal cover material such as growth media to help ensure revegetation in a reasonable timeframe.

The last question, which is, "Is it more cost effective to consolidate the waste rock (into mine pits, etc.) or cover them in place?" has been answered by comparing the costs for Alternatives 4 and 7 with some minor adjustments. Currently, Alternative 4 includes excavating just enough of the exterior waste rock to cover the ore sections exposed in the pits, then covering the remainder of the exterior waste rock dumps in place. Alternative 7 includes excavating all the exterior waste rock dumps and consolidating them into the pits, then placing a cover system on the interior graded waste surface and the exterior native areas that were formerly covered by wastes. Alternative 4's present worth value is approximately $51M and the complete backfilling of the waste rock proposed under Alternative 7 is $109M. If the exterior areas in Alternative 7 were not covered following waste rock removal (as is suggested), the ET cover cost would be reduced from $20.9M to approximately $9.6M (by eliminating the 294-acre exterior area for ET cover), which is a $11.3M reduction in cost. The total cost for Alternative 7 then would be reduced to approximately $95M, which still is nearly double Alternative 4 costs because moving the waste rock into the pits is much more expensive that grading/covering the waste rock in place. Also, regarding the surface of the waste rock dumps following excavation as discussed in the paragraph above, there undoubtedly would be some additional costs required for regrading and adding soil amendments to the 294 acres prior to revegetation, which is not considered in the total cost of Alternative 7.

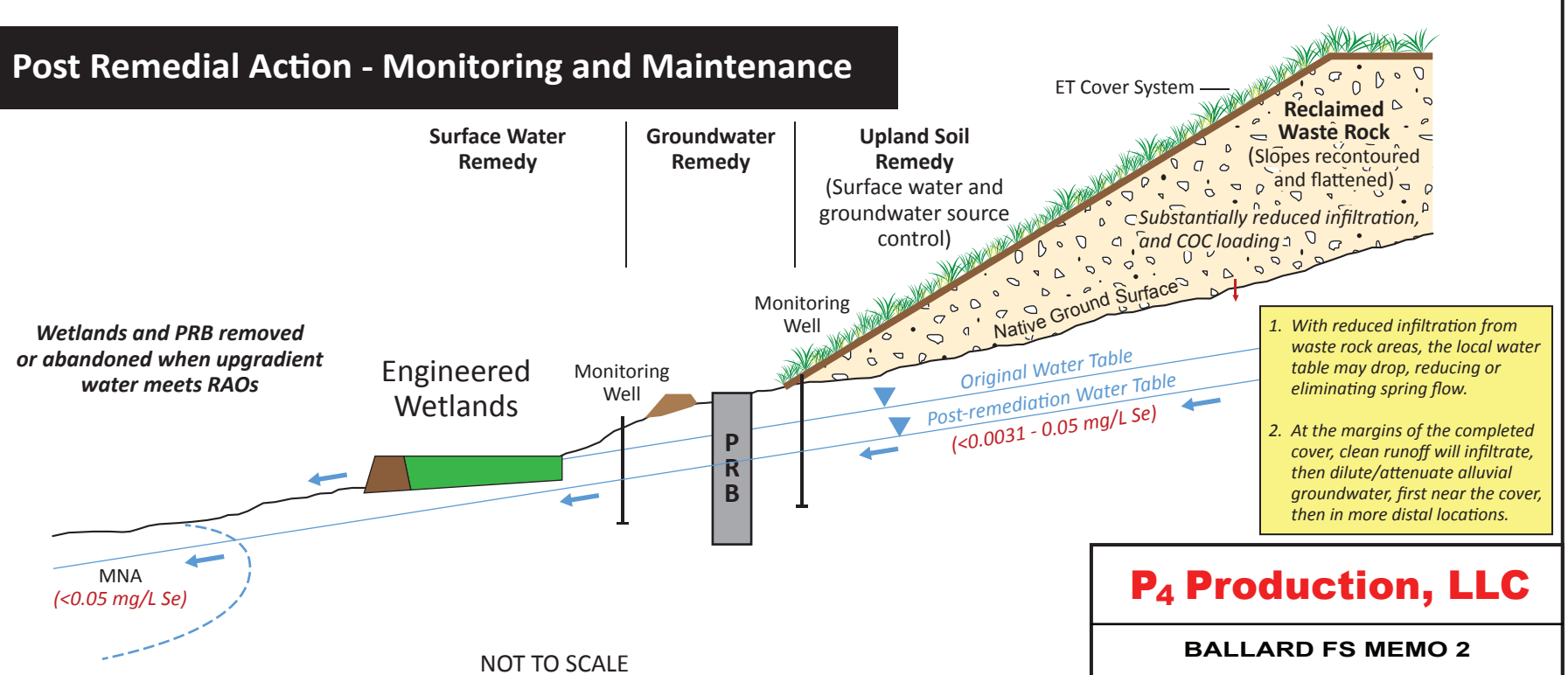
1 Current Conditions with Initial Remedial Action



2 Remedial Action - Installation of All Remedy Elements



3 Post Remedial Action - Monitoring and Maintenance



P_4 Production, LLC

BALLARD FS MEMO 2

SITE-WIDE REMEDIAL COMPONENTS CONCEPTUAL MODEL

Figure 1

MWH

APPENDIX C-5

A/T Comments to P4 Responses to A/T Additional Comments (dated January 13, 2017) on P*4's Ballard Mine Feasibility Study Report Memorandum 2 – Screening, Detailed, and Comparative Analysis of Assembled Remedial Alternatives, Draft Rev 0, July 2016*

Submitted to P4 on February 3, 2017

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 10
IDAHO OPERATIONS OFFICE
950 West Bannock, Suite 900
Boise, Idaho 83702

February 3, 2017

Molly R. Prickett
Environmental Engineer
Monsanto Company
Soda Springs Operations
1853 Highway 34
Soda Springs, Idaho 83276

Re: A/T Comments on Ballard Mine FS TM#2, Additional A/T Comments and P4 Responses to Comments Regarding TM#2.

Dear Ms. Prickett,

The Agencies and Tribes (A/T) have reviewed the above referenced deliverable, submitted pursuant to the 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 (or 2009 AOC). This letter transmits comments and direction on earlier responses to comments.

We will be available to discuss these comments in the coming weeks, and discuss next steps. Based on our review, it appears that comments have been resolved to the extent practical considering the information and data available. Thus, the next step is to re-issue TM#2 with revisions consistent with response resolution. Please contact me if you have questions. I can be reached at 208-378-5763 or electronically at tomten.dave@epa.gov.

Sincerely,

//s//

Dave Tomten
Remedial Project Manager

Enclosure

cc: Mike Rowe, IDEQ - Pocatello
Sandi Fisher, US FWS - Chubbuck
Kelly Wright, Shoshone Bannock Tribes
Susan Hanson (for the tribes)

Printed on Recycled Paper

Sherri Stumbo, Forest Service – Pocatello (electronic version only)
Colleen O'Hara, BLM – Pocatello
Vance Drain, MWH (electronic version only)
Cary Faulk, Integrated-Geosolutions (electronic version only)
Shannon Ansley, Shoshone Bannock Tribes (electronic version only)
Dennis Smith, CH2MHill (electronic version only)
Gary Billman, IDL – Pocatello (electronic version only)
Jeremy Moore, US FWS – Chubbuck (electronic version only)

Comments from Review of: *Ballard Mine FS TM#2, Additional A/T Comments and P4 Responses to Comments Regarding TM#2*.

Blue italics = P4 response; black type = Original A/T comments; and red type = A/T comment on P4 response.

Ballard Mine FS TM#2
Additional A/T Comments and P4 Responses to Comments Regarding TM #2.

In response to the A/Ts' additional comments on the combined Ballard Site preferred remedy discussed in the Ballard Mine FS TM #2, the following written materials and figure have been prepared and are provided below.

Additional A/T Comments:

GC-1: In recent weeks, the proposed strategy for remediating the Ballard Mine was presented to internal EPA Region 10 peer reviewers. Reviewers were generally supportive of the overall remedial strategy presented in the FS, including consideration of ore recovery, use of ET covers and other key elements. There were, however, a number of questions raised about the effectiveness and reliability of some elements of the recommended combined remedy. Generally, there were questions about:

- The basis for concluding that the polishing ponds/cells for treating seepage would have removal efficiency necessary to achieve PCLs for surface water.
- The basis for concluding that the PRBs for treating shallow groundwater would be effective at removing selenium.
- The length of time anticipated to meet PCLs in GW, SW and sediment, and the basis for those estimates. Related to that, how will different portions of GW plumes respond over time to engineering controls and MNA?
- How the elements of the combined remedy worked together; that is, the placement and sequencing of the elements.

P4 Response GC-1:

How will the elements of the combined remedy work together to remediate the Site?

The combined Ballard Site preferred remedy addresses four primary media: upland soil/waste rock, sediment/riparian soil, groundwater, and surface water. The remedy for upland soil/waste rock is the key component in the discussions of Site restoration because it addresses the source of contaminants of concern and contaminants of ecological concern (COCs/COECs) detected in all Site media. Completion of the upland soil/waste rock cover system and full site restoration will take several years to implement. Therefore, there are other components of the Site remedy that in the shorter-term substantially reduce or eliminate the transport of COCs/COECs in concentrations that exceed preliminary cleanup levels (PCLs). Concurrently with the active remediation, human and ecological receptors will be protected through institutional controls (ICs) and land use restrictions (LUCs) as other remedy elements are implemented. The major components of the remedy in the approximate sequence of implementation are as follows:

- ***Upland Soil/Waste Rock*** *- The upland soil/waste rock grading, consolidation, and partial mine pit backfill, incidental ore recovery, and ET cover system over the life of site restoration will prevent human/environmental exposure (i.e., contact) with upland soil/waste rock and*

vegetation. The ET cover will prevent contact with COC/COEC-impacted material allowing clean surface water and sediment to be shed from the Site. More importantly, the ET cover will substantially reduce infiltration into the waste rock and thereby control the release of COCs/COECs to groundwater and associated surface water seeps and springs. The regrading and ET cover also may facilitate increased selenium attenuation within the underlying waste rock as a result of decreased oxygen levels (Hay, et. al., 2016).

The construction of upland soil/waste rock remedy will begin early during the remedy implementation and will likely will take six to eight years to complete. The remedy elements below will address the other contaminated media in the short-term, until the positive effects of the upland soil/waste rock remediation on these media are realized.

- ***Sediment/Riparian Soil*** *- Sediment traps or basins will address contaminated sediment associated with overland flow from upland soil/waste rock by capturing this sediment and reducing potential sediment loading further downstream in the intermittent drainages during RA (construction). These features will be constructed at the beginning of the remedy implementation and will be maintained/modified as needed throughout the remedial construction of the ET cover. Once the cover system is in place, the sediment basins could be removed to allow clean sediments from throughout the headwaters to migrate into the lower portion of these channels. The response to comment SC-2e provides additional details regarding the sediment remedy component including monitored natural recovery (MNR).*
- ***Groundwater*** *- PRBs will be installed upgradient of locations where impacted groundwater is discharging to surface water (i.e., seeps and springs), often at the edge of the existing waste rock sources. The PRBs will be constructed early during remedy implementation and will help treat the cores of several alluvial groundwater plumes near the waste rock source areas. MNA is proposed for treatment of the remaining alluvial plumes and the Wells Formation as discussed in response to SC-2d. PRBs are shown to be effective for treating alluvial groundwater COCs/COECs to surface water PCLs in the regional phosphate mine area (Newfields, 2015, 2016a, b, and c).*
- ***Surface Water*** *- Engineered wetlands will be constructed to polish groundwater discharging to the surface as seeps/springs after treatment through the PRBs (as described in the wetland discussion below). The wetlands will address any variability in the PRB effectiveness and possible secondary issues like suspended solids. Individual wetlands will be constructed early during the remedy implementation, but at some locations wetlands construction may be delayed until after the upgradient PRB effectiveness is evaluated (which could affect design and sizing of the wetlands at the individual locations).*
- ***LUCs, ICs, and LTM*** *- These important administrative and monitoring elements to the combined remedy will be necessary to protect human and environmental receptors in the short/intermediate term and monitor the success of various remedy elements.*

Figure 1 illustrates conceptual cross-sections of the combined remedy components (or elements). The first frame depicts the current Site condition and shows the initial implementation of sediment controls to prevent COC/COEC-affected sediment transport from the Site. Frame 2 illustrates the upgradient groundwater and surface water remedies implemented during the RA – PRB and engineered wetlands-- and depicts details of the remediation processes. Frame 3 illustrates the on-going monitoring and maintenance following completion of the remedy with the ET cover emplaced over the waste rock. With large reductions in COC/COEC loading from the upland soil/waste rock, surface water that meets PCLs will flow from the cover systems.

Seeps/springs, as well as alluvial groundwater near the cover margin and Wells Formation groundwater, should meet (or be close to meeting) PCLs after construction of the cover system and after the existing contaminated interstitial groundwater drains out of the system. Eventually, it is thought that the PRBs and wetlands will be decommissioned (based on site monitoring and comparison to PCLs). Over the longer term, with the sources of contamination removed and the constant influx of clean water off the cover system, MNA in the alluvial and Wells Formation aquifers should be effective in addressing the remaining areas of groundwater contamination, and MNR will reduce sediment/riparian soil concentrations in the downstream drainages.

A/T Review Comment:

This comment is reasonably well addressed by the P4 response. However, it still seems ambiguous about which locations will have treatment wetlands constructed initially (early during the remedial action) versus where wetlands construction will be delayed, and possibly cancelled, pending results of monitoring to evaluate upgradient PRB treatment performance (more on this later).

Review Comment on Figure 1:

- Figure 1 is nicely done. It helps the reader visualize the remedy.
- Figure 1, part 3 says "Wetlands and PRB removed or abandoned when upgradient water meets RAOs". **Removal** is recommended, once PCLs are reliably achieved, to avoid re-mobilization of Se/COCs and release to the environment.

Permeable Reactive Barriers (PRBs) – Placement and Effectiveness for Selenium removal in alluvial groundwater

Selenium is the primary COC/COEC considered during the remediation of Site water, and its removal is a key consideration during the treatment of alluvial groundwater and surface water. P4 currently has three PRBs installed below the Horseshoe Overburden Area at the South Rasmussen Mine (i.e., in 2009, 2012, 2016) that are used to treat selenium/other COC contamination (e.g., nickel, cadmium, zinc) in alluvial groundwater. The Ballard Site is approximately six miles to the west-southwest of the South Rasmussen Mine, and the geology, hydrogeology, source waste rock, and COCs are very similar to the Ballard Site. The mines are similar enough that the South Rasmussen Mine PRB testing can be considered pilot testing for the Ballard Site.

These PRBs were installed at South Rasmussen Mine during 2009/2010 and 2012, with a larger expansion added in 2016. For the purpose of this response, we discuss only the 2012 and 2016 PRB construction and groundwater sampling results. Additional detail on the performance of both PRBs can be found in Newfields (2015, 2016a, 2016c).

The 2012 PRB is 137 feet long, 10 feet wide and 17 feet deep and was constructed in the alluvial aquifer with a residence time of 24 hours. The PRB is organic-based consisting of quartzite sand (50%), chopped alfalfa hay (25%), and wood chips (25%) (Newfields, 2016b). Injection laterals were installed should liquid carbon amendments be needed in the future to extend the PRB life. The 2016 PRB construction at South Rasmussen included PRBs based on the 2012 design and are

approximately 17 feet deep, 10 – 20 feet wide, and 1,150 feet long extending both ends of the 2012 PRB. The 2016 construction included most of the same design features but has a higher percentage of wood chips (50% sand, 12.5% alfalfa hay, and 37.5% woodchips) to increase longevity (currently assumed to be about 10 years) (Newfields, 2016c).

The 2012 PRB has reliably decreased selenium concentrations to less than 0.005 mg/L and is also effective for cadmium removal. Early data from the 2016 PRB is also favorable but indicated that some portions need further maturation. The performance of the 2012 PRB is monitored by four pairs of monitoring wells. Each pair consists of an upgradient and a downgradient monitoring wells where selenium concentrations throughout the alluvial aquifer (shallow to deep) are monitored.

The measured selenium concentrations upgradient of the 2012 PRB range from approximately 0.05 to 0.65 mg/L between 2012 and 2016 (with a few lower exceptions). These concentrations are similar to what is seen at the Ballard Site (0.05 to just above 1 mg/L). Immediately after PRB construction beginning in 2013, of 22 downgradient groundwater samples collected, only five sample results exceeded 0.0031 mg/L total selenium (the SW PCL). The five selenium concentrations above 0.0031 mg/L ranged from 0.0044 to 0.006 mg/L (Newfields, 2016a), approximately twice the SW PCL. The Ballard PRBs will utilize the designs and lessons learned at the South Rasmussen Mine and combine the Site PRBs with engineered wetlands for enhanced treatment of the surface water discharge, as discussed below.

A/T Review Comment:

We concur that the South Rasmussen Mine site PRBs provide a good set of performance data that can be used to evaluate potential Se removal in future PRBs at the Ballard Mine site. It is worth noting that while good Se treatment has been achieved by the 2012 and 2016 PRBs (although the 2016 PRB has a limited record), Se removal by the 2009 PRB at South Rasmussen was not particularly effective. This underscores the importance of the stated intent in the response to use design concepts from those latter systems, and take advantage of the lessons learned.

Engineered Wetlands – Placement and Effectiveness for Selenium removal to Surface Water PCL (as a tertiary treatment step)

Engineered wetlands were chosen for the combined Site remedy because they have proven to be effective at selenium removal, are simple to construct, and are relatively low cost. When these wetlands are combined with upgradient PRBs, compliance with surface water PCLs should be attainable.

The effectiveness of the upgradient PRBs needs to be considered when evaluating the selenium concentrations expected to be treated by the wetlands. As discussed above, the South Rasmussen Mine PRBs are consistently capable of treating groundwater to below the surface water standard (0.0031 mg/L; Newfields, 2016a). However, for the Ballard Site it was assumed the engineered wetlands will have to treat selenium concentrations up to 0.05 mg/L (post-PRB

treatment) if the expected PRB performance is not achieved. In any seep/spring location, should the upgradient PRB remove selenium to below the surface water standard there will be no need for an engineered wetlands. It is anticipated that initially each individual locations will have a PRB installed followed by groundwater monitoring downgradient of the PRB and sampling of the discharging water at the seep/spring location. If the results indicate there is no need for a wetlands they will not be installed.

It should be noted that industry, including power generation plants, agriculture, and mining (in particular coal), all have used engineered and natural wetlands for selenium removal. They are shown to be effective at treating concentrations of selenium and obtaining greater than 90 percent removal which is more than sufficient to reduce e.g., 0.05 mg/L to less than 0.005 mg/L (e.g., Bland, et. al., 2013; Bays, et. al., 2012, DWTTC, 1999). If other COCs/COECs are present, they also can be reduced by engineered wetland systems using the same mechanisms as for selenium.

The conceptual engineered wetlands design for the Site, as depicted in Frame 2 of Figure 1, is an upflow anaerobic/aerobic wetlands system. This conceptual system 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). Any of these components could be modified or eliminated during the remedial design phase to optimize the location-specific systems. Even after initial construction of these systems (e.g., following the RA phase of the project) they could be modified to optimize their performance and efficiency. During the design phase, site-specific design variables such as residence time, peak and low flow requirements, material needs, etc. will be evaluated and specified for construction of these wetlands.

The conceptual system will intercept the treated groundwater (from the PRB) in the subsurface prior to any atmospheric oxygenation. The water upwelling into the wetlands will be reduced and organic-rich. Filtration will occur as the water from the PRB is captured and enters the gravel then passes up through the various layers in the engineered wetlands (refer to Figure 1, Frame 2 flow arrows). The filtration component of the system could be important for any total suspended solids (TSS) downgradient of the PRB.

The anaerobic bed portion of the wetlands is somewhat redundant with the PRB. However, this component potentially could be beneficial because it would provide redundant selenium removal through enhanced precipitation or adsorption or if there is any short-circuiting/ bypassing of the PRB by contaminated alluvial groundwater.

The aerobic portion of the wetlands (i.e., plant growth media, plants, and open water) affect selenium removal by several additional processes not replicated in the anaerobic removal processes. These include:

- *Oxidation and hydrolysis of iron and manganese and subsequent selenium sorption or co-precipitation*
- *Plant uptake and subsequent sequestration in the dead organic matter of the wetlands*
- *Biological methylation and volatilization of selenium (DWTTC, 1999)*
- *Filtration of any selenium binding solids*

Most of these aerobic processes have been documented in wetlands, including at the nearby Wooley Valley Phosphate Mine (WVM), which effectively reduces selenium concentrations in waste rock seepage mine to below the surface water standard (Stillings and Amacher, 2004, sequestration by precipitants/sediments; Lamothe and Herring, 2004, volatilization; and Mackowiak, et. al., 2004, plant uptake). Selenium in the Wooley Valley wetlands was observed to drop from a range of 0.011 – 0.52 mg/L at the main seep to the wetland down to <0.005 mg/L within the wetland (Stillings and Amacher, 2004).

Oxidation in the aerobic portion of the wetlands will result in the precipitation of some solids, notably iron. The wetlands will sequester these solids, some of which may have selenium, and other COCs/COECs sorbed to them. The iron-oxyhydroxide precipitants are particularly important as it is these precipitants that were found to be the primary method of selenium attenuation in the WVM wetlands (Stilling and Amacher, 2004). Increasing the dissolved iron content of the seepage flow into the wetlands could be a design element considered (e.g., with the addition of zero-valent iron).

The primary limitation of the wetlands is their reduced effectiveness during winter conditions that are experienced at the Site, specifically the effectiveness of the plant and open water treatment components of the wetlands (i.e., aerobic portion). This concern is offset by the seasonality of many of the seeps/springs during the winter months, which is often a low-flow or no-flow time period.

A/T Review Comment:

The end of the second paragraph under this response heading indicates that PRB and treatment wetland construction will be stepwise procedure, using a "wait-and-see" approach, at ALL locations (where groundwater discharges to the surface as a seep/spring). In other words, the PRB will be constructed first, then monitoring will be performed to evaluate PRB performance, then a decision will be made whether or not a wetland is installed. A few comments on this:

- This seems inconsistent with presenting a conceptual model figure that shows wetlands in place. It also seems a bit inconsistent with the statement on page 2 saying "Individual wetlands ***will be constructed*** early during the remedy implementation, but at ***some*** locations wetland construction may be delayed until after upgradient PRB effectiveness is evaluated" [emphasis added]. The wetlands are referred to in numerous other places in the P4 responses as though they definitely will exist. We suggest the text and figures be consistent and specific, relative to when wetlands will be employed as a remedial action. Please clarify.

- What if a PRB achieves effective treatment of Se during the initial evaluation period, leading to a decision to omit the wetland; but then PRB performance deteriorates over time (e.g., over the first 1-2 years) as labile organic material is depleted? Will PRB performance monitoring continue and the decision about wetlands construction be left open-ended and re-visited if needed? Please state.

- There might be additional benefits to installing wetlands beyond just Se removal. For example, PRB-treated groundwater that discharges to the surface will likely have undesirable characteristics, such as H2S/other sulfides (odors, toxic if high enough),

dissolved iron (that will precipitate as "yellow boy") and manganese, organics, inorganic nutrients, etc. A wetland would help mitigate these undesirable treatment byproducts.

- The third paragraph about industries use of wetland remediation may overstate things somewhat, and a more cautious assessment is recommended. While natural and engineered wetlands, passive and semi-passive bioreactor, and active biological-based systems have been tested and piloted for Se treatment by a number of industries, the number of full-scale treatment systems of this type is still limited, and wetlands (alone) are not the presumptive treatment approach that this text implies. Achieving greater than 90% removal of Se on a consistent basis is not necessarily assured, and will require careful and conservative design/construction/ operation. The text cites a potential reduction requirement from 0.05 to 0.005 mg/L (i.e., 90%) and says that wetlands achieve "more than sufficient" Se removal to meet that requirement. Isn't the surface water standard 0.0031 mg/L? If so, that would require 94% reduction from the design influent concentration.

- Next to last paragraph under this heading mentions the possible addition of ZVI to (presumably) the organic matter/limestone bed in the wetlands. Clarify and state how will this be decided without testing?

Timeframe to Achieve PCLs

Timeframes for achieving PCLs are discussed for individual media below:

Upland Soil/Waste Rock *– Control of the source of contamination by regrading, consolidation and capping is the most important of the remedy components because it directly affects the other media of concern at the Site. Source control will be accomplished on the upland soil/waste rock in phases over six to eight years of remedy construction, and as a result, direct human health and ecological exposure pathways will be eliminated in stages as the cover systems are systematically installed throughout the Site. Any transfer of COCs/COECs to other media including sediment/riparian soil, surface water and groundwater either will be completely eliminated or substantially reduced as covers are completed in each of the Site's upland areas.*

Sediment/Riparian Soil *– The completed cover system on upland soil/waste rock substantially reduces precipitation infiltrating into the waste rock. This in turn eliminates COCs/COECs in the waste rock from dissolving into this water and the transport of contaminated sediment as particulates in runoff from the Site. These results will be achieved immediately in each area of the cover as the upland soil/waste rock areas are successively graded, covered and revegetated. Sediment control basins installed early in the RA, will allow for a reduction in transport of contaminated sediments prior to completion of the cover system. Once the cover system is in place, the sediment basins could be removed to allow clean sediments throughout the headwaters area to migrate into the lower portion of these channels and assist with the MNR. PCLs will be monitored in the lower reaches of the intermittent drainages and will be achieved via natural recovery over time following completion of the Site-wide remedy as further discussed in response to SC-2e.* ***Surface Water*** *– Surface water includes seeps and springs at the margin of the cover system and snow melt/stormwater that is running off the cover system.*

Implementation of the preferred remedy will result in runoff immediately attaining the surface water PCLs. Seeps and springs will be treated by a combination of PRBs and wetlands as discussed above and should within a matter of months attain the surface water PCLs.

Groundwater – *Groundwater includes the groundwater that directly discharges to the seeps and springs and is available to human and ecological receptors, alluvial groundwater that is distal from the source area, and the Wells Formation groundwater. Shallow groundwater, which emanates from seeps/springs, will be treated immediately upon installation the PRBs upgradient of seeps/springs and should attain, at a minimum, the groundwater MCLs immediately. The timeframe to achieve PCLs in distal portions of the alluvial aquifer as well as in the deeper Wells Formation aquifer cannot be well estimated using existing data due to the complexity of the Site. (Additional data collection is discussed below.)*

USEPA guidance for MNA provides context for allowing MNA where exposure pathways are not complete:

Per the USEPA MNA inorganic guidance (2015) "While remediation timeframes for organic plumes may be on the order of a few tens of years to more than a hundred years, remediation timeframes for inorganic plumes may be substantially longer. Ultimately, the timeframe for remediation will be based on site-specific conditions and chemical characteristics. The longer timeframes for inorganic plumes may be reasonable if the source term has already been addressed, the plume is stable or shrinking, the exposure risks for the source term and daughter products are acceptable, and when active measures have similar timeframes. Multiple lines of evidence are recommended for demonstrating "reasonable timeframe" considering the above factors in conjunction with the following: source control or removal is complete; there is high confidence in the attenuation mechanisms, rates and capacity identified; and contingency plans are included for both the monitoring program and containment or treatment approaches."

In evaluating whether PCLs in groundwater at the Site can be achieved in a reasonable timeframe, P4 has considered the factors discussed in the guidance document above.

- *The source of contamination (the source term mentioned above) will be graded and covered to substantially reduce or eliminate precipitation from moving through this medium, thereby eliminating it as a continuing source of contaminants to surface water, sediments, and groundwater.*

- *Based on relatively static groundwater concentrations in most monitoring wells provided by LTM data, the groundwater plumes appear to be stable. As discussed in response to SC-2d, there are lines of evidence that MNA can assist in achievement of PCLs.*

- *Human health and ecological exposure pathways and resulting risks will be controlled and largely eliminated through the implementation of ICs and LUCs. The majority of the impacted alluvial and Wells Formation groundwater is located on P4 property and where it is not, P4 will pursue land purchase, land exchanges, or agreements with property owners to implement appropriate ICs in order to control the beneficial use in these areas. As a result, there would be no current or anticipated future users of the mine-affected groundwater (no complete pathway of exposure), so there is not a significant driver for a potentially faster, but more costly treatment alternative. POC well locations will monitor compliance with RAOs in the alluvial and Wells Formation aquifers.*

- *The complex geology and heterogeneity of the aquifers is such that groundwater withdrawal, treatment and discharge to wells/ponds is not feasible, possibly has similar*

cleanup time frames as MNA, and contaminant rebound in the alluvial and Wells Formation aquifers could occur when MCLs are achieved and pumping is discontinued.

Additional data collection and monitoring likely are necessary to evaluate the performance and timeframes involved with MNA of the alluvial and Wells Formation aquifers. P4 is proposing that additional monitoring and evaluations be performed through collection of groundwater and aquifer solids data from existing and new monitoring points. The Ballard Site MNA evaluation will follow the USEPA tiered analysis approach and recommended analyses per the USEPA 2015 guidance document (e.g., groundwater chemistry, subsurface mineralogy, chemical speciation).

Further MNA evaluations and long-term performance monitoring (LTM) ultimately will provide the data as to whether the proposed remedies and factors mentioned immediately above can achieve PCLs in a reasonable timeframe. CERCLA five-year reviews will evaluate the LTM data and determine the performance/ effectiveness of the combined Site remedy. Contingency options will be explored if the data presented at the five-year reviews do not provide evidence that PCLs are being achieved in a reasonable amount of time.

A/T Review Comment:

This comment is reasonably well addressed in the P4 response. Only comment is that the support for MNA seems tenuous (discussed further under response to SC-2d below).

Groundwater Plumes responses – Alluvial and Wells Formation Aquifers

Regarding how different portions of the groundwater plumes will respond over time to as the combined remedy including MNA in the alluvial and Wells Formation aquifers is implemented, the following points are offered.

Alluvial Aquifer

- *Source control (in this case the cover system) will result in a reduction in flows and ultimately drying up of most of the existing seeps/springs at the waste rock margin, as any residual water in the waste rock and underlying alluvial groundwater drains through the hydrologic system.*
- *PRBs will treat impacted the alluvial groundwater upgradient of contaminated seeps/spring locations that then will have tertiary treatment through engineered wetlands during and following the RA. This cleanup near the cover margin, when combined with the infiltration of clean stormwater/snow melt runoff from the covered surfaces, will reduce concentrations of COCs/COECs in the shallow alluvial aquifer to below the MCLs. Cleanup will occur first near the margins of the cover and then expanding in a downgradient direction through infiltration of this water and dilution and natural attenuation. POC locations, established near P4's property line, will monitor compliance with RAOs. And ICs will be implemented on all P4-owned lands, and as necessary, on private land adjacent to the Site through legally binding agreements to restrict withdrawal and use of alluvial groundwater until ARARs are achieved.*

- *Groundwater plumes emanating from the southwest side of the Site toward the Blackfoot River encounter wetland areas near the river. Data from the RI suggest that there is possible attenuation through anaerobic processes occurring near the river where more favorable conditions might occur in these marshy wetland areas. This possibility will be further explored as part of the MNA evaluation mentioned above.*

Wells Formation Aquifer

- *Source control will result in the substantial reduction and/or elimination of the primary sources of contamination to the Wells Formation. In the case of the contaminated perennial springs which are a source of contamination to the Wells Formation aquifer, the reduced COC/COEC flux from the waste rock would result in improved water quality. This is especially true in the West Ballard Pit area (MWP035) where elimination of flow through the waste rock and diversion of contaminated surface water from the West Pit will greatly reduce or completely eliminate COC loading to the Wells Formation. In this area, any contaminated surface water will be rerouted as ore recovery is conducted and upland soil/waste rock concurrently are regraded and covered to reduce infiltration of precipitation.*
- *Residual impacts to the Wells Formation once the source of contamination is eliminated will be remedied by MNA as further discussed in response to SC-2e. Similar to alluvial groundwater, POC locations on the Ballard Site will be used to monitor compliance with RAOs in the Wells Formation. ICs will be established to eliminate groundwater removal from the Wells Formation until monitoring indicates groundwater has achieved necessary MCLs.*

A/T Review Comment:

No comment; P4 response seems adequate.

References:

Bays, J., Thomas, B.T., Harrison, T., and Evans, D., (CH2M Hill) 2012. *Advances in the use of passive wetlands systems for selenium treatment of mine-impacted water*. 9th INTCOL Internationals Wetlands Conference, Conference Abstract and Presentation, June, Orlando, Florida, pp. 272.

Bland, K.A., Snider, C.J., Morrison, J., and Von Hertsenburg, P., 2013. *Upcoming effluent guidelines, challenges: using constructed wetlands treatment systems to your advantage*. Proceedings of 74th Annual International Water Conference 2013, Orlando, Florida, November, IWC 13-58, vol. 2, pp. 926 – 945.

Drainage Water Treatment Technical Committee (DWTTC), 1999. *Task 2, Drainage Water Treatment, Final Report*. The San Joaquin Valley Drainage Implementation Program and the University of California Salinity/Drainage Program. 45p.

Hay, M.B., Leone, G., Partey, F., and Wilking, B., 2016. *Selenium attenuation via reductive precipitation in unsaturated waste rock as a control on groundwater impacts in the Idaho phosphate patch*. Applied Geochemistry, vol. 74, pp. 176-193.

Lamothe, P.J., and Herring, J.R., 2004. *Chapter 15 – Gaseous selenium and other elements in near-surface atmospheric samples, Southeast Idaho*. In J.R. Hein ed.*, Life Cycle of the Phosphoria Formation: From Deposition to Post-Mining Environment.* Handbook of Exploration and Environmental Geochemistry, Vol. 8, Elsevier B.V., pp. 427 – 435.

Mackowiak, C.L., Amacher, M.C., Hall, J.O., and Herring, J.R., 2004. *Chapter 19 - Uptake of selenium and other contaminants into plants and implications for grazing animals in Southeast Idaho*. In J.R. Hein ed.*, Life Cycle of the Phosphoria Formation: From Deposition to Post-Mining Environment.* Handbook of Exploration and Environmental Geochemistry, Vol. 8, Elsevier B.V., pp. 527 – 555.

Newfields, 2015. Final 2014 Annual Report, South Rasmussen Mine and Horseshoe Overburden Area, Caribou County, Idaho. Prepared for P4 Production, July.

Newfields, 2016a. Final 2015 Annual Report, South Rasmussen Mine and Horseshoe Overburden Area, Caribou County, Idaho. Prepared for P4 Production, August.

Newfields, 2016b. Remedial Design and Implementation Plan, Horseshoe Overburden Area, South Rasmussen Mine, Caribou County, Idaho. Prepared for P4 Production, January.

Newfields, 2016c. Construction Completion Report, Horseshoe Overburden Area, South Rasmussen Mine, Caribou County, Idaho. Prepared for P4 Production, December.

Stillings, L.L. and Amacher, M.C., 2004. *Chapter 17 - Selenium attenuation in a wetland formed from mine drainage in the Phosphoria Formation, Southeast Idaho*. In J.R. Hein ed.*, Life Cycle of the Phosphoria Formation: From Deposition to Post-Mining Environment.* Handbook of Exploration and Environmental Geochemistry, Vol. 8, Elsevier B.V., pp. 467 – 482.

Additional information and/or analyses are necessary to address these comments. For example:

1. Include a more thorough description, perhaps in section 4, of how the elements of the combined remedy work together to achieve PCLs for SW, GW and sediment. This text should discuss why the preferred combined alternative, as proposed, will succeed as a remedy. Much like in the risk assessment, lines of evidence for each remedial media alternative and their integration into a comprehensive long term remedy should be described in light of the specific setting, elevation, topography, geology, climate, water chemistry, etc. of the Ballard Mine. A figure may also be useful to emphasize that the separate elements must be considered as an integrated system.

   P4 Response SC-1: *Section 4.0 will be revised to incorporate pertinent sections of GC-1 response.*

A/T Comment:

No comment. Agree that this is reasonably well addressed in P4 response GC-1.

2. Provide more and specific information describing the technical basis for concluding that the PCLs (for GW, SW and sediment) will be achieved through use of the preferred

technologies. The technical basis for the choice of each media alternative should be clearly summarized for the reader (citing specific relevant remediation practices or results of pilot studies as backup would be helpful). For instance:

- SC-2a: What is it about constructed wetlands that make them the most effective treatment choice for polishing surface water runoff contaminated with residual selenium and other COCs and best choice to meet regulatory standards?

  P4 Response SC-2a: *See response to GC-1 above.*

- SC-2b: What criteria will be used to decide if the treatment effectiveness of engineered wetlands down gradient of mine seeps would be enhanced by upstream construction of a permeable reactive barrier?

  P4 Response SC-2b: *See response to GC-1 above.*

A/T Review Comment:

Agree that P4 response GC-1, along with Figure 1, describes wetlands adequately. Response does not really compare alternative technologies to demonstrate how wetlands were selected as the best choice for polishing surface water (as asked by the comment), although certain different treatment technologies were considered and screened out earlier in the FS.

- SC-2c: Suggest that the classes of media envisioned for use in treatment unit processes, including wetlands and PRBs, be described, as well as the intended mechanisms of contaminant treatment/removal. Details like the exact materials and amounts are appropriately left until the remedial design.

  P4 Response SC-2c: *See response to GC-1 above.*

A/T Review Comment:

Agree that P4 response GC-1 adequately addresses this comment – i.e., describes the classes of media materials to be used in the wetlands and PRBs. The P4 response is not clear about whether ZVI would be included in wetland media (discussed in a comment above).

- SC-2d: What is it about selenium and the chemistry of the Dinwoody and Wells Formation groundwater, or the location, size or setting of the contaminant plume, that make Monitored Natural Attenuation (MNA) the best choice to restore water quality in these aquifers?

  P4 Response SC-2d: *As presented in the RI Report (MWH, 2014), the Dinwoody Formation is not impacted at the Ballard Site, and in fact, where groundwater has been encountered in the Dinwoody Formation, it is a source of clean upwelling groundwater.*

The Wells Formation is impacted beneath and around the West Ballard Pit, which receives seep and spring water with elevated COCs.

When considering the Wells Formation, the physical configuration of the aquifer is an important aspect of its attenuation characteristics. The unit consists of alternating beds of limestone and calcareous sandstone beds and only locally one or two beds may be impacted by selenium concentrations that exceed MCLs. Locating these thin discontinuous interstitial layers can be a challenge for well installation. At the Ballard Site, these beds also are fractured and displaced by faulting and folding. In addition, the top of the Wells Formation is often located at considerable depth beneath the Site. These factors isolate and compartmentalize the Wells Formation and makes investigation (and remediation) difficult and costly. It is likely that segmentation of the Wells Formation keeps the groundwater contamination mostly local. Based on the current monitoring network at the Ballard Site, this appears to be the case, but because of the geologic complexity, it is not possible to know this with certainty.

No industrial, domestic or agricultural wells are known to be installed in the Wells Formation in the vicinity of the Ballard Site often because of the depth and difficulty of drilling to and locating permeable beds within the formation. As presented in the RI Report, the nearest location for Wells Formation groundwater discharge are regional aquifer springs located 5.5 miles from the Ballard Site. Discharge from these springs has been dated to between 10,000 and 20,000 years old. Currently, COCs in the Wells Formation at the Ballard Site are unlikely to reach any receptors.

These factors are considerations in deciding why MNA in the Wells Formation is the preferred remedy. Any active remediation would be difficult, complex and costly. The chemical conditions of the Wells Formation also are a consideration for MNA.

Chemically, the selenium attenuation capacity of the Wells Formation has not been evaluated at the Ballard Site. However, it has been evaluated for several new mine permitting studies in surrounding areas. Data as presented in the table below are summarized in the Smoky Canyon Mine, Panel F & G FEIS (BLM/USFS, 2007) and are compilation of literature values, data developed from laboratory batch attenuation tests, and evaluation of field data.

SELENIUM ATTENUATION SUMMARY

ATTENUATION EVIDENCE	EFFECTIVENESS (%)
Literature	11 - 46
Smoky Canyon Mine – Pole Canyon to Hoopes Spring	50
Smoky Canyon Mine – Panel A to Culinary Well	30 - 60
Smoky Canyon Mine – Batch Tests (1:4 to 1:10 rock:water ratio)	21 - 26
Dry Valley Mine – Batch Tests (1:4 rock:water ratio)	64

The data summarized above generally show that the Wells Formation rock in areas surrounding the Ballard Site have low to moderate attenuation capacity, primarily

attributed to adsorption onto carbonate minerals. Generally, the Wells Formation rock at these sites in SE Idaho and the Ballard Site do not differ significantly and so these finding should apply at the Site.

Anoxic conditions are more favorable for selenium attenuation, and once the source of oxygenated selenium-impacted water is cut off with source controls, then anoxia may develop and be maintained in the Wells formation which would enhance attenuation. MNA with implementation of ICs should be an acceptable remedy for the Wells aquifer given the physical characteristics of the Site (such as the long flow paths and lengthy residence time), the lack of receptors, and an suitable attenuation capacity.

References:

U.S. Bureau of Land Management and U.S. Forest Service (BLM/USFS), 2007. *Smoky Canyon Mine, Panels F & G, Final Environmental Impact Statement*. October 2007. http://www.fs.usda.gov/Internet/FSE_DOCUMENTS/fsm8_047445.pdf

BLM, 2011. *Final* Environmental *Impact Statement, Blackfoot Bridge Mine, Caribou County, Idaho.* March 2011

A/T Review Comment:

P4's assessment of MNA potential for Se in groundwater seems somewhat optimistic, and not particularly well supported. The document that presented the table of Se attenuation effectiveness included in the P4 response also stated that "the Agencies have adopted a selenium attenuation range of 15 to 25 percent to be used in the groundwater impact modeling" (to be conservative). The memorandum by Buck and Mayo (2005) titled *Evaluation of the Potential for Cadmium and Selenium Attenuation – F and G Panels, Smoky Canyon Mine* concluded that there is little or no potential for Se attenuation in the Wells Formation aquifer at Smoky Canyon Mine, other than what occurs due to dilution/dispersion:

- "There is no evidence that the requisite pH and Redox conditions for significant Se attenuation in the Wells Formation aquifer between Panels F and G and these springs are present"
- "Chemical attenuation of Se has not been demonstrated for flow pathways through the upper Wells Formation aquifer at the Smoky Canyon Mine"
- "After review of the information presented in this memo, at this time, we have not been able to identify quantifiable chemical attenuation mechanisms for Se that can be used in the Panels F and G groundwater impact analysis and recommend modeling Se attenuation due only to dilution and dispersion."

The response and text must acknowledge sources and magnitude of uncertainty.

In the last paragraph under this response heading, it is suggested that anoxic conditions more favorable for Se attenuation may develop once the caps are in place. In addition to anoxic conditions, a readily degradable supply of organics (i.e., electron donor) is also needed to drive Se bio-reduction. Please state if that is currently available and/or if it would be decreased by the cap.

- SC-2e: What is it about monitored natural recovery (MNR) that makes it the best choice for remediating contaminated riparian soils and sediment in local drainages? (On a technical basis, could the physical removal of more highly contaminated sediment and riparian soil close to the fringes of the mine dumps, in combination with MNR applied in downstream reaches that extend on to private property, be a more effective choice?)

P4 Response SC-2e: *MNR is a passive RA that would reduce risks in the long term. Comparison of alternatives in the detailed analysis show that MNR ranks high for effectiveness, implementability, and cost as well as several other criteria as discussed in Section 3.6.3 and Table 3.2 in FS Memo #2. The preferred alternative for sediment/riparian soil (Alterative 3) does not rely on MNR alone, but also includes source control, sediment traps, and ICs/LUCs. Alternative 4, which includes sediment removal in the upper drainages in addition to MNR and ICs/LUCs was evaluated in FS Memo #2 and was not proposed for the preferred remedy for several reasons as described in the memo and summarized below.*

There are several reasons why MNR (with sediment traps near the sources) was selected as the preferred remedy. MNR, under Alternative 3, is a passive remedial approach that prevents the destruction of approximately 3½ miles of established natural riparian corridor and associated habitat near the source areas (Alternative 4). The loss of this habitat through excavation could affect wetland areas downstream and negatively impact aquatic and terrestrial wildlife until well after reclamation of the excavated area is complete, and the riparian plant communities have time to partially re-establish themselves.

MNR processes may include physical, biological, and chemical mechanisms that act together to reduce the risk posed by the contaminants. It is anticipated that dispersion and burial would be the primary natural recovery mechanism in the intermittent drainages at the Site. When coupled with source controls in the Site's upland soil/waste rock (eliminate impacted sediment load), surface water remedies (clean runoff and reduced seep/spring flows and concentrations), as well as sediment control basins/traps during implementation of the RA, the combined Alternative 3 MNR mechanisms/ remedies are considered reasonable.

Additionally, COC/COEC concentrations decrease generally by an order of magnitude away from the Site and most COCs/COECs approach background levels in the furthest downstream stations in the current pre- remedial-action Site configuration where upstream sources of COCs/COECs are uncontrolled. Moreover, studies conducted in southeast Idaho indicate that selenium becomes less bioavailable as soil weathers (Mackowiak and Amacher, 2003).

Also of note is that as part of the upland soil/waste rock remedy (i.e., ore recovery, consolidation, and grading), it is likely that portions of impacted sediment in the upper intermittent drainages will be removed and/or ultimately covered. Also, sediment in

some drainage sections will be excavated and removed as a result of installation of sediment traps, engineered wetlands, and PRB installations. All these mentioned remedy components will in reality either remove or isolate under an ET cover some of the more highly contaminated sediment/riparian soil at the margins of the existing mine dumps. However, what will occur in those locations will only be understood once the design of the remedy is completed.

A/T Review Comment:

The P4 response addresses the comment about sediment MNR reasonably well.

3. Provide a summary statement describing the anticipated timeline for the comprehensive remedy to meet RAOs, and the basis for the time estimate.

   P4 Response SC-3: *See response to GC-1 above.*

   A/T Review Comment:

   Agree that P4 response GC-1 adequately addresses this comment. Suggest adding a graphic illustrating the anticipated timeline.

Responses to Earlier General and Specific Comments

H. In recent months, there have been two water quality standards developments that may have implications for cleanup levels and that may affect the evaluation of ARARs compliance. These include issuance by EPA of a revised criteria recommendation for Se, and EPA's recent disapproval of the State of Idaho's criterion for As for protection of human health. These are issues where additional information and direction are forthcoming.

   P4 Response (GC-H)*: As shown on Figure 2-5 of Ballard FS Memo #1, maximum Site surface water selenium concentrations are either well above the surface water standard of 0.005 mg/L or well below that standard. A reduction of the standard to 0.0031 mg/L would not impact the stream reaches considered under the evaluated alternatives. Nor should it affect the remedial alternative technologies considered in both Ballard FS memorandums.*

   <u>EPA Comment:</u> Does EPA's recent disapproval of the State's criterion for Arsenic for the protection of human health have any cleanup implications or effect on the preferred alternative's ability to comply with ARARS as a result of this change? Based on our preliminary analysis, it appears that the recent disapproval will require revision of the PCL for As in surface water from 10 to 6.2 ug/l in the intermittent streams in the vicinity of Ballard.

   P4 Supplemental Response (GC-H)*: Based on Drawing 4-14 from the Ballard RI Report (November 2014), a change in the PCL for arsenic in surface water to 6.2 ug/l would only add MSP012 and MST095 to the list of stations that exceed the PCL based on maximum detected concentrations. MSP012 is an interior pond, which will be removed as part of the upland soil remedy. MST095 is located in a headwater drainage on the east side of the Site. It is currently anticipated that a PRB*

and engineered wetland will be installed upgradient of this location as a result of elevated selenium concentrations. As discussed in response to GC-1, these treatment components (PRBs followed by wetlands polishing) can effectively be designed to treat a wide range of COCs/COECs including arsenic and selenium and comply with cleanup goals.

A/T Review Comment:

The P4 response addresses the comment about lower PCL for arsenic in surface water reasonably well. However, this is a case where construction of a wetland may be required. The PRB may or may not remove arsenic well. Arsenic may be removed via precipitation as an As-sulfide, but the anaerobic conditions produced by the PRB will keep iron in the dissolved FeII form and unavailable for As sorption/coprecipitation. The aerobic portion of the wetland, on the other hand, would oxidize iron to FeIII and lead to As removal via sorption to ferric oxyhydroxide precipitate.

Specific Comments

9. Section 2.3.2, Page 2-14, second paragraph under Alternative 3 bullet – Please qualify the description of the benefits of the wetlands treatment. As it stands, the paragraph describes water treatment benefits likely to come from established, mature wetlands, rather than newly "constructed" wetlands. Please include the likely maturation process and timetable of a constructed wetland that would eventually yield the desired results. Please cite local or related documented pilot studies as backup.

   ***P4 Response (SC-9)**: Please see comment response SC-14 regarding pilot testing. The maturation of the wetlands will be dependent upon a number of design items including time of year of construction (temperature), any seeding with bacteria, and type of organic matter used as substrate or introduced to kick start biological growth. These factors will be considered during the RD stage based on the design criteria and the overall sequencing of the RA. Because there are many design factors that can affect (accelerate or slow) the maturation, this detail is not necessary at the FS level, and the discussion of the maturation is not appropriate for the presentation in Section 2. However, a statement to the effect that the wetlands will not be immediately effective (e.g., may take several weeks to a year) because of the need for biological growth has been added to the "Short-term Effectiveness" item in Tables 2-2 and 3-2 for Alternative 3.*

   EPA Comment: Add a statement into the text that if wetlands treatment is not adequate to achieve required water quality standards at an approved compliance point within a reasonable time period, the remedy will be adapted to include another viable remedial technology to treat discharge, such as a passive bioreactor, runoff collection and conveyance to an infiltration gallery up gradient of a permeable reactive barrier, etc..

   ***P4 Supplemental Response (SC-9)**: Text will be added to Sections 4.1.2 and 4.1.4 as follows: "If proposed remedies for surface water and groundwater do not achieve RAOs at an approved compliance point within a reasonable time frame as established by USEPA in consultation with P4, the remedy will be evaluated and if necessary, adapted to include other viable remedial technologies for treating discharge. The LTM data, and possible alternative changes will be evaluated, discussed among stakeholders, and as necessary, implemented as part of the CERCLA 5-year review process."*

A/T Review Comment:

Agree that addition of the statement proposed by P4 will adequately address this comment.

11. Section 3, Page 3-16 etc., surface and groundwater alternatives under various *Detailed Analysis Summaries* – Please describe the method used to establish a cleanup timeframe cited for each surface water and groundwater alternative.

    ***P4 Response (SC-11)**: The broadly stated cleanup timeframes are based on professional judgment and familiarity with the technologies and the rate at which they can be implemented.*

    EPA Comment: Please cite, in the FS, relevant studies or technical publications that concur and substantiate the cleanup timeframes.

    ***P4 Supplemental Response (SC-11)**: See response to GC-1 above.*

A/T Review Comment:

Not sure that the SC-11 (GC-1) response fully addresses cleanup timeframes for all components (e.g., groundwater plumes, MNA), but probably does so to the extent practical.

40. Section 3.6.1, Page 3-29, Bullet 1 – It states "because the areas underlying the upland soil/waste rock dumps are assumed to be impacted by migration of constituents from the waste rock dumps to the underlying soil and would have to be graded and covered after the waste rock is removed." Intuitively this might make sense, but provide data to support this. Although not directly comparable (ore vs ROM or center waste shale), removal of phosphate ore at the Georgetown Canyon Industrial Complex Area did not require a cap on the daylighted native soil. A cap was placed on the area because of the buried elemental phosphorus.

    ***P4 Response (SC-40)**: This is prudent assumption for the FS. The converse assumption would be to assume that no cover or growth media would be needed in removal areas, which could lead to a significant underestimation of costs if some cover (or growth media) is needed in these areas.*

    EPA Comment: We agree this is the conservative approach, but this assumption has ramifications on the final, overall footprint of waste rock needing cover. We believe it would be prudent, and in the best interest of the remedy, to reduce the ultimate foot print of the waste rock and associated cover through consolidation (into pits, etc.) without compromising the final grading to facilitate drainage.

    Please provide available data that shows possible contamination of native ground under waste rock piles and justifies extending the cover in these areas? If there is no need to cover the native ground, it may be economically and environmentally prudent, to focus on consolidating all the waste rock into the pits and other areas and reduce the overall waste rock/cover footprint. This also begs the follow-on question: Is it more cost effective to consolidate the waste rock (into mine pits, etc.) or cover them in place?

P4 Supplemental Response (SC-40)*: Representative data are not available for waste rock dump subsoils at the Ballard Site. The substantive dumps have not been drilled and sub-dump soil samples analyzed. A limited number of soil samples currently are being analyzed as part of the 2016 Ballard Exploration field program. However, this small number of samples will not be representative of potential leaching impacts underlying the mine waste rock dumps across the Site. There are soil data from other P4 Sites (for example, underlying the more recent, reclaimed Enoch Valley Mine dumps). However, these data are not likely analogous due to the older and unreclaimed nature of the Ballard Site. In addition, based on elevated concentrations in sediment/riparian soil near the Ballard Site waste rock dumps, it is reasonable to assume that COCs/COECs have been leached from the waste rock into the underlying colluvial/alluvial soil.*

If necessary, sampling could be conducted during the RA to identify those areas that can remain uncovered (not impacted by leaching) at some cost, although the size of these areas left uncovered is likely minimal compared to the total covered area and shrinking the covered footprint would not result in reduced risks. Because of the unknowns and reasons stated above, assuming a cover for the FS costs are justified and prudent. In addition, waste rock pile removal will leave behind highly disturbed and potentially infertile soil (after up to 60 years of burial). At a minimum, regrading would be necessary, as would placement of some minimal cover material such as growth media to help ensure revegetation in a reasonable timeframe.

The last question, which is, "Is it more cost effective to consolidate the waste rock (into mine pits, etc.) or cover them in place?" has been answered by comparing the costs for Alternatives 4 and 7 with some minor adjustments. Currently, Alternative 4 includes excavating just enough of the exterior waste rock to cover the ore sections exposed in the pits, then covering the remainder of the exterior waste rock dumps in place. Alternative 7 includes excavating all the exterior waste rock dumps and consolidating them into the pits, then placing a cover system on the interior graded waste surface and the exterior native areas that were formerly covered by wastes. Alternative 4's present worth value is approximately $51M and the complete backfilling of the waste rock proposed under Alternative 7 is $109M. If the exterior areas in Alternative 7 were not covered following waste rock removal (as is suggested), the ET cover cost would be reduced from $20.9M to approximately $9.6M (by eliminating the 294-acre exterior area for ET cover), which is a $11.3M reduction in cost. The total cost for Alternative 7 then would be reduced to approximately $95M, which still is nearly double Alternative 4 costs because moving the waste rock into the pits is much more expensive that grading/covering the waste rock in place. Also, regarding the surface of the waste rock dumps following excavation as discussed in the paragraph above, there undoubtedly would be some additional costs required for regrading and adding soil amendments to the 294 acres prior to revegetation, which is not considered in the total cost of Alternative 7.

A/T Review Comment:

P4's response addresses the comment reasonably well, although the necessary data are not available for thorough evaluation.

APPENDIX C-6

A/T Comments on P4*'s Ballard Mine Feasibility Study Report Memorandum 2 – Screening, Detailed, and Comparative Analysis of Assembled Remedial Alternatives, Draft Final Rev 1, February 2017*

Submitted to P4 on March 30, 2017

From: Tomten, Dave <Tomten.Dave@epa.gov>
Sent: Thursday, March 30, 2017 5:20 PM
To: Barry Myers (bmyers@blm.gov); Bruce Narloch; Bruce Olenick; Cary Foulk (cfoulk@integrated-geosolutions.com); Celeste Christensen; Colleen O'Hara-Epperly (cohara@blm.gov); COOPER, RANDALL LEE [AG/1000]; Tomten, Dave; Dennis Smith (dennis.smith2@ch2m.com); Emily Yeager; Gary Billman; Jeff Cundick; Jeff Schut; Jeremy Moore (jeremy_n_moore@fws.gov); Wallace, Joe; Kelly Wright; Leah Wolf Martin (leah@wolfmartininc.com); LEATHERMAN, CHRIS R [AG/1850]; Michael Rowe; Norka Paden (Norka.Paden@deq.idaho.gov); PRICKETT, MOLLY [AG/1850]; Randy Vranes; Sandi Fisher; Shannon Leigh Ansley (sansley@sbtribes.com); Shephard, Burt; Stifelman, Marc; Stumbo, Sherri A -FS; susanh@ida.net; Trina Burgin; Vance Drain
Subject: comments on redline version of Ballard TM #2
Attachments: AT comments on Ballard FS-2 Draft Final (3-30-2017).docx

Molly, all –
We have reviewed the redline version of TM#2. Attached are comments to be incorporated. We can discuss, if necessary, during our bi-weekly call on Monday. Also, FYI, some of our reviewers are interested in additional information on material quantities and properties for construction of the proposed ET cover system (in advance of detailed design). This relates to providing additional assurance that the cover can be constructed as envisioned in the conceptual design with locally sourced materials (as assumed in the cost estimate). Could you please be prepared to discuss/walk through your findings on this topic during one of our next bi-weekly calls (either Monday or the following call)?

I'll send a hardcopy of these comments to you next week.

Thanks, and have a good weekend!
Dave

_____

Dave Tomten
EPA Region 10
950 W. Bannock Street
Suite 900
Boise, Idaho 83702

208-378-5763
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A/T Comments

Ballard Mine Feasibility Study Report, Draft Final Revision 01
Memorandum 2 – Screening, Detailed, and Comparative Analysis of Assembled Remedial Alternatives
(February 2017)

General Comments:

1. Correct all maps/figures (e.g. Figs. 3-7 & 3-8) to include data at new sampling location (MSP063) and to correct data box pointer to proper location of MST066.

2. Alfalfa is known to accumulate selenium and should not be considered as part of a seed mix for an ET cover at this site (App B). Final seed mix and revegetation specifications to be developed during design stage. Please delete.

3. The concept of MNA being proposed as a groundwater remedial alternative has received a fair amount of scrutiny and attention in A/T comments and subsequent P4 responses. In spite of this dialog, there remains uncertainty as to how effective MNA will be at the Ballard Mine, and expected time to achieve MCLs in groundwater. Its application is proposed for groundwater remediation in the Wells Formation, where exposure pathways are not complete. It is also acknowledged that P4 proposes to perform additional studies on this technology during remedial design. It would be helpful to the reader, and improve the FS conclusions, if additional discussion were added to Section 3.5.2, where MNA is first proposed as a remedial alternative (Groundwater Alternative 2- MNA and ICs, in conjunction with Source Controls in the Uplands Soil/Waste Rock). The text (or perhaps a table) should describe MNA (as applied to inorganics) from the context of what USEPA guidance allows/expects relative to remediation timeframes, source control; stability of plumes, control of risk exposure, and the intention for long-term monitoring and adaptive management strategies, if needed. It is suggested that P4 consider utilizing the text crafted for response to A/T additional comments (dated December 5, 2017) appearing in Appendix C-4; P4 February 3, 2017 response, "Timeframe to Achieve PCLs", groundwater subsection, on pages 8 and 9 of 19, to address this recommendation.

Ballard Mine Feasibility Study Report, Draft Final Revision 01
Memorandum 2 – Screening, Detailed, and Comparative Analysis of Assembled Remedial Alternatives
(February 2017)

Editorial Comment Table

Item No.	Section; Table; Figure	Page	Paragraph	Line (if not obvious)	Agency/Tribes Comment
General Comments					
	Somewhere in the document define "bank cubic yards" and "placed cubic yards."				

Ballard Mine Feasibility Study Report, Draft Final Revision 01
Memorandum 2 – Screening, Detailed, and Comparative Analysis of Assembled Remedial Alternatives
(February 2017)

Editorial Comment Table

Item No.	Section; Table; Figure	Page	Paragraph	Line (if not obvious)	Agency/Tribes Comment
	Be consistent on using a hyphen for "long-term" and "short-term."				
	Check citations to ensure there is a comma between the author(s) and year as appears to be the dominant style in the text.				
Specific Comments					
	2.3.4	2-20	Bullet 1 (Alternative 5b)	11	Change "discharged" to "infiltrated" to be consistent with similar language elsewhere in the document.
	2.3.4	2-20	Bullet 1 (Alternative 5b)	Sentence 5	Delete "through infiltration in the bottom of a mine pit or other Wells Formation exposure, or through shallow injection wells placed through pit backfill" to conform with response to Comment 52.
	3.2.4	3-11	Bullet 2 (last)	3	Insert a semi-colon to read "… 5.3M pcy; therefore, the backfill …"
	3.3.3	3-17	1 (partial)	9 & 10	Separate the citations with semi-colons to read "(DWTTC, 1999; Stillings and Amacher, 2004; Lamothe and Herring, 2004; Mackowiak, et. al., 2004)" for consistency.
	3.5.2	3-25	3	4	Delete the second "study."
	3.5.3	3-27	Bullet 2	5	Change "COC" to "COCs."
	3.5.3	3-27	Bullet 2	6 & 7	Delete "an" to read "… and with adequate retention times …"
	3.5.3	3-27	Bullet 2	14	Delete "the" to read "… placed under cover during RA …"
	3.6.1	3-31	Bullet 5 (Short-term effectiveness; last)	2	Insert "and" to read "… longer in duration and additional care …"
	3.6.1	3-33	Bullet 2 (Aesthetics)	2	Insert "a" and delete "with" to read "… that would be a more natural, thorough reclamation that blends into the surrounding …"
	3.6.3	3-37	Bullet 2 (Long-term Effectiveness and Permanence)	2	Change "is" to "are" for subject-verb agreement.
	3.6.3	3-39	Bullet 2 (Cost)	Sentence 1	So is this sentence saying that the no action alternative fails the Cost criterion? Explain how this could be.

Ballard Mine Feasibility Study Report, Draft Final Revision 01
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Editorial Comment Table

Item No.	Section; Table; Figure	Page	Paragraph	Line (if not obvious)	Agency/Tribes Comment
	4.1	4-2	1 (partial)	7	Change "on-Site" to "on Site to read "… (base on Site monitoring and comparison to PCLs)."
	4.1.1	4-3	3	Sentence 1	Insert "the" to read "The construction of the upland soil/waste rock remedy …"
	4.1.2	4-4	3	Sentence 6	Insert "the" to read "… groundwater down to the surface water …"
	4.1.4	4-8	Bullet 2	1	Delete "but uncertain" to read "Data from the Wells Formation indicates some attenuation potential …"
	4.1.4	4-9	2	4	Delete the comma to read "The LTM data and possible alternative changes …"
	4.2.1	4-11	1	7	Change "constituent" to "constituents" or perhaps, better yet, "COCs."
	4.2.1	4-11	1	7	Insert "the" to read "… human health and the environment …"
	4.2.1	4-11	2	Sentence 2	Consider changing to "These potential actions are described …"
	5	5-1 & 5-2			For consistency, when the citation includes two authors put a comma after the initials of the first author for these citations: Buck and Mayo; Mackowiak and Amacher; and Stillings and Amacher.
	5	5-1	Buck and Mayo citation	1	Add a period to read "Buck, B., and Mayo, A. …"
	5	5-3	U.S. EPA citation		Change to "U.S. Environmental Protection Agency (USEPA)" to be consistent with the rest of the EPA citations.
	Table 2-4	2 of 5	Row Alternative 3	Column Implementability	Technical Feasibility, bullet 3, sentence 1: Add a semi-colon and delete "a" to read "It is assumed that the PRB would be constructed with zero-valent iron; other media such as biological materials (hay, woodchips, and sand) could be evaluated during the RD."
	Table 2-4	4 of 5	Row Alternative 5a	Column Effectiveness	Short Term Effectiveness, bullet 4: Change "heterogeneous" to "heterogeneity."
	Table 3-4	1-9	Row Header	Column Alternative 5b	Paragraph 2, line 5 (last) Insert "the" and delete the second period to read "… alluvial aquifer and infiltrated back to the Wells Formation."

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Editorial Comment Table

Item No.	Section; Table; Figure	Page	Paragraph	Line (if not obvious)	Agency/Tribes Comment
	Table 3-4	3 of 9	Row Treatment Process Used and Materials Treated	Column Alternative 3	Paragraph 1, line 7: Delete "an" to read "… and with adequate retention times …"
	Table A-2c	1	Rows Project Management, Remedial Design, Construction Management and Oversight	Column Comments/Assumptions	Insert a space to read "…EPA 540-R-00-002). Because …" for all 3 rows.

APPENDIX C-7

P4 Responses to A/T Comments (dated March 30, 2017) on P*4's Ballard Mine Feasibility Study Report Memorandum 2 – Screening, Detailed, and Comparative Analysis of Assembled Remedial Alternatives, Draft Final Rev 1, February 2017*

Submitted to A/Ts in the Final April 2017

A/T Comments on Ballard Mine Feasibility Study Report, Draft Final Revision 01
Memorandum 2 – Screening, Detailed, and Comparative Analysis of Assembled Remedial Alternatives
(February 2017)
and
P4's Responses

General Comments:

1. Correct all maps/figures (e.g. Figs. 3-7 & 3-8) to include data at new sampling location (MSP063) and to correct data box pointer to proper location of MST066.

   P4 Response (GC-1)*: A note has been added to Figures 3-7 and 3-8 to indicate that sediment and riparian soils have not been collected at MSP063/SEPond or the NWPond. In addition the pointer box for MST066 has been revised.*

2. Alfalfa is known to accumulate selenium and should not be considered as part of a seed mix for an ET cover at this site (App B). Final seed mix and revegetation specifications to be developed during design stage. Please delete.

   P4 Response (GC-2)*: Table 3 in Appendix B was derived by Golder in their Reclamation Cover Design Report (Golder, 2015), which is included as Attachment 1 to Appendix B. The text in Section 2.3 of Appendix B has been revised to state that the seed mix used during implementation of the Site remedy will be evaluated during the RD with input from the A/Ts and documented in the Revegetation Plan prepared for the design. It also is noted throughout FS Memo #2 text that the seed mix evaluated in the RD would be selected to form extensive root systems to limit erosion, to slow stormwater and snowmelt movement off the cap, to transpire water that infiltrates and accumulates in the upper layers of the cover system, to penetrate the upper cap soil, but not into the underlying waste rock, and not to contain accumulator species.*

3. The concept of MNA being proposed as a groundwater remedial alternative has received a fair amount of scrutiny and attention in A/T comments and subsequent P4 responses. In spite of this dialog, there remains uncertainty as to how effective MNA will be at the Ballard Mine, and expected time to achieve MCLs in groundwater. Its application is proposed for groundwater remediation in the Wells Formation, where exposure pathways are not complete. It is also acknowledged that P4 proposes to perform additional studies on this technology during remedial design. It would be helpful to the reader, and improve the FS conclusions, if additional discussion were added to Section 3.5.2, where MNA is first proposed as a remedial alternative (Groundwater Alternative 2- MNA and ICs, in conjunction with Source Controls in the Uplands Soil/Waste Rock). The text (or perhaps a table) should describe MNA (as applied to inorganics) from the context of what USEPA guidance allows/expects relative to remediation timeframes, source control; stability of plumes, control of risk exposure, and the intention for long-term monitoring and adaptive management strategies, if needed. It is suggested that P4 consider utilizing the text crafted for response to A/T additional comments (dated December 5, 2017) appearing in Appendix C-4; P4 February 3, 2017 response, "Timeframe to Achieve PCLs", groundwater subsection, on pages 8 and 9 of 19, to address this recommendation.

***P4 Response (GC-3)**: As recommended by the A/Ts, additional text based on P4's January 13, 2017 responses for MNA "Timeframe to Achieve PCLS" provided in both Appendices C-4 and C-5 has been incorporated into Section 3.5.2. Note that that the February 3, 2017 date corresponds to the submittal of additional A/T comments as provided in Appendix C-5.*

Ballard Mine Feasibility Study Report, Draft Final Revision 01
Memorandum 2 – Screening, Detailed, and Comparative Analysis of Assembled Remedial Alternatives
(February 2017)

Editorial Comment Table

Item No.	Section; Table; Figure	Page	Paragraph	Line (if not obvious)	Agency/Tribes Comment
General Comments					
	Somewhere in the document define "bank cubic yards" and "placed cubic yards."				
	Be consistent on using a hyphen for "long-term" and "short-term."				
	Check citations to ensure there is a comma between the author(s) and year as appears to be the dominant style in the text.				
Specific Comments					
1	2.3.4	2-20	Bullet 1 (Alternative 5b)	11	Change "discharged" to "infiltrated" to be consistent with similar language elsewhere in the document.
2	2.3.4	2-20	Bullet 1 (Alternative 5b)	Sentence 5	Delete "through infiltration in the bottom of a mine pit or other Wells Formation exposure, or through shallow injection wells placed through pit backfill" to conform with response to Comment 52.
3	3.2.4	3-11	Bullet 2 (last)	3	Insert a semi-colon to read "… 5.3M pcy; therefore, the backfill …"
4	3.3.3	3-17	1 (partial)	9 & 10	Separate the citations with semi-colons to read "(DWTTC, 1999; Stillings and Amacher, 2004; Lamothe and Herring, 2004; Mackowiak, et. al., 2004)" for consistency.
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7	3.5.3	3-27	Bullet 2	6 & 7	Delete "an" to read "… and with adequate retention times …"
8	3.5.3	3-27	Bullet 2	14	Delete "the" to read "… placed under cover during RA …"
9	3.6.1	3-31	Bullet 5 (Short-term effectiveness; last)	2	Insert "and" to read "… longer in duration and additional care …"

Editorial Comment Table

Item No.	Section; Table; Figure	Page	Paragraph	Line (if not obvious)	Agency/Tribes Comment
10	3.6.1	3-33	Bullet 2 (Aesthetics)	2	Insert "a" and delete "with" to read "… that would be a more natural, thorough reclamation that blends into the surrounding …"
11	3.6.3	3-37	Bullet 2 (Long-term Effectiveness and Permanence)	2	Change "is" to "are" for subject-verb agreement.
12	3.6.3	3-39	Bullet 2 (Cost)	Sentence 1	So is this sentence saying that the no action alternative fails the Cost criterion? Explain how this could be.
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14	4.1.1	4-3	3	Sentence 1	Insert "the" to read "The construction of the upland soil/waste rock remedy …"
15	4.1.2	4-4	3	Sentence 6	Insert "the" to read "… groundwater down to the surface water …"
16	4.1.4	4-8	Bullet 2	1	Delete "but uncertain" to read "Data from the Wells Formation indicates some attenuation potential …"
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20	4.2.1	4-11	2	Sentence 2	Consider changing to "These potential actions are described …"
21	5	5-1 & 5-2			For consistency, when the citation includes two authors put a comma after the initials of the first author for these citations: Buck and Mayo; Mackowiak and Amacher; and Stillings and Amacher.
22	5	5-1	Buck and Mayo citation	1	Add a period to read "Buck, B., and Mayo, A. …"
23	5	5-3	U.S. EPA citation		Change to "U.S. Environmental Protection Agency (USEPA)" to be consistent with the rest of the EPA citations.

Editorial Comment Table

Item No.	Section; Table; Figure	Page	Paragraph	Line (if not obvious)	Agency/Tribes Comment
24	Table 2-4	2 of 5	Row Alternative 3	Column Implementability	Technical Feasibility, bullet 3, sentence 1: Add a semi-colon and delete "a" to read "It is assumed that the PRB would be constructed with zero-valent iron; other media such as biological materials (hay, woodchips, and sand) could be evaluated during the RD."
25	Table 2-4	4 of 5	Row Alternative 5a	Column Effectiveness	Short Term Effectiveness, bullet 4: Change "heterogeneous" to "heterogeneity."
26	Table 3-4	1-9	Row Header	Column Alternative 5b	Paragraph 2, line 5 (last) Insert "the" and delete the second period to read "… alluvial aquifer and infiltrated back to the Wells Formation."
27	Table 3-4	3 of 9	Row Treatment Process Used and Materials Treated	Column Alternative 3	Paragraph 1, line 7: Delete "an" to read "… and with adequate retention times …"
28	Table A-2c	1	Rows Project Management, Remedial Design, Construction Management and Oversight	Column Comments/Assumptions	Insert a space to read "…EPA 540-R-00-002). Because …" for all 3 rows.

P4 Response (editorial)*: The editorial comments have been addressed with the exceptions and clarifications listed below.*

- *Section 3.5.3, bullet 2, line 14, page 3-27 – "the" was not removed as the sentence reads awkwardly if "the" is removed.*
- *Section 3.6.3, bullet 2 (cost), sentence 1, page 3-39 – The No Action alternative would not fail the cost criterion and the text required revision. The text was changed from "including this one" to "except this one".*