Marietta Canty, LLC
Environmental Consulting

Revised Cleanup Criteria and Risk Assessment Report

Wastewater Facilities Comprising the Closed-Loop System
Plant Site Area
Colstrip Steam Electric Station
Colstrip, Montana

Project No. 17-1006

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CONTENTS

CONTENTS

CONTENTS

CONTENTS

Appendices

List of Acronyms

ABSd	Dermal Absorption Factor
ADD	Average Daily Dose
AF	Adherence Factor
AOC	Administrative Order on Consent
ARM	Administrative Rules of Montana
AT	Averaging Time
ATnc	Averaging Time – non-carcinogens
ATSDR	Agency for Toxic Substances and Disease Registry
AUF	Area Use Factor
BCa-UCL	Bias-corrected and accelerated bootstrap Upper Confidence Limit method
BCF	Bioconcentration Factor
BERA	Baseline Ecological Risk Assessment
bgs	below ground surface
BSL	Background Screening Levels
BTV	Background Threshold Value
BTAG	Biological Technical Assistance Group
BW	Body Weight
C	Concentration
Cal/EPA	California Environmental Protection Agency
CCR	Coal Combustion Residuals
CCRA	Cleanup Criteria and Risk Assessment
CDC	Centers for Disease Control and Prevention
cm	centimeters
cm^2	centimeters squared
COC	Chemical of Concern
COI	Constituent of Interest
COPC	Chemicals of Potential Concern
CR	Contact Rate
DEQ	Montana Department of Environmental Quality
DEQ-7	Circular DEQ-7 – Montana Numeric Water Quality Standards
EC	Exposure Concentration
ED	Exposure Duration
EF	Exposure Frequency
EPC	Exposure Point Concentration
ERA	Ecological Risk Assessment
EU	Exposure Unit
Ford Canty	Ford Canty & Associates, Inc.
gpm	gallons per minute
HAZWOPER	Hazardous Waste Operations and Emergency Response
HBI	Hilsenhoff Biotic Index
HEAST	Health Effects Assessment Summary Tables
HHRA	Human Health Risk Assessment

List of Acronyms
(Continued)

HHS	Human Health Standard
HQ	Hazard Quotient
Hydrometrics	Hydrometrics, Inc.
IRIS	Integrated Risk Information System
IRS	ingestion rate - soil
IUR	Inhalation Unit Risk
K_d	partitioning coefficient
Kg	kilograms
kg/d	kilograms per day
kg/kg-d	kilograms per kilograms of body weight per day
kg/mg	kilograms per milligram
LADD	Lifetime Average Daily Dose
L/cm^3	Liters per cubic centimeter
L/Kg	Liters per kilogram
LOAEL	Lowest Observed Adverse Effect Level
MCA	Montana Code Annotated
MCF	mass conversion factor
MCL	Maximum Contaminant Level
mg/cm^2	milligrams per centimeter squared
mg/day	milligrams per day
m^3/kg	cubic meters per kilogram
mg/kg	milligrams per kilogram
mg/kg-day	milligrams per kilogram per day
mg/L	milligrams per liter
MPC	Montana Power Company
MPDES	Montana Pollutant Discharge Elimination System
NCEA	National Center for Environmental Assessment
Neptune	Neptune and Company, Inc.
NOAEL	No Observed Adverse Effect Level
NSTP	North Sewage Treatment Pond
OEHHA	Office of Environmental Health Hazard Assessment
OSHA	Occupational Safety and Health Administration
pCi/L	picoCuries/liter
PPLM	PPL Montana, LLC
PPRTV	Provisional Peer Reviewed Toxicity Value
RAGS	Risk Assessment Guidance for Superfund
RBCA	Risk-Based Corrective Action
RBSL	Risk Based Screening Level
RCRA	Resource Conservation and Recovery Act
RfC	Reference Concentration
RfD	Reference Dose
RfD_i	Reference Dose – inhalation
RfD_o	Reference Dose – oral
RME	Reasonable Maximum Exposure

List of Acronyms
(Continued)

RSL	Regional Screening Level
SA	Surface Area
SC	Specific Conductance
SCEM	Site Conceptual Exposure Model
SES	Steam Electric Station
SF	Slope Factor
SLERA	Screening-level Ecological Risk Assessment
SOEP	Stage One Evaporation Pond
SSCL	Site Specific Cleanup Level
SSL	Soil Screening Level
STP	Sewage Treatment Pond
STEP	Stage Two Evaporation Pond
Talen	Talen Montana, LLC
t-UCL	Upper Confidence Limit based on a t distribution
TDS	Total Dissolved Solids
TRV	Toxicity Reference Value
UCL	Upper Confidence Limit
UTL	Upper Tolerance Level
95 UCL	95 Percent Upper Confidence Limit
USEPA	United States Environmental Protection Agency
USNRCS	United States Natural Resource and Conservation Service
WECO	Western Energy Company
yr	year
µg/dl	micrograms per deciliter
µg/L	micrograms per liter
µmhos/cm	micromhos per centimeter
3&4 EHP	Units 3&4 Effluent Holding Pond

EXECUTIVE SUMMARY

Hydrometrics, Inc. (Hydrometrics), on behalf of Talen Montana, LLC (Talen), retained Marietta Canty, LLC (Canty) and Neptune and Company, Inc. (Neptune) to prepare a Cleanup Criteria and Risk Assessment (CCRA) Report for the Wastewater Facilities Comprising the Closed-Loop System at the Plant Site area, "the Plant Site," of the Colstrip Steam Electric Station (SES), the "Facility," located in Colstrip, Montana. The Plant Site CCRA was submitted to the DEQ on June 8, 2017 (Canty, 2017a) and the Montana Department of Environmental Quality (DEQ) provided comments on September 15, 2017 (DEQ, 2017e). A revised version of the Plant Site CCRA was submitted to the DEQ on November 13, 2017 (Canty, 2017b) and DEQ provided comments on January 2, 2018 (DEQ, 2018a). A revised version of the Plant Site CCRA was submitted to the DEQ on January 29, 2018 (Canty, 2018a) and DEQ provided comments on April 12, 2018 (DEQ, 2018c). A revised version of the Plant Site CCRA was submitted to the DEQ on May 11, 2018 (Canty, 2018b) and DEQ provided comments on June 14, 2018 (DEQ, 2018d).DEQ's comments on the May 11, 2018 Revised Plant Site CCRA Report are addressed within this document. In addition, comment responses for the September 15, 2017; January 2, 2018; April 12, 2018; and June 14, 2018 DEQ comments are provided within (Appendix G).

To address potential process wastewater migration due to pond seepage and pipeline spills, PPL Montana, LLC (PPLM; Talen's predecessor) and DEQ entered into an Administrative Order on Consent (AOC) Regarding Impacts Related to Wastewater Facilities Comprising the Closed-Loop System at the Colstrip SES on August 3, 2012, (DEQ/PPLM Montana, 2012). It is important to note that the AOC addresses impacts related to process wastewater and does not address other media (unless impacted by the process wastewater). The Plant Site is one of three areas at the Colstrip SES identified in the AOC as having groundwater impacts attributable to the process wastewater.

Portions of the Plant Site pond system are presently being closed and capped in response to the United States Environmental Protection Agency (USEPA) Coal Combustion Residuals (CCR) Final Rule, and the planned shutdown of Units 1 and 2. Because requirements of the CCR Rule have been, or will be, implemented at the Plant Site under the CCR Rule, additional groundwater data collected as part of the CCR Rule were considered in the preparation of this CCRA Report.

In February 2017, a meeting was held with the DEQ, Talen, and Talen's consultants to discuss DEQ's comments (DEQ, 2017c) to the revised CCRA Work Plan. The requirements of both the AOC and the CCR Rule were discussed, including the overlapping and intersecting of requirements. The following general approach for the CCRA Report was developed:

1. Identification of the Plant Site Constituents of Interest (COIs) beginning with the list of CCR Rule detection and assessment monitoring constituents (Appendices III and IV)
    a. Begin with Source Data (Pond Data), as worst-case data
    b. Consider the CCR Well data, which are also worst-case (if any) because they were collected at the pond boundaries
    c. Consider DEQ-7 Standards
    d. Consider USEPA Maximum Contaminant Level (MCL) and USEPA Regional Screening Levels (RSLs) for Tapwater
    e. Consider Background Screening Levels (BSLs)
    f. Consider other constituents potentially posing a Human Health or Ecological Risk

EXECUTIVE SUMMARY
(Continued)

2. Preparation of the Site Conceptual Exposure Model (SCEM), including identification of the following:
    a. Potential Sources
    b. Potential Release Mechanisms
    c. Potential Media
    d. Potential Exposure Pathways
    e. Potential Receptors

3. Assess Human Health and Ecological Risks Associated with the COIs (also referred to as Chemicals of Potential Concern [COPCs] and, if retained after assessment, Chemicals of Concern [COC]) either Qualitatively or Quantitatively, as appropriate, for:
    a. Groundwater
    b. Surface Water
    c. Streambed Sediments
    d. Soil (in pipeline spill areas)

4. Development of Cleanup Criteria for COIs/COCs
    a. Review Groundwater and Surface Water Cleanup Criteria (following DEQ guidance and considering that DEQ-7 Values are Cleanup Standards)
    b. Determine Human Health-Based Cleanup Criteria
    c. Determine Ecological-Based Cleanup Criteria
    d. Determine Leaching-Based Cleanup Criteria (Soil)
    e. Compare to Background Screening Levels (BSLs)
    f. Determination of Final Cleanup Criteria

5. Develop Recommendations for the Incorporation of the Cleanup Criteria into the Remedy Evaluation

Using the above described approach, the following groundwater COIs/COCs were identified for the Plant Site as presented in the Table below.

Plant Site Groundwater COIs/COCs

CCR Appendix III Constituents	CCR Appendix IV Constituents	Other Potential Plant Site Constituents
Boron	Cobalt	Manganese
Sulfate	Lithium	
	Molybdenum	
	Selenium	

Note: Radium was not identified as a COI/COC; however, it will remain a COPC while additional radium groundwater data are collected. Radium will continue to be monitored and evaluated in groundwater as part of the Federal CCR Rule compliance monitoring and continue to be evaluated under the AOC.

A SCEM is presented within this CCRA to identify the contaminant sources, affected environmental media, release and transport mechanisms, potential human and ecological receptors, and exposure pathways under the current and reasonably anticipated future uses of the Plant Site. The preparation of the SCEM is a requirement of the AOC, as well as a required element in conducting a risk assessment.

Executive Summary
(Continued)

A Risk Assessment approach was developed and followed based on guidance of the AOC, as well as direction provided by the DEQ in a meeting held in February 2017 (DEQ, 2017c), in which DEQ indicated that risks should be evaluated for the Plant Site without the operation of the groundwater capture system. This Plant Site CCRA Report presents both a Human Health Risk Assessment (HHRA) and an Ecological Risk Assessment (ERA) following DEQ's Risk Assessment guidance. The risk assessment process was used to identify COPCs beyond the constituents listed in the Appendices III and IV of the CCR Rule. Depending on the type of media, both quantitative (i.e., forward risk calculations) and qualitative evaluations (i.e., comparison to screening levels or standards) were conducted. Neither human health nor ecological COCs were retained for surface water, sediment, or soil. As a final step in the CCRA, Cleanup Criteria were developed for the identified COIs/COCs. Summaries of the risk assessments and Cleanup Criteria are presented below by medium.

Surface Water (East Fork Armells Creek, the "Creek")

Human health COCs were not retained in surface water (see Section 10.1). Surface water is currently used for livestock (horses) watering in the northern tip of the Plant Site. Two ecological COPCs, boron and manganese, were identified in surface water. Manganese concentrations potentially pose a risk to benthic receptors (i.e., benthic macroinvertebrates living in sediment), while boron potentially poses a risk to aquatic life. The ecological COPCs were not found to pose a risk to livestock drinking surface water from the Creek, although the maximum concentrations of sulfate indicate the surface water is "marginal" for livestock watering (see Appendix C). Manganese and boron concentrations in the Creek appear to be consistent with background concentrations originating from regional geology, as well as coal mining and agricultural activities. Cleanup of surface water would be ineffective as upstream sources would continue to affect the Creek at the Plant Site. Therefore, manganese and boron were not retained as ecological COCs and Cleanup Criteria for surface water were not developed. No action is required in the Remedy Evaluation regarding surface water.

Streambed Sediment

One human health COPC, manganese, was identified in streambed sediments of the Creek at the Plant Site. However, concentrations in the streambed sediments were not found to pose a human health risk (see Section 9.1) and manganese was not retained as a human health COC. One ecological COPC, manganese, was identified in streambed sediments of the Creek that potentially poses a risk to benthic receptors (see Appendix C). However, manganese concentrations in streambed sediments appear to have originated from background sources (see Section 10.1). In addition, an aquatic habitat assessment and benthic community survey was conducted in upstream areas of the Creek (Arcadis, 2014) that indicated the lowest ratings of "fairly poor" to "poor" on the Hilsenhoff Biotic Index (HBI; see Section 6.1.3). The likely HBI would be similar for the Creek at the Plant Site. Cleanup of sediments would be ineffective as background sources would continue to affect the Creek at the Plant Site. Therefore, manganese was not retained as an ecological COC and Cleanup Criteria for streambed sediments were not developed. No action is required in the Remedy Evaluation regarding streambed sediments.

Soil

One human health COPC, lead, was identified in the former spill sites near the City of Colstrip Sewage Treatment Pond (STP) at the Plant Site area (see Section 6.3), but not retained as a human health COC.

EXECUTIVE SUMMARY
(Continued)

Ecological COPCs were identified in the pipeline spill areas at the Plant Site at the screening phase of the Ecological Risk Assessment, but not retained as COCs in the Baseline Ecological Risk Assessment (see Appendix C). Therefore, soil was not found to pose either a human health or ecological risk. In addition, leaching COIs/COCs were not retained for the pipeline spill areas of the Plant Site (see Section 10.2). No action is required in the Remedy Evaluation regarding soil in the pipeline spill areas.

Groundwater

Following DEQ guidance, human health risks were not forward calculated for groundwater. Rather, groundwater concentrations were compared to the DEQ-7 Standards as a qualitative evaluation of risk. If a DEQ-7 Standard was not available, groundwater concentrations were compared to the USEPA Maximum Contaminant Levels (MCL; if available) and the USEPA Tapwater RSL (if available) in accordance with the AOC. Per DEQ's request, ecological (livestock) Cleanup Criteria for groundwater were also developed. Ecological (livestock) Cleanup Criteria for groundwater were limited to one scenario (livestock consumption via groundwater pumping into stock tanks). The table below presents the groundwater COIs/COCs, DEQ-7 Standards, screening levels, BSLs, and proposed Cleanup Criteria by hydrostratigraphic unit.

The groundwater Cleanup Criteria should be used in the Remedy Evaluation to develop remedial alternatives to address COI/COC groundwater concentrations that exceed these values, including after the capture system is shut down. In addition, the remedial actions should address all the regulated substances listed in the AOC Control Action definition (Section IV.B.; DEQ/PPLM, 2012), which include three of the COIs/COCs (sulfate, boron, selenium), as well as potassium, sodium, magnesium, Total Dissolved Solids (TDS), and salinity. Lastly, radium concentrations in groundwater at the Plant Site appear to be consistent with background levels and radium was not identified as a groundwater COI/COC. However, because a radium groundwater BSL was not available for comparison, as a conservative measure radium will remain a COPC while additional radium groundwater data are collected. Radium will continue to be monitored and evaluated in groundwater as part of the Federal CCR Rule compliance monitoring and continue to be evaluated under the AOC.

EXECUTIVE SUMMARY

Groundwater Standards, Screening Levels and Proposed Cleanup Criteria

COI/COC	Ground-water DEQ-7/MCL (mg/L)	USEPA Tapwater RSL (mg/L)	BSL Range (mg/L)	Ecological (Livestock) Cleanup Criterion (mg/L)	Cleanup Criterion Source	Proposed Cleanup Criteria				
						Alluvium (mg/L)	Spoils (mg/L)	Clinker (mg/L)	Coal-Related (mg/L)	SubMcKay (mg/L)
CCR Appendix III Constituents										
Boron	NA(6)	4	0.818 – 4	39 (1)	RSL	4 (RSL)	4 (RSL)	4 (RSL)	4 (RSL)	4 (RSL)
Sulfate	NA(6)	NA	2,061 – 3,160	3,000 (2)	Livestock/ BSL	3,000 (livestock)	3,045 (BSL)	3,160 (BSL)	3,000 (livestock)	3,000 (livestock)
CCR Appendix IV Constituents										
Cobalt	NA(6)	0.006	0.00066 – 0.0232	0.03 (1)	RSL/BSL	0.02 (BSL)	0.0232 (BSL)	0.0232 (4) (BSL)	0.006 (RSL)	0.006 (RSL)
Lithium	NA(6)	0.04	0.072 – 0.092	NA (3)	BSL	0.092 (BSL)	0.09 (BSL)	0.09 (4) (BSL)	0.072 (BSL)	0.072 (4) (BSL)
Molybdenum	NA(6)	0.1	0.004 – 0.048	NA (3)	RSL	0.1 (RSL)	0.1 (RSL)	0.1(5) (RSL)	0.1 (RSL)	0.1 (RSL)
Selenium	0.05(7)	0.1	0.0023 – 0.01	0.28 (1)	DEQ-7	0.05 (DEQ-7)	0.05 (DEQ-7)	0.05 (DEQ-7)	0.05 (DEQ-7)	0.05 (DEQ-7)
Other Potential Plant Site Constituents										
Manganese	NA(6)	0.43	0.27 – 2.79	61 (1)	RSL/BSL	0.6 (BSL)	2.79 (BSL)	0.67 (BSL)	0.54 (BSL)	0.43 (RSL)

Notes:

BSL	Background Screening Level (Neptune, 2016)
CCR	Coal Combustion Residual
COI	Constituent of Interest
COC	Chemical of Concern
MCL	Maximum Contaminant Level
mg/L	Milligrams per liter
NA	Not available/not applicable
RSL	Regional Screening Level

(1) Calculated Cleanup Criterion protective of livestock (calf), see Appendix C

(2) Upper limit of “marginal” sulfate range for livestock (USDA-ARS, 2009)

(3) Cleanup Criterion could not be calculated – no mammalian Toxicity Reference Value (TRV) available, see Appendix C

(4) BSL not available. BSL for adjacent hydrostratigraphic layer used as a proxy value.

(5) BSL not available. RSL assumed to be applicable.

(6) Neither a DEQ-7, nor an MCL has been established.

(7) Value is both the DEQ-7 and the MCL.

1.0 INTRODUCTION AND PURPOSE

Hydrometrics, Inc. (Hydrometrics), on behalf of Talen Montana, LLC (Talen), retained Marietta Canty, LLC (Canty) and Neptune and Company, Inc. (Neptune) to prepare a Cleanup Criteria and Risk Assessment (CCRA) Report for the Wastewater Facilities Comprising the Closed-Loop System at the Plant Site area, "the Plant Site," of the Colstrip Steam Electric Station (Colstrip SES), the "Facility", located in Colstrip, Montana (see Figure 1).

A preliminary CCRA Work Plan was submitted to the Montana Department of Environmental Quality (DEQ) on behalf of Talen on October 1, 2015 (Ford Canty, 2015). It was developed following the guidance set forth in the Administrative Order on Consent (AOC) established by PPL Montana, LLC (PPLM; predecessor to Talen) and the DEQ (see Section 1.2.1 and Appendix A). The DEQ's Comments on the preliminary CCRA Work Plan were received on December 1, 2015 (DEQ, 2015). One of DEQ's main comments was that the Work Plan should follow DEQ's new Risk Assessment Scope of Work (DEQ, 2016a), rather than the more general guidance provided in the AOC. DEQ's Risk Assessment Scope of Work includes various risk assessment pre-calculations prior to the final calculation of risks and cleanup criteria to be presented in the final risk assessment (DEQ, 2016a). Ford Canty submitted comment responses on behalf of Talen on January 25, 2016 (Ford Canty, 2016a).

A revised CCRA Work Plan was submitted to the DEQ on behalf of Talen on August 2, 2016 (Ford Canty, 2016b) that addressed and incorporated DEQ's comments (DEQ, 2015). The DEQ provided conditional approval of the revised CCRA Work Plan on January 17, 2017. DEQ's conditional approval requested that specific information (DEQ's comments; DEQ, 2017a) be incorporated into the CCRA Report. For clarification of DEQ's comments, a meeting was held with the DEQ, Talen, and Talen's consultants on February 28, 2017, during which a plan was developed for proceeding with the CCRA Report (DEQ, 2017c). Comment responses were submitted to DEQ on behalf of Talen on March 17, 2017 (Hydrometrics, 2017a). DEQ approved the comment responses on March 23, 2017 (DEQ, 2017b). The Plant Site CCRA Report was submitted to DEQ on June 8, 2017 (Canty, 2017a) and DEQ provided comments on September 15, 2017 (DEQ, 2017e). A revised version of the Plant Site CCRA was submitted to the DEQ on November 13, 2017 (Canty, 2017b) and DEQ provided comments on January 2, 2018 (DEQ, 2018a). A revised version of the Plant Site CCRA was submitted to the DEQ on January 29, 2018 (Canty, 2018a) and DEQ provided comments on April 12, 2018 (DEQ, 2018c). A revised version of the Plant Site CCRA was submitted to the DEQ on May 11, 2018 (Canty, 2018b) and DEQ provided comments on June 14, 2018 (DEQ, 2018d).DEQ's comments on the May 11, 2018 Revised Plant Site CCRA Report are addressed within this document. In addition, comment responses for the September 15, 2017; January 2, 2018; April 12, 2018; and June 14, 2018 DEQ comments are provided within (Appendix G).

1.1 FACILITY BACKGROUND

The Colstrip SES Facility is a zero-discharge facility. As such, there are no direct wastewater discharge points from the Plant Site to surface water. However, seepage losses from the process wastewater ponds ("ponds") at the Plant Site have migrated from the ponds to shallow groundwater. In addition, because the shallow groundwater gradient is toward East Fork Armells Creek (the "Creek"), which runs adjacent to and downstream of the Plant Site, constituents in groundwater could potentially migrate toward Creek alluvium. Facility-related wastewater constituents are anticipated to be largely derived from constituents that occur naturally in the coal formations. To mitigate migration of the seepage losses, numerous capture wells have been placed at the Plant Site that provide ongoing groundwater capture of Plant Site wastewater, and to interrupt the potential migration of groundwater constituents toward Creek alluvium.

In an area due west of the Plant Site, the capture wells have changed the shallow gradient to be toward the capture wells, thus largely eliminating migration toward the Creek alluvium. In addition, some pond liner systems have been upgraded or replaced to reduce seepage, coal combustion residuals have been removed from some former process ponds to eliminate source material, affected soil has been removed from below some of the former ponds to reduce potential leaching, additional site awareness training has been conducted, and more efficient reuse of water is being implemented.

1.2 REGULATORY HISTORY

1.2.1 Administrative Order on Consent

To address seepage losses from the Plant Site ponds and potential wastewater migration, PPLM (Talen's predecessor) and the DEQ entered into an AOC Regarding Impacts Related to Wastewater Facilities Comprising the Closed-Loop System at the Colstrip SES on August 3, 2012, (DEQ/PPLM Montana, 2012). It is important to note that the AOC addresses impacts related to wastewater and does not address other media (unless impacted by the wastewater).

As part of the AOC, PPLM committed to prepare Site Reports for the three Colstrip SES Areas, as follows: (1) the Plant Site, (2) the Stage One Evaporation Pond/ Stage Two Evaporation Pond (SOEP/STEP), and (3) the Units 3&4 Effluent Holding Pond (3&4 EHP) areas (see Figure 1 for a depiction of these areas). These site reports are the basis for further remedial activities under the AOC. A fourth category of reporting, involving area process wastewater pipeline spills or releases not included in one of the previously mentioned areas, and other miscellaneous areas that are mutually agreed upon by the parties to address in the AOC, was also defined. All past process wastewater spills and releases have fallen into one of the three areas defined earlier in this paragraph.

The development of cleanup criteria, as well as human health and ecological risk assessments, associated with the wastewater of the Plant Site, is included within this report. The cleanup criteria and human health and ecological risk assessments for the wastewater associated with the remaining areas of the Colstrip SES Facility will be addressed in future documents.

The requirements of the AOC are provided in a detailed summary located in Appendix A. In summary, the AOC requires the CCRA Report to identify, at a minimum, the following (Article VI.B):

- Cleanup Criteria for the Constituents of Interest (COIs[1]);

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[1] *The AOC (DEQ/PPLM, 2012; Article IV.F) defines COIs as those parameters found in soil, groundwater, or surface water that (1) result from Site operations and the wastewater facilities and (2) exceed background or unaffected reference area concentrations. The AOC subsequently defines the development of cleanup criteria for the COIs generally following the DEQ risk assessment process (DEQ, 2016). The DEQ refers to potential contaminants within their Risk Assessment Scope of Work (DEQ, 2016) as Chemicals of Potential Concern (COPCs) and, if retained after assessment, Chemicals of Concern (COCs). As part of the risk assessment process, parameters were screened against background concentrations, as well as other appropriate screening levels following the DEQ risk assessment process. As such, the terms COIs and COPCs/COCs have nearly synonymous definitions for the purposes of this revised CCRA and are, therefore, used interchangeably within this report for practicality.*

- Identification of transport mechanisms for the COIs;
- Identification of potential receptors;
- Identification of exposure pathways; and
- If there are COIs, recommendation of additional site characterization needed to determine what, if any, human health or ecological risks are posed by releases from the Site.

Lastly, the AOC indicates:

- If the CCRA identifies one or more COIs that exceed Cleanup Criteria, then remedial measures are necessary and a Remedy Evaluation Report shall be prepared.
- If the CCRA does not identify COIs that exceed Cleanup Criteria, then remedial measures are not needed and there is no need for further action.

1.2.2 USEPA Coal Combustion Residuals Rule

Portions of the Plant Site pond system are presently being updated and retrofitted to meet the requirements of the new United States Environmental Protection Agency (USEPA) Coal Combustion Residuals (CCR) Final Rule that was initially signed December 19, 2014, was published in the Federal Register on April 17, 2015 (80 FR 21301), and became fully effective in October 2015 (USEPA, 2017).

The USEPA finalized the CCR regulations to provide comprehensive rules for the safe disposal of coal ash from coal-fired power plants. The rule establishes technical requirements for CCR landfills and surface impoundments under Subtitle D of the Resource Conservation and Recovery Act (RCRA).

Various activities at the Plant Site have been conducted, or are in the process of being conducted, in accordance with the CCR Rule. For example, various Plant Site ponds have been closed, updated, or retrofitted. Because requirements of the CCR Rule have been, or will be, implemented at the portions of the Plant Site under the CCR Rule, the requirements of the CCR Rule should be considered in conjunction with the requirements of the AOC at those areas. As such, requirements of both the CCR Rule and the AOC were considered in the preparation of this CCRA Report.

1.3 CCRA REPORT APPROACH

In February 2017, a meeting was held with the DEQ, Talen, and Talen's consultants to discuss DEQ's comments (DEQ, 2017c) to the revised CCRA Work Plan (Ford Canty, 2016b). The requirements of both the AOC and the CCR Rule were discussed, including the overlapping and intersecting requirements. The following general approach for the CCRA Report was developed:

1. Identification of the Plant Site COIs beginning with the list of CCR Rule detection and assessment monitoring constituents (Appendices III and IV)
    a. Begin with Source Data (Pond Data), as worst-case data
    b. Consider the CCR Well data, which are also worst-case (if any) because they were collected at the pond boundaries

   c. Consider DEQ-7 Standards
   d. Consider USEPA Maximum Contaminant Level (MCL) and USEPA Regional Screening Levels (RSLs) for Tapwater
   e. Consider Background Screening Levels (BSLs)
   f. Consider other constituents potentially posing a Human Health or Ecological Risk

2. Preparation of the Site Conceptual Exposure Model (SCEM), including identification of the following:
   a. Potential Sources
   b. Potential Release Mechanisms
   c. Potential Media
   d. Potential Exposure Pathways
   e. Potential Receptors

3. Assess Human Health and Ecological Risks Associated with the COIs (also referred to as Chemicals of Potential Concern [COPCs] and, if retained after assessment, Chemicals of Concern [COCs]) either Qualitatively or Quantitatively, as appropriate, for:
   a. Groundwater
   b. Surface Water
   c. Streambed Sediments
   d. Soil (in pipeline spill areas)

4. Development of Cleanup Criteria for COIs/COCs
   a. Review Groundwater and Surface Water Cleanup Criteria (following DEQ guidance and considering that DEQ-7 Values are Cleanup Standards)
   b. Determine Human Health-Based Cleanup Criteria
   c. Determine Ecological-Based Cleanup Criteria
   d. Determine Leaching-Based Cleanup Criteria (Soil)
   e. Compare to BSLs
   f. Determination of Final Cleanup Criteria

5. Develop Recommendations for the Incorporation of the Cleanup Criteria into the Remedy Evaluation

2.0 FACILITY OPERATION, BACKGROUND AND DESCRIPTION

2.1 FACILITY OPERATION

The Colstrip SES (the Facility) is located in the city of Colstrip, within Rosebud County in the south central area of the State of Montana. The Facility consists of four units: Units 1 and 2 are 333 megawatts each; and Units 3 and 4 are 805 megawatts each. Construction on Units 1 and 2 began in 1972 and they came on-line in the mid-1970s. Units 3 and 4 were constructed later; Unit 3 came on-line in 1983 and Unit 4 came on-line in 1985. Talen is the operator and an owner of the Facility, which is co-owned by PacifiCorp, Puget Sound Energy, Inc., Portland General Electric Company, Avista Corporation, and NorthWestern Corporation (Hydrometrics, 2015b).

The Facility generates electricity through the combustion of coal. Fly ash, a by-product of coal combustion, is removed by air scrubber systems to reduce emissions. Bottom ash collects at the bottom of the boiler. Fly ash, bottom ash, and Facility wastewaters contain constituents of the original coal. A closed-loop process water/scrubber system is used at the Facility to reduce impacts to water resources in the area. Ash and water based liquid wastes from the generating plants are impounded in ponds designed and constructed to control seepage losses. The Plant Site pond system includes ponds that serve all four generating units in various capacities. Fly ash disposal is not currently conducted on the Plant Site, but rather in holding ponds at two locations: (1) to the northwest of the Plant Site at the Units 1&2 SOEP/STEP and (2) to the east of the Plant Site at Units 3&4 EHP. Relatively minor amounts of fly ash deposited during previous operations remain in the Plant Site Units 1&2 Pond A. Flyash previously routed to the Units 3&4 Wash Tray Pond and Units 3&4 Scrubber Drain Collection pond has been removed from these ponds and each was converted to storm water ponds. Process ponds at the Facility have been servicing Colstrip Units 1&2 since 1975, although locations, function, and pond construction have changed, including closures and reconstruction (Hydrometrics, 2015b).

Portions of the Plant Site pond system are presently being updated and retrofitted to meet the requirements of the new USEPA CCR Final Rule that was initially signed into effect December 19, 2014 and became fully effective in October 2015 (USEPA, 2017).

2.2 PLANT SITE BOUNDARY

The Plant Site boundary was established and presented in the AOC to include (1) the active operations area, (2) pipelines in the area, and (3) areas influenced by the groundwater capture system. Some of the areas included in the Plant Site boundary are beyond the property line of areas owned by the Colstrip SES Facility. Figure 2 presents the boundary of the Plant Site.

2.2.1 Active Operations Area/Controlled Access Area

The active operations area of the Plant Site is a fenced, controlled access area. The active operations area of the Plant Site is owned by Talen, PacifiCorp, Puget Sound Energy, Inc., Portland General Electric Company, Avista Corporation, and NorthWestern Corporation. Figure 2 depicts the fencing at the Plant Site. For areas in Figure 2 where the fence appears open, gates are present that control access in that area.

2.2.2 Pipeline Areas/Uncontrolled Access Area

Various pipeline areas of the Plant Site are located outside the fenced area and, therefore, have uncontrolled access. The pipeline areas may or may not be owned by the Facility owners, but are generally considered to be part of the Plant Site because of the presence of pipelines. An example is the northern tip of the Plant Site with areas owned by the City of Colstrip, which contains pipelines associated with Units 1 &2 (fly ash pipelines and return effluent pipelines).

2.2.3 Groundwater Capture Areas/Uncontrolled Access Area

Portions of the areas affected by the groundwater capture system are located outside the fenced area and, therefore, also have uncontrolled access. An example is a portion of the residential area (a trailer park) located on the southwestern corner of the Plant Site (see Figures 2 and 3) that was included within the Plant Site boundary because of the active groundwater capture occurring within that area.

2.3 PHYSICAL CHARACTERISTICS OF THE SITE

2.3.1 Regional Geology

Colstrip is located in the northern portion of the Powder River Basin, an asymmetrical basin oriented northwest to southeast. This structural basin is responsible for the general regional orientation of bedding. “In general, Fort Union Strata dip very gently (less than a few degrees) in easterly and southerly orientations from west to east across the coalfield, respectively. Locally, however, dips are steepened by high-angle faults that are present at the Colstrip area” (Roberts, et. al, 1999, as cited in Hydrometrics, 2015b).

Stratigraphy in the Colstrip area consists of, in descending order, the Fort Union Formation, Hell Creek/Lance Formation, Fox Hills Sandstone, and Bearpaw Shale. The Fort Union Formation is divided into three members; the upper Tongue River Member, the middle Lebo Shale Member, and the lower Tullock Member. The Tongue River Member is at the surface in the Colstrip area. The deeper Lebo Shale, and then the Tullock Members are exposed to the north. At Colstrip, the total thickness of the Fort Union Formation is about 650 feet.

The Fort Union Formation consists of alternating and intercalated deposits of shale, claystone, mudstone, siltstone, sandstone, carbonaceous shale and coal. The formation was deposited in a fluvial system of meandering, braided, and anastomosed streams near the basin center and by alluvial fans at the margins. The fluvial systems were typically oriented northeast-southwest (Flores and Ethridge, 1985 as cited in Hydrometrics, 2015b).

- Anastomosing streams consist of multiple channels within a single drainage. Individual floodplains of an anastomosing system may include braided or meandering, or straight characteristics. Deposition typically occurs under low energy conditions near a local base level (Makaske, 2000 as cited in Hydrometrics, 2015b).
- Braided flow systems consist of a network of flow channels within a single floodplain or flow belt (Makaske, 2000 as cited in Hydrometrics, 2015b). These channels have multiple thalwegs that branch back and forth from single to multiple channels.
- Meandering streams consist of one or more individual channels that migrate back and forth across a single floodplain. Meandering channels consist of one thalweg.

Numerous coal seams are present in the Tongue River Member of the Fort Union Formation, the result of peat deposits that accumulated in swampy areas and channels. A tropical to sub-tropical climate resulted in thick peat deposits within the swamps and bogs (Nicols and others, 1989, Flores, R.M. and others, 1999 as cited in Hydrometrics, 2015b). Because of the depositional setting, the coal beds may pinch out laterally or stop abruptly. The main coal seams of interest near Colstrip are the sub-bituminous Rosebud (~ 24 feet thick) and McKay seams (~ 8-10 feet thick), which can economically be strip-mined. These two coal seams merge into a single seam on the west side of the Little Wolf Mountains near the Absaloka Mine. The Rosebud Coal, however, is the only seam mined in the Colstrip SES Facility area due to quality of the McKay Seam which makes it currently undesirable for use in many coal-fired boilers. Both the Rosebud and McKay coals are generally cleated. That is, they contain natural vertical fracturing generally oriented perpendicular to the bedding plane.

The depositional setting results in numerous lateral facies changes within the sedimentary rock deposits. Channel sandstones often grade laterally into siltstones or shale (facies changes) resulting in preferential pathways for groundwater flow within the more permeable sandstone. Cementation, or the chemical binding of individual grains to one another, is highly variable within the units, mostly consisting of weak calcium carbonate cement although thin deposits with silica cementation also occur. Localized thin limestone beds may also exist.

Alluvium is present along many of the drainage bottoms. The most prominent deposit at the Colstrip SES Facility is along the Creek. At the west edge of the Plant Site area, alluvial deposits of clay, silt, sand and gravel reach thickness of 35 feet or more. A basal gravel, comprised of clinker, is often present in the alluvium. Clinker fragments are typically also found throughout finer-grained alluvial deposits.

The ancestral East Fork Armells Creek eroded through the shallow bedrock, including the Rosebud and McKay Coals, and in some places into the sub-McKay deposits. This results in the potential for groundwater flow from the eroded units into the alluvium. The Creek alluvium acts as a hydrologic sink in the vicinity of the Colstrip SES Facility. This “hydrologic sink” tends to collect groundwater limiting, or eliminating, flow from one side of the creek to the other in shallow deposits.

As mentioned previously, the Rosebud Coal, and in some places, the McKay Coal has burned in the Colstrip area. This is most easily identified as red cap rock on hills around the region. Burning of the coal baked the overlying strata. As a result of the burning, the coal volume reduced either leaving a void for the overlying rock to collapse in or resulting in slow settling of the overlying rock into the space formerly held by the coal. The thermally altered rock is referred to as clinker or scoria. Collapse of the rock resulted in secondary porosity. Permeability varies but is typically very high and depends on the amount of fine grained sediments that have moved vertically into the available pore spaces, completeness of burning of the coal seam, and size and degree of packing of the clasts. No clinker has been confirmed on the Plant Site proper.

Mining of the coal on the Plant Site has resulted in lateral heterogeneities. Strip mining of coal involves removing the overburden (sediments and rock overlying the coal), removing the coal, then backfilling the pit with the previously removed overburden. The resulting spoil material exhibits a wide range of permeability from very low to high. It also results in a higher vertical permeability when compared to the pre-mining permeability. (Section 2.3.2 presents additional information regarding permeability). Spoil is present over much of the southeastern part of the Plant Site (directly east of Units 1&2 Pond B and Units 1&2 Cooling Tower Blowdown Ponds, and Units 3&4 Bottom Ash Ponds). A minor amount of spoil is present directly southeast of the Units 1&2 Pond A.

2.3.2 Groundwater

The classification and a description of the groundwater at the Facility are provided below.

Groundwater Classification

The BSLs (Neptune, 2016) determined that unimpacted background groundwater for all units at the Facility had a specific conductance (SC) greater than 2,500 µmhos/cm (equivalent to microSiemens/cm) ranging from 4,130 to 4,900 µmhos/cm. As such, groundwater at the Facility is a typical Class III water.

According to the Administrative Rules of Montana (ARM) 17.30.1006 Classifications, Beneficial Uses, and Specific Standards for Ground Waters, Class III ground waters are those ground waters with a natural specific conductance that is greater than 2,500 and less than or equal to 15,000 microSiemens/cm at 25°C. Further, ARM 17.30.1006(3) states:

(a) The quality of Class III ground water must be maintained so that these waters are at least marginally suitable for the following beneficial uses:

- (i) Irrigation of some salt tolerant crops;
- (ii) Some commercial and industrial purposes;
- (iii) Drinking water for some livestock and wildlife; and
- (iv) Drinking, culinary, and food processing purposes where the specific conductance is less than 7,000 microSiemens/cm at 25°C.

(b) Except as provided in ARM 17.30.1005(2), a person may not cause a violation of the following specific water quality standards for Class III ground water:

- (i) the human health standards listed in DEQ-7, except that the nitrate and nitrogen and nitrate plus nitrite nitrogen standards listed in DEQ-7 do not apply to groundwaters with specific conductance equal to or greater than 7,000 microSiemens/cm at 25°C. The nitrate nitrogen and nitrate plus nitrite nitrogen standards for these waters are each 50 milligrams per liter (mg/L); and
- (ii) for concentrations of parameters for which human health standards for ground water are not listed in DEQ-7, no increase of a parameter to a level that renders the waters harmful, detrimental, or injurious to the beneficial uses listed for Class III water. The department may use any pertinent credible information to determine these levels.

(c) The nondegradation provisions of 75-5-303, Montana Code Annotated (MCA), do not apply to Class III ground water.

Groundwater Description

Various lithological units are present at the Plant Site. These are, in ascending order; sub-McKay, McKay Coal, Rosebud-McKay Interburden (interburden), Rosebud Coal, spoil (laterally equivalent to the Rosebud Coal), overburden, and alluvium. Only the alluvium, McKay Coal, spoil and sub-McKay could accurately be referred to as aquifers. Intervals that are not aquifers include the overburden due to its limited extent and general absence of producible quantities of water; the Rosebud Coal because it is largely mined out; and the interburden due to its limited water content.

The following groundwater description begins with the deepest formation and proceeds to the shallowest formation. The deepest formation, the sub-McKay, is generally considered to not be impacted by process water. Deep groundwater in the sub-McKay units generally flows to the northeast under a regional gradient with presumed discharge points located at various locations to the north.

Spoil typically has a higher overall vertical permeability than the undisturbed sedimentary rocks. This is due to the fact that low permeability layers, such as claystone, shale, or clayey siltstone are broken up during mining and are placed back into the pits in random order and orientation. This removes the lateral continuity of confining or semi-confining layers that tend to restrict downward flow. The effect is generally an increase in the overall vertical and horizontal hydraulic conductivity of the spoil as related to the undisturbed sedimentary rock which results in a thick sequence of spoil that is capable of storing water (little restriction to vertical flow).

It should be noted that lateral variations in groundwater flow conditions may exist near mine spoil. These variations are generally a function of lateral heterogeneities that exist at the site and local vertical heterogeneities. Spoil are replaced overburden following mining of each pit. Topsoil is removed during each cut through an open pit mine and then the disturbed soil from the subsequent adjacent pit is placed in the cut mined immediately prior to the active cut. This results in an interface of undisturbed stratigraphic rock adjacent to the excavated and replaced overburden (spoil) from the first mining cut.

Materials (sedimentary rock, spoil, soil, coarser grained sediments) with higher permeability tend to result in lower hydraulic gradients than materials with lower permeability, which tend to have steeper gradients. This is apparent on the spacing between contours on potentiometric maps. Contours for water flowing through highly permeable material will be spaced farther apart than those for water flowing through materials with low permeability. So, if the hydraulic conductivity of the spoil is higher than the adjacent deposits, the spoil will act as a drain. That is, the gradient near the edge of the adjacent materials will steepen near the lateral contact because the water is essentially “draining” into the higher permeable material. Conversely, if the spoil hydraulic conductivity is lower, an impediment to flow will occur at the contact. This will tend to result in an increase in the water levels in the more permeable material at, and immediately upgradient, of the contact. If the upgradient flow is traveling along a preferential pathway (a more permeable zone), then the groundwater in the more permeable material will tend to extend more laterally (perpendicular to groundwater flow direction) along the contact.

Spoil are present in the eastern portion of the Plant Site. In general, permeability of the spoil is similar to the adjacent bedrock. However, spoil with a higher permeability are present north and west of the Units 3&4 Bottom Ash Ponds. The higher permeability of the spoil in this area appears to be the result of backfilling affects (vertical variations in spoil permeability mentioned above). This occurs when backfill is placed in the previously mined pit and larger rock fragments roll to the bottom of the pit resulting in a coarser deposit. If the spaces between the coarser rock are not filled with fines, this results in a much higher localized permeability. As an example, this can result in a high yield (~50 gallons per minute [gpm]) of the Western Energy Company (WECO) well. The WECO well was installed to lower the groundwater level below a coal crusher at the Rosebud Mine. The well was advanced to the base of the mine spoil (60 feet below ground surface [bgs]) and five feet into the underlying interburden to a depth of 65 feet.

Several indicator parameters are used to evaluate potential process wastewater impacts to groundwater at the Colstrip SES Facility. These include specific conductance (SC), dissolved boron, chloride, sulfate, and the ratio of calcium to magnesium. Chloride is considered a secondary indicator parameter due to multiple potential area sources that cause a high degree of concentration variability.

Existing groundwater capture systems in the areas where the highest concentrations of indicator parameters have been observed (both in the shallow units and in the McKay Coal) limit migration of impacted groundwater away from the Colstrip SES Facility. At the Plant Site, capture wells are located downgradient of the Units 1&2 B Pond, Units 1&2 Bottom Ash Ponds, Units 1&2 Sediment Retention Pond, North Cooling Tower Blowdown Pond C, and South Cooling Tower Blowdown Pond C. Additional capture wells are located at the former Brine Ponds, the former Unit 3&4 Drain Collection Pond, and Units 3&4 Bottom Ash Ponds. Consequently, the Plant Site capture wells are located between the various ponds and the Creek (see Figure 3). Capture wells are designed to capture shallow and deep groundwater.

It should be noted that a shallow groundwater divide is located just to the southeast of the Plant Site ponds. Groundwater in the shallow units in the southeastern part of the Plant Site flows to the east toward the Cow Creek alluvium. Shallow groundwater on the opposite side of the divide (northwest) flows toward the East Fork Armells Creek alluvium.

Shallow groundwater flow directions at the Plant Site are locally changed by the operation of current capture systems. Under non-pumping conditions, shallow groundwater flow is generally expected to mirror the topography with flow toward the Creek and discharging into the alluvium along the Creek. Under pumping conditions, overall shallow groundwater flow is locally diverted and interrupted by the capture systems.

2.3.3 Surface Water

The classification and a description of the surface water at the Facility are provided below.

Surface Water Classification

The nearest natural surface water is East Fork Armells Creek (the “Creek”). The Creek is part of the Yellowstone River Drainage. The water-use classification listed in ARM 17.30.611 for the Yellowstone River Drainage, described as follows, is subject to C-3 Classification Standards: (c) Yellowstone River Drainage from the Billings water supply intake to the North Dakota state line and including the Big Horn River drainage [except the water listed in (1)(c)(i) through IX-C-3 17.30.629].

The Creek is classified as a C-3 water, which means that the water is naturally marginal for drinking, culinary, and food processing purposes, agriculture, and industrial water supply. A C-3 water generally needs pre-treatment in order to be used as a potable water supply. Specifically, ARM 17.30.629 states:

(1) Waters classified C-3 are to be maintained suitable for bathing, swimming, and recreation, and growth and propagation of non-salmonid fishes and associated aquatic life, waterfowl, and furbearers. The quality of these waters is naturally marginal for drinking, culinary, and food processing purposes, agriculture, and industrial water supply.

(2) No person may violate the following specific water quality standards for waters classified C-3:

(a) The water quality standard for Escherichia coli bacteria (E-coli) varies according to season, as follows:

(i) from April 1 through October 31, the geometric mean number of E-coli may not exceed 126 colony forming units per 100 milliliters and 10% of the total samples may not exceed 252 colony forming units per 100 milliliters during any 30-day period; and
(ii) from November 1 through March 31, the geometric mean number of E-coli may not exceed 630 colony forming units per 100 milliliters and 10% of the samples may not exceed 1,260 colony forming units per 100 milliliters during any 30-day period.

(b) Dissolved oxygen concentration must not be reduced below the applicable standards specified in department Circular DEQ-7.

(c) Induced variation of hydrogen ion concentration (pH) within the range of 6.5 to 9.0 must be less than 0.5 pH unit. Natural pH outside this range must be maintained without change. Natural pH above 7.0 must be maintained above 7.0.

(d) The maximum allowable increase above naturally occurring turbidity is 10 nephelometric turbidity units, except as permitted in 75-5-318, MCA.

(e) A 3^{o}F maximum increase above naturally occurring water temperature is allowed within the range of 32^{o}F to 77^{o}F; within the range of 77^{o}F to 79.5^{o}F, no thermal discharge is allowed which will cause the water temperature to exceed 80^{o}F; and where the naturally occurring water temperature is 79.5^{o}F or greater, the maximum allowable increase in water temperature is 0.5^{o}F. A 2^{o}F per-hour maximum decrease below naturally occurring water temperature is allowed when the water temperature is above 55^{o}F. A 2^{o}F maximum decrease below naturally occurring water temperature is allowed within the range of 55^{o}F to 32^{o}F.

(f) No increases are allowed above naturally occurring concentrations of sediment or suspended sediment (except as permitted in 75-5-318, MCA), settleable solids, oils or floating solids, which will or are likely to create a nuisance or render the waters harmful, detrimental, or injurious to public health, recreation, safety, welfare, livestock, wild animals, birds, fish, or other wildlife.

(g) True color must not be increased more than five color units above naturally occurring color.

(h) Concentrations of carcinogenic, bioconcentrating, toxic, radioactive, nutrient, or harmful parameters may not exceed the applicable standards set forth in Department Circular DEQ-7 and, unless a nutrient standards variance has been granted, Department Circular DEQ-12A.

(i) (j) [Associated with discharge permits – not applicable for the Facility].

(k) In accordance with 75-5-306(1), MCA, it is not necessary that wastes be treated to a purer condition than the natural condition of the receiving water as long as the minimum treatment requirements, adopted pursuant to 75-5-305, MCA, are met.

Surface Water Description

Regionally, the Creek is an intermittent stream, but it generally flows continuously through the town of Colstrip along the western edge of the Plant Site (see Figures 1, 2, and 3). However, flow in the Creek may be diminished to zero during late summer and early fall. Flow directly upstream and downstream of Colstrip, as well as tributary drainages to the Creek, is ephemeral and is observed only in response to storm water or precipitation runoff events.

Topography mostly slopes downward from the Plant Site to the west/northwest toward the Creek. Colstrip SES is a zero-discharge facility, so there are no direct wastewater discharge points from the Plant to the Creek. Shallow groundwater from most of the Plant Site flows toward the northwest in the direction of the Creek, though as discussed previously, a series of capture wells interrupts the flow of groundwater toward the Creek alluvium.

A small area along the southeast portion of the Plant Site where surface topography slopes to the southeast resulting in potential runoff of surface water to the Cow Creek drainage. This drainage is ephemeral in this portion of the Plant Site. Mine spoil comprise the surface materials in the majority of this area.

The City of Colstrip sewage treatment ponds are located adjacent to the west bank of the Creek north and downstream of the Plant Site. Facility data indicate the sewage effluent ponds are contributing flow to the Creek. Data suggesting the Creek is receiving water from the sewage effluent ponds includes: increases in flow through the reach adjacent to the ponds; field observations; and variations in water quality observed above and below the ponds.

An irrigation pond at a public golf course (Ponderosa Butte) is located along the Creek downstream of the sewage effluent ponds. Treated water from the Colstrip wastewater treatment pond is pumped to this irrigation pond. Water from the pond is used for golf course irrigation. Castle Rock Lake is located west of the Creek and possibly contributes to flow in the Creek.

Surface water in the Creek varies in depth and flow rate throughout the year. In the area adjacent to the Plant Site and through the town of Colstrip, the Creek is generally shallow and slow moving with abundant emergent aquatic vegetation present during the summer months. In general, the Creek gains flow through the town of Colstrip. Higher amounts of flow are gained directly downstream of the City of Colstrip Wastewater Treatment Ponds. During the summer months, the Creek also may gain flow in the area of the golf course as a result of irrigation. Note that flow in the Creek decreases directly downstream of the north end of the golf course as surface water infiltrates to groundwater. The variable water levels within the Creek likely limit the types and abundance of aquatic organisms.

2.4 DEMOGRAPHICS AND LAND USE

2.4.1 Demographics

As of the 2010 Census, the population of Colstrip was 2,214 people, which included 863 households and 622 families (United States Census Bureau, 2014). The Colstrip SES Facility employs approximately 360 people (PPLM, 2014).

2.4.2 Past/Current Land Use

Colstrip was established in 1924 by Northern Pacific Railroad to provide coal for steam locomotives. Sub-bituminous coal was/is mined from the Fort Union Formation. In 1958, diesel fuel replaced coal to power the trains and the Montana Power Company (MPC) purchased the rights to the mine.

The Plant Site has been used as the location of a coal-fired power plant since the mid-1970's. A portion of the Plant Site was mined for coal prior to construction of the power plant units that commenced in 1972. In addition, soil, shallow bedrock, and coal were excavated from below the plant itself prior to construction.

The water supply for the Colstrip SES Facility and the town of Colstrip is Castle Rock Lake, which stores water pumped via a 30-mile pipeline from the Yellowstone River located to the north. Groundwater near the Plant Site is not currently used as drinking water. Domestic wells are not present in the Plant Site area. As a conservative measure, PPLM facilitated the connection of private properties with wells in the Units 1&2 SOEP/STEP Area to the City of Colstrip water supply; but, again, domestic wells are not present in the Plant Site area. In the Plant Site area, groundwater is not presently used for irrigation or livestock watering.

Surface water (i.e., East Fork Armells Creek) is currently used for livestock (horses) watering in the northern tip of the Plant Site.

Figure 4 depicts current land uses at the Plant Site area, including the uses of the uncontrolled access areas.

2.4.3 Future Use

The site is reasonably anticipated to remain as the location of a coal-fired power plant well into in the future. The associated land use activities in the town can also be reasonably anticipated to remain into the future.

In the future, groundwater is not anticipated to be used as drinking water because domestic wells are not present in the Plant Site area. In addition, PPLM previously facilitated the connection of private properties with wells to the City of Colstrip water supply in the Units 1&2 SOEP/STEP area as a conservative measure. Future drilling of domestic wells in the Plant Site area is not anticipated to be allowed based on previous PPLM actions (i.e., facilitated connection of private wells to City water). However, institutional controls are not in place to prevent the future domestic use of groundwater.

In the Plant Site area, groundwater is not anticipated to be used for irrigation or livestock watering. Plant Site groundwater could potentially be used for livestock water. However, the potential for future use as irrigation water is limited by yield and quality. Institutional controls are not in place to prevent irrigation/livestock use of groundwater.

DEQ-7 Standards apply to all groundwater in Montana and, hence, all groundwater at the site regardless of usage. Presently, no institutional controls are in place to prevent the domestic or irrigation/livestock use of groundwater at the site. It should be noted that if a remedial action includes institutional controls, that determination will not occur until DEQ chooses the final site remedy.

In the future, surface water (i.e., East Fork Armells Creek) may be used for livestock watering in the northern tip of the Plant Site.

3.0 IDENTIFICATION OF CONSTITUENTS OF INTEREST

The AOC applies to wastewater at the Colstrip SES, which is a closed-loop system that does not discharge wastewater. To identify the Plant Site COIs/COPCs as required by the AOC, data from the primary source of the potential constituents (i.e., the Plant Site Ponds) were used, as discussed in the February 2017 meeting with DEQ (2017c). The constituents present in the Plant Site ponds in the dissolved state have the potential for migration into groundwater.

As a first step in the identification of the COIs/COPCs, the dissolved pond water concentrations (i.e., filtered samples) presented in the Plant Site AOC Site Report (Hydrometrics, 2015a) for the constituents listed in Appendices III and IV of the CCR Rule (USEPA, 2017) were compared to standards and screening levels. Data were not available in the Plant Site AOC Site Report (Hydrometrics, 2015a) for two Appendix IV constituents, lithium and Radium 226/228. Recognizing this data gap, Hydrometrics collected Plant Site pond water samples on April 27, 2017 that were analyzed for these two constituents (Hydrometrics, 2017b).

As a second step in the identification of the COIs/COPCs, available data from numerous CCR wells installed around the perimeters of three Plant Site ponds (Units 1&2 Bottom Ash Pond, Units 1&2B Flyash Pond, and Units 3&4 Bottom Ash Pond) were compared to appropriate standards and screening levels. However, the CCR well data are generally total recoverable concentrations and, therefore, not directly comparable to groundwater standards and screening levels that are based on dissolved concentrations. Consequently, the CCR well data were used as a secondary, qualitative screening approach if concentrations of the CCR Appendices III and IV constituents in the pond water samples exceeded standards and screening levels. Because the CCR well data are generally total recoverable concentrations, comparisons of CCR well data to screening levels based on dissolved concentrations results in a conservative bias. However, screening levels for radium are based on total concentrations and, therefore, a conservative bias does not apply to radium. A total of 27 groundwater wells are used at the Plant Site to collect data required by the CCR Rule. Figure 5 depicts the locations of the CCR wells. CCR well data used in the COI/COPC identification process are presented in Appendix F.

In addition to the CCR Appendices III and IV constituents, additional constituents were assessed as potential COIs/COPCs that are present in the wastewater and had the potential to cause a human health or ecological risk based on the previous Plant Site CCRA Work Plan (Ford Canty, 2016b).

Table 3-1 presents various standards and screening levels for the CCR Appendix III and Appendix IV constituents, as well as other potential constituents identified in the risk assessment process.

Table 3-1 Potential Plant Site Wastewater COIs/COPCs

Constituent	Groundwater DEQ-7 Standard (mg/L)	MCL (mg/L)	USEPA Tapwater RSL (mg/L)	BSL Range (mg/L)	Toxicity (in water)
CCR Rule Appendix III Constituents					
Boron	NA	NA	4	0.818 – 4	non-carc
Calcium	NA	NA	NA	313 -495	non-carc*
Chloride*	NA	NA	NA	20-62	NA
Fluoride	4	4	0.8	0.4 – 2.1	non-carc
Sulfate	NA	NA	NA	2,061 – 3,160	non-carc*
pH (lab)	NA	NA	NA	7.8 – 8.2 s.u.	NA
TDS	NA	NA	NA	3,160 – 5,170	NA
CCR Rule Appendix IV Constituents					
Antimony	0.006	0.006	0.0078	0.15 – 0.45	non-carc
Arsenic	0.01	0.01	5.2 x 10^{-5}	0.005 – 0.01	carc
Barium	1	2	3.8	0.022 – 0.111	non-carc
Beryllium	0.004	0.004	0.025	0.003 – 0.01	non-carc
Cadmium	0.005	0.005	0.0092	0.002 – 0.01	non-carc
Chromium	0.1	0.1 (a)	NA	0.0146 – 0.1	non-carc
Cobalt	NA	NA	0.006	0.00066 – 0.0232	non-carc
Fluoride	4	4	0.8	0.4 – 2.1	non-carc
Lead	0.015	0.015 (b)	0.015	0.01 – 0.05	non-carc
Lithium	NA	NA	0.04	0.072 – 0.092	non-carc
Mercury	0.002	0.002 (c)	6.3 x 10^{-4}	0.001 – 0.005	non-carc
Molybdenum	NA	NA	0.1	0.004 – 0.048	non-carc
Radium 226/228	5 pCi/L	5 pCi/L	NA	NA	carc
Selenium	0.05	0.05	0.1	0.0023 – 0.01	non-carc
Thallium	0.002	0.002	0.0002	0.005 – 0.5	non-carc
Other Potential Plant Site Constituents (Identified in the Risk Assessment Process)					
Manganese	NA	NA	0.43	0.27 – 2.79	non-carc

Notes:	(a)	value for total chromium
	(b)	lead treatment technology action level is 0.015 mg/L
	(c)	value for inorganic mercury
	Chloride*	Chloride is a secondary indicator parameter
	BSL	Background Screening Level (Neptune, 2016)
	DEQ-7	Montana Numeric Water Quality Standard (DEQ, 2017d)
	MCL	Maximum Contaminant Level
	mg/L	milligrams per liter
	NA	Not Available/Not Applicable
	non-carc*	assumed non-carcinogenic, common constituent, human health toxicity data not available
	pCi/L	picocuries per liter
	RSL	Regional Screening Level
	s.u.	Standard Units

Tables 1A through 1C, located in the Tables section, present a summary of the pond water data for the potential COIs that were presented in the Plant Site AOC Site Report (Hydrometrics, 2015a). Table 1A presents a summary of the CCR Appendix III constituents. Table 1B presents a summary of the CCR Appendix IV constituents. Table 1C presents a summary of other potential groundwater Plant Site constituents that were selected based on the human health and ecological risk assessments.

Table 2, located in the Tables section, presents the groundwater BSLs (Neptune, 2016) by hydrostratigraphic layer for the CCR Appendices III and IV Constituents, as well as the other potential Plant Site constituents.

Table 3, located in the Tables section, presents the screening for the identification of COIs/COPCs. The rationale for selection or deletion of a potential COI/COPC is presented in the table; however, the following general points should be noted:

- To identify COIs/COPCs, the Plant Site pond water (wastewater) was considered the source (worst-case) of potential constituents.
- Migration of the COIs/COPCs from the Plant Site ponds to groundwater was considered the pathway of concern.
- Maximum dissolved concentrations of potential COIs/COPCs in the Plant Site pond water data were used for comparison against the standards and screening levels because the COIs/COPCs could potentially migrate to groundwater if pond seepage occurs. The DEQ-7 Standards for groundwater (DEQ, 2017d) are reported in dissolved concentrations, where applicable (e.g., metals), and particulates would not migrate through the bottom liners of the ponds. The groundwater BSLs (Neptune, 2016) also represent dissolved concentrations because constituents are expected to be present in the dissolved phase in groundwater due to slow velocities and filtering characteristics of most strata.
- If dissolved concentrations were not available in the Plant Site pond water data for a given potential COI/COPC, then the total concentrations were used.
- Maximum total concentrations of Radium 226/228 in the Plant Site pond water data were used for comparison against standards and screening levels because both the DEQ-7 and the MCL are based on total concentrations.
- For some potential COIs, the pond water data was not presented as either dissolved or total concentrations (e.g., fluoride, sulfate).
- Groundwater samples collected from the CCR wells were analyzed for total recoverable concentrations as required by the Federal CCR Rule. (In certain instances where turbidity is high, dissolved concentrations were also analyzed). As such, total recoverable concentrations reported in the CCR well data were used as proxy values for dissolved concentrations. Total recoverable concentrations are not directly comparable to groundwater standards and screening levels that are based on dissolved concentrations and, therefore, such comparisons add a conservative bias and should be made with careful consideration.

From the COPCs identified following the above described screening process, the following chemicals were retained as groundwater COCs presented in Table 3-2 below.

Table 3-2 Plant Site Groundwater COIs/COCs

CCR Rule Appendix III Constituents	CCR Rule Appendix IV Constituents	Other Potential Plant Site Constituents
Boron	Cobalt	Manganese
Sulfate	Lithium	
	Molybdenum	
	Selenium	

Note: Radium was not identified as a COI/COC; however, it will remain a COPC while additional radium groundwater data are collected. Radium will continue to be monitored and evaluated in groundwater as part of the Federal CCR Rule compliance monitoring and continue to be evaluated under the AOC.

3.1 AOC CONTROL ACTIONS AND REGULATED SUBSTANCES

The AOC (DEQ/PPLM, 2012) defines “Control Actions” (Section IV.B.) as “remedial actions directed toward reducing, containing or controlling the seepage or migration of regulated substances including but not limited to sulfate, boron, selenium, potassium, sodium, magnesium, total dissolved solids, and salinity measured by specific electrical conductance through the environment. Control actions shall include affirmative source mitigation measures.”

Of the regulated substances listed in the Control Action definition of the AOC (DEQ/PPLM, 2012), sulfate, boron, and selenium were selected as COIs/COCs. Potassium, sodium, magnesium, total dissolved solids (TDS), and salinity were not selected as COIs/COCs through the screening process described above and presented in Table 3. Although not all of the regulated substances listed in the Control Action definition were selected as COIs/COCs, all listed constituents will be addressed in the remedial action development. In most instances, remedial actions designed to directly mitigate the COIs/COCs will indirectly mitigate the remainder of the regulated substances, as well.

4.0 SITE CONCEPTUAL EXPOSURE MODEL

A Site Conceptual Exposure Model (SCEM) was prepared to identify the contaminant sources, affected environmental media, release and transport mechanisms, potential human receptors, exposure points and pathways under the current and reasonably anticipated future uses of the Plant Site (see also Sections 2.4.2 and 2.4.3 above). The preparation of the SCEM is requested in the AOC, as well as a required element in conducting a risk assessment. The SCEM is presented as Figure 6.

4.1 SOURCES OF FACILITY CHEMICALS AND AFFECTED ENVIRONMENTAL MEDIA

The following potential sources of chemicals from Plant Site wastewater were identified:

- Water based liquid waste (wastewater) that has been and is stored in the Plant Site Ponds and has seeped from the ponds.

- Water based liquid slurry waste (wastewater) that was accidentally released from pipeline spills in the northern tip of the Plant Site area.

- Water based liquid waste (storm water) that ponded in a low area near the Facility main gate.

- (Although not a source directly from Plant Site wastewater) - background-related chemicals in geological strata, such as rock, coal, spoils, previously burned coal seams, which may be leaching chemicals into groundwater.

Seepage from the Colstrip SES Facility ponds was assumed to have primarily affected groundwater. Potential groundwater migration and diffuse seepage are assumed to flow toward Creek alluvium. The pipeline spills were assumed to have primarily affected soil and secondarily affected creek water and sediments via over land flow. The storm water ponding area was assumed to have primarily affected soil.

Background-related chemicals in geological strata were assumed to have primarily affected groundwater and surface water. The area upstream of Colstrip and the Plant Site has undergone extensive coal mining, which has the potential to affect the quality of the surface water and sediment (i.e., the Creek) and the groundwater that flow into the Plant Site area. In addition, activities associated with the upstream coal mining, such as road maintenance of the mine haul roads, access roads, and local highways, may also affect the quality of the surface water, sediment, and groundwater at the Plant Site.

Wind suspension from the soil areas in the Plant Site area was assumed to have the potential to affect outdoor air (particulates) in the spill areas and the storm water ponding area (if COIs/COPCs were to be identified in soil).

The potential COIs originating from the Plant Site wastewater were evaluated using several data sources, but primarily the following:

- The Plant Site Report, prepared as a requirement of the AOC, summarizes the Plant Site Pond data, numerous investigations that have been conducted at the Plant Site relating to the ponds, spills associated with the pipelines, or changes in water quality identified in operational groundwater monitoring (Hydrometrics, 2015b). Table 3-2 of the Plant Site Report (Hydrometrics, 2015b) contains a list of the reports, dates of the reports, and short summaries of the work conducted and findings of the investigations or studies.

- The data collected from the numerous wells at the Plant Site pursuant to the Federal CCR Rule (see Appendix F.)

- The Synoptic Run data that included both surface water data and, selectively, streambed sediment data over a period of several years (Hydrometrics, 2016b).

- The soil investigation data from identified pipeline release areas and a storm water collection area (Hydrometrics, 2016a).

4.1.1 Anthropogenic Chemical Sources

The AOC addresses impacts related to the Colstrip SES Facility wastewater and does not address other media (unless impacted by the wastewater). As such, contaminants that have the potential to be present at the Plant Site that originated from sources other than the wastewater system, such as highway maintenance, residential lawn maintenance and other urban activities, or upstream mining areas, and for which little or no data are available, were not assessed within the CCRA Report. Several anthropogenic contaminants have the potential to impact surface water and sediment in the Creek throughout the reach that passes through the town of Colstrip. However, it should be noted that contaminants in the Creek upgradient of the Plant Site, as well as in the Colstrip area, were considered background concentrations for the Creek (see Sections 6.1.3 and 10.1). The source of background constituents are unknown, but may be present as a result of regional geology and mining activities.

4.2 CHEMICAL RELEASE MECHANISMS AND TRANSPORT PATHWAYS

Chemical releases and transport mechanisms are depicted in Figure 6, the SCEM. Primary chemical releases were assumed to occur by the following mechanisms:

- Pond seepage
- Pipeline releases
- Background-related geologic strata leaching, including upstream mining areas, and leaching/erosion from other anthropogenic background sources

The specific chemical transport pathways identified for the Plant Site and the identified transport mechanisms (i.e., migration) are discussed in the following sections. It should be noted that the AOC (Article VI.B) requires the CCRA Report to identify transport mechanisms for the COIs.

4.2.1 Pond Seepage and Groundwater Migration

Seepage losses from the process ponds at the Plant Site have historically impacted primarily shallow groundwater. However, numerous capture wells have been placed at the Plant Site downgradient of the process ponds that actively limit advective migration of impacted groundwater. The capture system continues to be evaluated and upgraded so that migration is limited to the extent practicable. Additional groundwater capture wells have been added as recently as 2016.

The DEQ (in the February 28 and April 21, 2017 meetings) has indicated that the CCRA, as well as the Remedy Evaluation Report, should consider conditions at the Plant Site if the capture well system was not operational (DEQ, 2017c). In this CCRA Report, Cleanup Criteria for groundwater COIs are developed (please see Section 12.5) to assist in assessing the necessity of remedial measures, as well as in designing remedial measures (the capture well system, or other measures). In addition, as previously discussed, the on-going Plant Site Pond modifications being conducted under the Federal CCR Rule should be considered in the development of the remedial measures.

In the area of the pond seepage losses, COIs could have been transported toward surface water in the alluvium via the shallow groundwater. Again, at present, an ongoing groundwater capture system limits migration of groundwater to the alluvium, but the future need of the capture system should be considered.

4.2.2 Surface Releases to Soil and Subsequent Migration

In the area of two surface spills (two pipeline releases near the treated sewage effluent ponds), released liquid waste slurry entered surface water (the Creek) releasing constituents to the surface water and sediment (see Section 4.2.2.1 below for additional information).

4.2.2.1 Surface Releases to Soil (Pipeline Releases and Subsequent Remediation, and Storm Water)

Three surface releases have occurred in the uncontrolled access area of the Plant Site (Hydrometrics 2015b). All three spills occurred in the northern tip of the Plant Site from pipeline releases and all three were remediated. One spill occurred near the Power Road Overpass, while the other two occurred near the Treated Sewage Effluent Ponds. Per the request of DEQ, additional soil sampling was conducted by Hydrometrics at the spill areas in 2016 (Hydrometrics, 2016a). The three surface releases are summarized below:

- September 18, 1998 – MPC Units 1 and 2 Fly Ash Pipeline near the City's Treated Sewage Effluent Ponds

  Approximately 80,000 gallons of fly ash slurry were released from a leak in the pipeline. Approximately 16,000 gallons of slurry may have flowed over the ground surface into East Fork Armells Creek. MPC placed two flow obstacles in the creek to create areas of slow moving water to promote slurry settling and limit migration. MPC also constructed a berm to divert the flow of slurry from entering the creek and constructed a containment pond. Lastly, MPC removed approximately 329 cubic yards of soil and fly ash from the ground, from a stockpiled area, and from the creek (Hydrometrics, 1998).

  East Fork Armells Creek has numerous meanders in the area of the release (south of the Treated Sewage Effluent ponds). At the time of the release, confirmation soil samples were collected verifying fly ash removal. Fly ash slurry was released to East Fork Armells Creek and assumed to have migrated downstream at least to some extent. Numerous synoptic run sampling events of the Creek have been performed since the spill. As requested by the DEQ (2015), additional surface and subsurface soil samples were collected in the area of this former spill and remediated area in April 2016 (Hydrometrics, 2016a).

- March 13, 2000 – PPLM Units 1 and 2 Fly Ash Pipeline near the Power Road Overpass

  Approximately 400 gallons of fly ash slurry water were released from a leak in the pipeline. Approximately 200 gallons were recovered (pumped from a low area) and 30 cubic yards of soil and fly ash were hauled from the site and disposed in the Evaporation Holding Ponds. The majority, if not all of the spilled slurry, was believed to be recovered (PPLM, 2000).

  The location of this spill is not immediately adjacent to East Fork Armells Creek. Slurry water was not reported to have reached the Creek; rather, the slurry ponded in a low area from which it was pumped. Migration of the spill was assumed to have penetrated into the soil and, therefore, impacted soil was excavated. It is unlikely that significant migration was associated with this spill. As requested by the DEQ (2015), additional surface and subsurface soil samples were collected in the area of this former spill and remediated area in April 2016 (Hydrometrics, 2016a).

- March 29, 2000 – PPLM Units 1 and 2 Effluent pipeline near the Treated Sewage Effluent Ponds

  Approximately 122,500 gallons of return liquid were released from a leak in the pipeline at nearly the same location as the 1998 spill and flowed over the ground surface. Containment measures had been previously installed in 1999, but ~9,000 gallons of returned liquid breached the measures. An estimated 114,000 gallons of return liquid were recovered from the containment pond and another 159,000 gallons of impacted water were recovered from the Creek. Water quality of the Creek after cleanup was indicative of background water quality. As requested by the DEQ (2015), additional surface and subsurface soil samples were collected in the area of this former spill and remediated area in April 2016 (Hydrometrics, 2016a).

During the additional soil sampling event in April 2016 of the former spill sites described above, an area at which storm water has the potential to pond was also sampled. The storm water ponding area is located near the main gate in an area immediately north of the railroad tracks near its intersection with Willow Avenue. Surface and near surface soil samples were collected in this area in April 2016 (Hydrometrics, 2016a).

4.3 WIND SUSPENSION (FUGITIVE DUST)

In the remediated surface spill areas and the storm water ponding area at the Plant Site, the potential exists for wind to suspend dry soil impacted with COIs, if present, from liquid waste, into the air as particulates (fugitive dust).

4.4 POTENTIALLY EXPOSED HUMAN RECEPTORS

Potential human receptors at the Plant Site were identified that might be exposed to constituents from the Colstrip SES Facility that originated from wastewater releases (see also Figure 6, the SCEM). Potential human receptors were limited to individuals who might be exposed at the Plant Site area outside of the active operations area and, therefore, beyond the controlled access (fenced) areas. Figure 2 depicts the fence line/controlled access areas of the Plant Site.

Within the active operations/controlled access area, current potential worker exposures to constituent residuals in the Plant Site ponds would predominantly fall under the Occupational Safety and Health Administration (OSHA). At present, Talen has a robust worker safety program, including awareness training, spill response training, Hazardous Waste Operations and Emergency Response (HAZWOPER) training (for select employees), etc. As such, potential human exposures to constituent residuals in the Plant Site ponds are presently managed through Talen's worker safety program and were not addressed in this CCRA.

Figure 4 identifies current land uses and areas at the Plant Site at which receptors could potentially be exposed. Generally, the western side of the Plant Site, along the southern and eastern edges of the town of Colstrip, contains areas outside the controlled access areas of the active operations with potential exposures to receptors from wastewater releases. Current and reasonably anticipated future uses of the uncontrolled access areas of the Plant Site were considered when identifying potential receptors. The following table presents the identified potential human receptors:

Table 4-1 Receptors Identified and Evaluated in the CCRA

Land Use	Receptor	On-Site*	
		Current	Future
Residential	Resident (Child*)	X	X
Industrial	Outdoor Worker	X	X
Construction	Construction Worker	X	X
Recreational Receptor	Child	X	X

Notes:

On-Site* Potential receptors on the uncontrolled access areas of the Plant Site, i.e., outside of the controlled-access (fenced) areas, but within the Plant Site boundary.

Child* For non-carcinogenic COPCs, the DEQ indicates that child receptors should be evaluated, as they are protective of adult exposures.

- Child Residents (children residing in the uncontrolled access areas of the Plant Site, e.g., the trailer park located along the Creek on the western side of the Plant Site).
- Adult Industrial Outdoor Workers (adults working outdoors in the uncontrolled access areas of the Plant Site, e.g., the sewage treatment plant or the animal control facility located in the northern most tip of the Plant Site).
- Adult Construction Workers (adults performing construction work in the uncontrolled access areas of the Plant Site, e.g., trench workers).
- Recreational Users (children recreating, such as playing in the Creek, in the uncontrolled access areas of the Plant Site, specifically in the area south of the sewage treatment pond where previous pipeline releases have occurred. This area is also used recreationally by adults, particularly by archery hunters).

4.5 POTENTIALLY COMPLETE EXPOSURE PATHWAYS

USEPA guidance (USEPA, 1989) defines a complete exposure pathway as consisting of four elements:

- A source and mechanism of chemical release
- A retention or transport medium (or media in cases involving transfer of chemicals)
- A point of potential human contact with the contaminated medium (referred to as an exposure point)
- An exposure route (such as ingestion or inhalation) at the contact point

An exposure pathway is considered complete when it has all four factors. Designation of an exposure pathway as complete indicates that human exposure is possible, but does not necessarily mean that exposure will occur, or that exposure will occur at the levels estimated in this CCRA. When any one of the factors is missing in the pathway, it is considered incomplete. Incomplete exposure pathways do not pose a health hazard and were not evaluated further. A key step of the exposure analysis was to determine whether there were plausible routes of human exposure to COIs/COPCs at the Plant Site.

The SCEM for the Plant Site summarizes the information on sources of COIs/COPCs, affected environmental media, COI/COPC release and transport mechanisms, potentially exposed receptors, and potential exposure pathways for each potential receptor (see Figure 6). Figure 6 includes information on both human and ecological receptors and exposure pathways. The discussion of the SCEM presented in this Section primarily includes potential human exposures. Ecological pathways and exposures are discussed in detail in the Ecological Risk Assessment presented in Appendix C of this Report.

Potentially complete human exposure pathways associated with surface soil in the former spill areas and streambed sediments within East Fork Armells Creek were identified in the SCEM:

- Surface Soil
    - Incidental ingestion
    - Dermal contact
    - Inhalation (particulates)

- Creek sediments
    - Incidental ingestion
    - Dermal contact

The surface soil exposure pathways were subsequently eliminated because no human health COIs/COCs were identified in surface soil. The dermal contact and incidental ingestion exposure pathways for sediment for the construction worker receptor was not evaluated. DEQ does not require evaluation of construction worker exposure to sediment as it is an infrequent exposure pathway (DEQ, 2017e).

Potentially complete exposure pathways associated with groundwater and surface water were identified for the Plant Site area and selected for comparison with DEQ-7 standards (DEQ, 2017d):

- Surface water
    - Ingestion
    - Dermal contact

- Groundwater

  - Ingestion
  - Dermal contact

DEQ-7 Standards apply to all state groundwaters and will, therefore, apply to all aquifers at the Facility. Dermal contact with groundwater was considered for instances in which a construction worker may have contact with shallow groundwater. However, per discussions with DEQ in the 2/28/2017 meeting, the DEQ-7 Standards are considered protective of this infrequent exposure pathway (DEQ, 2017c).

Bioconcentration of surface water COPCs in fish tissue was not identified as an exposure pathway because East Fork Armells Creek does not sustain a fish population that would provide for recreational fishing.

The basis for identifying each exposure pathway as complete or incomplete is summarized in Tables B-1.1 through B-1.4 of Appendix B (i.e., RAGS Part D Table 1).

5.0 RISK ASSESSMENT APPROACH AND GUIDELINES

Following the guidance of the AOC (DEQ/PPLM Montana, 2012), as well as direction provided by DEQ in the 2/28/2017 meeting (DEQ, 2017c), in which DEQ indicated that risks should be evaluated for the Plant Site without the operation of the capture well system, the following Risk Assessment approach was followed:

Human Health Risk Assessment

- Groundwater – forward calculations of human health risks associated with groundwater were not conducted for two main reasons. First, because the capture well system presently prevents migration of groundwater from the Plant Site and modeling of groundwater migration without the capture well system would need to be conducted adding substantial uncertainty into the forward calculation of human health risks associated with groundwater. Second, DEQ guidance indicates that groundwater risks should be evaluated qualitatively through the comparison to DEQ-7 Standards, rather than quantitatively through the forward calculation of human health risks. DEQ requested that human health Cleanup Criteria for groundwater be developed following the above described approach. Cleanup Criteria will be used in the Remedy Evaluation. Human health-based Cleanup Criteria for groundwater are discussed in Section 12.5.1.

- Surface water – similar to groundwater, forward calculations of human health risks associated with surface water were not conducted. Human health-based Cleanup Criteria for surface water are discussed in Section 12.1.

- Streambed Sediment – forward risk calculations of human health risks were calculated. Human health-based Cleanup Criteria for streambed sediments are discussed in Section 12.2.

- Soil – forward risk calculations of human health risks were not calculated because human health COIs/COCs were not identified in soil.

Ecological Risk Assessment

- Groundwater – one pathway was considered for ecological (livestock) exposure to groundwater, which is the potential future pathway of livestock consumption (i.e., pumping groundwater into a stock tank), as agreed to in the 2/28/2017 DEQ Meeting (DEQ, 2017c). Forward risk calculations were not performed for this pathway because it is not a current exposure. Rather, ecological (livestock)-based Cleanup Criteria for groundwater were developed for this potential future pathway (see Section 12.5.2).

- Surface Water, streambed sediment, and soil – forward risk calculations for ecological risks were calculated. Ecological Cleanup Criteria for surface water, streambed sediment, and soil are discussed in Sections 12.1, 12.2, and 12.3, respectively.

5.1 HUMAN HEALTH RISK ASSESSMENT APPROACH

As previously described in Section 1.0, the DEQ requested that the CCRA Work Plan include DEQ's new Risk Assessment Scope of Work guidance. This Plant Site CCRA Report follows DEQ's Risk Assessment guidance for both the Human Health Risk Assessment (HHRA) and Ecological Risk Assessment (ERA). DEQ's Risk Assessment guidance largely follows the USEPA Risk Assessment guidance.

Overviews of the frameworks for both the USEPA and DEQ Human Health Risk Assessment Process are presented in the following sections.

5.1.1 Framework of the USEPA Human Health Risk Assessment Process

The methods used to conduct the HHRA are based on USEPA guidance (USEPA, 1989, 2001, 2009b et al.) and DEQ guidance (DEQ, 2009, 2016a). The framework for a HHRA is presented in "Risk Assessment Guidance for Superfund (RAGS), Volume I, Human Health Evaluation Manual (Part A; USEPA, 1989) and consists of the following six main steps:

- Conceptual Site Exposure Model (also referred to as the Site Conceptual Exposure Model [SCEM] by DEQ) – during this step, contaminant sources, affected environmental media, release and transport mechanisms, potential human receptors and exposure pathways to the COPCs are identified for current and future site conditions.

- Data Evaluation and Selection of COPCs – during this step, the analytical data are evaluated for usability in the HHRA. In addition, the data are grouped by location and medium and COPCs are selected for each applicable site media.

- Exposure Assessment – during this step, exposures for identified potentially complete exposure pathways to the COPCs are quantified. Exposure Point Concentrations (EPCs) are estimated, generally using a statistical approach, for each of the COPCs in each media. Pathway-specific intakes are estimated using human exposure parameters for the current and future potential human receptors.

- Toxicity Assessment – during this step, toxicity values that characterize potential adverse health effects for the COPCs are compiled.

- Risk Characterization – during this step, information from the previous steps is used to characterize potential risks to human health associated with exposure to COPCs. Both potential cancer risks and non-cancer hazard indices are evaluated.

- Uncertainly Analysis - during this final step, the major uncertainties associated with the risks are evaluated.

5.1.2 Framework of DEQ's Human Health Risk Assessment Process

For the risk assessment portion of the CCRA, DEQ requested that the DEQ's new Risk Assessment Scope of Work guidance be followed (DEQ, 2016a). The DEQ has defined the following required components of a Risk Assessment:

1. History and setting of the Facility, including demographic information
2. Data evaluation and selection of COPCs
    a. Data Summary
    b. Data Evaluation
    c. Selection of COPC(s) for each media
3. Human health risk assessment
    a. Exposure assessment
        i. Site conceptual exposure model
        ii. Potential receptors and exposure pathways
        iii. Exposure assumptions
        iv. Definitions of exposure areas and calculations of exposure point concentrations
        v. Calculations of chronic daily intakes
    b. Toxicity assessment
        i. Definitions of carcinogenic and non-carcinogenic risks
        ii. Carcinogenic slope factors and inhalation unit risks
        iii. Non-carcinogenic reference doses and reference concentrations
        iv. Uncertainties associated with toxicity assessment
    c. Risk characterization
        i. Calculation and discussion of the carcinogenic risk estimates
        ii. Calculation and discussion of the non-carcinogenic risk estimates
        iii. Evaluation and discussion of uncertainties
    d. Ecological risk assessment
4. Fate and Transport Analysis
5. Calculation of Site-Specific Cleanup Levels (SSCLs)
    a. Human health-based SSCLs
    b. SSCLs based on groundwater protection
    c. Ecological risk-based SSCLs
6. Completed tables 1-10 of EPA's Risk Assessment Guidance for Superfund (RAGS) Part D.
7. Summary table and figure of media, receptors, and exposure areas that exceed SSCLs. (This information will be presented in the Remedy Evaluation as it requires groundwater modeling).

Per DEQ guidance, the following steps were included in the CCRA Work Plan (Ford Canty, 2016b) and are presented herein:

- SCEM
- Data Evaluation and Selection of COPCs
- Exposure Assessment
- Toxicity Assessment

Within this CCRA Report, the remaining steps of the HHRA have been completed.

The data, assumptions, and calculations associated with steps are provided in Appendix B of this Work Plan in RAGS Part D tabular format (USEPA, 2001).

The Human Health Risk Assessment is presented in Sections 6.0 thru 9.0.

5.2 ECOLOGICAL RISK ASSESSMENT APPROACH

Montana DEQ follows the 8-Step Ecological Risk Assessment (ERA) process developed by USEPA and detailed in *Ecological Risk Assessment Process for Superfund: Process for Designing and Conducting Ecological Risk Assessments, Interim Final* (USEPA, 1997b) and *Guidelines for Ecological Risk Assessment* (USEPA, 1998). Montana DEQ recognizes that not all sites will need to utilize the full 8-Step process identified by USEPA, and has further tailored the process to identify four different levels of ecological risk assessment based on site location, activities, habitats, and chemicals potentially present at the Site (DEQ, 2016a). The simplest of these, a Level 1 ERA, is for sites where no long-term ecological habitat is present, and simply requires documentation of site conditions (e.g., lack of ecological habitat) and consideration of future site use. The most complex, a Level 4 ERA, is for sites that represent critical ecological habitat, and requires the implementation of the full 8-Step Process.

Steps 1 and 2 of the USEPA process represent the screening phase of the ecological risk assessment. Step 1 is the Screening Level Problem Formulation and Ecological Effects Evaluation to identify site ecological receptors, exposure pathways, endpoints for evaluation, and ecological toxicity information, while Step 2 provides the Screening-level Exposure Estimates and Risk Calculations. The screening-level ecological risk assessment (SLERA) for the Plant Site was included as part of the CCRA Work Plan and is presented herein. Steps 3 through 8 comprise the baseline ecological risk assessment (BERA), though an informal “Step 3a”, in which the list of COPCs identified in Step 2 is refined prior to development of the BERA problem formulation, is often included as part of the SLERA. The steps of the BERA are:

- Step 3: BERA Problem Formulation
- Step 4: Study Design and Data Quality Objectives
- Step 5: Field Verification of Sampling Design
- Step 6: Site Investigation
- Step 7: Risk Characterization
- Step 8: Risk Management

Because of the presence of aquatic and wetland features (the Creek) at the Plant Site, a Level 3 Ecological Risk Assessment was assumed to be required, at a minimum. The results of the SLERA indicated a Level 4 Assessment was not necessary.

The Ecological Risk Assessment is presented in Appendix C.

6.0 HUMAN HEALTH DATA EVALUATION, DATA GROUPING, AND CHEMICALS OF POTENTIAL CONCERN

Within this section, the process used to evaluate and group the analytical data for both quantitative and qualitative evaluation in this CCRA is presented. This section also discusses the process used to identify additional COIs/COPCs beyond the constituents listed in Appendices III and IV of the Federal CCR Rule.

6.1 EVALUATION OF SITE DATA

Data were available from the following media:

- Surface water (the Creek)
- Streambed sediment (the Creek)
- Soil (associated with remediated areas of former pipeline releases and a storm water ponding area all located in the northern tip of the Plant Site Area)
- Groundwater

Potential sources of contaminants were identified and discussed in Section 4.1.

The available surface water, streambed sediment, soil, and groundwater data for the Plant Site were reviewed, as well as the list of Appendices III and IV CCR constituents, and used in the identification of Exposure Units (EUs) and additional COIs/COPCs.

6.1.1 Description of an Exposure Unit

A location at which a human receptor may be exposed to a medium, such as soil, streambed sediment, surface water or groundwater, is referred to as an Exposure Unit (EU). EUs were defined using the following information:

- Plant Site Land Use (specifically in the uncontrolled access areas, see Figure 4)
- Identified Potential Receptors (see Figure 6)
- Potential Chemical Releases and Migration from the Facility Wastewater System
- Available Site Data

The identified EUs for the Plant Site area are presented in Table 6-1 below and depicted in Figure 7. It should be noted that an Exposure Unit for groundwater was not defined as forward risk calculations were not prepared for groundwater exposure. Rather, as directed by DEQ, Cleanup Criteria for groundwater were developed for use in the Remedy Evaluation.

Table 6-1 Exposure Units

Exposure Unit	Description
EU 1	East Fork Armells Creek in the Plant Site area (surface water and streambed sediments)
EU 2	Former Spill Site near Power Road (soil)
EU 3	Former Spills Site near the Treated Effluent Sewage Lagoons (soil)
EU 4	Storm Water Ponding Area near the intersection of the railroad tracks and Willow Avenue (soil)

6.1.2 Description of Data used in the HHRA, by Exposure Unit

Data for each of the EUs are described in Table 6-2 below. The human health risk assessment data are summarized in Tables B-2.1 through B-2.5 (RAGS Part D Table 2) located in Appendix B. In addition, tables of the data used in the risk assessment are presented in Appendix E.

Table 6-2 Data Description by Exposure Unit

Exposure Unit	Media	Sample Locations	Sampling Dates	Description
EU1 East Fork Armells Creek Plant Site Area	Surface Water	Downgradient Creek sample locations: AR-4, AR-3, NSTP (North Sewage Treatment Pond – City of Colstrip), and AR-2 (Figure 8; Tables E-1 & E-2, Appendix E)	Spring 2014 through Fall 2015	Synoptic Run sampling data collected from 4 sampling events in spring and fall 2014 and spring and fall 2015. The sampling points are located in East Fork Armells Creek in the Plant Site Area and at the sewage lagoon operating by the City of Colstrip.
	Streambed Sediment			
EU 2 Former Spill Site near Power Road	Soil	BH-29 through BH-32 (Figure 9; Table E-3, Appendix E)	April 2016	Soil samples collected from various intervals from surface to 6 feet bgs
EU 3 Former Spill Site near Sewage Lagoons	Soil	BH-33 through BH-69, and BH-73 (Figure 10; Table E-4, Appendix E)	April 2016	Soil samples collected from various intervals from surface to 7 feet bgs
EU 4 Storm Water Ponding Area	Soil	BH-70 through BH-72 (Figure 11; Table E-5, Appendix E)	April 2016	Soil samples collected from various surface intervals from surface to 2 feet bgs

Surface water and streambed sediment data were limited to the two previous two years (i.e., 2014 and 2015) from the time the Work Plan was initiated (Ford Canty, 2016) for the following reasons:

(1) As a flowing surface water body, East Fork Armells Creek is expected to be very dynamic. COI/COPC concentrations in surface water and streambed sediment are expected to change frequently.

(2) The effectiveness of the capture well system is evaluated regularly with additional capture wells added, as needed. Capture wells have been added as recently as 2016 that function to improve capture and further limit migration of groundwater that has seeped from the process ponds toward the creek. (It should be noted that the DEQ requested evaluation of the Plant Site considering the absence of the capture wells system. The development of groundwater cleanup criteria [see Section 12.5] will be used in the Remedy Evaluation to address potential COI/COC migration).

(3) Comprehensive Synoptic Run data sets were available for this time period.

Soil data were limited to those collected during the April 2016 investigation of the remediated former spill areas and the storm water ponding area (Hydrometrics, 2016a).

Groundwater data were not directly used as forward calculations of human health risks associated with groundwater were not performed. Rather, per DEQ's request, human health and ecological (livestock) Cleanup Criteria for groundwater were developed (see Section 12) for use in the Remedy Evaluation. Ecological (livestock) Cleanup Criteria for groundwater were limited to one scenario (livestock consumption via groundwater pumping into stock tanks).

6.1.3 Reference/Background Samples

Surface Water

Various reference/background surface water sample data were available for comparison to the East Fork Armells Creek surface water data at the Plant Site, as summarized below:

- Upstream surface water background data were available to estimate the Background Screening Levels (BSLs) for the Colstrip SES (Neptune, 2016). The surface water BSLs were based on four upstream sampling locations (AR-12, SW-55, SW-60, SW-75) over a temporal span from February 1981 to October 2014. Please note that the revised BSLs (Neptune, 2017) did not include SW-60 in the BSL estimation. The 2016 BSLs were used in this Plant Site CCRA and the 2017 BSLs will be used in the Units 1 & 2 SOEP/STEP CCRA. The sampling locations for the estimation of surface water BSLs were limited to four locations because the statistical approach required a sufficient number of samples be available over time from each location, as well as continuous creek flow. In addition, spring water monitoring sites were not included in the calculation of the surface water BSLs; rather, spring water monitoring sites were included in the groundwater BSL calculations (Neptune, 2016). Please refer to the BSL document (Neptune, 2016) for a detailed discussion of the surface water BSLs. Surface water sampling locations AR-12 and SW-55 are located immediately upstream of the Plant Site AOC boundary. SW-60 and SW-75 are located approximately 4 and 8 miles, respectively, upstream of the Plant Site AOC boundary (see Figure 12). The surface water BSLs were included as background/reference data in Table B-2.1 (Appendix B).

- An upgradient surface water Background Threshold Value (BTV) based on the estimation of the 95/90 Upper Tolerance Level (UTL) for manganese in surface water upgradient of the Plant Site was developed following discussions with the DEQ (2018b). The 95/90 UTL is defined as the 95% confidence limit on the 90th percentile (see Appendix D). The surface water BTV for manganese was based on five surface water sampling locations upgradient of the Plant Site, for which total manganese concentrations were available over a temporal span from 1977 to 2015. The five upgradient surface water sampling locations included in the calculation estimation of the surface water manganese BTV are AR-5, AR-12, SW-03, SW-55, and SW-75. Surface water sampling locations AR-12, SW-55, and SW-03 are located near the upstream Plant Site AOC boundary. AR-5 is located immediately downstream of the Plant Site AOC boundary, but hydrologically upgradient of the Plant Site itself. SW-75 is located approximately 8 miles upstream of the Plant Site AOC boundary (see Figure 13). The surface water manganese BTV was included as a background/reference data point in Table B-2.1 (Appendix B).

- The upstream surface water data from sampling points AR-12 and AR-5, which are the closest upgradient sampling points, were considered to be a primary background data points. Upstream samples are affected by the Rosebud Mine. In discussions with the DEQ (DEQ, 2017c; DEQ, 2018b), AR-12 and AR-5, were determined to be the primary background data points for surface water data comparisons because of influence of upstream activities including coal mining. The surface water data from sampling points AR-12 and AR-5 are included as background/reference data in Table B-2.1 (Appendix B).

- Surface water background data were also available from a very large surface water sampling dataset compiled and statistically summarized by Western Energy for the preparation of the Comprehensive Evaluation of Probable Hydrologic Consequences document prepared to support the permitting process for the expansion of mining in Area B of the Rosebud Mine (Nicklin Earth & Water, 2014). However, the compiled dataset statistics were not limited to upgradient surface water locations. Rather, the dataset statistics included numerous downstream sampling locations in East Fork Armells Creek, as well as in adjacent drainages, over a temporal span of approximately 40 years. As such, the Rosebud Mine dataset statistics were not an appropriate comparison.

Sediment

Streambed sediment data were available from the primary upgradient background sampling points, AR-12 and AR-5. Considering the limited stretch of the Creek, streambed sediment background data were limited and streambed sediment BSLs were not generated. Upstream sediment data were not available from the Rosebud Mine (Nicklin Earth & Water, 2014). The sediment data from sampling points AR-12 and AR-5 were included as background/reference data in Table B-2.2 (Appendix B).

An aquatic habitat assessment and benthic community survey were conducted in upstream areas of the Creek at the Rosebud Mine. The locations of the assessment/survey were at approximately 1 mile and 2 miles upstream of the AOC Plant Site boundary. Following DEQ protocols, a community indicator metric (Hilsenhoff Biotic Index [HBI]) was calculated using Montana-specific tolerance values for identified taxa. The assessment indicated that upstream conditions of the Creek were “fairly poor” to “poor” (the lowest ratings of the HBI; Arcadis, 2014).

Soil

Soil background data, referred to as the BTVs for Inorganics in Montana Soils, were available from DEQ (Project Report Background Concentrations of Inorganic Constituents in Montana Surface Soils, 2013). The BTVs for Inorganics in Montana Soils were included as background/reference data in Tables B-2.3 through B-2.5 (Appendix B).

Groundwater

Groundwater background data were available from the 2016 BSL Report for the Colstrip SES (Neptune, 2016). BSLs were not available for all constituents (e.g., Radium 226/228).

6.2 DATA GROUPING

Data were grouped by each EU (e.g., EU1 data were grouped separately from EU2 data) and sample medium (e.g., surface water data were grouped separately from streambed sediment data). Data for soil were not grouped by depth interval because initial screening of the soil data (RAGS Part D Tables 2.3 thru 2.5 located in Appendix B) did not identify any human health COCs in soil.

6.3 IDENTIFYING HUMAN HEALTH COPCS

Data were screened using the flow charts and screening process described by the DEQ (2016a). Data were also screened against background concentrations described in Section 6.1.3. Specifically, data for each media were screened as summarized in Table 6-3 below to further identify COIs/COPCs, beyond the list of COIs identified thru screening of the Federal CCR Rule Appendices III and IV (see Report Table 3, located in the Tables section).

Table 6-3 Summary of Screening Values and Human Health COPCs

Media	**Screening Values**	**Identified Human Health COPCs/ Rationale**
Surface Water	• DEQ-7, which include MCLs • If no DEQ-7 (DEQ, 2017d), USEPA Regional Screening Level (RSL) for Tapwater was used • BSLs (Neptune, 2016) • Nearest Upgradient Background Data Points (focused on AR-12 and AR-5) • BTV (for manganese)	Manganese: > USEPA RSL for Tapwater > BSL
Streambed Sediments	• USEPA RSLs for Residential and Industrial Soil (following the DEQ screening process in which non-carcinogenic RSLs are reduced by a factor of 10 to account for cumulative health effects, [DEQ,2016a]) • Nearest Upgradient Background Data Points (focused on AR-12 and AR-5) • BTVs for Inorganics in Montana Soils (DEQ, 2013)	Manganese: > USEPA RSLs > BTV (soil)
Soil	• USEPA RSLs for Residential and Industrial Soil (following the DEQ screening process in which non-carcinogenic RSLs are reduced by a factor of 10 to account for cumulative health effects, [DEQ, 2016a]) • BTVs for Inorganics in Montana Soils (DEQ, 2013)	Lead: > USEPA Residential RSL

Data screening is presented in Tables B-2.1 through B-2.5 (RAGS Part D Table 2) located in Appendix B. The COPC column flags chemicals with either a “Y” for yes or an “N” for no. The chemicals flagged with an “N” were excluded from further human health risk evaluation.

If surface water chemicals were flagged with a “Y” in the COPC column, they were identified as COPCs. Following DEQ guidance (2016a), surface water COPCs were then further evaluated qualitatively in the risk evaluation through comparison to DEQ-7 standards (or USEPA MCLs and USEPA RSLs, if DEQ-7 standards were not available). In addition, comparisons were made to background surface water concentrations. Based on the additional evaluation, manganese was not retained as a surface water human health COC (see Section 10.1).

If sediments or soil chemicals were flagged with a “Y” in the COPC column, they were identified as COPCs and retained for quantitative risk evaluation. For the human health portion of the risk evaluation, streambed sediment and soil data were compared to direct contact screening levels (i.e., 1/10th the USEPA Regional Screening Level for residential and industrial soils (RSLs; USEPA, 2016a) following DEQ’s screening process (DEQ, 2016a) to identify potential human health COPCs. One human health COPC, manganese, was identified in streambed sediment and was quantitatively evaluated for health risks (see Section 9.0) and not retained as a COC. One human health COPC, lead, was identified in soil, but not retained as a COC (see Section 7.2.4, Section 10.2, and Appendix B, Table B-2.4).

6.3.1 Groundwater COIs/COPCs

As previously presented in Section 3.0, the Plant Site groundwater COIs/COPCs were identified through a screening process of the constituents listed in Appendices III and IV of the Federal CCR Rule (USEPA, 2015). The identified Plant Site groundwater COIs/COPCs are presented in Table 3, located in the Tables section.

6.3.2 Uncertainties in Identifying Human Health COIs/COPCs

The following uncertainties in the identification of human health COIs/COPCs are as follows:

- The AOC (DEQ/PPLM, 2012) regulated substances include sulfate, boron, selenium, potassium, sodium, magnesium, TDS, and salinity. Human health toxicity values have not been established for sulfate, potassium, sodium, magnesium, TDS, and salinity. These constituents were not identified as human health COPCs. (Sulfate was identified as an ecological [livestock] COPC). Uncertainty exists regarding the potential toxicity of constituents without human toxicity values to human receptors.

- Similarly, human health toxicity values have not been established for the following Appendix III and Appendix IV CCR Rule constituents: calcium, sulfate, TDS, and pH. These constituents were not identified as human health COPCs. Uncertainty exists regarding the human health concerns potentially posed by these constituents.

- True background samples and sampling locations for surface water and streambed sediments were not available because the Creek is intermittent and upstream locations have been affected by mining and other anthropogenic activities. Uncertainty exists regarding the comparison of sediment and surface water data to “background” concentrations.

- The CCR well data was used in the screening process to assist in the identification of COIs/COPCs. However, the CCR well data are total recoverable concentrations as required by the Federal CCR Rule. Total recoverable concentrations are not directly comparable to groundwater standards and screening levels that are based on dissolved concentrations. Uncertainty exists in using total recoverable concentrations as proxy dissolved concentrations. Specifically, because the CCR well data are generally total recoverable concentrations, comparisons of CCR well data to screening levels based on dissolved concentrations results in a conservative bias.

6.4 IDENTIFYING LEACHING COI/COPCS

Soil chemicals were also compared to the USEPA Soil Screening Levels (SSLs) for groundwater protection (USEPA, 2016) that were modified following the DEQ Soil Screening Process (DEQ, 2016a) to identify leaching COPCs. If soil chemicals were flagged with a "Y" in the Leaching COPC column, they were identified as a potential leaching COPC. Two chemicals, barium and lead, were identified as possible leaching COPCs (see Table B-2.4 in Appendix B). However, after a more detailed data comparison, these chemicals were not retained as leaching COCs. Please see Section 10.2 for additional information regarding leaching COIs/COPCs.

6.4.1 Vertical Connectivity between Hydrostratigraphic Units

As described previously in Section 2.3.2, various lithological units are present at the Plant Site. These are, in ascending order; sub-McKay, McKay Coal, Rosebud-McKay Interburden (interburden), Rosebud Coal, spoil and clinker (laterally equivalent to the Rosebud Coal), overburden, and alluvium. Only the alluvium, McKay Coal, spoil and sub-McKay could accurately be referred to as aquifers. Intervals that are not aquifers include the overburden due to its limited extent and general absence of producible quantities of water; the Rosebud Coal because it is largely mined out; and the interburden and clinker due to its limited water content.

The interburden which underlies the former Rosebud Coal is comprised of very fined grained rock (e.g. siltstone and claystone or shale). These sedimentary rocks exhibit low permeability. Even though the permeability of the interval is low, the vertical permeability is even lower due to anisotropy caused during deposition and subsequent loading. Flatter elongated grains tend to lay flat creating preferential flow in the horizontal direction. Loading from increased sediment deposition further exaggerates this condition. The permeability of the units is very low which inhibits horizontal flow and renders vertical flow negligible. The interburden contains very little water and would not sustain production as an aquifer.

Groundwater flow at the Plant Site generally flows either toward East Fork Armells Creek or toward the Cow Creek drainage. Groundwater flow directions are dictated by a hydrologic divide that is present along the eastern part of the Plant Site. Flow on the east side of the divide generally flows to the east and the converse is true on the west side of the divide.

Groundwater flow on the east side of divide occurs predominantly in the McKay Coal, spoil and sub-McKay. The overburden and Rosebud Coal are missing in this area, with spoil now occupying the interval.

Spoil on the Plant Site is comprised of overburden that was removed to mine the Rosebud Coal then replaced following mining. This process results in a hydrostratigraphic unit that is more homogeneous than the undisturbed overburden. Hydraulic conductivity of the spoil is similar both vertically and horizontally. Water entering the spoil will move vertically to the level of saturation (water table). Groundwater then flows in the spoil in a downgradient direction. Minimal water moves vertically into the interburden. As mentioned previously, the amount of water in the interburden is not sufficient to act as an aquifer and it is not uncommon for the interburden to be dry. These conditions cause water that enters the spoil to stay in that interval with horizontal flow.

The McKay Coal is a cleated coal. Cleats are basically joints that form perpendicular to the bedding planes. Groundwater flows through the cleats with hydraulic conductivity being determined by the size and interconnectivity of the cleats. In general, the hydraulic conductivity of the coal is between about 1 and 3 feet per day. Strata immediately below the coal is typically comprised of clayey siltstone to mudstone. The fine-grained nature of the sedimentary rock below the McKay Coal limits vertical flow of groundwater to the deeper sub-McKay strata.

Groundwater on the west side of the divide generally flows northwest towards East Fork Armells Creek. The ancestral creek eroded through the McKay Coal and into the sub-McKay in the area west and north of the Plant Site. The eroded interval was replaced by alluvium raising it to its current level. Groundwater flow characteristics on the west side of the divide are similar to the east side although spoil is largely absent and a small area of unmined Rosebud Coal is present. Groundwater flows into the alluvium, mainly through the McKay Coal, interburden, and in some cases unconsolidated sediment above the interburden.

Erosion removed the McKay Coal directly west and north of the Plant Site along the Creek so the shallow sub-McKay is in contact with the alluvium. The alluvium has much higher hydraulic conductivity so sub-McKay groundwater discharges through this interval. Potentiometric heads in the sub-McKay away from active capture wells are higher than those in the alluvium. This results in flow from the bedrock into the margins of the alluvium. Groundwater elevations in the bedrock east and west of the Creek are higher than in the alluvium. This results in flow towards East Fork Armells Creek alluvium.

7.0 HUMAN HEALTH EXPOSURE ASSESSMENT

The Human Health Exposure Assessment provides a description of the potential human health exposure to wastewater-related chemicals in the uncontrolled access areas of the Plant Site, including exposure routes, magnitudes, frequencies, and durations for both current and future Facility use. The exposure assessment identifies the reasonable maximum exposures (RME) that are reasonably expected to occur at the uncontrolled access areas of the Plant Site area (USEPA, 1989).

7.1 EXPOSURE POINTS AND EXPOSURE POINT CONCENTRATIONS

Present and anticipated future land use and human activity patterns are used to identify potential exposure points for human receptors and contaminated media. The exposure point is the location at which a human receptor might contact contaminated media. Potential exposures to identified COPCs are assumed to occur uniformly throughout each exposure point (or EU).

The concentration of a COPC at an exposure point is referred to as an Exposure Point Concentration (EPC). The description of the approach used to statistically assess the data and calculate EPCs is included in Appendix D. Tables B-3.1 through B-3.3 in Appendix B present data used to calculate EPCs.

One human health COPC was identified in surface water, but was not retained as a COC during further evaluation (see Section 10.1). One human health COPC was identified in streambed sediment, but, also was not retained as a COC, see Sections 9.1 and 12.2. Both COPCs were manganese.

7.2 CHEMICAL INTAKE ESTIMATES

Calculations of the non-carcinogenic average daily dose (ADD) and the carcinogenic lifetime average daily doses (LADD) for the HHRA are performed for complete exposure pathways using the equations available from the USEPA (1989, 2004, and 2009). Numerous updates have been made to the intake equations and exposure parameters since the initial publication of USEPA’s Risk Assessment Guidance for Superfund, Volume 1, Human Health Evaluation Manual, Part A (RAGS; USEPA, 1989), including, but not limited to, those listed below:

- Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment, 2004).

- Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual (Part F, Supplemental Guidance for Inhalation Risk Assessment, 2009).

- Exposure Factors Handbook: 2011 Edition (USEPA, 2011).

- Human Health Evaluation Manual, Supplemental Guidance: Update of Standard Default Exposure Factors, 2014.

In addition, DEQ has specific guidance for risk assessments available on their web-page (DEQ, 2016a).

The EPCs, scenario-specific assumptions, and intake parameters are used to estimate exposures (or intakes), which are expressed in terms of milligrams of chemical per kilogram body weight per day (mg/kg-day). Intakes are calculated for the RME, which is the highest exposure reasonably expected to occur.

The USEPA (1989) defines the generic equation for calculating human non-carcinogenic ADDs as follows:

$$Average\ Daily\ Dose\ (ADD) = \frac{C \times CR \times EF\ X\ ED}{BW \times ATnc}$$

where:

C = COPC concentration
CR = contact rate (amount of contact with impacted media per time)
EF = exposure frequency
ED = exposure duration
BW = body weight of the receptor
ATnc = averaging time (period over which the exposure is averaged)

Carcinogenic COPCs were not identified for the human health risk assessment.

Pathway-specific variations of the generic equations are used for non-carcinogenic COPCs to calculate intakes. The pathway specific variations are discussed in the following sections and presented in Table B-4 located in Appendix B.

7.2.1 Incidental Ingestion of Soil/Sediment for Non-Carcinogens

For non-carcinogenic ADD posed by incidental ingestion of soil/sediment, the childhood exposure is evaluated as it is considered to be protective of adult exposures (DEQ, 2016a).

The ADD for incidental soil/sediment ingestion for non-carcinogenic COPCs is calculated as follows:

$$ADDsoil\ ing = \frac{Cs \times IRSc\ \times BA\ \times\ EF\ \times\ ED\ \times MCF}{BWc\ \times\ ATnc}$$

where:

Cs = COPC EPC concentration in soil/sediment (milligrams/kilogram [mg/kg])
IRSc = ingestion rate soil (child; milligrams per day [mg/day])
BA = bioavailability factor (unitless)
EF = exposure frequency (days/year [yr])
ED = exposure duration (yrs)
MCF = mass conversion factor (1 x 10^{-6} kilograms per milligram [kg/mg])
BWc = body weight (child; kg)
ATnc = averaging time non-carcinogens (ED in days)

ADD calculations for incidental ingestion of streambed sediment impacted with the non-carcinogenic COPC (i.e., manganese) were calculated for the various receptors (see Tables B-7.1 through 7.3 in Appendix B, and Section 9.0).

7.2.2 Dermal Absorption of Soil/Sediment for Non-Carcinogens

For non-carcinogenic ADD posed by dermal absorption of soil/sediment, the childhood exposure was evaluated as it is considered to be protective of adult exposures (DEQ, 2016a).

The ADD for dermal absorption of soil/sediment is calculated as follows:

$$ADDsoil\ dermal = \frac{Cs \times ABS\ \times SAc\ \times AF\ \times\ EF\ \times\ ED\ \times MCF}{BWc\ \times\ ATnc}$$

where:

Cs = COPC EPC concentration in soil/sediment (mg/kg)
ABS = dermal absorption factor (unitless)
SAc = exposed skin surface area (child, square centimeters [cm^2])
AF = soil to skin adherence factor (milligrams per square centimeters [mg/cm^2])
EF = exposure frequency (days/yr)
ED = exposure duration (yrs)
MCF = mass conversion factor (1 x 10^{-6} kg/mg)
BWc = body weight (child; kg)
ATnc = averaging time non-carcinogens (ED in days)

ADD calculations for dermal absorption of soil impacted with the non-carcinogenic COPCs (i.e., manganese) were calculated for the various receptors (see Tables B-7.1 through B- 7.3 in Appendix B, and Section 9.0).

7.2.3 Inhalation of Volatiles or Fugitive Dust Particles

Human health COPCs were not identified in soil (fugitive dust particles). Volatile human health COPCs were also not identified.

7.2.4 Lead Exposures

Lead was identified in one surface soil sample in EU3 at a concentration above screening levels and was initially identified as a human health and a leaching COPC (see Appendix B, Table B-2.4). An evaluation of the soil lead data was conducted that considered the re-analysis of the one sample that exceeded the residential USEPA RSL and the remaining 88 samples that did not exceed the RSL. In addition, an evaluation of lead concentrations in deeper soil samples, as well as an evaluation of vadose zone travel time, was conducted (see Section 10.2). As a result of these evaluations, lead was not retained as either a human health COC or a leaching COC. Blood lead exposures were not assessed.

7.2.5 General Exposure Assumptions

Human exposure assumptions were based on USEPA and DEQ guidance. For the most part, the exposure parameters recommended by DEQ (and largely based on USEPA guidance) were used (DEQ, 2016a). Several of the exposure parameters recommended by DEQ include conditions, such as climate, specific to Montana. The exposure parameters are presented in Table B-4 located in Appendix B.

7.2.5.1 Exposure Time, Frequency, and Duration

The total extent of an exposure is defined by the exposure time, exposure frequency, and the exposure duration. The exposure time is limited to the inhalation pathway and is generally defined in hours per day. However, as previously described, the inhalation pathway was found to be incomplete for the EUs in the Plant Site and, therefore, was not evaluated (i.e., no surface soil COPCs were identified that could contribute to fugitive dust emissions).

The exposure frequency is the number of days per year when exposure occurs. Exposure frequencies for the one human health COPC, manganese, in streambed sediment for the various receptors are as follows:

- The exposure frequency for residential receptors was assumed to be 24 days per year, which assumes contact with streambed sediment two times per week during a three month summer, based on discussion with the DEQ (February 2017 meeting).
- The exposure frequency for industrial receptors was assumed to be 24 days per year. Of the 187 days per year assumed for an industrial receptor (which assumes a standard five-day work week, three months of snow cover, and a two-week vacation [DEQ, 2016a]), an industrial worker was assumed to have contact with streambed sediment two times per week during a three month summer, based on discussion with the DEQ (February 2017 meeting).
- The exposure duration for recreational user receptors was assumed to be 16 days per year which, based on professional judgment, assumes contact with streambed sediment one to two times per week during a three month summer.

The exposure duration is the total number of years over which an exposure occurs. Exposure durations for the various receptors are as follows:

- The exposure durations for the adult and child residential receptors were assumed to be 20 years and 6 years, respectively (DEQ, 2016a). However, when calculating intakes for an exposure to a non-carcinogenic COPC, DEQ guidance indicates the child exposure scenario (i.e., exposure duration of 6 years years) should be evaluated because it is assumed to be protective of the adult exposure scenario.
- The exposure duration for an industrial receptor was assumed to be 25 years (DEQ, 2016a).
- The exposure duration for the child recreational receptors was assumed to be 6 years (DEQ, 2016a).

7.2.5.2 Body Weight

Default body weights of 80 kilograms for adults and 15 kilograms for children were used in the assessment (USEPA, 2014; DEQ, 2016a).

7.2.5.3 Averaging Time

For non-cancer health effects, the averaging time is equal to the exposure duration (in years) multiplied by 365 days per year (USEPA, 1989). The averaging time for cancer risk estimation is the number of days in a 78-year lifetime or 28,470 days (DEQ, 2016a). The averaging time for oral and dermal exposures is expressed in days.

7.2.6 Pathway-Specific Exposure Factors

Pathway-specific exposure factors, which are unique to each exposure pathway, are summarized in Table B-4 (RAGS Table 4) located in Appendix B. Professional judgment was used to define exposure factors for which neither the USEPA nor the DEQ has established specific exposure assumptions.

7.2.6.1 Exposure Parameters for Incidental Ingestion of Streambed Sediment

Receptors may be exposed to COPCs in soil/sediment through inadvertent, or incidental ingestion. One human health COPC, manganese, was identified in streambed sediment. No human health COPCs were identified in soil.

Incidental streambed sediment ingestion rates for the various receptors are presented below.

- Child Resident – 200 mg/day
- Industrial Worker – 100 mg/day
- Recreational Receptor (child) - 200 mg/day

The exposure assumptions for assessing incidental streambed sediment ingestion, including rationales for selection of values, are summarized in Table B-4 located in Appendix B.

A bioavailability value for manganese in soil is not available (ATSDR, 2012). Therefore, following USEPA guidance, the bioavailability value for manganese was conservatively assumed to be one (100%, see Table 7-1 below).

Table 7-1 Bioavailability

COPC	Bioavailability	Reference
Manganese	NA	ATSDR, 2012

NA - not available, assumed to be 1.0.

7.2.6.2 Exposure Parameters for Dermal Contact with Streambed Sediment

Receptors may be exposed to COPCs through dermal absorption from direct contact with impacted streambed sediment. The dermal intake is an estimated absorbed dose (i.e., the amount of the COPC that crosses the skin and subsequently enters the human bloodstream). Parameters specific to the streambed sediment dermal pathway include the following:

1. the skin surface area (amount of skin in contact with the soil/sediment, cm^2).

2. amount of soil/sediment that adheres to the skin (adherence factor, AF, unitless).

3. the chemical-specific dermal absorption factor (ABSd, unitless).

Dermal exposure parameters for the various receptors are presented below.

- The child resident receptor was assumed to have 2,373 cm^2 of exposed skin surface area and a soil to skin AF of 0.2 mg/cm$^{2.}$

- The industrial worker receptor was assumed to have 3,527 cm^2 of exposed skin surface area and a soil to skin AF of 0.12 mg/cm^2.

- The child recreational receptor was assumed to have 2,373 cm^2 of exposed skin surface area and a soil to skin AF of 0.2 mg/ cm^2.

The exposure assumptions for assessing dermal exposures, including rationales for selection of values, are summarized in Table B-4 located in Appendix B.

The USEPA indicates that dermal exposures to sediments should be treated the same as dermal exposures to soil. The USEPA indicates that adherence factors are perhaps the most uncertain parameter in estimating dermal exposures to sediments, but does not provide AFs specific to sediments (USEPA, 2004).

A dermal absorption factor for manganese is not available from the USEPA (2016a) and, therefore, following USEPA guidance was assumed to be one (100%, see Table 7-2 below).

Table 7-2 Dermal Absorption Factor

COPC	Dermal Absorption Factor	Reference
Manganese	NA	USEPA, 2016a

NA - not available, assumed to be 1.0.

7.2.7 Exposure Point Concentrations/ 95 UCLs

Exposure Point Concentrations (also referred to as 95th Upper Confidence Limits on the mean [95 UCLs]) were calculated for the COPC, manganese, in two media, streambed sediment and surface water. Please see Appendix D for the Statistical Summary. Table 7-3 below presents the EPCs.

Table 7-3 Exposure Point Concentrations (95 UCLs)

COPC	Media	Minimum Value	Maximum Value	Average	EPC (95 UCL)
Manganese	Streambed Sediment (mg/kg)	412	3,910	1,737.9	2,755.4
	Surface Water (mg/L)	0.059	3.39	0.781	2.04

8.0 TOXICITY ASSESSMENT

The Toxicity Assessment follows the USEPA recommended approach (USEPA, 1989, et al). The toxicity assessment identifies, as necessary, the Reference Doses (RfDs), the Reference Concentrations (RfCs), cancer Slope Factors (SFs), and Inhalation Unit Risks (IURs) that will be used to evaluate adverse non-cancer health effects and cancer risks. Toxicity values for COPCs follows the hierarchy of human health toxicity (USEPA, 2003), which is also recommended by DEQ (2016a), as described below with the highest priority source listed first:

1. USEPA's Integrated Risk Information System (IRIS). IRIS is an on-line database that presents the latest EPA-approved RfDs, RfCs, SFs, and IURs as well as uncertainty and modifying factors (USEPA, 2016b). The toxicity values available from IRIS are recognized as USEPA-wide consensus information.

2. USEPA's Provisional Peer Reviewed Toxicity Values (PPRTV) Database. Similar to IRIS, the PPRTVs are USEPA-approved RfDs, RfCs, SFs, and IURs that have undergone peer review and recognized as consensus information (USEPA, 2013).

3. Other USEPA and non-USEPA toxicity values, such as:

    a. USEPA's Health Effects Assessment Summary Tables (HEAST; USEPA, 1997a).
    b. USEPA's National Center for Environmental Assessment (NCEA) papers, which are chemical-specific references (USEPA, 2013)
    c. California Environmental Protection Agency's (Cal/EPA) Office of Environmental Health Hazard Assessment (OEHHA) on-line database, which contains approved, peer-reviewed toxicity criteria (Cal/EPA OEHHA, 2016)

One human health COPC, manganese, which is a non-carcinogen, was identified in streambed sediment, but not retained as a human health COC (see Section 9.1). Manganese was also identified as a human health COPC in surface water, but was not retained as a COC during further evaluation (see Section 10.1). Carcinogenic COPCs were not identified.

8.1 REFERENCE DOSE

The non-carcinogen RfDs for manganese was used in the preparation of this CCRA to estimate potential non-cancer health hazards to receptors resulting from potential exposures. An RfD is an estimate of a daily exposure level for the human population, including sensitive subpopulations, that is likely to be without an appreciable risk of harmful effects (USEPA, 1989). An RfD has an uncertainty that spans perhaps an order of magnitude (USEPA, 1989). RfDs are chemical-specific and expressed as milligrams per kilogram-day (mg/kg-day). Oral RfDs are typically used to assess dermal exposures in the absence of route-specific dermal RfDs (USEPA, 1989). RfCs were not used as the inhalation pathway was not identified as a potentially complete pathway (USEPA, 2009).

Relevant human and animal studies are used to derive RfDs. Specifically, measured or observed No Observed Adverse Effect Levels (NOAEL) are typically used in the derivation, which correspond to the dose that can be administered without inducing observable adverse effects. If a NOAEL cannot be established, the Lowest Observed Adverse Effect Level (LOAEL) is used, which corresponds the lowest daily dose administered that induces an observable adverse effect (the "critical effect").

The manganese RfD used in the toxicity assessment is a chronic RfD, as few subchronic RfDs are available. A chronic RfD is intended for chronic exposures (i.e., exposures greater than seven years). Subchronic RfDs are intended for subchronic exposures (i.e., exposures less than seven years). Using a chronic RfD for all exposure durations, which for this assessment ranged from one to 25 years, is expected to result in conservative estimates of potential human health hazards.

Because NOAELs and LOAELs are typically established based on experimental animal studies, uncertainty factors are applied to be protective of human health. Uncertainty factors usually occur in multiples of 10 and account for the following:

- Extrapolation of data from animals to humans, known as interspecies extrapolation.
- Variation in human sensitivity to the toxic effect of the COPC, known as intraspecies extrapolation.
- Derivation of a chronic RfD based on subchronic data, rather than chronic data.
- Derivation of an RfD based on the LOAEL, rather than the NOAEL.

Modifying factors between 0 and 10 may also be applied in addition to uncertainty factors to accommodate for other additional uncertainty factors.

A summary of the non-cancer toxicity information is presented in Table B-5 (RAGS Part D Table 5) located in Appendix B.

The following RfD was identified for manganese (Table 8-1).

Table 8-1 COPC Reference Dose

COPC	RfD (mg/kg-day)	Source	Reference
Manganese	2.4E-02	IRIS*	USEPA, 2016b

IRIS* - The IRIS RfD of 0.14 mg/kg-day includes manganese from all sources. IRIS recommends an RfD of 0.071 mg/kg-day for non-food items; however, the IRIS explanatory text recommends using a modifying factor of three when calculating risks associated with non-food sources because of a number of uncertainties, resulting in an RfD of 0.024 mg/kg-day (USEPA, 2016b).

8.2 ROUTE-TO-ROUTE EXTRAPOLATION

Because toxicity criteria were not available for the dermal exposure route, route-to-route extrapolations of oral toxicity criteria were used to evaluate dermal exposures for the identified COPC.

8.3 TOXICITY PROFILE - MANGANESE

Manganese is a naturally occurring metal that makes up about 0.10 percent of the earth's crust. Manganese is typically found combined with other substances, such as oxygen, sulfur, or chlorine. Manganese is also found in anthropogenic organic compounds, such as pesticides (maneb and mancozeb) and a fuel additive known as methylcyclopentadienyl manganese tricarbonyl.

Manganese is also an essential trace element that is nutritionally necessary for good health. Manganese nutritional requirements are typically satisfied through the diet with minor contributions arising from water and air. Manganese can be found in several food items, including grains, cereals, and tea. The National Research Council recommends a dietary allowance of 2-5 mg/day of manganese for an adult human for a safe and adequate intake.

If humans are exposed on a prolonged basis to elevated concentrations, manganese can elicit a variety of serious toxic responses with the central nervous system being the primary target. Headache, insomnia, disorientation, anxiety, lethargy, and memory loss are initial symptoms. With continued exposure, the initial symptoms progress to include motor disturbances, tremors, and difficulty in walking. These motor difficulties are similar to those seen with Parkinsonism and are often irreversible. This combination of symptoms is a disease called “manganism.”

No human cancer data are available for manganese. The USEPA weight-of-evidence classification is D, not classifiable as to human carcinogenicity, based on no evidence in humans and inadequate evidence in animals. However, some conflicting data exists on possible carcinogenesis in mice (USEPA 2016a, 2016b).

The toxicity criteria used in the HHRA to quantify risks for exposure to manganese are summarized in Table B-5 in Appendix B. This table includes information on the primary target organ, and the uncertainty and modifying factors associated with toxicity criteria used to evaluate systemic (noncancer) effects.

8.4 UNCERTAINTIES ASSOCIATED WITH TOXICITY ASSESSMENT

The following uncertainties associated with the Toxicity Assessment were identified:

- A modifying factor of three was used in the development of the oral RfD (non-diet) for manganese because of a number of IRIS-identified uncertainties (USEPA, 2016b).
- The manganese RfD is intended for chronic exposures. One of the receptors, the construction worker, is a subchronic exposure. The use of a chronic RfD for a subchronic exposure is expected to overestimate potential health risks.
- A dermal RfD for manganese was not available and the oral RfD was used based on route-to-route extrapolation. Generally, the use of an oral RfD for a dermal exposure is expected to overestimate potential health risks.

9.0 RISK CHARACTERIZATION

For complete exposure pathways, risk characterization was performed to combine the exposure and toxicity assessments to produce quantitative estimates of potential non-cancer health hazards associated with the identified COPC, manganese. Because no carcinogenic or carcinogenic mutagenic COPCs were identified, cancer risk probabilities were not calculated.

9.1 CHARACTERIZATION OF NON-CANCER HEALTH HAZARDS

Non-carcinogenic health hazards can be described as the potential of a receptor developing non-cancer health concerns around the time of an exposure to non-cancer causing compounds.

Non-cancer hazard quotients (HQ) were calculated according to the USEPA (1989) equation as presented below:

$$Hazard\ Quotient\ (HQ) = \frac{ADD}{RfDi\ or\ RfDo}$$

where:

ADD = Average Daily Dose
RfD_i = inhalation Reference Dose
RfD_o = oral Reference Dose

HQ's that affect the same target organ are summed together to form the Hazard Index. However, this step was unnecessary as only one COPC was identified. The non-cancer hazard index is based on a comparison of the estimated site-related dose to the USEPA acceptable dose. The USEPA (2001) has indicated that a hazard index of less than 1.0 indicates an acceptable potential for non-cancer health hazards (USEPA, 2001). Similarly, the DEQ (2016a) has indicated that a total hazard index for non-carcinogenic compounds may not exceed 1.0 for each target organ. As such, the hazard indices (hazard quotients in this case) were compared to 1.0 as a not-to-exceed value.

Hazard quotients for the various receptors for the one non-carcinogenic COPC were calculated and are summarized in Table 9-1 below, as well as in Tables B-7.1 through B-10 located in Appendix B. No hazard quotients exceeded 1.0 indicating that non-cancer health effects are not expected to occur as a result of potential human exposures to the one identified COPC in streambed sediment, manganese. As such, manganese was not retained as a human health COC.

Table 9-1 Non-Cancer Hazard Quotients/Indices

COPC	Receptor	EPC (mg/kg)	Hazard Quotient (unitless)
Manganese (non-carcinogen)	Current/Future Child Resident	2,755.4	0.3
	Current/Future Industrial Worker		0.05
	Current/Future Child Recreational Receptor		0.2

9.2 EVALUATION OF UNCERTAINTIES

The following uncertainties associated with the Risk Characterization were identified:

- Uncertainties exist regarding the exposure parameters. However, the majority of exposure parameters were either USEPA or DEQ defined values that are expected to be conservative.
- Exposure parameters based on professional judgment also have uncertainty; however, they were conservatively selected.
- Human toxicity values have not been established for various constituents listed in the AOC, as well as in Appendices III and IV of the Federal CCR Rule. These constituents were not identified as COPCs/COIs. Uncertainties exist regarding potential human health concerns potentially posed by these constituents.
- Various uncertainties regarding the toxicity of the one identified COPC, manganese, exist as presented in Section 8.4.
-
- Uncertainties are intrinsically inherent in the intake and hazard quotient calculations.

Overall, uncertainties in the risk characterization are expected to originate from a cumulative effect of the uncertainties in the Exposure Assessment, the Toxicity Assessment, and the Characterization of Risk. Based on the conservative nature of the various assumptions used to characterize risk, the uncertainties are not expected to underestimate human health risks.

9.3 RISK ASSESSMENT GUIDANCE FOR SUPERFUND PART D TABLES

Following DEQ Guidance (DEQ, 2016a), the table format from RAGS Part D are used for the risk assessment tables. This CCRA includes RAGS Part D Tables 1 through 10, which are included in Appendix B.

10.0 COMPARISON OF DATA TO MEDIUM-SPECIFIC STANDARDS AND SCREENING LEVELS

10.1 COMPARISON OF SURFACE WATER COPC CONCENTRATIONS TO DEQ-7 STANDARDS

DEQ guidance (2016a) indicates surface water concentrations of COPCs should be compared to DEQ-7 standards, rather than being quantitatively evaluated in the HHRA. DEQ-7 (2017d) indicates that for metals in surface water, total recoverable concentrations (excluding aluminum) should be used in the comparison. Surface water concentrations from the Creek in the Plant Site area were compared to DEQ-7 standards, or other appropriate screening levels if DEQ-7 standards were not available, and are presented in Table B-2.1 (RAGS Table 2) in Appendix B. Following DEQ guidance (DEQ, 2017d) and the AOC (DEQ/PPLM, 2012), if a DEQ-7 Human Health Standard (HHS) was not available, the USEPA MCL, or the USEPA Tapwater RSL (Traditional RSL Tables) was used.

One surface water human health COPC, manganese, was identified during data screening (see Table B-2.1, Appendix B) and was further evaluated within this section. The maximum total manganese concentration in the downgradient portion of the Creek at the Plant Site (AR-3, 3.27 mg/L) was greater than the 2016 BSL (1.6 mg/L) and the USEPA Tapwater RSL (0.43 mg/L). A DEQ-7 Standard for manganese has not been established. Because the maximum total manganese concentration was greater than the USEPA Tapwater RSL and the BSL, it was identified as a surface water human health COPC as summarized in Table 10-1 below. Manganese was also identified as a surface water ecological COPC (see Appendix C).

Table 10-1 Comparison of Surface Water Manganese Total Concentrations to the Screening Level

COPC	Minimum Value (total, mg/L)	Maximum Value (total, mg/L)	BSL* (total and dissolved, mg/L)	BTV (total, mg/L)	Upgradient Background Maximum (total, mg/L)	Tapwater RSL (mg/L)
Manganese	0.059 NSTP 10/16/2014	3.27 AR-3 10/15/2015	1.6	5.08	11.6 AR-5 10/15/2015	0.43

Notes:

BSL*	Upstream Background Screening Level based on total and dissolved concentrations (Neptune, 2016 and Appendix D)
BTV	Upgradient Background Threshold Value (see Section 6.1.3 and Appendix D)
COPC	Chemical of Potential Concern
Creek	East Fork Armells Creek
NSTP	North Sewage Treatment Pond
RSL	Residential Screening Level

Further evaluation of manganese concentrations in surface water indicated the maximum total manganese concentration (AR-3, 3.27 mg/L) was not greater than the BTV (5.08 mg/L) or the maximum upgradient concentration (AR-5, 11.6 mg/L). Note that the highest manganese concentrations in the Creek downgradient of the Plant Site (AR-3) and upgradient of the Plant Site (AR-5) were both measured in October 2015 when flow in the Creek was very low. It should also be noted that the manganese surface water BSL of 1.6 mg/L (Neptune, 2016) was changed (increased) to 3.68 mg/L when the BSLs were updated (Neptune, 2017). The maximum total manganese concentration (AR-3, 3.27 mg/L) does not exceed the revised BSL (3.68 mg/L; Neptune, 2017).

An upgradient surface water BTV based on the estimation of the 95/90 UTL for manganese in surface water upgradient of the Plant Site was developed following discussions with the DEQ (2018b). The 95/90 UTL is defined as the 95% confidence limit on the 90th percentile (see summary statistics in Table 10-2 below and Appendix D). The surface water BTV for manganese was based on five surface water sampling locations upgradient of the Plant Site, for which total manganese concentrations were available over a temporal span from 1977 to 2015. The five upgradient surface water sampling locations included in the calculation estimation of the surface water manganese BTV are AR-5, AR-12, SW-03, SW-55, and SW-75 (see Figure 13). The surface water manganese BTV was included as a background/reference data point in Table B-2.1 (Appendix B).

Table 10-2 Summary Statistics and Estimated UTL-95/90 (BTV) for Total Manganese in Surface Water

COPC	Total # of Samples 1977-2015	Minimum Value (total, mg/L)	Median* (total, mg/L)	Average (total, mg/L)	Max Value (total, mg/L)	90th Percentile	95/90 UTL (BTV, mg/L)
Manganese	32	0.028 SW-75 4/25/2001	0.347	1.128	11.6 AR-5 10/15/2015	2.127	**5.08**

Notes:

95/90UTL	Upper Tolerance Level- 95% Confidence Limit on the 90th Percentile
BTV	Background Threshold Value
Median*	A single median value isn't available because the data set has an even number. The median represents an average of the two median values (0.344 mg/L, SW-75, 5/20/2014 and 0.35 mg/L, SW-55, 5/30/2012).

Based on this further evaluation, total manganese concentrations in the Creek appear to be consistent with background concentrations originating from regional geology, as well as coal mining and agricultural activities. In addition, the Creek is not used as a potable drinking water source. The Creek is classified as a C-3 water, which means that the water is naturally marginal for drinking, culinary, and food processing purposes, agriculture, and industrial water supply. A C-3 water generally needs pre-treatment in order to be used as a potable water supply. Considering the above assessment of background surface water manganese concentrations in the Colstrip area, manganese was not retained as a surface water human health COC. Manganese was also not retained as a surface water ecological COC (see Appendix C).

10.2 EVALUATION OF LEACHING COPCS

Two leaching COPCs, barium and lead, were identified from the comparison of soil concentrations in the spill area near the sewage lagoons to the USEPA Soil Screening Levels (SSLs) for groundwater protection (USEPA, 2016a) that were modified following the DEQ Soil Screening Process (DEQ, 2016a; see Appendix B, Table B-2.4). The two leaching COPCs were further evaluated through the comparison of leaching COPC concentrations in the surface and near surface soil depth intervals, as well as, through an analysis of vadose zone time travel. The vadose zone time travel analysis was requested by DEQ (2017e).

10.2.1 Comparison of Leaching COPCs to USEPA SSLs for Groundwater Protection

The two leaching COPCs, barium and lead, were both measured in EU3 (former spills area near the sewage lagoons) in the shallow soil interval (i.e., 0 to six inches) at concentrations exceeding their respective USEPA SSLs for groundwater protection, as summarized in Table 10-3 below. Barium and lead concentrations in the underlying soil interval (i.e., 12 to 24 inches) were significantly lower than the surface soil concentrations and did not exceed the USEPA SSLs for groundwater protection.

Table 10-3 Comparison of Barium and Lead Concentrations

COPC	Minimum Value 0-6” (mg/kg)	Average (mg/kg)	Maximum Value 0-6” (mg/kg)	Concentration in 12-24” located below max Conc. (mg/kg)	BTV (mg/kg)	USEPA SSL for Groundwater Protection (mg/kg)
Barium	106	230.3	1,130 (BH-54) Re-analysis 1,050	218 (BH-54)	429	421
Lead	11.4	32.16	504 (BH-56) Re-analysis 18.8	10.7 (BH-56)	29.8	140

10.2.2 Vadose Zone Travel Time Analysis

Potential times required for lead and barium to leach from the shallow soils to the groundwater table were evaluated to determine if either metal detected in Plant Site soils should have (theoretically) already leached to groundwater, or if migration to the water table is expected to occur sometime in the future. The evaluation was based on Plant Site soil sampling results, typical properties of the fine grained soils and groundwater conditions present at the Plant Site, United States Natural Resource and Conservation Service (USNRCS) Soil Classification, and the method outlined in DEQ’s Risk-Based Corrective Action (RBCA) guidance document (DEQ, 2016b). Values utilized in the evaluation, as well as calculated results, are included in Tables 10-4 and 10-5 and described below with the evaluation details.

Estimation of the lead and barium travel times through the vadose zone consists of three steps: (1) calculation of the vertical pore water velocity; (2) determination of the contaminant (lead and barium) retardation factor; and (3) calculation of the contaminant travel and breakthrough time based on the contaminant velocity and depth to groundwater. The vertical pore water velocity is dependent on the soil infiltration rate and water filled porosity, which in turn is dependent on the soil bulk density and moisture content. Soil at the Plant Site was identified as a Borollic Camborthids-Ustic Torrifluvents Complex soil (USNRCS, 1996). These soils consist of silty clay loam, silty clay and clay type of soil. Based on weighted average infiltration rates for this soil classification, the vertical pore water velocity is estimated to be 0.4 feet/day (Tables 10-4 and 10-5).

Table 10-4 Pore Water and Lead Travel Times through the Vadose Zone

Step 1. Vertical Pore Water Velocity			
Value	**Units**	**Description**	**Source**
0.06	in/hr	Weighted average for Clay to silty clay - Borollic Camborthids-Ustic Torrifluvents Complex	NRCS, 1996
1.5	g/cm^3	soil bulk density	assumed
20%	na	soil moisture content	assumed
0.3	cm^3/cm^3	water filled porosity	calculated
0.2	inches/hour	vertical pore water velocity	calculated
0.4	**ft/day**	**vertical pore water velocity**	calculated
Step 2. Retardation Factor for Lead			
$R=1 + \rho*K_d/\theta$			
1.5	g/cm^3	ρ - soil bulk density	assumed
10,000	Liters/Kg	K_d - Pb partitioning coefficient	Sheppard, et al.,2009
60%		θ - volumetric water content	assumed
26	$Liters/cm^3$	Retardation Factor	calculated
Step 3. Lead Travel Times to Water Table			
0.014	ft/day	Pb migration velocity	calculated
4	feet	Depth to water below Pb soil	calculated
284	days	Pb travel time to water table	calculated
0.78	**years**	**Pb travel time to water table**	calculated

Table 10-5 Pore Water and Barium Travel Times through the Vadose Zone

Step 1. Vertical Pore Water Velocity			
Value	**Units**	**Description**	**Source**
0.06	in/hr	Weighted average for Clay to silty clay - Borollic Camborthids-Ustic Torrifluvents Complex	NRCS, 1996
1.5	g/cm^3	soil bulk density	assumed
20%	na	soil moisture content	assumed
0.3	cm^3/cm^3	water filled porosity	calculated
0.2	inches/hour	vertical pore water velocity	calculated
0.4	**ft/day**	**vertical pore water velocity**	calculated
Step 2. Retardation Factor for Ba			
$R=1+\rho*K_d/\theta$			
1.5	g/cm^3	ρ - soil bulk density	assumed
32	Liters/Kg	K_d - Ba partitioning coefficient	Sheppard, et al.,2009
60%		θ - volumetric water content	assumed
1.08	$Liters/cm^3$	Retardation Factor	calculated
Step 3. Barium Travel Times to Water Table			
0.340	ft/day	Ba migration velocity	calculated
4	feet	Depth to water below Ba soil	calculated
12	days	Ba travel time to water table	calculated
0.032	**years**	**Ba travel time to water table**	calculated

The contaminant retardation factor is a function of the soil bulk density, the contaminant partitioning coefficient (K_d), and the volumetric water content of the soil. Based on an extensive review of the literature, a K_d of 10,000 liters per kilogram (L/kg) was used for lead based on the Plant Site soil pH and texture (USEPA, 1999, Sheppard et al., 2009). Similarly, a K_d of 32 L/Kg was used for barium based on the midrange of values (11-52 L/Kg) listed by the USEPA (https://nepis.epa.gov). Using a moisture content of 60% for the fine grained soil, the estimated retardation factor in the Plant Site soils is 26 liters per cubic centimeter (L/cm^3) for lead and 1.08 L/cm^3 for barium.

Once the vertical pore water velocity and contaminant retardation factor are known, the vertical migration rate is simply the pore water velocity divided by the retardation factor. Using the values outlined above yields a vertical migration velocity of 0.014 feet/day for lead and 0.34 feet/day for barium. Based on a vertical distance of four feet between the lead- and barium-bearing soils and the water table (depth to groundwater six feet, lead and barium bearing soils 0 to two feet), the time required for lead to migrate to the water table at the Plant Site is estimated to be approximately 286 days or 0.78 years. The estimated time for barium to migrate to groundwater is 12 days. Note that using the range of K_d referenced above for barium (11 to 52 L/kg), the estimated travel times vary only from 11 to 12 days (0.03 years).

The evaluation required use of estimated soil properties for a soil mapped in the area (NRCS, 1996). In most cases, the estimated values are considered to be well constrained based on the extensive sources available for soil bulk density, moisture content, etc. available in the literature. Of all the variables used in the evaluation, the lead K_d is the least well constrained due to the sensitivity of K_d to specific soil conditions. However, even if the K_d is an order of magnitude higher that the 10,000 used in the evaluation, a much higher value than indicated by the literature, the time required for lead to migrate to the water table would still be less than five years, suggesting that potential impacts to groundwater from the lead bearing soils should be reflected in current subsurface soils data and in current groundwater data. Calculated travel times for barium on the other hand, only vary slightly over the referenced range of K_d, demonstrating the more mobile nature of the element and suggesting that potential impacts to groundwater from the barium bearing soils should also be reflected in current subsurface soils data and current groundwater data.

Although the results of the vadose zone travel time analysis indicate that lead and barium should leach relatively quickly through the soil column, the soil sampling data do not indicate leaching is occurring. The spills in this area of the Plant Site occurred in 1998 (Hydrometrics, 1998) and 2000 (Hydrometrics, 2016a). However, the lead and barium measured in surface soils (0 to six inches) has not migrated to the next soil depth interval (12 to 24 inches) based on soil sampling conducted in 2016 (see Table 10-3 above). Concentrations of both barium and lead in the 12 to 24 inch soil interval are a full order of magnitude less than in the 0 to six inch soil interval after a substantial amount of time. The minimum time interval between the most recent spill (2000) and the sampling event (2016) is 16 years. In other words, lead and barium in soil have not migrated from the surface depth interval (0 to six inches) to the underlying sampling interval (12 to 24 inches) in at least 16 years indicating their immobile nature in Plant Site soils. As such, if leaching were occurring, sampling results of the underlying soil interval would demonstrate this through the detection of higher barium and lead concentrations, which has not been observed.

10.2.3 Leaching Evaluation Conclusions

Based on the results of the leaching evaluation, neither barium, nor lead were retained as leaching COCs, as summarized below:

Barium

- Barium was measured at a concentration of 1,130 mg/kg (BH-54) that exceeded the USEPA SSL for Groundwater Protection of 421 mg/kg. However, the barium concentration in BH-54 in the 12”-24” soil interval (218 mg/kg) was approximately five times lower than the concentration measured in the 0-6” interval. The concentration in this interval, collected directly below the 0-6” soil interval sample, did not exceed the USEPA SSL and demonstrated that barium is not leaching through the soil column.
- Of the remaining 88 data points in EU3, only the re-analysis of the BH-54 sample and the sample from BH-73 exceeded the USEPA SSL for barium (as modified per DEQ, 2016a). The concentration in BH-73 of 429 mg/kg matched the BTV for barium in Montana soils and just slightly exceeded the USEPA SSL of 421 mg/kg.
- Barium exceedances are limited to the 0-6” soil interval and appear very limited in area. For example, barium concentrations in BH-59, which is located approximately 20 feet to the southeast of BH-54, ranged from 153 mg/kg to 240 mg/kg (all below the USEPA SSL).
- The BTV for barium in Montana soils of 429 mg/kg exceeds the USEPA SSL (as modified per DEQ, 2016a).
- The 95 UCL for barium in the 0-6” soil depth of EU3 was 301.8 mg/kg, which was below the USEPA SSL for barium (see Appendix D for the statistical summary).

- A vadose zone travel time analysis indicated barium could leach in a short time period (days); however, soil samples indicate it has not leached from surface soil even to just the underlying soil interval (< 1 foot) in at least the past 16 years. As such, it was concluded that barium is not leaching through the soil column.

Lead

Although lead was measured at a concentration of 504 mg/kg (BH-56) that exceeded the USEPA SSL for Groundwater Protection of 140 mg/kg, it was not selected as a leaching COC for the following reasons:

- The lead concentration in BH-56 in the 12”-24” soil interval (10.7 mg/kg) was substantially lower than both lead concentrations measured in the 0-6” interval. The concentration in this interval, collected directly below the 0-6” soil interval sample, did not exceed the USEPA SSL and indicates that lead is not leaching through the soil column.
- The sample was re-analyzed resulting in a lead concentration of 18.8 mg/kg. As such, the concentration of 504 mg/kg was possibly a laboratory error, or represented a “nugget effect” within a very small soil volume (i.e., within the sample aliquot).
- The remaining 88 data points in EU3 did not exceed the USEPA SSL for lead (as modified per DEQ, 2016a). The remaining data ranged from 9.5 mg/kg to 124 mg/kg.
- The 95 UCL for lead in the 0-6” soil depth of EU3 was 47.8 mg/kg, which was below the USEPA SSL for lead (see Appendix D for the statistical summary).
- A vadose zone travel time analysis indicated lead would leach to groundwater in a relatively short time period (< one year); however, soil samples indicate it has not leached from surface soil even to just to the underlying soil interval (< 1 foot) in at least the past 16 years. As such, it was concluded that lead is not leaching through the soil column.

10.3 COMPARISON OF GROUNDWATER COPC CONCENTRATIONS TO DEQ-7 STANDARDS

DEQ guidance (2016a) indicates groundwater concentrations should be compared to DEQ-7 Standards, rather than being quantitatively evaluated in the human health risk assessment. DEQ-7 (2017d) indicates that for metals, dissolved concentrations (i.e., the portion that passes through a 0.45 micron filter) should be used in the comparison. In addition, DEQ-7 (2017d) indicates that for alpha emitters, beta emitters and gamma emitters (such as radium), unfiltered samples should be used for comparison.

As previously described in Section 5.0, forward calculations of human health risks associated with groundwater were not conducted. Instead, DEQ requested that human health Cleanup Criteria for groundwater be developed, which involved the comparison of source concentrations (i.e., Plant Site pond data) and groundwater data from the CCR wells to DEQ-7 Standards, as well as other screening levels (see Table 3 located behind the Tables tab). Human health-based Cleanup Criteria for groundwater are discussed in Section 12.5.1.

10.4 EVALUATION OF RADIUM CONCENTRATIONS IN GROUNDWATER

Radium was initially flagged as a groundwater COPC during the screening process for cOIs (see Sections 1.3 and 3.0 and Table 3). Radium concentrations in two sets of water samples from the Plant Site process ponds were well below the DEQ-7 standard of 5 pCi/L for total recoverable concentrations of Radium 226/228 (the MCL is also 5 pCi/L for Radium 226/228). However, a limited number of groundwater samples collected from wells located around the process pond perimeters and used as part of the Federal CCR Rule compliance monitoring had concentrations of Radium 226/228 that were above the DEQ-7 standard. Subsequently, radium was further evaluated as presented within this section.

<u>Previous Evaluation and Approval of Radiological Content in Ash</u>
In 2004, an Environmental Assessment was prepared and approved by the DEQ for the use of Units 1&2 and 3&4 bottom ash for on- and off-site construction projects (DEQ, 2004). The Environmental Assessment determined the following:

- The measured radiological content of bottom ash (alpha, beta, and gamma radiological characteristics) was within the range of naturally occurring soil and geological materials in the Colstrip area. Please note that radium was only one contributor to the total radiological content.
- No land-use controls over development, population, waste disposal, or special safeguards or monitoring were required for radiation impacts associated with the ash.

<u>Evaluation of Radium under the Federal CCR Rule</u>
As previously described in Section 1.2.2, the SES must meet several requirements under the new USEPA CCR Rule. To meet the requirements of the CCR Rule, 27 wells have been used that are located around the perimeters of the Plant Site process ponds. In addition, 7 background wells are used in the Plant Site area as part of the CCR Rule (see Figure 5). Groundwater samples have been collected from the CCR wells regularly since February 2016. Radium 226/228 is an Appendix IV constituent under the CCR Rule and was routinely analyzed in the CCR well groundwater samples at the Plant Site to establish baseline conditions.

The Federal CCR Rule includes rigorous statistical analyses of the groundwater data for the purpose of identifying constituents requiring corrective action. Based on the analytical results of the groundwater samples collected from the CCR wells, as well as the preliminary statistical evaluation, Radium 226/228 does not appear to be a constituent requiring corrective action under the CCR Rule.

<u>Radium 226/228 Concentrations in Process Pond Water</u>
Following the COI/COPC identification approach described in Section 3.0, process pond water Radium 226/228 concentrations were assumed to be the source, as a worst-case scenario, of Radium 226/228 in groundwater surrounding the ponds. Pond water samples were collected from the Plant Site process ponds using a depth-integrated sampling technique to allow for the collection of samples representative of the water column (Hydrometrics, 2017b).

Radium 226/228 concentrations measured in the Plant Site process ponds were well below the DEQ-7/MCL of 5 pCi/L (a summary, which includes CCR Well data, is presented in Table 10-6 below).

Table 10-6 Summary of Radium Concentrations for the Plant Site Pond Water and Groundwater

	Radium 226+228 Maximum (pCi/L)	**Radium 226+228[(1)] Average (pCi/L)**
Units 1&2 BACW (sampled May 2018 only)	1.2	NA
Units 1&2 PNDC	1.3	0.8
Units 1&2 PNDC N	1.3	0.6
Units 1&2 B Pond	1.1	0.7
CCR Wells		
Plant Site CCR Wells	**12.1**	2.17 -2.84[(2)]
Plant Site CCR Background Wells	**5.1**	2.15
Groundwater Standards		
DEQ-7/MCL	5.0	5.0

Notes:

BOLD	Measured concentration exceeds relevant screening level or standard.
DEQ-7	Montana Department of Environmental Quality Water Quality Standards
MCL	Maximum Contaminant Level
NA	Not Applicable
pCi/L	picoCuries per liter
(1)	If Ra 226 or Ra 228 concentration was less than zero (negative value), then zero used as a proxy value.
(2)	CCR Well data were grouped by Plant Site Process Pond and averages were calculated for each pond.

Radium 226/228 Concentrations in Colstrip SES Pond Solids (Fly Ash) and Paste

Because the radium concentrations measured in the Plant Site process pond water were well below the DEQ-7/MCL of 5 pCi/L, radium concentrations measured in groundwater were not sourced from the process ponds. In June 2018, a meeting was held with DEQ to discuss the radium in groundwater issue (DEQ, 2018e). DEQ subsequently requested that samples be collected and analyzed for radium from the following locations to evaluate the source of the radium:

1. Pond solids (fly ash and/or paste) from the bottom of the Colstrip SES ponds (i.e., Plant Site ponds, STEP ponds and the 3&4 EHP ponds).
2. Paste from the Paste Plants.

On July 10, 2018, samples of the pond solids and plant paste were collected at the Facility, as described below.

Pond Solids

Five-part composite samples were collected from various Plant Site ponds, STEP ponds, and the 3&4 EHP cells as follows:

Plant Site

- Units 1&2 Bottom Ash Pond – bottom ash is directed to this pond and solids are periodically removed and placed in the 3&4 EHP. Solids drop out quickly and the water decants to the adjacent clearwell. Samples were collected at five locations from below the water level at the edge of the water.
- Units 1&2 B Pond – B Pond receives return water from the STEP Clearwell. Flyash is only placed in B Cell during upset conditions. As such, flyash is limited to the NW corner of the pond. Samples were collected from below the water at five locations.

- Units 3&4 Bottom Ash Pond – Bottom ash is directed to one of two active cells. Solids quickly drop out and the water is decanted to adjacent cells. Bottom ash is periodically removed and placed in the 3&4 EHP. Samples were collected with a shovel by digging at five locations around the perimeter of the active cell.

STEP

- STEP A Cell – A Cell no longer receives scrubber slurry. Samples were collected from near the surface at five locations by excavating into the flyash at five locations.
- STEP E Cell – E Cell is the current active cell. Samples were collected by digging to below the water level at five locations along the edge of the ponded area.

3&4 EHP

- 3&4 EHP C Cell – samples were collected by digging holes below the water level and collecting a saturated sample.
- 3&4 EHP B Cell (New Clearwell) – B Cell has been used as a clearwell. However, a minor amount of paste was directed to B Cell during upset conditions. This flyash is limited to near the discharge point in the northeast corner of the cell. Samples were collected from five locations from below the water level.
- 3&4 EHP G Cell – A small amount of water is present in the southwest corner of G Cell. This water is contained within a small berm and is periodically pumped into C Cell. Solids samples were collected from below water along the inside of the north side of the berm

Solids collected at each of the areas were mixed thoroughly, placed in sample containers, and shipped to Energy Laboratories for analysis.

Paste Plants

Solids in scrubber slurry are concentrated to develop a "paste" for placement in the disposal cells. Samples can be collected in the Paste Plant from a hopper (referred to as Gob Hopper) after the paste has been formed and prior to pumping it to the destination cell. Samples were collected as "grab" samples from the hopper, placed in sample bottles, and delivered to Energy Laboratories for analysis from the two paste plants:

- 3&4 EHP Paste Plant
- STEP Paste Plant

Radium concentrations measured in the pond solids and paste were all very low (< 1.0 picoCuries per gram [pCi/g]). The background radium concentration in United States soils is approximately 2 pCi/g for Radium 226 + 228 (ATSDR, 1990), indicating that the measured concentrations in the fly ash and paste are well below background. A summary of the radium concentrations in solids is presented in Table 10-7 below.

Table 10-7 Summary of Radium Concentrations in the Colstrip SES Pond Solids and Paste

	Radium 226	**Radium 228**
Pond Solids (Fly Ash)	**pCi/g**	
Plant Site – Units 1&2 Bottom Ash Pond	0.2	0.2
Plant Site – Units 1&2 B Pond	0.09	0.2
Plant Site – Units 3&4 Bottom Ash Pond	0.2	0.2
STEP A Cell	0.2	0.2
STEP E Cell	0.2	0.4
3&4 EHP B Cell	0.2	0.3
3&4 EHP C Cell	0.2	0.4
3&4 EHP G Cell	0.2	0.4
Paste		
STEP Paste Plant	0.2	0.4
3&4 EHP Paste Plant	0.2	0.02
Soil Standards		
USDOE RAIS PRG Calculator (DOE RAIS, 2018)	**Screening Level* (pCi/g)**	
Outdoor Worker PRG	4.73	10.0
Excavation PRG	71.2	38.6
USEPA Remediation Goals for Radioactively Contaminated CERCLA Sites (USEPA, 2000)	**Remediation Goal (pCi/g)**	
Surface Soil (0 to 15 cm, 6 inches)	5	5
Subsurface Soil (below 15 cm, 6 inches)	15	15
Background	**Background Concentrations (pCi/g)**	
Surface Soil (0 to 6 cm; Myrick et al., 1981 as cited in ATSDR, 1990)	1.1	NA
Surface and Subsurface Soil (ATSDR, 1990)	1.0	1.0

Notes:

Pond Solids and Plant Paste Samples were collected in July 2018.

BOLD	Measured concentration exceeds relevant screening level or standard.
ATSDR	Agency for Toxic Substances and Disease Registry
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
pCi/g	picoCuries per gram
PRG	Preliminary Remediation Goal
Residential PRG	Calculated Residential PRGs were concentrations below background – Ra 226 (0.124 pCi/g), Ra 228 (0.147 pCi/g)
Screening Level*	Site-specific soil screening levels were calculated using Montana-specific exposure frequencies (DEQ, 2016a). Use of site-specific exposure frequencies in the PRG model requires the use of a site-specific area correction factor from the model's default of an "infinite slab". Per USEPA guidance (2016a), an aerial extent of 1,000 m^2 was used, which the USEPA considers comparable to that of an infinite slab. See also Canty, 2018c.
USDOE RAIS	United States Department of Energy Risk Assessment Information System

Summary

Based on further evaluation of Radium 226/228 groundwater concentrations presented within this section, Radium 226/228 groundwater concentrations at the Plant Site appear to be consistent with background concentrations. Consequently, Radium 226/228 was not retained as a groundwater COI; however, it will remain a COPC while additional radium groundwater data are collected. The further evaluation of Radium 226/228 groundwater concentrations is summarized below

- A previous Environmental Assessment concluded the radiological content of the Units 1&2 and 3&4 bottom ash was within background for soil and geological materials in the Colstrip area.

- Following the COI/COPC identification approach, the Radium 226/228 concentrations in the process ponds were assumed to be the source, as a worst-case scenario, of Radium 226/228 in groundwater surrounding the Plant Site process ponds. The scrubber slurry that is piped to the ponds is well mixed having been subjected to physical mixing, pressure, and temperature changes. Furthermore, the process water is continuously circulated through the scrubber process under these conditions (i.e., process water is circulated from the scrubbers through the pipelines to the ponds and then back to the scrubbers). Hence, the process water through its exposure to these conditions numerous times results in a "worst-case" condition. Radium 226/228 concentrations in the scrubber slurry, and in free water derived from the scrubber slurry, are expected to be uniform and representative of maximum possible levels.

    - The Radium 226/228 concentrations measured in the Plant Site ponds (assumed worst-case concentrations) were generally less than groundwater concentrations and well below the DEQ-7 standard. Therefore, pond water does not appear to be the source of radium concentrations measured in groundwater.
    - Radium 226/228 concentrations measured in ponds solid samples (i.e., fly ash) collected from the Colstrip SES Process Ponds, as well as the Paste Plant samples, were very low at concentrations below appropriate soil screening levels and well below background. Therefore, the fly ash does not appear to be the source of radium measured in groundwater.
    - The assumption that Radium 226/228 concentrations in groundwater were attributable to seepage from the process ponds was not validated.

In conclusion, there is no evidence to substantiate that the source of radium in groundwater is the process pond water, bottom ash, fly ash, or plant paste. Radium concentrations in groundwater at the Plant Site appear to be consistent with background levels and radium was not identified as a groundwater COI. However, because a radium groundwater BSL was not available for comparison, as a conservative measure radium will remain a COPC while additional groundwater data are collected. Radium will continue to be monitored and evaluated in groundwater as part of the Federal CCR Rule compliance monitoring and continue to be evaluated under the AOC.

11.0 FATE AND TRANSPORT ANALYSIS

The AOC (Article VI.B) requires the CCRA Report to identify transport mechanisms for the COIs (COPCs). In Section 4.2 Chemical Releases and Transport Mechanisms, various transport mechanisms were discussed that largely consisted of the following:

- Seepage losses from the process ponds that are presently mitigated by an extensive capture well system. Comprehensive groundwater sampling is conducted regularly to evaluate groundwater quality trends and evaluate the effectiveness of the capture well system. Groundwater analytical results are compared to the BSLs as part of this evaluation. The groundwater BSLs are not clean-up levels, but are used as one criterion for evaluating capture well or monitoring well data when baseline specific data are not available.

- Historical surface releases to soil (pipeline releases and subsequent remediation).

A fate and transport analysis of COIs/COPCs potentially leaching through the soil column was performed through the comparison of soil chemicals (i.e., metals) to the USEPA SSLs for Groundwater Protection (USEPA, 2016) that were modified following the DEQ Soil Screening Process (DEQ, 2016a). The two identified leaching COPCs were further evaluated through the comparison of leaching COPC concentrations in the surface and near surface soil depth intervals, as well as, through an analysis of vadose zone time travel. The leaching COPCs were not retained as COCs during further analysis (see Section 10.2).

In addition, extensive fate and transport modeling has been conducted in support of the Plant Site Remedy Evaluation. Please refer to the Plant Site Fate and Transport Model Development and Remedial Alternatives Analysis (NewFields, 2016), as well as the Plant Site Remedy Evaluation Report (GeoSyntec, 2016).

12.0 DEVELOPMENT OF CLEANUP CRITERIA

The methods used to develop the Cleanup Criteria (also referred to as Site-Specific Cleanup Levels [SSCL]) are described in the sections below.

12.1 SURFACE WATER CLEANUP CRITERIA

Human health COCs were not retained in surface water (see Section 10.1). Two ecological COPCs, boron and manganese, were identified in surface water. Manganese concentrations potentially pose a risk to benthic receptors (i.e., benthic macroinvertebrates living in sediment), while boron potentially poses a risk to aquatic life. The ecological COPCs were not found to pose a risk to livestock drinking surface water from the Creek, although the maximum concentrations of sulfate indicate the surface water is “marginal” for livestock watering (see Appendix C). Manganese and boron concentrations in the Creek appear to be consistent with background concentrations originating from regional geology, as well as coal mining and agricultural activities. Cleanup of surface water would be ineffective as background sources would continue to affect the Creek at the Plant Site. Therefore, manganese and boron were not retained as ecological COCs and Cleanup Criteria for surface water were not developed.

12.2 STREAMBED SEDIMENT CLEANUP CRITERIA

One human health COPC, manganese, was identified in streambed sediments of the Creek at the Plant Site. However, concentrations in the streambed sediments were not found to pose a human health risk (see Section 9.1) and it was not retained as a human health COC. One ecological COC, manganese, was identified in streambed sediments of the Creek that potentially poses a risk to benthic receptors (see Appendix C). However, manganese concentrations in streambed sediments appear to have originated from background sources. In addition, an aquatic habitat assessment and benthic community survey was conducted in upstream areas of the Creek (Arcadis, 2014) that indicated the lowest ratings of “fairly poor” to “poor” on the HBI (see Section 6.1.3). The likely HBI would be similar for the Creek at the Plant Site. Cleanup of sediments would be ineffective as upstream and regional sources would continue to affect the Creek at the Plant Site. Therefore, manganese was not retained as an ecological COC and Cleanup Criteria for streambed sediments were not developed.

12.3 SOIL CLEANUP CRITERIA

One human health COPC, lead, was identified in the former spill sites near the STP of the Plant Site (see Section 6.3), but not retained as a human health COC (see Appendix B, Table B-2.4, Section 7.2.4, and Section 10.2). Ecological COPCs were identified in the pipeline spill areas at the Plant Site at the screening phase of the Ecological Risk Assessment, but not retained as COCs in the Baseline Ecological Risk Assessment (see Appendix C). Therefore, Cleanup Criteria for soil were not developed.

12.4 LEACHING TO GROUNDWATER CLEANUP CRITERIA

Leaching COIs/COPCs were identified for the pipeline spill areas of the Plant Site (see Sections 6.4 and 10.2), but none were retained as COCs. Therefore, leaching to groundwater Cleanup Criteria were not developed.

12.5 GROUNDWATER CLEANUP CRITERIA

The groundwater COCs/COIs were identified through a detailed screening process presented in Section 3.0 and shown in Table 3, located in the Tables section. Both human health and ecological (livestock) risks were considered for the development of the groundwater Cleanup Criteria. Groundwater standards, screening levels, and proposed Cleanup Criteria by hydrostratigraphic layer are presented in Table 12-1 below.

12.5.1 Groundwater Human Health Cleanup Criteria

Following DEQ guidance, human health risks were not forward calculated for groundwater. Rather, groundwater concentrations were compared to the DEQ-7 Standards as a qualitative evaluation of risk. If a DEQ-7 Standard was not available, groundwater concentrations were compared to the USEPA MCL (if available) and the USEPA Tapwater RSL (if available) in accordance with the AOC. In addition, the AOC indicates that Cleanup Criteria may not be more stringent than background concentrations (i.e., the BSLs).

12.5.2 Groundwater Ecological (Livestock) Cleanup Criteria

Groundwater data were not directly used for forward calculations of human health risks associated with groundwater. Rather, per DEQ's request, human health and ecological (livestock) Cleanup Criteria for groundwater were developed. Ecological (livestock) Cleanup Criteria for groundwater were limited to one scenario (livestock consumption via groundwater pumping into stock tanks; see Appendix C).

12.5.3 Cleanup Criteria Discussion

The proposed Cleanup Criteria are discussed within this section.

Boron

A DEQ-7 Standard has not been established for boron. A USEPA Tapwater RSL for boron of 4 mg/L is available, which is a conservative value as the groundwater is classified as Class III and pre-treatment would be necessary for the groundwater to be potable. An ecological (livestock) Cleanup Criterion for boron of 39 mg/L was calculated, which is conservatively based on the protection of the most sensitive livestock receptor (calves) using the NOAEL (the level at which no adverse effects have been observed in the livestock receptor).

The proposed groundwater Cleanup Criterion for boron in all hydrostratigraphic units was selected as 4 mg/L, which is the USEPA Tapwater RSL.

Sulfate

Neither a DEQ-7 Standard, nor a USEPA Tapwater RSL has been established for sulfate. An ecological (livestock) Cleanup Criterion for sulfate was established at 3,000 mg/L, which represents the upper end of the “marginal” sulfate range of 1,500 to 3,000 mg/L for livestock as established by United States Department of Agriculture (USDA) and Montana State University Agricultural Experiment Station (USDA-ARS, 2009). The “marginal” sulfate range was selected because the groundwater is classified as Class III indicating it must be maintained at least marginally suitable as drinking water for some livestock.

The proposed groundwater Cleanup Criterion for sulfate was selected as either the livestock Cleanup Criterion of 3,000 mg/L or the BSL, depending on the hydrostratigraphic unit. According to the AOC (MDEQ/PPLM, 2012), a Cleanup Criterion may not be more stringent than background. For hydrostratigraphic units in which the BSL is less than the livestock Cleanup Criterion, then the livestock Cleanup Criterion was selected as the proposed Cleanup Criterion. Conversely, for hydrostratigraphic units in which the BSL is greater than the livestock Cleanup Criterion, then the BSL was selected as the proposed Cleanup Criterion.

Cobalt

A DEQ-7 Standard has not been established for cobalt. A USEPA Tapwater RSL for cobalt of 0.006 mg/L has been established, which is a conservative value as the groundwater is classified as Class III and pre-treatment would be necessary for the groundwater to be potable. An ecological (livestock) Cleanup Criterion for cobalt of 0.03 mg/L was calculated, which is conservatively based on the protection of the most sensitive livestock receptor (calves) using the NOAEL (the level at which no adverse effects have been observed in the livestock receptor).

The proposed groundwater Cleanup Criterion for cobalt was selected as either the USEPA Tapwater RSL of 0.006 mg/L or the BSL, depending on the hydrostratigraphic unit. According to the AOC (MDEQ/PPLM, 2012), a Cleanup Criterion may not be more stringent than background. For hydrostratigraphic units in which the BSL is less than the RSL, then the USEPA Tapwater RSL was selected as the proposed groundwater Cleanup Criterion. Conversely, for hydrostratigraphic units in which the BSL is greater than the RSL, then the RSL was selected as the proposed groundwater Cleanup Criterion.

Lithium

A DEQ-7 Standard has not been established for lithium. A USEPA Tapwater RSL for lithium of 0.04 mg/L has been established, which is a conservative value as the groundwater is classified as Class III and pre-treatment would be necessary for the groundwater to be potable. The RSL of 0.04 mg/L is more stringent than background. According to the AOC (MDEQ/PPLM, 2012), a Cleanup Criterion may not be more stringent than background. An ecological (livestock) Cleanup Criterion could not be calculated because a mammalian Toxicity Reference Value (TRV) has not been established for lithium.

The proposed groundwater Cleanup Criterion for lithium was selected as the BSL for all hydrostratigraphic units.

Molybdenum

A DEQ-7 Standard has not been established for molybdenum. A USEPA Tapwater RSL for molybdenum of 0.1 mg/L has been established, which is a conservative value as the groundwater is classified as Class III and pre-treatment would be necessary for the groundwater to be potable. An ecological (livestock) Cleanup Criterion could not be calculated because a mammalian TRV has not been established for molybdenum.

The proposed groundwater Cleanup Criterion for molybdenum was selected as the USEPA Tapwater RSL of 0.1 mg/L for all hydrostratigraphic units.

Selenium

DEQ-7 Standards apply to all waters of the State of Montana. According to the AOC (MDEQ/PPLM, 2012), a Cleanup Criterion may not be more stringent than background. The DEQ-7 for selenium is not more stringent than the BSLs. A USEPA Tapwater RSL for selenium of 0.1 mg/L has been established, which is a conservative value as the groundwater is classified as Class III and pre-treatment would be necessary for the groundwater to be potable. An ecological (livestock) Cleanup Criterion for selenium of 0.28 mg/L was calculated, which is conservatively based on the protection of the most sensitive livestock receptor (calves) using the NOAEL (the level at which no adverse effects have been observed in the livestock receptor).

The proposed groundwater Cleanup Criterion for selenium was selected as the DEQ-7 Standard of 0.05 mg/L for all hydrostratigraphic units.

Manganese

A DEQ-7 Standard has not been established for manganese. A USEPA Tapwater RSL for manganese of 0.43 mg/L has been established, which is a conservative value as the groundwater is classified as Class III and pre-treatment would be necessary for the groundwater to be potable. An ecological (livestock) Cleanup Criterion for manganese of 61 mg/L was calculated, which is conservatively based on the protection of the most sensitive livestock receptor (calves) using the NOAEL (the level at which no adverse effects have been observed in the livestock receptor).

The proposed groundwater Cleanup Criterion for manganese was selected as either the USEPA Tapwater RSL or the BSL, depending on the hydrostratigraphic unit. According to the AOC (MDEQ/PPLM, 2012), a Cleanup Criterion may not be more stringent than background. For hydrostratigraphic units in which the BSL is less than the RSL, then the USEPA Tapwater RSL was selected as the proposed groundwater Cleanup Criterion. Conversely, for hydrostratigraphic units in which the BSL is greater than the RSL, then the RSL was selected as the proposed groundwater Cleanup Criterion.

Table 12-1 Groundwater Standards, Screening Levels and Proposed Cleanup Criteria

COI/COC	Ground-water DEQ-7/MCL (mg/L)	USEPA Tapwater RSL (mg/L)	BSL Range (mg/L)	Ecological (Livestock) Cleanup Criterion (mg/L)	Cleanup Criterion Source	Proposed Cleanup Criteria				
						Alluvium (mg/L)	Spoils (mg/L)	Clinker (mg/L)	Coal-Related (mg/L)	SubMcKay (mg/L)
CCR Appendix III Constituents										
Boron	NA(6)	4	0.818 – 4	39 (1)	RSL	4 (RSL)	4 (RSL)	4 (RSL)	4 (RSL)	4 (RSL)
Sulfate	NA(6)	NA	2,061 – 3,160	3,000 (2)	Livestock/ BSL	3,000 (livestock)	3,045 (BSL)	3,160 (BSL)	3,000 (livestock)	3,000 (livestock)
CCR Appendix IV Constituents										
Cobalt	NA(6)	0.006	0.00066 – 0.0232	0.03 (1)	RSL/BSL	0.02 (BSL)	0.0232 (BSL)	0.0232 (4) (BSL)	0.006 (RSL)	0.006 (RSL)
Lithium	NA(6)	0.04	0.072 – 0.092	NA (3)	BSL	0.092 (BSL)	0.09 (BSL)	0.09 (4) (BSL)	0.072 (BSL)	0.072 (4) (BSL)
Molybdenum	NA(6)	0.1	0.004 – 0.048	NA (3)	RSL	0.1 (RSL)	0.1 (RSL)	0.1(5) (RSL)	0.1 (RSL)	0.1 (RSL)
Selenium	0.05(7)	0.1	0.0023 – 0.01	0.28 (1)	DEQ-7	0.05 (DEQ-7)	0.05 (DEQ-7)	0.05 (DEQ-7)	0.05 (DEQ-7)	0.05 (DEQ-7)
Other Potential Plant Site Constituents										
Manganese	NA(6)	0.43	0.27 – 2.79	61 (1)	RSL/BSL	0.6 (BSL)	2.79 (BSL)	0.67 (BSL)	0.54 (BSL)	0.43 (RSL)

Notes:

BSL	Background Screening Level (Neptune, 2016)
CCR	Coal Combustion Residual
COI	Constituent of Interest
COC	Chemical of Concern
MCL	Maximum Contaminant Level
mg/L	Milligrams per liter
NA	Not available/not applicable
RSL	Regional Screening Level

(1) Calculated Cleanup Criterion protective of livestock (calf), see Appendix C
(2) Upper limit of “marginal” sulfate range for livestock (USDA-ARS, 2009)
(3) Cleanup Criterion could not be calculated – no mammalian Toxicity Reference Value (TRV) available, see Appendix C
(4) BSL not available. BSL for adjacent hydrostratigraphic layer used as a proxy value.
(5) BSL not available. RSL assumed to be applicable.
(6) Neither a DEQ-7, nor an MCL has been established.
(7) Value is both the DEQ-7 and the MCL.

13.0 APPLICATION OF THE CCRA RESULTS TO THE REMEDY EVALUATION

Within this section, the CCRA results are discussed as they apply to the remedial evaluation.

13.1 SURFACE WATER

No action is required in the Remedy Evaluation regarding surface water.

13.2 STREAMBED SEDIMENT

No action is required in the Remedy Evaluation regarding streambed sediment.

13.3 SOIL

No action is required in the Remedy Evaluation regarding soil in the pipeline spill areas.

13.4 GROUNDWATER

Cleanup Criteria for the groundwater COIs/COCs were presented in Section 12.5. The groundwater Cleanup Criteria should be used in the Remedy Evaluation to develop remedial alternatives to address COI/COC groundwater concentrations that exceed these values, including after the capture system is shut down. In addition, the remedial actions should include all the regulated substances listed in the AOC Control Action definition (Section IV.B.; DEQ/PPLM, 2012), which include three of the COIs/COCs (sulfate, boron, selenium), as well as potassium, sodium, magnesium, TDS, and salinity. Lastly, radium concentrations in groundwater at the Plant Site appear to be consistent with background levels and radium was not identified as a groundwater COI/COC. However, because a radium groundwater BSL was not available for comparison, as a conservative measure radium will remain a COPC while additional radium groundwater data are collected. Radium will continue to be monitored and evaluated in groundwater as part of the Federal CCR Rule compliance monitoring and continue to be evaluated under the AOC.

CLEANUP CRITERIA AND RISK ASSESSMENT REPORT

Wastewater Facilities Comprising the Closed-Loop System
Plant Site Area
COLSTRIP STEAM ELECTRIC STATION

Pursuant to:* *ADMINISTRATIVE ORDER ON CONSENT REGARDING IMPACTS RELATED TO WASTEWATER FACILITIES COMPRISING THE CLOSED-LOOP SYSTEM AT COLSTRIP STEAM ELECTRIC STATION, COLSTRIP, MONTANA SECTION XI – SUBMISSIONS

CERTIFICATION:
I, the undersigned, hereby certify that this document was prepared under my direction and to the best of my knowledge the information contained herein is correct and accurate.

Compliance Professional 10/29/18
Name Title Date

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REFERENCES

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TABLES

Table 1A
Preliminary Screening of Plant Site Wastewater CCR Rule Appendix III Constituents
Wastewater Facilities Comprising the Closed Loop System
Plant Site Pond Water, Colstrip Steam Electric Station, Colstrip, Montana

	Sampling Period	Boron (Dissolved)		Boron (Total)		Calcium (Dissolved)		Calcium (Total)		Fluoride		Sulfate (SO_4)		pH (lab)*		Total Dissolved Solids (TDS)	
Groundwater DEQ-7 (mg/L)		**NA**		**NA**		**NA**		**NA**		**4**		**NA**		**NA**		**NA**	
MCL (mg/L)		**NA**		**NA**		**NA**		**NA**		**4**		**NA**		**NA**		**NA**	
RSL (mg/L)		**4**		**4**		**NA**		**NA**		**0.8**		**NA**		**NA**		**NA**	
BSL (mg/L)		**0.818-4**		**0.818-4**		**313-495**		**313-495**		**0.4-2.1**		**2,061-3,160**		**7.8-8.2 s.u.**		**3,160-5,170**	
Values (units)		Max (mg/L)	Mean (mg/L)	Max (mg/L)	Mean (mg/L)	Max (mg/L)	Mean (mg/L)	Max (mg/L)	Mean (mg/L)	Max (mg/L)	Mean (mg/L)	Max (mg/L)	Mean (mg/L)	Max (s.u.)	Mean (s.u.)	Max (mg/L)	Mean (mg/L)
Site Descriptor																	
Units 1&2 B Pond Between Liner	3/2007 - 4/2014	111	64.2	118	107	519	455	423	399	0.97	0.955	21,300	13,537	8.4	7.51	30,300	19,153
Units 1&2 B Pond Underliner	9/2004 - 4/2014	34.7	22.7	NA	NA	515	483	NA	NA	NA	NA	6,830	5,305	7.6	7.28	10,500	8,119
Units 1&2 Bottom Ash Clearwell (converted to secondary settling cell)	1/1977 - 4/2008	52.7	41.7	2.4	1.4	824	557	NA	NA	3.1	1.09	7,970	3,758	11.6	9.57	12,000	5,892
Units 1&2 Bottom Ash Clearwell (New)	6/2007 - 7/2012	14.6	11.5	15	15	664	532	NA	NA	1	1	3,990	3,242	9.1	8.86	5,700	5,098
Units 1&2 Bottom Ash Clearwell Underdrain	8/2007 - 4/2011	16	9.8	NA	NA	579	540	NA	NA	NA	NA	2,520	2,268	9.7	9.28	4,170	3,686
Units 1&2 Flyash AB Pond Clearwell (A side and B side)	9/1996 - 4/2005	89.5	55.1	10.1	10.1	508	430	NA	NA	2.59	1.98	18,100	9,250	9.1	7.35	28,900	14,398
Units 3&4 Bottom Ash Clearwell	12/2002 - 7/2012	4.4	2.9	2.98	2.09	631	497	NA	NA	0.7	0.585	2,570	2,018	11.4	10.8	4,220	3,094
Units 1&2 AB Pond (A side and B side)	1/1977 - 3/2003	111	71.9	NA	NA	667	505	NA	NA	8.5	2.97	20,000	10,420	9.2	5.63	29,400	15,292
Units 1&2 Bottom Ash Pond	4/2008 - 9/2009	11	10.1	NA	NA	692	642	NA	NA	NA	NA	3,320	3,280	9.3	9.05	5,610	7,625
Units 3&4 Bottom Ash Pond	2/1984 - 9/2009	6.5	2.7	NA	NA	647	401	NA	NA	0.9	0.529	2,830	1,899	11.8	10.1	5,180	3,133
Units 1&2 Cooling Tower Blowdown Pond C - South Pond	4/1993 - 7/2012	13.2	3.74	11.8	6.25	589	331	NA	NA	1.81	1.45	5,540	2,463	8.7	8.39	7,730	3,898
Units 1&2 Cooling Tower Blowdown Pond C - North Pond	5/2004 - 9/2009	10.6	6.83	NA	NA	449	356	NA	NA	NA	NA	5,260	4,060	8.6	8.25	7,810	6,268
Units 1&2 Pond A	4/2005 - 5/2014	16.5	13.2	15.1	15.1	517	444	NA	NA	1.6	1.6	4,870	3,988	9	8.52	7,200	5,994
Units 1&2 Pond B	6/2005 - 7/2012	114	92	87	87	442	434	NA	NA	3	3	19,600	16,625	7.9	7.4	27,500	22,700
Units 3&4 Wash Tray Pond (3&4 WTP)	2/1984 - 9/2011	112	54.5	NA	NA	618	455	NA	NA	15	4.68	27,800	12,202	9.4	6.28	44,200	17,680
Units 1&2 Concentrator Disposal Pond D4 (Closed in 2005)	6/1979 - 6/1999	854	367	NA	NA	1,426	737	NA	NA	234	115	159,000	115,129	7.9	7.46	272,000	187,725
Units 1&2 Brine Waste Disposal Pond Underdrain Sump	5/2008 - 4/2013	186	114	NA	NA	394	329	NA	NA	NA	NA	277,000	149,500	7.9	7.6	332,000	185,750
Units 3&4 Scrubber Drain Collection Pond (DC Pond)	2/1984 - 11/2009	112	48	NA	NA	745	497	NA	NA	13.7	9.04	14,000	8,940	9.4	7.98	23,600	13,702
Units 3&4 North Plant Area Drain Pond (North Pond)	5/1996 - 7/2012	1.9	1.09	0.7	0.7	434	259	NA	NA	2.1	2.1	2,560	1,454	8.4	7.84	4,350	2,596
Units 1-4 North Plant Sediment Retention Pond	6/1984 - 7/2012	1.4	0.668	0.96	0.96	555	185	NA	NA	4.1	1.4	3,140	979	9.3	7.83	4,780	1,647
Units 1-4 Sediment Retention Pond	2/1985 - 7/2012	67	22.5	27.9	14	1,030	458	NA	NA	4.51	2.61	12,800	5,219	8.8	7.75	19,900	8,800

Notes:

* - pH measurement reported in standard units (s.u.)

NA - Not Available/Not Applicable

DEQ - Montana Department of Environmental Quality (2017)

MCL - Maximum Contaminant Level

RSL - USEPS Tapwater Regional Screening Level

BSL - Background Screening Level (Neptune, 2016)

mg/L - milligrams per liter

Table 1B
Preliminary Screening of Plant Site Wastewater CCR Rule Appendix IV Constituents
Wastewater Facilities Comprising the Closed Loop System
Plant Site Pond Water, Colstrip Steam Electric Station, Colstrip, Montana

	Sampling Period	Antimony (Dissolved)		Antimony (Total)		Arsenic (Dissolved)		Arsenic (Total)		Barium (Dissolved)		Barium (Total)		Beryllium (Total)		Cadmium (Dissolved)	
Groundwater DEQ-7		**0.006**		**0.006**		**0.01**		**0.01**		**1**		**1**		**0.004**		**0.005**	
MCL (mg/L)		**0.006**		**0.006**		**0.01**		**0.01**		**2**		**2**		**0.004**		**0.005**	
RSL (mg/L)		**0.0078**		**0.0078**		**$5.2X10^{-5}$**		**$5.2X10^{-5}$**		**3.8**		**3.8**		**0.025**		**0.0092**	
BSL (mg/L)		**0.15-0.45**		**0.15-0.45**		**0.005-0.01**		**0.005-0.01**		**0.022-0.111**		**0.022-0.111**		**0.003-0.01**		**0.002-0.01**	
Values (units)		Max (mg/L)	Mean (mg/L)	Max (mg/L)	Mean (mg/L)	Max (mg/L)	Mean (mg/L)	Max (mg/L)	Mean (mg/L)	Max (mg/L)	Mean (mg/L)	Max (mg/L)	Mean (mg/L)	Max (mg/L)	Mean (mg/L)	Max (mg/L)	Mean (mg/L)
Site Descriptor																	
Units 1&2 B Pond Between Liner	3/2007 - 4/2014	<0.006	<0.006	0.007	0.006	0.01	0.007	0.011	0.007	0.064	0.059	0.061	0.059	NA	NA	<0.031	<0.031
Units 1&2 B Pond Under liner	9/2004 - 4/2014	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Units 1&2 Bottom Ash Clearwell (converted to secondary settling cell)	1/1977 - 4/2008	NA	NA	<0.05	<0.05	NA	NA	<0005	<0.005	NA	NA	<0.3	<0.3	<0.001	<0.001	0.005	0.004
Units 1&2 Bottom Ash Clearwell (New)	6/2007 - 7/2012	NA	NA	0.001	0.001	NA	NA	0.002	0.002	NA	NA	0.11	0.11	<0.001	<0.001	NA	NA
Units 1&2 Bottom Ash Clearwell Underdrain	8/2007 - 4/2011	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Units 1&2 Flyash AB Pond Clearwell (A side and B side)	9/1996 - 4/2005	NA	NA	<0.05	<0.05	NA	NA	0.006	0.006	NA	NA	0.2	0.2	<0.001	<0.001	NA	NA
Units 3&4 Bottom Ash Clearwell	12/2002 - 7/2012	NA	NA	0.05	0.027	NA	NA	0.005	0.004	NA	NA	0.3	0.21	<0.001	<0.001	NA	NA
Units 1&2 AB Pond (A side and B side)	1/1977 - 3/2003	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.22	0.023
Units 1&2 Bottom Ash Pond	4/2008 - 9/2009	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Units 3&4 Bottom Ash Pond	2/1984 - 9/2009	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.005	0.003
Units 1&2 Cooling Tower Blowdown Pond C - South Pond	4/1993 - 7/2012	NA	NA	<0.05	<0.026	NA	NA	0.017	0.014	NA	NA	<0.1	<0.075	<0.001	<0.001	<0.001	<0.001
Units 1&2 Cooling Tower Blowdown Pond C - North Pond	5/2004 - 9/2009	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Units 1&2 Pond A	4/2005 - 5/2014	NA	NA	<0.002	<0.002	NA	NA	<0.002	<0.002	NA	NA	<0.07	<0.07	<0.001	<0.001	NA	NA
Units 1&2 Pond B	6/2005 - 7/2012	NA	NA	0.003	0.003	NA	NA	0.006	0.006	NA	NA	0.15	0.15	<0.001	<0.001	NA	NA
Units 3&4 Wash Tray Pond (3&4 WTP)	2/1984 - 9/2011	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.017	0.009
Units 1&2 Concentrator Disposal Pond D4 (Closed in 2005)	6/1979 - 6/1999	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.233	0.054
Units 1&2 Brine Waste Disposal Pond Underdrain Sump	5/2008 - 4/2013	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Units 3&4 Scrubber Drain Collection Pond (DC Pond)	2/1984 - 11/2009	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.012	0.006
Units 3&4 North Plant Area Drain Pond (North Pond)	5/1996 - 7/2012	NA	NA	0.001	0.001	NA	NA	0.032	0.032	NA	NA	0.16	0.16	<0.001	<0.001	NA	NA
Units 1-4 North Plant Sediment Retention Pond	6/1984 - 7/2012	NA	NA	0.001	0.001	NA	NA	0.014	0.014	NA	NA	0.39	0.39	0.001	0.001	0.005	0.003
Units 1-4 Sediment Retention Pond	2/1985 - 7/2012	NA	NA	0.002	0.002	NA	NA	0.006	0.006	<10	<10	0.09	0.09	<0.001	<0.001	<0.005	<0.001

Notes:
* - pH measurement reported in standard units (s.u.)
**- Sum total of Radium 226 and 228
NA - Not Available/Not Applicable
(a) lead treatment technology action level is 0.015 mg/L
(b) value for inorganic mercury

DEQ - Montana Department of Environmental Quality (2017)
MCL - Maximum Contaminant Level
RSL - USEPS Tapwater Regional Screening Level
BSL - Background Screening Level (Neptune, 2016)
mg/L - milligrams per liter

Table 1B
Preliminary Screening of Plant Site Wastewater CCR Rule Appendix IV Constituents
Wastewater Facilities Comprising the Closed Loop System
Plant Site Pond Water, Colstrip Steam Electric Station, Colstrip, Montana

	Sampling Period	Cadmium (Total)		Chromium (Total)		Cobalt (Total)		Fluoride		Lead (Dissolved)		Lead (Total)		Lithium		Mercury (Dissolved)	
Groundwater DEQ-7		**0.005**		**0.1**		**NA**		**4**		**0.015**		**0.015**		**NA**		**0.002**	
MCL (mg/L)		**0.005**		**0.1**		**NA**		**4**		**0.015(a)**		**0.015(a)**		**NA**		**0.002 (b)**	
RSL (mg/L)		**0.0092**		**NA**		**0.006**		**0.8**		**0.015**		**0.015**		**0.04**		**6.3X10^{-4}**	
BSL (mg/L)		**0.002-0.01**		**0.0146-0.1**		**0.00066-0.0232**		**0.4-2.1**		**0.01-0.05**		**0.01-0.05**		**0.072-0.092**		**0.001-0.005**	
Values (units)		Max (mg/L)	Mean (mg/L)	Max (mg/L)	Mean (mg/L)	Max (mg/L)	Mean (mg/L)	Max (mg/L)	Mean (mg/L)	Max (mg/L)	Mean (mg/L)	Max (mg/L)	Mean (mg/L)	Max (mg/L)	Mean (mg/L)	Max (mg/L)	Mean (mg/L)
Site Descriptor																	
Units 1&2 B Pond Between Liner	3/2007 - 4/2014	0.035	0.032	<0.01	<0.01	NA	NA	0.97	0.955	<0.001	<0.001	<0.001	<0.001	NA	NA	<0.00005	<0.00005
Units 1&2 B Pond Under liner	9/2004 - 4/2014	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	<0.001	0.001
Units 1&2 Bottom Ash Clearwell (converted to secondary settling cell)	1/1977 - 4/2008	0.003	0.002	<0.02	<0.02	<0.01	<0.01	3.1	1.09	0.5	0.078	<0.01	<0.01	NA	NA	<0.0001	<0.0001
Units 1&2 Bottom Ash Clearwell (New)	6/2007 - 7/2012	<0.001	<0.001	<0.005	<0.005	0.01	0.01	1	1	NA	NA	NA	NA	NA	NA	<0.001	<0.001
Units 1&2 Bottom Ash Clearwell Underdrain	8/2007 - 4/2011	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	<0.001	<0.001
Units 1&2 Flyash AB Pond Clearwell (A side and B side)	9/1996 - 4/2005	0.001	0.001	<0.01	<0.01	<0.01	<0.01	2.59	1.98	NA	NA	NA	NA	NA	NA	NA	NA
Units 3&4 Bottom Ash Clearwell	12/2002 - 7/2012	<0.001	<0.001	0.02	0.013	0.01	0.008	0.7	0.585	NA	NA	NA	NA	NA	NA	<0.001	<0.001
Units 1&2 AB Pond (A side and B side)	1/1977 - 3/2003	NA	NA	NA	NA	NA	NA	8.5	2.97	0.7	0.099	NA	NA	NA	NA	<0.001	<0.001
Units 1&2 Bottom Ash Pond	4/2008 - 9/2009	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	<0.001	<0.001
Units 3&4 Bottom Ash Pond	2/1984 - 9/2009	NA	NA	NA	NA	NA	NA	0.9	0.529	0.02	0.013	NA	NA	NA	NA	<0.001	<0.001
Units 1&2 Cooling Tower Blowdown Pond C - South Pond	4/1993 - 7/2012	<0.001	<0.001	<0.01	<0.008	<0.01	<0.008	1.81	1.45	<0.01	<0.01	NA	NA	NA	NA	<0.001	<0.001
Units 1&2 Cooling Tower Blowdown Pond C - North Pond	5/2004 - 9/2009	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	<0.001	<0.001
Units 1&2 Pond A	4/2005 - 5/2014	<0.001	<0.001	<0.005	<0.005	<0.005	<0.005	1.6	1.6	NA	NA	NA	NA	NA	NA	<0.001	<0.001
Units 1&2 Pond B	6/2005 - 7/2012	0.025	0.025	0.008	0.008	0.239	0.239	3	3	NA	NA	NA	NA	NA	NA	<0.001	<0.001
Units 3&4 Wash Tray Pond (3&4 WTP)	2/1984 - 9/2011	NA	NA	NA	NA	NA	NA	15	4.68	0.41	0.08	NA	NA	NA	NA	<0.001	<0.001
Units 1&2 Concentrator Disposal Pond D4 (Closed in 2005)	6/1979 - 6/1999	NA	NA	NA	NA	NA	NA	234	115	2	0.408	NA	NA	NA	NA	0.001	0.001
Units 1&2 Brine Waste Disposal Pond Underdrain Sump	5/2008 - 4/2013	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.001	0.001
Units 3&4 Scrubber Drain Collection Pond (DC Pond)	2/1984 - 11/2009	NA	NA	NA	NA	NA	NA	13.7	9.04	0.07	0.025	NA	NA	NA	NA	0.001	0.001
Units 3&4 North Plant Area Drain Pond (North Pond)	5/1996 - 7/2012	<0.001	<0.001	<0.005	<0.005	<0.005	<0.005	2.1	2.1	NA	NA	NA	NA	NA	NA	<0.001	<0.001
Units 1-4 North Plant Sediment Retention Pond	6/1984 - 7/2012	0.001	0.001	0.012	0.012	<0.005	<0.005	4.1	1.4	0.02	0.014	NA	NA	NA	NA	<0.001	<0.001
Units 1-4 Sediment Retention Pond	2/1985 - 7/2012	<0.001	<0.001	<0.005	<0.005	<0.005	<0.005	4.51	2.61	0.06	0.035	NA	NA	NA	NA	<0.001	<0.001

Notes:

* - pH measurement reported in standard units (s.u.)
**- Sum total of Radium 226 and 228
NA - Not Available/Not Applicable
(a) lead treatment technology action level is 0.015 mg/L
(b) value for inorganic mercury

DEQ - Montana Department of Environmental Quality (2017)
MCL - Maximum Contaminant Level
RSL - USEPS Tapwater Regional Screening Level
BSL - Background Screening Level (Neptune, 2016)
mg/L - milligrams per liter

Table 1B
Preliminary Screening of Plant Site Wastewater CCR Rule Appendix IV Constituents
Wastewater Facilities Comprising the Closed Loop System
Plant Site Pond Water, Colstrip Steam Electric Station, Colstrip, Montana

	Sampling Period	Mercury (Total)		Molybdenum (Dissolved)		Molybdenum (Total)		Radium 226/228		Selenium (Dissolved)		Selenium (Total)		Thallium (Total)	
Groundwater DEQ-7		**0.002**		**NA**		**NA**		**5 pCi/L****		**0.05**		**0.05**		**0.002**	
MCL (mg/L)		**0.002 (b)**		**NA**		**NA**		**5 pCi/L****		**0.05**		**0.05**		**0.002**	
RSL (mg/L)		**$6.3X10^{-4}$**		**0.1**		**0.1**		**NA**		**0.1**		**0.1**		**0.0002**	
BSL (mg/L)		**0.001-0.005**		**0.004-0.048**		**0.004-0.048**		**NA**		**0.0023-0.01**		**0.0023-0.01**		**0.005-0.5**	
Values (units)		Max (mg/L)	Mean (mg/L)	Max (mg/L)	Mean (mg/L)	Max (mg/L)	Mean (mg/L)	Max (pCi/L)	Mean (pCi/L)	Max (mg/L)	Mean (mg/L)	Max (mg/L)	Mean (mg/L)	Max (mg/L)	Mean (mg/L)
Site Descriptor															
Units 1&2 B Pond Between Liner	3/2007 - 4/2014	<0.00005	<0.00005	0.11	0.105	0.12	0.105	NA	NA	0.172	0.072	0.191	0.16	NA	NA
Units 1&2 B Pond Under liner	9/2004 - 4/2014	NA	NA	NA	NA	NA	NA	NA	NA	0.025	0.011	NA	NA	NA	NA
Units 1&2 Bottom Ash Clearwell (converted to secondary settling cell)	1/1977 - 4/2008	<0.001	<0.001	NA	NA	0.091	0.091	NA	NA	0.054	0.016	0.043	0.026	<0.1	<0.1
Units 1&2 Bottom Ash Clearwell (New)	6/2007 - 7/2012	<0.001	<0.001	NA	NA	0.033	0.033	NA	NA	0.016	0.012	0.024	0.024	<0.0005	<0.0005
Units 1&2 Bottom Ash Clearwell Underdrain	8/2007 - 4/2011	NA	NA	NA	NA	NA	NA	NA	NA	0.025	0.01	NA	NA	NA	NA
Units 1&2 Flyash AB Pond Clearwell (A side and B side)	9/1996 - 4/2005	<0.0001	<0.0001	NA	NA	0.151	0.151	NA	NA	0.106	0.063	0.016	0.016	<0.1	<0.1
Units 3&4 Bottom Ash Clearwell	12/2002 - 7/2012	<0.0002	<0.0001	NA	NA	0.301	0.248	NA	NA	0.013	0.01	0.007	0.006	0.1	0.05
Units 1&2 AB Pond (A side and B side)	1/1977 - 3/2003	NA	NA	NA	NA	NA	NA	NA	NA	0.175	0.034	NA	NA	NA	NA
Units 1&2 Bottom Ash Pond	4/2008 - 9/2009	NA	NA	NA	NA	NA	NA	NA	NA	0.012	0.009	NA	NA	NA	NA
Units 3&4 Bottom Ash Pond	2/1984 - 9/2009	NA	NA	NA	NA	NA	NA	NA	NA	0.025	0.011	NA	NA	NA	NA
Units 1&2 Cooling Tower Blowdown Pond C - South Pond	4/1993 - 7/2012	<0.0001	<0.0001	NA	NA	0.066	0.037	NA	NA	0.026	0.011	0.007	0.006	<0.1	<0.0502
Units 1&2 Cooling Tower Blowdown Pond C - North Pond	5/2004 - 9/2009	NA	NA	NA	NA	NA	NA	NA	NA	0.013	0.007	NA	NA	NA	NA
Units 1&2 Pond A	4/2005 - 5/2014	<0.001	<0.001	NA	NA	0.065	0.065	NA	NA	0.024	0.016	0.007	0.007	<0.001	<0.001
Units 1&2 Pond B	6/2005 - 7/2012	NA	NA	NA	NA	0.098	0.098	NA	NA	0.188	0.139	0.25	0.25	0.003	0.003
Units 3&4 Wash Tray Pond (3&4 WTP)	2/1984 - 9/2011	NA	NA	NA	NA	NA	NA	NA	NA	0.14	0.065	NA	NA	NA	NA
Units 1&2 Concentrator Disposal Pond D4 (Closed in 2005)	6/1979 - 6/1999	NA	NA	NA	NA	NA	NA	NA	NA	1.05	0.158	NA	NA	NA	NA
Units 1&2 Brine Waste Disposal Pond Underdrain Sump	5/2008 - 4/2013	NA	NA	NA	NA	NA	NA	NA	NA	0.109	0.064	NA	NA	NA	NA
Units 3&4 Scrubber Drain Collection Pond (DC Pond)	2/1984 - 11/2009	NA	NA	NA	NA	NA	NA	NA	NA	0.287	0.085	NA	NA	NA	NA
Units 3&4 North Plant Area Drain Pond (North Pond)	5/1996 - 7/2012	<0.0001	<0.0001	NA	NA	0.005	0.005	NA	NA	0.02	0.009	0.011	0.011	<0.0005	<0.0005
Units 1-4 North Plant Sediment Retention Pond	6/1984 - 7/2012	<0.0001	<0.0001	NA	NA	0.006	0.006	NA	NA	0.02	0.007	0.001	0.001	<0.0005	<0.0005
Units 1-4 Sediment Retention Pond	2/1985 - 7/2012	<0.0001	<0.0001	NA	NA	0.019	0.019	NA	NA	0.125	0.013	0.01	0.01	<0.0005	<0.0005

Notes:

* - pH measurement reported in standard units (s.u.)
**- Sum total of Radium 226 and 228
NA - Not Available/Not Applicable
(a) lead treatment technology action level is 0.015 mg/L
(b) value for inorganic mercury

DEQ - Montana Department of Environmental Quality (2017)
MCL - Maximum Contaminant Level
RSL - USEPS Tapwater Regional Screening Level
BSL - Background Screening Level (Neptune, 2016)
mg/L - milligrams per liter

Table 1C
Preliminary Screening of Other Potential Plant Site Constituents
Wastewater Facilities Comprising the Closed Loop System
Plant Site Pond Water, Colstrip Steam Electric Station, Colstrip, Montana

	Sampling Period	Manganese (Dissolved)		Manganese (Total)	
Groundwater DEQ-7		**NA**		**NA**	
MCL (mg/L)		**NA**		**NA**	
RSL (mg/L)		**0.43**		**0.43**	
BSL (mg/L)		**0.27-2.79**		**0.27-2.79**	
Values (units)		Max (mg/L)	Mean (mg/L)	Max (mg/L)	Mean (mg/L)
Site Descriptor					
Units 1&2 B Pond Between Liner	3/2007 - 4/2014	71.6	71	77.4	70.5
Units 1&2 B Pond Underliner	9/2004 - 4/2014	NA	NA	NA	NA
Units 1&2 Bottom Ash Clearwell (converted to secondary settling cell)	1/1977 - 4/2008	6.07	1.53	3.64	1.83
Units 1&2 Bottom Ash Clearwell (New)	6/2007 - 7/2012	NA	NA	2.37	2.37
Units 1&2 Bottom Ash Clearwell Underdrain	8/2007 - 4/2011	NA	NA	NA	NA
Units 1&2 Flyash AB Pond Clearwell (A side and B side)	9/1996 - 4/2005	26.8	26.8	2.36	2.36
Units 3&4 Bottom Ash Clearwell	12/2002 - 7/2012	NA	NA	0.01	0.008
Units 1&2 AB Pond (A side and B side)	1/1977 - 3/2003	71.9	26.4	NA	NA
Units 1&2 Bottom Ash Pond	4/2008 - 9/2009	NA	NA	NA	NA
Units 3&4 Bottom Ash Pond	2/1984 - 9/2009	0.12	0.033	NA	NA
Units 1&2 Cooling Tower Blowdown Pond C - South Pond	4/1993 - 7/2012	0.02	0.02	0.152	0.091
Units 1&2 Cooling Tower Blowdown Pond C - North Pond	5/2004 - 9/2009	NA	NA	NA	NA
Units 1&2 Pond A	4/2005 - 5/2014	NA	NA	0.182	0.182
Units 1&2 Pond B	6/2005 - 7/2012	NA	NA	55.9	55.9
Units 3&4 Wash Tray Pond (3&4 WTP)	2/1984 - 9/2011	18.9	9.87	NA	NA
Units 1&2 Concentrator Disposal Pond D4 (Closed in 2005)	6/1979 - 6/1999	79.6	26.3	NA	NA
Units 1&2 Brine Waste Disposal Pond Underdrain Sump	5/2008 - 4/2013	NA	NA	NA	NA
Units 3&4 Scrubber Drain Collection Pond (DC Pond)	2/1984 - 11/2009	13.1	5.92	NA	NA
Units 3&4 North Plant Area Drain Pond (North Pond)	5/1996 - 7/2012	NA	NA	0.112	0.112
Units 1-4 North Plant Sediment Retention Pond	6/1984 - 7/2012	0.17	0.079	0.868	0.868
Units 1-4 Sediment Retention Pond	2/1985 - 7/2012	35.2	12.8	3.32	3.32

Notes:
NA - Not Available/Not Applicable

DEQ - Montana Department of Environmental Quality (2017)
MCL - Maximum Contaminant Level
RSL - USEPS Tapwater Regional Screening Level
BSL - Background Screening Level (Neptune, 2016)
mg/L - milligrams per liter

Table 2

Summary of Background Screening Levels for Potential Constituents of Interest
Wastewater Facilities Comprising the Closed Loop System
Plant Site Pond Water, Colstrip Steam Electric Station, Colstrip, Montana

Constituent	Alluvium (mg/L)	Spoils (mg/L)	Clinkers (mg/L)	Coal-Related (mg/L)	SubMcKay (mg/L)
CCR Appendix III Constituents					
Boron	1.6	0.818	4	1.1	1.3
Calcium	378	495	367	351	313
Chloride	45	62	34	20	24
Fluoride	0.65	0.4	0.81	0.51	2.1
Sulfate	2,600	3,045	3,160	2,061	2,200
pH (lab)	7.8	7.88	8.2	7.8	8.2
Total Dissolved Solids	4,000	4,930	5,170	3,160	3,710
CCR Appendix IV Constituents					
Antimony	0.15	0.45	---	0.39	0.15
Arsenic	0.01	0.005	---	0.005	0.005
Barium	0.022	0.27	---	0.111	0.09
Beryllium	0.003	0.01	---	0.005	0.003
Cadmium	0.005	0.005	0.01	0.002	0.003
Chromium	0.1	0.0215	---	0.0146	0.1
Cobalt	0.02	0.0232	---	0.0034	0.00066
Fluoride	0.65	0.4	0.81	0.51	2.1
Lead	0.01	0.05	0.02	0.01	0.01
Lithium	0.092	0.09	---	0.072	---
Mercury	0.001	0.005	0.001	0.001	0.001
Molybdenum	0.04	0.048	---	0.02	0.004
Radium 226/228	---	---	---	---	---
Selenium	0.009	0.0023	0.01	0.005	0.005
Thallium	0.5	0.05	---	0.005	0.5
Other Potential Plant Site Groundwater Constituents					
Barium	0.022	0.27	NA	0.111	0.09
Manganese	0.6	2.79	0.67	0.54	0.27

Notes:
Source: Neptune, 2016
--- Not Analyzed
CCR - Coal Combustion Residuals
mg/L - milligrams per liter

5/9/2018

Table 3
Screening for the Identification of Groundwater Constituents of Interest
Wastewater Facilities Comprising the Closed Loop System
Plant Site Pond Water, Colstrip Steam Electric Station, Colstrip, Montana

5/9/2018

Chemical	Plant Site Pond Data				CCR Data					DEQ-7 Ground-water Standard (Dissolved) (mg/L)	MCL (mg/L)	USEPA Tapwater RSL (mg/L)	Background Screening Level Range (3) (Dissolved) (mg/L)	COI? (Y/N)	Rationale for Selection or Deletion
					CCR Wells			Background CCR Wells							
	Sampling Period (Maximum Concentration Location)	Pond (Maximum Concentration Location)	Maximum Dissolved (1) Conc (mg/L)	Mean Dissolved (1) Conc (mg/L)	Sampling Period	Total (2) Conc Range (mg/L)	Frequency of Detection	Total (2) Conc Range (mg/L)	Frequency of Detection						
CCR Rule Appendix III Constituents															
Boron	6/1979 - 6/1999	Units 1&2 Concentrator Disposal Pond D4 (Closed in 2005)	854	367	2/18/2016-9/8/2017	0.45 to 60.6 Tot 0.39 to 58.5 Dis	268/268	0.11 to 1.65	70/70	NA	NA	4	0.818 - 4	Y	Ponds: >RSL, >BSL CCR Wells: >RSL, >BSL
Calcium	6/1979 - 6/1999	Units 1&2 Concentrator Disposal Pond D4 (Closed in 2005)	1,426	737	2/18/2016-9/8/2017	105 to 687 Tot 224 to 390 Dis	268/268	151 to 441	70/70	NA	NA	NA	313 - 495	N	No standards or screening levels. No human health or ecological toxicity values
Fluoride (4)	6/1979 - 6/1999	Units 1&2 Concentrator Disposal Pond D4 (Closed in 2005)	234	115	2/18/2016-9/8/2017	0.1 to 2.5	255/268	0.1 to 0.3	69/70	4	4	0.8	0.4 - 2.1	N	Ponds: >DEQ-7, >BSL CCR Wells: <DEQ-7, =BSL CCR data indicates F not migrating
Sulfate (4)	5/2008 - 4/2013	Units 1&2 Brine Waste Disposal Pond Underdrain Sump	277,000	149,500	2/18/2016-9/8/2017	979 to 12,200	268/268	834 to 2,840	70/70	NA	NA	NA	2,061-3,160	Y	Ponds: >BSL CCR Wells: >BSL No standards or screening levels. No human health toxicity values, but ecological toxicity values available
pH (s.u.)	1/1977 - 4/2008	Units 1&2 Bottom Ash Clearwell (converted to secondary settling cell)	11.6	9.57	2/18/2016-9/8/2017	5.6 to 7.8	NA	7.0 to 7.6	NA	NA	NA	NA	7.8 - 8.2	N	Ponds: >BSL CCR Wells: <BSL No standards or screening levels. pH may exceed BSL, but would neutralize with migration
TDS	5/2008 - 4/2013	Units 1&2 Brine Waste Disposal Pond Underdrain Sump	332,000	185,750	2/18/2016-9/8/2017	1,850 to 17,200	268/268	1,640 to 4,090	70/70	NA	NA	NA	3,160 - 5,170	N	Ponds: >BSL CCR Wells: >BSL No standards or screening levels. No human health toxicity values available. No specific ecological toxicity values available.
CCR Rule Appendix IV Constituents															
Antimony	3/2007 - 4/2014	Units 1&2 B Pond Between Liner	<0.006	<0.006	2/18/2016-9/8/2017	0.001	2/268	<0.001	0/70	0.006	0.006	0.0078	0.15 - 0.45	N	Ponds: <DEQ-7, <BSL CCR Wells: <DEQ-7, <BSL
Arsenic	3/2007 - 4/2014	Units 1&2 B Pond Between Liner	0.01	0.007	2/18/2016-9/8/2017	0.001 to 0.008	96/268	0.001 to 0.004	11/70	0.01	0.01	5.2 x 10^{-5}	0.005 - 0.01	N	Ponds: =DEQ-7 , =BSL (does not exceed either) CCR Wells: <DEQ-7, <BSL
Barium	3/2007 - 4/2014	Units 1&2 B Pond Between Liner	0.064	0.059	2/18/2016-9/8/2017	0.05 to 0.12	12/268	<0.05	0/70	1	2	3.8	0.022 - 0.111	N	Ponds: <DEQ-7, <BSL CCR Wells: <DEQ-7, =BSL
Beryllium	several	Not detected	<0.001 (total)	<0.001 (total)	2/18/2016-9/8/2017	0.001 to 0.007	8/268	0.002	1/70	0.004	0.004	0.025	0.003 - 0.01	N	Ponds: <DEQ-7, <BSL CCR Wells: >DEQ-7, <BSL 1 of 268 CCR well samples (total concentration) > DEQ-7, but <BSL.
Cadmium	6/1979 - 6/1999	Units 1&2 Concentrator Disposal Pond D4 (Closed in 2005)	0.233	0.054	2/18/2016-9/8/2017	0.001 to 0.007	9/268	0.002	2/70	0.005	0.005	0.0092	0.002 - 0.01	N	Ponds: >DEQ-7, >BSL CCR Wells : >DEQ-7, <BSL 1 of 268 CCR well samples (total concentration) > DEQ-7, but < BSL. CCR data indicated Cd not migrating (low detection frequency 9/268)
Chromium	12/2002 - 7/2012	Units 3&4 Bottom Ash Clearwell	0.02 (total)	0.013 (total)	2/18/2016-9/8/2017	0.014	1/268	0.005	1/70	0.1	0.1	NA	0.0146 - 0.1	N	Ponds: <DEQ-7, <BSL CCR Wells: <DEQ-7, <BSL
Cobalt	6/2005 - 7/2012	Units 1&2 Pond B	0.239 (total)	0.239 (total)	2/18/2016-9/8/2017	0.005 to 0.176 Tot 0.006 to 0.015 Dis	159/268	0.005 to 0.012	4/70	NA	NA	0.006	0.00066 - 0.0232	Y	Ponds: >RSL, >BSL CCR Wells: >RSL, <BSL
Fluoride (4)	6/1979 - 6/1999	Units 1&2 Concentrator Disposal Pond D4 (Closed in 2005)	234	115	2/18/2016-9/8/2017	0.1 to 2.5	255/268	0.1 to 0.3	69/70	4	4	0.8	0.4 - 2.1	N	Ponds: >DEQ-7, >BSL CCR Wells <DEQ-7, =BSL CCR data indicates F not migrating
Lead	6/1979 - 6/1999	Units 1&2 Concentrator Disposal Pond D4 (Closed in 2005)	2	0.408	2/18/2016-9/8/2017	0.001 to 0.014	34/268	0.001	1/70	0.015	0.015	0.015	0.01 - 0.05	N	Ponds: >DEQ-7, >BSL CCR Wells:<DEQ-7, <BSL CCR data indicated Pb not migrating
Lithium(5)	4/27/2017	Units 1 and 2 B Pond	4.9	1.1	2/18/2016-9/8/2017	0.1 to 1.3	171/268	0.1 to 0.2	15/70	NA	NA	0.04	0.072 - 0.092	Y(5)	Ponds: >RSL, >BSL CCR Wells: >RSL, >BSL

Table 3
Screening for the Identification of Groundwater Constituents of Interest
Wastewater Facilities Comprising the Closed Loop System
Plant Site Pond Water, Colstrip Steam Electric Station, Colstrip, Montana

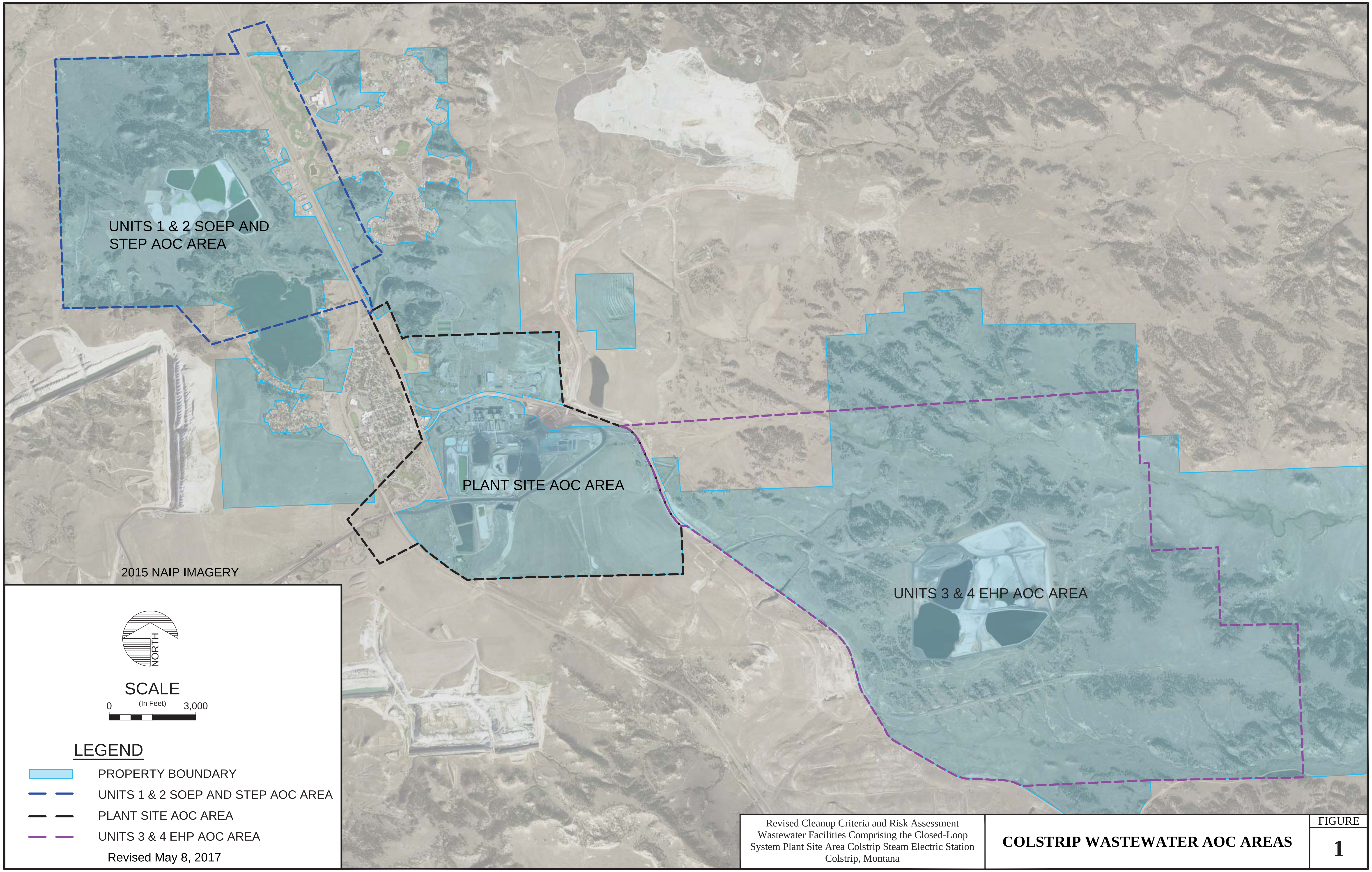
5/9/2018

Chemical	Plant Site Pond Data				CCR Data					DEQ-7 Ground-water Standard (Dissolved) (mg/L)	MCL (mg/L)	USEPA Tapwater RSL (mg/L)	Background Screening Level Range (3) (Dissolved) (mg/L)	COI? (Y/N)	Rationale for Selection or Deletion
					CCR Wells			Background CCR Wells							
	Sampling Period (Maximum Concentration Location)	Pond (Maximum Concentration Location)	Maximum Dissolved (1) Conc (mg/L)	Mean Dissolved (1) Conc (mg/L)	Sampling Period	Total (2) Conc Range (mg/L)	Frequency of Detection	Total (2) Conc Range (mg/L)	Frequency of Detection						
Mercury	6/1979 - 6/1999 5/2008 - 4/2013 2/1984 - 11/2009	Three ponds: - Units 1&2 Concentrator Disposal Pond D4 (Closed in 2005) - Units 1&2 Brine Waste Disposal Pond Underdrain Sump - Units 3&4 Scrubber Drain Collection Pond (DC Pond)	0.001	0.001	2/18/2016-9/8/2017	0.0001	1/268	<0.0001	0/70	0.002	0.002	6×10^{-4}	0.001 - 0.005	N	Ponds: <DEQ-7, <BSL CCR Wells: <DEQ-7, <BSL
Molybdenum	3/2007 - 4/2014	Units 1&2 B Pond Between Liner	0.11	0.105	2/18/2016-9/8/2017	0.001 to 0.41 Tot 0.001 to 0.384 Dis	190/268	0.001 to 0.002	25/70	NA	NA	0.1	0.004 - 0.048	Y	Ponds: >RSL, >BSL CCR Wells: >RSL, >BSL
Radium 226/228(5)	4/27/2017	Storm Water Pond 2 (SWP-2) - (newly constructed in the footprint of the former Drain Collection Pond [DC Pond])	2.0 Tot	1.1 Tot	2/18/2016-9/8/2017	-4 to 12.1	268/268	-0.8 to 5.1	70/70	5 pCi/L	5 pCi/L	NA	NA	N(5)	Ponds: <DEQ-7 CCR Wells: >DEQ-7 BSL not available. Radium initially flagged as a COPC, but not identified as a COI after further evaluation (see Section 10.4).
Selenium	2/1984 - 11/2009	Units 3&4 Scrubber Drain Collection Pond (DC Pond)	1.05	0.085	2/18/2016-9/8/2017	0.001 to 0.018	15/268	0.001 to 0.008	11/70	0.05	0.05	0.1	0.0023 - 0.01	Y	Ponds: >DEQ-7, >BSL CCR Wells: <DEQ-7, =BSL Although CCR data indicated Se not leaching, wells outside source area >DEQ-7
Thallium	12/2002 - 7/2012	Units 3&4 Bottom Ash Clearwell	0.1	0.05	2/18/2016-9/8/2017	0.0005 to 0.0022	34/268	0.0006 to 0.0025	4/70	0.002	0.002	0.0002	0.005 - 0.5	N	Ponds: >DEQ-7, >BSL CCR Wells: >DEQ-7, <BSL 1 of 268 CCR well samples (total concentration) > DEQ-7, but < BSL. CCR data indicated Tl not migrating
Other Potential Plant Site Constituent															
Manganese	6/1979 - 6/1999	Units 1&2 Concentrator Disposal Pond D4 (Closed in 2005)	79.6	26.3	2/18/2016-9/8/2017	0.001 to 15.6 Tot 0.421 to 5.64 Dis	263/268	0.004 to 2.84	70/70	NA	NA	0.43	0.27 - 2.79	Y	Ponds: >RSL, >BSL CCR Wells: >RSL, >BSL Mn also identified as a surface water and sediment COI/COPC in the Human Health and Ecological Risk Assessments

Notes:

(1)	Dissolved concentration unless otherwise noted.
(2)	CCR data is reported as total recoverable concentrations, unless otherwise noted.
(3)	Background Screening Levels for Colstrip Steam Electric Station (Neptune 2016).
(4)	Concentration reported as neither dissolved or total recoverable.
(5)	Lithium and Radium 226/228 data are preliminary data collected on 4/27/2017 (Hydrometrics, 2017b). Lithium and Radium 226/228 data were not available for Plant Site Ponds (Hydrometrics, 2015d) and, therefore, subsquently sampled.
BSL	Background Screening Level (Neptune, 2016)
CCR	Coal Combustion Residual
COI	Constituent of Interest
DEQ-7	Montana Department of Environmental Quality Circular DEQ-7 Numerical Water Quality Standards (DEQ, 2017)
MCL	Maximum Contaminant Level
mg/L	milligrams per liter
NA	Not Available/Not Applicable
pCi/L	picoCuries per liter
RSL	USEPA Regional Screening Level
s.u.	standard units
TDS	Total Dissolved Solids
USEPA	United States Environmental Protection Agency

FIGURES



Revised Cleanup Criteria and Risk Assessment
Wastewater Facilities Comprising the Closed-Loop
System Plant Site Area Colstrip Steam Electric Station
Colstrip, Montana

COLSTRIP WASTEWATER AOC AREAS

FIGURE

1

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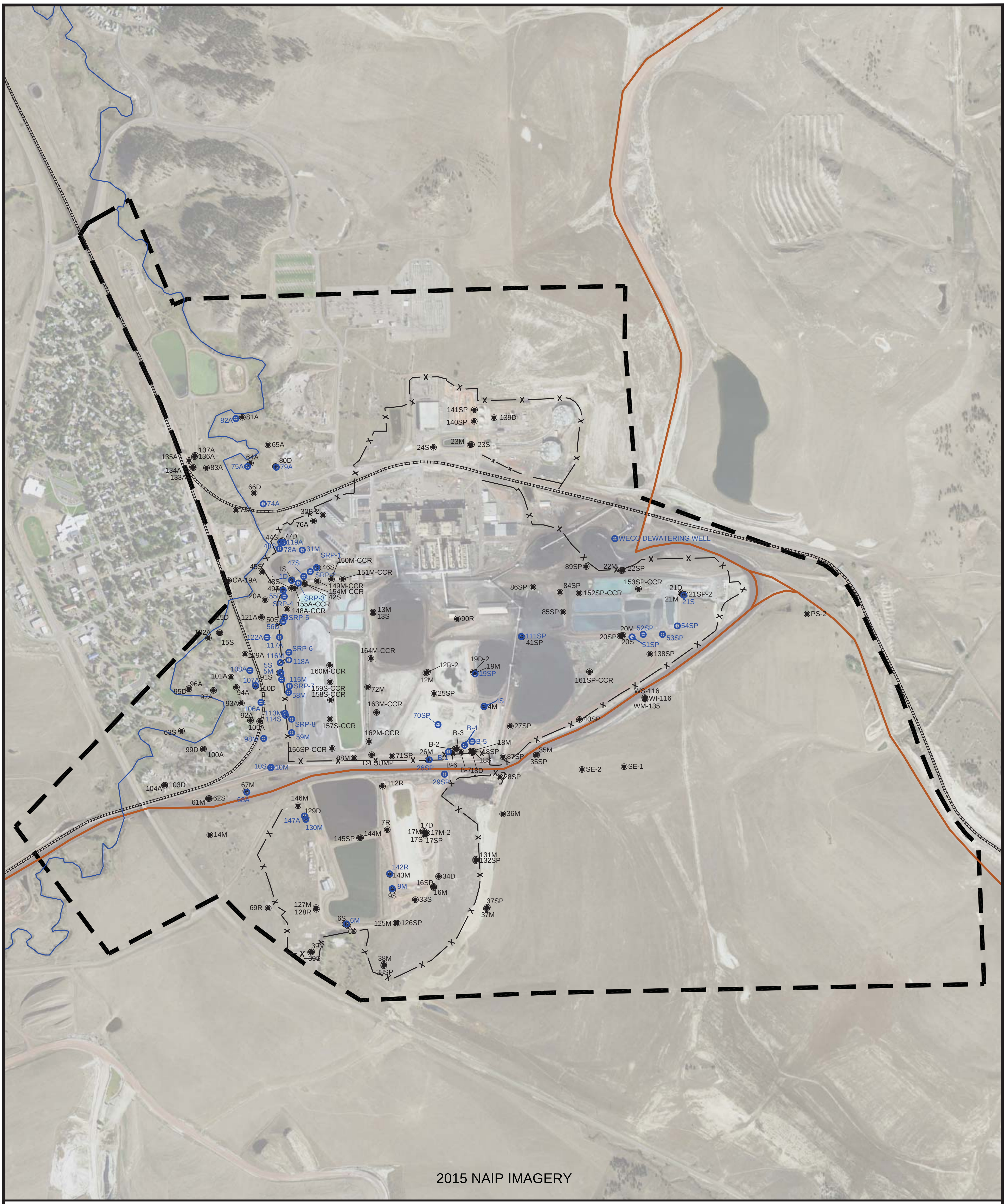

LEGEND

ROSEBUD MINE HAUL ROAD (RESTRICTED ACCESS)

RAIL ROAD

—x— FENCELINE

PLANT SITE AOC BOUNDARY

EAST FORK ARMELLS CREEK

⊕ 10M CAPTURE WELL

● 62S MONITORING WELL

NORTH

SCALE
(In Feet)
0 1200

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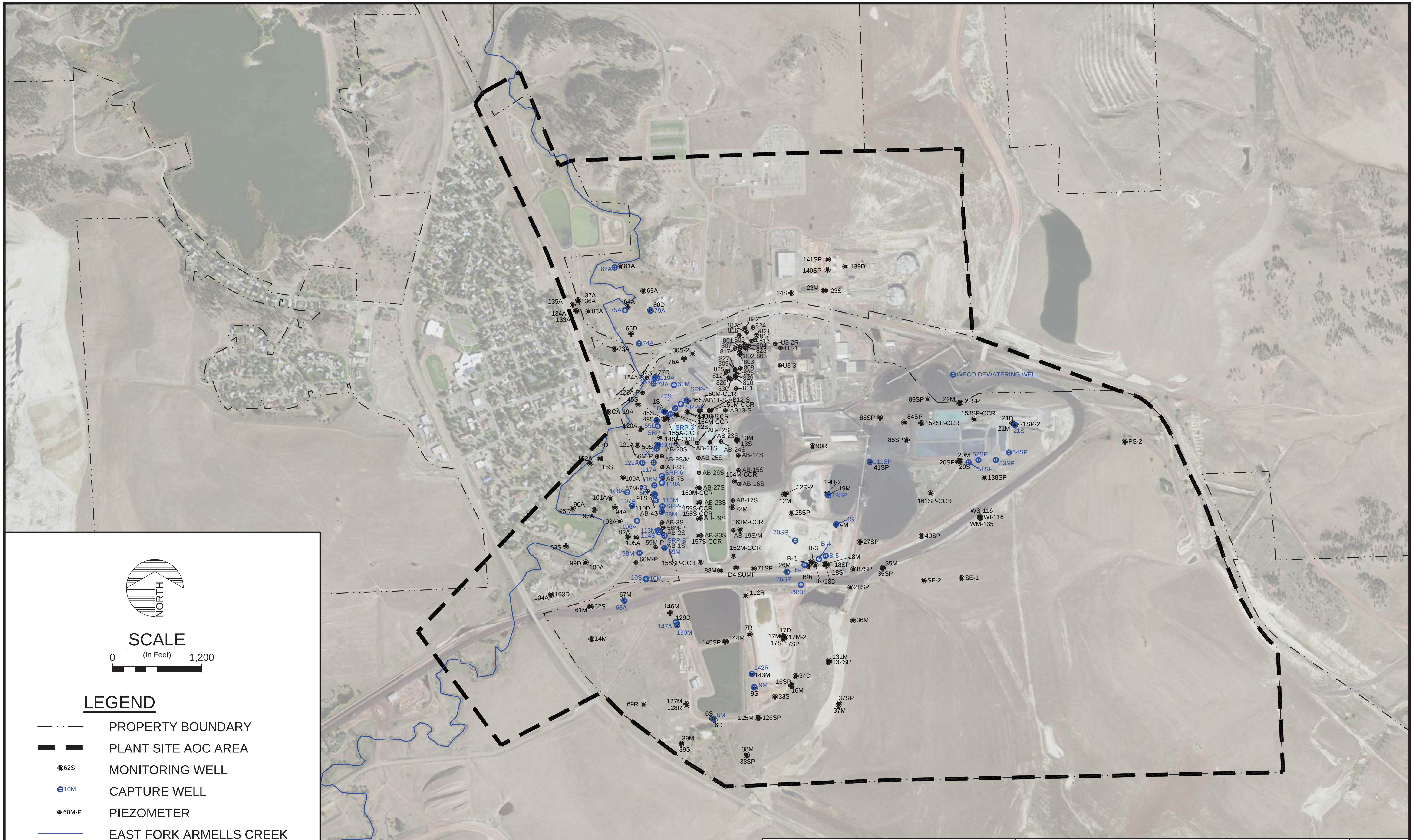
Revised Cleanup Criteria and Risk Assessment
Wastewater Facilities Comprising the
Closed-Loop System Plant Site Area Colstrip
Steam Electric Station Colstrip, Montana

PLANT SITE AREA AND FENCELINE

FIGURE
2



LEGEND

- · · — PROPERTY BOUNDARY
▬ ▬ PLANT SITE AOC AREA
● 62S MONITORING WELL
⊕ 10M CAPTURE WELL
● 60M-P PIEZOMETER
— EAST FORK ARMELLS CREEK

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Revised Cleanup Criteria and Risk Assessment
Wastewater Facilities Comprising the
Closed-Loop System Plant Site Area Colstrip
Steam Electric Station Colstrip, Montana

**PLANT SITE AREA
GROUNDWATER WELLS**

FIGURE
3

UPDATE TIME: 9:11 AM
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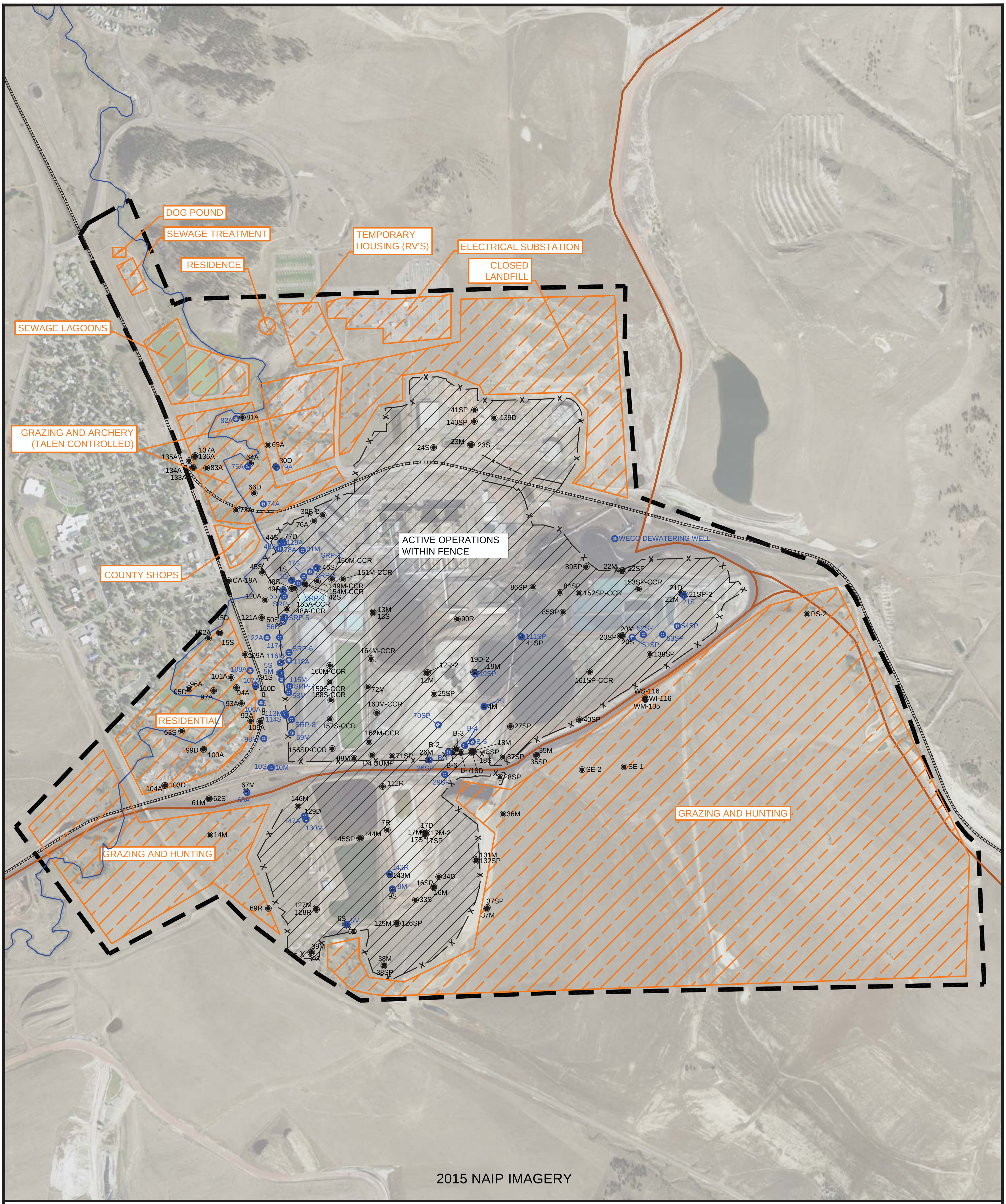

LEGEND

ROSEBUD MINE HAUL ROAD (RESTRICTED ACCESS)

RAIL ROAD

x FENCELINE (ACTIVE OPERATIONS WITHIN FENCE)

PLANT SITE AOC BOUNDARY

EAST FORK ARMELLS CREEK

▨ ACTIVE OPERATIONS WITHIN FENCE

▨ OTHER AREAS

NORTH

SCALE

0 (In Feet) 1200

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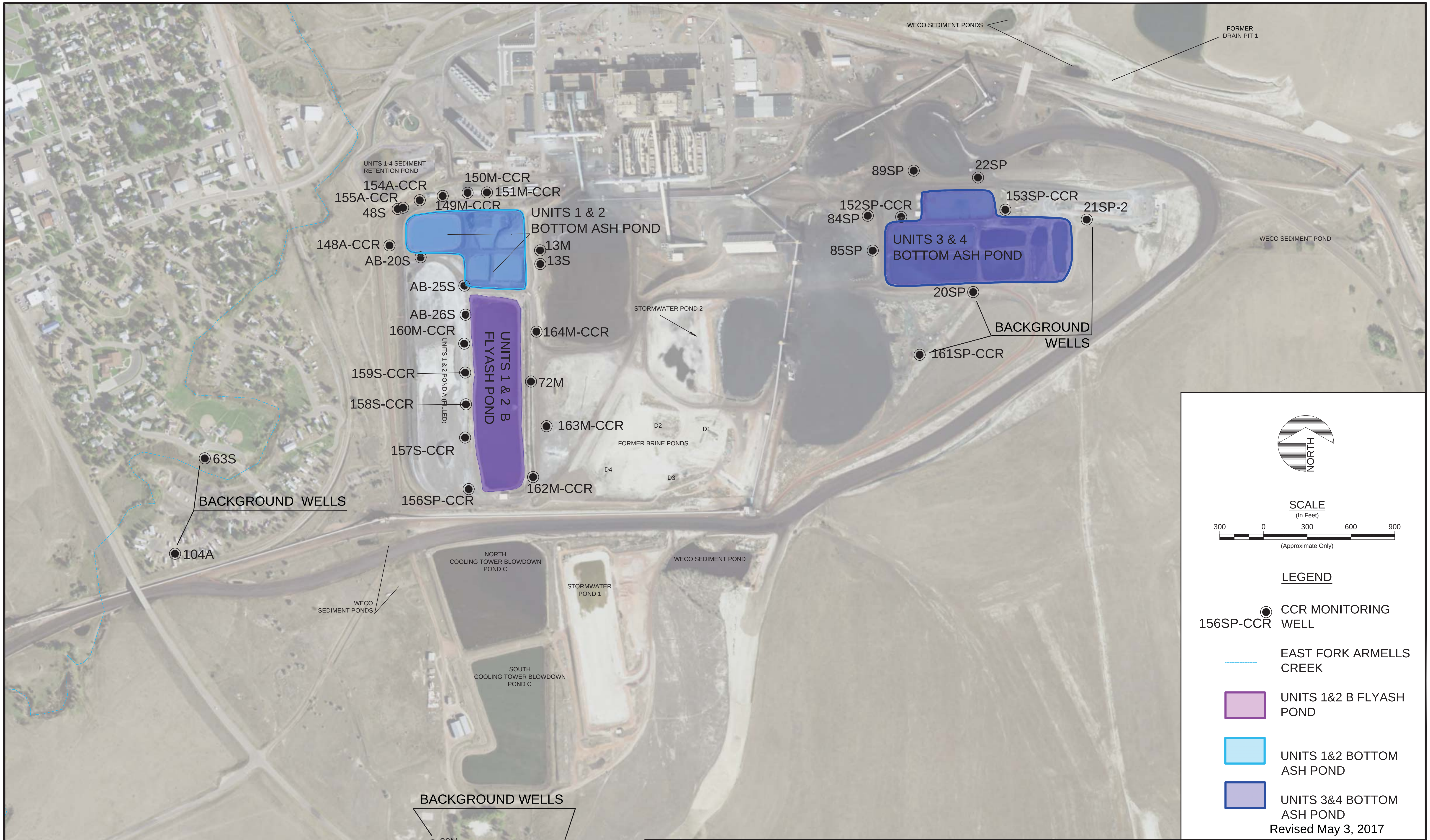
Revised Cleanup Criteria and Risk Assessment
Wastewater Facilities Comprising the
Closed-Loop System Plant Site Area Colstrip
Steam Electric Station Colstrip, Montana

PLANT SITE AREA AND CURRENT LAND USE

FIGURE
4



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Revised Cleanup Criteria and Risk Assessment
Wastewater Facilities Comprising the Closed-Loop
System Plant Site Area
Colstrip Steam Electric Station Colstrip, Montana

PLANT SITE CCR UNITS AND MONITORING WELLS

DRAWING FILE NUMBER
1207116B010
AUTOCAD 2000 DRAWING (DWG)
FIGURE
5

UPDATE TIME: 4:27 PM
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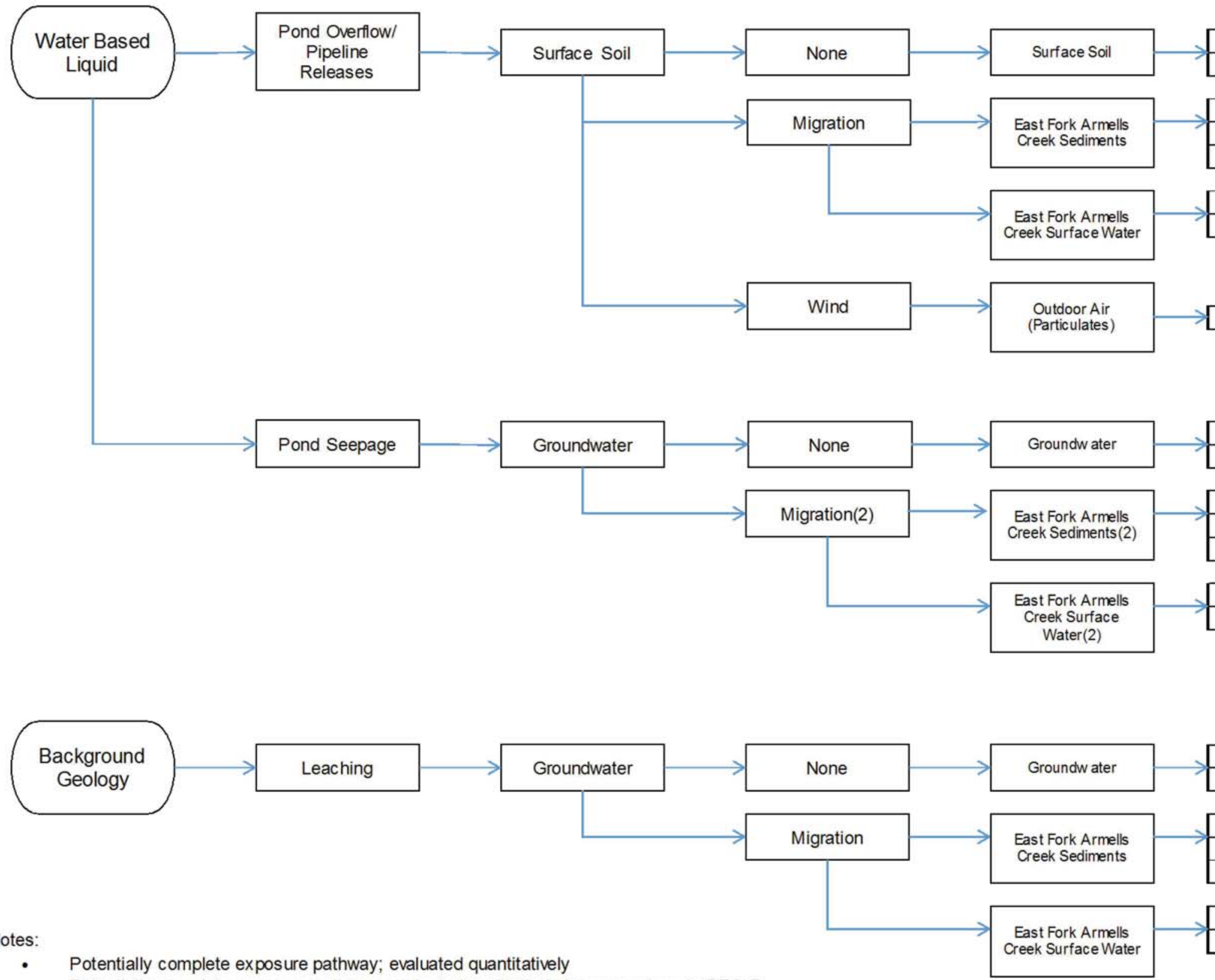

Primary Source	Primary Release Mechanism	Secondary Source	Secondary Release Mechanism	Media	Exposure Pathway	Current and Future Residents (Adult and Child)	Current and Future Industrial Outdoor Workers	Current and Future Construction Worker	Current and Future Recreational User	Terrestrial Ecological	Aquatic Ecological
						Current/Future Land Use					
						Human Receptors				Ecological Receptors	
Water Based Liquid	Pond Overflow/ Pipeline Releases	Surface Soil	None	Surface Soil	Ingestion	O (1)	•	•	•	•	O
					Dermal	O (1)	•	•	•	•	O
			Migration	East Fork Armells Creek Sediments	Ingestion	O (1)	•	(3)	•	•	•
					Dermal	O (1)	•	(3)	•	†	•
					Inhalation	O	O	O	O	O	O
				East Fork Armells Creek Surface Water	Ingestion	O (1)	~	(3)	~	•	~
					Dermal	O (1)	~	(3)	~	†	~
			Wind	Outdoor Air (Particulates)	Inhalation	O (1)	•	•	•	†	O
	Pond Seepage	Groundwater	None	Groundwater	Ingestion	~	~	~	O	Δ	O
					Dermal	~	~	~	O	O	O
			Migration(2)	East Fork Armells Creek Sediments(2)	Ingestion	•	•	(3)	•	•	•
					Dermal	•	•	(3)	•	†	•
					Inhalation	O	O	O	O	O	O
				East Fork Armells Creek Surface Water(2)	Ingestion	~	~	(3)	~	•	~
					Dermal	~	~	(3)	~	†	~
Background Geology	Leaching	Groundwater	None	Groundwater	Ingestion	~	~	~	O	Δ	O
					Dermal	~	~	~	O	O	O
			Migration	East Fork Armells Creek Sediments	Ingestion	•	•	(3)	•	•	•
					Dermal	•	•	(3)	•	†	•
					Inhalation	O	O	O	O	O	O
				East Fork Armells Creek Surface Water	Ingestion	~	~	(3)	~	•	~
					Dermal	~	~	(3)	~	†	~

Notes:

•	Potentially complete exposure pathway; evaluated quantitatively
~	Potentially complete exposure pathway; evaluated qualitatively by comparison to DEQ-7
†	Minor pathway, not quantitatively evaluated
O	Incomplete exposure pathway
(1)	Spill areas not located in a residential area
(2)	Groundwater migration to the creek is a hypothetical scenario to fulfill DEQ's request to evaluate the Facility without the capture system. At present, the capture system interupts this migration pathway.
(3)	Construction worker exposures to sediment and surface water are not required by DEQ (infrequent, minor pathways)
Δ	Livestock groundwater consumption (pumping of groundwater to stock tanks)

Marietta Canty, LLC
Environmental Consulting

Revised October 2017

Revised Cleanup Criteria and Risk Assessment
Wastewater Facilities Comprising the Closed-Loop
System Plant Site Area Colstrip Steam Electric Station
Colstrip, Montana

PRELIMINARY
SITE CONCEPTUAL EXPOSURE MODEL

FIGURE
6

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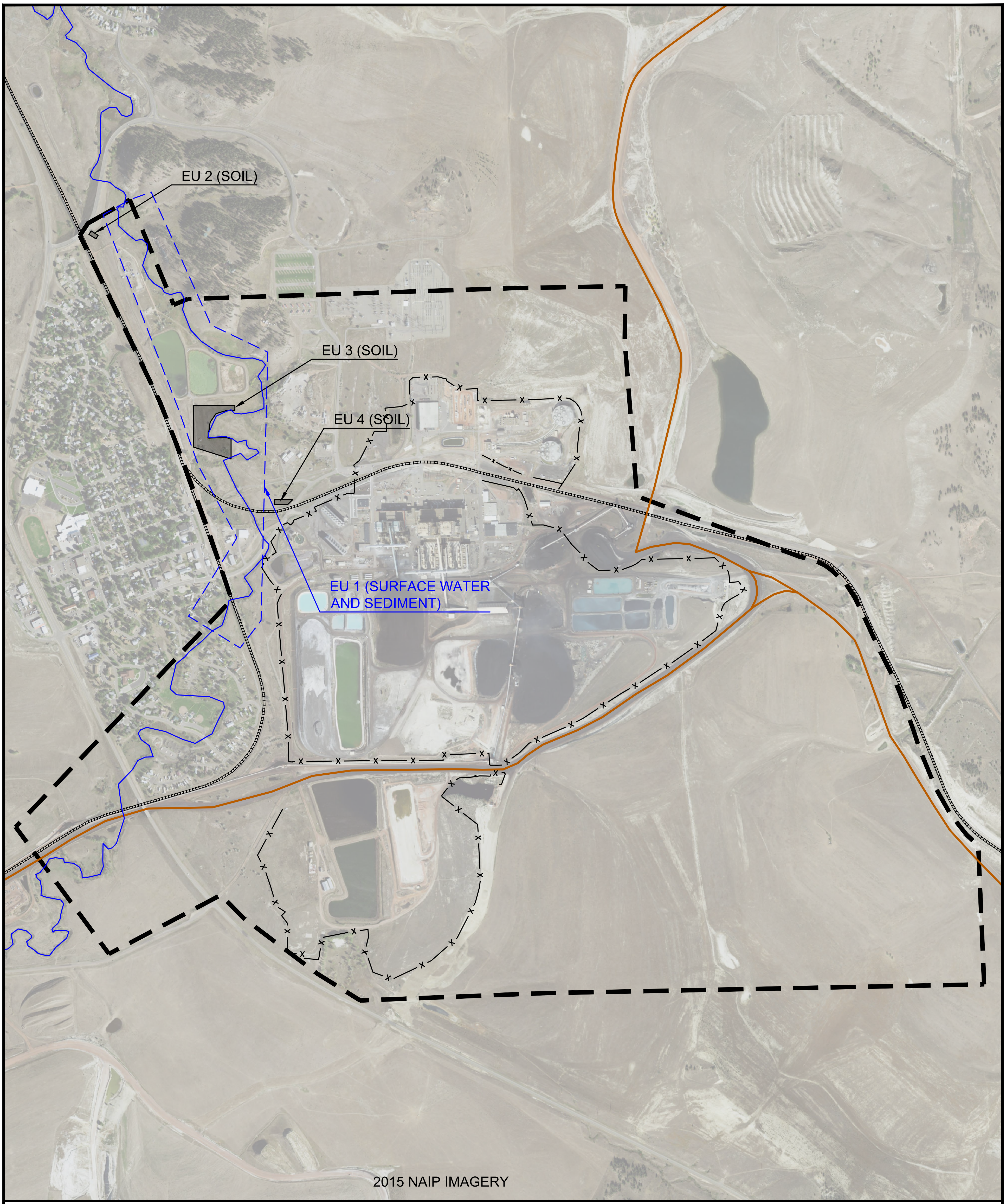

LEGEND

ROSEBUD MINE HAUL ROAD (RESTRICTED ACCESS)

RAILROAD

—x— FENCE (CHAIN-LINK WITH BARBED WIRE TOP)

PLANT SITE AOC BOUNDARY

EAST FORK ARMELLS CREEK

EU EXPOSURE UNIT

NORTH

SCALE
0 (In Feet) 1200

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Revised May 8, 2017

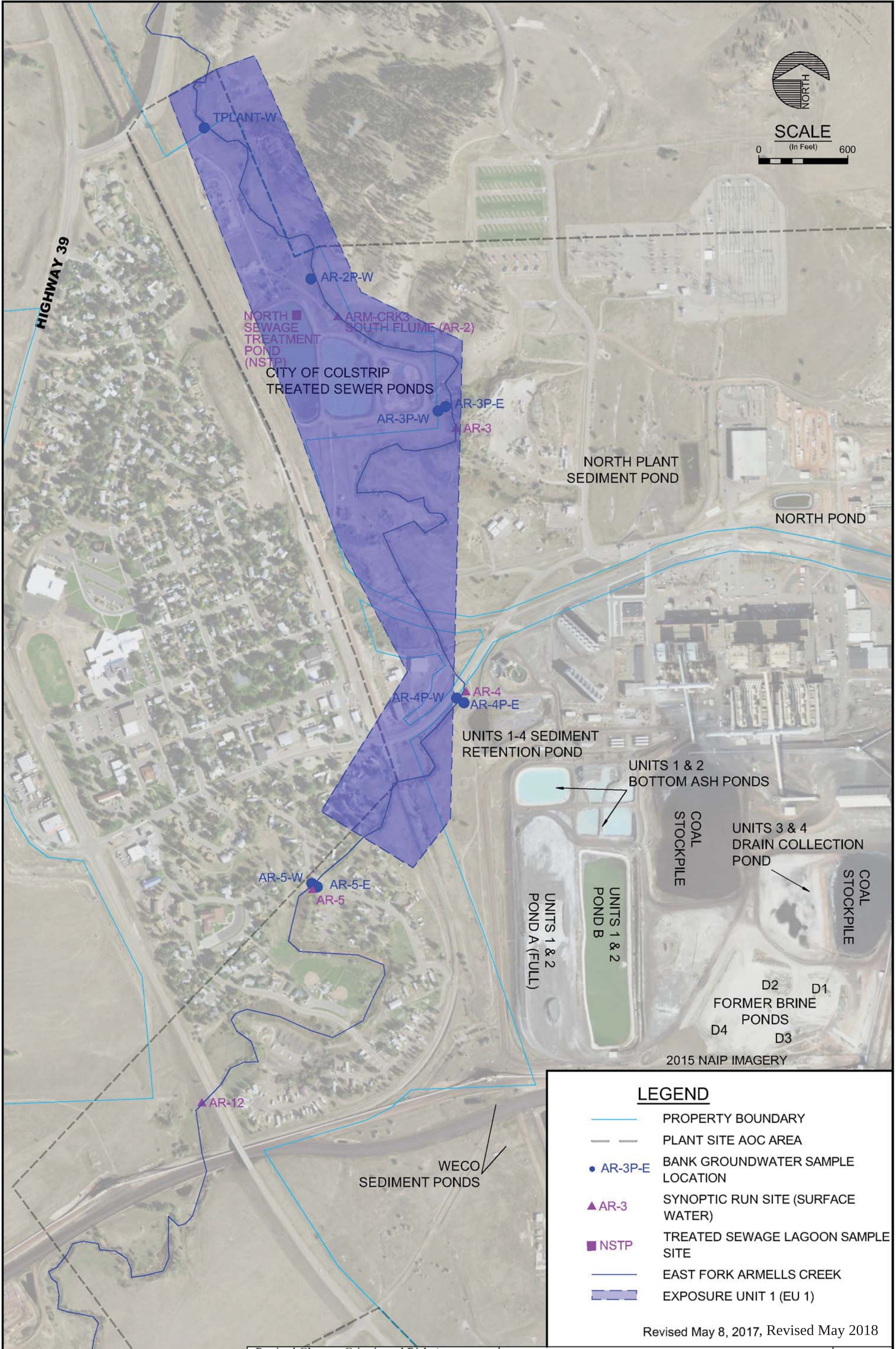
Revised Cleanup Criteria and Risk Assessment
Wastewater Facilities Comprising the
Closed-Loop System Plant Site Area Colstrip
Steam Electric Station Colstrip, Montana

PLANT SITE EXPOSURE UNITS

FIGURE
7

Revised May 2018

Revised May 2018



Revised May 8, 2017, Revised May 2018

Revised Cleanup Criteria and Risk Assessment Wastewater Facilities Comprising the Closed-Loop System Plant Site Area Colstrip Steam Electric Station Colstrip, Montana	**PLANT SITE EAST FORK ARMELLS CREEK SYNOPTIC RUN SAMPLING SITES (EU 1)**	FIGURE **8**

UPDATE TIME: 4:38 PM
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Revised May 3, 2017

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Revised Cleanup Criteria and Risk Assessment
Wastewater Facilities Comprising the Closed-Loop
System Plant Site Area Colstrip Steam Electric Station
Colstrip, Montana

BORING LOCATIONS - FORMER POWER ROAD SPILL AREA (EU2)

FIGURE
9

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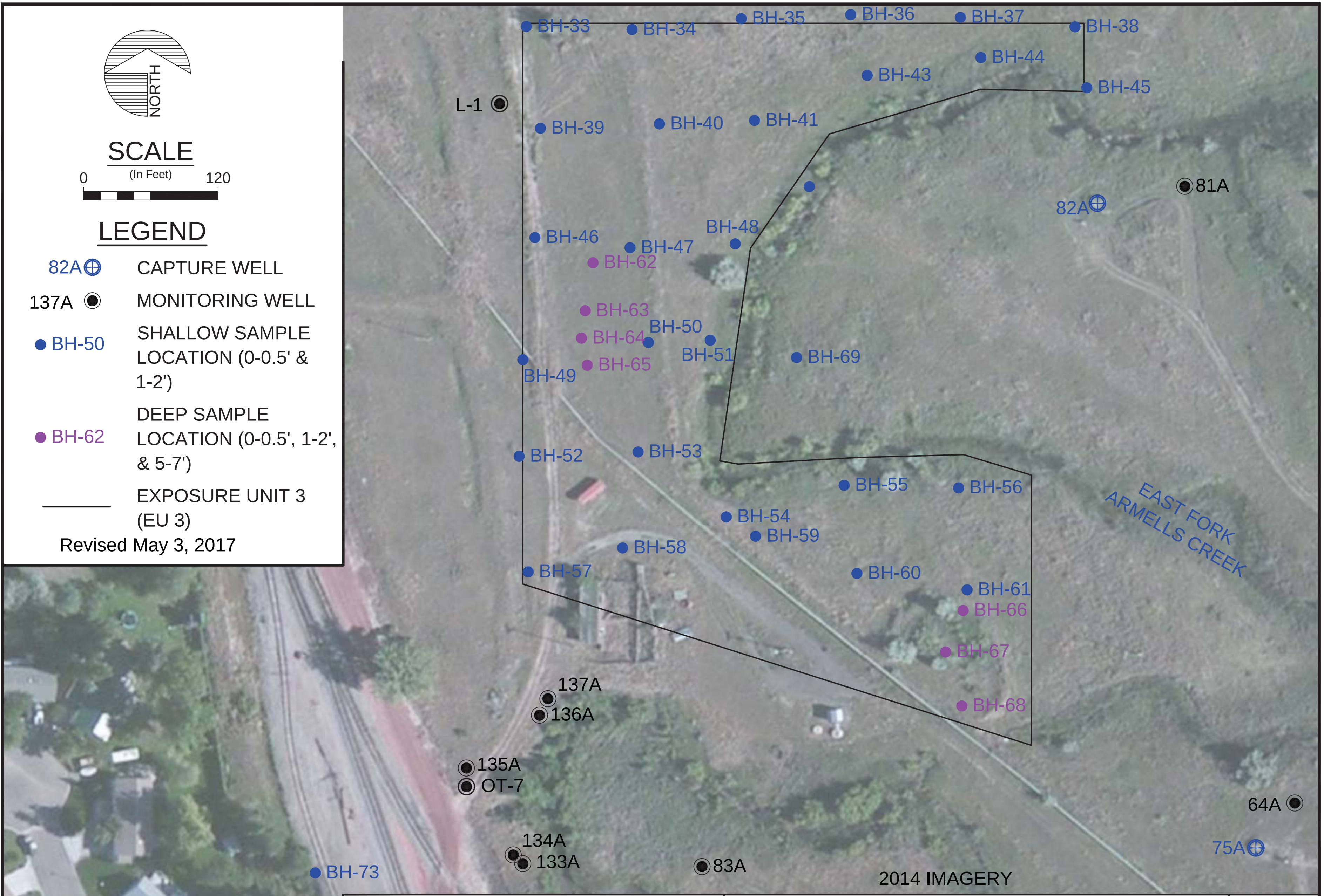

Revised Cleanup Criteria and Risk Assessment
Wastewater Facilities Comprising the Closed-Loop
System Plant Site Area Colstrip Steam Electric Station
Colstrip, Montana

BORING LOCATION - FORMER SPILL AREA NEAR SEWAGE LAGOONS (EU3)

FIGURE
10

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LEGEND

74A ⊕ CAPTURE WELL

66D ◉ MONITORING WELL

● BH-70 SHALLOW SAMPLE LOCATION (0-0.5' & 1-2')

——— EXPOSURE UNIT 4 (EU 4)

Revised May 3, 2017

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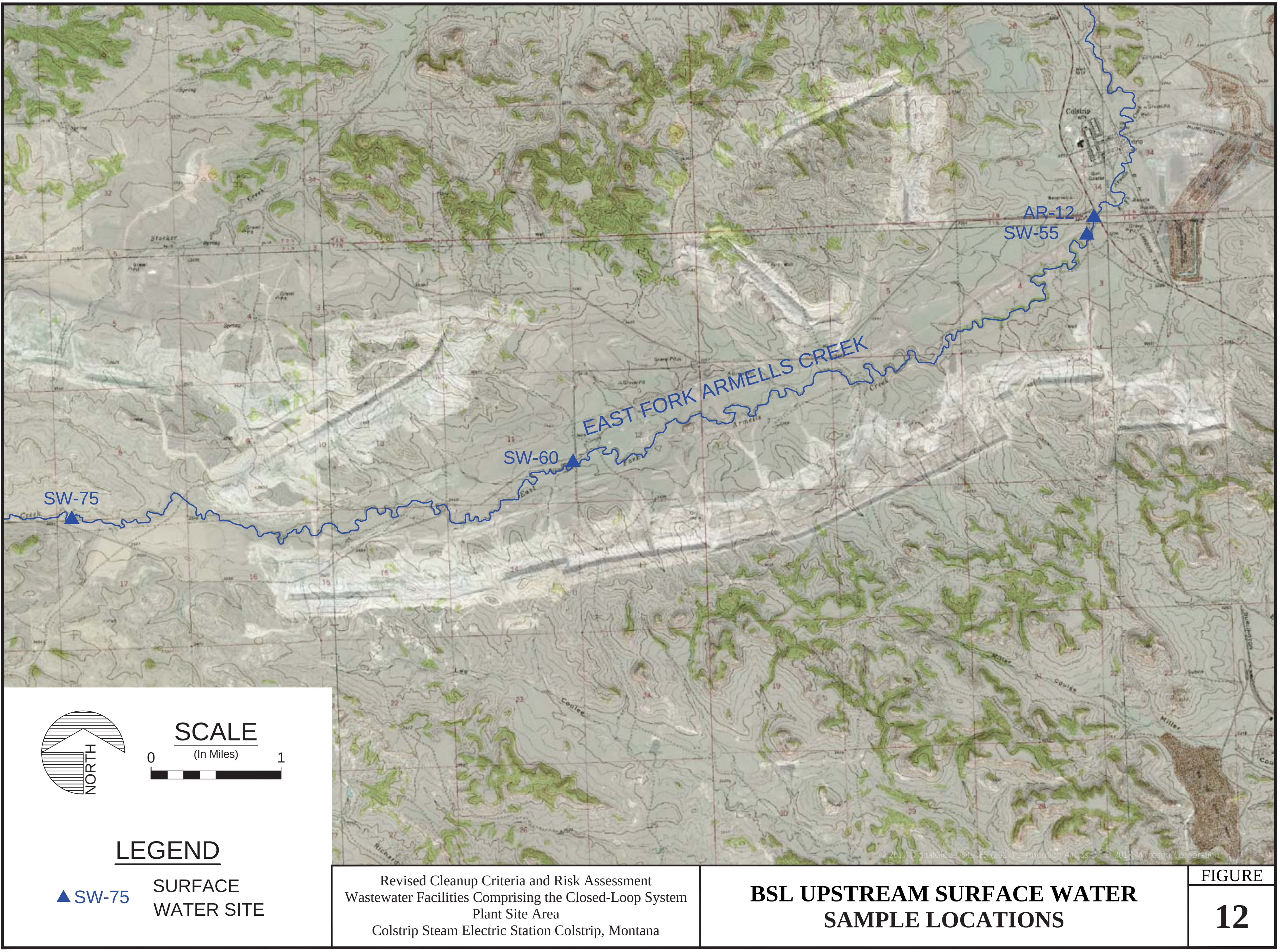
Revised Cleanup Criteria and Risk Assessment
Wastewater Facilities Comprising the Closed-Loop
System Plant Site Area Colstrip Steam Electric Station
Colstrip, Montana

BORING LOCATIONS - STORM WATER PONDING AREA (EU 4)

FIGURE
11



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LEGEND

▲ SW-75 SURFACE WATER SITE

Revised Cleanup Criteria and Risk Assessment
Wastewater Facilities Comprising the Closed-Loop System
Plant Site Area
Colstrip Steam Electric Station Colstrip, Montana

BSL UPSTREAM SURFACE WATER SAMPLE LOCATIONS

FIGURE
12

UPDATE TIME: 11:32 AM
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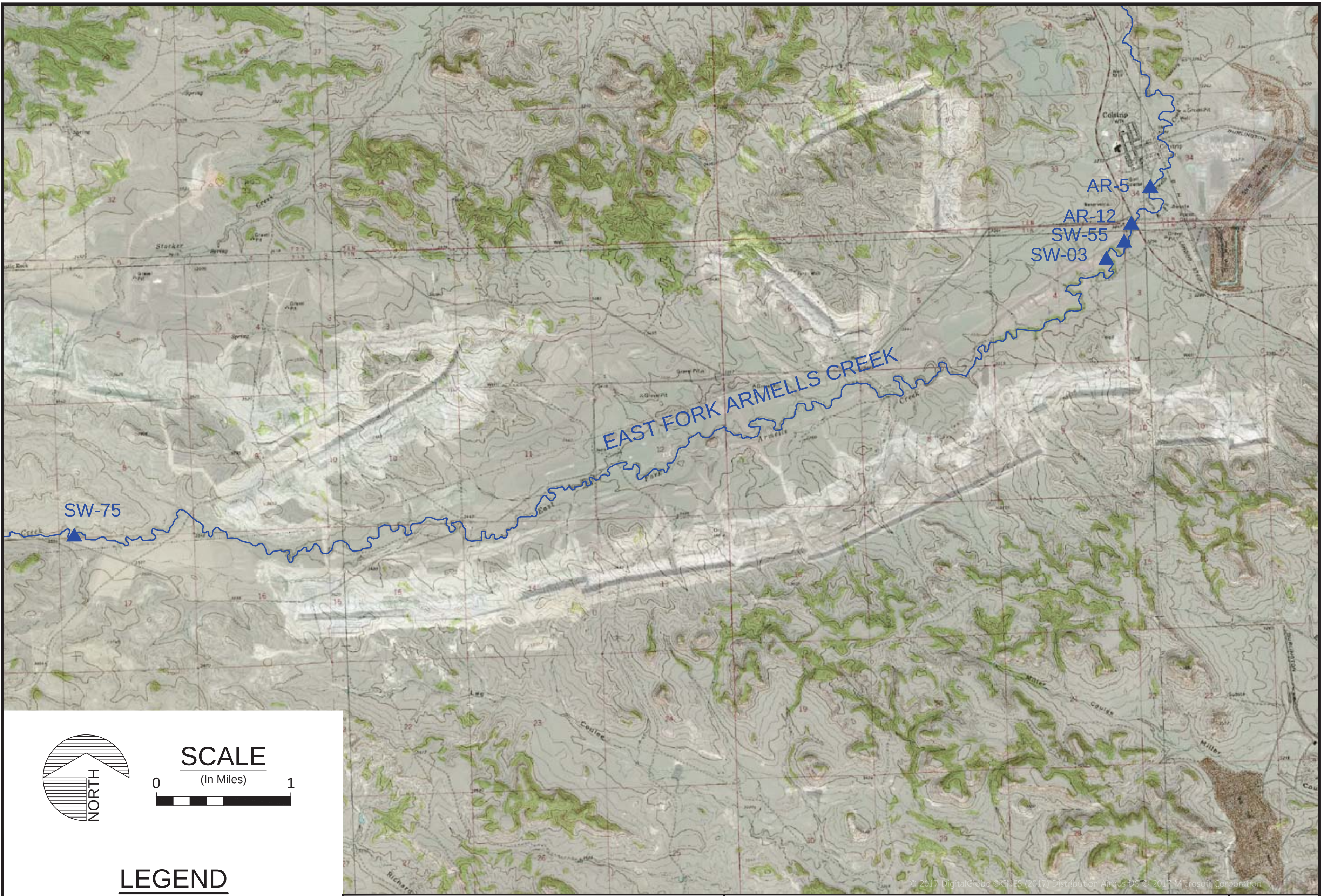

LEGEND

▲ SW-75	SURFACE WATER SITE

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Revised Cleanup Criteria and Risk Assessment
Wastewater Facilities Comprising the Closed-Loop System
Plant Site Area
Colstrip Steam Electric Station Colstrip, Montana

BTV UPGRADIENT SURFACE WATER LOCATIONS FOR MANGANESE

FIGURE
13

APPENDIX A

Administrative Order on Consent Summary

A. SUMMARY OF THE ADMINISTRATIVE ORDER ON CONSENT

The proposed approach for the selection of the Constituents of Interest (COIs) is presented in the following sections.

A.1 AOC DEFINITION OF COI AND CONTROL ACTIONS

The AOC (MDEQ/PPLM, 2012; Article IV.F) defines Constituents of Interest (COI) as those parameters found in soil, groundwater, or surface water that (1) result from Site operations and the wastewater facilities and (2) exceed background or unaffected reference area concentrations.

The AOC (MDEQ/PPLM, 2012; Article IV.B) defines Control Actions as remedial actions directed exclusively toward reducing, containing or controlling the seepage or migration of regulated substances including but not limited to sulfate, boron, selenium, potassium, sodium, magnesium, total dissolved solids, and salinity measured by specific electrical conductance through the environment. Control actions shall include affirmative source mitigation measures.
Based on the above AOC definitions, COIs and regulated substances may overlap. The regulated substances listed in the Control Action definition (sulfate, boron, selenium, potassium, sodium, magnesium, total dissolved solids, and salinity) are interpreted as the minimum required constituents that should be included in the remedial action development. The COIs are interpreted as constituents beyond the minimum required constituents that may be identified in soil, groundwater, or surface that resulted from Site operations and exceed background concentrations. Both the regulated substances and the COIs are interpreted to require inclusion in the remedial action development. Remedial actions designed to directly mitigate certain constituents will indirectly mitigate other constituents, as well.

A.2 AOC DEFINITION OF CLEANUP CRITERIA

The AOC (MDEQ/PPLM, 2012; Article IV.G) defines the following Cleanup Criteria for the COIs:

1. For each COI in ground or surface water, except for the evaluation for ecological receptors, the applicable standard contained in the most current version of Circular DEQ-7 Montana Numeric Water Quality Standards ("DEQ-7"), the USEPA maximum contaminant level, the risk-based screening level contained in the most current version of Montana Risk-Based Guidance for Petroleum Releases, *whichever* is more stringent; and, for COIs for which there is not a DEQ-7 standard, a maximum contaminant level, or a risk-based screening level contained in the Montana Risk-Based Guidance for Petroleum Releases, the tap water screening level contained in the most current version of USEPA Regional Screening Levels for Chemical Constituents at Superfund Sites, except that no criterion may be more stringent than the background or unaffected reference areas concentrations; and

2. For each COI in ground or surface water that may impact an ecological receptor, an acceptable ecological risk determined using the most current versions of standard USEPA ecological risk assessment guidance if the criteria set pursuant to (1) above are not adequate to protect ecological receptors, except that no criterion may be more stringent than the background or unaffected reference areas concentrations;

3. For each COI in soil, the more stringent of:

    (a) A cumulative human health risk of 1 x 10^{-5} for carcinogens or a cumulative hazard index of 1 for non-carcinogenic COIs, except that no criterion may be more stringent than the background or unaffected reference areas concentrations;

    (b) An acceptable ecological risk, determined using the most current versions of standard USEPA ecological risk assessment guidance if the criteria set pursuant to (a) above are not adequate to protect ecological receptors, except that no criterion may be more stringent than the background or unaffected reference areas concentrations; or

    (c) The risk-based screening level contained in the most current version of Montana Risk-Based Guidance for Petroleum Releases, except that no criterion may be more stringent than the background or unaffected reference areas concentrations.

A.2.1 Groundwater Cleanup Criteria

According to the AOC, the Cleanup Criteria for each groundwater COI, except for the evaluation for ecological receptors, is the most stringent of the following:

- The applicable standard contained in the most current version of Circular DEQ-7 Montana Numeric Water Quality Standards ("DEQ-7"). It should be noted, in addition, that the MDEQ considers the DEQ-7 Standards to be clean-up values for groundwater, rather than screening levels (MDEQ, 2014).

- The USEPA maximum contaminant level (MCL)

- The risk-based screening level (RBSL) contained in the most current version of Montana Risk-Based Guidance for Petroleum Releases

In addition, for COIs for which there is not a DEQ-7 standard, a maximum contaminant level, or a risk-based screening level contained in the Montana Risk-Based Guidance for Petroleum Releases, the cleanup criteria will be the tap water screening level contained in the most current version of the USEPA Regional Screening Levels (RSLs) for Chemical Constituents at Superfund Sites. No cleanup criterion, however, may be more stringent than the background or unaffected reference areas concentrations.

A.2.2 Surface Water Cleanup Criteria

According to the AOC, the Cleanup Criteria for each COI in surface water, except for the evaluation for ecological receptors, is the most stringent of the following:

- The applicable standard contained in the most current version of the DEQ-7 Circular. It should be noted, in addition, that the MDEQ considers the DEQ-7 Standards to be clean-up values for groundwater, rather than screening levels (MDEQ, 2014).

- The USEPA MCL.

- The RBSL contained in the most current version of Montana Risk-Based Guidance for Petroleum Releases.

In addition, for COIs for which there is not a DEQ-7 standard, a MCL, or a RBSL contained in the Montana Risk-Based Guidance for Petroleum Releases, the cleanup criteria will be the tap water screening level contained in the most current version of the EPA RSLs for Chemical Constituents at Superfund Sites. No cleanup criterion, however, may be more stringent than the background or unaffected reference areas concentrations. Note also, that some special cases may exist due to geospatial variations, in which ambient water at one site is naturally above background screening levels. Such cases will require examination on an individual basis in conjunction with the MDEQ.

A.2.3 Soil Cleanup Criteria

According to the AOC, the cleanup criteria for each COI in soil (soil data is available for areas of surface releases and sediment data is available for the Creek) is the most stringent of the following:

(a) A cumulative human health risk of 1×10^{-5} for carcinogens or a cumulative hazard index of 1 for non-carcinogenic constituents of interest, except that no criterion may be more stringent than the background or unaffected reference areas concentrations;

(b) An acceptable ecological risk, determined using the most current versions of standard USEPA ecological risk assessment guidance if the criteria set pursuant to (a) above are not adequate to protect ecological receptors, except that no criterion may be more stringent than the background or unaffected reference areas concentrations; or

(c) The risk-based screening level contained in the most current version of Montana Risk-Based Guidance for Petroleum Releases, except that no criterion may be more stringent than the background or unaffected reference areas concentrations.

Note: The AOC does not specifically define sediment cleanup criteria separately from soil cleanup criteria. However, according to DEQ guidance (2016a), sediment concentrations should be compared to the following ecological screening levels.

- USEPA Region 3 Biological Technical Assistance Group (BTAG) Freshwater Sediment Screening Benchmarks.

APPENDIX B

USEPA RAGS Part D Tables 1 through 10

Table B-1.1 USEPA RAGS Part D Table 1 , Selection of Exposure Pathways for Surface Water 5/1/2018

Human Health Risk Assessment

Wastewater Facilities Comprising the Closed Loop System

Plant Site Area, Colstrip Steam Electric Station, Colstrip Montana

Scenario Timeframe	Medium	Exposure Medium	Exposure Point	Receptor Population	Receptor Age	Exposure Route	Type of Analysis	Rational for Selection or Exclusion of Exposure Path
Current and Future	Surface Water	Surface Water	EU 1 East Fork Armells Creek Plant Site Area	Resident	Adult and Child	Dermal and Incidental Ingestion	Qual.	East Fork Armells Creek runs through the residential area southwest of the Plant Site. Note: the spill areas are not located in residential areas.
				Industrial Outdoor Worker	Adult		Qual.	In the commercial/industrial areas of the Creek, industrial outdoor workers may be exposed (e.g., sewage treatment plant area).
				Construction* Worker	Adult		None	Infrequent minor exposure.
				Recreational User	Adult and Child		Qual.	Adults and children may use the creek recreationally. Particularly children may play in the Creek. The creek, however, does not support a fishing resource.

Notes:

Construction*	DEQ does not require evaluation of the construction worker receptor to surface water as it is an infrequent minor exposure
EU	Exposure unit
RAGS	Risk Assessment Guidance for Superfund
Qual.	Qualitative; this scenario qualitatively assessed through comparison (as appropriate) to DEQ-7 standards, MCLs, Tapwater RSLs and BSLs
Quan.	Quantitative; this scenario was quantitatively assessed in the human health risk assessment
USEPA	United States Environmental Protection Agency

Table B-1.2 USEPA RAGS Part D Table 1 , Selection of Exposure Pathways for Sediment 5/1/2018
Human Health Risk Assessment
Wastewater Facilities Comprising the Closed Loop System
Plant Site Area, Colstrip Steam Electric Station, Colstrip Montana

Scenario Timeframe	Medium	Exposure Medium	Exposure Point	Receptor Population	Receptor Age	Exposure Route	Type of Analysis	Rational for Selection or Exclusion of Exposure Path
Current and Future	Sediment	Sediment	EU 1 East Fork Armells Creek Plant Site Area	Resident	Adult and Child	Dermal and Incidental Ingestion	Quan.	East Fork Armells Creek runs through the residential area southwest of the Plant Site. Note: the spill areas are not located in residential areas.
				Industrial Outdoor Worker	Adult		Quan.	In the commercial/industrial areas of the Creek, industrial outdoor workers may be exposed (e.g., sewage treatment plant area).
				Construction* Worker	Adult		None	Infrequent minor exposure.
				Recreational User	Adult and Child		Quan.	Adults and children may use the creek recreationally. Particularly children may play in the Creek.
Current and Future	Sediment	Sediment	EU 1 East Fork Armells Creek	Resident	Adult and Child	Inhalation	None	Sediments within East Fork Armells Creek are saturated in the Exposure Unit with significant vegetation along the streambanks. As such, inhalation via fugitive dust emissions are unlikely making it an incomplete pathway.
				Industrial Outdoor Worker	Adult		None	
				Construction* Worker	Adult		None	
				Recreational User	Adult and Child		None	

Notes:

Construction*	DEQ does not require evaluation of the construction worker receptor to sediment as it is an infrequent minor exposure
EU	Exposure unit
RAGS	Risk Assessment Guidance for Superfund
Quan.	Quantitative; this scenario was quantitatively assessed in the human health risk assessment
USEPA	United States Environmental Protection Agency

Table B-1.3 USEPA RAGS Part D Table 1 , Selection of Exposure Pathways for Soil 5/1/2018

Human Health Risk Assessment

Wastewater Facilities Comprising the Closed Loop System

Plant Site Area, Colstrip Steam Electric Station, Colstrip Montana

Scenario Timeframe	Medium	Exposure Medium	Exposure Point	Receptor Population	Receptor Age	Exposure Route	Type of Analysis	Rational for Selection or Exclusion of Exposure Path
Current and Future	Soil	Soil	EUs 2 thru 4 Former Spill Areas Plant Site Area	Resident	Adult and Child	Dermal and Incidental Ingestion	None	The former spill areas are not located within the residential area of the Plant Site Area.
				Industrial Outdoor Worker	Adult		Quan.	In the commercial/industrial areas, industrial outdoor workers may be exposed (e.g., sewage treatment plant area).
				Construction Worker	Adult		Quan.	Construction work may occur in the former spill areas.
				Recreational User	Adult and Child		Quan.	Adults and children may recreationally use the former spill areas.
Current and Future	Soil	Soil	EUs 2 thru 4 Former Spill Areas Plant Site Area	Resident	Adult and Child	Inhalation of Soil Particulates	None	The former spill areas are not located within the residential area of the Plant Site Area.
				Industrial Outdoor Worker	Adult		Quan.	In the commercial/industrial areas, industrial outdoor workers may be exposed (e.g., sewage treatment plant area).
				Construction Worker	Adult		Quan.	Construction work may occur in the former spill areas.
				Recreational User	Adult and Child		Quan.	Adults and children may recreationally use the former spill areas.

Notes:

EU	Exposure unit
RAGS	Risk Assessment Guidance for Superfund
Quan.	Quantitative; this scenario was quantitatively assessed in the human health risk assessment
USEPA	United States Environmental Protection Agency

Table B-1.4 USEPA RAGS Part D Table 1 , Selection of Exposure Pathways for Groundwater 5/1/2018

Human Health Risk Assessment

Wastewater Facilities Comprising the Closed Loop System

Plant Site Area, Colstrip Steam Electric Station, Colstrip Montana

Scenario Timeframe	Medium	Exposure Medium	Exposure Point	Receptor Population	Receptor Age	Exposure Route	Type of Analysis	Rational for Selection or Exclusion of Exposure Path
Current and Future	Groundwater	Groundwater	EU 5 Groundwater Plant Site Area	Resident	Adult and Child	Ingestion and Dermal	Qual.	Although groundwater is not currently used as a potable water source, no current restrictions prevent groundwater from being used as drinking water.
				Industrial Outdoor Worker	Adult		Qual.	Although groundwater is not currently used as a potable water source, no current restrictions prevent groundwater from being used as drinking water.
				Construction Worker	Adult		Qual.	Construction workers may come into contact with shallow groundwater. DEQ-7 standards are considered protective of this infrequent exposure.
				Recreational User	Adult and Child		None	Recreational users do not have groundwater access and, thus, there is no potential exposure for these receptors.

Notes:

EU	Exposure unit
RAGS	Risk Assessment Guidance for Superfund
Qual.	Qualitative; this scenario qualitatively assessed through comparison (as appropriate) to DEQ-7 standards, MCLs, Tapwater RSLs and BSLs
Quan.	Quantitative; this scenario was quantitatively assessed in the human health risk assessment
USEPA	United States Environmental Protection Agency

Table B-2.1 USEPA RAGS Part D Table 2, Data Summary for Surface Water, EU1, mg/L
Human Health Risk Assessment
Wastewater Facilities Comprising the Closed Loop System
Plant Site Area, Colstrip Steam Electric Station, Colstrip, Montana

5/1/2018

Exposure Unit	Surface Water Sampling Locations	CAS Number	Chemical*	Data Time Range	Minimum (6) Concentration/ Location/ Date	Maximum (6) Concentration/ Location/Date	Detection Frequency (6)	Range of Detection Limits for Non-Detects	Most Recent Concentration Maximum/ Location/ Date	Maximum Upgradient Concentration/ AR-12 or AR-5 / Date (7)	Background Screening Level (2016)	Background Threshold Value*	Screening Value DEQ-7	COPC? (Y/N)	Rationale for Selection or Deletion
EU 1 East Fork Armells Creek	AR-2 to AR-4	7429-90-5	Aluminum Dissolved	4/8/2014 - 10/16/2014 (1)	0.011 AR-2SF 10/16/2014	0.019 NSTP 10/16/2014	2/8	<0.009 to <0.05	0.019 NSTP 10/16/2014 (1)	0.015 AR-12 10/16/2014	NA	NA	No HHS(2) NC 20 Tap Water RSL	N	BSL BB
EU 1 East Fork Armells Creek	AR-2 to AR-4	7429-90-5	Aluminum Total	4/8/2014 - 10/15/2015	0.01 AR-2SF 3/19/2015	2.48 AR-3 10/15/2015	14/15	<0.009 to <0.05	2.48 AR-3 10/15/2015	24 AR-12 10/15/2015	34.3	NA	No HHS(2) NC 20 Tap Water RSL	N	BSL BB
EU 1 East Fork Armells Creek	AR-2 to AR-5	7440-38-2	Arsenic Total	4/8/2014 - 10/15/2015	0.001 several	0.019 AR-3 10/15/2015	11/15	<0.001	0.019 AR-3 10/15/2015	0.058 AR-5 10/15/2015	0.017	NA	0.010 (3) C	N	BB
EU 1 East Fork Armells Creek	AR-2 to AR-4	7440-41-7	Beryllium Total	4/8/2014 - 10/15/2015	<0.001 several	<0.002 several	0/15	<0.001 to <0.002	<0.002 several 10/15/2015	<0.002 AR-12/AR-5 10/15/2015	NA	NA	0.004(3) C	N	All ND DL is BSL
EU 1 East Fork Armells Creek	AR-2 to AR-4	7440-42-8	Boron Total	4/8/2014 - 10/15/2015	0.51 AR-4, 3/19/2015	1.83 AR-2SF 10/15/2015	15/15	NA	1.83 AR-2SF 10/15/2015	2.06 AR-5 10/15/2015	0.88	NA	No HHS(2) NC 4.0 Tapwater RSL	N	No HHS (DEQ-7) BSL BB
EU 1 East Fork Armells Creek	AR-2 to AR-4	7440-43-9	Cadmium Total	4/8/2014 - 10/15/2015	0.00007 NSTP 3/19/2015	0.00017 AR-3 10/15/2015	2/11	<0.00003 to <0.0005	0.00017 AR-3 10/15/2015	0.0006 AR-12 10/15/2015	0.002	NA	0.005 (3) NC	N	High % of ND BSL BB
EU 1 East Fork Armells Creek	AR-2 to AR-4	7440-70-2	Calcium	4/8/2014 - 10/15/2015	84 NSTP 4/8/2014	361 AR-2SF 9/3/2014	18/18	NA	349 AR-2SF 10/15/2015	397 AR-5 10/15/2015	369	NA	NA	N	BB
EU 1 East Fork Armells Creek	AR-2 to AR-4	16887-00-6	Chloride	4/8/2014 - 10/15/2015	39 AR-4 3/19/2015	166 AR-4 10/16/2014	18/18	NA	125 NTSP 10/15/2015	239 AR-12 10/15/2015	228	NA	NA	N	BB
EU 1 East Fork Armells Creek	AR-2 to AR-4	7440-50-8	Copper Total	4/8/2014 - 10/15/2015	0.003 NTSP 10/16/2014	0.009 AR-3 10/15/2015	4/15	<0.002	0.009 AR-3 10/15/2015	0.032 AR-12 10/15/2015	0.1	NA	1.3 (4) NC	N	BB BSL

Table B-2.1 USEPA RAGS Part D Table 2, Data Summary for Surface Water, EU1, mg/L 5/1/2018
Human Health Risk Assessment
Wastewater Facilities Comprising the Closed Loop System
Plant Site Area, Colstrip Steam Electric Station, Colstrip, Montana

Exposure Unit	Surface Water Sampling Locations	CAS Number	Chemical*	Data Time Range	Minimum (6) Concentration/ Location/ Date	Maximum (6) Concentration/ Location/Date	Detection Frequency (6)	Range of Detection Limits for Non-Detects	Most Recent Concentration Maximum/ Location/ Date	Maximum Upgradient Concentration/ AR-12 or AR-5 / Date (7)	Background Screening Level (2016)	Background Threshold Value*	Screening Value DEQ-7	COPC? (Y/N)	Rationale for Selection or Deletion
EU 1 East Fork Armells Creek	AR-2 to AR-4	16984-48-8	Fluoride	4/8/2014 - 10/15/2015	0.2 several	0.4 NSTP, 4/8/2014 AR-2SF, 10/15/2015	14/14	NA	0.4 NSTP, 4/8/2014 AR-2SF, 10/15/2015	0.3 AR-12 10/16/2014	0.32	NA	4.0 (3) NC	N	BSL NB
EU 1 East Fork Armells Creek	AR-2 to AR-4	7439-92-1	Lead Total	4/8/2014 - 10/15/2015	0.0007 AR-2SF 10/15/2015	0.0072 AR-3 10/15/2015	4/15	<0.0003	0.0072 AR-3 10/15/2015	0.0233 AR-12 10/15/2015	0.06	NA	0.015 (3) NC	N	BSL BB
EU 1 East Fork Armells Creek	AR-2 to AR-4	7439-96-5	Manganese Total	4/8/2014 - 10/15/2015	0.059 NSTP, 10/16/2014	3.27 AR-3 10/15/2015	15/15	NA	3.27 AR-3 10/15/2015	11.6 AR-5 10/15/2015	1.6	5.08	No HHS(2) NC 0.43 Tap Water RSL	Y (8)	ASL
EU 1 East Fork Armells Creek	AR-2 to AR-4	7439-97-6	Mercury Total	4/8/2014 - 10/15/2015	0.00005 NSTP 10/16/2014	0.00005 NSTP 10/16/2014	1/15	<0.00005 to <0.0001	<0.00005 several	<0.0002 AR-12 10/15/2015	0.001	NA	0.00005 (4) NC	N	High % of ND BB
EU 1 East Fork Armells Creek	AR-2 to AR-4	7440-02-0	Nickel Total	4/8/2014 - 10/15/2015	0.002 AR-4 10/16/2014	0.01 AR-3 10/15/2015	12/15	<0.002	0.01 AR-3 10/15/2015	0.064 AR-12 10/15/2015	0.0217	NA	0.1 (5) NC	N	BB BSL
EU 1 East Fork Armells Creek	AR-2 to AR-4	NA	pH	4/8/2014 - 10/15/2015	7.39 AR-3 10/16/2014	8.69 NSTP 10/15/2015	NA	NA	8.69 NSTP 10/15/2015	7.97 AR-12 10/15/2015	NA	NA	NA	N	No DEQ-7
EU 1 East Fork Armells Creek	AR-2 to AR-4	7782-49-2	Selenium Total	4/8/2014 - 10/15/2015	0.001 NSTP,3/19/2015 AR-2SF, 3/19/2015	0.002 AR-3 3/19/2015	3/15	<0.001 to <0.002	<0.001 AR-3,NSTP, AR-2SF 10/15/2015	0.004 AR-5 10/15/2015	0.01	NA	0.050 (3) NC	N	BB BSL
EU 1 East Fork Armells Creek	AR-2 to AR-4	7447-24-6	Strontium Total	4/8/2014 - 10/15/2015	1.16 NSTP 4/8/2014	8.13 AR-4 10/16/2014	15/15	NA	5.43 AR-3 10/15/2015	11.8 AR-12 10/15/2015	NA	NA	4.0 (5) NC	N	BB
EU 1 East Fork Armells Creek	AR-2 to AR-4	14808-79-8	Sulfate	4/8/2014 - 10/15/2015	419 NSTP 3/19/2015	2,190 AR-4 10/16/2014	18/18	NA	1,400 AR-3 10/15/2015	2,800 AR-5 10/15/2015	2,260	NA	NA	N	BB No Tox Values
EU 1 East Fork Armells Creek	AR-2 to AR-4	7440-28-0	Thallium Total	4/8/2014 - 10/15/2015	<0.0003 all	<0.0003 all	0/15	<0.0003	<0.0003 AR-3,NSTP, AR-2SF 10/15/2015	0.0006 AR-12 10/15/2015	NA	NA	0.00024 (4) NC	N	All ND DL is BB
EU 1 East Fork Armells Creek	AR-2 to AR-4	NA	Total Dissolved Solids (TDS)	4/8/2014 - 10/15/2015	1,120 NSTP 4/8/2014	4,070 AR-3 10/16/2014	18/18	NA	2,430 AR-3 10/15/2015	6,590 AR-12 10/15/2015	NA	NA	NA	N	BB
EU 1 East Fork Armells Creek	AR-2 to AR-4	7440-62-2	Vanadium Total	4/8/2014 - 10/15/2015	0.02 AR-3 10/15/2015	0.02 AR-3 10/15/2015	1/15	<0.01	0.02 AR-3 10/15/2015	0.18 AR-12 10/15/2015	0.1	NA	No HHS(2) NC 0.086 Tap Water RSL	N	High % of ND BB BSL

Table B-2.1 USEPA RAGS Part D Table 2, Data Summary for Surface Water, EU1, mg/L

5/1/2018

Human Health Risk Assessment

Wastewater Facilities Comprising the Closed Loop System

Plant Site Area, Colstrip Steam Electric Station, Colstrip, Montana

Exposure Unit	Surface Water Sampling Locations	CAS Number	Chemical*	Data Time Range	Minimum (6) Concentration/ Location/ Date	Maximum (6) Concentration/ Location/Date	Detection Frequency (6)	Range of Detection Limits for Non-Detects	Most Recent Concentration Maximum/ Location/ Date	Maximum Upgradient Concentration/ AR-12 or AR-5 / Date (7)	Background Screening Level (2016)	Background Threshold Value*	Screening Value DEQ-7	COPC? (Y/N)	Rationale for Selection or Deletion
EU 1 East Fork Armells Creek	AR-2 to AR-4	7440-66-6	Zinc Total	4/8/2014 - 10/15/2015	0.009 NSTP 4/8/2014	0.051 AR-3 10/15/2015	5/15	<0.008	0.051 AR-3 10/15/2015	0.706 AR-12 10/15/2015	0.29	NA	7.4 (4) NC	N	BB BSL

Notes:

DEQ-7	Screening Levels are based on DEQ-7 values (DEQ, 2017) and DEQ guidance if DEQ-7 values are not available (DEQ, 2016a). DEQ-7 values are total recoverable concentrations in surface water (DEQ, 2017).
Background Screening Level	Background Screening Levels for Colstrip Steam Electric Station (Neptune 2016)
Neptune 2016	Final Report on Updated Background Screening Levels, Plant Site, 1&2 SOEP and STEP, and 3&4 EHP, Colstrip Steam Electric Station, Colstrip, Montana.
Background Threshold Value*	Background Threshold Value (BTV) calculated for manganese in surface water in the Creek upgradient of the Plant Site (see Section 6.1.3 and Appendix D).
(1)	Dissolved concentrations not measured during 2015 sampling events.
(2)	No Human Health Standard (HHS) available from DEQ-7 and no MCL available. Tap Water RSL (traditional tables) was used as the screening value (DEQ, 2016a).
(3)	DEQ-7, Human Health Surface Water, based on the MCL
(4)	DEQ-7, Human Health Surface Water, based on Priority Pollutant (PP) Criteria
(5)	DEQ-7, Human Health Surface Water, based on health advisory (HA) from EPA's "Drinking Water Standards and Health Advisories" October 1996
(6)	Minimum and maximum concentrations and detection frequencies may differ in comparison to the Statistical Analysis (App D) as samples were averaged with their duplicates in the statistical analysis.
(7)	Given the limited background surface water data available, data from the closest upgradient data points, AR-5 and AR-12, are appropriate primary upgradient (background) data points (DEQ, 2017c, 2018b).
(8)	Although manganese was initially flagged as a COPC, it was ultimately not identified as a COC based on a more detailed evaluation (please see Section 10.1 for further discussion).
Chemical*	Chemical lists vary between media because they were established at different times and for different objectives, but all were approved by DEQ. Some of the analyte lists were developed prior to the establishment of the Federal CCR Appendices III and IV lists.

Definitions:

AB	Above Background
ASL	Above Screening Level
BB	Below background
BSL	Below screening level
C	Carcinogen
CAS	Chemical Abstract Service
COPC	Chemical of Potential Concern
DL	Detection Level
mg/L	milligrams per liter
NA	Not Available/Not Applicable
NB	Near Background, essentially background
NC	Non-Carcinogen
ND	Non-detect
HHS	Human Health Standard
No Tox Values	No Human Health Toxicity Values available

Table B-2.2 USEPA RAGS Part D Table 2, Data Summary for Sediment, EU1, mg/kg, except where noted 5/1/2018
Human Health Risk Assessment
Wastewater Facilities Comprising the Closed Loop System
Plant Site Area, Colstrip Steam Electric Station, Colstrip, Montana

Exposure Unit	Sediment Sampling Locations	CAS Number	Chemical*	Data Time Range	Minimum (1) Concentration/ Location/ Date	Maximum (1) Concentration/ Location/Date	Detection Frequency (1)	Range of Detection Limits for Non-Detects	Most Recent Concentration Maximum/ Location/ 10/15/2015	Maximum Upgradient Concentration/ AR-12 or AR-5 / Date (2)	RSLs - Carcinogens Residential Industrial	RSLs - Non-carcinogens Residential Industrial 1/10th	BTV for Inorganics in Montana Soils	COPC? (Y/N)	Rationale for Selection or Deletion
EU 1 East Fork Armells Creek	AR-2 to AR-4	7429-90-5	Aluminum	4/8/2014 - 10/15/2015	1,510 AR-2 4/8/2014	5,490 AR-4 10/15/2015	12/12	NA	5,490 AR-4	9,840 AR-12 4/25/2007	NA	7,700 110,000	25,941	N	BSL BB
EU 1 East Fork Armells Creek	AR-2 to AR-4	7440-38-2	Arsenic	4/8/2014 - 10/15/2015	1.0 AR-2SF 4/8/2014	5.6 AR-3 4/8/2014	12/12	NA	3.9 AR-3	16.6 AR-5 4/25/2007	NA	NA	22.5	N	BSL BB
EU 1 East Fork Armells Creek	AR-2 to AR-4	7440-41-7	Beryllium	4/8/2014 - 10/15/2015	0.08 AR-2 4/8/2014	0.37 AR-4 3/19/2015	12/12	NA	0.32 AR-4	0.59 AR-12 4/25/2007	NA	16 230	1.1	N	BSL BB
EU 1 East Fork Armells Creek	AR-2 to AR-4	7440-42-8	Boron	4/8/2014 - 10/15/2015	4.4 AR-4 3/19/2015	19.9 AR-3 4/8/2014	12/12	NA	15.4 AR-4	56.0 AR-5 4/25/2007	NA	1,600 23,000	NA	N	BSL BB
EU 1 East Fork Armells Creek	AR-2 to AR-4	7440-43-9	Cadmium	4/8/2014 - 10/15/2015	0.12 AR-3 10/15/2015	0.25 AR-4 10/15/2015	7/12	<0.05	0.25 AR-4	0.37 AR-5 4/25/2007	NA	7.1 98	0.7	N	BSL BB
EU 1 East Fork Armells Creek	AR-2 to AR-4	7440-70-2	Calcium (meq/L) sat. paste	4/8/2014 - 10/15/2015	14.1 AR-4 3/19/2015	33.5 AR-3 4/8/2014	12/12	NA	31.0 AR-3	32.0 AR-5 3/19/2015	NA	NA	NA	N	NB
EU 1 East Fork Armells Creek	AR-2 to AR-4	16887-00-6	Chloride (mg/L) sat. paste	4/8/2014 - 10/15/2015	58 AR-4 3/19/2015	233 AR-2 10/16/2014	12/12	NA	199 AR-4	324 AR-12 10/15/2015	NA	NA	NA	N	BB
EU 1 East Fork Armells Creek	AR-2 to AR-4	7440-50-8	Copper	4/8/2014 - 10/15/2015	3 AR-2 4/8/2014	11.7 AR-3 3/19/2015	12/12	NA	10.3 AR-4	127.0 AR-5 4/25/2007	NA	310 4,700	165	N	BSL BB
EU 1 East Fork Armells Creek	AR-2 to AR-4	16984-48-8	Fluoride (mg/L) sat. paste	4/8/2014 - 10/15/2015	19 AR-3 4/8/2014	26 AR-2SF 4/8/2014	2/12	<5 - <20	<10 AR-3, AR-2SF	<20 AR-5, AR-12 all	NA	310 4,700	NA	N	BSL NB
EU 1 East Fork Armells Creek	AR-2 to AR-4	7439-92-1	Lead	4/8/2014 - 10/15/2015	2.3 AR-2 4/8/2014	12.8 AR-4 10/15/2015	12/12	NA	12.8 AR-4	4.71 AR-12 10/16/2014	400 800	NA	29.8	N	BSL
EU 1 East Fork Armells Creek	AR-2 to AR-4	7439-96-5	Manganese	4/8/2014 - 10/15/2015	412 AR-4 3/19/2015	3,910 AR-2 4/8/2014	12/12	NA	2,060 AR-3	5,910 AR-5 10/162014	NA	180 2,600	880	Y(3)	ASL
EU 1 East Fork Armells Creek	AR-2 to AR-4	7439-97-6	Mercury	4/8/2014 - 10/15/2015	ND	ND	0/12	<0.02 to <0.1	ND	0.03 AR-5 4/25/2007	NA	1.1 4.6	<0.05	N	ND
EU 1 East Fork Armells Creek	AR-2 to AR-4	7440-02-0	Nickel	4/8/2014 - 10/15/2015	4.2 AR-2 4/8/2014	9.4 AR-4 10/15/2015	12/12	NA	9.4 AR-4	39.8 AR-5 4/25/2007	NA	150 2,200	31.4	N	BSL BB

Table B-2.2 USEPA RAGS Part D Table 2, Data Summary for Sediment, EU1, mg/kg, except where noted 5/1/2018
Human Health Risk Assessment
Wastewater Facilities Comprising the Closed Loop System
Plant Site Area, Colstrip Steam Electric Station, Colstrip, Montana

Exposure Unit	Sediment Sampling Locations	CAS Number	Chemical*	Data Time Range	Minimum (1) Concentration/ Location/ Date	Maximum (1) Concentration/ Location/Date	Detection Frequency (1)	Range of Detection Limits for Non-Detects	Most Recent Concentration Maximum/ Location/ 10/15/2015	Maximum Upgradient Concentration/ AR-12 or AR-5 / Date (2)	RSLs - Carcinogens Residential Industrial	RSLs - Non-carcinogens Residential Industrial 1/10th	BTV for Inorganics in Montana Soils	COPC? (Y/N)	Rationale for Selection or Deletion
EU 1 East Fork Armells Creek	AR-2 to AR-4	NA	pH std sat. paste	4/8/2014 - 10/15/2015	7.3 AR-3 AR-2SF 4/8/2014	7.8 AR-4 4/8/2014, 3/19/2015, 10/15/2015	NA	NA	7.8 AR-4	7.7 10/16/2014 10/15/2015	NA	NA	NA	N	NB
EU 1 East Fork Armells Creek	AR-2 to AR-4	7782-49-2	Selenium	4/8/2014 - 10/15/2015	0.3 AR-4 4/8/2014 10/16/2014 3/19/2015 AR-3 4/8/2014 AR-2 3/19/2015	0.5 AR-3 10/16/2014 3/19/2015	8/12	<0.02	<0.02 AR-2,AR-3, AR-4	6 AR-5 4/25/2007	NA	39 580	0.7	N	BSL BB
EU 1 East Fork Armells Creek	AR-2 to AR-4	14808-79-8	Sulfate mg/L sat. paste	4/8/2014 - 10/15/2015	1,780 AR-4 3/19/2015	4,630 AR-2 10/16/2014	12/12	NA	4,520 AR-3 10/15/2015	6,050 AR-5 4/8/2014	NA	NA	NA	N	BB
EU 1 East Fork Armells Creek	AR-2 to AR-4	7440-24-6	Strontium	4/8/2014 - 10/15/2015	119 AR-4 10/16/2014	1,040 AR-3 10/16/2014	12/12	NA	412 AR-4	786 AR-5 4/25/2007	NA	4,700 70,000	NA	N	BSL
EU 1 East Fork Armells Creek	AR-2 to AR-4	7440-28-0	Thallium	4/8/2014 - 10/15/2015	0.06 AR-3, 4/8/2014 AR-2SF, 4/8/2014 AR-4, 10/15/2015	0.35 AR-2 10/16/2014	11/12	<0.05	0.17 AR-2	0.07 AR-12 10/16/2014	NA	0.078 1.2	0.41	N	BSL
EU 1 East Fork Armells Creek	AR-2 to AR-4	7440-62-2	Vanadium	4/8/2014 - 10/15/2015	5.4 AR-3 10/15/2015	13 AR-4 10/15/2015	12/12	NA	13 AR-4	16.8 AR-5 10/16/2014	NA	39 580	52.6	N	BSL
EU 1 East Fork Armells Creek	AR-2 to AR-4	7440-66-6	Zinc	4/8/2014 - 10/15/2015	18.3 AR-3 10/15/2015	76.2 AR-4 4/8/2014	12/12	NA	32.4 AR-4	127 AR-12 10/16/2014	NA	2,300 35,000	118	N	BSL BB

Notes:

(1)	Minimum and maximum concentrations and detection frequencies may differ in comparison to the Statistical Analysis (App D) as samples were averaged with their duplicates in the statistical analysis.
(2)	Given the limited background sediment data available, data from the closest upgradient data points, AR-5 and AR-12, are appropriate primary upgradient (background) data points (DEQ, 2017c, 2018b).
(3)	Although manganese was initially flagged as a COPC, it was ultimately not identified as a COC based on more detailed data comparisons with upstream surface water samples (please see Sections 9.1 and 12.2 for further discussion).
DEQ, 2013	Project Report Background Concentrations of Inorganic Constituents in Montana Surface Soils. Prepared for DEQ by Hydrometrics, Inc. Available on-line at http://deq.mt.gov/StateSuperfund/background.mcpx September.
Chemical*	Chemical lists vary between media because they were established at different times and for different objectives, but all were approved by DEQ. Some of the analyte lists were developed prior to the establishment of the Federal CCR Appendices III and IV lists.

Definitions:

ASL	Above Screening Level
BB	Below Background
BSL	Below Screening Level
BTV	Background Threshold Value for Inorganics in Montana Soils (DEQ, 2013)
CAS	Chemical Abstract Service
COPC	Chemical of Potential Concern
meq/L	milliequivalents per liter
NA	Not Available/Not Applicable
NB	Near Background Concentration, maximum concentration near background concentration, and contaminant not specific to wastewater.
ND	Not Detected
NS	No Standard
RSL	USEPA Regional Screening Level May 2016

Table B-2.3 USEPA RAGS Part D Table 2, Data Summary for Soil, Former Spill Area near Power Road, EU2, mg/kg
Human Health Risk Assessment
Wastewater Facilities Comprising the Closed Loop System
Plant Site Area, Colstrip Steam Electric Station, Colstrip, Montana

5/1/2018

Exposure Unit	Sampling Location	CAS Number	Chemical*	Date	Depth Range	Minimum (3) Concentration/ Location/Depth	Maximum (3) Concentration/ Location/Depth	Detection Frequency (3)	Range of Detection Limits for Non-Detects	RSLs - Carcinogens Residential Industrial	RSLs - Non-carcinogens Residential Industrial 1/10th	BTV for Inorganics in Montana Soils	COPC? (Y/N)	Rationale for Selection or Deletion	Protection of Groundwater SSL (1)	Leaching COPC Flag (Y/N)
EU 2 Spill Area Power Rd	BH-29 to BH-32	7440-38-2	Arsenic	4/15/2016	0 to 7 feet	5.1 BH-32 12 to 24 inches	6.8 BH-29 12 to 24 inches	11/11	NA	NA	NA	22.5	N	BSL	22.5 (2)	N
EU 2 Spill Area Power Rd	BH-29 to BH-32	7440-39-3	Barium	4/15/2016	0 to 7 feet	115 BH-32 12 to 24 inches	270 BH-29(dup) 0 to 6 inches	11/11	NA	NA	1,500 22,000	429	N	BSL	421	Y
EU 2 Spill Area Power Rd	BH-29 to BH-32	7440-42-8	Boron	4/15/2016	0 to 7 feet	6.6 BH-31 0 to 6 inches	11.7 BH-29 0 to 6 inches	11/11	NA	NA	1,600 23,000	NA	N	BSL	130	N
EU 2 Spill Area Power Rd	BH-29 to BH-32	7440-43-9	Cadmium	4/15/2016	0 to 7 feet	0.31 BH-32 12 to 24 inches	0.71 BH-29 12 to 24 inches	10/11	<0.05	NA	7.1 98	0.7	N	BSL	3.8	N
EU 2 Spill Area Power Rd	BH-29 to BH-32	7440-70-2	Calcium (meq/L) sat. paste	4/15/2016	0 to 7 feet	3.92 BH-29 0 to 6 inches	27.8 BH-32 0 to 6 inches	10/10	NA	NA	NA	NA	N	NS	NA	N
EU 2 Spill Area Power Rd	BH-29 to BH-32	16887-00-6	Chloride (mg/L) sat. paste	4/15/2016	0 to 7 feet	6 BH-32 0 to 6 inches	110 BH-30 12 to 24 inches	10/10	NA	NA	NA	NA	N	NS	NA	N
EU 2 Spill Area Power Rd	BH-29 to BH-32	7440-47-3	Chromium	4/15/2016	0 to 7 feet	17.0 BH-32 12 to 24 inches	33.9 BH-29(dup) 0 to 6 inches	11/11	NA	NA	12,000 180,000	41.7	N	BSL	4×10^8	N
EU 2 Spill Area Power Rd	BH-29 to BH-32	16984-48-8	Fluoride (mg/L) sat. paste	4/15/2016	0 to 7 feet	<1 several	<10 BH-30, 5 to 6 feet BH-32, 6 to7 feet	0/10	<1 - <10	NA	310 4,700	NA	N	BSL	1,200	N
EU 2 Spill Area Power Rd	BH-29 to BH-32	7439-92-1	Lead	4/15/2016	0 to 7 feet	14.6 BH-30 5 to 6 feet	73.9 BH-30 12 to 24 inches	11/11	NA	NA	400 800	29.8	N	BSL	140	N
EU 2 Spill Area Power Rd	BH-29 to BH-32	7439-95-4	Magnesium (ppm) sat. paste	4/15/2016	0 to 7 feet	28.2 BH-29 0 to 6 inches	999.6 BH-32 6 to 7 feet	10/10	NA	NA	NA	NA	N	NS	NA	N
EU 2 Spill Area Power Rd	BH-29 to BH-32	7439-96-5	Manganese	4/15/2016	0 to 7 feet	335 BH-32 12 to 24 inches	411 BH-29(dup) 0 to 6 inches	11/11	NA	NA	180 2,600	880	N	ASL BB (BTV)	280	N(4)
EU 2 Spill Area Power Rd	BH-29 to BH-32	7439-97-6	Mercury	4/15/2016	0 to 7 feet	ND	ND	0/11	<0.1	NA	1.1 4.6	<0.05	N	BSL	1.0	N
EU 2 Spill Area Power Rd	BH-29 to BH-32	NA	pH std sat. paste	4/15/2016	0 to 7 feet	7.50 BH-31 12 to 24 inches	8.00 BH-30 5 to 6 feet	9/10	NA	NA	NA	NA	N	NS	NA	N
EU 2 Spill Area Power Rd	BH-29 to BH-32	7782-49-2	Selenium	4/15/2016	0 to 7 feet	0.3 BH-32 12 to 24 inches	0.6 BH-29 0 to 6 inches BH-32 6 to 7 feet	11/11	NA	NA	39 580	0.7	N	BSL	2.6	N

Table B-2.3 USEPA RAGS Part D Table 2, Data Summary for Soil, Former Spill Area near Power Road, EU2, mg/kg

Human Health Risk Assessment
Wastewater Facilities Comprising the Closed Loop System
Plant Site Area, Colstrip Steam Electric Station, Colstrip, Montana

5/1/2018

Exposure Unit	Sampling Location	CAS Number	Chemical*	Date	Depth Range	Minimum (3) Concentration/ Location/Depth	Maximum (3) Concentration/ Location/Depth	Detection Frequency (3)	Range of Detection Limits for Non-Detects	RSLs - Carcinogens Residential Industrial	RSLs - Non-carcinogens Residential Industrial 1/10th	BTV for Inorganics in Montana Soils	COPC? (Y/N)	Rationale for Selection or Deletion	Protection of Groundwater SSL (1)	Leaching COPC Flag (Y/N)
EU 2 Spill Area Power Rd	BH-29 to BH-32	14808-79-8	Sulfate mg/L sat. paste	4/15/2016	0 to 7 feet	74 BH-29 0 to 6 inches	6,390 BH-32 6 to 7 feet	10/10	NA	NA	NA	NA	N	NS	NA	N

Notes:

(1) Value derived following DEQ Soil Screening Process, Part 2 - Leaching to Groundwater, 2016a

(2) Background Threshold Value for arsenic in Montana was used rather than SSL based on MCL

(3) Minimum and maximum concentrations and detection frequencies may differ in comparison to the Statistical Analysis (App D) as samples were averaged with their duplicates in the statistical analysis.

(4) BTV exceeds Protection of Groundwater SSL.

DEQ, 2013 Project Report Background Concentrations of Inorganic Constituents in Montana Surface Soils. Prepared for DEQ by Hydrometrics, Inc. Available on-line at http://deq.mt.gov/StateSuperfund/background.mcpx September.

Chemical* Chemical lists vary between media because they were established at different times and for different objectives, but all were approved by DEQ. Some of the analyte lists were developed prior to the establishment of the Federal CCR Appendices III and IV lists.

Definitions:

ASL	Above Screening Level
BB	Below Background
BSL	Below Screening Level
BTV	Background Threshold Value for Inorganics in Montana Soils (DEQ, 2013)
CAS	Chemical Abstract Service
COPC	Chemical of Potential Concern
MCL	Maximum Contaminant Level
meq/L	milliequivalents per liter
mg/kg	milligram per kilogram
NA	Not Available/Not Applicable
ND	Not Detected
NS	No Standard
RSL	USEPA Regional Screening Level May 2016
SSL	USEPA Soil Screening Level for Groundwater Protection May 2016

Table B-2.4 USEPA RAGS Part D Table 2, Data Summary for Soil, Former Spills near Sewage Treatment Lagoons, EU3, mg/kg
Human Health Risk Assessment
Wastewater Facilities Comprising the Closed Loop System
Plant Site Area, Colstrip Steam Electric Station, Colstrip, Montana

5/1/2018

Exposure Unit	Sampling Location	CAS Number	Chemical*	Date	Depth Range	Minimum $^{(6)}$ Concentration/ Location/Depth	Maximum $^{(6)}$ Concentration/ Location/Depth	Detection Frequency $^{(6)}$	Range of Detection Limits for Non-Detects	RSLs - Carcinogens Residential Industrial	RSLs - Non-carcinogens Residential Industrial 1/10th	BTV for Inorganics in Montana Soils	COPC? (Y/N)	Rationale for Selection or Deletion	Protection of Groundwater SSL $^{(1)}$	Leaching COPC Flag (Y/N)
EU 3 Spill Site Sewage Lagoons	BH-33 to BH-69, BH-73	7440-38-2	Arsenic	4/13/2016 to 4/15/2016	0 to 7 ft	4.7 BH-33 0 to 6 inches	7.9 BH-62 0 to 6 inches	83/83	NA	NA	NA	22.5	N	BSL	22.5 $^{(2)}$	N
EU 3 Spill Site Sewage Lagoons	BH-33 to BH-69, BH-73	7440-39-3	Barium	4/13/2016 to 4/15/2016	0 to 7 ft	96.3 BH-33 12 to 24 inches	1,130 BH-54 0 to 6 inches	83/83	NA	NA	1,500 22,000	429	N	BSL	421	Y $^{(4)}$
EU 3 Spill Site Sewage Lagoons	BH-33 to BH-69, BH-73	7440-42-8	Boron	4/13/2016 to 4/15/2016	0 to 7 ft	5.9 BH-63 0 to 6 inches	68.5 BH-54 0 to 6 inches	83/83	NA	NA	1,600 23,000	NA	N	BSL	130	N
EU 3 Spill Site Sewage Lagoons	BH-33 to BH-69, BH-73	7440-43-9	Cadmium	4/13/2016 to 4/15/2016	0 to 7 ft	0.07 BH-35 0 to 6 inches	0.57 BH-54 0 to 6 inches	71/83	<0.05	NA	7.1 98	0.7	N	BSL	3.8	N
EU 3 Spill Site Sewage Lagoons	BH-33 to BH-69, BH-73	7440-70-2	Calcium (meq/L) sat. paste	4/13/2016 to 4/15/2016	0 to 7 ft	2.05 BH-52 12 to 24 inches	29.5 BH-54 12 to 24 inches	79/79	NA	NA	NA	NA	N	NS	NA	N
EU 3 Spill Site Sewage Lagoons	BH-33 to BH-69, BH-73	16887-00-6	Chloride (mg/L) sat. paste	4/13/2016 to 4/15/2016	0 to 7 ft	5 BH-39 0 to 6 inches	306 BH-56 12 to 24 inches	79/79	NA	NA	NA	NA	N	NS	NA	N
EU 3 Spill Site Sewage Lagoons	BH-33 to BH-69, BH-73	7440-47-3	Chromium	4/13/2016 to 4/15/2016	0 to 7 ft	11.9 BH-56 0 to 6 inches	34.0 BH-65 6 to 7 feet	83/83	NA	NA	12,000 180,000	41.7	N	BSL	4×10^8	N
EU 3 Spill Site Sewage Lagoons	BH-33 to BH-69, BH-73	16984-48-8	Fluoride (mg/L) sat. paste	4/13/2016 to 4/15/2016	0 to 7 ft	0.5 BH-63 12 to 24 inches	39 BH-59 0 to 6 inches	5/79	<0.5 - <20	NA	310 4,700	NA	N	BSL	1,200	N
EU 3 Spill Site Sewage Lagoons	BH-33 to BH-69, BH-73	7439-92-1	Lead	4/13/2016 to 4/15/2016	0 to 7 ft	9.47 BH-61 12 to 24 inches	504 BH-56 0 to 6 inches	83/83	NA	NA	400 800	29.8	Y $^{(3)}$	ASL	140	Y $^{(5)}$
EU 3 Spill Site Sewage Lagoons	BH-33 to BH-69, BH-73	7439-95-4	Magnesium (ppm) sat. paste	4/13/2016 to 4/15/2016	0 to 7 ft	20.28 BH-63 0 to 6 inches	4,476 BH-63 6 to 7 feet	83/83	NA	NA	NA	NA	N	NS	NA	N
EU 3 Spill Site Sewage Lagoons	BH-33 to BH-69, BH-73	7439-96-5	Manganese	4/13/2016 to 4/15/2016	0 to 7 ft	271 BH-39 0 to 6 inches	481 BH-60 0 to 6 inches	83/83	NA	NA	180 2,600	880	N	ASL BB (BTV)	280	N $^{(7)}$
EU 3 Spill Site Sewage Lagoons	BH-33 to BH-69, BH-73	7439-97-6	Mercury	4/13/2016 to 4/15/2016	0 to 7 ft	ND	ND	0/83	<0.1	NA	1.1 4.6	<0.05	N	ND BSL	1.0	N

Table B-2.4 USEPA RAGS Part D Table 2, Data Summary for Soil, Former Spills near Sewage Treatment Lagoons, EU3, mg/kg
Human Health Risk Assessment
Wastewater Facilities Comprising the Closed Loop System
Plant Site Area, Colstrip Steam Electric Station, Colstrip, Montana

5/1/2018

Exposure Unit	Sampling Location	CAS Number	Chemical*	Date	Depth Range	Minimum (6) Concentration/ Location/Depth	Maximum (6) Concentration/ Location/Depth	Detection Frequency (6)	Range of Detection Limits for Non-Detects	RSLs - Carcinogens Residential Industrial	RSLs - Non-carcinogens Residential Industrial 1/10th	BTV for Inorganics in Montana Soils	COPC? (Y/N)	Rationale for Selection or Deletion	Protection of Groundwater SSL (1)	Leaching COPC Flag (Y/N)
EU 3 Spill Site Sewage Lagoons	BH-33 to BH-69, BH-73	NA	pH std sat. paste	4/13/2016 to 4/15/2016	0 to 7 ft	7.3 BH-46 0 to 6 inches BH-59 0 to 6 inches	9.10 BH-35 12 to 24 inches	79/79	NA	NA	NA	NA	N	NS	NA	N
EU 3 Spill Site Sewage Lagoons	BH-33 to BH-69, BH-73	7782-49-2	Selenium	4/13/2016 to 4/15/2016	0 to 7 ft	0.3 BH-56 12 to 24 inches BH-66 6 to 7 feet BH-68 4.5 to 5.5 feet	1.3 BH-54 0 to 6 inches	83/83	NA	NA	39 580	0.7	N	BSL	2.6	N
EU 3 Spill Site Sewage Lagoons	BH-33 to BH-69, BH-73	14808-79-8	Sulfate mg/L sat. paste	4/13/2016 to 4/15/2016	0 to 7 ft	19 BH-48 0 to 6 inches	22,300 BH-63 6 to 7 feet	79/79	NA	NA	NA	NA	N	NS	NA	N

Notes:

(1) Value derived following DEQ Soil Screening Process, Part 2 - Leaching to Groundwater, 2016a

(2) Background Threshold Value for arsenic in Montana was used rather than SSL based on MCL

(3) One sample (BH-54, 504 mg/kg) exceeded screening level; however, the sample was re-analyzed resulting in a lead concentration of 18.8 mg/kg. First result likely a laboratory error. Remaining 88 soil samples below lead screening level. Lead was not retained as a human health COC.

(4) Although barium was initially flagged as a leaching COPC, it was ultimately not identified as a leaching COC based on a more detailed evaluation (please see Section 10.2 for further discussion).

(5) Although lead was initially flagged as a leaching COPC, it was ultimately not identified as a leaching COC based on a more detailed evaluation (please see Section 10.2 for further discussion).

(6) Minimum and maximum concentrations and detection frequencies may differ in comparison to the Statistical Analysis (App D) as samples were averaged with their duplicates in the statistical analysis.

(7) BTV exceeds Protection of Groundwater SSL.

DEQ, 2013 Project Report Background Concentrations of Inorganic Constituents in Montana Surface Soils. Prepared for DEQ by Hydrometrics, Inc. Available on-line at http://deq.mt.gov/StateSuperfund/background.mcpx September.

Chemical* Chemical lists vary between media because they were established at different times and for different objectives, but all were approved by DEQ. Some of the analyte lists were developed prior to the establishment of the Federal CCR Appendices III and IV lists.

Definitions:

ASL	Above Screening Level
BB	Below Background
BSL	Below Screening Level
BTV	Background Threshold Value for Inorganics in Montana Soils (DEQ, 2013)
CAS	Chemical Abstract Service
COC	Chemical of Concern
COPC	Chemical of Potential Concern
MCL	Maximum Contaminant Level
meq/L	milliequivalents per liter
NA	Not Available/Not Applicable
ND	Not Detected
NS	No Standard
RSL	USEPA Regional Screening Level May 2016
SSL	USEPA Soil Screening Level for Groundwater Protection May 2016

Table B-2.5 USEPA RAGS Part D Table 2, Data Summary for Soil, Stormwater Ponding Area, EU4, mg/kg

Human Health Risk Assessment
Wastewater Facilities Comprising the Closed Loop System
Plant Site Area, Colstrip Steam Electric Station, Colstrip, Montana

5/1/2018

Exposure Unit	Sampling Location	CAS Number	Chemical*	Date	Depth Range	Minimum (3) Concentration/ Location/Depth	Maximum (3) Concentration/ Location/Depth	Detection Frequency (3)	Range of Detection Limits for Non-Detects	RSLs - Carcinogens Residential Industrial	RSLs - Non-carcinogens Residential Industrial 1/10th	BTV for Inorganics in Montana Soils	COPC? (Y/N)	Rationale for Selection or Deletion	Protection of Groundwater SSL (1)	Leaching COPC Flag (Y/N)
EU 4 Storm Water	BH-70 to BH-72	7440-38-2	Arsenic Total	4/13/2016	0 to 24 inches	5.4 BH-70 12 to 24 inches	6.9 BH-72 0 to 6 inches	7/7	NA	NA	NA	22.5	N	BSL	22.5 (2)	N
EU 4 Storm Water	BH-70 to BH-72	7440-39-3	Barium Total	4/13/2016	0 to 24 inches	119 BH-72(dup) 0 to 6 inches	188 BH-72 12 to 24 inches	7/7	NA	NA	1,500 22,000	429	N	BSL	421	N
EU 4 Storm Water	BH-70 to BH-72	7440-42-8	Boron Total	4/13/2016	0 to 24 inches	9.8 BH-70 12 to 24 inches	35.3 BH-72 12 to 24 inches	7/7	NA	NA	1,600 23,000	NA	N	BSL	130	N
EU 4 Storm Water	BH-70 to BH-72	7440-43-9	Cadmium Total	4/13/2016	0 to 24 inches	0.39 BH-70 0 to 6 inches	0.39 BH-70 0 to 6 inches	1/7	<0.05	NA	7.1 98	0.7	N	BSL	3.8	N
EU 4 Storm Water	BH-70 to BH-72	7440-70-2	Calcium (meq/L) sat. paste	4/13/2016	0 to 24 inches	2.31 BH-70 12 to 24 inches	24.8 BH-71 12 to 24 inches	7/7	NA	NA	NA	NA	N	NS	NA	N
EU 4 Storm Water	BH-70 to BH-72	16887-00-6	Chloride (mg/L) sat. paste	4/13/2016	0 to 24 inches	11 BH-71 0 to 6 inches	79 BH-71 12 to 24 inches	7/7	NA	NA	NA	NA	N	NS	NA	N
EU 4 Storm Water	BH-70 to BH-72	7440-47-3	Chromium Total	4/13/2016	0 to 24 inches	18.7 BH-71 12 to 24 inches	25.2 BH-72 0 to 6 inches	7/7	NA	NA	12,000 180,000	41.7	N	BSL	4×10^8	N
EU 4 Storm Water	BH-70 to BH-72	16984-48-8	Fluoride (mg/L) sat. paste	4/13/2016	0 to 24 inches	0.7 BH-70 12 to 24 inches	0.7 BH-70 12 to 24 inches	1/7	<1 - <10	NA	310 4,700	NA	N	BSL	1,200	N
EU 4 Storm Water	BH-70 to BH-72	7439-92-1	Lead Total	4/13/2016	0 to 24 inches	11 BH-71 12 to 24 inches	18 BH-70 0 to 6 inches BH-72 0 to 6 inches	7/7	NA	NA	400 800	29.8	N	BSL	140	N
EU 4 Storm Water	BH-70 to BH-72	7439-95-4	Magnesium (ppm) sat. paste	4/13/2016	0 to 24 inches	29.64 BH-70 12 to 24 inches	1069.20 BH-72 12 to 24 inches	7/7	NA	NA	NA	NA	N	NS	NA	N
EU 4 Storm Water	BH-70 to BH-72	7439-96-5	Manganese	4/13/2016	0 to 24 inches	295 BH-71 12 to 24 inches	497 BH-70 0 to 6 inches	7/7	NA	NA	180 2,600	880	N	ASL BB (BTV)	280	N(4)
EU 4 Storm Water	BH-70 to BH-72	7439-97-6	Mercury Total	4/13/2016	0 to 24 inches	ND	ND	0/7	<0.1	NA	1.1 4.6	<0.05	N	ND BSL	1.0	N
EU 4 Storm Water	BH-70 to BH-72	NA	pH std sat. paste	4/13/2016	0 to 24 inches	7.10 BH-72 0 to 6 inches	8.10 BH-72 12 to 24 inches	7/7	NA	NA	NA	NA	N	NS	NA	N

Table B-2.5 USEPA RAGS Part D Table 2, Data Summary for Soil, Stormwater Ponding Area, EU4, mg/kg
Human Health Risk Assessment
Wastewater Facilities Comprising the Closed Loop System
Plant Site Area, Colstrip Steam Electric Station, Colstrip, Montana

5/1/2018

Exposure Unit	Sampling Location	CAS Number	Chemical*	Date	Depth Range	Minimum (3) Concentration/ Location/Depth	Maximum (3) Concentration/ Location/Depth	Detection Frequency (3)	Range of Detection Limits for Non-Detects	RSLs - Carcinogens Residential Industrial	RSLs - Non-carcinogens Residential Industrial 1/10th	BTV for Inorganics in Montana Soils	COPC? (Y/N)	Rationale for Selection or Deletion	Protection of Groundwater SSL (1)	Leaching COPC Flag (Y/N)
EU 4 Storm Water	BH-70 to BH-72	7782-49-2	Selenium Total	4/13/2016	0 to 24 inches	0.5 BH-70 0 to 6 inches 12 to 24 inches BH-71 0 to 6 inches 12 to 24 inches BH-72 0 to 6 inches	0.6 BH-72 12 to 24 inches	7/7	NA	NA	39 580	0.7	N	BSL	2.6	N
EU 4 Storm Water	BH-70 to BH-72	14808-79-8	Sulfate mg/L sat. paste	4/13/2016	0 to 24 inches	27 BH-70 0 to 6 inches	6,520 BH-72 12 to 24 inches	7/7	NA	NA	NA	NA	N	NS	NA	N

Notes:

(1) Value derived following DEQ Soil Screening Process, Part 2 - Leaching to Groundwater, 2016a

(2) Background Threshold Value for arsenic in Montana was used rather than SSL based on MCL

(3) Minimum and maximum concentrations and detection frequencies may differ in comparison to the Statistical Analysis (App D) as samples were averaged with their duplicates in the statistical analysis.

(4) BTV exceeds Protection of Groundwater SSL.

DEQ, 2013 Project Report Background Concentrations of Inorganic Constituents in Montana Surface Soils. Prepared for DEQ by Hydrometrics, Inc. Available on-line at http://deq.mt.gov/StateSuperfund/background.mcpx September.

Chemical* Chemical lists vary between media because they were established at different times and for different objectives, but all were approved by DEQ. Some of the analyte lists were developed prior to the establishment of the Federal CCR Appendices III and IV lists.

Definitions:

ASL	Above Screening Level
BB	Below Background
BSL	Below Screening Level
BTV	Background Threshold Value for Inorganics in Montana Soils (DEQ, 2013)
CAS	Chemical Abstract Service
COPC	Chemical of Potential Concern
MCL	Maximum Contaminant Level
meq/L	milliequivalents per liter
mg/kg	milligrams per kilogram
NA	Not Available/ Not Applicable
ND	Not Detected
NS	No Standard
RSL	USEPA Regional Screening Level May 2016
SSL	USEPA Soil Screening Level for Groundwater Protection 2016

Table B-3.1 USEPA RAGS Part D Table 3, Exposure Point Concentration Summary, Surface Water, mg/L

5/1/2018

Human Health Risk Assessment

Wastewater Facilities Comprising the Closed Loop System

Plant Site Area, Colstrip Steam Electric Station, Colstrip, Montana

Scenario Timeframe:	Current/Future
Medium:	Surface Water
Exposure:	Incidental Ingestion/ Dermal

Exposure Unit	Chemicals of Potential Concern	Detection Frequency	Number of High Censored Results	Average	95 UCL Distribution	Maximum Concentration	Exposure Point Concentration			Screening Level
							Value	Statistic	Method	
EU 1 East Fork Armells Creek Surface Water (1)	Manganese Total	11/11	0	0.781	non-parametric	3.39	2.04	95 UCL	t - corrected (3)	No HHS(2) NC 0.43 Tap Water RSL

Notes:

(1) Surface water exposures evaluated qualitatively through comparison to DEQ-7 Values (see Section 10.1).

(2) No Human Health Standard (HHS) available from DEQ-7 and no MCL available.

(3) t-UCL after adjusting for lack of independence in the samples due to same sampling periods. See Appendix D for UCL method justification.

Table B-3.2 USEPA RAGS Part D Table 3, Exposure Point Concentration Summary, Sediment, mg/kg
Human Health Risk Assessment
Wastewater Facilities Comprising the Closed Loop System
Plant Site Area, Colstrip Steam Electric Station, Colstrip, Montana

Scenario Timeframe:	Current/Future
Medium:	Sediment
Exposure:	Incidental Ingestion/ Dermal

Exposure Unit	Depth Interval (feet bgs)	Chemicals of Potential Concern	Detection Frequency	Number of High Censored Results	Average	95 UCL Distribution	Maximum Concentration	Exposure Point Concentration		
								Value	Statistic	Method
EU1 East Fork Armells Creek Sediment	Surface	Manganese	12/12	0	1,737.8	non- parametric	3,910	2,755.4	95 UCL	t - corrected (1)

Notes:

(1) t-UCL after correcting for lack of independence in the samples due to same locations and same sampling occasions. See Appendix D for UCL method justification.

Table B-3.3 USEPA RAGS Part D Table 3, Exposure Point Concentration Summary, Soil 5/1/2018
Human Health Risk Assessment
Wastewater Facilities Comprising the Closed Loop System
Plant Site Area, Colstrip Steam Electric Station, Colstrip, Montana

Scenario Timeframe:	Current/Future
Medium:	Soil
Exposure:	Incidental Ingestion/Dermal/ Inhalation

Exposure Unit	Depth Interval (feet bgs)	Chemicals of Potential Concern	Detection Frequency	Number of High Censored Results	Average	95 UCL Distribution	Maximum Concentration	Exposure Point Concentration		
								Value	Statistic	Method
EU2-EU4	No COPCs identified for soil (samples collected from 3 spill areas and a stormwater collection area) (1).									

Notes:

(1) Barium and lead were inititally identified as leaching COPCs, but were eliminated based on further analysis (see Section 10.2)

Table B-4 USEPA RAGS PART D TABLE 4, VALUES USED FOR DAILY INTAKE, RME SEDIMENT EXPOSURE

5/1/2018

Human Health Risk Assessment
Wastewater Facilities Comprising the Closed Loop System
Plant Site Area, Colstrip Steam Electric Station, Colstrip, Montana

Scenario Timeframe:	Current/Future
Medium:	Sediment
Exposure:	Incidental Ingestion, Dermal

Exposure Route	Receptor Population	Receptor Age	Exposure Unit	Parameter Code	Parameter Definition	Value	Units	Rationale/Reference	Intake Equation/Model Name
Ingestion	Resident	Child	EU1 East Fork Armells Creek Plant Site Area	CS	Chemical Concentration	EPC	mg/kg	The RAGS Part D Table 3 series for each EU documents the rationale	ADD (noncarcinogen) Intake (mg/kg-day) = (CS x IRS x BA x EF x ED x MCF) / (BW x AT)
				IRS	Ingestion Rate - Soil/ Sediment	200	mg/day	USEPA 2014, DEQ 2016a	
				BA	Bioavailability in soil/ sediment	chemical-specific	unitless	chemical-specific	
				EF	Exposure Frequency	24	days/year	Assumes 2 days per week during 3 summer months (DEQ meeting, 2017c)	
				ED	Exposure Duration	6	years	Upperbound time estimate for residing in one location and childhood exposure duration (USEPA 2014, DEQ 2016a)	
				MCF	Mass Conversion Factor	1.00E-06	kg/mg	Not applicable	
				BW	Body Weight	15	kg	USEPA 2014, DEQ 2016a	
				AT-NC	Averaging Time - Noncancer	2,190	days	ED x 365 days/year (DEQ 2016a)	
Ingestion	Industrial Worker	Adult	EU1 East Fork Armells Creek Plant Site Area	CS	Chemical Concentration	EPC	mg/kg	The RAGS Part D Table 3 series for each EU documents the rationale	Intake (mg/kg-day) = (CS x IRS x BA x EF x ED x MCF) / (BW x AT)
				IRS	Ingestion Rate - Soil/ Sediment	100	mg/day	USEPA 2014, DEQ 2016a	
				BA	Bioavailability in soil/ sediment	chemical-specific	unitless	chemical-specific	
				EF	Exposure Frequency	24	days/year	Assumes a standard 5-day work week, 3 months of snow cover or frozen ground, and a 2-week vacation (DEQ 2016a). Of the 187 days of outdoor work, 24 days (2x per week during 3 summer months) are assumed to involve contact with creek sediment (Discussion with DEQ, [DEQ, 2017c]).	
				ED	Exposure Duration	25	years	USEPA 2014, DEQ 2016a	
				MCF	Mass Conversion Factor	1.00E-06	kg/mg	Not applicable	
				BW	Body Weight	80	kg	USEPA 2014, DEQ 2016a	
				AT-NC	Averaging Time - Noncancer	9,125	days	ED x 365 days/year (DEQ 2016a)	
Ingestion	Recreational Receptor	Child	EU1 East Fork Armells Creek Plant Site Area	CS	Chemical Concentration	EPC	mg/kg	The RAGS Part D Table 3 series for each EU documents the rationale	Intake (mg/kg-day) = (CS x IRS x BA x EF x ED x MCF) / (BW x AT)
				IRS	Ingestion Rate - Soil/ Sediment	200	mg/day	USEPA 2014, DEQ 2016a	
				BA	Bioavailability in soil/ sediment	chemical-specific	unitless	chemical-specific	
				EF	Exposure Frequency	16	days/year	Professional Judgment. Based on 1 to 2X per week during a 3 month summer.	
				ED	Exposure Duration	6	years	Upperbound time estimate for residing in one location and childhood exposure duration (USEPA 2014, DEQ 2016a)	
				MCF	Mass Conversion Factor	1.00E-06	kg/mg	Not applicable	
				BW	Body Weight	15	kg	USEPA 2014, DEQ 2016a	
				AT-NC	Averaging Time - Noncancer	2,190	days	ED x 365 days/year (DEQ 2016a)	

Table B-4 USEPA RAGS PART D TABLE 4, VALUES USED FOR DAILY INTAKE, RME SEDIMENT EXPOSURE   5/1/2018

Exposure Route	Receptor Population	Receptor Age	Exposure Unit	Parameter Code	Parameter Definition	Value	Units	Rationale/Reference	Intake Equation/Model Name
Dermal	Resident	Child	EU1 East Fork Armells Creek Plant Site Area	CS	Chemical Concentration	EPC	mg/kg	The RAGS Part D Table 3 series for each EU will document the rationale	Intake (mg/kg-day) = (CS x ABS x SA x AF x EF x ED x MCF) / (BW x AT)
				ABS	Dermal Absorption Factor	Chemical-specific	unitless	USEPA 2016a	
				SA	Exposed Skin Surface Area	2,373	cm^2	DEQ 2016a	
				AF	Soil to Skin Adherence Factor	0.2	mg/cm^2	USEPA 2014, DEQ 2016a	
				EF	Exposure Frequency	24	days/year	Assumes 2 days per week during 3 summer months (DEQ meeting, 2017c).	
				ED	Exposure Duration	6	years	Upperbound time estimate for residing in one location and childhood exposure duration (USEPA 2014, DEQ 2016a)	
				MCF	Mass Conversion Factor	1.00E-06	kg/mg	Not applicable	
				BW	Body Weight	15	kg	USEPA 2014, DEQ 2016a	
				AT-NC	Averaging Time - Noncancer	2,190	days	ED x 365 days/year (DEQ 2016a)	
Dermal	Industrial Worker	Adult	EU1 East Fork Armells Creek Plant Site Area	CS	Chemical Concentration	EPC	mg/kg	The RAGS Part D Table 3 series for each EU will document the rationale	Intake (mg/kg-day) = (CS x ABS x SA x AF x EF x ED x MCF) / (BW x AT)
				ABS	Dermal Absorption Factor	Chemical-specific	unitless	USEPA 2016a	
				SA	Exposed Skin Surface Area	3,527	cm^2	DEQ 2016a	
				AF	Soil to Skin Adherence Factor	0.12	mg/cm^2	USEPA 2014, DEQ 2016a	
				EF	Exposure Frequency	24	days/year	Assumes a standard 5-day work week, 3 months of snow cover or frozen ground, and a 2-week vacation (DEQ 2016a). Of the 187 days of outdoor work, 24 days (2x per week during 3 summer months are assumed to involve contact with creek sediment (Discussion with DEQ, 2/2017).	
				ED	Exposure Duration	25	years	USEPA 2014, DEQ 2016a	
				MCF	Mass Conversion Factor	1.00E-06	kg/mg	Not applicable	
				BW	Body Weight	80	kg	USEPA 2014, DEQ 2016a	
				AT-NC	Averaging Time - Noncancer	9,125	days	ED x 365 days/year (DEQ 2016a)	
Dermal	Recreational Receptor	Child	EU1 East Fork Armells Creek Plant Site Area	CS	Chemical Concentration	Sample Result	mg/kg	The RAGS Part D Table 3 series for each EU documents the rationale	Intake (mg/kg-day) = (CS x ABS x SA x AF x EF x ED x MCF) / (BW x AT)
				ABS	Dermal Absorption Factor	Chemical-specific	unitless	USEPA 2016a	
				SA	Exposed Skin Surface Area	2,373	cm^2	Professional judgment. Assume similar exposed skin surface as residential child.	
				AF	Soil to Skin Adherence Factor	0.2	mg/cm^2	USEPA 2014	
				EF	Exposure Frequency	16	days/year	Professional Judgment. Based on 1 to 2X per week during a 3 month summer.	
				ED	Exposure Duration	6	years	Upperbound time estimate for residing in one location and childhood exposure duration (USEPA 2014, DEQ 2016a)	
				MCF	Mass Conversion Factor	1.00E-06	kg/mg	Not applicable	
				BW	Body Weight	15	kg	USEPA 2014, DEQ 2016a	
				AT-NC	Averaging Time - Noncancer	2,190	days	ED x 365 days/year (DEQ 2016a)	

References:

DEQ 2016a	DEQ Remediation Division, State Superfund FAQs. Available on-line at: https://deq.mt.gov/Land/statesuperfund/frequentlyaskedquestions.
DEQ 2017c	Meetings held between DEQ, Talen, and Talen's consultants regarding the preparation of the CCRAs for the Colstrip Steam Electric Station under the AOC. February 28 and April 21.
USEPA 2004	Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment), Final. EPA/540/R/99/005 OSWER 9285.7-02EP PB99-963312, July.
USEPA 2014	Human Health Evaluation Manual, Supplemental Guidance: Update of Standard Default Exposure Factors, OSWER Directive 9200.1-120, February.
USEPA 2016a	Regional Screening Levels for Chemical Contaminants at Superfund Sites. May. Available on-line at https://www.epa.gov/risk/regional-screening-levels-rsls.

Definitions:

cm^2	square centimeter
DEQ	Montana Department of Environmental Quality
EPC	exposure point concentration
kg	kilogram
kg/mg	kilogram per milligram
mg/cm^2	milligram per square centimeter
mg/day	milligram per day
mg/kg-day	milligram per kilogram per day
mg/kg	milligram per kilogram
RAGS	Risk Assessment Guidance for Superfund
RME	reasonable maximum exposure
USEPA	United States Environmental Protection Agency

Table B-5.1 USEPA RAGS PART D TABLE 5, FEDERAL NON-CANCER TOXICITY DATA - ORAL / DERMAL

Human Health Risk Assessment

5/1/2018

Wastewater Facilities Comprising the Closed Loop System

Plant Site Area, Colstrip Steam Electric Station, Colstrip, Montana

Chemical of Potential Concern	Chronic / Subchronic	Oral RfD		Oral Absorption Efficiency for Dermal (1)	Gastro-intestinal Absorption Factor (2)	Absorbed RfD for Dermal		Primary Target Organ(s) (3)	Combined Uncertainty/Modifying Factors	Oral Reference Dose	
		Value	Units			Value	Units			Source(s)	Date(s)
Manganese(4)	Chronic	2.4 E-02 (5)	mg/kg-day	100%	4%	2.4E-02	mg/kg-day	Central Nervous System	1	IRIS (5)	May 2016

Notes:

RAGS	Risk Assessment Guidance for Superfund
RfD	Reference Dose
IRIS	Integrated Risk Information System
mg/kg-day	milligrams per kilogram-day
USEPA	United States Environmental Protection Agency

(1) Risk Assessment Guidance for Superfund, Volume 1: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment), July 2004. If not available, assumed to be 100%. The absorbed dermal RfD is derived by multiplying the oral RfD by the oral absorption efficiency. A manganese dermal ABS is not available (USEPA, 2016); therefore, 100% was assumed.

(2) Gastrointestinal Absorption Factor as presented in the USEPA RSL Tables (USEPA, 2016). The manganese RfD was modified from the IRIS value due to uncertainties discussed in the IRIS file associated with non-diet manganese vs. diet manganese (USEPA 2016).

(3) Primary target(s) listed are those associated with the critical effect(s) on which the RfD was based.

(4) The toxicity value for manganese excludes dietary contribution.

(5) The IRIS RfD is 0.14 mg/kg-day; however, the IRIS explanatory text recommends using a modifying factor of 3 when calculating risks associated with non-food sources because of a number of uncertainties, leading to an RfD of 0.024 mg/kg-day.

Table B-5.2 USEPA RAGS PART D TABLE 6, FEDERAL NON-CANCER TOXICITY DATA - INHALATION
Human Health Risk Assessment
Wastewater Facilities Comprising the Closed Loop System
Plant Site Area, Colstrip Steam Electric Station, Colstrip, Montana

5/1/2018

Chemical of Potential Concern	Chronic/ Subchronic	Inhalation RfC		Primary Target Organ(s)	Combined Uncertainty/ Modifying Factors	Inhalation Reference Concentration	
		Value	Units			Source(s)	Date(s)
No COPCs via the Inhalation Pathway Identified							

Notes:

RAGS	Risk Assessment Guidance for Superfund
RfC	Reference Concentration
USEPA	United States Environmental Protection Agency

Table B-6.1 USEPA RAGS PART D TABLE 5, FEDERAL CANCER TOXICITY DATA - ORAL / DERMAL

Human Health Risk Assessment

Wastewater Facilities Comprising the Closed Loop System

Plant Site Area, Colstrip Steam Electric Station, Colstrip, Montana

5/1/2018

Chemical of Potential Concern	Oral Cancer Slope Factor		Oral Absorption Efficiency for Dermal	Absorbed Cancer Slope Factor for Dermal		Weight of Evidence / Cancer Guidance Description	Oral Cancer Slope Factor	
	Value	Units		Value	Units		Source(s)	Date(s)
No carcinogenic COPCs identified.								

Notes:

COPC	Chemical of Potential Concern
RAGS	Risk Assessment Guidance for Superfund
USEPA	United States Environmental Protection Agency

Table B-6.2 USEPA RAGS PART D TABLE 6, FEDERAL CANCER TOXICITY DATA - INHALATION

Human Health Risk Assessment

Wastewater Facilities Comprising the Closed Loop System

Plant Site Area, Colstrip Steam Electric Station, Colstrip, Montana

5/1/2018

<table>
<tr><th rowspan="2">Chemical of Potential Concern</th><th colspan="2">Unit Risk</th><th rowspan="2">Weight of Evidence / Cancer Guidance Description</th><th colspan="2">Unit Risk: Inhalation Cancer Slope Factor</th></tr>
<tr><th>Value</th><th>Units</th><th>Source(s)</th><th>Date(s)</th></tr>
<tr><td colspan="6">No carcinogenic COPCs identified.</td></tr>
</table>

Notes:

COPC	Chemical of Potential Concern
RAGS	Risk Assessment Guidance for Superfund
USEPA	United States Environmental Protection Agency

Table B-7.1 USEPA RAGS PART D TABLE 7, CALCULATION OF RME CHEMICAL CANCER RISK AND NONCANCER HAZARDS FOR SEDIMENT EXPOSURE, EU1, RESIDENT 5/1/2018

Human Health Risk Assessment

Wastewater Facilities Comprising the Closed Loop System

Plant Site Area, Colstrip Steam Electric Station, Colstrip, Montana

Receptor Population:	Resident
Receptor Age:	Child

Medium	Exposure Medium	Exposure Point	Exposure Route	Chemical of Potential Concern	EPC		Cancer Risk Calculations					Noncancer Hazard Quotient				
							Intake/Exposure Concentration		CSF / Unit Risk		Cancer Risk	Intake/Exposure Concentration		RfD / RfC		Noncancer Hazard Quotient
					Value	Units	Value	Units	Value	Units		Value	Units	Value	Units	
Sediment	Sediment	East Fork Armells Creek Sediment	Ingestion	Manganese	2,755.4	mg/kg	NA	mg/kg-day	NA	(mg/kg-day)-1	NA	2.4E-03	mg/kg-day	2.40E-02	mg/kg-day	1.0E-01
			Exposure Route Total								NA					1.0E-01
			Dermal	Manganese	2,755.4	mg/kg	NA	mg/kg-day	NA	(mg/kg-day)-1	NA	5.7E-03	mg/kg-day	2.40E-02	mg/kg-day	2.4E-01
			Exposure Route Total								NA					2.4E-01
		Exposure Point Total									NA					
		Outdoor Air	Inhalation (Particulates)	NA	NA	mg/kg	NA	mg/kg-day	NA	(mg/kg-day)-1	NA	NA	mg/kg-day	NA	mg/kg-day	NA
			Exposure Route Total								NA					NA
		Exposure Point Total									NA					NA
	Exposure Medium Total										NA					3E-01
Medium Total											NA					3E-01

Notes:

CSF	Cancer Slope Factor	NA	Not Available/Not Applicable
EPC	Exposure Point Concentration	RAGS	Risk Assessment Guidance for Superfunc
EU	Exposure Unit	RfD	Reference Dose
mg/kg	milligrams per kilogram	RfC	Reference Concentration
mg/kg-day	milligrams per kilogram per day	RME	Reasonable Maximum Exposure
		USEPA	United States Environmental Protection Agency

Table B-7.2 USEPA RAGS PART D TABLE 7, CALCULATION OF RME CHEMICAL CANCER RISK AND NONCANCER HAZARDS FOR SEDIMENT EXPOSURE, EU1, INDUSTRIAL WORKER 5/1/2018
Human Health Risk Assessment
Wastewater Facilities Comprising the Closed Loop System
Plant Site Area, Colstrip Steam Electric Station, Colstrip, Montana

Receptor Population:	Industrial Worker
Receptor Age:	Adult

Medium	Exposure Medium	Exposure Point	Exposure Route	Chemical of Potential Concern	EPC		Cancer Risk Calculations					Noncancer Hazard Quotient				
							Intake/Exposure Concentration		CSF / Unit Risk		Cancer Risk	Intake/Exposure Concentration		RfD / RfC		Noncancer Hazard Quotient
					Value	Units	Value	Units	Value	Units		Value	Units	Value	Units	
Sediment	Sediment	East Fork Armells Creek Sediment	Ingestion	Manganese	2,755.4	mg/kg	NA	mg/kg-day	NA	(mg/kg-day)-1	NA	2.3E-04	mg/kg-day	2.40E-02	mg/kg-day	9.4E-03
			Exposure Route Total								NA					9.4E-03
			Dermal	Manganese	2,755.4	mg/kg	NA	mg/kg-day	NA	(mg/kg-day)-1	NA	9.6E-04	mg/kg-day	2.40E-02	mg/kg-day	4.0E-02
			Exposure Route Total								NA					4.0E-02
		Exposure Point Total									NA					
		Outdoor Air	Inhalation (Particulates)	NA	NA	mg/kg	NA	mg/kg-day	NA	(mg/kg-day)-1	NA	NA	mg/kg-day	NA	mg/kg-day	NA
			Exposure Route Total								NA					NA
		Exposure Point Total									NA					NA
	Exposure Medium Total										NA					5E-02
Medium Total											NA					5E-02

Notes:

CSF	Cancer Slope Factor	NA	Not Available/Not Applicable
EPC	Exposure Point Concentration	RAGS	Risk Assessment Guidance for Superfur
EU	Exposure Unit	RfD	Reference Dose
mg/kg	milligrams per kilogram	RfC	Reference Concentration
mg/kg-day	milligrams per kilogram per day	RME	Reasonable Maximum Exposure
		USEPA	United States Environmental Protection Agency

Table B-7.3 USEPA RAGS PART D TABLE 7, CALCULATION OF RME CHEMICAL CANCER RISK AND NONCANCER HAZARDS FOR SEDIMENT EXPOSURE, EU1, RECREATIONAL USER 5/1/2018
Human Health Risk Assessment
Wastewater Facilities Comprising the Closed Loop System
Plant Site Area, Colstrip Steam Electric Station, Colstrip, Montana

Receptor Population:	Recreational User
Receptor Age:	Child

Medium	Exposure Medium	Exposure Point	Exposure Route	Chemical of Potential Concern	EPC		Cancer Risk Calculations					Noncancer Hazard Quotient				
							Intake/Exposure Concentration		CSF / Unit Risk		Cancer Risk	Intake/Exposure Concentration		RfD / RfC		Noncancer Hazard Quotient
					Value	Units	Value	Units	Value	Units		Value	Units	Value	Units	
Sediment	Sediment	East Fork Armells Creek Sediment	Ingestion	Manganese	2,755.4	mg/kg	NA	mg/kg-day	NA	(mg/kg-day)-1	NA	1.6E-03	mg/kg-day	2.40E-02	mg/kg-day	6.7E-02
			Exposure Route Total								NA					6.7E-02
			Dermal	Manganese	2,755.4	mg/kg	NA	mg/kg-day	NA	(mg/kg-day)-1	NA	3.8E-03	mg/kg-day	2.40E-02	mg/kg-day	1.6E-01
			Exposure Route Total								NA					1.6E-01
		Exposure Point Total									NA					
		Outdoor Air	Inhalation (Particulates)	NA	NA	mg/kg	NA	mg/kg-day	NA	(mg/kg-day)-1	NA	NA	mg/kg-day	NA	mg/kg-day	NA
			Exposure Route Total								NA					NA
		Exposure Point Total									NA					NA
	Exposure Medium Total										NA					2E-01
Medium Total											NA					2E-01

Notes:

CSF	Cancer Slope Factor	NA	Not Available/Not Applicable
EPC	Exposure Point Concentration	RAGS	Risk Assessment Guidance for Superfur
EU	Exposure Unit	RfD	Reference Dose
mg/kg	milligrams per kilogram	RfC	Reference Concentration
mg/kg-day	milligrams per kilogram per day	RME	Reasonable Maximum Exposure
		USEPA	United States Environmental Protection Agency

TABLE B-9.1 USEPA RAGS PART D TABLE 9, CALCULATION OF RME CHEMICAL CANCER RISK AND NONCANCER HAZARDS FOR SEDIMENT EXPOSURE, EU1, RESIDENT

Human Health Risk Assessment
Wastewater Facilities Comprising the Closed Loop System
Plant Site Area, Colstrip Steam Electric Station, Colstrip, Montana

5/1/2018

Receptor Population:	Resident
Receptor Age:	Child

Medium	Exposure Medium	Exposure Point	Chemical of Potential Concern	Cancer Risk Calculations				Noncancer Hazard Quotient				
				Ingestion	Inhalation	Dermal	Exposure Routes Total	Primary Target Organ(s)	Ingestion	Inhalation	Dermal	Exposure Routes Total
Sediment	Sediment	East Fork Armells Creek	Manganese	NA	NA	NA	NA	Central Nervous System	1.0E-01	NA	2.4E-01	3E-01
			Chemical Total	NA	NA	NA	NA		1.0E-01	NA	2.4E-01	3E-01
		Exposure Point Total					NA					3E-01
		Outdoor Air (Particulates)	NA	NA	NA	NA	NA		NA	NA	NA	NA
			Chemical Total	NA	NA	NA	NA		NA	NA	NA	NA
		Exposure Point Total					NA					NA
	Exposure Medium Total						NA					3E-01
Medium Total							NA					3E-01

Notes:

NA	Not Available/Not Applicable
RAGS	Risk Assessment Guidance for Superfund
RME	Reasonable Maximum Exposure
USEPA	United States Environmental Protection Agency

Target Organ Hazard Index

Target Organ	Sediment
Central Nervous System	3E-01
Maximum	3E-01

TABLE B-9.2 USEPA RAGS PART D TABLE 9, CALCULATION OF RME CHEMICAL CANCER RISK AND NONCANCER HAZARDS FOR SEDIMENT EXPOSURE, EU1, INDUSTRIAL WORKER

Human Health Risk Assessment
Wastewater Facilities Comprising the Closed Loop System
Plant Site Area, Colstrip Steam Electric Station, Colstrip, Montana

5/1/2018

Receptor Population:	Industrial Worker
Receptor Age:	Adult

Medium	Exposure Medium	Exposure Point	Chemical of Potential Concern	Cancer Risk Calculations				Noncancer Hazard Quotient				
				Ingestion	Inhalation	Dermal	Exposure Routes Total	Primary Target Organ(s)	Ingestion	Inhalation	Dermal	Exposure Routes Total
Sediment	Sediment	East Fork Armells Creek	Manganese	NA	NA	NA	NA	Central Nervous System	9.4E-03	NA	4.0E-02	5E-02
			Chemical Total	NA	NA	NA	NA		9.4E-03	NA	4.0E-02	5E-02
		Exposure Point Total					NA					5E-02
		Outdoor Air (Particulates)	NA	NA	NA	NA	NA		NA	NA	NA	NA
			Chemical Total	NA	NA	NA	NA		NA	NA	NA	NA
		Exposure Point Total					NA					NA
	Exposure Medium Total						NA					5E-02
Medium Total							NA					5E-02

Notes:

NA	Not Available/Not Applicable
RAGS	Risk Assessment Guidance for Superfund
RME	Reasonable Maximum Exposure
USEPA	United States Environmental Protection Agency

Target Organ Hazard Index	
Target Organ	Sediment
Central Nervous System	5E-02
Maximum	5E-02

TABLE B-9.3 USEPA RAGS PART D TABLE 9, CALCULATION OF RME CHEMICAL CANCER RISK AND NONCANCER HAZARDS FOR SEDIMENT EXPOSURE, EU1, RECREATIONAL USER

Human Health Risk Assessment
Wastewater Facilities Comprising the Closed Loop System
Plant Site Area, Colstrip Steam Electric Station, Colstrip, Montana

5/1/2018

Receptor Population:	Recreational User
Receptor Age:	Child

Medium	Exposure Medium	Exposure Point	Chemical of Potential Concern	Cancer Risk Calculations				Noncancer Hazard Quotient				
				Ingestion	Inhalation	Dermal	Exposure Routes Total	Primary Target Organ(s)	Ingestion	Inhalation	Dermal	Exposure Routes Total
Sediment	Sediment	East Fork Armells Creek	Manganese	NA	NA	NA	NA	Central Nervous System	6.7E-02	NA	1.6E-01	2E-01
			Chemical Total	NA	NA	NA	NA		6.7E-02	NA	1.6E-01	2E-01
		Exposure Point Total					NA					2E-01
		Outdoor Air (Particulates)	NA	NA	NA	NA	NA		NA	NA	NA	NA
			Chemical Total	NA	NA	NA	NA		NA	NA	NA	NA
		Exposure Point Total					NA					NA
	Exposure Medium Total						NA					2E-01
Medium Total							NA					2E-01

Notes:

NA	Not Available/Not Applicable
RAGS	Risk Assessment Guidance for Superfund
RME	Reasonable Maximum Exposure
USEPA	United States Environmental Protection Agency

Target Organ Hazard Index	
Target Organ	Sediment
Central Nervous System	2E-01
Maximum	2E-01

TABLE B-10 USEPA RAGS PART D TABLE 10, RISK SUMMARY FOR SEDIMENT EXPOSURE, EU1
Human Health Risk Assessment
Wastewater Facilities Comprising the Closed Loop System
Plant Site Area, Colstrip Steam Electric Station, Colstrip, Montana

5/1/2018

Receptor Population:	Resident	Industrial Worker	Construction Worker	Recreational User
Receptor Age:	Child	Adult	Adult	Child

Medium	Exposure Medium	Exposure Point	Chemical of Potential Concern	Cancer Risk Calculations				Noncancer Hazard Quotient				
				Ingestion	Inhalation	Dermal	Exposure Routes Total	Primary Target Organ(s)	Ingestion	Inhalation	Dermal	Exposure Routes Total
Sediment	Sediment	East Fork Armells Creek	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
			Chemical Total	NA	NA	NA	NA		NA	NA	NA	NA
		Exposure Point Total					NA					NA
		Outdoor Air (Particulates)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
			Chemical Total	-	NA	-	NA		-	NA		NA
		Exposure Point Total					NA					NA
	Exposure Medium Total						NA					NA
Medium Total							NA					NA

This table is intentionally blank - no carcinogenic COPCs were identified and noncancer hazards do not exceed 1.0 for any of the receptors.

Notes:

NA	Not Available/Not Applicable
RAGS	Risk Assessment Guidance for Superfund
USEPA	United States Environmental Protection Agency

APPENDIX C

Ecological Risk Assessment

Appendix C: Ecological Risk Assessment for the CCRA Waste Water Facilities Comprising the Closed Loop Plant Site Area, Colstrip Power Plant

Prepared for Hydrometrics, Inc.

9 May 2018

Prepared by

NEPTUNE AND COMPANY, INC.
1435 Garrison St, Suite 201, Lakewood, CO 80215

List of Acronyms

ADD	Average Daily Dose
AUF	Area Use Factor
BERA	Baseline ecological risk assessment
bgs	below ground surface
BSL	Background screening level
BTAG	Biological Technical Assistance Group
BTV	Background threshold value
BW	Body weight
CCME	Canadian Council of Ministers of the Environment
CCRA	Cleanup Criteria and Risk Assessment
COC	Chemical of Concern
COPC	Chemical of Potential Concern
DL	Detection Limit
EcoSSL	Ecological Soil Screening Levels
EPC	Exposure Point Concentration
ERA	Ecological Risk Assessment
ESL	Ecological Screening Level
HQ	Hazard Quotient
IR	Ingestion rate
LANL	Los Alamos National Laboratory
LOAEL	Lowest Observed Adverse Effect Level
MDEQ	Montana Department of Environmental Quality
NOAEL	No Observed Adverse Effects Level
PAUF	Population Area Use Factor
SCEM	Site conceptual exposure model
SLERA	Screening-level ecological risk assessment
SOEP	Stage I Evaporation Pond
STEP	Stage II Evaporation Pond
T&E	Threatened and endangered
TDS	Total dissolved solids
TRVs	Toxicity Reference Values
UCL	Upper Confidence Level
USEPA	United States Environmental Protection Agency

EXECUTIVE SUMMARY

The SLERA was implemented pursuant to the United States Environmental Protection Agency (USEPA) guidance (USEPA, 1993, 1997b, 1998 et al.) and Montana Department of Environmental Quality (MDEQ) guidance (DEQ, 2009, 2016).

This ERA presents an evaluation of the potential for exposure and ecological risks in the East Fork Armells Creek (the Creek) adjacent to the Colstrip Power Plant. The ERA uses environmental data related to present-day concentrations of chemicals in sediment, soil, and surface water adjacent to the Plant Site (the Site) along the Creek. Groundwater was not directly assessed, however protective groundwater clean-up numbers were derived based upon a livestock ingestion model.

ES-1 Overview of the Ecological Risk Assessment Process

The ERA for the Plant Site area consists of a screening level ecological risk assessment (SLERA), SLERA refinement, and baseline ecological risk assessment (BERA). An ecological Site Conceptual Exposure Model (SCEM) identified the ecological exposures associated with the Creek, as well as the Facility-specific contaminant sources, release mechanisms, transport routes and media, and potential receptors. The SLERA (Steps 1 and 2 of the EPA Process) conservatively ruled out further evaluation of constituents and media that did not pose an ecological risk. Constituents that remained following the SLERA were carried to the SLERA refinement, which represents Step 3A of the USEPA ERA process. Chemicals of potential concern (COPCs) were carried forward from the SLERA refinement to the BERA, wherein chemicals of concern (COCs) were identified utilizing realistic, site-specific exposure assumptions.

ES-2 Ecological Risk Assessment

Evaluation of the Site for sensitive environments identified wetland areas in and adjacent to the Creek within the investigation area. Delineated wetland types include Riparian Lotic Scrub-shrub, Palustrine Aquatic Bed Semi-permanently Flooded wetland, and Palustrine Emergent Seasonally Flooded wetland. East Fork Armells Creek and its immediate environs provide habitat for aquatic and terrestrial plants, aquatic and benthic invertebrates, and small fish. Terrestrial habitats adjacent to the Creek are comprised of grasslands with scattered shrubs, which provide habitat for a variety of birds and small mammals. It is assumed that the creek is used by wildlife and livestock as a drinking water source. Therefore, ecological exposure pathways are considered complete for all trophic levels to surface water, sediment, and soil.

Ecological exposure pathways to groundwater are considered incomplete for wildlife receptors. However, the groundwater at the Site is designated Class III under the Administrative Rules of Montana, which means it must be of at least marginal quality for livestock watering and industrial use. Protective clean-up levels were calculated for chemicals in Site groundwater based upon the assumption that groundwater could be pumped to provide a drinking water source for livestock. The livestock groundwater evaluation is not part of the ERA, but is discussed separately following the BERA risk characterization.

SLERA Results: The SLERA compared maximum detected concentrations in sediment, surface water and soil to ecological screening levels. Background or reference concentrations of metals were also factored into the determination of preliminary COPCs. Manganese was the only constituent in sediment retained as a COPC. Boron, manganese, calcium, and magnesium were all retained as surface water COPCs. In shallow soils barium, boron, lead, and selenium exceeded ecological soil screening levels and were retained as COPCs. In mid-depth soils boron, cadmium, lead, and selenium were retained as COPCs. No unacceptable risk was posed to livestock from ingestion of East fork Armells Creek surface water, though maximum concentrations of sulfate in the water render the creek marginal for livestock watering.

SLERA refinement results: The SLERA refinement process used the 95 UCL to represent exposure point concentrations for site receptors, and included an expanded screening to focus the list of receptors potentially at risk from Site COPCs. Manganese and boron were both retained as COPCs in surface water after screening refinement based on potential risk to aquatic life. Manganese was also retained as a sediment COPC for the BERA based on potential risk to sediment-dwelling organisms. In shallow soils barium, boron, lead and selenium were retained as COPCs and evaluated further in the expanded soil screening to determine which receptors were at potential risk from these constituents in surface soil, and to focus the BERA evaluation. Barium and selenium were designated as COPCs based on potential risk to plants in shallow soil, and selenium was also retained as a COPC based on potential risk to plants in mid-depth soil. Boron, lead, and selenium were retained as COPCs in the SLERA based on potential risk to terrestrial wildlife. In mid-depth soils only selenium was retained as COPC following screening refinement.

BERA results: The BERA risk characterization involved calculation of average daily doses of COPCs to wildlife potentially exposed to Creek sediment and surface water, and Site soils. Manganese was retained as a COC for both sediment and surface water based on risk to sediment-dwelling organisms, and boron was retained as a COC for surface water based on risk to aquatic life. Boron and manganese were found to pose no unacceptable risk to aquatic-dependent wildlife. Barium and selenium were not retained as risk drivers for plants growing in Site soil. Boron doses to insectivorous birds and herbivorous birds did not pose unacceptable risk in surface soil. Lead doses to insectivorous birds, herbivorous birds, and insectivorous mammals did not pose unacceptable risk in the Site soil areas. Selenium doses to insectivorous mammals did not pose an unacceptable risk in mid-depth soils.

Conclusions: The BERA risk characterization identified manganese in sediment and surface water as posing potential risk to benthic and aquatic life. Boron in surface water was found to pose potential risk to aquatic life. However, both manganese and boron concentrations were higher in surface water upgradient of the Plant Site (Locations AR-12, AR-5 and various surface water sampling locations used to estimate the surface water Background Screening Level [BSL]) than downstream of the Plant site, suggesting that the elevated concentrations of these chemicals are not Site related. In addition, more recent toxicity evaluations of boron indicate that the initial effects-levels used in the ERA are overly conservative. Therefore, risk-based clean-up levels for manganese and boron in sediment and surface water were not developed. Following the BERA, groundwater cleanup-levels were calculated based on protection of livestock potentially utilizing pumped groundwater as a drinking water source. Calves were the most sensitive livestock receptor for all chemicals evaluated.

C-1 Introduction

The Ecological Risk Assessment (ERA) was prepared by Neptune and Company, Inc. The ERA was conducted following United States Environmental Protection Agency (USEPA) guidance (USEPA, 1993, 1997b, 1998 et al.) and Montana Department of Environmental Quality (MDEQ) guidance (DEQ, 2009, 2016).

The ERA focuses on potential exposure to chemicals of potential concern (COPCs) in surface water and sediment in East Fork Armells Creek adjacent to the Plant Site and extending downstream as far as Power Road, and exposure to soil in three areas along the Creek north of the Plant Site, as shown in Figure 7 of the main text and detailed in the Interim Response Action Work Plan for Soil Sampling at Historic Release Sites along East Fork Armells Creek (Hydrometrics, 2016a). Potential risk from chemical concentrations in groundwater were not directly assessed, though protective groundwater clean-up numbers were derived as part of this ERA based upon a livestock ingestion model, assuming that groundwater at the site could be pumped for livestock watering purposes. Potential ecological risk associated with sediment and water within the ponds at the Plant Site will be addressed as part of the closure process for those ponds. Potential risk associated with East Fork Armells Creek sediment and surface water downstream of Power Road will be assessed as part of the Clean-up Criteria and Risk Assessment Work Plan (CCRA) for the Units 1 & 2 Stage I Evaporation Pond (SOEP) and Stage II Evaporation Pond (STEP) area.

Initially, a screening-level ecological risk assessment (SLERA) was presented as part of the CCRA Work Plan to conservatively rule out further evaluation of constituents and media that do not pose an ecological risk. The SLERA represents Steps 1 and 2 of the USEPA ecological risk assessment process (USEPA, 1997b). Any constituents that remained following the initial SLERA were carried to the screening refinement, informally known as Step 3A of the USEPA ecological risk assessment process. COPCs remaining following screening refinement were carried forward to the baseline ecological risk assessment (BERA), where the conservative assumptions used in the SLERA were replaced with more realistic, site-specific exposure assumptions.

The ecological risk assessment was conducted with existing synoptic run data for East Fork Armells Creek. Synoptic run sediment data for the ecological risk assessment were collected in Spring and Fall 2014. Synoptic run surface water data used in the ERA were collected seasonally, and data collected in 2014 and 2015 were used to represent current conditions within the Creek. Contaminants in the Creek upgradient of the Plant Site, as well as in the Colstrip area, were considered background concentrations for the Creek.

C-2 Ecological Exposure Assessment

The Ecological Exposure Assessment provides a description of the environmental exposure to releases or threatened releases of wastewater COPCs from the ponds at the Plant Site based upon the current use of the Facility and adjacent properties and reasonably anticipated future uses of the Facility and adjacent properties. The Ecological Exposure Assessment was prepared following MDEQ and USEPA guidance as described in the following sections.

C-2.1 Ecological Site Conceptual Exposure Model

An ecological Site Conceptual Exposure Model (SCEM) was prepared as the first step in the Exposure Assessment. The ecological SCEM identifies the ecological exposures associated with the Creek, as well as the Facility-specific contaminant sources, release mechanisms, transport routes and media, and potential receptors. The ecological exposures assessed in the ERA are presented in the SCEM (Figure 6 of main text).

C-2.2 Assessment Endpoints, Measures of Effect, and Exposure Pathways

Ecological assessment endpoints represent the ecological values to be protected at the Facility. Potential receptors for the SLERA and BERA have been selected based on a site visit conducted in July 2014 and information obtained from the Montana Natural Heritage Program. Receptors, include the plants, animals and components of the environment (e.g., habitats, populations, communities) that may potentially be exposed to contamination in East Fork Armells Creek and adjacent soil areas. Exposure pathways are identified in the SCEM (see Figure 6 of main text). Preliminary assessment endpoints for the SLERA and screening refinement include:

- Protection of populations of aquatic plants exposed to surface water and sediment in East Fork Armells Creek.
- Protection of benthic invertebrate communities exposed to surface water and sediment in East Fork Armells Creek.
- Protection of populations of riparian birds and mammals exposed to surface water and sediment in East Armells Creek.
- Protection of populations of soil invertebrates exposed to upland soil in the soil historic release areas.
- Protection of populations of plants exposed to upland soil in the soil historic release areas.
- Protection of populations of terrestrial birds and mammals exposed to upland soil in the historic release areas.

Ecological risk assessments focus on the protection of populations of organisms, except when the potential exists for threatened and endangered (T&E) species to occur at the Facility. Protection of individuals of T&E species is a goal of the ERA if such species are known or suspected to occur. Information on the potential for T&E species to be present along the Creek was obtained from the Montana Natural Heritage Program. According to the Species of Concern list updated on 6/23/2015, there are 45 animal species of concern in Rosebud County. Of these, only one, the Pallid Sturgeon, is listed as endangered. The Pallid Sturgeon occurs in large rivers, and would not occur in East Fork Armells Creek. A second species, Yellow-billed Cuckoo, is listed as threatened in the portion of its range that includes the State of Montana. The Yellow-billed Cuckoo inhabits prairie riparian forests and may utilize streamside cottonwoods during migration, but trees are likely too sparse in the area of East Fork Armells Creek and the Plant Site to support breeding yellow-billed cuckoos. A third species, Sprague's Pipit, is a candidate species for listing. Sprague's Pipit inhabits open grassland with no trees or shrubs, and may occur on open grassland portions of the Plant Site, but would not be expected along East Fork Armells Creek. USFWS published a finding in October 2015 on a petition to list the greater sage grouse as endangered or threatened across its range, including Montana. The 2015 finding concluded that listing of the greater sage grouse was not warranted. Two other species, Bald

Eagle and Golden Eagle, receive protection under the Bald and Golden Eagle Protection Act. Bald Eagles normally stay near large bodies of water, while Golden Eagles prefer open country. Of the two, Golden eagles are more likely to occur on the Plant Site, where they would be expected to feed on a variety of small mammals in the open grasslands. Utilization of East Fork Armells Creek by Bald and Golden Eagles is expected to be minimal. Any exposure to East Fork Armells Creek water and sediment is expected to be limited to surface water ingestion.

According to information, obtained from the Montana Natural Heritage Program's Wetland's Mapper (http://geoinfo.msl.mt.gov/home/msdi/wetlands), the following delineated wetland occur within the study area:

- Upgradient sampling location AR-12 is adjacent to Riparian Lotic Scrub-shrub wetland.
- Upgradient Sampling location AR-5 is located in Palustrine Emergent Seasonally Flooded wetland.
- East Armells Creek between sampling location AR-4 and AR-3 includes Palustrine Aquatic Bed Semi-permanently Flooded wetland, and Palustrine Emergent Seasonally Flooded wetland.
- The area between location AR-3 and Power Road contains Palustrine Emergent Seasonally Flooded wetland.

Measures of Effect describe how assessment endpoints will be evaluated to determine whether potential risk exists to a specific assessment endpoint. Measures of Effect for the SLERA and screening refinement include:

- Comparison of Creek surface water concentrations to chronic aquatic life standards published in Montana DEQ-7.
- Comparison of Creek sediment concentrations to USEPA Region 3 Biological Technical Assistance Group (BTAG) freshwater sediment screening benchmarks.
- Comparison of soil concentrations to EPA Ecological Soil Screening Levels (EcoSSLs) or other ecological soil screening benchmarks if EPA EcoSSLs have not been derived for a given constituent.
- Comparison of soil, sediment, and surface water concentrations to appropriate background or reference areas that are not impacted by Plant Site wastewater operations.

Additional Measures of effect for a baseline ecological risk assessment include:

- Food chain modeling to terrestrial birds and mammals utilizing upland soil areas and the Creek as a source of food and drinking water, and comparison of average daily doses to toxicity reference values (TRVs). Food-chain models were constructed as needed for the following representative receptors that may forage in upland soil areas and/or the Creek:
    - Raccoon (*Procyon lotor*), representative of omnivorous mammals utilizing East Fork Armells Creek.

  - Common yellowthroat (*Geothlypis trichas*), representative of insectivorous birds utilizing East Fork Armells Creek.
  - Great blue heron (*Ardea herodias*), representative of piscivorous birds utilizing East Fork Armells Creek.
  - Ord's kangaroo rat (*Dipodomys ordii*), representative of herbivorous mammals utilizing upland soil areas at the Plant Site.
  - Masked shrew (*Sorex cinereus*), representative of insectivorous mammals utilizing upland soil areas at the Plant Site.
  - Lark sparrow (*Chondestes grammacus*), representative of herbivorous birds utilizing upland soil areas at the Plant Site.
  - Sprague's pipit (*Anthus spragueii*), representative of insectivorous birds utilizing upland soil areas at the Plant Site.

Food chain modeling to terrestrial receptors utilizing the creek as a food/water source was included as part of the BERA because these receptors have exposures across multiple media (soil, sediment, and water).

Following the SLERA and screening refinement, the list of assessment endpoints and the SCEM were refined based upon the results of the screening-level assessment. Current and reasonably anticipated future uses of adjacent properties were also considered when identifying potential receptors and exposure pathways.

East Fork Armells Creek within the investigation area is a generally slow-moving creek containing permanent water and in places, abundant emergent vegetation. East Fork Armells Creek is designated a Class C-3 surface water body under the Montana Water Quality Act. A Class C-3 waterbody is defined as suitable for bathing, swimming, and recreation; and growth and propagation of non-salmonid fishes and associated aquatic life, waterfowl, and furbearers. The quality of Class C-3 waters is naturally marginal for drinking, culinary, and food processing purposes, agriculture, and industrial water supply.

Wetland areas are present in and adjacent to the Creek within the investigation area. Delineated wetland types include Riparian Lotic Scrub-shrub, Palustrine Aquatic Bed Semi-permanently Flooded wetland, and Palustrine Emergent Seasonally Flooded wetland. East Fork Armells Creek and its immediate environs provide habitat for aquatic and terrestrial plants, aquatic and benthic invertebrates, and small fish. The utility of the creek as a drinking water source for wildlife is uncertain due to the high concentrations of cations and dissolved solids, which make the water in the creek more akin to saltwater than freshwater. However, for risk assessment purposes it is assumed that the creek is used by wildlife as a drinking water source. Terrestrial habitats adjacent to the Creek, including the three soil spill areas evaluated in this report, are comprised of grasslands with scattered shrubs. These provide habitat for a variety of birds and small mammals. Some of the surrounding grasslands on and adjacent to the Plant Site are fenced to allow grazing by cattle and horses. Therefore, ecological exposure pathways are considered complete for all trophic levels to surface water, sediment, and soil. Complete exposure pathways for each ERA receptor group are shown in Table C-1.

Ecological exposure pathways to groundwater are considered incomplete for wildlife receptors. However, the groundwater at the Site is designated Class III under the Montana Water Quality Act. Class III ground waters are those ground waters with a natural specific conductance that is greater than 2,500 and less than or equal to 15,000 microSiemens/cm at 25ºC. Groundwater in Colstrip typically exhibits a specific conductance above 4000 umhos/cm. Class III ground waters are not suitable for potable use without treatment, but must be of at least marginal quality for livestock watering and industrial use. Protective clean-up levels were calculated for chemicals in Site groundwater based upon the assumption that groundwater could be pumped to provide a drinking water source for livestock. The livestock groundwater evaluation is not part of the ERA, but is discussed in Section C-4 immediately following the BERA risk characterization.

Table C-1. Ecological Exposure Pathways

Ecological Receptor	**Exposure Pathway**				
	Root Uptake	**Dermal Contact**	**Surface Water Ingestion**	**Soil/Sediment Ingestion**	**Food-chain Ingestion**
Benthic Invertebrates/Fish	NA	1°	1°	1°	2°
Soil Invertebrates	NA	1°	NA	1°	2°
Aquatic Plants / Terrestrial Plants	1°	2°	NA	NA	NA
Terrestrial Mammals	NA	2°	1°	2°	1°
Terrestrial Birds	NA	2°	1°	2°	1°

1° = Primary or major pathway
2° = Secondary or minor pathway
N/A = Insignificant or Incomplete Pathway

C-2.3 Exposure Assumptions

Ecological exposure scenarios are identified based on the current and reasonably anticipated future Facility use (and adjacent areas), the potential receptors, and complete exposure pathways. For the SLERA, conservative exposure assumptions are used so that risk is not underestimated. These assumptions include:

- An Area Use Factor (AUF) of 1 (i.e., an organism gets 100% of its exposure from East Fork Armells Creek or the soil area)
- 100% bioavailability of chemical constituents in sediment and surface water
- Use of No Observed Adverse Effects Level (NOAEL) screening levels and TRVs

For the BERA food chain modeling of dose to birds and mammals exposed to soil and Creek surface water and sediments, more realistic exposure assumptions are used to represent exposure, and Lowest Observed Adverse Effects Level (LOAEL) TRVs are used. Organism body weights, food ingestion rates, and water ingestion rates for use in the food-chain modeling are shown in Tables C-2 and C-3 below. Because no biotic tissue has been analyzed to provide estimates of contaminant concentrations in the food chain, estimates of bioaccumulation into food/prey items were selected from available literature.

Table C-2. Food Chain Modeling Exposure Parameters For East Fork Armells Creek Receptors

Parameter	Value	Source
Raccoon		
Body Weight (kg)	6	Average of the mean values of studies reporting weights of adult raccoons, reported in Wildlife Exposure Factors Handbook (USEPA, 1993).
Food Ingestion Rate (kg/d dry wt.)	0.3	Calculated using allometric equation for All Mammals (Equation 3-7) from Wildlife Exposure Factors Handbook (USEPA 1993).
Water Ingestion Rate (L/d)	0.5	Based on water ingestion rate of 0.083 grams per grams of body weight per day (g/g-d) as reported in Wildlife Exposure Factors Handbook (USEPA, 1993)
Incidental Sediment Ingestion Rate (k/d dry wt)	0.03	Beyer et al., 1994.
Fraction Plants in Diet (unitless)	0.4	A study of raccoons in bottomland riparian habitat found that plant material made up ~40% of the raccoon diet when averaged across all four seasons, ranging from less than 5% in spring to ~60% in fall and winter (Llewellyn and Uhler as reported in USEPA 1993). Raccoon diets in Spring, Summer, and Fall are dominated by fruits and nuts (Tesky, 1995).
Fraction Invertebrates in Diet (unitless)	0.5	A study of raccoons in bottomland riparian habitat found that invertebrates made up ~50% of the raccoon diet when averaged across all four seasons, ranging from ~25% in fall and winter to 82% in spring (Llewellyn and Uhler as reported in USEPA 1993). According to Tesky (1995), Spring is the only time of year when animal material comprises more than 50% of raccoons diet, with small invertebrates the most important animal foods consumed by raccoons.
Fraction Fish in Diet (unitless)	0.1	A study of raccoons in bottomland riparian habitat found that fish and other vertebrates made up ~10% of the raccoon diet when averaged across all four seasons, ranging from ~3% in fall to 16% in winter and spring (Llewellyn and Uhler as reported in USEPA 1993). In summer, this category also includes eggs of nesting birds, particularly waterfowl eggs in regions of the northern great plains (Tesky 1995).
Area Use Factor	1	An AUF of 1 is used to be protective of all omnivorous mammals for which the raccoon serves as a surrogate.
Common Yellowthroat		
Body Weight (kg)	0.01	Mean of all adult body weights from Guzy and Ritchison, 1999.
Food Ingestion Rate (kg/d dry wt.)	0.0033	Calculated using allometric equation for passerine birds (Equation 3-4) in Wildlife Exposure Factors Handbook (USEPA, 1993).
Water Ingestion Rate (L/d)	0.0028	Based on water ingestion rate of 0.28 g/g-d as reported in Wildlife Exposure Factors Handbook (USEPA, 1993)
Incidental Sediment Ingestion Rate (k/d dry wt)	0.000066	Calculated as 2% of total ingestion rate
Fraction Invertebrates in Diet (unitless)	1	Diet assumed to be 100% invertebrates to be protective of all insectivorous birds utilizing the Creek
Area Use Factor	1	The AUF of 1 is applied to each individual area within East Fork Armells Creek, assuming that individual common yellowthroats defend territories in the wetland portions of each area.

Table C-2. Food Chain Modeling Exposure Parameters For East Fork Armells Creek Receptors (continued)

Great Blue Heron Exposure Parameters		
Body Weight (kg)	2.336	Mean of all adult body weights reported in Wildlife Exposure Factors Handbook (USEPA, 1993).
Food Ingestion Rate (kg/d dry wt.)	0.105	Total Ingestion of 0.105 kg/d (dry weight) based on ingestion rate of 0.18 kg/kg-d (kilograms per kilograms of body weight per day; wet weight) from Wildlife Exposure Factors Handbook (USEPA, 1993) adjusted for body weight and converted to dry weight by assuming average of 75% moisture in prey items.
Water Ingestion Rate (L/d)	0.105	Based on water ingestion rate of 0.045 g/g-d as reported in Wildlife Exposure Factors Handbook (USEPA, 1993)
Incidental Sediment Ingestion Rate (k/d dry wt)	0.002	Calculated as 2% of total ingestion rate
Fraction Fish in Diet	1	The four studies listed in USEPA (1993) report the diet of the great blue heron as comprised of 94 to 100% fish, with invertebrates, amphibians, birds and mammals comprising the non-fish portion of the diet. For the purposes of evaluating risk to piscivores, the great blue heron will be assumed to have a diet of 100% fish from East Fork Armells Creek.
Area Use Factor	1	The AUF of 1 is applied to each individual area within East Fork Armells Creek. Great Blue Herons have been reported to forage in areas as small as 1.5 acres.

Table C-3. Food Chain Modeling Exposure Parameters For Plant Site Soil Area Receptors

Ord's Kangaroo Rat (mammalian herbivore)		
Body Weight (kg)	0.052	Mean adult body mass reported in Garrison and Best, 1990.
Food Ingestion Rate (kg/d dry wt.)	0.0058	Calculated using allometric equation for rodents (Equation 3-8) in Wildlife Exposure Factors Handbook (USEPA, 1993)
Water Ingestion Rate (L/d)	0.007	Calculated using allometric equation for mammals (Equation 3-17) in Wildlife Exposure Factors Handbook (USEPA, 1993)
Incidental Soil Ingestion Rate (k/d dry wt)	0.0058	Calculated as 10% of total ingestion
Fraction Plants in Diet	1	Diet assumed to be 100% plant material to be protective of all herbivorous mammals utilizing the upland soil areas
Area Use Factor	1	
Masked Shrew (mammalian insectivore)		
Body Weight (kg)	0.004	Recommended value for masked shrew from Warrington, P.D. 2001.
Food Ingestion Rate (kg/d dry wt.)	0.00084	Based upon a high point recommended value for short-tailed shrew of 0.209 g dw food/g body weight/d (Table 1 of EPA 2007)
Water Ingestion Rate (L/d)	0.0005	Recommended value for masked shrew from Warrington, P.D. 2001.
Incidental Soil Ingestion Rate (k/d dry wt)	0.000325	Calculated as 10% of total ingestion
Fraction Invertebrates in Diet	1	Assumed to be 100% to be protective of all insectivorous mammals
Area Use Factor	1	
Lark Sparrow (avian herbivore)		
Body Weight (kg)	0.0289	Mean adult weight from four studies reported in Martin and Parrish (2000)
Food Ingestion Rate (kg/d dry wt.)	0.00694	Calculated using allometric equation for passerine birds (Equation 3-4) in Wildlife Exposure Factors Handbook (USEPA, 1993).
Water Ingestion Rate (L/d)	0.005	Calculated using allometric equation for birds (Equation 3-15) in Wildlife Exposure Factors Handbook (USEPA, 1993)
Incidental Soil Ingestion Rate (k/d dry wt)	0.00014	Calculated as 2% of total ingestion
Fraction Plants in Diet	0.75	Martin and Parrish, 2000
Fraction Invertebrates in Diet	0.25	Martin and Parrish, 2000
Area Use Factor	1	
Spraque's Pipit (avian insectivore)		
Body Weight (kg)	0.02375	Mean of 343 territorial males and breeding females reported in Davis et al., 2014.
Food Ingestion Rate (kg/d dry wt.)	0.00588	Calculated using allometric equation for passerine birds (Equation 3-4) in Wildlife Exposure Factors Handbook (USEPA, 1993).
Water Ingestion Rate (L/d)	0.005	Calculated using allometric equation for birds (Equation 3-15) in Wildlife Exposure Factors Handbook (USEPA, 1993)
Incidental Soil Ingestion Rate (k/d dry wt)	0.00012	Calculated as 2% of total ingestion
Fraction Invertebrates in Diet	1	According to Davis et al. (2014) diet consists of a wide array of arthropods with a small amount of plant matter. For risk assessment purposes, 100% invertebrate ingestion is assumed
Area Use Factor	1	

Table C-4. Bioaccumulation Factors for Metals in Soil

	Soil to Plant BAF	Soil to Invertebrate BAF	Soil to Flesh BAF
Arsenic[1]	$B_i = 0.03752 * Soil_j$	$\ln(B_i) = 0.706 * \ln(Soil_j) - 1.421$	$\ln(B_i) = 0.8188 * \ln(Soil_j) - 4.8471$
Barium[1]	$B_i = 0.156 * Soil_j$	$B_i = 0.091 * Soil_j$	$B_i = C_{diet} * 0.0075$
Boron[2]	$B_i = 4.0 * Soil_j$	$B_i = 1 * Soil_j$ (Default)	$B_i = 0.000817 * Soil_j$
Cadmium[1]	$\ln(B_i) = 0.546 * \ln(Soil_j) - 0.475$	$\ln(B_i) = 0.795 * \ln(Soil_j) + 2.114$	$\ln(B_i) = 0.4723 * \ln(Soil_j) - 1.2571$
Chromium[1]	$B_i = 0.041 * Soil_j$	$B_i = 0.306 * Soil_j$	$\ln(B_i) = 0.7338 * \ln(Soil_j) - 1.4599$
Lead[1]	$\ln(B_i) = 0.561 * \ln(Soil_j) - 1.328$	$\ln(B_i) = 0.807 * \ln(Soil_j) - 0.218$	$\ln(B_i) = 0.4422 * \ln(Soilj) + 0.0761$
Manganese[1]	$B_i = 0.079 * Soil_j$	$\ln(B_i) = 0.682 * \ln(Soil_j) - 0.809$	$B_i = 0.0205 * Soil_j$
Mercury[2]	$B_i = 0.663 * Soil_j$	$B_i = 3.933 * Soil_j$	$B_i = 0.49 * Soil_j$
Selenium[1]	$\ln(B_i) = 1.104 * \ln(Soilj) - 0.677$	$\ln(B_i) = 0.733 * \ln(Soil_j) - 0.075$	$\ln(B_i) = 0.3764 * \ln(Soil_j) - 0.4158$

[1] Bioaccumulation factors from USEPA EcoSSL guidance documents (USEPA, 2003c)

[2] Bioaccumulation factors from LANL EcoRisk Database (LANL, 2014)

Table C-5. Bioaccumulation / Bioconcentration Factors for Metals in Sediment / Surface Water

	Bioaccumulation / Bioconcentration Factor		
	Sediment – Plant [1]	**Sediment – Invert [1]**	**Surface Water – Fish [2]**
Arsenic	B_i = 0.0375 * Sediment	B_i = 0.236 * Sediment	B_i = 44 * Surface Water
Barium	B_i = 0.156 * Sediment	B_i = 0.091 * Sediment	B_i = 129 * Surface Water [3]
Beryllium	B_i = 0.01 * Sediment	B_i = 0.045 * Sediment	B_i = 19 * Surface Water
Boron	B_i = 4.0 * Sediment	B_i = 1 * Sediment (Default)	B_i = 0.3 * Surface Water [4]
Cadmium	B_i = 0.833 * Sediment	B_i = 14.26 * Sediment	B_i = 64 * Surface Water
Chromium	B_i = 0.041 * Sediment	B_i = 0.1607 * Sediment	B_i = 16 * Surface Water
Copper	B_i = 0.288 * Sediment	B_i = 0.6364 * Sediment	B_i = 36 * Surface Water
Lead	B_i = 0.58 * Sediment	B_i = 0.225 * Sediment	B_i = 49 * Surface Water
Manganese	B_i = 0.15 * Sediment	B_i = 0.0605 * Sediment	B_i = 600 * Surface Water [5]
Mercury	B_i = 0.663 * Sediment	B_i = 3.933 * Sediment	B_i = 5500 * Surface Water
Nickel	B_i = 0.372 * Sediment	B_i = 0.778 * Sediment	B_i = 47 * Surface Water
Selenium	B_i = 0.7 * Sediment	B_i = 0.99 * Sediment	B_i = 4.8 * Surface Water
Thallium	B_i = 0.004 * Sediment	B_i = 0.0541 * Sediment	B_i = 119 * Surface Water
Vanadium	B_i = 0.0055 * Sediment	B_i = 0.042 * Sediment	B_i = 1 * Surface Water (default)
Zinc	B_i = 0.88 * Sediment	B_i = 3.78 * Sediment	B_i = 47 * Surface Water

[1] Sediment – Plant and Sediment – Invert bioaccumulation factors obtained from LANL EcoRisk Database (LANL, 2014).

[2] Bioconcentration factor based on ratio of dissolved concentration in water to wet weight concentration in fish tissue. Fish tissue wet weight concentration is converted to dry weight in the food chain models by dividing wet weight concentration by 0.25 (assuming moisture content of 75%). Unless otherwise noted, wet weight values obtained from DEQ-7.

[3] BCF for Barium from ATSDR, 2007

[4] BCF for Boron from CCME, 2009b.

[5] BCF for Manganese from Karlsson et al., 2002

Bioaccumulation factors used to estimate contaminant concentrations in food items are shown in Tables C-4 and C-5. For contaminants in East Fork Armells Creek, concentrations in aquatic plants and benthic invertebrates are estimated based on bioaccumulation from sediment. Concentrations in fish tissue are estimated based on bioconcentration from surface water.

C-2.4 Ecological Exposure Areas and Exposure Point Concentrations

The exposure area for the ERA is defined as East Fork Armells Creek adjacent to and extending downstream of the Plant Site as far as Power Road. The Creek downstream of Power Road is be evaluated as part of the ERA for Units 1 &2 SOEP and STEP Area. The Plant Site ERA also includes the three soil areas detailed in the Interim Response Action Work Plan for Soil Sampling at Historic Release Sites along East Fork Armells Creek (Hydrometrics, 2016a).

For the initial screening-level assessment, the maximum concentration of each COPC in sediment, surface water, and soil is used. Refinement of the SLERA and the BERA utilized a 95% Upper Confidence Level (95 UCL) to represent more realistic exposure integrated across the exposure area. Because the creek extends across a relatively large area, 95 UCL Exposure Point Concentrations (EPC) in the BERA were calculated differently for the raccoon, which has relatively large home range/foraging area, versus the common yellowthroat and great blue heron, which have relatively small foraging areas. For the raccoon, the 95 UCL was calculated across all sampling locations in the Creek included in this investigation (AR-4, AR-3, AR-2), while 95 UCL EPCs for common yellowthroat and great blue heron were calculated for each sampling location. Thus, the 95 UCLs for widely ranging raccoon encompass spatial and temporal variability across the creek, while the EPCs for the smaller ranging receptors encompass only temporal variability at each sampling location. Locations AR-5 and AR-12 were not included in the 95 UCL calculations because they are upgradient of the Plant Site.

The 95 UCLs for soil were calculated across all soil sampling locations because the soil areas represent a much smaller areal extent than Creek sediment and water. Statistical and graphical summaries of the data to support EPC calculations are presented in Appendix D. Details of the 95 UCL calculations for surface water, sediment, and soil are presented in Appendix D. For certain data sets with small sample sizes, the calculated 95 UCL may exceed the maximum reported concentration. Exposure units and type of EPC used for each line of evidence in the SLERA and BERA are shown in Table C-6.

C-3 Ecological Toxicity Assessment

The Toxicity Assessment for the COPCs identified for East Fork Armells Creek follows the USEPA recommended approach (USEPA, 1997b, 1998). Surface water screening values were chosen to represent chronic criteria for protection of aquatic life as published in DEQ-7, and sediment screening values were selected from freshwater sediment screening criteria recommended by USEPA Region 3 BTAG. Surface water and sediment screening levels used in the SLERA are shown in Table C-7. Soil screening criteria represent EcoSSLs developed by the USEPA. Alternative sources of screening values, such as the EcoRisk Database developed by Los Alamos National Laboratory (LANL), were used when the primary sources listed above lack screening values for a given COPC. Soil screening levels for plants, invertebrates and wildlife are shown in Table C-8. The screening values for the SLERA and screening refinement are based on NOAEL toxicity levels, while the BERA considered both NOAEL and LOAEL toxicity values. TRVs for evaluation of dose to upper-trophic level birds and mammals likewise represent NOAEL values for screening and NOAEL and LOAEL values for screening refinement and the BERA. TRVs were selected from available sources, including those derived by USEPA as part of the Ecological Soil Screening Level Guidance (USEPA, 2003c), and Los Alamos National Laboratory (LANL, 2014). NOAEL TRVs for use in food chain modeling are presented in Table C-9, and LOAEL TRVs are presented in table C-10.

Table C-6. Exposure Units for Plant Site Ecological Risk Assessment

Receptor	Ecological Exposure Unit	Exposure Medium	EPC
SLERA			
Aquatic Plants	East Fork Armells Creek	Surface Water	Maximum
Aquatic Plants and Animals	East Fork Armells Creek	Sediment	Maximum
Terrestrial Plants and Animals	Soil Areas 1 – 3 (Combined)	Soil	Maximum
BERA			
Aquatic Plants and Animals	East Fork Armells Creek	Surface Water	95 UCL (all locations)
		Sediment	95 UCL (all locations)
Terrestrial Plants	Soil Areas 1 – 3 (Combined)	Soil	95 UCL (all locations)
Terrestrial Invertebrates	Soil Areas 1 – 3 (Combined)	Soil	95 UCL (all locations)
Terrestrial Omnivorous Mammals	Soil Areas 1 – 3 (Combined)	Soil	95 UCL (all locations)
		Food Chain	Bioaccumulation based on Soil 95 UCL
	East Fork Armells Creek	Surface Water	95 UCL (all locations)
		Sediment	95 UCL (all locations)
		Food Chain	Bioaccumulation based on Sediment/Water 95%UCLs
Terrestrial Insectivorous Birds	Soil Areas 1 – 3 (Combined)	Soil	Bioaccumulation based on Soil 95 UCL
		Food Chain	95 UCL (all locations)
	East Fork Armells Creek	Surface Water	95 UCL (each location)
		Sediment	95 UCL (each location)
		Food Chain	Bioaccumulation based on Sediment 95UCL
Aquatic/Terrestrial Piscivorous Birds	Soil Areas 1 – 3 (Combined)	Soil	95 UCL (all locations)
		Food Chain	Bioaccumulation based on Soil 95 UCL
	East Fork Armells Creek	Surface Water	95 UCL (each location)
		Sediment	95 UCL (each location)
		Food Chain	Bioconcentration based on Surface Water 95 UCL

Table C-7. Ecological Screening Criteria For Protection Of Aquatic Life

	Surface Water Screening Level (µg/L)	**Source [1]**	**Sediment Screening Level (mg/kg)**	**Source [1]**
Trace Metals				
Arsenic	150	DEQ-7	9.8	Region 3
Barium	4	Region 3	150	LANL ER Db
Beryllium	0.66	Region 3	NA	NA
Boron	1.6	Region 3	NA	NA
Cadmium	2.39 (adjusted for maximum hardness of 400 mg/kg $CaCO_3$)	DEQ-7	0.99	Region 3
Chromium (III)	268 (adjusted for maximum hardness of 400 mg/kg $CaCO_3$)	DEQ-7	43.4	Region 3
Copper	30.5 (adjusted for maximum hardness of 400 mg/kg $CaCO_3$)	DEQ-7	31.6	Region 3
Lead	18.6 (adjusted for maximum hardness of 400 mg/kg $CaCO_3$)	DEQ-7	35.8	Region 3
Manganese	120	Region 3	460	Region 3
Mercury	0.91	DEQ-7	0.18	Region 3
Nickel	168 (adjusted for maximum hardness of 400 mg/kg $CaCO_3$)	DEQ-7	22.7	Region 3
Selenium	5	DEQ-7	2	Region 3
Thallium	0.8	Region 3	NA	NA
Vanadium	20	Region 3	NA	NA
Zinc	387 (adjusted for maximum hardness of 400 mg/kg $CaCO_3$)	DEQ-7	121	Region 3
Common Ions				
Calcium	116,000	Region 3	NA	NA
Chloride	230,000	Region 3	NA	NA
Fluoride	7450 (adjusted for maximum hardness of 400 mg/kg $CaCO_3$)	Region 3	NA	NA
Magnesium	82,000	Region 3	NA	NA
Potassium	53,000	Region 3	NA	NA
Sodium	680,000	Region 3	NA	NA
Sulfate	3,000,000	USDA-ARS	NA	NA

[1] DEQ-7 = Montana Numeric Water Quality Standards, Chronic Aquatic Life Standards (DEQ, 2017)
Region 3 = USEPA Region 3 Ecological Screening Benchmarks for Freshwater and Freshwater Sediment, published 2006. Obtained from https://www.epa.gov/risk/biological-technical-assistance-group-btag-screening-values on 4/30/2016
USDA-ARS = USDA-ARS, 2009. Livestock Water Quality. USDA-ARS Fort Keough Livestock and Range Research Laboratory. Online at http://www.ars.usda.gov/SP2UserFiles/Place/30300000/Research/WATERQUALITYMKP6-09.pdf
LANL ER Db = TRVs obtained from Los Alamos National Laboratory EcoRisk Database v3.3 (LANL, 2014)
NA = Not available

Table C-8. Ecological Soil Screening Levels for Plants, Invertebrates and Wildlife

	Plant Soil Screening Level (mg/kg)	**Source [1]**	**Invert. Soil Screening Level (mg/kg)**	**Source [1]**	**Wildlife Soil Screening Level [2] (mg/kg)**	**Source [1]**
Arsenic	18	EPA EcoSSL	6.8	LANL ER Db	43	EPA EcoSSL
Barium	110	LANL ER Db	330	EPA EcoSSL	2000	EPA EcoSSL
Boron	36	LANL ER Db	NA	NA	2	LANL ER Db
Cadmium	32	EPA EcoSSL	140	EPA EcoSSL	0.36	EPA EcoSSL
Chromium (III)	NA	NA	NA	NA	26	EPA EcoSSL
Lead	120	EPA EcoSSL	1700	EPA EcoSSL	11	EPA EcoSSL
Manganese	220	EPA EcoSSL	450	EPA EcoSSL	4000	EPA EcoSSL
Mercury	34	LANL ER Db	0.05	LANL ER Db	0.013	LANL ER Db
Selenium	0.52	EPA EcoSSL	4.1	EPA EcoSSL	0.63	EPA EcoSSL

[1] EPA EcoSSL = TRVs obtained from EPA Ecological Soil Screening Levels documents (USEPA, 2003c, 2005a though 2005e, 2007a, 2007b)
LANL ER Db = TRVs obtained from Los Alamos National Laboratory EcoRisk Database (LANL, 2014)
[2] Wildlife Soil Screening Level represents the minimum soil screening value for birds and mammals
NA = Not available

Table C-9. NOAEL Toxicity Reference Values For Wildlife Food Chain Models

	Mammalian NOAEL TRV (mg/kg/d)	Source [1]	Avian NOAEL TRV (mg/kg/d)	Source [1]
Arsenic	1.04	EPA EcoSSL	2.24	EPA EcoSSL
Barium	51.8	EPA EcoSSL	73.5	LANL ER Db
Beryllium	0.532	LANL ER Db	NA	LANL ER Db
Boron	28	LANL ER Db	2.92	LANL ER Db
Cadmium	0.77	EPA EcoSSL	1.47	EPA EcoSSL
Chromium (III)	2.4	EPA EcoSSL	2.66	EPA EcoSSL
Copper	5.6	EPA EcoSSL	4.05	EPA EcoSSL
Lead	4.7	EPA EcoSSL	1.63	EPA EcoSSL
Manganese	51.5	EPA EcoSSL	179	EPA EcoSSL
Mercury	1.41	LANL ER Db	0.019	LANL ER Db
Nickel	1.7	EPA EcoSSL	6.71	EPA EcoSSL
Selenium	0.143	EPA EcoSSL	0.29	EPA EcoSSL
Thallium	0.0071	LANL ER Db	0.35	LANL ER Db
Vanadium	4.16	EPA EcoSSL	0.344	EPA EcoSSL
Zinc	75.4	EPA EcoSSL	66.1	EPA EcoSSL

[1] EPA EcoSSL = TRVs obtained from EPA Ecological Soil Screening Levels documents (USEPA, 2003c, 2005, 2007), LANL ER Db = TRVs obtained from Los Alamos National Laboratory EcoRisk Database (LANL, 2014)
NA = Not available

Table C-10. LOAEL Toxicity Reference Values for BERA Food Chain Modeling

	Mammalian LOAEL TRV (mg/kg/d)	Source [1]	Avian LOAEL TRV (mg/kg/d)	Source [1]
Arsenic	1.66	LANL ER Db	22.4	LANL ER Db
Barium	518	LANL ER Db	131	LANL ER Db
Beryllium	5.32	LANL ER Db	NA	NA
Boron	280	LANL ER Db	14.5	LANL ER Db
Cadmium	7.7	LANL ER Db	14.7	LANL ER Db
Chromium (III)	24	LANL ER Db	26.6	LANL ER Db
Copper	9.34	LANL ER Db	12.1	LANL ER Db
Lead	8.9	LANL ER Db	3.26	LANL ER Db
Manganese	515	LANL ER Db	1790	LANL ER Db
Mercury	14.1	LANL ER Db	0.19	LANL ER Db
Nickel	3.4	LANL ER Db	67.1	LANL ER Db
Selenium	0.215	LANL ER Db	0.579	LANL ER Db
Thallium	0.071	LANL ER Db	3.5	LANL ER Db
Vanadium	8.31	LANL ER Db	0.688	LANL ER Db
Zinc	754	LANL ER Db	661	LANL ER Db

[1] LANL ER Db = TRVs obtained from Los Alamos National Laboratory EcoRisk Database (LANL, 2014)
NA = Not available

C-4 Ecological Risk Characterization

For complete pathways, the risk characterization combines the exposure and toxicity assessments to produce quantitative estimates of potential ecological risks associated with the COPCs.

Ecological risk assessments generally characterize risk based on direct toxicity of COPCs. Unlike the human health risk characterization, ecological risk characterization does not calculate carcinogenic risk directly. Ecological risk is concerned primarily with risk to populations, and the life-span of most ecological receptors is not long enough for cancer endpoints to pose population level effects.

The potential for direct toxicity of COPCs to ecological receptors was evaluated through calculation of hazard quotients. For screening of sediment and surface water data for the protection of aquatic life, and screening of soil data for protection of plants, soil invertebrates, and wildlife, hazard quotients were calculated as follows:

$$\boldsymbol{Hazard\ Quotient = \frac{EPC}{Media\ Specific\ Screening\ Level}}$$

where:

EPC = media-specific exposure concentration

In the BERA, potential risk to birds and mammals using the East Fork Armells Creek area and Plant Site soil areas was assessed through calculation of hazard quotients based upon the average daily food chain dose to the organisms identified in Tables C-2 and C-3:

$$\boldsymbol{Hazard\ Quotient = \frac{ADD}{TRV}}$$

where:

ADD = average daily dose (mg/kg-d)
TRV = toxicity reference value (mg/kg-d)

The average daily dose was calculated as follows:

$$\boldsymbol{ADD = \frac{\sum(C_i * IR_i) * AUF}{BW}}$$

where:

ADD = average daily dose (mg/kg-d)
C_i = concentration of chemical in media “i” (mg/kg)
IR_i = organism-specific ingestion rate of media “i” (mg/kg-d)
AUF = Area Use Factor (unitless)
BW = organism body weight (kg)

C-4.1 Screening-Level Ecological Risk Characterization

C-4.1.1 Preliminary Screening of COPCs

Preliminary COPCs for the East Armells Creek exposure unit and the soil exposure unit were determined by comparing maximum detected concentrations in sediment, surface water and soil to the ecological screening levels presented in Section C.2. Background or reference concentrations of metals were also factored into the determination of preliminary COPCs. A site-specific background data set for soil has not been developed, therefore Background Threshold Values (BTV) for Montana surface soils were used for comparison (DEQ/Hydrometrics, 2013). No background data set was available for Creek sediment or surface water, so a comparison of downstream sediment and surface water concentrations was made to concentrations at upgradient locations AR-5 and AR-12 as well as Background Screening Levels (BSLs) for surface water calculated by Neptune and Company (2016).

Sediment

In East Fork Armells Creek sediment, only manganese had maximum detected concentrations exceeding sediment screening levels and upgradient background concentrations. Sediment screening levels were not available for beryllium, boron, and thallium, and maximum concentrations of each of these downstream of the Plant Site exceeded their concentrations at upgradient locations AR-5 and AR-12. Because sediment screening levels were not available for these metals, they are not retained as COPCs in sediment, but decisions on their overall status as COPCs in the Creek was based on the results of the surface water screening.

Mercury was not detected in any of the sixteen East Fork Armells Creek samples, nor was it detected at upgradient locations AR-5 and AR-12. Results of the initial sediment screening are shown in Table C-11. Based on the initial screening, arsenic and manganese are the only two constituents in sediment retained as potential sediment COPCs, and are evaluated further in the screening refinement.

Surface Water

Preliminary ecological screening results for thirteen metals and six common cations in East Fork Armells Creek surface water are presented in Table C-12. Two metals, boron and manganese, and two cations, calcium and magnesium, had maximum observed concentrations greater than ecological screening levels. Maximum manganese concentrations downgradient of the Plant Site were less than the background threshold value (BTV) for manganese (see Appendix D). Maximum concentrations of calcium and magnesium downgradient of the Plant Site were less than concentrations observed at upgradient AR-5 and/or AR-12. In the interest of screening-level conservatism, these four potential COPCs were retained for further evaluation in the screening refinement for surface water based on exceedances of their respective ecological screening levels. The maximum concentration of vanadium in surface water was equal to the ecological screening level of 20 μg/L, but was less than the vanadium surface water BSL, indicating that creek concentrations of vanadium are not site related. Because the hazard quotient for vanadium did not exceed 1, vanadium was not retained as a potential COPC. Beryllium was not detected in any of the eighteen surface water samples, but the maximum reporting limit was greater than the ecological screening level. Beryllium is discussed further in the ERA uncertainty discussion.

Soil

Ecological screening of metals concentrations in soil was divided into shallow depth (0 - 6 inches), and mid-depth (12 – 24 inches) surface soils. All ecological receptors included in this evaluation (plants, invertebrates, birds, mammals) were considered to have potential exposure to soils in the shallow depth. Only plants, soil invertebrates, and burrowing mammals were considered to have direct contact with soils in the mid-depth horizon. The ecological screening results for shallow soils are presented in Table C-13. Screening results for mid-depth soils are presented in Table C-14. Soil screening levels in Table C-14 have been adjusted to reflect only the receptor groups that have direct contact with mid-depth soils.

In the shallow soils barium, boron, lead and selenium had maximum concentrations exceeding ecological soil screening levels and Montana surface soil BTVs. These four constituents are retained for evaluation in screening refinement. Arsenic, cadmium, chromium, and manganese had maximum concentrations exceeding soil screening levels, but were less than Montana surface soil BTVs. Therefore arsenic, cadmium, chromium, and manganese are not considered

COPCs in surface soil. Mercury was not detected in any soil samples, but had maximum reporting limits greater than screening levels. Mercury is discussed further in the SLERA uncertainty discussion. In mid-depth surface soils boron, cadmium, lead and selenium had maximum concentrations exceeding ecological soil screening levels and Montana surface soil BTVs. These four constituents are retained for evaluation in screening refinement. Arsenic, barium, chromium and manganese had maximum concentrations exceeding soil screening levels, but less than Montana surface soil BTVs and are not considered COPCs in mid-depth soils. As in shallow soils, mercury was not detected in any mid-depth soil samples, but had maximum reporting limits greater than screening levels, and is discussed further in the SLERA uncertainty discussion.

Livestock Ingestion of East Fork Armells Creek Surface Water

A focused screening of analytes in surface water was performed for livestock who may utilize the creek as a source of drinking water. The screening was conducted using maximum measured chemical concentrations in surface water and livestock-specific water quality guidelines published by Colorado State University (Soltenpour and Raley, 1999) and the Canadian Council of Ministers of the Environment (CCME, 2009a). Results of this focused screening are shown in Table C-15. Concentrations of all chemicals in East Fork Armells Creek surface water are less than livestock water quality guidelines, with the exception of total sulfates, which exceeded the CCME guideline of 1,000 mg/L, The maximum sulfate concentration observed in East Fork Armells creek was 2,800 mg/L. USDA-ARS considers sulfate levels between 1,500 and 3,000 mg/L as “marginal” for ingestion by livestock (USDA-ARS, 2009).

Table C-11. Ecological Screening of East Fork Armells Creek Sediment – Plant Site Area

Analyte	Detects / Samples	Maximum (mg/kg)	Location	Upgradient Concentration (AR-5 and AR-12)	Ecological Screening Level (mg/kg)	Hazard Quotient	COPC?	Reason
Arsenic	16/16	5.6	AR-3	12.6	9.8	0.57	No	HQ < 1
Beryllium	16/16	0.37	AR-4	0.27	NA	NA	(1)	No ESL, Exceeds Upgradient Conc.
Boron	16/16	19.9	AR-3	19.4	NA	NA	(1)	No ESL, Exceeds Upgradient Conc.
Cadmium	9/16	0.25	AR-4	0.14	0.99	0.25	No	HQ < 1
Copper	16/16	11.7	AR-3	7.4	31.6	0.4	No	HQ < 1
Lead	16/16	12.8	AR-4	4.71	35.8	0.4	No	HQ < 1
Manganese	16/16	3,910	AR-2	5,910	460	13	Yes	HQ > 1
Mercury	0/16	ND	NA	ND	0.18	NA	No	Not Detected
Nickel	16/16	9.4	AR-4	6.5	22.7	0.5	No	HQ < 1
Selenium	12/16	0.5	AR-3	1.1	2	0.25	No	HQ < 1
Thallium	11/16	0.35	AR-2	0.07	NA	NA	(1)	No ESL, Exceeds Upgradient Conc.
Vanadium	16/16	13	AR-4	16.8	NA	NA	No	No ESL, does not exceed Upgradient Conc.
Zinc	16/16	76.2	AR-4	127	121	0.6	No	HQ < 1

(1) No ecological screening levels are available for these constituents in sediment. Determination of COPC status for the Site for these constituents is based on results of surface water screening in Table C-12

ND = Not detected

NA = Not available

Table C-12. Ecological Screening of East Fork Armells Creek Surface Water – Plant Site Area

Analyte	Detects / Samples	Maximum (µg/L)	Background Conc. (µg/L)[1]	Ecological Screening Level (µg/L)	HQ	COPC?	Reason
Arsenic	13/18	19	17	150	0.13	No	HQ < 1
Beryllium	0/18	ND	ND	0.66	NA	No	Not Detected
Boron	18/18	1,830	880	1.6	1140	Yes	HQ > 1, Max > BSL
Cadmium	2/18	0.17	0.6	2.39(2)	0.07	No	HQ < 1
Copper	4/18	9	32	30.5(2)	0.30	No	HQ < 1
Lead	4/18	7.2	23.3	18.6(2)	0.40	No	HQ < 1
Manganese	18/18	3,270	5,080(3)	120	27	Yes	HQ > 1, Max < BTV
Mercury	0/8	ND	ND	0.91	NA	No	Not Detected
Nickel	12/18	10	64	168(2)	0.06	No	HQ < 1
Selenium	4/18	2	4	5	0.4	No	HQ < 1
Thallium	0/18	ND	ND	0.8	NA	No	Not Detected
Vanadium	2/18	20	100	20	1.0	No	Max less than BSL
Zinc	5/18	51	290	387(2)	0.13	No	HQ < 1
Calcium	20/20	361,000	397,000	116,000	3.1	Yes	HQ > 1, Max < upgradient
Chloride	20/20	166,000	239,000	230,000	0.72	No	HQ < 1
Fluoride	20/20	400	300	7450(2)	0.05	No	HQ < 1
Magnesium	20/20	348,000	501,000	82,000	4.3	No	HQ > 1, Max < upgradient
Potassium	20/20	43,000	51,000	53,000	0.81	No	HQ < 1
Sodium	20/20	280,000	214,000	680,000	0.41	No	HQ < 1
Sulfate	20/20	2,190,000	2,260,000	3,000,000(3)	0.73	No	HQ < 1

(1) Unless noted, the Background Concentration represents the lower of the surface water BSL (Neptune and Company, 2016) and the maximum measured upgradient concentration at locations AR-5 and AR-12.

(2) Ecological Screening Level adjusted for the maximum allowable hardness of 400 mg/kg $CaCO_3$, per DEQ-7. Upgradient concentration represents the maximum detected concentration at upgradient sampling locations AR-5 and AR-12 in 2014-2015 surface water samples.

(3) Background concentration for manganese represents background threshold value developed using regional manganese data set. See Appendix D.

(4) No ecological screening level is available for sulfate for protection of aquatic life. Site and upgradient surface water concentrations are less than the recommended limits for livestock watering (3,000,000 ug/L).

ND = Not detected

NA = Not applicable

Table C-13. Ecological Screening of Soil Areas 1, 2, and 3 – Shallow Depth

Analyte	Detects / Samples	Maximum (mg/kg)	Ecological Soil Screening Level (mg/kg)	Background Threshold Value[1] (mg/kg)	HQ	COP C?	Reason
Arsenic	44/44	7.90	6.8	22.5	1.2	No	Max Less than BTV
Barium	44/44	1,090	110	429	9.9	Yes	HQ > 1, Max > BTV
Boron	44/44	68.2	2	NA	34	Yes	HQ > 1, No Background value
Cadmium	36/44	0.64	0.36	0.7	1.8	No	Max Less than BTV
Chromium (III)	44/44	30.8	26	41.7	1.2	No	Max Less than BTV
Lead	44/44	261	11	29.8	23.7	Yes	HQ > 1, Max > BTV
Manganese	44/44	497	220	880	2.3	No	Max Less than BTV
Mercury	0/44	ND	0.013	NA	ND	No	Not detected
Selenium	44/44	1.25	0.52	0.7	2.4	Yes	HQ > 1, Max > BTV

[1] Background values represent Background Threshold Values for Montana Surface Soils from DEQ/Hydrometrics, 2013.

ND = Not detected

NA = Not available

Table C-14. Ecological Screening of Soil Areas 1, 2, and 3 – Mid-Depth

Analyte	Detects / Samples	Maximum (mg/kg)	Minimum Soil Screening Level for Plants, Invertebrates, and Burrowing Mammals (mg/kg)	Background Threshold Value[1] (mg/kg)	HQ	COPC?	Reason
Arsenic	43/43	6.8	6.8	22.5	1.0	No	Max Less than BTV
Barium	43/43	237	110	429	2.2	No	Max Less than BTV
Boron	43/43	35.3	36	NA	0.98	Yes	HQ = 1, No Background value
Cadmium	34/43	0.71	0.36	0.7	2	Yes	HQ > 1, Max > BTV
Chromium (III)	43/43	32.3	34	41.7	1.2	No	Max Less than ESL and BTV
Lead	43/43	73.9	56	29.8	1.3	Yes	HQ > 1, Max > BTV
Manganese	43/43	491	220	880	2.2	No	Max Less than BTV
Mercury	0/43	ND	0.05	NA	ND	No	Not detected
Selenium	43/43	1.20	0.52	0.7	2.3	Yes	HQ > 1, Max > BTV

[1] Background values represent Background Threshold Values for Montana Surface Soils from DEQ/Hydrometrics, 2013.

ND = Not detected

NA = Not available

Table C-15. Screening of East Fork Armells Creek Surface Water for Use as a Drinking Water Source by Livestock

	Maximum Measured Concentration (mg/L)	Calculated - All Livestock (mg/L) (See Section C-5)	Soltanpour and Raley (1999) (mg/L)	CCME (2009a) (mg/L)
Arsenic	0.054	NA	0.2	0.5
Beryllium	ND	NA	NA	0.1
Boron	2.2	39	5	5
Cadmium	0.00008	1.5	0.05	0.02
Copper	0.025	NA	0.5	0.5
Lead	0.018	NA	0.1	0.1
Manganese	11.6	61	NA	NA
Mercury	ND	NA	0.01	0.003
Nickel	0.028	NA	NA	1
Selenium	0.004	0.28	0.05	0.05
Thallium	ND	NA	NA	NA
Vanadium	0.05	NA	0.1	0.1
Zinc	0.19	NA	24	50
Calcium	397	NA	NA	1000
Chloride	125	NA	NA	NA
Fluoride	0.4	NA	NA	1 to 2
Magnesium	501	NA	NA	NA
Potassium	43	NA	NA	NA
Sodium	348	NA	NA	NA
Sulfate	2800	NA	NA	1,000

ND = Not Detected

NA = Not Available

CCME = Canadian Council of Ministers of the Environment

C-4.1.2 Ecological Screening Refinement Results

The refinement of the initial Plant Site ecological screening results encompasses two steps. The first step replaces the use of the maximum concentration as the EPC with the 95 UCL concentration to represent a more realistic exposure scenario for ecological receptors. The use of the 95 UCL as the EPC is a more realistic exposure scenario for receptors that move across the area, because COPC concentrations are variable spatially across the site, and in the case of surface water, temporally variable as well. Methods for obtaining the 95 UCLs for each media are detailed in Appendix D.

The second step of the refinement process is applied to the soil data only. In the second step, maximum and 95 UCL concentrations of COPCs are compared to an expanded list of screening levels specific for each of the eight receptor groups used in the derivation of EPA EcoSSLs (plants, soil invertebrates, herbivorous mammals, insectivorous mammals, carnivorous mammals, herbivorous birds, insectivorous birds, carnivorous birds). This allows for a more focused evaluation of potential risk to specific receptor groups in the BERA.

Comparison of 95UCL Exposure Point Concentrations to Ecological Screening Levels

Sediment

One metal, manganese, had maximum concentrations in East Fork Armells Creek sediment exceeding its ecological screening benchmark, and was carried forward to screening refinement. The 95 UCL concentration of manganese in Creek sediment exceeded the ecological screening level. Concentrations of manganese exceeded the ecological screening level at all locations, including upgradient locations AR-5 and AR-12. Screening refinement results suggest that manganese poses potential risk to aquatic life in all areas of the Creek, including areas upgradient of the Plant Site. Manganese is retained as a COPC in sediment for further evaluation in the BERA, and the regional aspects of the risk from manganese will be discussed further in the baseline risk characterization. Results of the 95 UCL comparisons to sediment screening levels are presented in Table C-16.

Surface water

Two metals (boron and manganese) and two common cations (calcium and magnesium) had maximum concentrations in surface water exceeding their respective ecological screening benchmarks. The 95 UCL concentrations of boron, manganese, calcium, and magnesium also exceeded their respective surface water screening levels. Results of the surface water screening refinement are presented in Table C-17. Manganese and boron are retained as COPCs for further evaluation in the BERA because 95 UCL concentrations indicate that potential risk exists to aquatic receptors. Calcium and magnesium will be discussed further in the uncertainty discussion of the BERA. Although their concentrations exceed freshwater screening levels, the elevated nature of these constituents, together with high specific conductance, high levels of total dissolved solids, water hardness, and concentrations of other cations such as sodium and potassium, suggest that East Fork Armells Creek is atypical of freshwater streams. Freshwater streams typically have specific conductance values ranging from 100 to 2,000 µmhos/cm, and TDS concentrations less than 500 mg/L. East Fork Armells Creek surface water has specific conductance values ranging from 2,600 to 5,900 µmhos/cm, and TDS concentrations ranging from 2,200 to 5,900 mg/L, which fall within the definition range of “brackish water”.

Soil

Four metals, barium, boron, lead, and selenium, were carried forward to screening refinement from the initial screening step because maximum concentrations in surface soil exceeded soil screening levels. The 95 UCL concentrations of all four of these metals exceeded the minimum ecological screening levels (Table C-18). Barium, boron, lead and selenium are evaluated further in the expanded soil screening to assess which receptors are at potential risk from these constituents in surface soil, and to focus the BERA evaluation.

In addition, boron, cadmium, lead and selenium were retained for screening refinement in mid-depth soils (12 – 24” bgs). The comparison to 95 UCLs (Table C-19) shows that 95 UCL concentrations of selenium exceed the surface soil screening level for selenium, while 95 UCL concentrations of boron, cadmium, and lead were below their respective screening benchmarks. As stated in Section C.3.1.1, soil screening levels for the mid-depth soils were limited to receptors that may have direct contact with mid-depth soils, specifically plants, soil invertebrates, and burrowing mammals (insectivorous or herbivorous). Selenium is evaluated further in the expanded soil screening to assess which receptors are at potential risk from this constituent in mid-depth soil, and to focus the BERA evaluation to those receptors.

Table C-16. Comparison of 95 UCLs to Sediment Screening Levels

Analyte	Detects / Samples	95 UCL (mg/kg)	Background Concentration	Ecological Screening Level (mg/kg)	Hazard Quotient	COPC?
Manganese	16/16	2755	5,910	460	5.8	Yes, HQ > 1

Table C-17. Comparison of 95 UCLs to Surface Water Screening Levels

Analyte	Detects / Samples	95 UCL (µg/L)	Background Conc. (µg/L)	Ecological Screening Level (µg/L)	HQ	Reason
Boron	11/11	1,390	880	1.6	940	HQ > 1
Manganese	11/11	2,040	5080	120	32	HQ > 1
Calcium	13/13	327,700	397,000	116,000	2.9	HQ > 1
Magnesium	13/13	378,800	501,000	82,000	4.8	HQ > 1

Table C-18. Comparison of 95 UCLs to Soil Screening Levels – Shallow Only

Analyte	**Detects / Samples**	**95 UCL (mg/kg)**	**Minimum Ecological Soil Screening Level (mg/kg)**	**Hazard Quotient**	**Surface Soil (0-6” bgs) COPC?**
Barium	44/44	285	110	2.6	Yes, HQ > 1
Boron	44/44	17.2	2	8.6	Yes, HQ > 1
Lead	44/44	69.1	11	6.3	Yes, HQ > 1
Selenium	44/44	0.59	0.52	1.1	Yes, HQ > 1

Table C-19. Comparison of 95 UCLs to Soil Screening Levels – Mid-depth Only

Analyte	**Detects / Samples**	**95 UCL (mg/kg)**	**Minimum Ecological Soil Screening Level plants, inverts, burrowing mammals (mg/kg)**	**Hazard Quotient**	**Subsurface Soil (12 – 24” bgs) COPC?**
Boron	43/43	13.8	36	0.38	No, HQ < 1
Cadmium	43/43	0.321	0.36	0.89	No, HQ < 1
Lead	43/43	21.1	56	0.38	No, HQ < 1
Selenium	43/43	0.63	0.52	1.2	Yes, HQ > 1

Expanded Screening of Soil COPCs

In deriving ecological soil screening levels for metals, both USEPA (2003c) and LANL (2014) modeled doses to multiple trophic levels and feeding guilds, and then selected the most sensitive trophic receptor as the basis for the soil screening level. The receptor group/trophic levels evaluated include plants, invertebrates, herbivorous mammals, herbivorous birds, insectivorous mammals, insectivorous birds, carnivorous mammals, and carnivorous birds. To assist in focusing the BERA to those receptors most at potential risk, the ecological screening levels for all eight receptor categories is compared to the 95 UCL for the mean concentrations in soil. The expanded screening for barium, boron, lead, and selenium in surface soil are shown in Tables C-20 through C-23, respectively. The expanded screening for selenium in mid-depth soil is presented in Table C-24. The expanded screening shows that 95 UCL concentrations of barium in surface soil exceed only NOAEL-based screening levels for plants. 95 UCL concentrations of boron in surface soil exceed NOAEL screening levels for herbivorous birds and insectivorous birds. 95 UCL lead concentrations in surface soil exceed NOAEL screening levels for herbivorous birds, insectivorous birds, and insectivorous mammals; and 95 UCL selenium concentrations in surface soil exceed screening levels for plants and insectivorous mammals. In mid-depth soil, 95 UCL EPCs of selenium exceed NOAEL screening benchmarks for plants and insectivorous mammals. The list of COPCs and the associated endpoints retained for evaluation in the BERA are summarized in Table C-25.

Table C-20. Expanded Screening of Barium in Shallow Soil (0 – 6”)

Screening-level Receptor	Ecological Soil Screening Level (mg/kg)	Maximum Concentration in Surface Soil (mg/kg)	Number of Detects in Surface Soil Exceeding Eco-SSL	95 UCL Concentration in Surface Soil (mg/kg)	Does 95%UCL Concentration in Surface Soil Exceed Soil Screening Level?
Plants	110	1090	43	285	Yes
Soil Invertebrates	330	1090	4	285	No
Herbivorous Birds	NA	1090	NA	285	NA
Insectivorous Birds	NA	1090	NA	285	NA
Carnivorous Birds	NA	1090	NA	285	NA
Herbivorous Mammals	3200	1090	0	285	No
Insectivorous Mammal	2000	1090	0	285	No
Carnivorous Mammals	9100	1090	0	285	No

NA = Not available

Table C-21. Expanded Screening of Boron in Shallow Soil (0 – 6”)

Screening-level Receptor	Ecological Soil Screening Level (mg/kg)	Maximum Concentration in Surface Soil (mg/kg)	Number of Detects in Surface Soil Exceeding Eco-SSL	95 UCL Concentration in Surface Soil (mg/kg)	Does 95%UCL Concentration in Surface Soil Exceed Soil Screening Level?
Plants	36	68.2	2	17.2	No
Soil Invertebrates	NA	68.2	NA	17.2	NA
Herbivorous Birds	2	68.2	44	17.2	Yes
Insectivorous Birds	7.5	68.2	39	17.2	Yes
Carnivorous Birds	43	68.2	1	17.2	No
Herbivorous Mammals	68	68.2	1	17.2	No
Insectivorous Mammal	120	68.2	0	17.2	No
Carnivorous Mammals	21,000	68.2	0	17.2	No

NA = Not available

Table C-22. Expanded Screening of Lead in Shallow Soil (0 – 6")

Screening-level Receptor	Ecological Soil Screening Level (mg/kg)	Maximum Concentration in Surface Soil (mg/kg)	Number of Detects in Surface Soil Exceeding Eco-SSL	95 UCL Concentration in Surface Soil (mg/kg)	Does 95%UCL Concentration in Surface Soil Exceed Soil Screening Level?
Plants	120	261	2	69.1	No
Soil Invertebrates	1,700	261	0	69.1	No
Herbivorous Birds	46	261	3	69.1	Yes
Insectivorous Birds	11	261	44	69.1	Yes
Carnivorous Birds	510	261	0	69.1	No
Herbivorous Mammals	1,200	261	0	69.1	No
Insectivorous Mammal	56	261	2	69.1	Yes
Carnivorous Mammals	460	261	0	69.1	No

Table C-23. Expanded Screening of Selenium in Shallow Soil (0 – 6")

Screening-level Receptor	Ecological Soil Screening Level (mg/kg)	Maximum Concentration in Surface Soil (mg/kg)	Number of Detects in Surface Soil Exceeding Eco-SSL	95 UCL Concentration in Surface Soil (mg/kg)	Does 95%UCL Concentration in Surface Soil Exceed Soil Screening Level?
Plants	0.52	1.25	12	0.59	Yes
Soil Invertebrates	4.1	1.25	0	0.59	No
Herbivorous Birds	2.2	1.25	0	0.59	No
Insectivorous Birds	1.2	1.25	1	0.59	No
Carnivorous Birds	83	1.25	0	0.59	No
Herbivorous Mammals	2.7	1.25	0	0.59	No
Insectivorous Mammal	0.63	1.25	7	0.59	No
Carnivorous Mammals	2.8	1.25	0	0.59	No

Table C-24. Expanded Screening of Selenium in Mid-depth Soil (12 – 24")

Screening-level Receptor	Ecological Soil Screening Level (mg/kg)	Maximum Concentration in Mid-depth Soil (mg/kg)	Number of Detects in Mid-depth Soil Exceeding Eco-SSL	95%UCL Concentration in Mid-depth Soil (mg/kg)	Does 95%UCL Concentration in Mid-depth Soil Exceed Soil Screening Level?
Plants	0.52	1.2	20	0.63	Yes
Soil Invertebrates	4.1	1.2	0	0.63	No
Herbivorous Birds	2.2	1.2	0	0.63	No
Insectivorous Birds	1.2	1.2	1	0.63	No
Carnivorous Birds	83	1.2	0	0.63	No
Herbivorous Mammals	2.7	1.2	0	0.63	No
Insectivorous Mammal	0.63	1.2	13	0.63	Yes
Carnivorous Mammals	2.8	1.2	0	0.63	No

Table C-25. COPCs and Endpoints for Evaluation in the BERA

	Aquatic Life	Omnivorous Mammals	Piscivorous Birds	Herbivorous Birds	Insectivorous Birds	Carnivorous Birds	Herbivorous Mammals	Insectivorous Mammals	Carnivorous Mammals	Plants	Soil Invertebrates
Sediment											
Manganese	X	X	X		X						
Surface Water											
Manganese	X	X	X		X						
Boron	X	X	X		X						
Surface Soil											
Barium										X	
Boron				X	X						
Lead				X	X			X			
Selenium										X	
Mid-depth Soil											
Selenium								X		X	

C-4.2 Baseline Ecological Risk Characterization

Based on the results of the SLERA and COPC refinement steps, manganese was carried forward to the BERA for further evaluation in East Fork Armells Creek sediment and surface water, boron was retained for surface water, and barium, boron, lead, and selenium were retained for further evaluation in Plant Site soils. Specific ecological receptor groups evaluated for each chemical in each media are summarized in Table C-25. As discussed in Section C.2.2, Assessment Endpoints, Measures of Effect, and Exposure Pathways, the BERA risk characterization involved calculation of average daily doses of COPCs to wildlife potentially exposed to Creek sediment and surface water, and Site soils. The BERA risk characterization also included consideration of LOAEL toxicity levels in addition to NOAEL levels. LOAEL-based aquatic life criteria for boron and manganese were derived by LANL in the EcoRisk Database (LANL, 2014). BERA risk characterization for aquatic organisms in East Fork Armells Creek was based on the manganese LOAEL thresholds of 2,300 micrograms per liter (µg/L) for surface water and 1,100 mg/kg for sediment, and boron LOAEL thresholds of 16 micrograms per liter (µg/L) for surface water. Risk characterization for plants exposed to barium and selenium in soil was based on the LOAEL toxicity values of 260 mg/kg for barium, and 3.0 mg/kg for selenium (LANL, 2014).

C-4.2.1 Sediment and Surface Water

Aquatic Life

Manganese exceeded both sediment and surface water screening levels and was retained as a COPC for both media for evaluation in the BERA. Boron was retained as a surface water COPC in the BERA for exceeding surface water screening levels. The manganese sediment 95 UCL concentration of 2755 mg/kg exceeded the LOAEL threshold for sediment with an HQ of 2.5. The manganese surface water 95 UCL concentration of 2040 micrograms/L (µg/L) was less than the LOAEL threshold for surface water (2300 µg/L) with an HQ of 0.9. The 2015 observed upgradient concentrations of manganese in surface water at locations AR-12 and AR-5 were 5,080 µg/L and 11,900 µg/L, respectively. To further evaluate manganese concentrations in surface water, an upgradient surface water Background Threshold Value (BTV) based on the estimation of the 95/90 Upper Tolerance Level (UTL) for manganese in surface water upgradient of the Plant Site was developed following discussions with the DEQ (2018). The 95/90 UTL is defined as the 95% confidence limit on the 90th percentile (see Appendix D). The surface water BTV of 5,080 µg/L for manganese was based on five surface water sampling locations upgradient of the Plant Site, for which total manganese concentrations were available over a temporal span from 1977 to 2015. The five upgradient surface water sampling locations included in the calculation estimation of the surface water manganese BTV included (AR-5, AR-12, SW-03, SW-55, and SW-75). Surface water sampling locations AR-12, SW-55, and SW-03 are located near the upstream Plant Site AOC boundary. AR-5 is located immediately downstream of the Plant Site AOC boundary, but hydrologically upgradient of the Plant Site itself. SW-75 is located approximately 8 miles upstream of the Plant Site AOC boundary (see Figure 13). The surface water manganese BTV was included as a background/reference data point in Table C-12. This provides strong indication that manganese concentrations in East Fork Armells Creek surface water are not Site related. Manganese concentrations in surface water adjacent to the Plant Site were highest in fall 2015 synoptic run sampling, when concentrations at multiple locations including upgradient AR-5 and AR-12 exceeded LOAEL thresholds, with concentrations generally decreasing in a downstream direction. Manganese in surface water did not exceed LOAEL thresholds in any synoptic run sampling period except Fall 2015. Literature based toxicity information for manganese in surface water suggest possible risk exists due to manganese concentrations in East Fork Armells Creek, but potential Site risk cannot be differentiated from risk posed by upstream waters entering the site. Manganese in sediment did not exceed LOAEL thresholds in any synoptic run sampling period at upgradient location AR-12 or Site location AR-4, but did exceed LOAEL thresholds for aquatic life at upgradient location AR-5 and Site locations AR-3, and AR-2. Lacking site-specific toxicity information, the LOAEL value of 1,100 mg/kg would serve as the risk-based clean-up goal for manganese in sediment. However, due to partitioning of manganese between surface water and sediment, achievement of the risk-based goal for sediment is unlikely as long as upgradient surface water concentrations continue to exceed those found at the Site.

The boron surface water 95 UCL concentration of 1390 µg/L exceeded the LOAEL threshold of 16 (HQ = 87. The maximum upgradient concentration of boron in surface water at AR-5 of 2060 µg/L also significantly exceeded the LOAEL threshold of 16 µg/L. In addition, more recent reviews of aquatic toxicity information for boron suggest that the NOAEL and LOAEL values used in the SLERA and BERA for protection of aquatic life may be overly conservative. Uncertainties associated with the NOAEL and LOAEL surface water criteria for boron are discussed further in the uncertainty evaluation in Section C-4.3. Because of the elevated upgradient surface water concentrations of boron, and the more recent aquatic toxicity information discussed in C-4.3, boron is not retained as a surface water COC at the site.

Manganese and boron do not have DEQ-7 surface water values for protection of aquatic life, which would serve as surface water clean-up levels for those constituents. Implementation of risk-based clean-up goals for sediment and surface water at the site would be ineffective as long as upstream non-site related concentrations in excess of those clean-up goals continue to influence East Fork Armells Creek adjacent to and downstream of the Plant Site.

Aquatic Dependent Wildlife

Risk characterization to wildlife utilizing the creek was based on the average daily doses of boron and manganese to piscivorous birds, insectivorous birds, and omnivorous mammals, as shown in Tables C-26 to C-28, respectively. For piscivorous birds (Table C-26) the dose modeling indicated manganese risk was between the NOAEL and LOAEL for the whole creek, as well as for locations AR-3 and AR-2SF. Manganese doses to insectivorous birds did not exceed the NOAEL or LOAEL TRVs for either the whole creek, or any of the individual subareas to which insectivorous birds may be exposed (Table C-27). Manganese doses to omnivorous mammals foraging in the creek exceeded NOAEL TRVs across the creek, but were less than LOAEL TRVs (Table C-28). Because manganese doses did not exceed LOAEL TRVs for any food chain receptors, no unacceptable risk is posed to aquatic dependent wildlife from manganese in East Fork Armells Creek surface water or sediment.

Boron doses did not exceed the NOAEL or LOAEL TRVs for piscivorous birds (Table C-26). For insectivorous birds, boron doses exceeded NOAEL TRVs but were less than LOAEL TRVs for the creek as a whole and all four subareas within the creek (Table C-27). For omnivorous mammals, boron doses did not exceed either the NOAEL or LOAEL thresholds (Table C-28). Based on the results of the food chain modeling, boron does not pose unacceptable risk to aquatic dependent wildlife utilizing East Fork Armells Creek.

C-4.2.2 Soil

Plants

Based on the SLERA refinement, barium and selenium were designated as COPCs based on potential risk to plants in shallow soil, and selenium was also retained as a COPC for mid-depth soil. The barium 95 UCL concentration in surface soil (285 mg/kg) exceeded the LOAEL threshold for plants (260 mg/kg). Barium concentrations in surface soil exceeded the LOAEL threshold in 7 of the 36 surface soil samples associated with Soil Area 1. However, the Montana background threshold value for barium in soil is 429 mg/kg, and only a single soil sample (BH-54) exceeded the Montana BTV for barium. Given that only one of 36 samples exceeded the barium BTV across the 4.26 acres of Soil Area 1, potential risk to plants from barium is low and very localized, and barium is therefore not retained as a risk driver for plants growing in Site soil. The selenium 95 UCL did not exceed the LOAEL threshold for plants in soil in either the shallow-depth surface soils or the mid-depth soils (HQs of 0.12 and 0.21, respectively). Selenium is therefore eliminated from further consideration as a risk driver for plants in soil.

Terrestrial Wildlife

Boron, lead, and selenium were retained as COPCs in the SLERA based on potential risk to terrestrial wildlife receptors as summarized in Table C-25. Baseline risk characterization for terrestrial wildlife potentially exposed to boron, lead, and selenium in soil was based on the calculated average daily doses presented in Tables C-29 through C-31 for insectivorous birds, herbivorous birds, and insectivorous mammals, respectively.

Boron doses to insectivorous birds and herbivorous birds exceeded NOAEL TRVs but were less than LOAEL TRVs (Table C-29 and C-30). Because boron doses did not exceed LOAEL TRVs, no unacceptable risk from boron in surface soil is present in Site soil areas.

Lead doses to insectivorous birds were greater than the LOAEL TRV, with a HQ of 1.97 (Table C-29). The 95 UCL lead concentration in surface soil of 69.1 mg/kg is skewed by one elevated concentration of 504 mg/kg reported in sample BH-56 in Soil Area 1. Only one out of 36 other soil samples in Soil Area 1 contained lead concentrations greater than the Montana soil BTV for lead of 29.8 mg/kg. Based on the results of the initial lead analysis, the laboratory reanalyzed a second aliquot of soil from BH-56 sample, and the result of the reanalysis was 18.8 mg/kg. Because there was not an easily identifiable reason for the differences between the original sample and the reanalyzed sample, the original result of 504 mg/kg was included in the risk assessment. However, the remainder of the lead results for soil indicate that the original result, if correct, represents an exposure area that is a very small fraction of the 4.62 acres contained within the combined soil areas. Aside from the one elevated sampling result that could not duplicated in laboratory reanalysis, lead does not pose an unacceptable risk to insectivorous birds in the Site soil areas. Lead doses to herbivorous birds and insectivorous mammals were greater than NOAEL TRVs but less than LOAEL TRVs even when the one elevated concentration was included in the UCL calculation (Tables C-30 and C-31). Lead concentrations in soil do not pose unacceptable risk to herbivorous birds or insectivorous insects in the Site soil areas.

Selenium in mid-depth soil was retained in the SLERA refinement for evaluation in the BERA due to potential risk to insectivorous mammals. BERA results indicate that calculated average daily doses of selenium to insectivorous mammals exceed NOAEL TRVs but are less than LOAEL TRVs

(Table C-30). Therefore, selenium concentrations in mid-depth soil do not pose unacceptable risk to insectivorous mammals.

C-4.3 Evaluation of Uncertainties

Uncertainties in the risk characterization originate from a cumulative effect of the uncertainties in the Exposure Assessment, the Toxicity Assessment, and the Characterization of Risk, including lack of toxicity information for certain chemicals, uncertainties in exposure parameters, and uncertainties associated with deriving exposure point concentrations for specific chemicals and organisms given the spatial and temporal variability observed in the data.

Available Ecological Toxicity Information. Availability of ecological toxicity information represents an uncertainty for a number of chemicals in Site sediment, soil, and surface water. No ecological screening levels were available to evaluate potential risk to aquatic receptors from beryllium, boron, thallium, or vanadium in sediment. Screening levels for each of these constituents were available for surface water, so the risk assessment assumes that surface water levels that are protective of aquatic organisms are also protective of benthic organisms. This may underestimate risk to benthic receptors that get their primary exposure from sediment, not surface water. Uncertainty exists for a number of the constituents for which screening-levels are available due to methodologies used in deriving screening-levels and the scarcity of toxicity information for some chemicals. As an example, the SLERA uses a surface water screening level of 1.6 µg/L and a LOAEL threshold of 16 µg/L for boron. These numbers are based on a Tier II value derived from a limited amount of toxicity information by Suter et al in 1996. Tier II values were developed so that aquatic benchmarks could be established with fewer data than are required for the National Ambient Water Quality Criteria, which are the equivalent of DEQ-7 aquatic life criteria. More recent publications from the Canadian Council of Ministers of the Environment calculated protective levels of boron in surface water based on six fish studies, six invertebrate studies, six amphibian studies, and ten plant studies, and derived a Canadian Water Quality Guideline for long-term exposure of 1,500 µg/L (CCME, 2009b). This guideline represents a 5th percentile low-effects species sensitivity distribution, meaning that 95% percent of species have a low-effects threshold for boron greater than 1,500 µg/L. Thus the use of the Tier II derived screening level and LOAEL value for boron is likely overly conservative.

In addition, no field evaluations were performed for visual signs of toxicity in vegetation, and no bioassay testing of site soils and water was conducted. This lack of field information represents uncertainty in interpolating from literature effect levels to actual Site population effects. An aquatic habitat assessment and benthic community survey was conducted in upstream areas of East Fork Armells Creek as part of surface water discharge permitting efforts for the Western Energy Rosebud Mine (Arcadis, 2014). Conditions of East Fork Armells Creek immediately downstream of Rosebud Mine differ from stream conditions through the town of Colstrip in terms of flow rate and ephemerality, but the results of the surveys are suggestive of what is expected throughout East Fork Armells Creek. Surveys were conducted according to MDEQ protocols. Benthic survey results were indicative of a low-gradient stream supportive of a tolerant benthic community dominated by chironomid (midge) larvae and amphipods. The Hilsenhoff Biotic Index scores were representative of “Fairly Poor” to “Poor” benthic community conditions. The habitat assessment characterized the stream as heavily silted, low flow, with prevalent emergent riparian vegetation. Though the section of East Fork Armells Creek through the town of Colstrip tends to contain more permanent water than upstream areas of the Creek, it is also low gradient, with a lack of riffle areas, and contains abundant emergent riparian vegetation. Based on those conditions, a tolerant community would also be expected throughout the stretch of the Creek flowing through Colstrip. A Hilsenhoff Biotic Index score of “Poor”, as assigned to the upstream area of East Fork Armells Creek, is the lowest ranking on the index.

Uncertainties in Exposure Point Calculations. In the screening refinement and BERA, exposure for each ecological receptor group is estimated based on a central tendency estimate of COPC concentrations in the various exposure media. The 95% UCL of the mean concentration is the typical central tendency estimator used as the EPC in ecological risk assessment. Sediment and surface water EPC calculations for East Fork Armells Creek are based on four locations and four sampling occasions. For the smaller location-specific ecological exposure units (i.e., those used for great blue heron and common yellowthroat based on individual sampling locations), the estimated EPC is based on four sampling occasions for a single location and only captures variability over time, not space. Therefore, all estimates are based on a small quantity of data informing the mean concentration in time and space, meaning they are highly uncertain in their representativeness of the mean concentration over the defined exposure unit. Calculation of 95 UCLs based on small sample sizes often result in a 95 UCL value greater than the observed maximum value. In the interest of conservatism, the ecological risk assessment used the 95 UCL values even when the UCL was greater than the observed maximum. This conservatism reduces the chance that a COPC will be eliminated from consideration when it should have been retained.

Uncertainties in Exposure Parameters. The SLERA utilized conservative assumptions regarding site use by ecological receptors by assuming that an individual organism gets 100% of its exposure from the site. This is a valid assumption for some of the receptors, such as individual great blue herons and common yellowthroats, which may conduct all of their foraging in a small area. Raccoons, however, range widely and would be expected to only receive a portion of their exposure from the area included within this investigation. The focus of the ERA is protection of populations of ecological receptors, and all of the organisms included in this ERA have populations that extend beyond the sediment, water, and soil boundaries included in this investigation. Ryti et al. (2004) proposed the use of a population area use factor (PAUF) for assessing risk to populations. The PAUF concept assumes that population areas for wildlife are correlated to the median dispersal distance of individuals within the population. In this approach, the population area is defined as a circle where the radius of the circle is the median dispersal distance of the organism. For instance, a masked shrew with a dispersal distance of 150 meters, would have a PAUF of approximately 17.5 acres, or four times the size of the combined soil areas included in the ERA. Therefore, assessing risk to an individual of a population overestimates risk to the population itself.

All COPCs were conservatively assumed to be 100 percent bioavailable for all receptors. Depending on the COPC and receptor, however, bioavailability may be significantly less than 100 percent. This is particularly true for metals in the environment, where bioavailability is often tied to chemical form present, and geochemical parameters such as soil pH, organic carbon, and oxidation-reduction potential. Consideration of bioavailability and bioaccumulation potential of chemicals is important with regard to understanding the risk implications and the potential ecotoxicological effects of total concentrations of chemicals detected in soils. This conservative estimate of 100 percent bioavailability may overestimate risk.

Site-specific tissue residue data were not collected; thus, concentrations in food items for food chain receptors were estimated based on literature bioaccumulation factors and other parameters. This approach is generally associated with more uncertainty than an approach based on collection of site-specific prey/food tissue concentrations. Estimates of food concentration based on literature values do not include accurate predictors of assimilation and depuration of COPCs in the same way as time-averaged tissue concentrations. The estimates of prey concentrations at East Fork Armells Creek and associated soil areas may be either overestimated or underestimated because conditions at the site are likely different from those in the literature.

C-4.4 Ecological Clean-up Goals

Based on the results of the ecological risk characterization, no risk-based clean up levels were derived for chemicals in East Fork Armells Creek surface water and sediment. Concentrations of both boron and manganese in upgradient surface water are higher than maximum site concentrations. Maximum surface water concentrations of boron at the Site were lower than risk-based levels established through a more recent review of boron aquatic toxicity by CCME (2009b). Manganese in Site sediment is higher than the LOAEL level of 1,100 mg/kg, and also exceeds upgradient concentrations at AR-12. The LOAEL value of 1,100 mg/kg would serve as the basis for a risk-based sediment clean-up goal for manganese, but the ability to achieve this goal throughout the creek is questionable as long as surface water entering the site from upstream contains high levels of manganese.

C-5 Derivation of Groundwater Clean-up Levels for Livestock

The groundwater clean-up levels protective of livestock were NOAEL TRVs for water ingestion. The clean-up levels were back-calculated using TRVs, livestock Body Weights (BW), and livestock Water Ingestion Rates (IR_{wat}), and are based on a hazard quotient of one. The drinking-water TRVs were extracted from the Los Alamos National Laboratory (LANL) EcoRisk Database v3.3 (LANL, 2014), and the BW and IR_{wat} parameters were extracted from Pattanayek and DeShields (2004). The clean-up levels were calculated for six categories of livestock for seven chemicals found in the groundwater (barium, boron, cadmium, cobalt, fluoride, manganese, and selenium). Clean-up levels could not be calculated directly for sulfate or total dissolved solids (TDS) due to lack of TRVs, but clean-up values for these parameters were taken from published literature. The livestock categories were comprised of six mammals commonly found at Montana farms including dairy cattle, beef cattle, calves, horses, sheep, and goats. The NOAEL values and equation parameters can be found in Table C-32 and Table C-33, respectively.

$$Clean\ up\ Level = \frac{(TRV \times BW)}{IR_{wat}}$$

Dose-based radionuclide clean-up levels for radium-226 and radium-228 in groundwater were also calculated using the equation for mammalian radionuclide doses from a water-based media presented in the LANL EcoRisk Database v3.3 Ecological Screening Level Model Equations (LANL, 2014). The radionuclide doses assume a NOAEL-based dose limit of 0.1 rad/day (Table C-34). The radionuclide dose equations include a lifespan parameter, therefore, the radium clean-up levels were calculated using the average lifespans of cattle, horse, sheep, and goats.

The NOAEL-based clean-up levels for livestock are shown in Table C-34. The order of the lowest to highest clean-up levels for all seven non-radionuclide chemicals in each livestock category is as follows: calves, goats, sheep, beef cattle, dairy cattle, and horses. Clean-up levels based on protection of calves were approximately half that of the next highest category (goats), and were approximately 10-times lower than clean-up levels based on protection of horses. Radium-226 and -228 clean-up levels are lowest for cattle.

Clean-up levels were also identified for TDS and sulfate (Table C-34). The values given are the upper limits that distinguish marginal water quality from poor water quality for livestock consumption (USDA-ARS and MSU). MDEQ specifies that Class 3 groundwater must be of at least marginal quality for consumption by livestock. TDS concentrations greater than 5000 mg/L are considered of poor quality, which decreases performance and health of livestock. Sulfate concentrations greater than 3000 mg/L are also indicative of poor quality, which may increase cases of polio and decrease performance of grazing livestock.

Table C-26. Food Chain Model Dose Calculations for Great Blue Heron as Surrogate for Piscivorous Birds

	Analyte	95%UCL Sediment Conc. (mg/kg dw)	95%UCL Water Conc. (mg/L), unfiltered	Modeled Fish Conc. (mg/kg dry wt)	Fish Ingestion Rate (kg/d)	Sediment Ingestion Rate (kg/d)	Water Ingestion Rate (L/d)	Body Weight (kg)	AUF
Whole Creek	Manganese	2755	2.04	6120	0.105	0.0021	0.105	2.336	1
AR-4	Manganese	924.5	0.53	1590	0.105	0.0021	0.105	2.336	1
AR-3	Manganese	2876	2.78	8340	0.105	0.0021	0.105	2.336	1
AR-2SF	Manganese	3586	1.97	5910	0.105	0.0021	0.105	2.336	1
Whole Creek	Boron	16.6	1.39	0.45	0.105	0.0021	0.105	2.336	1
AR-4	Boron	15.5	1.17	0.351	0.105	0.0021	0.105	2.336	1
AR-3	Boron	21.0	1.4	0.42	0.105	0.0021	0.105	2.336	1
AR-2SF	Boron	16.8	1.83	0.549	0.105	0.0021	0.105	2.336	1

Table C-26. (continued)

	Analyte	Average Daily Dose (mg/kg-d)	NOAEL TRV (mg/kg-d)	LOAEL TRV (mg/kg-d)	NOAEL HQ	LOAEL HQ
Whole Creek	Manganese	278	179	1790	1.55	0.16
AR-4	Manganese	72.3	179	1790	0.40	0.04
AR-3	Manganese	378	179	1790	2.11	0.21
AR-2SF	Manganese	270	179	1790	1.50	0.15
Whole Creek	Boron	0.170	2.92	14.5	0.06	0.01
AR-4	Boron	0.146	2.92	14.5	0.05	0.01
AR-3	Boron	0.176	2.92	14.5	0.060	0.01
AR-2SF	Boron	0.220	2.92	14.5	0.075	0.02

Table C-27. Food Chain Model Dose Calculations for Common Yellowthroat as Surrogate for Insectivorous Birds

	Analyte	95%UCL Sediment Conc. (mg/kg dw)	95%UCL Water Conc. (mg/L), total	Modeled Invertebrate Conc. (mg/kg dw)	Invertebrate Ingestion Rate (kg/d)	Sediment Ingestion Rate (kg/d)	Water Ingestion Rate (L/d)	Body Weight (kg)	AUF
Whole Creek	Manganese	2755	2.04	166.7	0.0033	0.000066	0.0028	0.01	1
AR-4	Manganese	924.5	0.53	55.9	0.0033	0.000066	0.0028	0.01	1
AR-3	Manganese	2876	2.78	174.0	0.0033	0.000066	0.0028	0.01	1
AR-2SF	Manganese	3586	1.97	217.0	0.0033	0.000066	0.0028	0.01	1
Whole Creek	Boron	16.6	1.39	15.5	0.0033	0.000066	0.0028	0.01	1
AR-4	Boron	15.62	1.17	15.62	0.0033	0.000066	0.0028	0.01	1
AR-3	Boron	21.01	1.4	21.01	0.0033	0.000066	0.0028	0.01	1
AR-2SF	Boron	16.8	1.83	16.8	0.0033	0.000066	0.0028	0.01	1

Table C-27. (continued)

	Analyte	Average Daily Dose (mg/kg-d)	NOAEL TRV (mg/kg-d)	LOAEL TRV (mg/kg-d)	NOAEL HQ	LOAEL HQ
Whole Creek	Manganese	73.76	179	1790	0.41	0.04
AR-4	Manganese	24.71	179	1790	0.14	0.01
AR-3	Manganese	77.18	179	1790	0.43	0.04
AR-2SF	Manganese	95.81	179	1790	0.54	0.05
Whole Creek	Boron	5.61	2.92	14.5	1.92	0.39
AR-4	Boron	5.59	2.92	14.5	1.91	0.38
AR-3	Boron	7.46	2.92	14.5	2.56	0.51
AR-2SF	Boron	6.17	2.92	14.5	2.11	0.43

Table C-28. Food Chain Model Dose Calculations for Raccoon as Surrogate for Omnivorous Mammals

	Analyte	95%UCL Sediment Conc. (mg/kg dw)	95%UCL Water Conc. (mg/L), total	Modeled Plant Conc. (mg/kg dry wt)	Modeled Invertebrate Conc. (mg/kg dry wt)	Modeled Fish Conc. (mg/kg dry wt)	Plant Ingestion Rate (kg/d)	Invert. Ingestion Rate (kg/d)	Fish Ingestion Rate (kg/d)	Sediment Ingestion Rate (kg/d)
Whole Creek	Manganese	2755	2.04	413	166.7	6120	0.12	0.15	0.03	0.03
Whole Creek	Boron	15.5	1.39	62	15.5	2.25	0.12	0.15	0.03	0.03

Table C-28 (continued)

	Analyte	Water Ingestion Rate (L/d)	Body Weight (kg)	AUF	Average Daily Dose (mg/kg-d)	NOAEL TRV (mg/kg-d)	LOAEL TRV (mg/kg-d)	NOAEL HQ	LOAEL HQ
Whole Creek	Manganese	0.5	6	1	57.0	51.5	515	1.11	0.11
Whole Creek	Boron	0.5	6	1	1.83	28	280	0.07	0.007

Table C-29. Food Chain Model Dose Calculations for Sprague's Pipit as Surrogate for Insectivorous Birds

Analyte	95%UCL Soil Conc. (mg/kg dw)	95%UCL Water Conc. (mg/L), total	Modeled Invert. Conc. (mg/kg dw)	Invert. Ingestion Rate (kg/d)	Soil Ingestion Rate (kg/d)	Water Ingestion Rate (L/d)	Body Weight (kg)	AUF	Average Daily Dose (mg/kg-d)	NOAEL TRV (mg/kg-d)	LOAEL TRV (mg/kg-d)	NOAEL HQ	LOAEL HQ
Boron	17.2	1.284	17.1	0.00588	0.00012	0.005	0.02375	1	4.62	2.92	14.5	1.58	0.32
Lead	69.1	0.018	24.5	0.00588	0.00012	0.005	0.02375	1	6.43	1.62	3.26	3.97	1.97

Table C-30. Food Chain Model Dose Calculations for Lark Sparrow as Surrogate for Herbivorous Birds

Analyte	95%UCL Soil Conc. (mg/kg dw)	95%UCL Water Concentration (mg/L), total	Modeled Plant Conc. (mg/kg dry wt)	Modeled Invert Conc. (mg/kg dry wt)	Plant Ingestion Rate (kg/d)	Invert. Ingestion Rate (kg/d)	Soil Ingestion Rate (kg/d)	Water Ingestion Rate (L/d)	Body Weight (kg)	AUF	Average Daily Dose (mg/kg-d)	NOAEL TRV (mg/kg-d)	LOAEL TRV (mg/kg-d)	NOAEL HQ	LOAEL HQ
Boron	17.2	1.284	68.8	17.2	0.005205	0.001735	0.00014	0.005	0.0289	1	13.73	2.92	14.5	4.70	0.95
Lead	69.1	0.018	2.85	24.5	0.005205	0.001735	0.00014	0.005	0.0289	1	2.32	1.62	3.26	1.4	0.7

Table C-31. Food Chain Model Dose Calculations for Masked Shrew as Surrogate for Insectivorous Mammals

Analyte	95%UCL Water Conc. (mg/L), total	95%UCL Soil Conc. (mg/kg dw)	Modeled Invert. Conc. (mg/kg dw)	Invert. Ingestion Rate (kg/d)	Soil Ingestion Rate (kg/d)	Water Ingestion Rate (L/d)	Body Weight (kg)	AUF	Average Daily Dose (mg/kg-d)	NOAEL TRV (mg/kg-d)	LOAEL TRV (mg/kg-d)	NOAEL HQ	LOAEL HQ
Lead (surface)	0.018	69.1	24.53	0.000836	0.0000836	0.0005	0.004	1	6.57	4.7	8.9	1.4	0.74
Selenium (mid-depth)	0.004	0.633	0.661	0.00084	0.000084	0.0005	0.004	1	0.152	0.143	0.215	1.07	0.71

Table C-32. TRVs for Chemicals and Radionuclides in Groundwater.

Chemical	**NOAEL-TRV (mg/kg-d)**	**LOAEL-TRV (mg/kg-d)**
Barium	1.38	1.98
Boron	28	280
Cadmium	1.08	3.94
Cobalt	0.02	0.5
Fluoride	26.6	49
Manganese	44	158
Selenium	0.2	0.33
Radionuclide dose	**(rad/d)**	**(rad/d)**
Radium-226	0.1	1
Radium-228	0.1	1

Table C-33. Exposure Parameters for Livestock Consuming Groundwater.

Livestock	**Ingestion Rate Water (L/d)**	**Body Weight (kg)**	**Lifespan (days)**
Calf	36	50	3650
Dairy Cattle	95	540	
Beef Cattle	86	454	
Horse	42	550	9125
Sheep	14	56.7	3650
Goat	10	29.5	5475

Table C-34. Protective Groundwater Clean-up levels for Livestock Ingesting Groundwater.

	Livestock (mg/L)					
Chemical	Calf	Dairy Cattle	Beef Cattle	Horse	Sheep	Goat
Barium	1.9	7.8	7.3	18	5.6	4.0
Boron	39	160	148	370	113	83
Cadmium	1.5	6.1	5.7	14	4.4	3.2
Cobalt	0.03	0.11	0.11	0.26	0.08	0.06
Fluoride	37	151	140	348	108	78
Manganese	61	250	230	576	178	130
Selenium	0.28	1.1	1.0	2.6	0.8	0.60
Radionuclide	**(pCi/L)**					
Radium-226	63[a]			150	290	210
Radium-228	88[a]			350	410	360
Parameter	**(mg/L)**					
TDS	NR	5000	5000	NR	NR	NR
Sulfate	NR	3000	3000	NR	NR	NR

[a] Radionuclide dose calculations require a lifespan parameter, therefore, one dose was calculated for the general lifespan of cattle.

NR = values were not reported.

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APPENDIX D

Statistical Analysis

Appendix D:
Statistical Analysis to support the CCRA for the Wastewater Facilities Comprising the Closed-Loop System Plant Site Area, Colstrip Power Plant

Prepared for Hydrometrics, Inc.

18 October 2018

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Contents

Appendix D Statistical Analysis

D-1 Summary and Background Information

D-1.1 Executive Summary

Appendix D describes the exploratory data analysis and estimation of Exposure Point Concentrations (EPCs) for the Wastewater Facilities Comprising the Closed-Loop System Plant Site Area at the Colstrip Stream Electric Station, Colstrip, MT CCRA to support the human health and ecological risk assessments. Statistical analysis and results are described for surface water (Section D-2), sediment (Section D-3), soil (Section D-4), and manganese in upgradient surface water (Section D-5). Potential chemicals of potential concern (COPCs) identified after first stage screening for the human health and ecological RA are the focus of the graphical and statistical analyses presented in this report. Human health identified manganese as the only preliminary COPC for surface water and sediment, and no preliminary COPCs for soil. Five ecological preliminary COPCs were identified for surface water (boron, calcium, magnesium, manganese, and vanadium), and three for sediment (arsenic, boron, and manganese). Ecological preliminary COPCs for soil were identified within the two surface soil depth intervals: 0-6'' (barium, boron, lead, and selenium) and 12-24'' (cadmium, boron, lead, and selenium). Recommended EPCs for each preliminary COPC and exposure scenario are presented for each medium within each respective section.

General information applicable to estimation of EPCs using 95% upper confidence limits (UCLs) for the mean for all media (surface water, sediment, and soil) is presented in Sections D-1.2, D-1.3, and D-1.4, with additional medium-specific information provided within the subsequent sections. An upgradient upper tolerance limit (UTL) for manganese in surface water is estimated in Section D-1.5. Graphical displays of the data available to support the risk assessment and inform the estimation of EPCs and the UTL are included in the Figures section, and summary tables of relevant data are included within the each section. In summary, Appendix D documents the work performed to explore and evaluate the available data for analytes identified as preliminary COPCs, to calculate 95% UCLs to be used as estimates of EPCs to inform subsequent stages of the assessments, and an upgradient surface water UTL-95/90 for manganese. The quality and quantity of data available for the intended use are discussed throughout the report.

D-1.2 Background for Statistical Analysis

The Cleanup Criteria and Risk Assessment Work Plan (Ford Canty & Associates, Inc., 2015) specifies that upper confidence limits on the mean (UCLs) will be used to represent exposure point concentrations for chemicals identified through the human health and ecological risk assessment screening processes. The following subsections provide general statistical information related to the use of 95% UCLs as estimates of the mean concentration in an exposure unit.

D-1.2.1 **Use of the UCL of the mean as an exposure point concentration (EPC)**

In the context of estimating EPCs, the 95% UCL of the mean is often used as an estimate of the mean, providing a protective (conservative) estimate of the mean concentration over a spatial area defined by a specified exposure unit (EU) and a specified time interval for inclusion of data. Using an estimate of the mean as an EPC is justified under two scenarios: (1) the concentration of the COPC is homogeneous over the EU so that receptors are only exposed to concentrations close to the mean, or (2) the concentration is not homogeneous, but the receptors make a random walk around the EU over time so that their average exposure can be captured using the mean concentration over the EU.

The use of a single point estimate (an average or a UCL) as the EPC does not incorporate uncertainty in the estimate into the risk assessment. A confidence interval is typically developed to express uncertainty in estimation of the mean due to randomness inherent in the specific data obtained through a random sampling procedure. When the UCL is used as a single EPC to calculate risk, it does build conservatism into the calculation of exposure, but it does not explicitly allow uncertainty to be taken into account in decision-making. For example, the same UCL could be reported for two problems with very different degrees of uncertainty (one with a high estimated mean and little uncertainty in the estimate and another with a low estimated mean and a great deal of uncertainty in the estimate). A probabilistic risk assessment explicitly incorporates uncertainty in mean concentration based on available data (USEPA, 2001) using distributions rather than point estimates. However, this risk assessment is specified to be deterministic, meaning a single number is used to represent exposure for each scenario; uncertainty is dealt with informally through discussions of data quantity and quality and careful investigation of available data.

The concept of “confidence” is based on the idea of quantifying statistical outcomes over different possible random sets of data (referred to as “random samples” in statistical literature) that could have been taken from the population under the specified sampling procedure. Different random samples from the same exposure unit will lead to different estimates of the mean of the concentration and different values for the 95% UCL. By definition, the 95% UCL is expected to be smaller than the true mean concentration of the exposure unit in 5% of datasets from random sampling, and larger than the mean in 95% of other possible datasets that could have been collected using different randomly selected locations and/or times. Therefore, the 95% UCL is *expected* to overestimate the mean 95% of the time (i.e. be “protective”); however, for a particular set of data, it cannot be known whether the mean is over- or underestimated.

D-1.2.2 **Choice of method for calculating a UCL**

There are many methods currently used for calculating UCLs to be used as EPCs in risk assessments, and it is common to simply choose the suggested method as provided by the ProUCL software (Singh & Singh, 2015a; Singh & Singh, 2015b; USEPA, 2015). The focus of ProUCL has been finding methods with a specified “coverage” of the mean, which is translated into a desired underestimation rate of 5% or less for 95% UCLs, under strict assumptions about the underlying distributions of concentrations in the population. ProUCL’s data-specific recommendations for methods are based on outcomes of goodness-of-fit hypothesis tests related to particular distributions; the outcomes of these tests are often misinterpreted as evidence *for* a particular distribution and such results are often given too much weight in the process of choosing a UCL estimator of the mean. The applicability and defensibility of statistical results, particularly for small data sets and non-random samples, are context dependent and therefore the methods should not be applied blindly or automatically to any data set. For example, restricting methods to those in ProUCL does not allow for use of fairly basic methods for dealing with clear violations of the assumption of independence in data sets due to repeat measurements on the same locations and/or on the same days (see discussion of this problem in USEPA 2006). The methods available in ProUCL for calculating UCLs assume all observations are independent and random measurements from the population of interest over the specified time period. Often, results for estimating a mean are more sensitive to violations of independence than they are to departures from an assumed distribution for the underlying population of values. The data for this risk assessment have clear violations of independence. Therefore, methods used in this report to obtain 95% UCLs may appear non-traditional from a risk assessment perspective, but are very traditional from the perspective of statistical data analysis focused on the estimating a mean.

In June 2016 Neptune conducted a large simulation study, using artificial data generated under different scenarios, to compare many UCL estimators in terms of their coverage of the mean (i.e. how often they under or over estimate the mean over different random samples), as well as their bias (average distance from the mean) and variability over possible random samples (Flagg et al., in preparation). This differs from the focus of ProUCL, which has been almost solely on coverage, or equivalently how often estimates may be above or below the mean. A method can achieve a specified coverage rate but have estimates that are extremely far from the actual population mean; which is clearly undesirable for risk assessment (such behavior has been documented for methods such as Land's H, Hall's, and Chebyshev's). Therefore, it is important to also consider how close different possibly estimates from a method are to the true mean (i.e. consider the size of errors). This can be assessed through quantifying bias (average size of estimation errors) and the variability in possible estimates from different random sampling outcomes (or equivalently variability of estimation errors).

The Neptune simulation study was performed over a wide range of population distributions with varying degrees of skewness and kurtosis and at sample sizes of 5, 10, 20, and 30. The goal of study was to identify methods with relatively low bias and variability over a wide range of population distributions, that still maintained reasonable underestimation rates, to help simplify the decision flow chart and reduce reliance on inappropriate use of goodness-of-fit hypothesis tests. Two estimators were identified as having reasonable properties when considered simultaneously over all scenarios and all sample sizes: (1) the Student's t method based on the assumption that the sampling distribution of the average is well-approximated by a t distribution, and (2) the bias-corrected and accelerated (BCa) bootstrap method based on resampling from the observed data, along with bias and skew adjustments, to approximate the sampling distribution of the average. When the distribution of the sample is relatively symmetric and sample sizes are greater than approximately 10, the two methods produce very similar estimates. When the sample is skewed to the right, the BCa typically results in larger estimates, though avoids extreme overestimation which is common with other methods available in ProUCL intended to account for potential skew in population distributions (e.g. Chebyshev's). For small sample sizes, the bootstrap is not appropriate because it tends to underestimate variance, and therefore the t-UCL is recommended because sample size is accounted for in its calculation through the multiplier obtained as a quantile of the associated t-distribution (smaller sample sizes lead to a larger t-multiplier). Neptune's simulation study indicates that choosing the maximum between the t and the BCa estimates typically provides a nice balance of underestimation rate, bias, and variance, across a broad range of population distribution shapes, and is thus a reasonable starting place for obtaining a 95% UCL of the mean for use as an EPC.

However, as with any statistical analysis, each study design and data set should be checked individually to assess the reasonableness of the approach. For example, the implications of violations of independence on UCL estimator performance have not been assessed in simulation studies comparing options for UCL estimators of the mean, though they are well studied in general outside the specific context of UCLs used in risk assessment. The presence of clear violations of assumptions may require more sophisticated methods to produce defensible UCLs, such as random effects models, other methods explicitly incorporating dependence among observations from the same site or same date, or models allowing for spatial and/or temporal correlation. For the analysis in this report, the *t*- and BCa-based UCLs represent a starting point, and other methods meant to account for clear violations of the independence assumption are implemented as needed.

D-1.2.3 **Use of sample maximum as the EPC**

In risk assessments, the maximum observed value is often considered for use as the estimated EPC when the 95% UCL exceeds the maximum observed value. For relatively large sample sizes, it is rare to obtain a sample maximum that is less than the true mean. Therefore, the logic behind the decision to choose the sample maximum as the EPC in such cases is that the sample maximum is expected to be larger than the mean (so it is still "protective"), but it is closer to the mean than the 95% UCL. However, there is a tendency to assume the sample maximum is always greater than the true population mean, which is not true for small sample sizes, particularly if areas with higher concentrations are not captured in the sampling locations just by chance. Likewise, it is tempting to assume that the sample maximum should be greater than the 95% UCL. However, with very small sample sizes, it is not rare for a sample maximum to be less than the true 95% UCL (theoretically defined as the 95th percentile of the distribution of possible sample averages). Therefore, in practice, a choice must be made between using a 95% UCL or the maximum observed sample value as the EPC, and the decision should be problem dependent, depending on both the conceptual model for the site and the observed data.

Generally, when confronted with a 95% UCL estimate of the mean that is greater than the sample maximum, the high uncertainty surrounding the value used for the EPC should be acknowledged. The USEPA (2004) states in Section 5.2.2 that "when data are insufficient to estimate the 95% UCL, any value used [as an EPC estimate] (such as the maximum value or arithmetic mean) is likely to contribute significantly to the uncertainty in estimates" of risk. USEPA (2002) allows use of the sample maximum as the EPC when the UCL exceeds the max, but only if the sample size is large because the maximum may not be protective if the sample size is small.

For this risk assessment, uncertainty in the EPCs should be considered large given the small number of locations informing each EPC. Further information regarding expectations of the maximum and the 95% UCL, relative to the mean, are provided in Sections D-2 and D-3 in the context of estimating the EPC for the smaller location-specific ecological EUs with only four observations each.

D-1.2.4 **Software used for UCL calculations**

Analyses are performed using R statistical software (R Core Team, 2016). This software allows for flexibility in exploratory data analysis and in methods for calculating UCLs. By not restricting methods to only those available in packages such as ProUCL, methods addressing violations of assumptions can be investigated and more defensible EPCs can be produced. Methods for addressing violations of independence assumptions are described in further detail in Sections D-2 and D-3, and rely on the nlme package ( ). For exploratory data analysis, the ggplot2 R package (Wickham, 2009) is used to create all figures in this report. Several other packages are used behind the scenes: the dplyr R package was used to manipulate and subset the data (Wickham et al., 2015), the lubridate package to manipulate dates within the data (Grolemund et al., 2011), the knitr package to make tables (Xie, 2016), the openxlsx package to make tables in Excel from R (Walker, 2015), and the sp package to make plots referenced to spatial locations or distances (Pebesma & Bivand, 2005; Bivand et al., 2013).

D-1.3 Information available for censored observations (non-detects)

Laboratory data are often reported with multiple "detection limits" (e.g. method detection limit, quantitation limit, reporting limit, etc.), and censored using one of them (i.e. instrument measurements are only reported if above the chosen limit). For UCLs meant to describe an entire population, it is desirable to retain as much information from the lab data as possible, which corresponds to using the smallest detection limit deemed appropriate for censoring (resulting in fewer observations labeled as “non-detect”). Method detection limits (MDLs), if available, often fill that need. The lowest detection limits are suggested because they provide the most information available to estimate mean concentrations using all data from an exposure unit, rather than make datum-based decisions from individual concentrations. For the data used in this report, the laboratory measurements were censored using the contract required quantitation limits (CRQLS), meaning that any laboratory measurements below the CRQL were labeled as “non-detects” and assigned a label “< CRQL”. The CRQLs are also referred to as “contract required reporting limits” and simply “reporting limits” (RLs). CRQLs are targets the lab is required to meet and may not be appropriate for use as reporting limits. Lower detection limits are available (MDLs), but the data were censored using the CRQLs and there are no concentrations available for those original instrument readings falling between the MDL and CRQL (used as the RL); therefore, it is impossible to re-censor the data using the lower MDL. Additionally, MT DEQ recommends use of the RL over the MDL. Fortunately, this has very little impact on this risk assessment because only two of the identified preliminary COPCs for the ecological RA have censored observations (vanadium for surface water and cadmium for soil). Any discussion in the following sections using the term “detection limits” is referring to CRQLs (referred to as RLs in the dataset). Using larger detection limits in UCL calculations does not necessarily lead to larger UCLs because the detection limits used also affect the estimated standard deviation, which can be smaller with use of larger detection limits. Information about associated MDLs for observations summarized in this report is provided as footnotes with tables when appropriate.

D-1.4 Data quantity and scope of inference

The data used to inform this risk assessment were collected as part of the monitoring and investigation of the area around the Colstrip Power Plant. The scope of inference for the risk assessment refers to how broadly the results from statistical analysis should be applied over time and space (i.e. over what spatial area and temporal span can the results be justifiably applied to?), and depends on the sampling design or availability of data over time and space. A particular scope of inference can be justified based on the study design and expert considerations regarding the context of the risk problem.

Data to inform this risk assessment are restricted to 2014 and 2015 under the assumption that these recent data best reflect the current conditions. Assuming the results apply into the future assumes conditions will remain constant. For surface water and sediment, there are typically four sampling dates within these two years, with one sampling event in the spring and one in the fall of each year.

The spatial extent of this risk assessment is defined as the Plant Site Area. Surface water and sediment calculations are based on only four sampling locations on the East Fork Armells Creek within the Plant Site. Therefore, use of the data to make statements about the entire creek in the Plant Site Area should be made with caution. For soil, sampling areas are spatially restricted and do not necessarily support generalization to all soil in the Plant Site Area.

It is important to not only consider the total number of samples available, but the larger context in which they were collected over space and time. The total number of available concentrations might not seem limited when ignoring the number of unique locations and/or number of unique sampling events. The common methods available for UCL calculations (e.g. available in ProUCL) assume independence among samples and have been tested under the assumption of independent samples. Sections D-2 and D-3 discuss this in more detail within the context of surface water and sediment.

D-1.5 Organization of the report

This report is organized by medium: surface water (Section D-2), sediment (Section D-3), soil (Section D-4), and manganese in upgradient surface water (Section D-5). Within each section, exposure scenarios, chemicals of potential concern, and available data are described. Data summary tables are provided for identified preliminary COPCs, graphical summaries are presented in the Figures section of this appendix, and EPCs estimated by 95% UCLs for the mean are reported for each EU and preliminary COPC at the end of each section.

D-2 Surface Water

The relevant surface water is the segment of East Fork Armells Creek running through the Plant Site Area. Exposure point concentrations (EPCs) are estimated for each preliminary chemical of potential concern (COPC) identified for each identified exposure unit (EU). Exposure units are defined for each exposure scenario identified for the human health and ecological risk assessments.

D-2.1 Exposure Units and Chemicals of Potential Concern

D-2.1.1 **Human Health**

For human health, a single EU (EU1) is defined to cover all surface water in East Fork Armells Creek within the Plant Site Area (see Figures 7 and 8 in the CCRA). First stage screening, using maximum concentrations, identified manganese (Mn) as the only preliminary COPC.

D-2.1.2 **Ecological**

For ecological health, there are two exposure scenarios defined for East Armells Creek surface water: (1) animals using the entire Plant Site Area, and (2) plants or animals restricted to smaller areas on the creek within the Plant Site. Corresponding to the exposure scenarios, one EU is defined as all surface water within the Plant Site (same as EU1 for human health), and then additional smaller EUs are defined as areas around each of four sampling locations along the creek (described in Section D-2.2). First stage screening using maximum concentrations identified five preliminary COPCs: boron (B), calcium (Ca), magnesium (Mg), manganese (Mn), and vanadium (V).

D-2.2 Available data

D-2.2.1 **Sampling Locations**

There are three sampling locations (AR-2, AR-3, and AR-4) along East Fork Armells Creek within EU1 (see Figure 8 in CCRA) used to inform EPCs. Data available from the North Sewage Treatment Pond (NSTP) within the Plant Site are not used to inform EPCs because NSTP is not a stream location and generally has different (lower) concentrations for the COPCs than those measured in at the nearby stream location (AR-2). AR-5 and AR-12 are sampling locations upstream of the Plant Site boundary and are used only as primary background points. For comparison, NSTP, AR-5, and AR-12 are included in exploratory plots of available concentrations in Figures D-2.1 – D-2.4.

D-2.2.2 **Sampling Dates**

Data from 2014 and 2015 are used to inform EPCs, with the goal of representing current conditions at the site given available data. For most locations and COPCs, there were two samples taken per year, one in the fall and one in the spring on the following dates: April 8, 2014; October 16, 2014; March 19, 2015; and October 15, 2015. AR-2 had a field duplicate taken in April 8, 2014.

Total concentrations for analytes are used for analysis when available. The exceptions are calcium (Ca) and magnesium (Mg) because only concentrations from filtered samples (“dissolved”) are available and the criteria used for screening these two analytes are based on dissolved concentrations (see Appendix C for more detail). There were an additional three sampling occasions (September 3, 2014; March 24, 2015; and August 28, 2015) at location AR-2 providing “dissolved” concentrations and these were used for analysis of calcium and magnesium for the ecological risk assessment. Therefore, calcium and magnesium have two measurements from AR-2 in fall 2014, spring 2015, and fall 2015, while other analytes only have one.

D-2.3 Exploratory Data Analysis

D-2.3.1 **Graphical displays and general observations**

All years of data available for boron, calcium, magnesium, manganese, and vanadium are plotted over time and by location in Figures D-2.1 (calcium and magnesium) and D-2.2 (boron, manganese, and vanadium), allowing comparison of the 2014 and 2015 data to historical concentrations. Figures D-2.3 and D-2.4 display only the data from 2014 and 2015 used to calculate 95% UCLS as estimated EPCs. Both measurements from the field duplicate pair at AR-2 are included as separate points in the plots, and locations AR-5, AR-12, and NSTP are included for comparison. The lower concentrations at NSTP relative to AR-2 are clearly noticeable in Figures D-2.3 and D-2.4, supporting the decision to not use NSTP data in the risk assessment. As expected due to differences in flow, fall concentrations are generally larger than spring concentrations in 2014 and 2015 (Figures D-2.3 and D-2.4). EPCs are estimated using both spring and fall concentrations and therefore will generally reflect conditions between the two.

For all COPCs, the variability among locations in October 2015 is greater than in October 2014, with some locations having greater concentrations in 2015 and some have lower concentrations, depending on the analyte. Concentrations were higher in AR-5, a primary background location, in October 2015 for all five analytes explored (Figure D-2.5) and this is consistent with the results for sediment as well. The spring 2015 concentrations tend to be lower than, or equal to, the 2014 spring concentrations. It is assumed that the two sampling occasions per year for two years adequately capture variability in concentrations to inform estimation of the mean concentration over time for the area to be used as the EPC.

AR-12 is within the AOC boundary, but outside the property boundary, and is used as a primary background location. In Fall 2015, AR-12 was the location with the maximum concentration for vanadium, and concentrations for manganese and magnesium were larger than all location within the property boundary except AR-5, the other primary background location. For boron, however, AR-12 had smaller concentrations than all locations within the boundary for all sampling occasions.

D-2.3.2 **Field duplicates**

The only pair of field duplicates was collected from AR-2 on April 8, 2014. Concentrations within the field duplicate pair are very close relative to variability among concentrations from different locations and/or dates (Table D-2.1); the points representing the concentrations in Figures D-2.3 and D-2.4 are indistinguishable for most analytes. MT DEQ requires that only the maximum concentration within a field duplicate pair be used for estimation of EPCs, and therefore this approach is used for this report.

Table D-2.1. Field duplicate results (mg/L) recorded from location AR-2 on April 8, 2014.

Boron (B)	Calcium (Ca)[b]	Magnesium (Mg)[b]	Manganese (Mn)	Vanadium (V)[a]
1.28	281	322	0.366	<0.01[a]
1.17	287	333	0.351	<0.01[a]

[a] Value is a reporting limit (RL). The MDLs associated with the observations are 0.0004 and 0.009.

D-2.3.1 **Summary statistics**

Summary statistics for data used to estimate EPCs for surface water exposure scenarios are provided in Table D-2.2 for all ecological and human health preliminary COPCs (manganese is the only preliminary COPC for human health). Location-specific data used to support the smaller ecological EUs are displayed in Figures D-3.1, D-3.2, and D-3.3.

Table D-2.2. Summary statistics (mg/L) for all identified preliminary COPCs for the ecological and human health risk assessments. Summaries are calculated using the maximum of the field duplicates from AR-2 and excluding data from AR-5 and AR-12 (the primary background points) and the North Sewage Treatment Pond (NSTP) locations. There are no samples from AR-4 in fall 2015, and there are an additional three samples at AR-2 for calcium and magnesium over the two years.

	#	Total #	Detects					Non-detects		
	Locations	samples	#	Min	Median	Average	Max	#	Min RL	Max RL
Boron	3	11	11	0.51	1.15	1.050	1.62	0	NA	NA
Calcium[a]	3	13	13	221	287	284.7	361	0	NA	NA
Magnesium[a]	3	13	13	261	329	330.7	441	0	NA	NA
Manganese	3	11	11	0.073	0.28	0.781	3.39	0	NA	NA
Vanadium	3	11	1	0.02	0.02	0.02	0.02	10	0.01[b]	0.01[b]

[a] Concentrations are for filtered samples (dissolved) because results were only available for filtered samples for these analytes

[b] Values are reporting limits (RLs) which are contract required quantitation limits (CRQLs). The minimum and maximum MDLs are 0.00008 and 0.01, respectively.

D-2.4 Assessing assumptions and available data for EPC calculations

D-2.4.1 **Quantity of data**

Surface water EPC calculations for EU1 are based on three locations; AR-3 has four sampling occasions, AR-4 has three sampling occasions, and AR-2 has four sampling occasions for boron, manganese, and vanadium and six for calcium and magnesium. For the smaller location-specific ecological EUs, the estimated EPC is based on only three or four sampling occasions for a single location and only captures variability over time, not space. Therefore, all estimates are based on a very small quantity of data informing the mean concentration in time and space, and as such are highly uncertain in their representativeness of the mean concentration over the defined EUs. EPCs are estimated using 95% upper confidence limits for the mean to provide estimates that are protective of human and ecological health given the uncertainty. However, use of point estimates, even conservative ones, does not explicitly incorporate uncertainty into decision-making.

D-2.4.2 **Implications of independence violations on calculating UCLs**

The statistical properties of UCL estimators of the mean are assessed under the assumption that independent samples from the population are available. Violations of the independence assumption can be identified by describing reasons why some samples are expected to have more similar concentrations to each other than other samples (e.g. samples coming from the same location and/or same sampling period). For surface water, there are repeat measurements from the same locations (rather than different locations within the EUs) over time and repeat measurements on the same sampling date at all locations. That is, samples are naturally clustered into groups by location and sampling date, and observations within a cluster are expected to be more similar than those from different clusters, as seen in general in Figures D-2.1 – D-2.4, where some locations tend to be greater than average for all dates, and some dates tend to be greater than average for all locations.

In the context of producing protective estimates of the mean, the potential negative implication of not accounting for sources of dependence in the data is that the standard deviation of the population of interest may be underestimated, (because smaller variability is expected among dependent measurements than among the same number of independent measurements). Additionally, the degrees of freedom may be inflated because the number of independent pieces of information being used to estimated the mean is not directly related to the sample size (because of dependence among sample). These two implications can lead to a UCL that is smaller than would be obtain under independence. However, in practice, the effects on the UCL depend on the balance between the degrees of freedom (from the number of assumed independent samples) and the estimated standard deviation, and the seriousness of the implications depends on the severity of the violation of independence.

For the UCLs presented for sediment and surface water for EU1, the clustering of observations into locations and sampling occasions is accounted for in the analysis using a random effects model allowing for correlation among observations from the same location or same sampling occasion, where sampling occasion is defined by the combination of year and season. If this results in a larger 95% UCL than methods assuming independence, then this *corrected* UCL is recommended for use as the estimated EPC. Note that ProUCL treats all observations as independent and does not have the capability to account for dependence in obtaining a UCL as done in this report.

Dependence also arises on a more continuous manner in time and space, rather than just by clearly defined groups or clusters. Temporal autocorrelation generally captures that measurements taken closer in time tend to be more similar, and spatial autocorrelation captures that measurements taken closer in space tend to be more similar. The general idea is that if samples are taken very close together in time and/or space, they do not contain the same amount of information as two samples taken farther apart in time and space. If the samples are treated as if they are two independent measurements, then they are given more weight in the analysis than they should be. For the data described in this report, there are too few measurements over time and space to adequately estimate the degree of dependence due to these sources. Instead, it is assumed that the locations and sampling occasions (different years and seasons) are spaced far enough apart that the spatial and temporal autocorrelation does not need to be dealt with beyond that already accounted for by incorporating the clusters of observations from the same location and/or sampling occasion into the analysis.

D-2.5 95% UCLs

This section describes the methods used to obtain 95% UCLs and provides the estimated EPCs for the exposure units described in Section D-2.1.1.

D-2.5.1 All surface water in the Plant Site Area (EU1)

As described in Section D-1.1, the EPCs are calculated as the maximum of the 95% *t*-UCL, BCa-UCL, and the t-UCL *corrected* for lack of independence. The data used to calculate UCLs are limited in time and space, resulting in large uncertainty in estimating the mean concentration. The 95% UCLs from all three methods are shown in Table D-2.3, along with the average and maximum concentrations from available data and the recommended estimated EPC based on the 95% UCL results. The dependence due to sampling period is more severe than that due to location, and the *corrected* UCLs are obtained by estimating the overall mean after accounting for dependence among sampling periods (season-year combinations) using a linear mixed model and the method of maximum likelihood (using the *lme* function in the *nlme* R package; Pinheiro et al. 2017) and these UCLs are recommended for use as EPCs

Summary information for censored observations (non-detects) is available in Table D-2.2. The only analyte with non-detects is the ecological COPC vanadium (V), with 13 censored observations of the 15 total. The only detects for vanadium are from the October 15, 2015 sampling occasion from locations AR-3, as well as the primary background points of AR-5 and AR-12 which had larger concentrations than all downgradient locations within the Plant Site Area. The same RL is reported for every vanadium non-detect, and though MDLs do differ, because the data were censored using the RL and MT DEQ requires use of the RL in risk assessment, there is a single detection limit for the purpose of statistical analysis (i.e. all "non-detects" have the same reporting limit). The UCL is sensitive to the method used to incorporate non-detects given the large proportion of censored observations. Given only one uncensored observation (i.e. "detect") from the three locations used in UCL calculations, and the single detection limit, commonly used methods such as robust regression on order statistics (rROS) and Kaplan-Meier (K-M) methods are not recommended. Instead, UCLs are calculated by relying on the method of substitution at half the reporting limit, as recommended by MT DEQ. Results after substituting the MDLs are also provided in the footnotes of Table D-2.3, though recall discussion of censoring of these data from Section D-1.2.

Table D-2.3. 95% UCLs (mg/L) for all human health and ecological COPCs in EU1, using data from 2014 and 2015 from locations AR-2, AR-3, and AR-4.

	Boron (B)	Calcium (Ca)[b]	Magnesium (Mg)[b]	Manganese (Mn)	Vanadium (V)[a]
Average	1.05	284.7	330.7	0.781	0.0064[a]
Maximum	1.62	361	441	3.39	0.0200
95% t-UCL	1.24	309.4	360.1	1.36	0.0088[a]
95% BCa-UCL	1.21	306.8	360.0	1.49	0.0077[a]
95% UCL corrected[c]	1.39	327.7	378.8	2.04	--
Estimated EPC	**1.39**	**327.7**	**378.8**	**2.04**	**0.0088**[a]

[a] – Due to the large proportion of non-detects reported as <RL=0.01, the results for vanadium should be used with caution. The one detect comes from a single sampling location and it is less than the concentrations from primary background point AR-12. The average and UCL are calculated using substitution at half the single reporting limit (RL=0.01) as required by MT DEQ. If the MDL is substituted, the average is 0.004, the 95% t-UCL is 0.0096, and the 95% BCa-UCL is 0.0099.

[b] Concentrations are for filtered samples (dissolved) because results were only available for filtered samples for these analytes

[c] 95% t-UCLs after adjusting for lack of independence in the samples due to same sampling periods. The 95% UCLs were obtained by modeling sampling period (year and season) as a random effect.

D-2.5.2 **Smaller location-specific EUs for the ecological RA**

There are three locations used to define smaller exposure units along East Fork Armells Creek in the Plant Site to accompany ecological exposure scenarios. 95% UCLs are calculated for each location separately. Due to the small number of samples at each location, bootstrap methods are not recommended and only t-based UCLs are calculated; t-UCLs are larger than BCa UCLs would be because they account for the uncertainty in estimating the standard deviation from few observations.

The source of variability in the data used to calculate these UCLs comes from repeat measurements over time for each location, and does not include variability over space within areas around each sampling location. UCLs are not provided for vanadium because of the large number of non-detects; the number of detects out of the total number of observations is 0/5 (AR-2), 1/4 (AR-3), and 0/3 (AR-4). Both primary background points, AR-5 and AR-12, had 1 detect out of 4 samples. Note that results for AR-5, AR-12, and NSTP are included in Tables D-2.4 through D-2.7 only for comparison, and are not intended for use in the risk assessment.

For some locations and chemicals, the reported 95% UCL exceeds the maximum observed concentration over individual samples (see Section D-1.1.3 for more discussion). This is not unexpected for a sample size of 4 where the sample maximum and 95% t-UCL should be close together for most samples (assuming normality, independence, and random sampling). The underestimation rate for the 95% t-UCL is 0.05 (by definition) and the underestimation rate for the sample maximum is about 0.06. If the minimum of the sample maximum and the 95% t-UCL is chosen, then the underestimation rate increases to about 0.07. The sample maximum is actually expected to be less than the 95% t-UCL in 57% of random datasets, meaning a 95% UCL greater than the sample maximum should not be interpreted as evidence of an unreasonably conservative UCL. Therefore, for a sample size of 4, it is recommended that the t-UCL be used over the sample maximum (even if the maximum is smaller) if 5% underestimation rate is desired. Both are similarly conservative estimates of the mean and any estimate of the mean should be used with caution when the sample size is 4.

Table D-2.4. Boron 95% UCLs (mg/L) for the small ecological EUs based on four concentrations collected over 2014 and 2015 for each location. The 95% UCL should be used as the EPC with caution given the small number of samples informing it. AR-5 and AR-12 are included for comparison as the primary background points.

Boron (B)	AR-2	AR-3	AR-4	AR-5	AR-12	NSTP
Sample Avg	1.32	1.07	0.76	1.07	0.663	0.79
Sample Max	1.83	1.26	0.99	2.06	0.89	1.02
95% t-UCL	**1.83**	**1.40**	**1.17**	1.88	0.90	1.14

Table D-2.5. Manganese 95% UCLs (mg/L) for the small ecological EUs based on four concentrations collected over 2014 and 2015 for each location. The 95% UCL should be used as the EPC with caution given the small number of samples informing it. AR-5 and AR-12 are included for comparison as the primary background points.

Manganese (Mn)	AR-2	AR-3	AR-4	AR-5	AR-12	NSTP
Sample Avg	0.98	0.98	0.20	3.02	1.38	0.100
Sample Max	2.00	3.27	0.43	11.60	5.08	0.151
95% t-UCL	**1.97**	**2.78**	**0.53**	9.75	4.28	0.178

Table D-2.6. Calcium 95% UCLs (mg/L) for the small ecological EUs based on four concentrations collected over 2014 and 2015 for each location. The 95% UCL should be used as the EPC with caution given the small number of samples informing it. The 95% UCL for AR-2 is obtained after accounting for having multiple samples per season. AR-5 and AR-12 are included for comparison as the primary background points.

Calcium (Ca)	AR-2	AR-3	AR-4	AR-5	AR-12	NSTP
Sample Avg	297.0	275.0	272.0	302.8	280.8	97.3
Sample Max	361	333	326	397	334	112
95% t-UCL	**351.2**	**331.9**	**360.6**	391.2	342.6	121.0

Table D-2.7. Magnesium 95% UCLs (mg/L) for the small ecological EUs based on four concentrations collected over 2014 and 2015 for each location. The 95% UCL should be used as the EPC with caution given the small number of samples informing it. The 95% UCL for AR-2 is obtained after accounting for having multiple samples per season. AR-5 and AR-12 are included for comparison as the primary background points.

Magnesium (Mg)	AR-2	AR-3	AR-4	AR-5	AR-12	NSTP
Sample Avg	321.1	329.5	347.0	379.8	362.8	102.0
Sample Max	375	432	441	501	458	124
95% t-UCL	**366.0**	**421.0**	**492.7**	**501.7**	462.7	134.8

D-3 Sediment

The relevant sediment is contained in the segment of East Fork Armells Creek running through the Plant Site. Exposure point concentrations (EPCs) are estimated for each preliminary chemical of potential concern (COPC) identified for each exposure unit (EU). EUs are defined for each exposure scenario identified for the human health and ecological risk assessments, and the EUs sediment are the same as those described for surface water in Section D-2.

D-3.1 Exposure Units and Chemicals of Potential Concern

D-3.1.1 **Human Health**

For human health, a single EU (EU1) is defined to cover all sediment in the East Fork Armells Creek within the Plant Site (see Figures 7 and 8 in the CCRA). First stage screening using the maximum concentrations identified manganese (Mn) as the only preliminary COPC.

D-3.1.2 **Ecological**

For ecological health, the exposure scenarios are the same as defined for surface water in Section D-2.1.2: (1) animals using the entire Plant Site, and (2) plants or animals restricted to smaller areas within the Plant Site. Corresponding to the exposure scenarios, EU1 is defined as all sediment within the Plant Site Area (same as EU1 for human health), and then additional smaller EUs are defined around each of the four sampling locations along the creek (described in Section D-3.2). First stage screening using the maximum concentrations identified three preliminary COPCs: arsenic (As), boron (B), and manganese (Mn).

D-3.2 Available Data

D-3.2.1 **Sampling Locations**

There are three sampling locations (AR-2, AR-3, and AR-4) along East Fork Armells Creek within the Plant Site Area boundary (see Figure 8 in the CCRA) used to inform EPCs for sediment. They are the same three locations used for surface water (see description in Section D-2.2.1). AR-5 and AR-12 are sampling locations upstream of the Plant Site and are used as the primary background points; they are included in exploratory plots of available concentrations in Figures D-3.1 – D-3.3.

D-3.2.2 **Sampling Dates**

Data from 2014 and 2015 are used to inform EPCs, with the goal of representing current conditions at the site given available data. For most locations and analytes, there were two samples taken per year, one in the fall and one in the spring on the following dates: April 8, 2014; October 16, 2014; March 19, 2015; and October 15, 2015. These are the same sampling occasions as described for surface water. AR-12, a primary background point, had a field duplicate taken on October 16, 2014.

D-3.3 Exploratory Data Analysis

D-3.3.1 **Graphical displays and general observations**

All years of data available for arsenic, boron, and manganese are plotting over time and by location in Figure D-3.1. Figure D-3.2 includes only data from 2014 and 2015. The field duplicates from AR-12 are both included as points in the figures.

The concentrations in April 2007 are generally larger than the 2014 and 2015 concentrations for arsenic and boron over all locations. The concentrations of arsenic and manganese at AR-5, a primary background point, are large relative to the other locations in the October 2014 sampling occasion. The maximum manganese concentration occurred in October 2014 at location AR-5 and is much larger than those from April 2014 and March 2015 (Figures D-3.1, D-3.2, D-3.3). AR-5 had the largest concentrations for all analytes investigated in October 2014. The concentrations are included in EPC estimation because there is no reason to justify them as being erroneous. They are assumed to represent possible concentrations under the conditions of Fall 2014, which could occur again the future.

As with surface water, concentrations tend to be larger in the fall sampling occasions. However, for a few location-analyte combinations, concentrations in fall 2015 were slightly smaller than spring 2015. Overall, there appears to be large variability in concentrations over time, with measured concentrations generally larger in the fall sampling occasions. In general, the locations within the Plant Site boundary are consistent with the observed trends over time for AR-12.

D-3.3.2 **Field duplicates**

A pair of field duplicates was collected from the background location AR-12 on October 16, 2014. The data are presented in Table D-3.1 for exploratory purposes, but will not affect EPCs because AR-12 is included only as the primary background point. The concentrations are plotted as separate points in Figures D-3.1 and D-3.2, but are indistinguishable on the scale provided for arsenic and manganese.

Table D-3.1. Field duplicate concentrations (mg/kg) from AR-12 taken on October 16, 2014. The concentrations are similar compared to concentrations from different times and/or locations.

Arsenic (As)	Boron (B)	Manganese (Mn)
2.8	15.8	534
2.7	18.8	564

D-3.3.3 **Summary statistics**

Summary statistics for data available to estimate EPCs are presented in Table D-3.2. Primary background locations AR-5 and AR-12 are excluded from these summaries. Manganese is the only preliminary COPC for human health.

Table D-3.2. Summary statistics (mg/kg) for all identified COPCs in the ecological and human health risk assessments for 2014 and 2015 data. Data from the primary background locations AR-5 and AR-12 are excluded from the summaries.

Metal	# Locations	Total Samples	Detects					Non-detects		
			#	Min	Median	Average	Max	#	Min	Max
Arsenic	3	12	12	1.0	3.15	3.33	5.6	0	NA	NA
Boron	3	12	12	4.4	11.9	12.6	19.9	0	NA	NA
Manganese	3	12	12	412	1845	1738	3910	0	NA	NA

D-3.4 Assessing assumptions and available data for EPC calculations

D-3.4.1 **Quantity of data**

Sediment EPC calculations for EU1 are based on three locations with four sampling occasions each. For the smaller location-specific ecological EUs, the estimated EPC is based on four sampling occasions for a single location and only captures variability over time, not space. Therefore, all estimates are based on a small quantity of data informing the mean concentration in time and space, meaning they are highly uncertain in their representativeness of the mean concentration over the defined EUs. EPCs are estimated using 95% confidence limits for the mean to provide estimates that are protective of human and ecological health given the uncertainty. However, use of point estimates, even conservative ones, does not explicitly incorporate uncertainty into decision-making.

D-3.4.2 **Implications of independence assumption violations**

The description of potential violations of independence and its implications described in Section D-2.4.1. for surface water, also apply here to the sediment data.

D-3.4.3 **Choice of UCL estimator for the mean**

The method of selecting the type of UCL estimator of the mean used to estimate EPCs for sediment is described for surface water in Section D-2.4.2.

D-3.5 95% UCLs

This section describes the methods used to obtain 95% UCLs and provides the estimated EPCs for the exposure units described in Section D-2.1.1.

D-3.5.1 **All sediment in the Plant Site Area (EU1)**

As described in Section D-1.1, EPCs are estimated as the maximum of the 95% t-UCL, BCa-UCL, and the t-UCL *corrected* for lack of independence. The data used to calculate UCLs are limited in time and space, resulting in large uncertainty in estimating the mean concentration. The 95% UCLs from all three methods are shown in Table D-3.3, along with the average and maximum concentrations from available data and the recommended estimated EPC based on the 95% UCL results. The UCLs corrected for lack of independence are obtained after accounting multiple measurements from the same location and/or same sampling occasion. For sediment, the dependence due to sampling period is less severe than that observed for surface water and depends on metal. To be consistent across the metals, both location and sampling period were accounted for in the analysis using the *lme* function in the *nlme* R package (Pinheiro et al. 2017) and these UCLs are recommended for use as EPCs.

Table D-3.3. 95% UCLs (mg/kg) for the human health and ecological COPCs in EU1 for sediment, using data from 2014 and 2015 from locations AR-2, AR-3, and AR-4. There were no field duplicates and no non-detects for these metals.

	Arsenic (As)	Boron (B)	Manganese (Mn)
Average	3.33	12.63	1737.8
Maximum	5.6	19.9	3910
95% t-UCL	4.11	15.03	2283.9
95% BCa-UCL	4.03	14.71	2265.1
95% UCL corrected[a]	4.63	15.54	2755.4
Estimated EPC	**4.63**	**15.54**	**2755.4**

[a] t- UCL after correcting for lack of independence in the samples due to same locations and same sampling occasions.

D-3.5.2 **Smaller location-specific ecological EUs**

There are three locations informing the smaller exposure units along the East Fork Armells Creek in the Plant Site Area. 95% UCLs are calculated for each location separately, meaning there are only four samples per location. Due to the small number of samples at each location, bootstrap methods are not recommended. Therefore, *t*-based UCLs are calculated, which are larger than BCa-UCLs would be in this case because they account for the uncertainty in estimating the standard deviation from few observations.

All variability associated with these UCLs is from variability over time for that location, and does not capture variability over space within the smaller EUs. 95% UCLs are presented for arsenic (Table D-3.4), boron (Table D-3.5), and manganese (Table D-3.6). Results for the primary background points AR-5 and AR-12 are included in the tables for only for comparison. See Section D-2.5.2 for discussion about comparisons of the sample maximum to the 95% UCL.

Table D-3.4. Arsenic 95% UCLs (mg/kg) for the small location-specific ecological EUs. Each UCL is based on only four samples collected during 2014 and 2015. AR-5 and AR-12, the primary background points, are included for comparison only and was calculated using the maximum from the field duplicate pair.

Arsenic (As)	AR-2	AR-3	AR-4	AR-5	AR-12
Average	2.00	4.50	3.53	5.33	2.33
Maximum	3.3	5.6	5.1	12.6	2.9
95% t-UCL	**3.17**	**5.84**	**5.16**	11.03	3.14

Table D-3.5. Boron 95% UCLs (mg/kg) for the small location-specific ecological EUs. Each UCL is based on only four samples collected during 2014 and 2015. AR-5 and AR-12, the primary background points, are included for comparison only and was calculated using the maximum from the field duplicate pair.

Boron (B)	AR-2	AR-3	AR-4	AR-5	AR-12
Average	11.98	15.65	10.28	16.53	14.55
Maximum	16.4	19.9	15.4	19.4	18.8
95% t-UCL	**16.85**	**21.01**	**15.62**	20.14	20.29

Table D-3.6. Manganese 95% UCLs (mg/kg) for the small location-specific ecological EUs. Each UCL is based on only four three samples collected during 2014 and 2015. AR-5 and AR-12, the primary background points, are included for comparison only and was calculated using the maximum from the field duplicate pair.

Manganese (Mn)	AR-2	AR-3	AR-4	AR-5	AR-12
Average	2217.5	2365.0	630.8	2545.0	538.5
Maximum	3910	2970	986	5910	700
95% t-UCL	**3586.0**	**2875.8**	**924.5**	5214.3	762.9

D-4 Soil

Soil sampling was performed by Hydrometrics following an Interim Response Action Work Plan (Hydrometrics, Inc., 2016). The soil samples are limited in spatial scale relative to the Plant Site Area and represent three small areas with known history of spills or ponding of storm water (see Figure 7 in CCRA).

D-4.1 Exposure Units and Chemicals of Potential Concern

As described above, the soil sampling covered a small portion of the total area comprising the Plant Site Area. Data only exist from areas where spills are known to have occurred, and two of the areas have been remediated; there is no information on background soil concentrations in the Plant Site Area. The available data are described in more detail in Section D-4.2. Exposure units are defined around the areas where data were collected.

D-4.1.1 **Human health**

For human health, only the 0-6’’ (shallow) soil depth interval in each of the three soil sampling areas was considered for exposure scenarios (see Figure 7 in the CCRA). The first stage screening process using maximum concentrations did not identify any preliminary COPCs. Larger concentrations, relative to all other samples, were found for barium in one location and lead in another location; these are discussed further in Section D-4.2.4. Table D-4.5 provides data summaries for metals for the 0-6’’ depth interval in soil sampling Area 1 (HH EU3) because the data were of interest in screening for preliminary COPCs for human health.

D-4.1.2 **Ecological**

Two ecological EUs are defined by different soil depth intervals for the area covered by the three soil sampling areas. The first exposure scenario is defined only for 0-6’’ (shallow), while the second exposure scenario captures plants and burrowing animals using mainly soil from the 12-24’’ (mid-depth). Preliminary COPCs identified through the first stage screening process using maximum concentrations are barium (Ba), boron (B), lead (Pb), and selenium (Se) for the shallow depth exposure unit (0-6’’); and cadmium (Cd), boron (B), lead (Pb), and selenium (Se) for the mid-depth surface soil exposure unit (12-24’’). Summary statistics for available data for each exposure scenario are provided in Tables D-4.2 (0-6’’) and D-4.3 (12-24’’). All metals of initial interest are included and the identified preliminary COPCs are included highlighted in gray.

D-4.2 Available Data

D-4.2.1 **Soil sampling areas**

The three distinct sampling areas are shown in a series of figures in the CCRA (Figures 7, 9, 10, and 11). The middle area, Soil Sampling Area 1 as defined in Hydrometrics (2016), is defined as HH EU3 (Soil) in Figure 7 in CCRA; the northern Soil Sampling Area 2 is defined as HH EU2 (Soil); and the southern Soil Sampling Area 3 is defined as HH EU4 (Soil). This report refers to the originally defined Soil Sampling Areas: Area 1 is the largest area in the middle, Area 2 is the northern area, and Area 3 is the southern area.

Area 1 soil samples were collected based on an approved DEQ grid and spacing. Variations in sample locations from the work plan are the result of slight inconsistencies related to the use of handheld Global Positions System (GPS) and site conditions, which included marshy areas, roads, and physical obstacles (Hydrometrics, 2016). Area 1 contains 37 sampling locations, mostly on a grid with 100 ft centers. It covers an area where two spills are known to have occurred at approximately the same location, one in 1998 and one in 2000. Most of the locations have only samples from the shallow (0-6'') and mid (12-24'') surface soil depth intervals (see Figure 10 in the CCRA). Deep (5-7') soil samples were only taken from a smaller area used to stage excavated materials during the spill clean-up in 1998, and three additional locations at the site of a temporary retention pond that used to hold water from the 2000 spill (Figure 10 in the CCRA). Note the data include one location immediately outside the Plant Site Area (BH-73). This sample was collected off the sampling grid in an area unaffected by the spills to the southwest of Area 1 (Hydrometrics, 2016). It is included in the analysis because it is close to the border of the Plant Site and was collected at the same time as the other samples.

The four sampling locations to the north come from Area 2 (Figure 9 in the CCRA). The sampling locations were chosen to be centrally located along the long axis of a spill that occurred in March 2000, and deep (5'-7') samples were taken from two of the four locations.

Area 3 was defined because storm water overflows have been historically documented in the area. Three locations were sampled for surface soil (Figure 11 in the CCRA). While the spills associated with Area 1 and Area 2 were remediated, Area 3 has not been remediated from possible overflows. Therefore, based on this information, it is expected that Area 1 and Area 2 may appear similar in their concentrations of chemicals, though possibly different from Area 3.

D-4.2.2 **Soil sampling depths**

According to the Soil Sampling plan for the Interim Response Action Work Plan, surface soil samples were collected from two depth intervals at every location: 0-6 inches below the ground cover and 12-24 inches. The shallowest samples are recorded as 0-6 inches in the data set, and mid depth samples are 12-24 inches. Subsurface soil samples were planned from 6'-7' from a subset of proposed locations. However, for subsurface samples, end depths do vary from 7', with end depths of 5.5' (1 sample), 6.0' (1 sample), and 6.5' (1 sample) in the data set due to the presence of shallow groundwater. In the plots and summaries, the following labels are used: shallow depth (0-6''), mid depth (12"-24''), and deep depth (5'-7').

D-4.2.3 **Sieved samples**

Concentrations from sieved samples are used for all analysis.

D-4.2.4 **Laboratory re-runs**

The 0-6'' samples from BH-54 and BH-56 were re-run for metals in June 2016 because the lead concentration in the BH-56 sample, and the barium concentration in the BH-54 sample, were substantially larger than in all other samples. Laboratory re-runs were conducted by preparing completely new aliquots from the original soil and not as a re-run of the original aliquot. The re-run lead concentration from the BH-56 sample was 18.8 mg/kg compared to the original 504.0 mg/kg, and the re-run barium concentration for BH-54 was 1130 mg/kg compared to the original 1050 mg/kg. Samples were analyzed again for all metals and there is no evidence in the data to suggest that the first laboratory analysis was not correct; depending on the source, lead concentrations are sometimes affected by small lead particles or fragments which can explain the discrepancy between the two measurements. Consequently, the re-run results are treated as additional measurements for those samples. As required by MT DEQ, the maximum of the two concentrations is used in subsequent analysis. Table D-4.1 displays the individual concentrations, the maximums in bold, and the average of the two re-runs for exploratory purposes.

Table D-4.1. Concentrations (mg/kg) for the laboratory re-runs for 0-6'' samples at locations BH-54 and BH-56. Ecological COPCs are highlighted in gray and the maximum for the two runs is in bold. The maximums are used analyses, as required by MT DEQ.

Location	Analyte	Run1	Run2	Average
BH-54	Arsenic	**6.9**	6.3	6.6
	Barium	**1130**	1050	1090
	Boron	**68.5**	67.8	68.2
	Cadmium	0.57	0.57	0.57
	Chromium	**31.5**	21.9	26.7
	Lead	**17.4**	17.1	17.25
	Manganese	**375**	347	361
	Mercury	0.10[a]	0.10[a]	0.10[a]
	Selenium	**1.3**	1.2	1.25
BH-56	Arsenic	**4.8**	4.7	4.75
	Barium	116	**163**	139.5
	Boron	14.4	**18.3**	16.4
	Cadmium	**0.54**	0.41	0.48
	Chromium	11.9	**16.8**	14.35
	Lead	**504**	18.8	261.4
	Manganese	324	**406**	365
	Mercury	0.10[a]	0.10[a]	0.10[a]
	Selenium	0.4	**0.7**	0.55

[a] Value is the reporting limit for a censored concentration (non-detect). The method detection limit is 0.0003.

D-4.2.5 **Field duplicates**

There are five pairs of field duplicates taken at five different locations (BH-29, BH-43, BH-53, BH-69, and BH-72). All are taken at the shallowest depth interval (0-6''). BH-29 is in Soil Area 2, BH-72 is in Soil Area 3, and the remaining three are in Soil Area 1. The pairs of field duplicates generally have similar concentrations relative to variability among observations that are not duplicates (Figures D-4.1 and Figure D-4.2). MT DEQ requires that the maximum of the field duplicate pair be used in estimation of the EPC, and therefore this approach is used for the analysis.

D-4.3 Exploratory Data Analysis

Tabular and graphical summaries of available data are presented in this section. The maximum of the two measurements is used for field duplicates and laboratory re-runs.

D-4.3.1 **Graphical displays and general observations**

Barium and lead both contain one large concentration in the 0-6'' depth interval at locations BH-54 and BH-56, respectively. The largest lead concentrations for the 0-6'' depth are found in Area 1 (Figures D-4.3, D-4.4, and D-4.6), though there are also two concentrations in Area 2 near 50 mg/kg. For barium, the largest concentrations are found in Area 1, although there is one value from Area 2 near 300 mg/kg.

Sampling location BH-54 stands out as having large concentrations for multiple metals. This is one of the locations chosen for the laboratory re-run because of the unusually large concentration for barium, but it is also associated with the maximum concentrations for boron, cadmium, and selenium for the 0-6'' samples (Figure D 4.6).

Many locations appear to exhibit similar concentrations for different depths at the same sampling location, though data occasionally indicate a large value in the 0-6'' interval and a small value in the 12-24'' interval, or vice-versa (Figures D-4.3, D-4.4, and D-4.5).

In general, the six metals included in the plots exhibit a similar spatial pattern, though manganese tends to have relatively higher concentrations in the northern part of Area 1 than the other metals. Spatial patterns of concentrations are similar between the 0-6'' and 12-24'' depth intervals for Area 1.

Cadmium is the only preliminary COPC with censored observations (non-detects). It has a single reporting limit of 0.05 mg/kg, though MDLs took values of 0.003, 0.004, 0.006, 0.04, and 0.05 mg/kg. For cadmium in the 0-6'' depth interval, nine of the 49 total measurements are classified as non-detects (18.4 %), with two of those coming from a field duplicate pair at BH-72 in Area 3. There are eight unique locations with non-detects at the 0-6''depth interval, with six in Area 1 (BH-33, BH-34, BH-36, BH-37, BH-38, and BH-45) and two in Area 3 (BH-71 and BH-72). For 12-24'' depth interval, nine of 43 samples are classified as non-detects (26 %); three of the nine locations are in Area 3 (BH-70, BH-71, and BH-72), and five are close together within Area 1 (BH-33, BH-34, BH-35, BH-36, BH-37, and BH-38). Most of these locations are the same as those with non-detects at the 0-6'' depth. For subsurface depths (5-7'), one of the nine samples was a non-detect at location BH-32, which did not have any non-detects in surface soil.

D-4.3.2 **Summary tables**

Summary statistics tables are presented for (1) all soil sampling areas for 0-6'' (Table D-4.2), (2) all soil sampling areas for 12-24'' (Table D-4.3), (3) all soil sampling areas for 5-7' (Table D-4.4), and (4) soil sampling Area 1 for 0-6'' (Table D-4.5). The maximums from field duplicate pairs and laboratory re-runs are used, as required by MT DEQ.

The summaries indicate that the concentrations are relatively consistent across depth intervals. For a few metals, the average concentration in the 0-6'' depth interval is greater than in the deeper intervals (e.g., barium and lead). Concentrations for individual samples are mostly within range of the regional Montana state background data that are generally available.

Table D-4.2. Summary of metals concentration data (mg/kg) from all three soil sampling areas for the shallow depth (0-6'') interval. The maximums from field duplicate pairs and laboratory re-runs are used in the summary. Barium, boron, lead, and selenium are identified as COPCs (highlighted in gray) for the ecological RA.

	#	Total	Detects					Non-detects		
Metal	Locations	Samples	#	Min	Median	Average	Max	#	Min	Max
Arsenic	44	44	44	4.7	6.20	6.20	7.9	0	NA	NA
Barium	44	44	44	106	171.5	219.3	1130	0	NA	NA
Boron	44	44	44	5.9	10.55	13.29	68.5	0	NA	NA
Cadmium	44	44	36	0.07	0.35	0.362	0.66	8	0.05[a]	0.05[a]
Chromium	44	44	44	15.6	22.8	23.02	33.9	0	NA	NA
Lead	44	44	44	11.4	16.75	31.38	504	0	NA	NA
Manganese	44	44	44	271	389.0	388.8	497	0	NA	NA
Mercury	44	44	0	NA	NA	NA	NA	44	0.10[a]	0.10[a]
Selenium	44	44	44	0.4	0.50	0.54	1.3	0	NA	NA

[a] Value is the reporting limit for a censored concentration (non-detect). The method detection limit for cadmium non-detects is either 0.04 or 0.05, and for mercury it is 0.0003 for all samples.

Table D-4.3. Summary of metals concentration data (mg/kg) from all three soil sampling areas for the middle depth (12-24'') interval. Boron, cadmium, lead, and selenium are identified as COPCs for the ecological risk assessment.

	#	Total	Detects					Non-detects		
Metal	Locations	Samples	#	Min	Median	Average	Max	#	Min	Max
Arsenic	43	43	43	4.9	5.80	5.88	6.8	0	NA	NA
Barium	43	43	43	96.3	166	165.7	237	0	NA	NA
Boron	43	43	43	6.9	10.2	12.05	35.3	0	NA	NA
Cadmium	43	43	34	0.23	0.31	0.327	0.71	9	0.05[a]	0.05[a]
Chromium	43	43	43	15.5	21.8	22.75	32.3	0	NA	NA
Lead	43	43	43	9.47	12.6	15.97	73.9	0	NA	NA
Manganese	43	43	43	277	357	360.1	491	0	NA	NA
Mercury	43	43	0	NA	NA	NA	NA	43	0.10[a]	0.10[a]
Selenium	43	43	43	0.3	0.50	0.58	1.2	0	NA	NA

[a] Value is the reporting limit for a censored concentration (non-detect). The method detection limit for cadmium non-detects is either 0.04 or 0.05, and for mercury it is 0.0003 for all samples.

Table D-4.4. Summary of metals concentration data (mg/kg) from all three soil sampling areas for the deep depth (5-7') interval. No COPCs are identified for ecological or human health.

	#	Total	Detects					Non-detects		
Metal	Locations	Samples	#	Min	Median	Average	Max	#	Min	Max
Arsenic	9	9	9	5.5	6.0	6.02	6.7	0	NA	NA
Barium	9	9	9	137	160	163.9	193	0	NA	NA
Boron	9	9	9	7.8	8.3	8.63	10.7	0	NA	NA
Cadmium	9	9	8	0.28	0.32	0.324	0.37	1	0.05[a]	0.05[a]
Chromium	9	9	9	18.4	25.3	26.06	34.0	0	NA	NA
Lead	9	9	9	10.1	13.2	13.12	15.3	0	NA	NA
Manganese	9	9	9	331	401	395.8	469	0	NA	NA
Mercury	9	9	0	NA	NA	NA	NA	9	0.10[a]	0.10[a]
Selenium	9	9	9	0.3	0.4	0.46	0.8	0	NA	NA

[a] Value is the reporting limit for a censored concentration (non-detect). The method detection limit for cadmium non-detects is either 0.04 or 0.05, and for mercury it is 0.0003 for all samples.

Table D-4.5. Summary of concentrations (mg/kg) from 0-6'' in soil sampling Area 1. The maximums from field duplicates and laboratory re-runs are used in the summaries. The data summarized in this table were specifically of interest for human health EU3, though no COPCs are identified.

	#	Total	Detects					Non-detects		
Metal	Locations	Samples	#	Min	Median	Average	Max	#	Min	Max
Arsenic	37	37	37	4.7	6.20	6.23	7.9	0	NA	NA
Barium	37	37	37	106	175	230.3	1130	0	NA	NA
Boron	37	37	37	5.9	10.2	13.74	68.5	0	NA	NA
Cadmium	37	37	31	0.07	0.35	0.35	0.57	6	0.05[a]	0.05[a]
Chromium	37	37	37	15.6	22.2	22.54	31.5	0	NA	NA
Lead	37	37	37	11.4	16.0	32.16	504	0	NA	NA
Manganese	37	37	37	271	389	384.1	481	0	NA	NA
Mercury	37	37	0	NA	NA	NA	NA	37	0.10[a]	0.10[a]
Selenium	37	37	37	0.4	0.50	0.55	1.3	0	NA	NA

[a] Value is the reporting limit for a censored concentration (non-detect). The method detection limit for cadmium non-detects is either 0.04 or 0.05, and for mercury it is 0.0003 for all samples.

D-4.4 Assessing assumptions and available data for EPC calculations

D-4.4.1 **Quantity of data**

As discussed in Section D-4.1, the soil samples are limited in spatial scale relative to the Plant Site Area and represent three small areas with known history of spills or ponding of storm water (see Figure 7 in the CCRA); the estimated EPCs in this report apply only to the sampled areas defined.

D-4.4.2 **Implications of independence violations**

Common methods for calculating 95% UCLs assume all observations are independent. However, samples taken closer together in space tend to be more similar than those taken far apart and this is described as spatial autocorrelation. The general idea is that if samples are taken close enough together in space, the samples actually overlap in their information about the mean concentration and therefore contain less information than independent samples would. The soil data indicate evidence of positive autocorrelation, which tapers off within about 200 meters for most metals. However, the spatial autocorrelation is not judged to be severe enough to warrant accounting for it in the UCL calculations.

D-4.4.3 **Choice of UCL estimator for the mean**

The general approach to estimating UCLs is described on Section D-1.1, and involves choosing the maximum of the *t*-UCL or the BCa-UCL. No corrections are made for potential lack of independence for soil.

D-4.5 95% UCLs

95% UCLs are calculated for use as estimated ecological EPCs using data from all three soil sampling areas combined for (1) shallow depth (0-6 ʹʹ) surface soil only, and (2) mid depth surface soil (12-24ʹʹ) only. No UCLs are calculated for human health because no preliminary COPCs were identified.

The results are presented in Tables D-4.6 and D-4.7, and all data used in the calculations are summarized in Tables D-4.2 and D-4.3 along with Figures D-4.3, D-4.4, D-4.14, and D-4.15.

For cadmium, several statistical methods were investigated for incorporating the censored observations through the EnvStats R package (Millard 2013). As described in Section D-1.2, the RL is used as the detection limit because of how the data are reported and requirements of MT DEQ. All the cadmium non-detects are examples of Type I censored observations with a single censoring limit. The distribution of uncensored concentrations (“detects”) for cadmium is fairly symmetric, leading to reasonable use of robust regression on order statistics (rROS) with the normal distribution. Note that ProUCL recommends implementation of Kaplan-Meier (K-M), though in the case of a single detection limit K-M gives the same result as substituting the detection limit. The method of maximum likelihood, rROS method, and substituting half the detection limit all result in BCa-method 95% UCLs of 0.30 (rounded to the nearest 100th). The rROS used with the t-UCL method gives a slightly higher 95% UCL at 0.32. The linear relationship with the normal distribution quantiles appears reasonable for use of the rROS and therefore this method is recommended over maximum likelihood.

Table D-4.6. Estimated EPCs (mg/kg) for the COPCs identified for the ecological exposure scenario for only shallow (0-6ʹʹ) soil and all three soil sampling areas using the maximum of field duplicates and the maximum of the laboratory re-runs for BH-54 and BH-56.

	Barium	Boron	Lead	Selenium
Average	219.3	13.29	31.38	0.541
Maximum	1130	68.5	504	1.30
95% t-UCL	259.5	15.89	50.40	0.583
95% BCa-UCL	284.8	17.23	69.07	0.591
Estimated EPC	**284.8**	**17.23**	**69.07**	**0.591**

Table D-4.7. Estimated EPCs (mg/kg) for the COPCs identified for the ecological exposure scenario for only the mid depth (12-24'') soil and all three soil sampling areas.

	Boron	**Cadmium 1/2 RL**	**Cadmium rROS**[a]	**Lead**	**Selenium**
Average	12.05	0.264	0.29	15.97	0.581
Maximum	35.3	0.71	0.71	73.9	1.20
95% t-UCL	13.45	0.301	0.321	19.40	0.630
95% BCa-UCL	13.79	0.299	0.308	21.11	0.633
Estimated EPC	**13.79**	0.301	**0.321**	**21.11**	**0.633**

[a] rROS is the "robust regression on order statistics" method based on normal distribution quantile regression and imputation. Results using half the MDL and half the RL result in the same value 0.299 for BCa and 0.301 for t. The UCL based on the rROS method is recommended for use for the UCL. The K-M method is not used because there is a single detection limit of 0.05 and 9/43 concentrations were censored.

D-5 Upgradient Surface Water UTL-95/90 for Manganese

This section describes the calculation of an upper tolerance level (UTL) for manganese in surface water, where the UTL is defined as the 95% confidence limit on the 90th percentile (UTL-95/90). The UTL is estimated using data from five locations upgradient of the Plant Site Area with measurements based on total (i.e., unfiltered) samples: AR-5, AR-12, SW-03, SW-55, and SW-75. Three additional upgradient locations exist, but they are not used to inform the UTL because they have only dissolved (i.e., filtered) samples available (SW-91, SW-02A, and SW-60). Table D-5.1 presents a summary of the data available for each of the five locations, and concentrations are plotted over time by location in Figure D-5.1. The two largest concentrations come from the October, 2015 sampling date (11.6 mg/L at AR-5 and 5.08 mg/L at AR-12). All other concentrations are below 3 mg/L, and there are no non-detects.

Table D-5.1 Summary of surface water data for manganese (Mn) used to estimate the UTL-95/90. There are no non-detects, and units are mg/L. SW-75 has three sampling dates with two measurements each; summaries are presented using all 10 samples and using 7 (assuming samples from the same date are a field duplicate pair).

Location	# Samp	# Dates	Years with Sampling Dates (# of dates)	Min (mg/L)	Median (mg/L)	Avg (mg/L)	Max (mg/L)
SW-03	4	4	1977	0.180	0.945	1.050	2.13
SW-55	11	11	2000 (1), 2012 (3), 2013 (2), 2014 (5)	0.0706	0.450	0.658	2.10
SW-75	10	7	2000 (1*), 2001 (2*), 2003 (1*), 2014 (3)	0.028	0.527 (0.344)*	0.700 (0.666)*	1.98
AR-5	5	5	2007 (1), 2014 (2), 2015 (2)	0.059	0.146	2.441	11.6
AR-12	5	5	2007(1), 2014 (2), 2015 (2)	0.078	0.198	1.561	5.08

*A date in that year has two samples and summary uses the maximum of two measurements collected on the same day

Previous work in calculating background screening levels (BSLs) for manganese in upstream surface water is described in an initial report before revisions (Neptune, 2016) and in a final report after revisions (Neptune, 2017). The BSLs are represented statistically as the 95th upper confidence limit on the 90th percentile, referred to as a 95/90 upper tolerance limit (UTL-95/90), and the methods used to estimate the UTL-95/90 are described in Section 5.0 of Neptune (2017). Use of the UTL-95/90 for the BSLs for Colstrip is consistent with the methodology used by Montana DEQ to calculate background threshold values (BTVs) for inorganic constituents in Montana surface soils (MDEQ, 2013).

Section 2.2 of Neptune (2017) describes the development of the surface water data set of upstream locations to inform BSLs. The BSL for manganese reported in Neptune (2016) differs from that reported in Neptune (2017) because they are based on slightly different data. The 2016 BSL does not include 2015 AR-12 samples, and does include some dissolved fraction samples that were later identified as such and removed from the data used for the 2017 BSL (see Table D-5.2 for summaries of the data and the reported BSLs). The 2016 BSL was based on four upstream locations: AR-12, SW-55, SW-75, and SW-60 (dissolved only), and the 2017 BSL excluded SW-60. The upgradient UTL-95/90 estimated and presented within is based on data from five locations: the three upstream surface water samples used to calculate the 2017 upstream BSL (AR-12, SW-55, and SW-75), plus two additional sample locations (SW-03 located upstream near AR-12, as well as AR-5 located just downstream of AR-12, but upgradient of the Plant Site itself). Please see Figure 13 of main report for a figure depicting the sample locations. AR-5 has samples taken at the same five dates as AR-12, and is the location of the observed maximum concentration. SW-03 has four samples taken at four different dates in 1977.

SW-75 has 10 total samples, but only 7 unique sampling dates (as described in Table D-5.1). The samples are not labeled as field duplicates within the dataset obtained by Neptune, but the concentrations are close together relative to concentrations from other dates and locations (see Figure D-5.1). For this analysis, they are treated as duplicates and only the maximum of each pair is used, as required by MT DEQ for field duplicates. Summaries and results are presented for both in Table D-5.1 and Table D-5.2.

The upgradient UTL-95/90 for manganese described in this report is estimated using the same bootstrap method used to obtain BSLs for surface water in the original BSLs report (Neptune, 2017). Bootstrapping uses only the information available in the data without additional distributional assumptions (Efron 1993). A single bootstrap dataset is created by taking values at random from the dataset until the sample size of the data is reached (e.g. draw 32 numbers from the data with replacement). To obtain a bootstrap-based UTL-95/90, 10,000 bootstrap datasets are created and the 90th percentile is calculated for each one. This creates a distribution of bootstrap 90th percentiles that are deemed possible based on the observed data, and this approximates the sampling distribution of the sample 90th percentile. The 95% upper confidence limit is then obtained by calculating the 95th percentile of the bootstrap distribution of the 90th percentile, thus resulting in an estimated UTL-95/90.

The estimated UTL-95/90 for manganese in surface water based on the five upgradient locations presented is 5.08 mg/L (boldface row 1 of Table D-5.2). The UTL-95/90 based on the bootstrap method does not change if the observations from SW-75 considered field duplicates are also used. In general, the UTL-95/90 is, in this case, robust to the method used to estimate it, with distribution-based methods also providing estimates near 5 mg/L. Neptune (2016) provided an associated UTL-95/90 of 1.6 mg/L, which was used for the Plant Site CCRA because the 2017 revised report was not yet available. The revised 2017 UTL-95/90 was 3.68 mg/L. Table D-5.2 presents a summary of the data used for the UTL-95/90 calculations described here, as well as a summary of the 2016 and 2017 BSLs for future reference.

As noted in Neptune (2017), the only appropriate use of UTLs is for comparison to individual measurements from single locations and sampling occasions; they should not be used in comparisons to other statistics calculated from Site data, such as estimated mean concentrations or upper confidence limits (UCLs) on mean concentrations. They should also not be used as a surrogate for statistical comparisons of Site and background conditions.

Table D-5.2 Summary statistics and estimated UTL-95/90s for manganese in surface water. The first row, in boldface, is based on five upgradient locations and is the recommended UTL-95/90. The additional rows display summaries and UTLs for other data sets that have been, or could be used, for the sake of comparison and to provide a record of the comparisons. The samples used for the Neptune (2016) result include 15 non-detects from dissolved concentrations with detection limits ranging from 0.005 to 0.20 mg/L.

Data Used	# Locs	# Dates	Total # Samples	Min	Med	Avg	Max	90th percentile	UTL – 95/90
All locations, no SW-75 duplicate dates	**5**	**27**	**32**	**0.028**	**0.347**	**1.128**	**11.60**	**2.127**	**5.08**
All locations, all SW-75 samples	5	27	35	0.028	0.350	1.098	11.60	2.118	5.08
Neptune (2016) (upstream data through 2014, includes dissolved)	4	40	73	0.005	0.165	0.385	2.6	1.156	1.60
Neptune (2017) (upstream data through 2015, only total)	3	23	26	0.028	0.400	0.8477	5.08	2.04	3.68

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Figures

D-2 Figures: Surface water

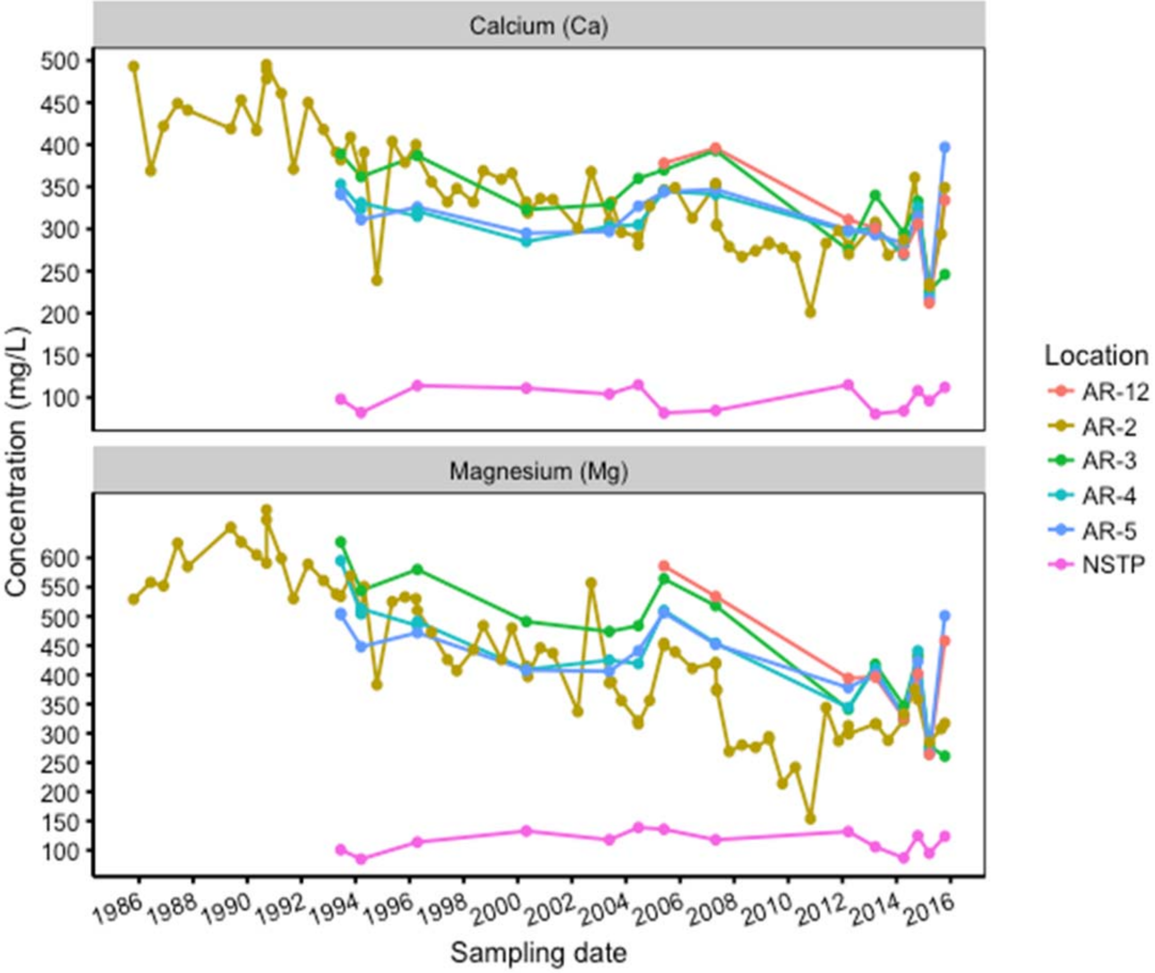


Figure D-2.1 Dissolved concentrations (mg/L) over time for all data available for the ecological preliminary COPCs of calcium (Ca) and magnesium (Mg) from locations AR-2, AR-3, AR-4; AR-5 and AR-12 (upgradient locations); and North Sewage Treatment Pond (NSTP). Only 2014 and 2015 data from AR-2, AR-3, and AR-4 are used in estimation of EPCs. Calcium and magnesium are only COPCs for ecological health.

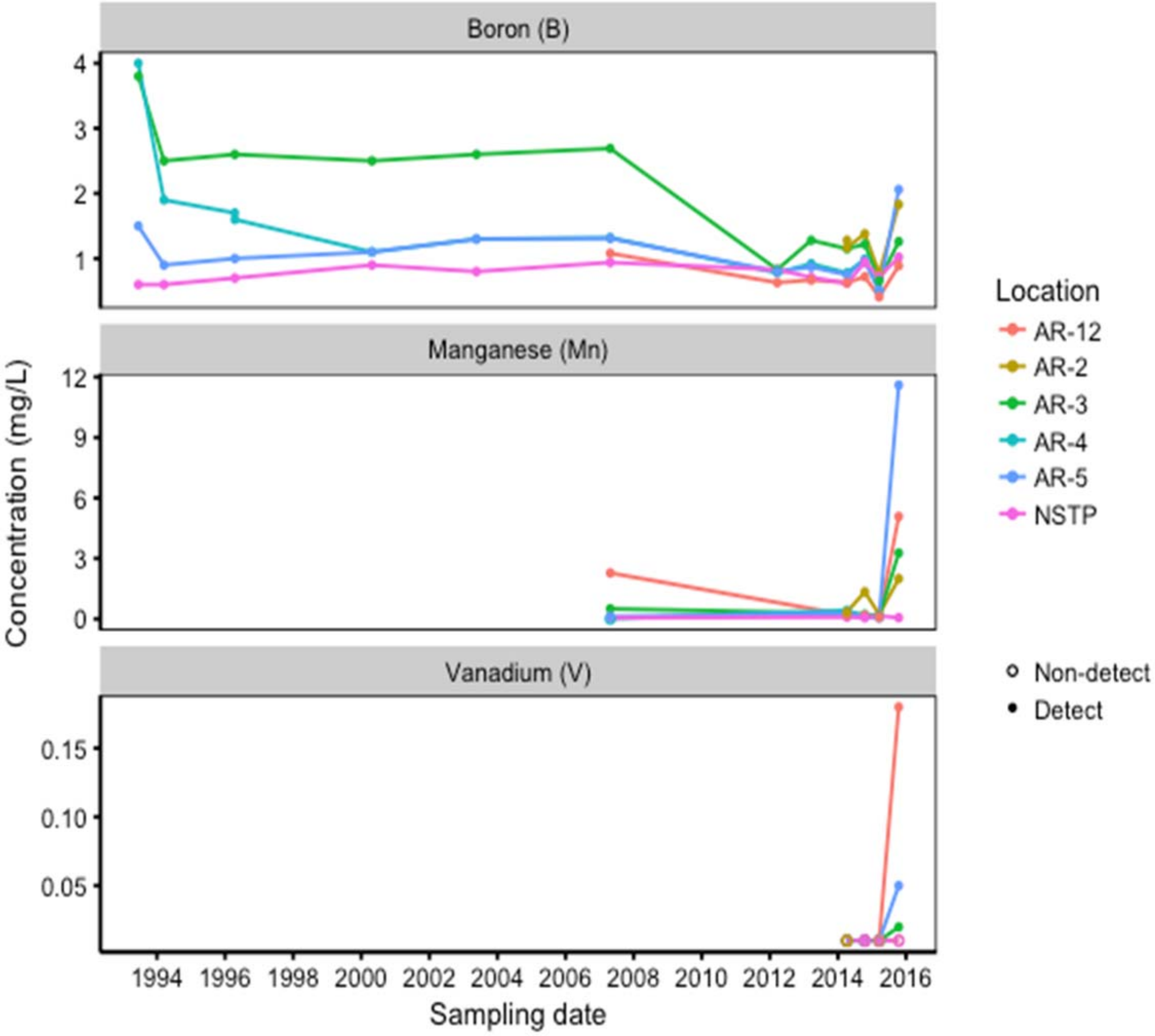


Figure D-2.2 Concentrations (mg/L) over time for all data available for boron (B), manganese (Mn), and vanadium (V) from locations AR-2, AR-3, AR-4, AR-5 (primary background point), AR-12 (primary background point), and North Sewage Treatment Pond (NSTP). Only 2014 and 2015 data from AR-2, AR-3, and AR-4 are used in estimating EPCs. Manganese is the only preliminary COPC for human health.

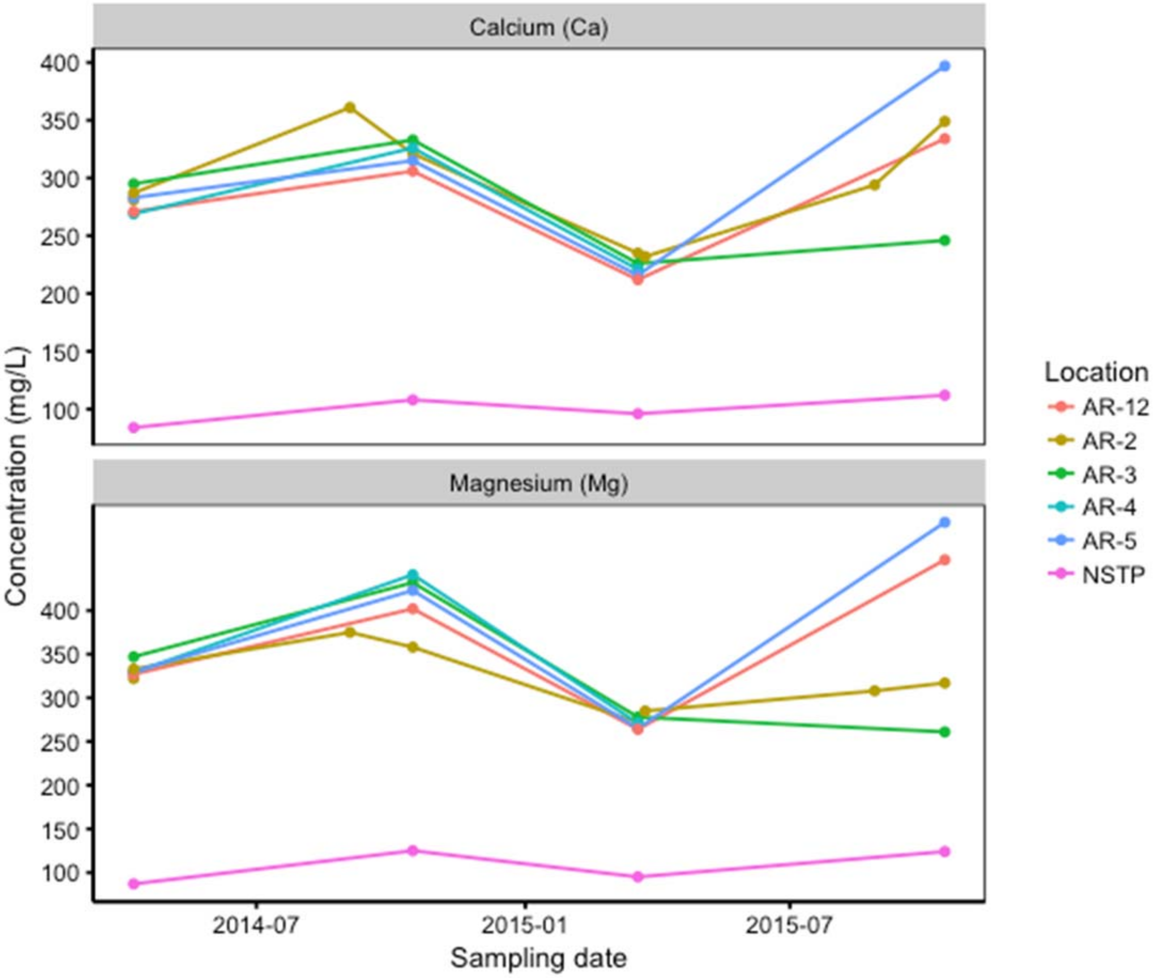


Figure D-2.3 Concentrations (mg/L) over time for all data available for ecological COPCs of calcium (Ca) and magnesium (Mg). Only the data from AR-2, AR-3, and AR-4 are used in estimation of EPCs.

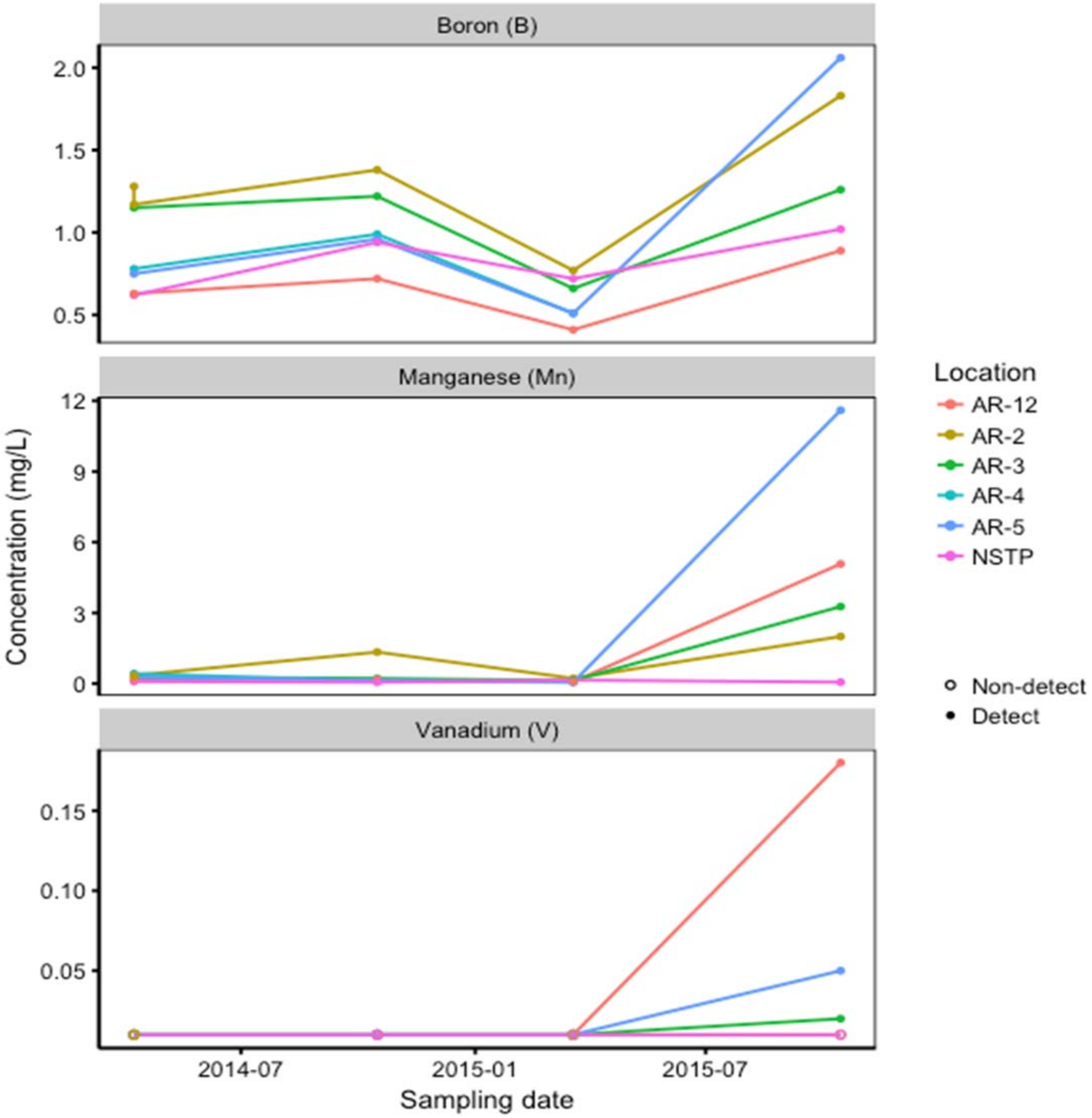


Figure D-2.4 Concentrations (mg/L) over time for all data available for metals boron (B), manganese (Mn), and vanadium (V). Only the data from AR-2, AR-3, and AR-4 are used in estimation of EPCs, and manganese is the only COPC for human health.

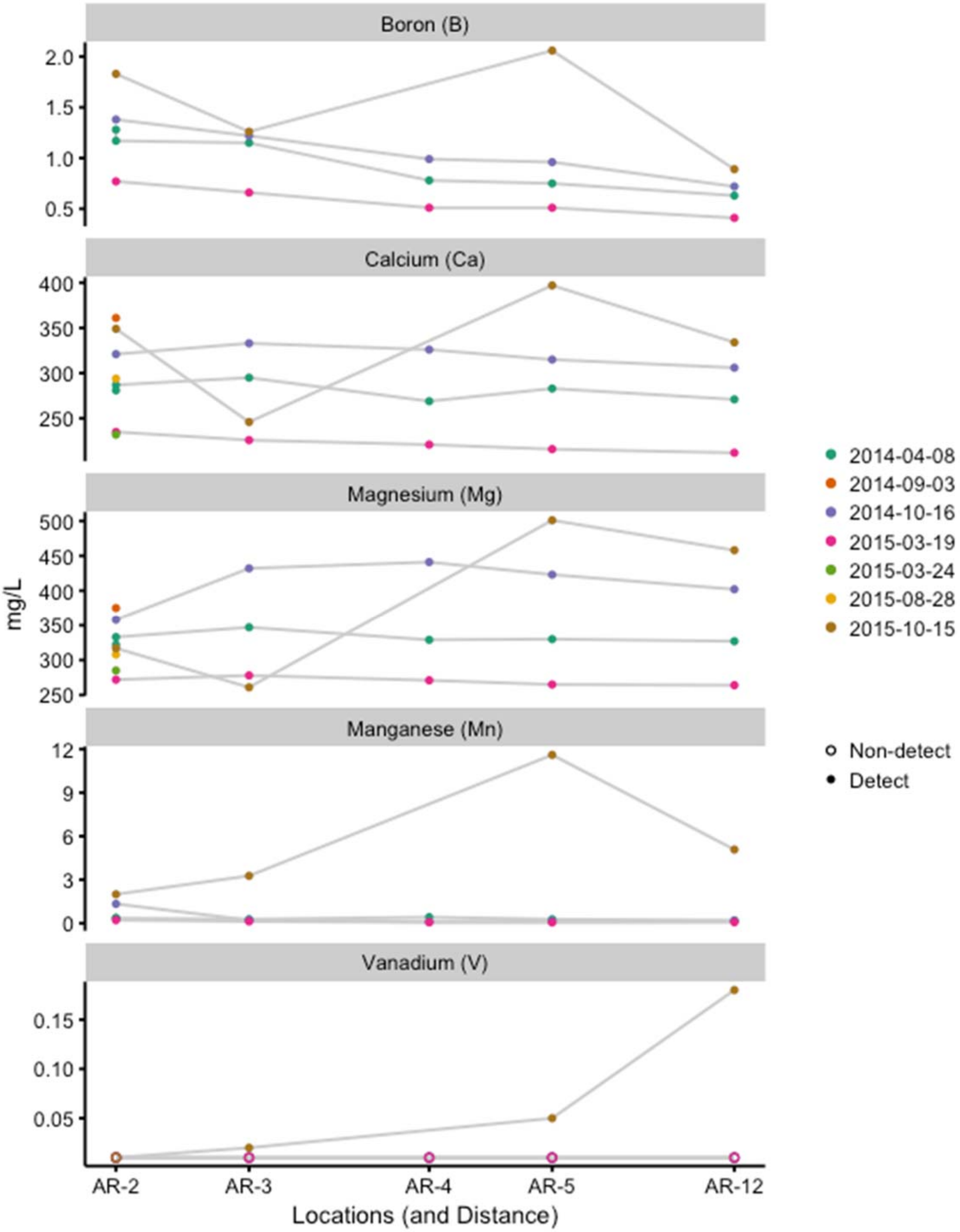


Figure D-2.5 Concentrations (mg/L) across locations for each analyte and each sampling date (concentrations for Ca and Mg are dissolved). The placement of sampling locations along the horizontal axis corresponds to the straight-line distance from AR-2 (moving upstream). AR-5 and AR-12 are upgradient and not included in UCL calculations.

D-3 Figures: Sediment

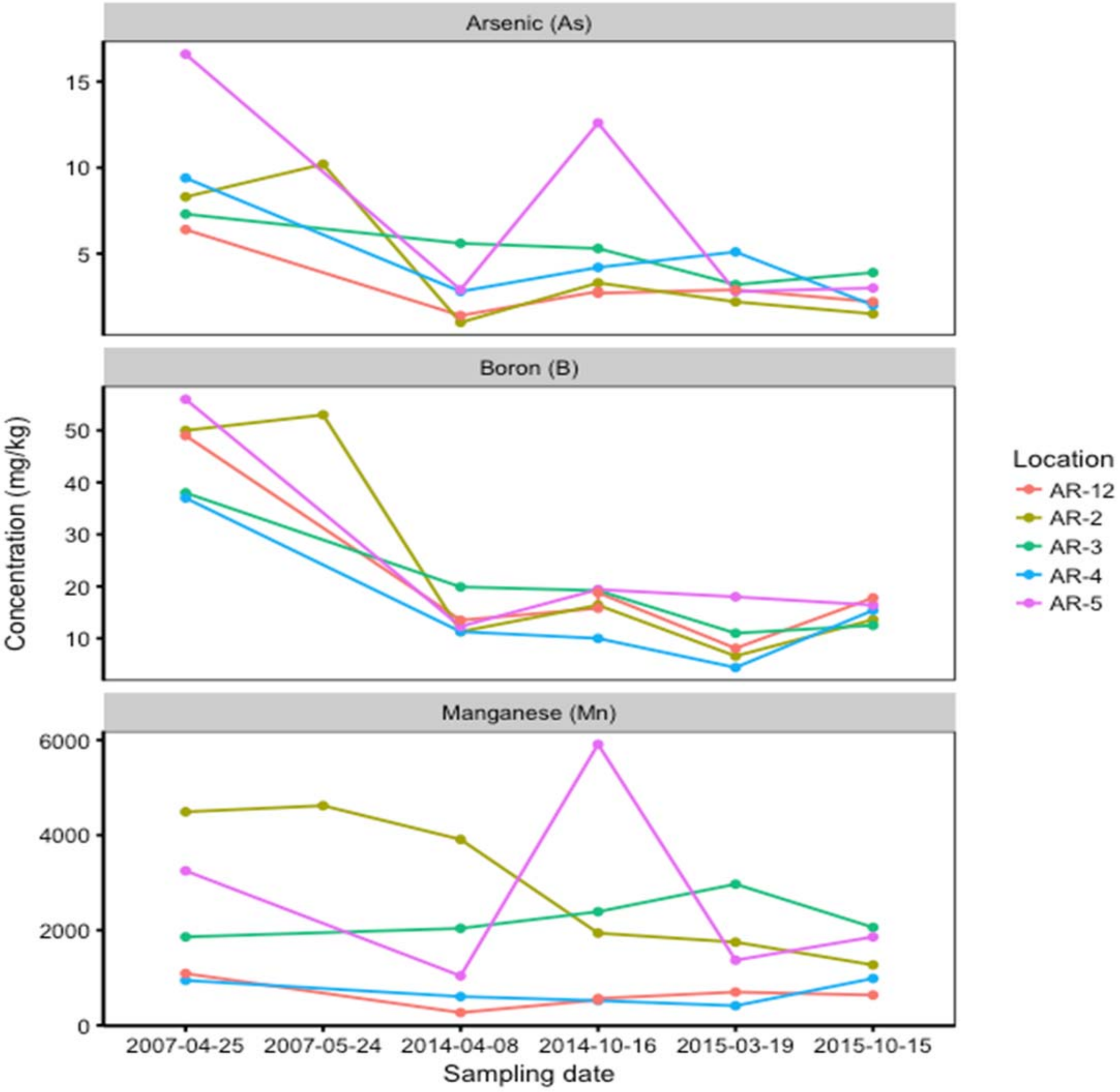


Figure D-3.1 Concentrations (mg/kg) over time for sampling occasions available by location (lines and colors) and by analyte (panels). AR-5 and AR-12 are included for comparison as the upgradient primary background points.

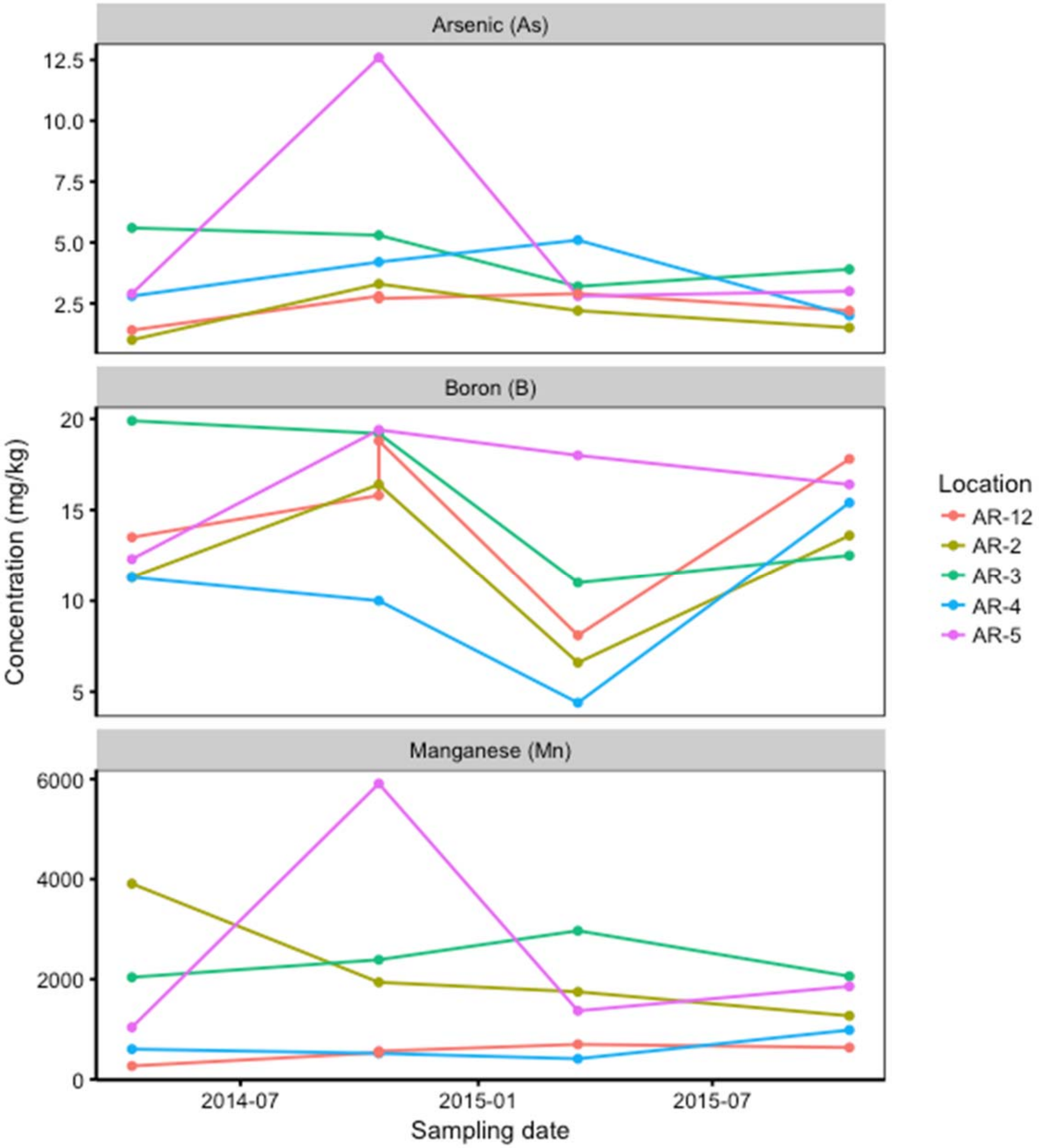


Figure D-3.2 Concentrations (mg/kg) over time for 2014 and 2015 by location (lines and colors) and metal (panels). AR-5 and AR-12 are included for comparison as upgradient primary background points.

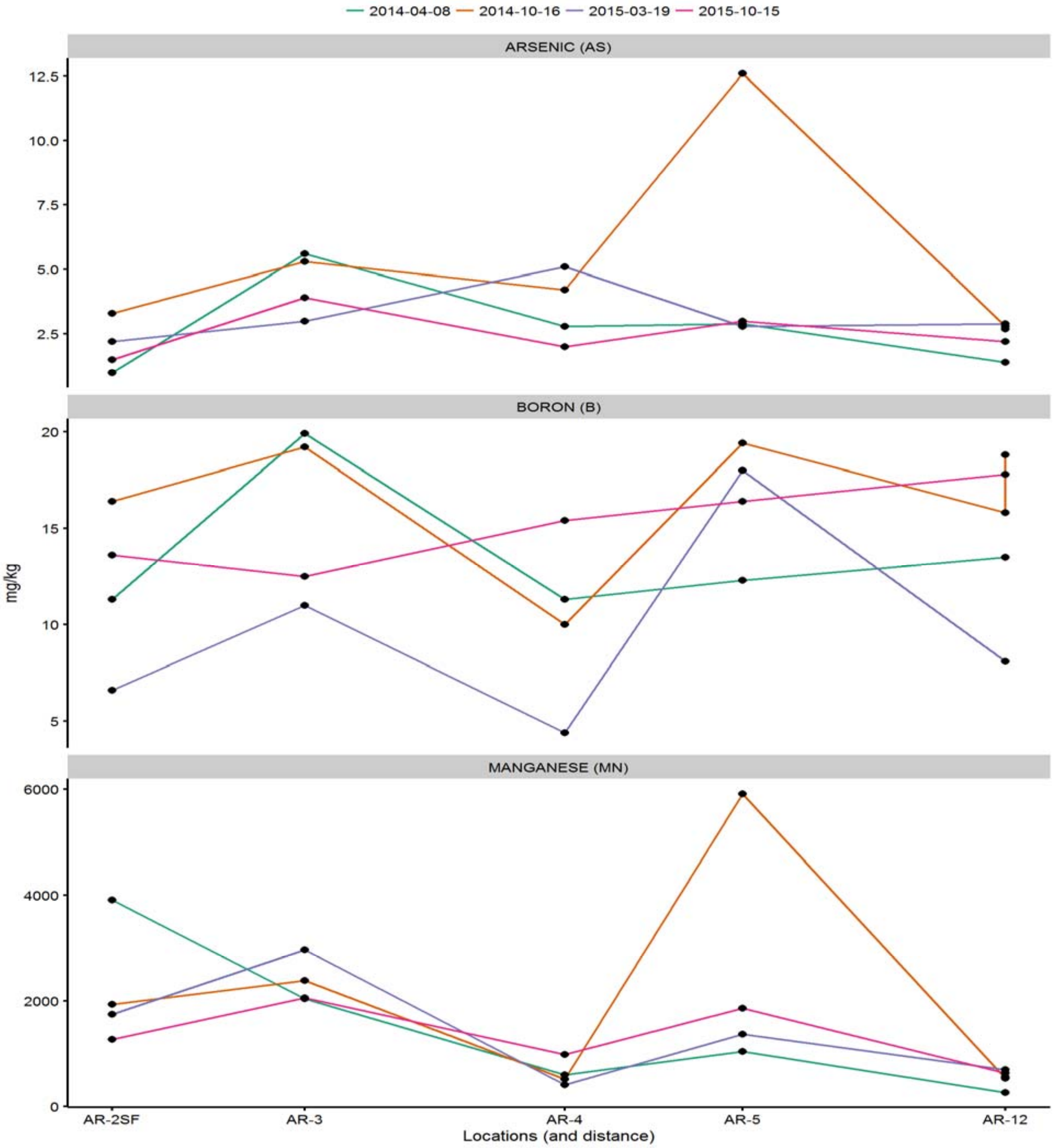
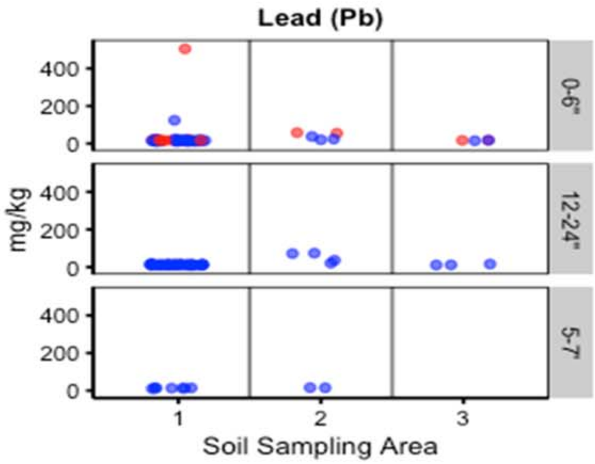
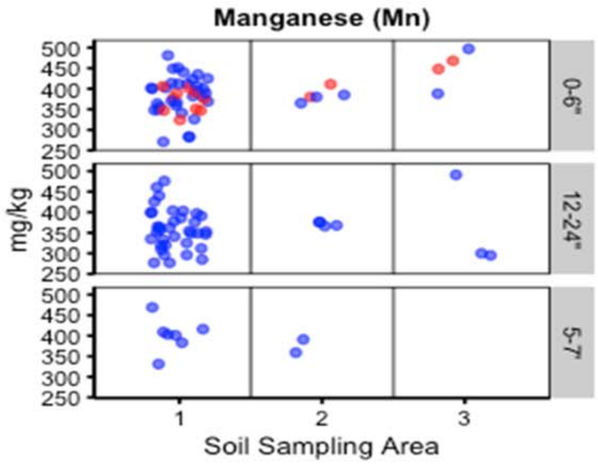
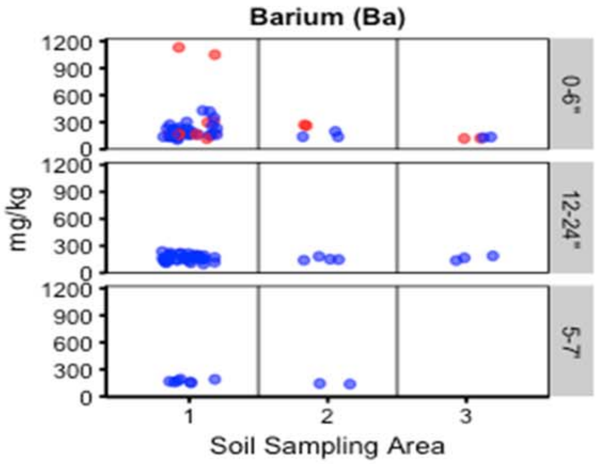


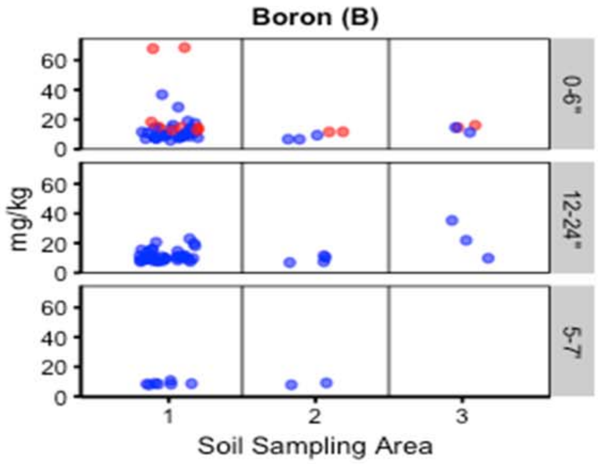
Figure D-3.3 Concentrations (mg/kg) across locations for each metal and each sampling date. The placement of sampling locations along the horizontal axis corresponds to the distance from AR-2 (moving upstream) and both AR-5 and AR-12 are considered upgradient background points.

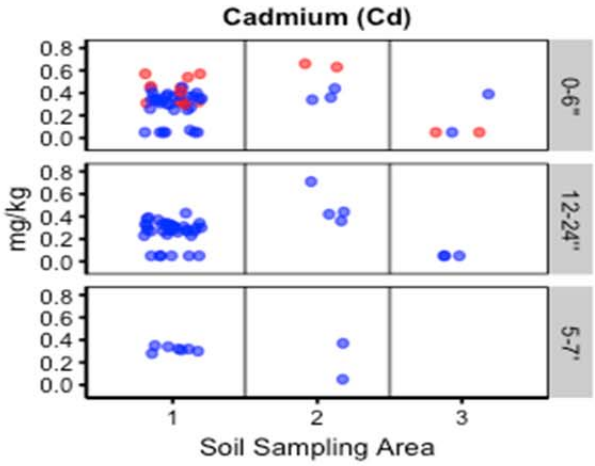
D-4 Figures: Soil


Lead (Pb)


Manganese (Mn)


Barium (Ba)


Boron (B)


Cadmium (Cd)

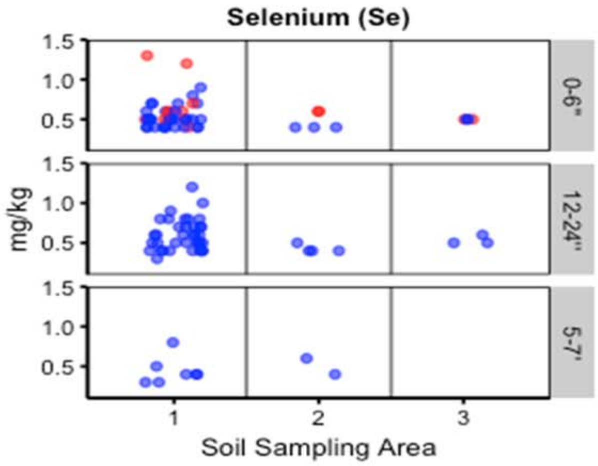

Selenium (Se)

Figure D-4.1 Concentrations (mg/kg) by soil sampling area and depth. Field duplicate pairs and laboratory re-run pairs are in red. Points are jittered horizontally within each soil sampling area.

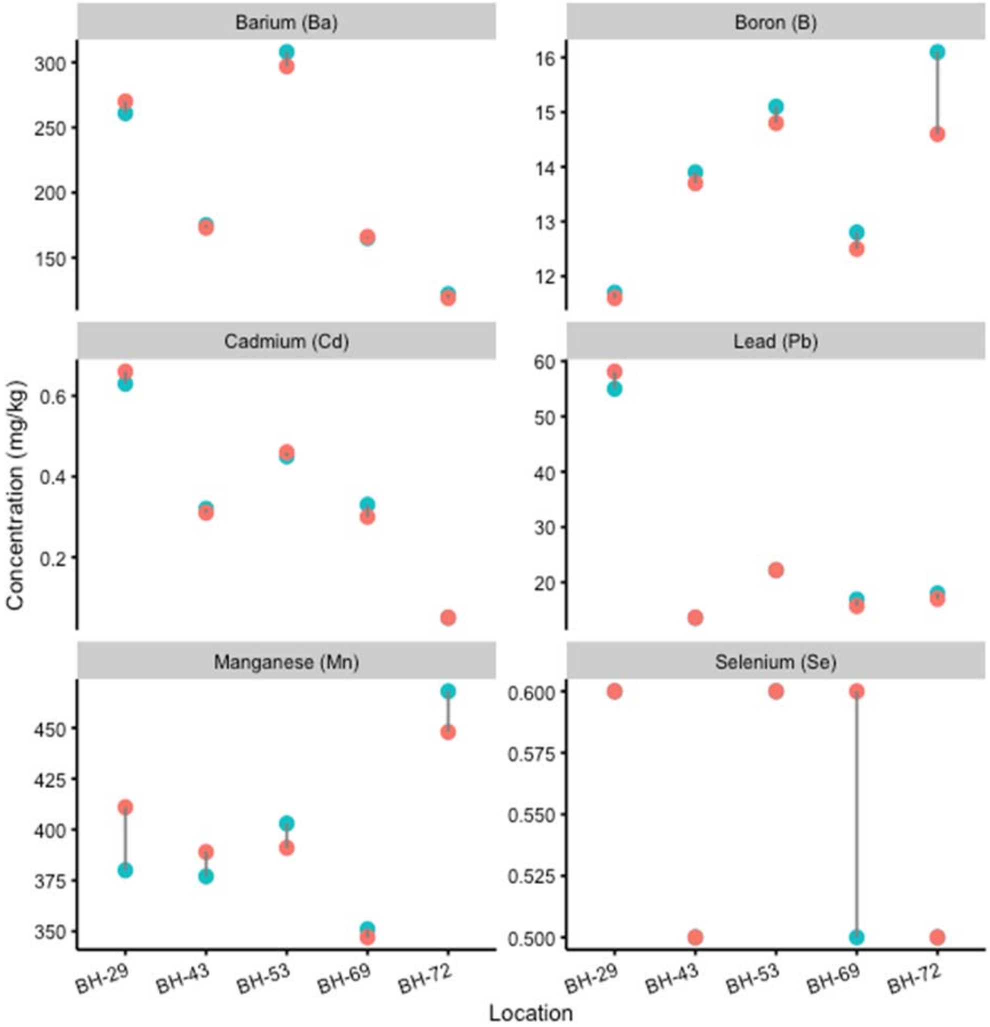


Figure D-4.2 Plots comparing concentrations (mg/kg) within field duplicate pairs for each metal by location. Locations displaying a single red point had two concentrations close enough together that the points completely overlap.

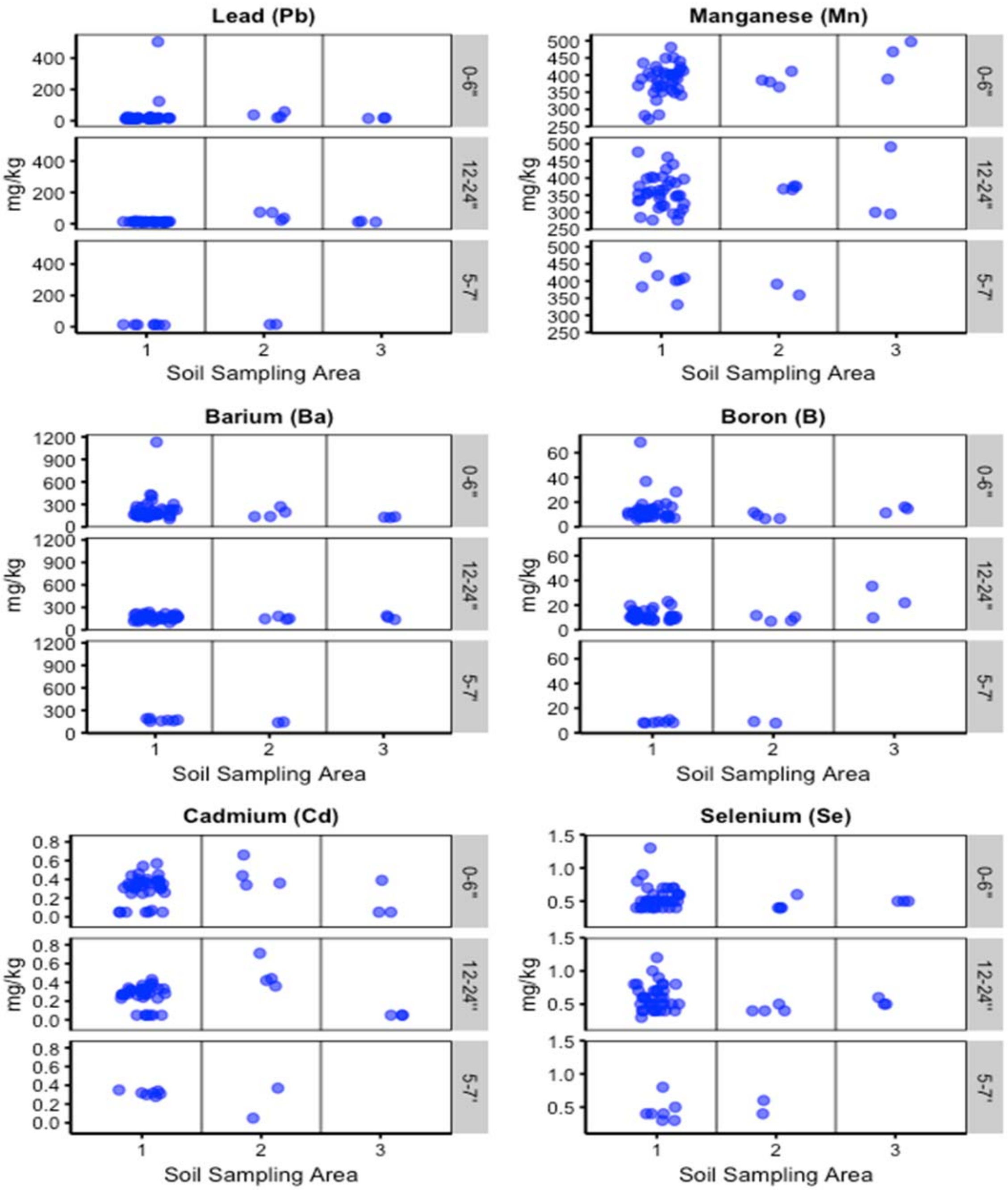


Figure D-4.3 Concentrations in mg/kg by soil sampling area and depth. Field duplicates and laboratory re-runs are plotted at the maximum concentration from the pair. Points are jittered horizontally within each soil sampling area.

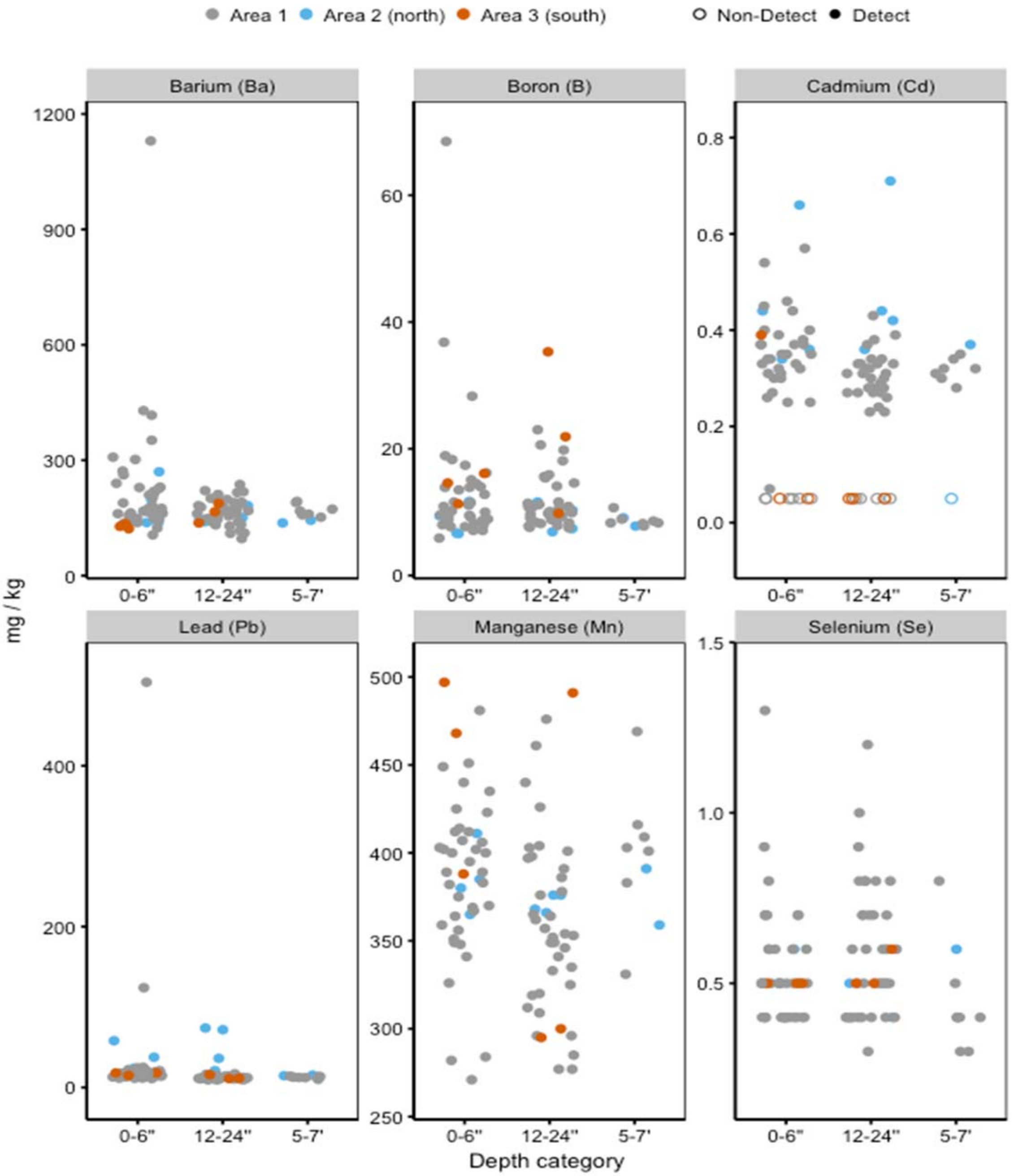


Figure D-4.4 All soil concentrations (mg/kg) available for the six metals of interest. Scales are different for the different metals. Soil sampling areas are distinguished by color of points.

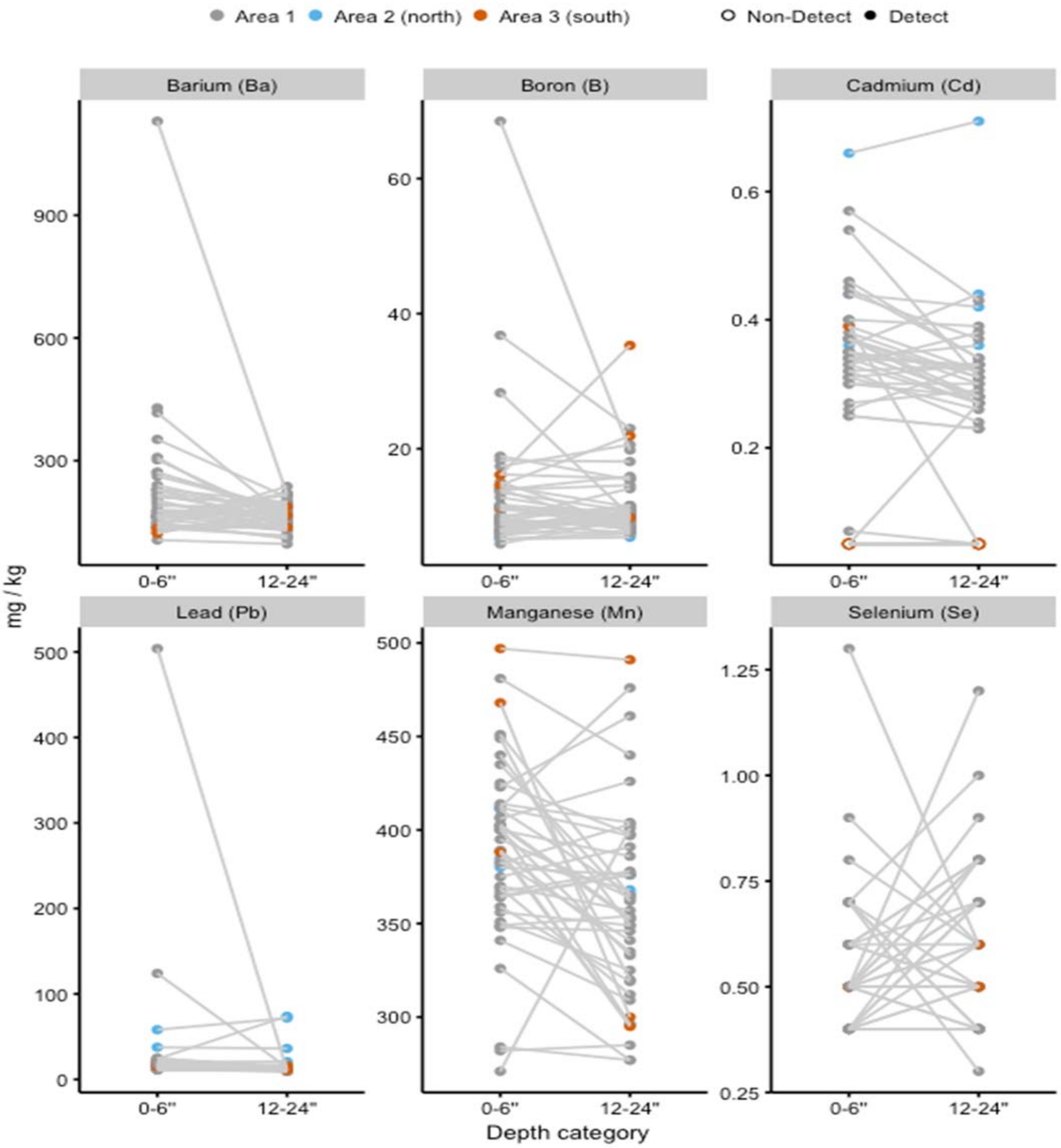


Figure D-4.5 Comparison of concentrations (mg/kg) from the 0-6'' depth interval and the 12-24'' depth interval for the same location. Scales are different for the different metals.

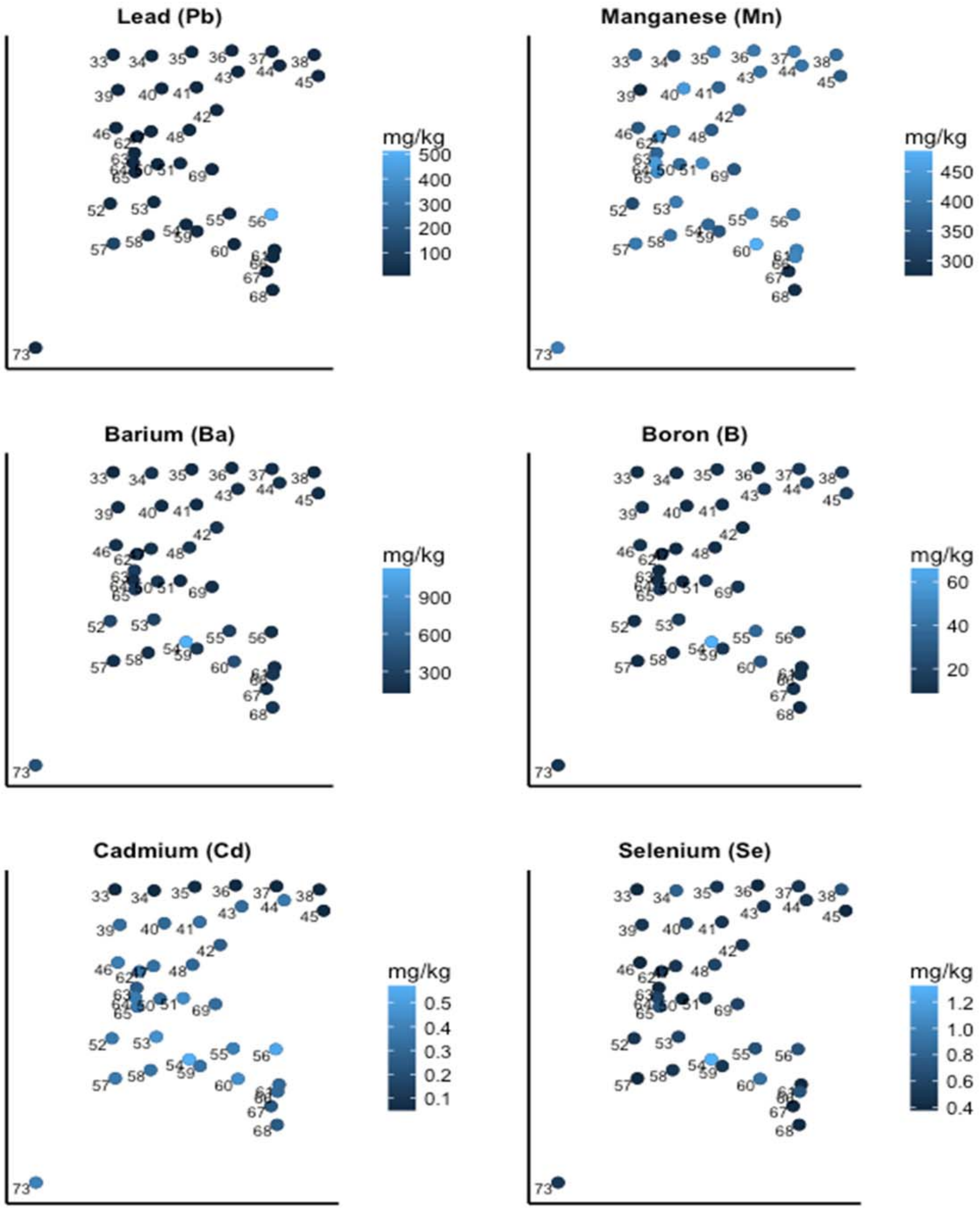
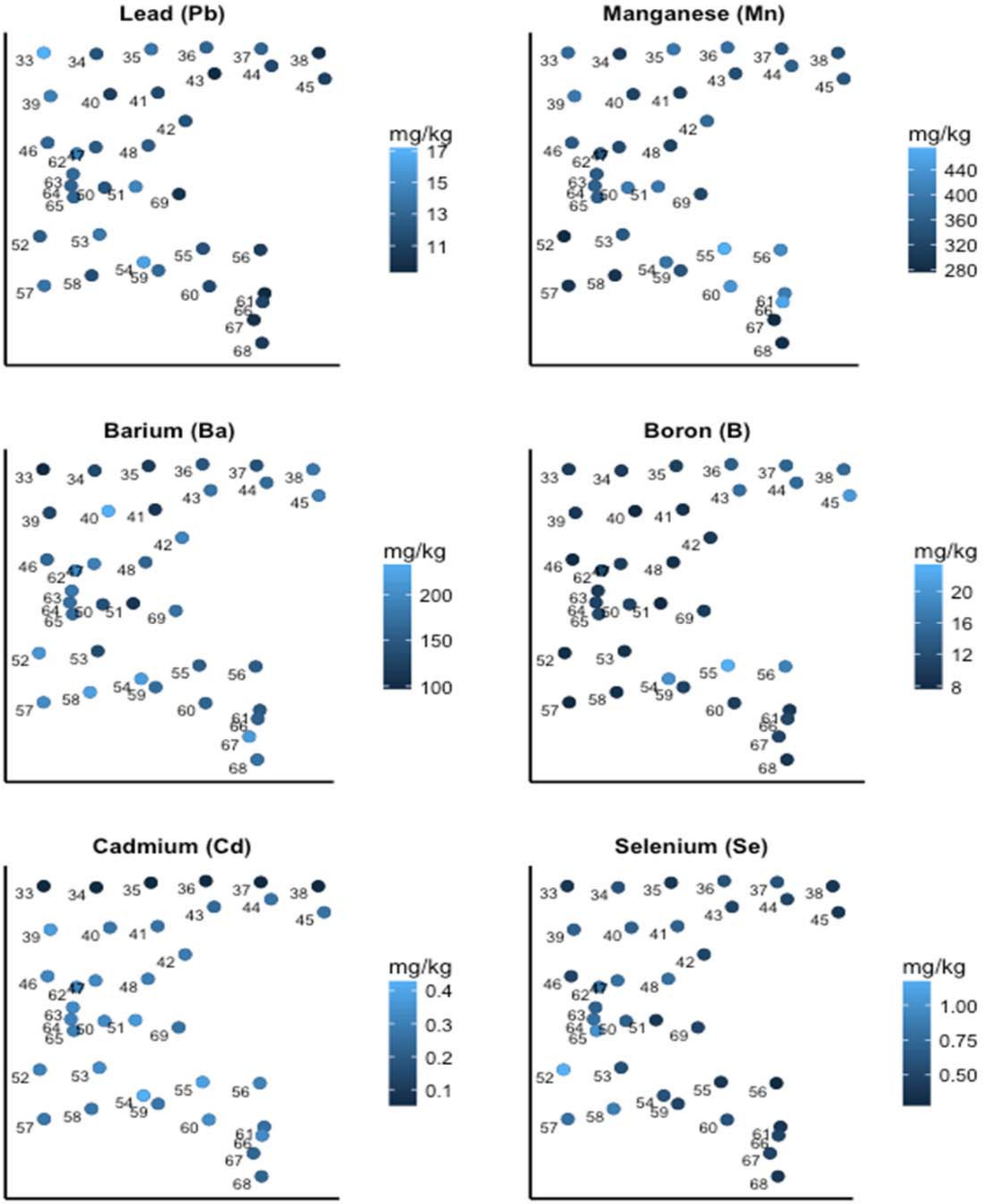


Figure D-4.6 Sampling locations in Soil Sampling Area 1 for the 0-6'' depth interval with concentrations (mg/kg) indicated by the color gradient. Scales are different for the different metals.


Lead (Pb)

Manganese (Mn)

Barium (Ba)

Boron (B)

Cadmium (Cd)

Selenium (Se)

Figure D-4.7 Sampling locations in Soil Sampling Area 1 for the 12-24'' depth interval with concentrations (mg/kg) indicated by the color gradient. Scales are different for the different metals.

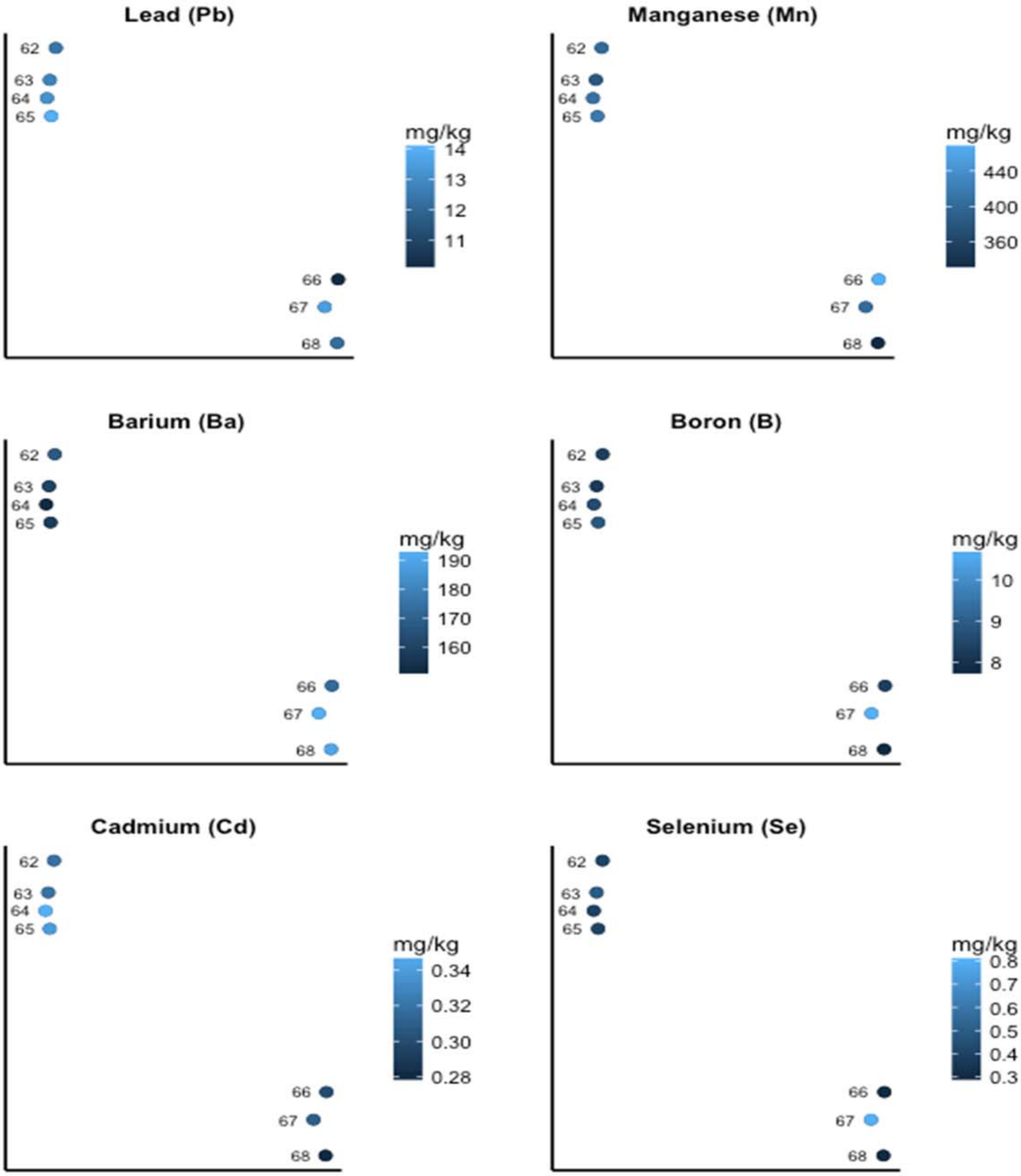


Figure D-4.8 Sampling locations for the 5-7' depth interval in Soil Sampling Area 1 with concentrations (mg/kg) indicated by the color gradient. Scales are different for the different metals.

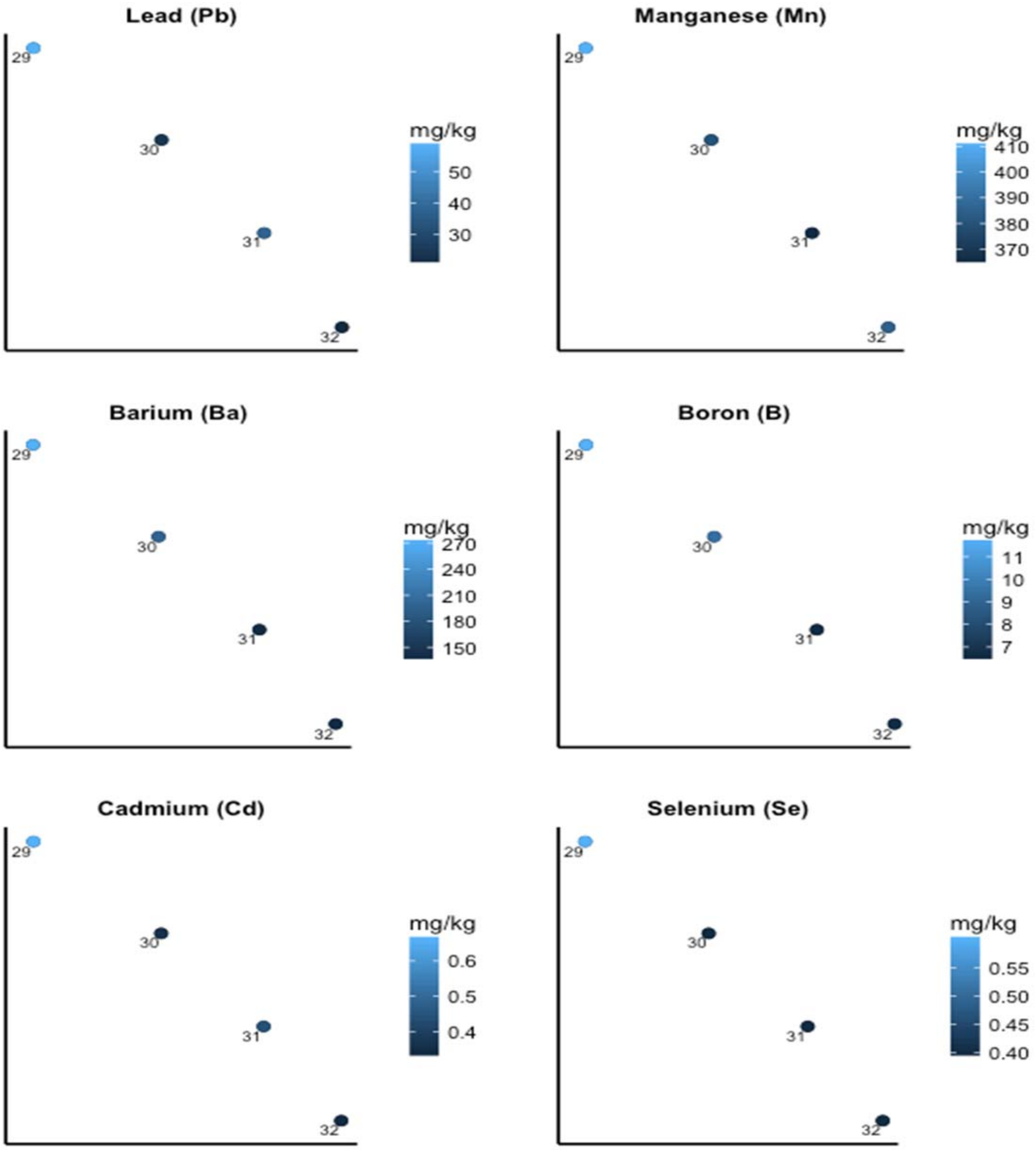


Figure D-4.9 Sampling locations in Soil Sampling Area 2 for the 0-6'' depth interval with concentrations (mg/kg) indicated by the color gradient. Scales are different for the different metals.

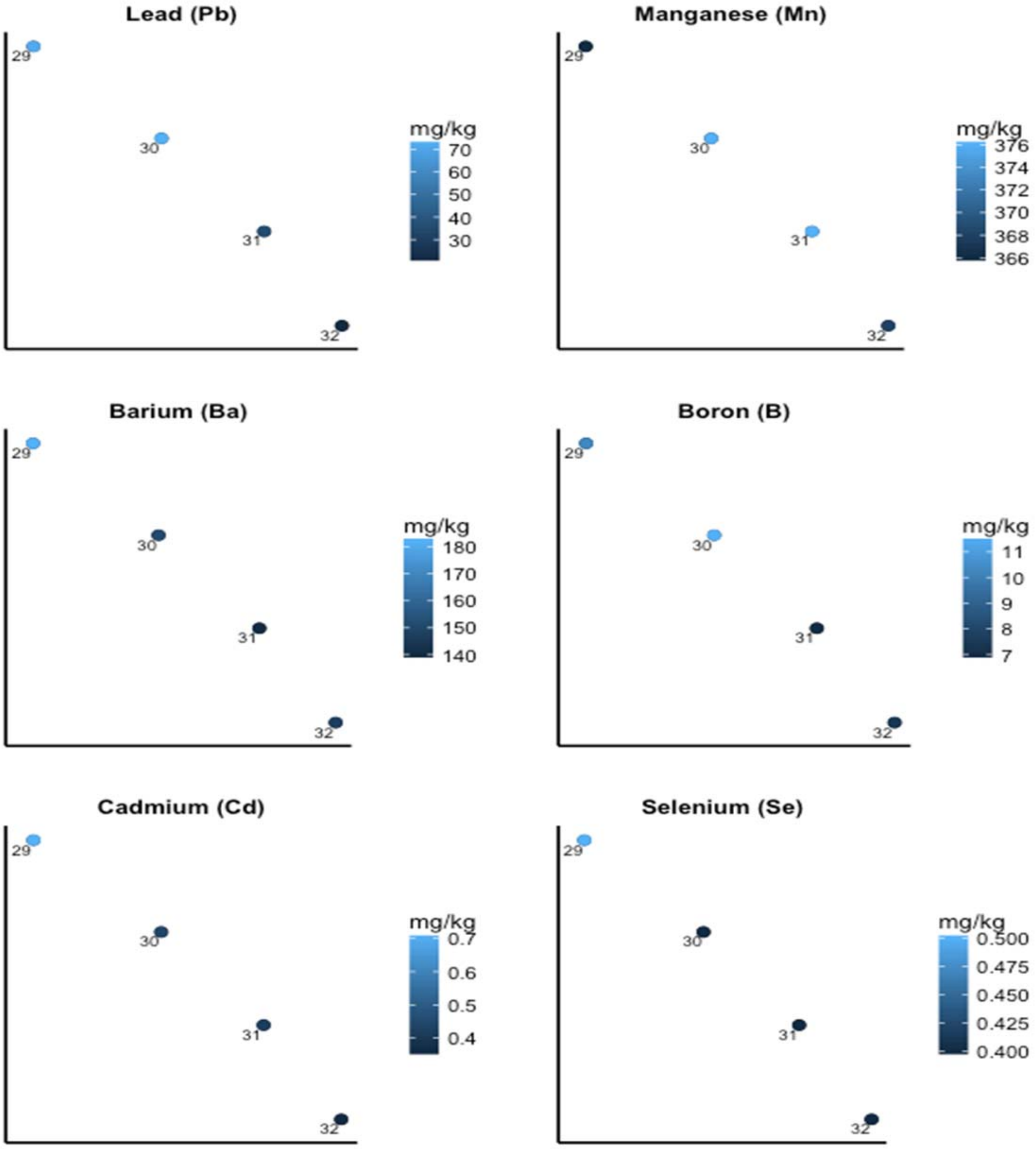


Figure D-4.10 Sampling locations in Soil Sampling Area 2 for the 12-24'' depth interval with concentrations (mg/kg) indicated by the color gradient. Scales are different for the different metals.

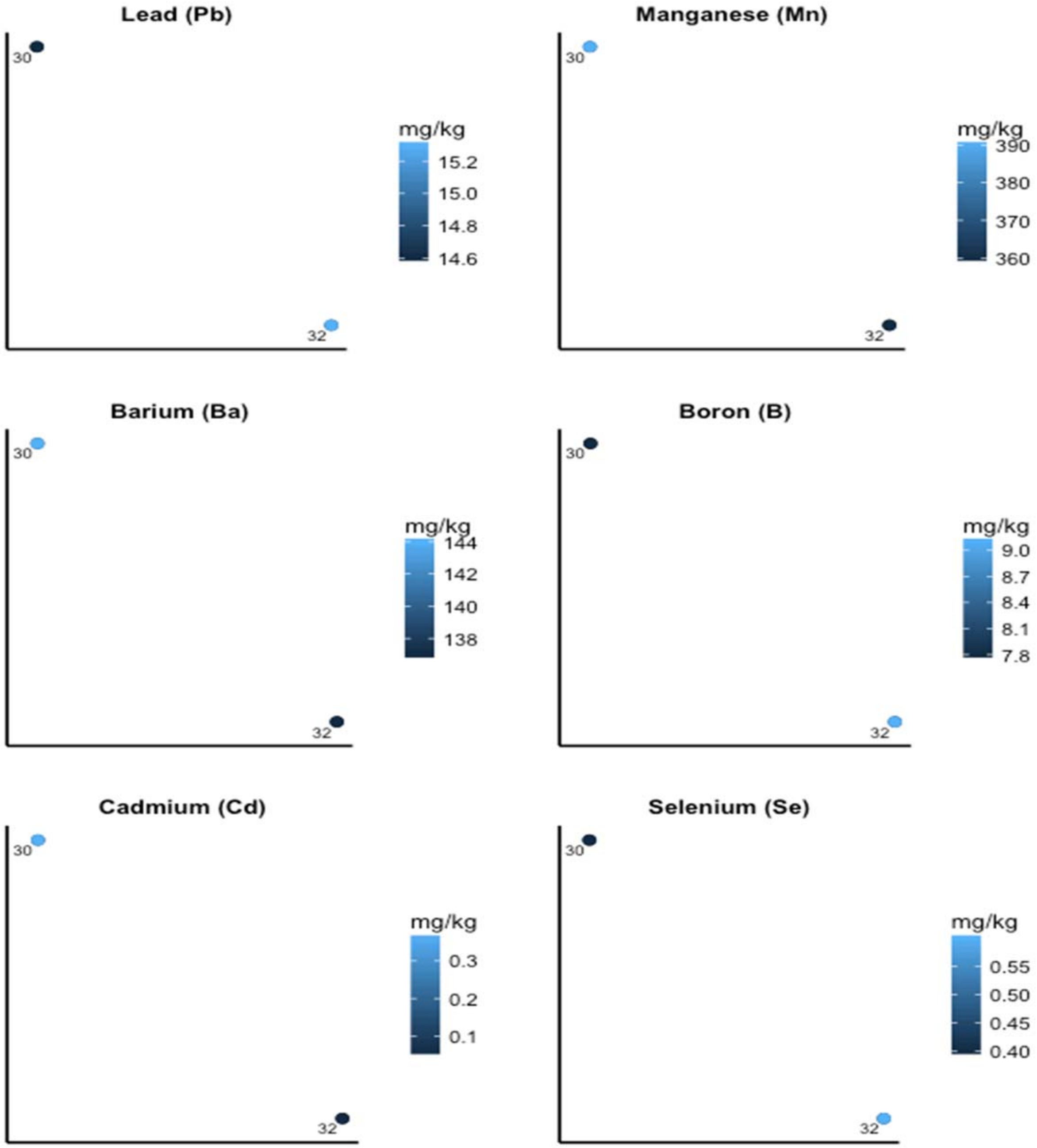


Figure D-4.11 Sampling locations in Soil Sampling Area 2 for the 5-7' depth interval with concentrations (mg/kg) indicated by the color gradient. Scales are different for the different metals.

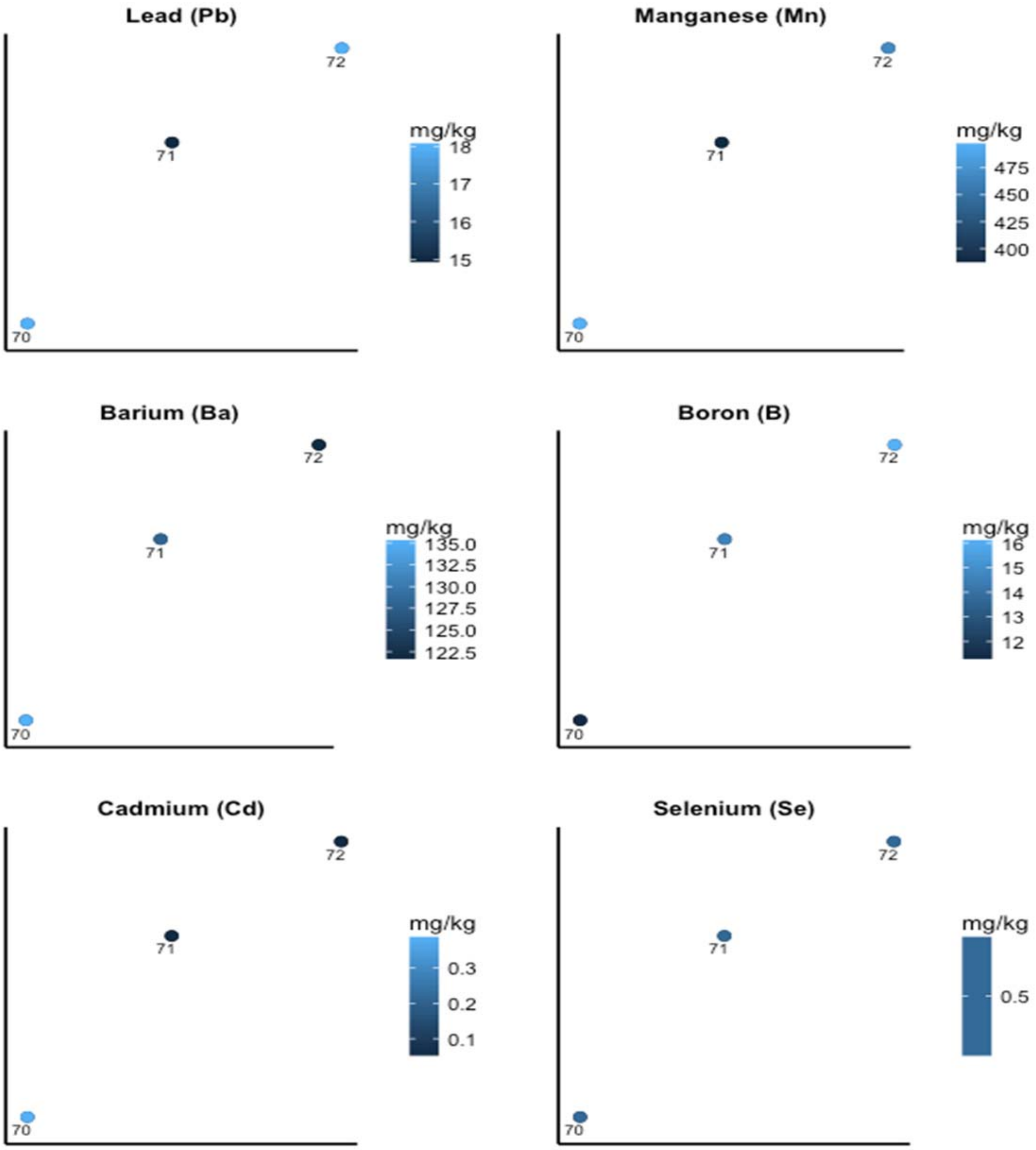


Figure D-4.12 Sampling locations in Soil Sampling Area 3 for the 0-6’’ depth interval with concentrations (mg/kg) indicated by the color gradient. Scales are different for the different metals.

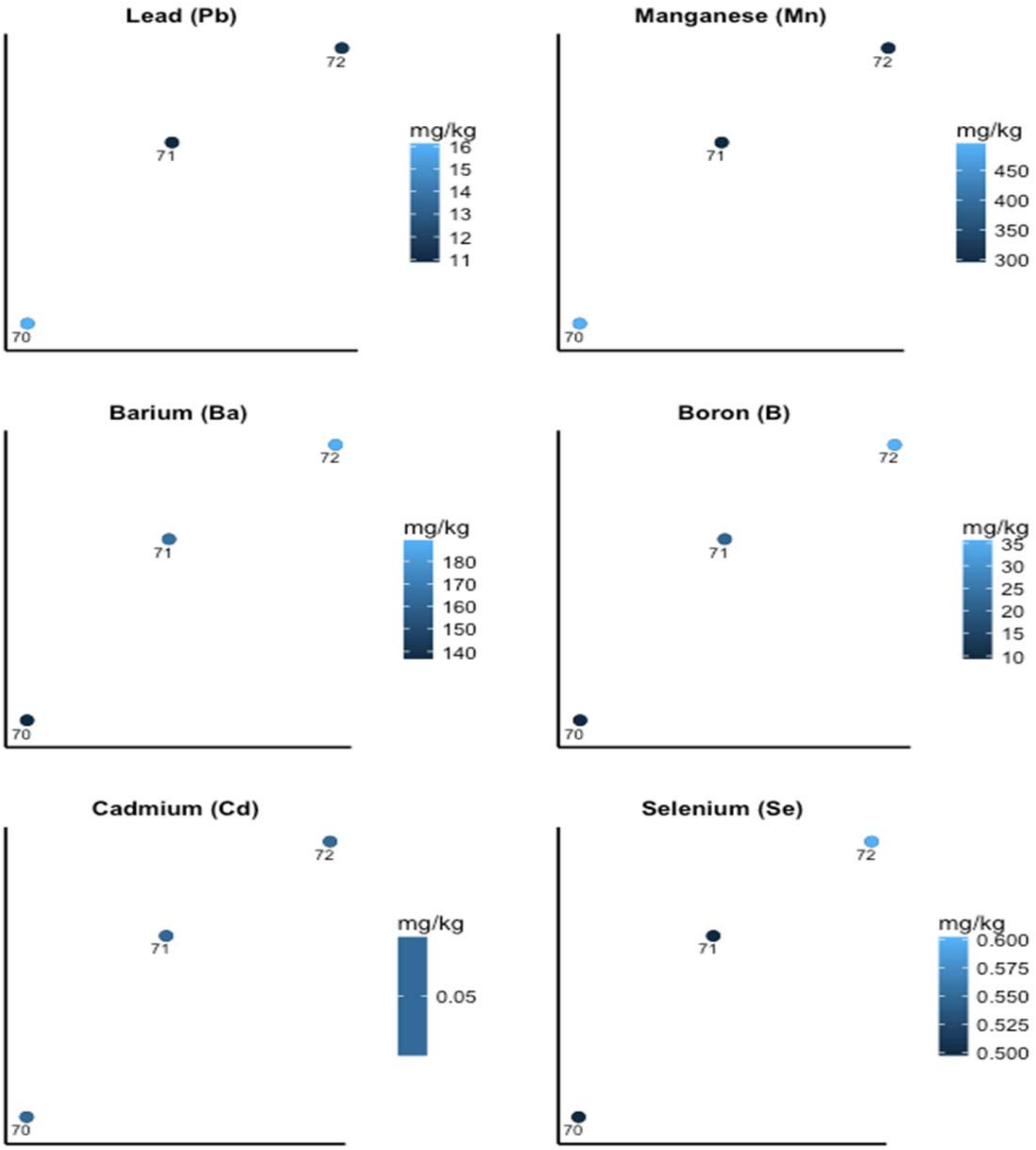


Figure D-4.13 Sampling locations in Area 3 for the 12-24'' depth interval with concentrations (mg/kg) indicated by the color gradient. Scales are different for the different metals.

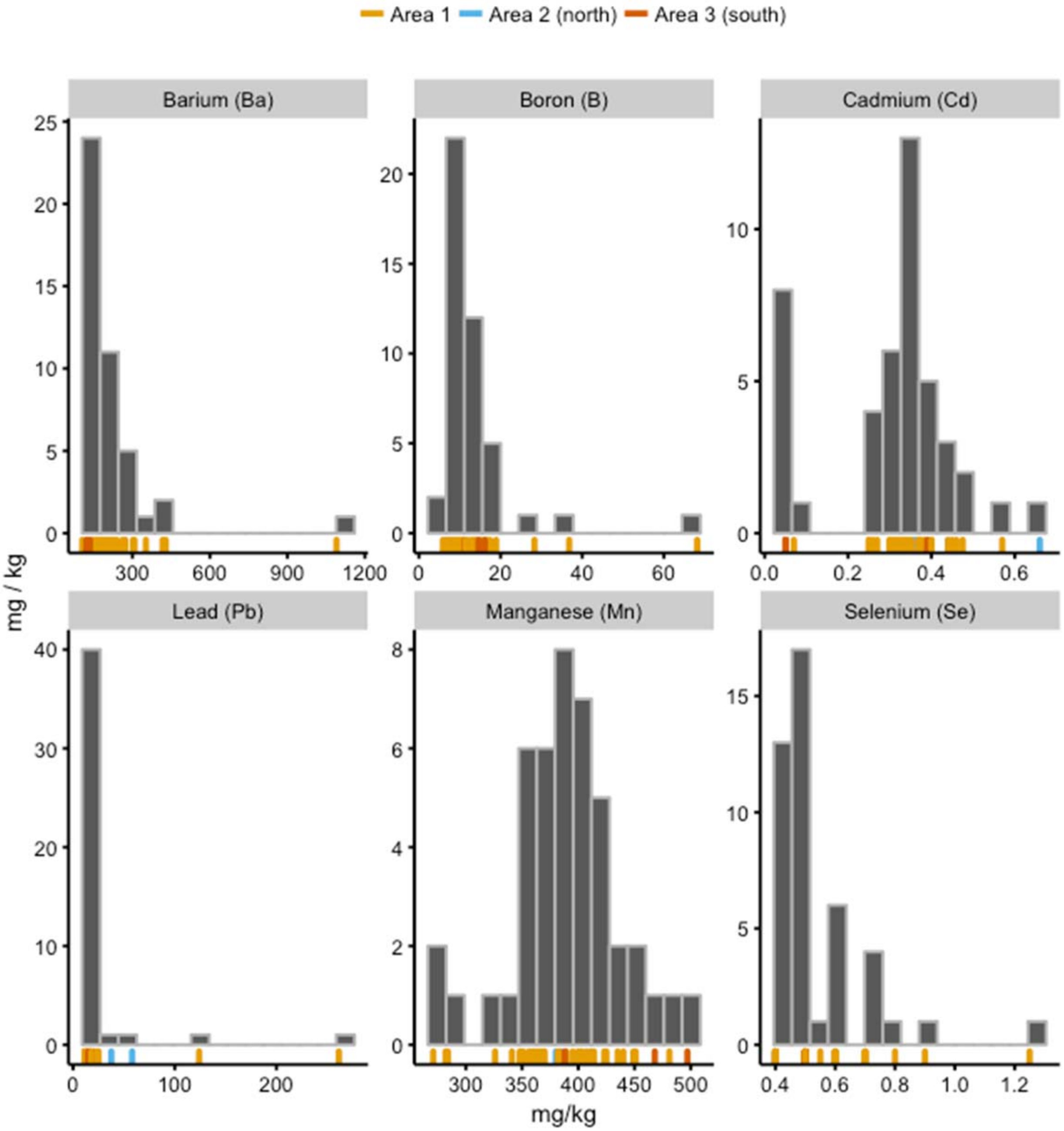


Figure D-4.14 Concentrations (mg/kg) used in UCL calculations for the 0-6'' depth interval and all soil sampling areas combined. Observations classified as "non-detects" for cadmium are plotted at the reporting limit (RL).

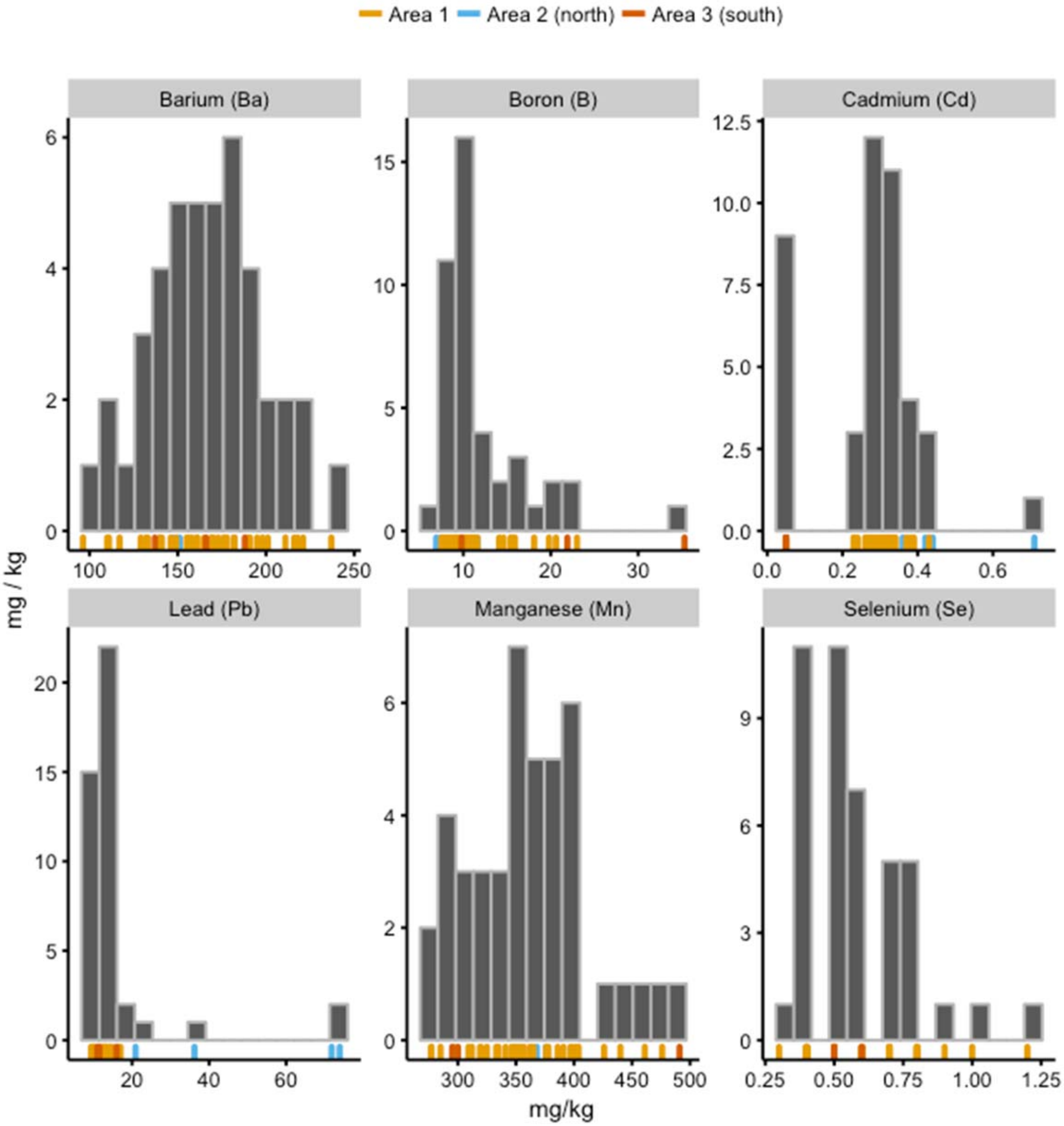
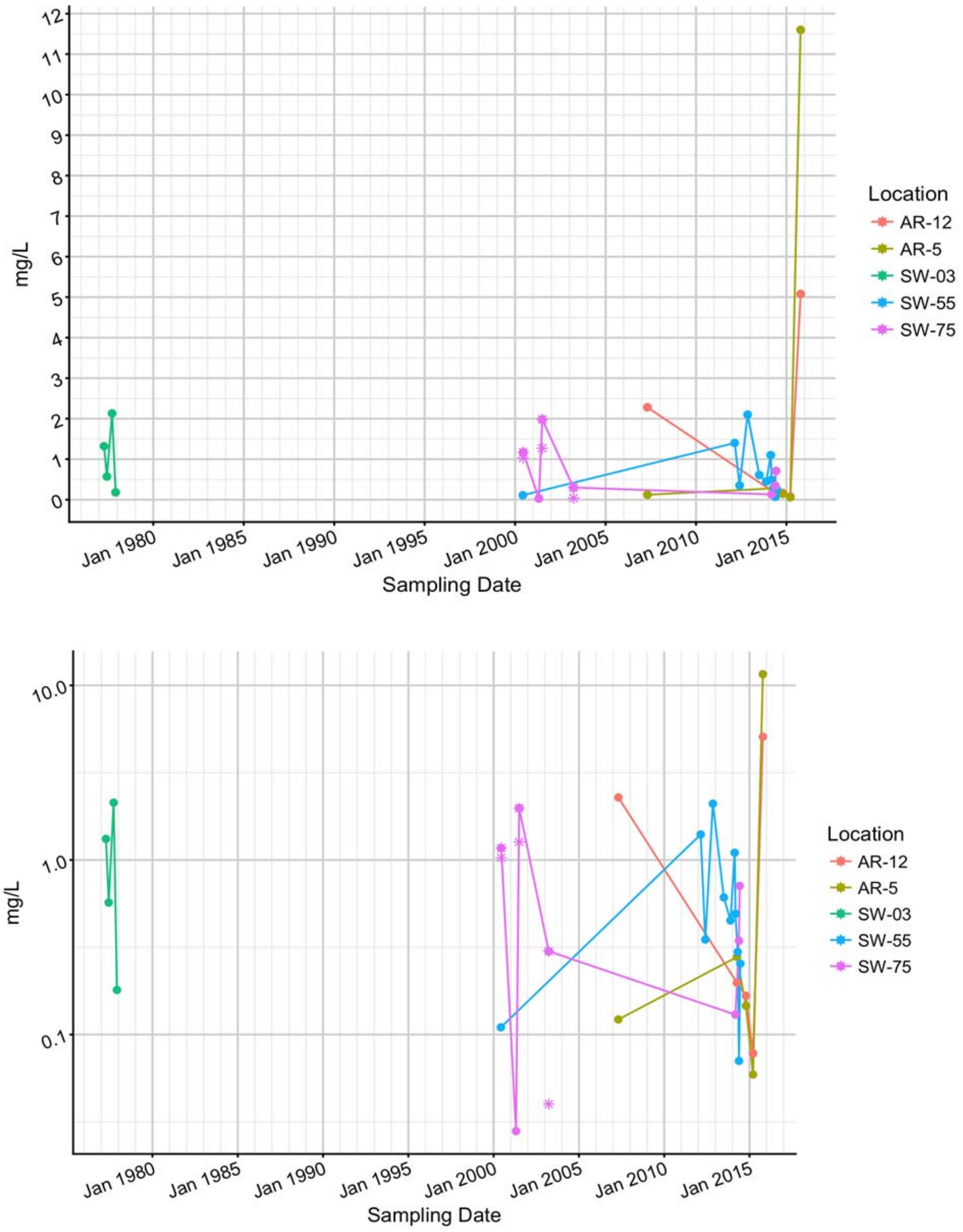


Figure D-4.15 Concentrations (mg/kg) used in EPC estimation for the 12-24'' depth interval and all soil sampling areas combined. Observations classified as "non-detects" for cadmium are plotted at the reporting limit (RL).

D-5 Figures: Upgradient surface water data

(a)



(b)

Figure D-5.1 (a) Upgradient surface water data used for UTL 95/90 on the original (a) and logarithmic scale (b). The points denoted with a star were collected on the same day and assumed to be field duplicates.

APPENDIX E

Data Used in the Risk Assessment

Table E-1
Colstrip Plant Site Area, EU1
Surface Water Data Used in the HHRA (Total Metals)
2014 and 2015

Sample	Date	Al (DIS)	Al	As	Be	B	Cd	Cu	Pb	Mn	Hg	Ni	Se	Sr	Tl	V	Zn	Ca (DIS)	Cl (DIS)	F (DIS)	Mg (DIS)	Sulfate (DIS)	pH (Field)	TDS
		mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	std	mg/L
AR-12	4/8/2014	< 0.05	0.10	0.001	< 0.001	0.63	< 0.0005	< 0.002	< 0.0003	0.198	< 0.00005	0.002	< 0.001	6.23	< 0.0003	< 0.01	< 0.008	271	132	0.2	327	1950	7.78	3350
AR-5	4/8/2014	< 0.05	< 0.05	< 0.001	< 0.001	0.75	< 0.0005	< 0.002	< 0.0003	0.278	< 0.00005	< 0.002	< 0.001	6.28	< 0.0003	< 0.01	< 0.008	283	126	0.2	330	1900	7.49	3210
AR-4	4/8/2014	< 0.05	0.07	< 0.001	< 0.002	0.78	< 0.0005	< 0.002	< 0.0003	0.426	< 0.00005	< 0.002	< 0.001	6.21	< 0.0003	< 0.01	< 0.008	269	123	0.2	329	1870	7.74	3100
AR-3	4/8/2014	< 0.05	< 0.05	< 0.001	< 0.001	1.15	< 0.0005	< 0.002	< 0.0003	0.281	< 0.00005	0.005	< 0.001	6.69	< 0.0003	< 0.01	< 0.008	295	118	0.2	347	2080	7.64	3530
NSTP	4/8/2014	< 0.05	0.17	0.006	< 0.001	0.62	< 0.0005	< 0.002	< 0.0003	0.09	<0.00005	0.004	< 0.001	1.16	< 0.0003	< 0.01	0.009	84	73	0.4	87	450	7.85	1120
AR-2SF	4/8/2014	< 0.05	0.06	< 0.001	< 0.001	1.28	< 0.0005	< 0.002	< 0.0003	0.366	< 0.00005	0.005	< 0.001	6.19	< 0.0003	< 0.01	< 0.008	281	105	0.3	322	1950	7.56	3270
AR-2SF (dup)	4/8/2014	< 0.05	< 0.05	< 0.001	< 0.001	1.17	< 0.0005	0.003	< 0.0003	0.351	< 0.00005	0.004	0.001	6.21	< 0.0003	< 0.01	< 0.008	287	109	0.3	333	1990	7.90	3350
AR-2SF	9/3/2014	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	361	97	--	375	2110	--	3500
AR-12	10/16/2014	0.015	0.038	0.002	< 0.002	0.72	--	< 0.002	< 0.0003	0.167	< 0.00005	< 0.002	< 0.001	7.95	< 0.0003	< 0.01	< 0.008	306	132	0.3	402	1940	7.51	3770
AR-5	10/16/2014	0.01	0.014	0.001	< 0.002	0.96	--	< 0.002	< 0.0003	0.146	< 0.00005	0.003	< 0.001	8.32	< 0.0003	< 0.01	< 0.008	315	170	0.2	423	2180	7.38	3950
AR-4	10/16/2014	< 0.009	0.029	0.001	< 0.002	0.99	--	< 0.002	< 0.0003	0.104	< 0.00005	0.002	< 0.001	8.13	< 0.0003	< 0.01	< 0.008	326	166	0.3	441	2190	7.63	3920
AR-3	10/16/2014	< 0.009	0.020	0.001	< 0.002	1.22	--	< 0.002	< 0.0003	0.221	< 0.00005	0.003	< 0.001	7.03	< 0.0003	< 0.01	< 0.008	333	165	0.3	432	2350	7.39	4070
NSTP	10/16/2014	0.019	0.133	0.006	< 0.002	0.94	--	0.003	<0.0003	0.059	0.00005	0.005	< 0.001	1.3	< 0.0003	< 0.01	0.011	108	118	--	125	645	8.26	1460
AR-2SF	10/16/2014	0.011	1.59	0.002	< 0.002	1.38	--	0.004	0.0018	1.34	< 0.00005	0.008	< 0.001	6.3	< 0.0003	< 0.01	0.013	321	125	0.3	358	1960	7.64	3510
AR-12	3/19/2015	--	0.019	0.001	< 0.002	0.41	< 0.00003	< 0.002	< 0.0003	0.078	< 0.00005	< 0.002	< 0.001	6.33	< 0.0003	< 0.01	< 0.008	212	37	0.2	264	1410	7.94	2470
AR-5	3/19/2015	--	< 0.009	0.002	< 0.002	0.51	< 0.00003	< 0.002	< 0.0003	0.059	< 0.00005	< 0.002	< 0.001	6.29	< 0.0003	< 0.01	< 0.008	216	38	0.2	265	1400	7.71	2460
AR-4	3/19/2015	--	0.072	0.001	< 0.002	0.51	< 0.00003	< 0.002	< 0.0003	0.073	< 0.00005	< 0.002	< 0.001	5.88	< 0.0003	< 0.01	< 0.008	221	39	0.2	271	1430	8.13	2450
AR-3	3/19/2015	--	0.066	0.002	< 0.002	0.66	< 0.00003	< 0.002	< 0.0003	0.133	< 0.00005	< 0.002	0.002	5.78	< 0.0003	< 0.01	< 0.008	226	50	0.2	278	1450	7.9	2570
NSTP	3/19/2015	--	1.26	0.005	< 0.002	0.72	0.00007	0.004	0.002	0.151	< 0.00005	0.006	0.001	1.17	< 0.0003	< 0.01	0.018	96	82	0.3	95	419	7.98	1140
AR-2SF	3/19/2015	--	0.01	< 0.001	< 0.002	0.77	< 0.00003	< 0.002	< 0.0003	0.223	< 0.00005	0.003	0.001	5.67	< 0.0003	< 0.01	< 0.008	235	60	0.2	272	1310	7.94	2650
AR-2SF	3/24/2015	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	232	60	--	285	1530	--	2650
AR-2SF	8/28/2015	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	294	70	--	308	1780	--	2980
AR-12	10/15/2015	--	24	0.056	< 0.002	0.89	0.0006	0.032	0.0233	5.08	< 0.0002	0.064	< 0.002	11.8	0.0006	0.18	0.706	371	239	0.2	458	1360	7.97	6590
AR-5	10/15/2015	--	11.2	0.058	< 0.002	2.06	0.00042	0.026	0.0192	11.6	< 0.0001	0.030	0.004	8.61	0.0004	0.05	0.202	397	87	0.2	501	2800	7.85	4540
AR-4	10/15/2015	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
AR-3	10/15/2015	--	2.48	0.019	< 0.002	1.26	0.00017	0.009	0.0072	3.27	< 0.00005	0.01	< 0.001	5.43	< 0.0003	0.02	0.051	246	61	0.2	261	1400	7.52	2430
NSTP	10/15/2015	--	0.11	0.007	< 0.002	1.02	< 0.00004	< 0.002	< 0.0003	0.061	< 0.00005	0.004	< 0.001	1.25	< 0.0003	< 0.01	< 0.008	112	125	0.3	124	616	8.69	1570
AR-2SF	10/15/2015	--	0.51	0.002	< 0.002	1.83	< 0.00004	< 0.002	0.0007	2.00	< 0.00005	0.006	< 0.001	5.47	< 0.0003	< 0.01	< 0.008	349	62	0.4	317	1740	8.19	2990

Notes:

DIS	All concentrations are from filtered samples (dissolved) because only dissolved are available for this analyte
mg/L	milligrams per liter
pCi/L	picoCuries per liter
TDS	Total Dissolved Solids
<	Measured concentration below the reporting limit (< RL)

Table E-2
Colstrip Plant Site Area, EU1
Sediment Data Used in the HHRA
2014 and 2015

Sample	Date	Al	As	Be	B	Cd	Cu	Pb	Mn	Hg	Ni	Se	Sr	Tl	V	Zn	Ca	Cl	F	Sulfate	pH
		mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	ppm	mg/L	mg/L	mg/L	std
																	sat. paste	sat. paste	sat. paste	sat. paste	sat. paste
AR-12	4/8/2014	2930	1.4	0.13	13.5	0.08	5.1	3.5	268	< 0.02	5.0	< 0.2	166	< 0.05	6.6	37.8	568	149	< 10	4080	7.4
AR-5	4/8/2014	1020	2.9	0.05	12.3	< 0.05	2	2.3	1040	< 0.02	2.3	0.7	180	< 0.05	4.1	14.9	560	203	< 10	6050	7.5
AR-4	4/8/2014	4850	2.8	0.25	11.3	< 0.05	8.9	8.38	605	< 0.02	7.7	0.3	157	0.08	9.8	76.2	368	170	< 10	2600	7.8
AR-3	4/8/2014	2310	5.6	0.16	19.9	< 0.05	6.4	3.92	2040	< 0.02	4.8	0.3	199	0.06	7.1	43.6	670	178	19	3440	7.3
AR-2SF	4/8/2014	1510	1.0	0.08	11.3	< 0.05	3.0	2.3	3910	< 0.02	4.2	< 0.2	222	0.06	7.2	18.9	638	179	26	3690	7.3
AR-12	10/16/2014	4980	2.8	0.2	15.8	< 0.05	7.4	4.71	534	< 0.1	6.2	0.3	313	0.07	12	127	558	230	< 20	4850	7.5
AR-12 (dup	10/16/2014	5700	2.7	0.25	18.8	< 0.05	8.1	5.09	564	< 0.1	6.7	0.2	266	0.08	11.9	79.6	562	160	< 20	4230	7.6
AR-5	10/16/2014	1150	12.6	0.06	19.4	< 0.05	6.1	2.89	5910	< 0.1	2.4	0.5	568	< 0.05	16.8	112	640	250	< 20	4170	7.7
AR-4	10/16/2014	4580	4.2	0.25	10	< 0.05	7.8	8.22	520	< 0.1	6.9	0.3	119	0.08	12.6	38.4	442	206	< 20	2880	7.7
AR-3	10/16/2014	3170	5.3	0.19	19.2	< 0.05	9.4	6.65	2390	< 0.1	6.3	0.5	1040	0.08	12.2	35.7	624	169	< 20	3710	7.6
AR-2SF	10/16/2014	3840	3.3	0.23	16.4	0.18	8.2	5.52	1940	< 0.1	6.1	0.4	315	0.35	11.1	30.9	644	233	< 20	4630	7.5
AR-12	3/19/2015	4030	2.9	0.27	8.1	0.11	6.3	4.17	700	< 0.1	4.7	0.2	227	0.06	8.4	78	570	124	< 5	4140	7.5
AR-5	3/19/2015	2110	2.8	0.15	18	0.08	5	4.36	1370	< 0.1	3.9	1.1	353	< 0.05	6.1	27	586	105	< 5	4460	7.6
AR-4	3/19/2015	5150	5.1	0.37	4.4	0.16	8.6	7.83	412	< 0.1	7.9	0.3	156	0.08	12.1	50	282	58	< 5	1780	7.8
AR-3	3/19/2015	3850	3.2	0.3	11	0.18	11.7	7.78	2970	< 0.1	8.8	0.5	652	0.11	9.8	46	618	90	< 5	3630	7.4
AR-2SF	3/19/2015	3290	2.2	0.24	6.6	0.18	7.9	4.96	1750	< 0.1	5.4	0.3	302	0.28	7.2	27	546	160	< 5	4310	7.5
AR-12	10/15/2015	4120	2.2	0.22	17.8	0.14	6.4	4.68	637	< 0.1	6.5	< 0.2	354	< 0.05	9.9	44.9	564	324	< 10	5330	7.6
AR-5	10/15/2015	1650	3	0.11	16.4	0.08	3.8	3.47	1860	< 0.1	3.9	0.5	349	< 0.05	7	17.7	568	166	< 10	4880	7.7
AR-4	10/15/2015	5490	2	0.32	15.4	0.25	10.3	12.8	986	< 0.1	9.4	< 0.2	412	0.06	13	32.4	374	199	< 5	2650	7.8
AR-3	10/15/2015	1740	3.9	0.15	12.5	0.12	5.9	7.02	2060	< 0.1	4.8	< 0.2	281	< 0.05	5.4	18.3	620	149	< 10	4520	7.5
AR-2SF	10/15/2015	2980	1.5	0.21	13.6	0.18	8.7	5.43	1270	< 0.1	6.2	< 0.2	280	0.17	8.7	20	552	138	< 10	4510	7.6

Notes:

mg/kg	milligram per kilogram
pCi/kg	picoCuries per kilogram
ppm	parts per million converted from milliequivalents per liter
NA	Not Analyzed
Analytes	The following CCR Rule Appendix IV Constituents were not analyzed in sediment during the included sampling period: Sb, Be, Co, Li, Mo, Ra 226/228, and Tl.

Table E-3
Colstrip Plant Site Area, EU2
Borehole Soil Data - Power Road Spill Area
2016

Sample	Date	Depth	Remarks	As	Ba	B	Cd	Cr	Pb	Mn	Hg	Se	Cl	F	Mg	Sulfate	pH
				mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/L	mg/L	ppm	mg/L	std
													sat. paste	sat. paste	sat. paste	sat. paste	sat. paste
BH-29	4/15/2016	0-6"	sieved	6.1	261	11.7	0.63	27.6	55.0	380	<0.1	0.6	16	< 1	28.2	74	7.70
BH-29 (dup)	4/15/2016	0-6"	sieved	6.4	270	11.6	0.66	33.9	58.1	411	<0.1	0.6	14	< 1	42.48	225	7.70
BH-29	4/15/2016	12"-24"	sieved	6.8	182	10.3	0.71	28.4	71.8	366	<0.1	0.5	23	< 1	67.80	437	7.60
BH-30	4/15/2016	0-6"	sieved	5.8	197	9.4	0.36	24.3	24.0	380	<0.1	0.4	8	< 1	38.88	154	7.70
BH-30	4/15/2016	12"-24"	sieved	5.9	151	11.6	0.44	24.2	73.9	376	<0.1	0.4	110	< 5	535.20	3810	7.70
BH-30	4/15/2016	5'-6'	sieved	5.7	144	7.8	0.37	31.9	14.6	391	<0.1	0.4	67	< 10	758.4	5260	8.00
BH-31	4/15/2016	0-6"	sieved	5.4	137	6.6	0.44	24.1	37.6	365	<0.1	0.4	8	< 1	33.12	207	7.70
BH-31	4/15/2016	12"-24"	sieved	5.8	140	6.9	0.42	28.2	36.2	376	<0.1	0.4	8	< 5	189.60	2130	7.50
BH-32	4/15/2016	0-6"	sieved	5.4	138	6.7	0.34	26.0	20.2	385	<0.1	0.4	6	< 5	184.8	2090	7.60
BH-32	4/15/2016	12"-24"	sieved	5.1	147	7.4	0.36	24.5	20.9	368	<0.1	0.4	109	< 5	514.80	3970	7.70
BH-32	4/15/2016	12"-24"	bulk-not sieved	5.8	115	8.0	0.31	17.0	21.3	335	<0.1	0.3	--	--	--	--	--
BH-32	4/15/2016	6'-7'	sieved	6.3	137	9.1	<0.05	25.3	15.3	359	<0.1	0.6	59	< 10	999.6	6390	7.90

Notes:

mg/kg	kilogram
mg/L	milligrams per liter
ppm	parts per million converted from milliequivalents per liter
Analytes	The following CCR Rule Appendix IV Constituents were not analyzed in soil: Sb, Be, Co, Li, Mo, Ra 226/228, and Tl.

Table E-4
Colstrip Plant Site Area, EU3
Borehole Soil Data - Former Sewage Treatment Lagoon Spills Area
2016

Sample	Date	Depth	Remarks	As	Ba	B	Cd	Cr	Pb	Mn	Hg	Se	Ca	Cl	F	Mg	Sulfate	pH
				mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	ppm	mg/L	mg/L	ppm	mg/L	std
													sat. paste	sat. paste	sat. paste	sat. paste	sat. paste	sat. paste
BH-33	4/13/2016	0-6"	sieved	4.7	106	8	<0.05	21.3	14.0	367	<0.1	0.4	112.2	20	< 1	30.96	41	7.40
BH-33	4/13/2016	12"-24"	sieved	4.9	96	9.9	<0.05	21.2	17.0	378	<0.1	0.4	63.2	27	0.7	40.56	118	7.90
BH-34	4/13/2016	0-6"	sieved	5.7	203	8.9	<0.05	19.3	13.0	341	<0.1	0.8	64.6	9	< 0.5	42.24	64	7.90
BH-34	4/13/2016	12"-24"	sieved	5.3	132	10.1	<0.05	23.3	12.0	309	<0.1	0.6	440	35	< 10	1272.00	7330	8.10
BH-35	4/13/2016	0-6"	sieved	6.2	135	10.2	0.07	22.2	16.0	412	<0.1	0.5	67.8	7	< 1	34.44	130	7.80
BH-35	4/13/2016	12"-24"	sieved	6.1	117	10.3	<0.05	21.1	14.0	397	<0.1	0.4	460	108	< 10	1824.00	10100	9.10
BH-36	4/13/2016	0-6"	sieved	5.9	138	9.6	<0.05	21.5	17.0	400	<0.1	0.4	504	20	< 5	304.8	2720	7.70
BH-36	4/13/2016	12"-24"	sieved	5.7	146	14.1	<0.05	19.8	13.0	386	<0.1	0.6	440	106	< 20	2832.00	15700	8.30
BH-37	4/13/2016	0-6"	sieved	6.1	162	13.9	<0.05	26.8	15.0	402	<0.1	0.5	512	10	< 5	325.2	2670	8.10
BH-37	4/13/2016	12"-24"	sieved	5.1	141	14.6	<0.05	19.9	13.0	352	<0.1	0.6	446	58	< 20	3192.00	17000	8.20
BH-38	4/13/2016	0-6"	sieved	5.2	124	16.2	<0.05	16.8	16.0	383	<0.1	0.7	139.6	13	< 2	113.76	715	7.70
BH-38	4/13/2016	12"-24"	sieved	5.1	182	15.6	<0.05	15.8	10.0	341	<0.1	0.4	460	232	< 2	1728.00	10000	8.30
BH-39	4/14/2016	0-6"	sieved	4.8	156	11.1	0.33	21.4	13.9	271	<0.1	0.5	113.2	5	< 1	45.96	98	7.60
BH-39	4/14/2016	12"-24"	sieved	6.4	129	9.3	0.38	31.4	14.5	401	<0.1	0.7	242	9	< 2	219.60	1570	7.70
BH-40	4/14/2016	0-6"	sieved	7.5	141	8.8	0.30	25.1	14.2	449	<0.1	0.6	484	18	< 5	129.6	1720	7.40
BH-40	4/14/2016	12"-24"	sieved	6.0	237	7.6	0.28	21.8	10.7	320	<0.1	0.7	53	15	< 0.5	28.68	90	8.00
BH-41	4/13/2016	0-6"	sieved	6.1	146	9.3	0.34	21.8	16.0	369	<0.1	0.5	121.2	11	< 1	35.76	106	7.50
BH-41	4/13/2016	12"-24"	sieved	6.1	111	8.8	0.27	22.1	11.4	312	<0.1	0.7	452	100	< 10	1392.00	8630	8.10
BH-42	4/13/2016	0-6"	sieved	6.6	210	7.7	0.27	18.7	12.4	364	<0.1	0.5	91.6	11	< 0.5	29.04	31	7.70
BH-42	4/13/2016	12"-24"	sieved	6.3	195	9.7	0.29	21.6	11.9	376	<0.1	0.5	466	86	< 5	429.60	3300	7.90
BH-43	4/13/2016	0-6"	sieved	6.0	175	13.9	0.32	18.0	13.6	377	<0.1	0.5	212	26	< 2	217.2	1330	7.70
BH-43 (dup)	4/13/2016	0-6"	sieved	6.2	173	13.7	0.31	19.3	13.6	389	<0.1	0.5	200	20	< 2	206.4	1250	7.60
BH-43	4/13/2016	12"-24"	sieved	6.2	178	15.9	0.24	16.7	9.5	335	<0.1	0.5	452	297	< 20	2688.00	16400	8.40
BH-44	4/13/2016	0-6"	sieved	5.7	180	18.9	0.37	17.9	16.4	395	<0.1	0.5	96.6	23	< 1	45.24	71	7.60
BH-44	4/13/2016	12"-24"	sieved	5.6	170	15.4	0.27	17.2	11.5	364	<0.1	0.5	518	147	< 10	808.80	5070	8.00
BH-45	4/13/2016	0-6"	sieved	5.2	148	17.4	<0.05	15.6	13.0	356	<0.1	0.4	133.6	42	< 2	74.04	496	7.80
BH-45	4/13/2016	12"-24"	sieved	5.8	191	20.6	0.27	19.1	10.9	349	<0.1	0.4	494	188	< 10	1155.60	6500	8.10
BH-46	4/14/2016	0-6"	sieved	5.4	175	11.6	0.39	26.2	20.7	349	<0.1	0.4	163.6	25	< 1	47.16	30	7.30
BH-46	4/14/2016	12"-24"	sieved	6.0	165	7.9	0.32	28.0	13.0	354	<0.1	0.5	50.8	21	1.0	27.36	64	7.90
BH-47	4/14/2016	0-6"	sieved	6.7	189	7.7	0.34	30.0	17.0	400	<0.1	0.5	100.2	11	< 1	31.32	26	7.60
BH-47	4/14/2016	12"-24"	sieved	6.4	190	10.2	0.33	26.6	12.5	333	<0.1	0.8	498	42	< 5	454.80	3170	7.70
BH-48	4/14/2016	0-6"	sieved	6.6	216	9.2	0.30	24.3	13.1	359	<0.1	0.6	114.6	10	< 1	22.8	19	7.60
BH-48	4/14/2016	12"-24"	sieved	5.6	161	8.4	0.30	24.3	12.6	319	<0.1	0.8	454	73	< 10	855.60	5510	7.80
BH-50	4/14/2016	0-6"	sieved	6.8	229	7.1	0.32	22.7	13.1	382	<0.1	0.4	78.8	10	< 0.5	26.28	27	7.60
BH-50	4/14/2016	12"-24"	sieved	6.4	140	10.9	0.33	20.2	12.2	403	<0.1	0.7	428	72	< 10	2076.00	11400	8.10
BH-51	4/14/2016	0-6"	sieved	6.4	149	14	0.44	18.7	24.4	425	<0.1	0.5	112.2	29	< 1	36.12	46	7.40
BH-51	4/14/2016	12"-24"	sieved	6.5	110	7.8	0.37	25.7	14.8	398	<0.1	0.4	258	73	< 2	55.44	697	7.50
BH-52	4/14/2016	0-6"	sieved	7.3	352	9.7	0.37	22.4	25.0	326	<0.1	0.5	90.4	7	< 0.5	27.84	46	7.70
BH-52	4/14/2016	12"-24"	sieved	5.8	211	8.2	0.31	23.6	12.6	277	<0.1	1.2	41	10	< 0.5	29.28	49	8.00
BH-53	4/14/2016	0-6"	sieved	6.9	308	15.1	0.45	27.2	22.2	403	<0.1	0.6	582	8	< 2	98.4	1840	7.50
BH-53 (dup)	4/14/2016	0-6"	sieved	6.7	297	14.8	0.46	25.2	22.2	391	<0.1	0.6	578	8	< 5	95.16	1820	7.50
BH-53	4/13/2016	12"-24"	sieved	5.6	133	8.5	0.34	27.7	14.1	353	<0.1	0.6	532	18	< 5	171.60	2220	7.70
BH-54	4/14/2016	0-6"	sieved	6.9	1130	68.5	0.57	31.5	17.4	375	<0.1	1.3	116	17	< 1	34.32	90	7.60
BH-54 (rerun)	4/14/2016	0-6"	sieved	6.3	1050	67.8	0.57	21.9	17.1	347	<0.1	1.2	116	17	< 1	--	90	7.6
BH-54	4/14/2016	12"-24"	sieved	6.8	218	19.8	0.43	27.8	16.3	391	<0.1	0.6	590	33	< 5	164.40	2100	7.70
BH-55	4/14/2016	0-6"	sieved	6.3	302	36.8	0.40	25.9	16.6	412	<0.1	0.7	582	81	< 5	451.2	3150	7.80
BH-55	4/14/2016	12"-24"	sieved	6.0	156	23.0	0.39	19.0	12.0	476	<0.1	0.4	516	165	< 10	1416.00	7550	8.10

Table E-4
Colstrip Plant Site Area, EU3
Borehole Soil Data - Former Sewage Treatment Lagoon Spills Area
2016

Sample	Date	Depth	Remarks	As	Ba	B	Cd	Cr	Pb	Mn	Hg	Se	Ca	Cl	F	Mg	Sulfate	pH
				mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	ppm	mg/L	mg/L	ppm	mg/L	std
													sat. paste	sat. paste	sat. paste	sat. paste	sat. paste	sat. paste
BH-56	4/14/2016	0-6"	sieved	4.8	116	14.4	0.54	11.9	504	324	<0.1	0.4	456	42.0	< 5	420	3030	7.40
BH-56 (rerun)	4/14/2016	0-6"	sieved	4.7	163	18.3	0.41	16.8	18.8	406	<0.1	0.7	456	42.0	< 5	--	3030	7.40
BH-56	4/14/2016	12"-24"	sieved	5.7	155	18.1	0.31	17.5	10.7	426	<0.1	0.3	526	306	< 20	3996.00	21600	8.30
BH-57	4/15/2016	0-6"	sieved	6.7	163	7.6	0.37	25.0	124	402	<0.1	0.4	77	11	< 0.5	26.76	28	7.40
BH-57	4/15/2016	12"-24"	sieved	5.9	201	7.5	0.28	24.4	13.9	296	<0.1	0.8	44.4	7	< 0.5	34.68	41	7.90
BH-58	4/15/2016	0-6"	sieved	6.8	165	9.5	0.35	24.6	17.8	389	<0.1	0.5	115	13	< 1	39	41	7.40
BH-58	4/15/2016	12"-24"	sieved	5.8	221	8.3	0.28	21.8	11.7	296	<0.1	0.9	56.4	15	< 1	54.48	112	7.90
BH-59	4/15/2016	0-6"	sieved	6.8	240	13.5	0.35	22.9	19.7	348	<0.1	0.5	157	21	39	49.2	67	7.30
BH-59	4/15/2016	12"-24"	sieved	6.5	170	10.8	0.28	24.2	13.2	346	<0.1	0.5	111	26	< 1	55.80	283	7.70
BH-59	4/15/2016	12"-24"	bulk-not sieved	6.3	153	10.0	0.28	18.8	13.9	357	<0.1	0.5	--	--	--	--	--	--
BH-60	4/14/2016	0-6"	sieved	6.6	417	28.3	0.45	19.2	14.4	481	<0.1	0.9	538	18	< 5	410.4	3130	7.70
BH-60	4/14/2016	12"-24"	sieved	5.9	161	10.1	0.34	18.9	11.4	440	<0.1	0.6	544	119	< 20	2940.00	17700	8.40
BH-61	4/14/2016	0-6"	sieved	5.8	168	8.7	0.31	16.8	11.5	414	<0.1	0.4	270	8	< 2	97.8	816	7.60
BH-61	4/14/2016	12"-24"	sieved	5.7	149	9.4	0.26	15.5	9.5	404	<0.1	0.4	456	184	< 10	1980.00	11700	8.30
BH-62	4/15/2016	0-6"	sieved	7.9	230	8.0	0.35	27.5	17.7	440	<0.1	0.5	73.2	11	< 0.5	25.44	25	7.70
BH-62	4/15/2016	12"-24"	sieved	6.0	198	11.6	0.32	28.9	14.4	349	<0.1	0.8	46.8	12	0.6	35.64	68	7.90
BH-62	4/15/2016	12"-24"	bulk-not sieved	6.3	174	11.3	0.34	23.3	15.5	349	<0.1	0.6	--	--	--	--	--	--
BH-62	4/15/2016	5.5'-6.5'	sieved	5.9	168	8.3	0.32	26.4	12.4	401	<0.1	0.4	468	102	< 10	2904	15000	8.00
BH-63	4/15/2016	0-6"	sieved	5.9	262	5.9	0.26	24.2	11.8	370	<0.1	0.4	74.8	8	< 0.5	20.28	30	7.80
BH-63	4/15/2016	12"-24"	sieved	5.6	182	9.6	0.33	32.3	13.3	357	<0.1	0.7	56	12	0.5	43.08	112	7.90
BH-63	4/15/2016	6'-7'	sieved	5.9	160	8.2	0.32	23.7	12.8	383	<0.1	0.5	500	135	< 20	4476	22300	8.20
BH-64	4/15/2016	0-6"	sieved	6.6	161	8.2	0.38	29.6	21.0	451	<0.1	0.6	79.6	11	< 0.5	27	36	7.70
BH-64	4/15/2016	12"-24"	sieved	5.6	173	10.7	0.31	28.3	12.9	365	<0.1	0.8	482	36	< 5	458.40	3260	7.80
BH-64	4/15/2016	6'-7'	sieved	6.1	152	8.6	0.35	31.8	13.2	409	<0.1	0.4	468	118	< 10	2952	16200	8.20
BH-65	4/15/2016	0-6"	sieved	6.3	272	14.5	0.37	28.2	18.8	435	<0.1	0.7	184.2	10	< 1	55.08	437	7.70
BH-65	4/15/2016	12"-24"	sieved	5.8	169	11.4	0.30	30.0	13.0	362	<0.1	1.0	512	42	< 5	472.80	3200	7.80
BH-65	4/15/2016	6'-7'	sieved	6.0	158	8.9	0.34	34.0	14.0	416	<0.1	0.4	478	100	< 10	1716	10800	8.20
BH-65	4/15/2016	6'-7'	bulk-not sieved	6.4	144	8.9	0.31	21.2	14.6	380	<0.1	0.3	--	--	--	--	--	--
BH-66	4/14/2016	0-6"	sieved	6.0	219	10.0	0.31	16.6	11.6	423	<0.1	0.7	88	12	< 1	32.76	98	7.80
BH-66	4/14/2016	12"-24"	sieved	6.6	158	11.2	0.33	18.7	11.2	461	<0.1	0.5	458	88	< 10	1095.60	6770	8.10
BH-66	4/14/2016	6'-7'	sieved	5.5	173	8.3	0.30	18.4	10.1	469	<0.1	0.3	396	58	< 5	490.8	3390	7.90
BH-66	4/14/2016	6'-7'	bulk-not sieved	5.7	164	8.8	0.25	17.8	11.6	390	<0.1	0.3	--	--	--	--	--	--
BH-67	4/14/2016	0-6"	sieved	5.7	165	10.9	0.25	18.9	11.4	284	<0.1	0.4	488	12	< 5	284.4	2330	7.80
BH-67	4/14/2016	12"-24"	sieved	6.0	216	10.9	0.23	17.3	9.9	277	<0.1	0.5	478	102	< 10	2244.00	13300	8.20
BH-67	4/14/2016	6'-7'	sieved	6.7	193	10.7	0.31	21.1	13.5	403	<0.1	0.8	436	89	< 10	853.2	5340	8.10
BH-68	4/14/2016	0-6"	sieved	6.2	227	7.1	0.25	17.7	11.4	282	<0.1	0.4	70	8	< 0.5	31.32	80	7.70
BH-68	4/14/2016	12"-24"	sieved	6.1	177	9.1	0.23	19.0	10.5	285	<0.1	0.4	476	206	< 10	2352.00	13000	8.30
BH-68	4/14/2016	4.5'-5.5'	sieved	6.1	190	7.8	0.28	21.9	12.2	331	<0.1	0.3	514	114	< 10	729.6	5120	8.00
BH-69	4/15/2016	0-6"	sieved	5.9	165	12.8	0.33	20.1	16.9	351	<0.1	0.5	522	50	< 5	247.2	2350	7.40
BH-69 (dup)	4/15/2016	0-6"	sieved	5.8	166	12.5	0.30	20.2	15.7	347	<0.1	0.6	564	64	< 5	304.8	2680	7.50
BH-69	4/15/2016	12"-24"	sieved	5.3	176	9.8	0.27	21.3	10.1	325	<0.1	0.5	570	143	< 10	1058.40	6720	8.10
BH-73	4/15/2016	0-6"	sieved	7.2	429	11.5	0.40	29.2	18.0	407	<0.1	0.5	128.8	8	< 1	24.6	97	7.50

Notes:

mg/kg	milligram per kilogram
pCi/kg	picoCuries per kilogram
ppm	parts per million converted from milliequivalents per liter
Analytes	The following CCR Rule Appendix IV Constituents were not analyzed in soil: Sb, Be, Co, Li, Mo, Ra 226/228, and Tl.

Table E-5
Colstrip Plant Site Area, EU4
Borehole Soil Data - Storm Water Ponding Area
2016

Sample	Date	Depth	Remarks	As	Ba	B	Cd	Cr	Pb	Mn	Hg	Se	Ca	Cl	F	Mg	Sulfate	pH
				mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	ppm	mg/L	mg/L	ppm	mg/L	std
													sat. paste	sat. paste	sat. paste	sat. paste	sat. paste	sat. paste
BH-70	4/13/2016	0-6"	sieved	5.9	135	11.3	0.39	23.7	18.0	497	<0.1	0.5	68.80	16	< 1	30	27	7.30
BH-70	4/13/2016	12"-24"	sieved	5.4	137	9.8	<0.05	23.1	16.0	491	<0.1	0.5	46.20	39	0.7	29.64	64	7.30
BH-71	4/13/2016	0-6"	sieved	6.7	128	14.6	< 0.05	21.7	15.0	388	<0.1	0.5	101.80	11	< 1	50.88	37	7.50
BH-71	4/13/2016	12"-24"	sieved	5.8	166	21.9	< 0.05	18.7	11.0	295	<0.1	0.5	496.00	79	< 5	448.80	3570	7.90
BH-72	4/13/2016	0-6"	sieved	6.9	122	16.1	< 0.05	25.2	18.0	468	<0.1	0.5	79.80	17	< 1	57.84	61	7.10
BH-72 (dup)	4/13/2016	0-6"	sieved	6.4	119	14.6	< 0.05	23.2	17.0	448	<0.1	0.5	78.80	13	< 1	57.96	59	7.20
BH-72	4/13/2016	12"-24"	sieved	5.8	188	35.3	< 0.05	19.0	11.5	300	<0.1	0.6	472.00	75	< 10	1069.20	6520	8.10

Notes:

mg/kg	milligram per kilogram
pCi/kg	picoCuries per kilogram
ppm	parts per million converted from milliequivalents per liter
Analytes	The following CCR Rule Appendix IV Constituents were not analyzed in soil: Sb, Be, Co, Li, Mo, Ra 226/228, and Tl.

APPENDIX F

Federal CCR Rule Baseline Monitoring Data

*** * DRAFT * ***

5/9/2018

APPENDIX F

Colstrip SES Federal CCR Rule Groundwater Draft Baseline Monitoring Data - 2016 Through November 30, 2017

Comparison For Montana DEQ Human Health GW MCLs (If No MCL Listed Then EPA RSL For Tapwater - Ingestion For Child, RSL Limit Was Used)

***Metals analyzed as Total Recoverable (TRC) unless turbidity >10, then metals ran both as Total Recoverable (TRC) and Dissolved (DIS).**

🟧 ***Highlighted Values Exceed MCL or EPA Tapwater RSL***

🟦 ***Highlighted Values Are Detection Limits Higher than the MCL or EPA Tapwater RSL***

Site Code	Sample Code	Date	ANTIMONY 7440-36-0 mg/L	ARSENIC 7440-38-2 mg/L	BARIUM 7440-39-3 mg/L	BERYLLIUM 7440-41-7 mg/L	BORON 7440-42-8 mg/L	CADMIUM 7440-43-9 mg/L	CALCIUM 7440-70-2 mg/L	CHROMIUM 7440-47-3 mg/L	COBALT 7440-48-4 mg/L	FLUORIDE 16984-48-8 mg/L	IRON 7439-89-6 mg/L	LEAD 7439-92-1 mg/L	LITHIUM 7439-93-2 mg/L	MANGANESE 7439-96-5 mg/L	MERCURY 7439-97-6 mg/L	MOLYBDENUM 7439-98-7 mg/L	pH NA standard units	RADIUM 226/228 7440-14-4 pCi/L	SELENIUM 7782-49-2 mg/L	SULFATE 14808-79-8 mg/L	THALLIUM 7440-28-0 mg/L	TDS NA mg/L
			MCL - 0.006	MCL - 0.01	MCL - 1.0	MCL - 0.004	RSL - 4.0	MCL - 0.005	no MCL/ RSL	MCL - 0.1	RSL - 0.006	MCL - 4.0	No MCL/ RSL	MCL - 0.015	RSL - 0.04	RSL 0.43	MCL - 0.002	RSL - 0.1	no MCL/ RSL	MCL - 5.0	MCL - 0.05	no MCL/ RSL	MCL - 0.002	no MCL/ RSL
s 3&4 Bottom Ash Pond																								
22SP	TLN-1602-910-CCR	2/23/2016	< 0.001	< 0.001	< 0.05	< 0.001	1.45	< 0.001	361	< 0.005	0.008	0.2	< 0.02	< 0.001	0.1	1.48	< 0.0001	0.001	7.0	2.2	< 0.001	2,240	< 0.0005	3,690
22SP	CTLN-1605-203	5/11/2016	< 0.001	< 0.001	< 0.05	< 0.001	1.48	< 0.001	366	< 0.005	0.009	0.2	0.03	< 0.001	0.2	1.55	< 0.0001	< 0.001	7.0	3	< 0.001	2,220	< 0.0005	3,770
22SP	CTLN-1606-450	6/21/2016	< 0.001	< 0.001	< 0.05	< 0.001	1.39	< 0.001	346	< 0.005	0.007	0.2	0.03	< 0.001	0.2	1.46	< 0.0001	0.001	7.1	0.08	< 0.001	2,140	< 0.0005	3,610
22SP	CTLN-1608-900	8/12/2016	< 0.001	< 0.001	< 0.05	< 0.001	1.49	< 0.001	360	< 0.005	0.008	0.2	0.09	< 0.001	0.1	1.55	< 0.0001	0.001	7.2	1.6	< 0.001	2,230	< 0.0005	3,600
22SP	CTLN-1609-367	9/27/2016	< 0.001	< 0.001	< 0.05	< 0.001	1.59	< 0.001	365	< 0.005	0.008	0.2	< 0.02	< 0.001	0.2	1.5	< 0.0001	0.001	7.1	1.3	< 0.001	2,170	< 0.0005	3,510
22SP	CTLN-1612-244	12/5/2016	< 0.001 DIS < 0.001 TRC	< 0.001 DIS < 0.001 TRC	< 0.05 DIS < 0.05 TRC	< 0.001 DIS < 0.001 TRC	1.37 DIS 1.46 TRC	< 0.001 DIS < 0.001 TRC	330 DIS 389 TRC	< 0.005 DIS < 0.005 TRC	0.007 **DIS** 0.007 **TRC**	0.2	< 0.02 DIS 0.25 TRC	< 0.001 DIS 0.001 TRC	0.2 **DIS** 0.2 **TRC**	1.29 **DIS** 1.32 **TRC**	< 0.0001 DIS < 0.0001 TRC	0.001 DIS 0.001 TRC	7.1	0.03 TRC	< 0.001 DIS < 0.002 TRC	2,370	< 0.0005 DIS < 0.0005 TRC	3,950
22SP	CTLN-1701-145	1/30/2017	< 0.001	< 0.001	< 0.05	< 0.001	1.52	< 0.001	351	< 0.005	0.008	0.2	0.02	< 0.001	0.1	1.53	< 0.0001	0.002	7.1	2.6	< 0.001	2,210	< 0.0005	3,510
22SP	CTLN-1703-745	3/9/2017	0.001	0.001	< 0.05	< 0.001	1.46	< 0.001	358	< 0.005	0.009	0.2	0.12	0.002	0.1	1.32	< 0.0001	0.003	7.1	1.3	0.003	2,300	0.0012	3,720
22SP	CTLN-1703-363	3/14/2017	< 0.001	< 0.001	< 0.05	< 0.001	1.45	< 0.001	357	< 0.005	0.008	0.2	0.05	< 0.001	0.1	1.55	< 0.0001	0.001	7.1	1.1	< 0.002	2,270	< 0.0005	3,490
22SP	CTLN-1705-954	5/2/2017	< 0.001	< 0.001	< 0.05	< 0.001	1.62	0.001	353	< 0.005	0.009	0.2	0.06	< 0.001	0.1	1.57	< 0.0001	0.002	7.2	1.2	< 0.002	2,250	< 0.0005	3,310
22SP	CTLN-1705-421	5/31/2017	< 0.001	0.004	< 0.05	< 0.001	1.67	< 0.001	359	< 0.005	0.008	0.2	0.16	0.002	0.1	1.67	< 0.0001	0.002	7.1	3	0.016	2,370	< 0.0005	3,550
22SP	CTLN-1706-356	6/28/2017	< 0.001	< 0.001	< 0.05	< 0.001	1.67	< 0.001	331	< 0.005	0.007	0.2	< 0.02	< 0.001	0.1	1.46	< 0.0001	0.001	7.1	1.8	< 0.001	2,300	< 0.0005	3,460
22SP	CTLN-1708-332	8/1/2017	< 0.001	< 0.001	< 0.05	< 0.001	1.49	< 0.001	346	< 0.005	0.007	0.2	0.04	< 0.001	< 0.1	1.65	< 0.0001	0.001	7.1	0.7	< 0.001	2,170	< 0.0005	3,480
22SP	CTLN-1709-491	9/7/2017	< 0.001	< 0.001	< 0.05	< 0.001	1.51	< 0.001	308	< 0.005	0.007	0.2	< 0.02	< 0.001	0.1	1.4	< 0.0001	0.001	7.2	2.3	< 0.001	2,490	0.0007	3,520
84SP	TLN-1602-909-CCR	2/23/2016	< 0.001	0.005	< 0.05	< 0.001	2.47	< 0.001	507	< 0.005	0.007	0.1	2.66	< 0.001	< 0.1	3.43	< 0.0001	0.007	6.6	2.6	< 0.002	2,980	< 0.0005	5,080
84SP	CTLN-1605-204	5/11/2016	< 0.001	0.004	< 0.05	< 0.001	2.26	< 0.001	485	< 0.005	0.008	0.1	2.53	< 0.001	0.2	3.6	< 0.0001	0.006	6.7	3.2	< 0.002	3,040	< 0.0005	5,120
84SP	CTLN-1606-449	6/21/2016	< 0.001	0.004	< 0.05	< 0.001	2.02	< 0.001	443	< 0.005	0.006	0.1	2.45	< 0.001	0.1	3.22	< 0.0001	0.007	6.8	1.9	< 0.001	2,420	< 0.0005	5,030
84SP	CTLN-1608-362	8/11/2016	< 0.001	0.004	< 0.05	< 0.001	2.25	< 0.001	484	< 0.005	0.007	0.1	2.53	< 0.001	< 0.1	3.31	< 0.0001	0.008	6.7	1.7	< 0.002	3,000	< 0.0005	5,060
84SP	CTLN-1609-362	9/26/2016	< 0.001	0.004	< 0.05	< 0.001	2.38	< 0.001	508	< 0.005	0.006	0.1	2.61	< 0.001	0.1	3.13	< 0.0001	0.007	6.7	2.5	< 0.001	2,970	< 0.0005	5,030
84SP	CTLN-1612-247	12/5/2016	< 0.001	0.004	< 0.05	< 0.001	2.26	< 0.001	516	< 0.005	0.006	0.1	2.6	< 0.001	0.2	3.18	< 0.0001	0.007	6.7	2.4	< 0.002	2,960	< 0.0005	4,960
84SP	CTLN-1701-150	1/31/2017	< 0.001	0.004	< 0.05	< 0.001	2.18	< 0.001	480	< 0.005	0.006	0.1	2.36	< 0.001	< 0.1	3.28	< 0.0001	0.007	6.7	2.3	< 0.001	3,030	< 0.0005	4,940
84SP	CTLN-1703-362	3/14/2017	< 0.001	0.004	< 0.05	< 0.001	2.21	< 0.001	490	< 0.005	0.007	0.1	2.74	< 0.001	< 0.1	3.43	< 0.0001	0.008	6.7	1.9	< 0.002	3,100	< 0.0005	4,910
84SP	CTLN-1704-921	4/14/2017	< 0.001	0.001	< 0.05	< 0.001	2.29	< 0.001	496	< 0.005	0.007	0.1	2.75	< 0.001	< 0.1	3.55	< 0.0001	0.008	6.8	2.4	< 0.001	3,060	< 0.0005	4,710
84SP	CTLN-1705-418	5/31/2017	< 0.001	0.004	< 0.05	< 0.001	2.32	< 0.001	595	< 0.005	0.006	0.1	3.24	< 0.001	< 0.1	3.79	< 0.0001	0.007	6.6	3.7	0.004	3,700	< 0.0007	5,770
84SP	CTLN-1706-351	6/27/2017	< 0.001	0.004	< 0.05	< 0.001	2.29	< 0.001	584	< 0.005	0.007	0.1	3.19	< 0.001	0.1	4.01	< 0.0001	0.008	6.7	4.5	< 0.001	3,510	< 0.0005	5,850
84SP	CTLN-1708-328	8/1/2017	< 0.001	0.004	< 0.05	< 0.001	2.01	< 0.001	687	< 0.005	0.008	0.1	3.41	< 0.001	< 0.1	4.68	< 0.0001	0.007	6.6	2.6	< 0.002	4,060	< 0.0005	6,410
84SP	CTLN-1709-496	9/8/2017	< 0.001	0.004	< 0.05	< 0.001	2.16	< 0.001	663	< 0.005	0.009	0.1	3.81	< 0.001	< 0.1	4.56	< 0.0001	0.008	6.6	3.9	< 0.001	4,520	< 0.0005	6,740
85SP	TLN-1603-302-CCR	3/31/2016	< 0.001	0.003	< 0.05	< 0.001	0.53	< 0.001	470	< 0.005	0.007	0.1	7.45	< 0.001	< 0.1	2.91	< 0.0001	0.013	6.7	3.3	< 0.001	2,620	< 0.0005	4,390
85SP	CTLN-1606-451	6/21/2016	< 0.001	0.003	< 0.05	< 0.001	0.49	< 0.001	435	< 0.005	< 0.005	0.1	6.9	< 0.001	< 0.1	2.68	< 0.0001	0.013	6.8	0.8	< 0.001	2,550	< 0.0005	4,330
85SP	CTLN-1608-361	8/11/2016	< 0.001	0.003	< 0.05	< 0.001	0.53	< 0.001	461	< 0.005	0.005	< 0.1	8.11	< 0.001	< 0.1	2.84	< 0.0001	0.013	6.7	1.2	< 0.001	2,630	< 0.0005	4,370
85SP	CTLN-1609-361	9/26/2016	< 0.001	0.004	< 0.05	< 0.001	0.59	< 0.001	472	< 0.005	0.006	0.1	8.43	< 0.001	0.1	2.81	< 0.0001	0.013	6.7	1.4	< 0.001	2,650	< 0.0005	4,410
85SP	CTLN-1612-249	12/6/2016	< 0.001 DIS < 0.001 TRC	0.003 DIS 0.005 TRC	< 0.05 DIS < 0.05 TRC	< 0.001 DIS < 0.001 TRC	0.39 DIS 0.53 TRC	< 0.001 DIS < 0.001 TRC	307 DIS 456 TRC	< 0.005 DIS < 0.005 TRC	0.006 DIS 0.005 TRC	0.1	6.86 DIS 7.16 TRC	< 0.001 DIS < 0.001 TRC	0.1 **DIS** 0.1 **TRC**	2.79 **DIS** 2.56 **TRC**	< 0.0001 DIS < 0.0001 TRC	0.012 DIS 0.013 TRC	6.7	2.1 TRC	< 0.001 DIS < 0.002 TRC	2,660	< 0.0005 DIS < 0.0005 TRC	4,070
85SP	CTLN-1701-148	1/30/2017	< 0.001	0.003	< 0.05	< 0.001	0.47	< 0.001	446	< 0.005	< 0.005	0.1	6.41	< 0.001	< 0.1	2.66	< 0.0001	0.012	6.8	1.2	< 0.001	2,560	< 0.0005	4,270
85SP	CTLN-1703-360	3/14/2017	< 0.001	0.004	< 0.05	< 0.001	0.45	< 0.001	460	< 0.005	0.006	0.1	7.88	< 0.001	< 0.1	3.05	< 0.0001	0.015	6.8	1.1	< 0.002	2,700	< 0.0005	4,270
85SP	CTLN-1705-952	5/2/2017	< 0.001	0.002	< 0.05	< 0.001	0.51	0.001	472	< 0.005	0.007	0.1	7.48	< 0.001	< 0.1	2.92	< 0.0001	0.013	6.8	0.8	< 0.002	2,800	< 0.0005	4,200
85SP	CTLN-1705-417	5/31/2017	< 0.001	0.004	< 0.05	< 0.001	0.52	< 0.001	490	< 0.005	0.005	0.1	8	< 0.001	< 0.1	2.99	< 0.0001	0.013	6.7	1.6	0.005	2,830	< 0.0005	4,580
85SP	CTLN-1706-350	6/27/2017	< 0.001	0.003	< 0.05	< 0.001	0.49	< 0.001	471	< 0.005	0.005	0.1	7.08	< 0.001	< 0.1	3.01	< 0.0001	0.014	6.7	3.8	< 0.001	3,020	< 0.0005	4,370
85SP	CTLN-1708-326	8/1/2017	< 0.001	0.003	< 0.05	< 0.001	0.46	< 0.001	464	< 0.005	0.006	0.1	7.94	< 0.001	< 0.1	3.27	< 0.0001	0.013	6.7	2.4	< 0.001	3,130	< 0.0005	4,790
85SP (Dup)	CTLN-1708-327	8/1/2017	< 0.001	0.003	< 0.05	< 0.001	0.45	< 0.001	520	< 0.005	0.006	0.1	7.82	< 0.001	< 0.1	3.58	< 0.0001	0.013	6.7	1.9	< 0.001	3,300	< 0.0005	4,800
85SP	CTLN-1709-493	9/7/2017	< 0.001	0.002	< 0.05	< 0.001	0.49	< 0.001	559	< 0.005	0.006	0.1	7.87	< 0.001	< 0.1	3.51	< 0.0001	0.012	6.7	1.4	< 0.001	3,740	< 0.0005	5,260
89SP	TLN-1602-907-CCR	2/23/2016	< 0.001	< 0.001	< 0.05	< 0.001	1.03	< 0.001	473	< 0.005	0.011	0.1	0.23	< 0.001	< 0.1	3.14	< 0.0001	< 0.001	6.7	3	< 0.001	2,830	< 0.0005	4,740
89SP (Dup)	TLN-1602-908-CCR	2/23/2016	< 0.001	< 0.001	< 0.05	< 0.001	1.08	< 0.001	496	< 0.005	0.011	0.1	0.25	< 0.001	< 0.1	3.08	< 0.0001	< 0.001	6.7	1.9	< 0.001	2,850	< 0.0005	4,810
89SP	CTLN-1605-205	5/11/2016	< 0.001	< 0.001	< 0.05	< 0.001	1.01	< 0.001	489	< 0.005	0.013	0.1	0.29	< 0.001	0.1	3.18	< 0.0001	< 0.001	6.7	1.8	< 0.001	2,800	< 0.0005	4,770
89SP	CTLN-1606-445	6/20/2016	< 0.001	< 0.001	< 0.05	< 0.001	0.95	< 0.001	467	< 0.005	0.011	0.1	0.23	< 0.001	0.1	3.07	< 0.0001	< 0.001	6.8	0.7	< 0.001	2,850	< 0.0005	4,660
89SP (Dup)	CTLN-1606-446	6/20/2016	< 0.001	< 0.001	< 0.05	< 0.001	0.95	< 0.001	476	< 0.005	0.011	0.1	0.23	< 0.001	0.1	3.12	< 0.0001	< 0.001	6.8	2.4	< 0.001	2,830	< 0.0005	4,700
89SP	CTLN-1608-363	8/11/2016	< 0.001	< 0.001	< 0.05	< 0.001	0.93	< 0.001	445	< 0.005	0.01	< 0.1	0.23	< 0.001	< 0.1	2.99	< 0.0001	< 0.001	6.8	3.4	< 0.001	2,800	< 0.0005	4,710
89SP	CTLN-1609-365	9/27/2016	< 0.001	< 0.001	< 0.05	< 0.001	1.07	< 0.001	499	< 0.005	0.011	0.1	0.26	< 0.001	0.1	3.12	< 0.0001	< 0.001	6.8	1	< 0.001	2,800	< 0.0005	4,620
89SP (Dup)	CTLN-1609-366	9/27/2016	< 0.001	< 0.001	< 0.05	< 0.001	1.07	< 0.001	500	< 0.005	0.011	0.1	0.26	< 0.001	0.1	3.09	< 0.0001	< 0.001	6.8	2.2	< 0.001	2,840	< 0.0005	4,540
89SP	CTLN-1612-245	12/5/2016	< 0.001	< 0.001	< 0.05	< 0.001	0.93	< 0.001	479	< 0.005	0.011	0.1	0.32	0.002	0.2	3.01	< 0.0001	< 0.001	6.8	4.3	< 0.002	2,810	< 0.0005	4,610
89SP	CTLN-1701-144	1/30/2017	< 0.001	< 0.001	< 0.05	< 0.001	0.91	< 0.001	451	< 0.005	0.011	0.1	0.25	< 0.001	< 0.1	3.1	< 0.0001	< 0.001	6.8	2.6	< 0.001	2,850	< 0.0005	4,610
89SP	CTLN-1703-747	3/9/2017	< 0.001	< 0.001	< 0.05	< 0.001	0.9		459			0.1	0.27	< 0.001	< 0.1	2.93		< 0.001	6.8	2.1		2,790	< 0.0005	4,560
89SP	CTLN-1705-953	5/2/2017	< 0.001	< 0.001	< 0.05	< 0.001	0.95	< 0.001	466	< 0.005	0.012	0.1	0.27	< 0.001	< 0.1	3.17	< 0.0001	< 0.001	6.8	3.9	< 0.002	2,780	< 0.0005	4,450
89SP	CTLN-1705-420	5/31/2017	< 0.001	0.002	< 0.05	< 0.001	0.96	< 0.001	475	< 0.005	0.011	0.1	0.26	< 0.001	< 0.1	3.29	< 0.0001	< 0.001	6.8	3	0.007	3,130	< 0.0005	4,630
89SP	CTLN-1706-410	6/21/2017	< 0.001	< 0.001	< 0.05	< 0.001	0.94	< 0.001	469	< 0.005	0.011	0.1	0.24	< 0.001	< 0.1	3.33	< 0.0001	< 0.001	6.8	3	< 0.002	2,890	< 0.0005	4,580
89SP	CTLN-1708-331	8/1/2017	< 0.001	< 0.001	< 0.05	< 0.001	0.85	< 0.001	490	< 0.005	0.011	0.1	0.27	< 0.001	< 0.1	3.44	< 0.0001	< 0.001	6.7	3.7	< 0.001	3,080	< 0.0005	4,710
89SP	CTLN-1708-476	8/31/2017	< 0.001	< 0.001	< 0.05	< 0.001	0.93	< 0.001	486	< 0.005	0.012	0.1	0.29	< 0.001	< 0.1	3.45	< 0.0001	< 0.001	6.7	0.9	< 0.001	3,140	< 0.0005	4,710
152SP-2-CCR	CTLN-1704-919	4/14/2017	< 0.001	< 0.001	< 0.05	0.007	0.68	< 0.001	464	< 0.005	0.015	0.1	6.92	< 0.001	< 0.1	3.89	< 0.0001	0.002	6.8	1.5	< 0.001	2,830	< 0.0005	4,400
152SP-2-CCR (Dup)	CTLN-1704-920	4/14/2017	< 0.001	< 0.001	< 0.05	< 0.001	0.67	< 0.001	451	< 0.005	0.015	0.1	6.62	< 0.001	< 0.1	3.74	< 0.0001	0.002	6.8	1.5	< 0.001	2,870	< 0.0005	4,710
152SP-2-CCR	CTLN-1705-955	5/2/2017	< 0.001	< 0.001	< 0.05	< 0.001	0.66	0.007	467	< 0.005	0.015	0.1	6.82	< 0.001	< 0.1	3.7	< 0.0001	0.001	6.7	1.9	< 0.002	2,880	< 0.0005	4,260
152SP-2-CCR	CTLN-1705-419	5/31/2017	< 0.001	0.002	< 0.05	< 0.001	0.66	< 0.001	490	< 0.005	0.014	0.1	7.4	< 0.001	< 0.1	3.87	< 0.0001	0.001	6.7	7.2	0.006	3,160	< 0.0005	4,640
152SP-2-CCR	CTLN-1706-353	6/27/2017	< 0.001	0.001	< 0.05	< 0.001	0.66	< 0.001	477	< 0.005	0.012	0.1	7.15	< 0.001	< 0.1	3.49	< 0.0001	< 0.001	6.7	1.9	< 0.001	3,110	< 0.0005	4,410
152SP-2-CCR	CTLN-1708-329	8/1/2017	< 0.001	0.001	< 0.05	< 0.001	0.57	< 0.001	488	< 0.005	0.014	0.1	7.3	< 0.001	< 0.1	4.1	< 0.0001	0.001	6.7	2.6	< 0.001	3,100	< 0.0005	4,700
152SP-2-CCR	CTLN-1709-490	9/7/2017	< 0.001	< 0.001	< 0.05	< 0.001	0.59	< 0.001	488	< 0.005	0.018	0.2	7.29	< 0.001	< 0.1	4.19	< 0.0001	< 0.001	6.7	2.5	< 0.001	3,430	0.001	4,940
152SP-2-CCR	CTLN-1711-400	11/30/2017	< 0.001	0.001	< 0.05	< 0.001	0.62	< 0.001	581	< 0.005	0.019	0.2	8.16	< 0.001	< 0.1	4.84	< 0.0001	< 0.001	6.6	3	< 0.001	3,240	< 0.0005	5,210
153SP-CCR	CTLN-1604-122	4/11/2016	< 0.001	0.002	< 0.05	< 0.001	2.06	< 0.001	345	< 0.005	< 0.005	0.3	0.46	< 0.001	0.4	0.55	< 0.0001	0.384	7.8	1.6	0.001	2,000	< 0.0005	3,080
153SP-CCR	CTLN-1606-448	6/20/2016	< 0.001 DIS < 0.001 TRC	0.002 DIS 0.002 TRC	< 0.05 DIS < 0.05 TRC	< 0.001 DIS < 0.001 TRC	1.88 DIS 1.95 TRC	< 0.001 DIS < 0.001 TRC	274 DIS 281 TRC	< 0.005 DIS < 0.005 TRC	< 0.005 TRC	0.4	0.48 DIS 0.82 TRC	< 0.001 DIS < 0.001 TRC	0.3 **DIS** 0.3 **TRC**	0.537 **DIS** 0.535 **TRC**	< 0.0001 DIS < 0.0001 TRC	0.365 **DIS** 0.400 **TRC**	7.7	2.4 TRC	< 0.001 DIS < 0.001 TRC	1,730	< 0.0005 DIS < 0.0005 TRC	2,680

APPENDIX F

Colstrip SES Federal CCR Rule Groundwater Draft Baseline Monitoring Data - 2016 Through November 30, 2017

Comparison For Montana DEQ Human Health GW MCLs (If No MCL Listed Then EPA RSL For Tapwater - Ingestion For Child, RSL Limit Was Used)

***Metals analyzed as Total Recoverable (TRC) unless turbidity >10, then metals ran both as Total Recoverable (TRC) and Dissolved (DIS).**

🟧 ***Highlighted Values Exceed MCL or EPA Tapwater RSL***

🟦 ***Highlighted Values Are Detection Limits Higher than the MCL or EPA Tapwater RSL***

Site Code	Sample Code	Date	ANTIMONY 7440-36-0 mg/L	ARSENIC 7440-38-2 mg/L	BARIUM 7440-39-3 mg/L	BERYLLIUM 7440-41-7 mg/L	BORON 7440-42-8 mg/L	CADMIUM 7440-43-9 mg/L	CALCIUM 7440-70-2 mg/L	CHROMIUM 7440-47-3 mg/L	COBALT 7440-48-4 mg/L	FLUORIDE 16984-48-8 mg/L	IRON 7439-89-6 mg/L	LEAD 7439-92-1 mg/L	LITHIUM 7439-93-2 mg/L	MANGANESE 7439-96-5 mg/L	MERCURY 7439-97-6 mg/L	MOLYBDENUM 7439-98-7 mg/L	pH NA standard units	RADIUM 226/228 7440-14-4 pCi/L	SELENIUM 7782-49-2 mg/L	SULFATE 14808-79-8 mg/L	THALLIUM 7440-28-0 mg/L	TDS NA mg/L
			MCL - 0.006	MCL - 0.01	MCL - 1.0	MCL - 0.004	RSL - 4.0	MCL - 0.005	no MCL/ RSL	MCL - 0.1	RSL - 0.006	MCL - 4.0	No MCL/ RSL	MCL - 0.015	RSL - 0.04	RSL 0.43	MCL - 0.002	RSL - 0.1	no MCL/ RSL	MCL - 5.0	MCL - 0.05	no MCL/ RSL	MCL - 0.002	no MCL/ RSL
Units 3&4 Bottom Ash Pond (continued)																								
153SP-CCR	CTLN-1608-908	8/18/2016	< 0.001 DIS < 0.001 TRC	0.002 DIS 0.003 TRC	< 0.05 DIS < 0.05 TRC	< 0.001 DIS < 0.001 TRC	1.97 DIS 1.87 TRC	< 0.001 DIS < 0.001 TRC	227 DIS 222 TRC	< 0.005 DIS < 0.005 TRC	< 0.005 DIS < 0.005 TRC	0.4	0.51 DIS 0.81 TRC	< 0.001 DIS < 0.001 TRC	**0.3 DIS** **0.3 TRC**	0.421 DIS 0.419 TRC	< 0.0001 DIS < 0.0001 TRC	**0.384 DIS** **0.408 TRC**	7.7	1.1 TRC	< 0.001 DIS < 0.001 TRC	1,440	0.0007 DIS < 0.0005 TRC	2,230
153SP-CCR	CTLN-1609-368	9/27/2016	< 0.001	0.003	< 0.05	< 0.001	2	< 0.001	216	< 0.005	< 0.005	0.4	0.49	< 0.001	**0.3**	0.4	< 0.0001	**0.41**	7.8	1.7	< 0.001	1,350	< 0.0005	2,110
153SP-CCR	CTLN-1612-250	12/6/2016	< 0.001 DIS < 0.001 TRC	0.002 DIS 0.005 TRC	< 0.05 DIS < 0.05 TRC	< 0.001 DIS < 0.001 TRC	2.15 DIS 1.92 TRC	< 0.001 DIS < 0.001 TRC	224 DIS 227 TRC	< 0.005 DIS < 0.005 TRC	< 0.005 DIS < 0.005 TRC	0.3	0.53 DIS 1.23 TRC	< 0.001 DIS < 0.001 TRC	**0.3 DIS** **0.3 TRC**	**0.451 DIS** 0.415 TRC	< 0.0001 DIS < 0.0001 TRC	**0.365 DIS** **0.367 TRC**	7.7	1.6 TRC	0.002 DIS < 0.002 TRC	1,370	< 0.0005 DIS < 0.0005 TRC	2,130
153SP-CCR	CTLN-1701-146	1/30/2017	< 0.001	0.003	< 0.05	< 0.001	2.13	< 0.001	247	< 0.005	< 0.005	0.4	0.6	< 0.001	**0.3**	**0.452**	< 0.0001	**0.36**	7.7	1.2	< 0.001	1,480	< 0.0005	2,250
153SP-CCR	CTLN-1703-359	3/14/2017	< 0.001	0.003	< 0.05	< 0.001	1.89	< 0.001	250	< 0.005	< 0.005	0.4	0.64	< 0.001	**0.3**	**0.5**	< 1e-04	**0.392**	7.7	1.8	< 0.002	1,470	< 0.0005	2,260
153SP-CCR	CTLN-1704-947	4/27/2017	< 0.001	0.003	< 0.05	< 0.001	2.08	< 0.001	253	< 0.005	< 0.005	0.4	0.64	< 0.001	**0.3**	**0.514**	< 1e-04	**0.354**	7.6	1.4	< 0.002	1,500	< 0.0005	2,220
153SP-CCR	CTLN-1705-422	5/31/2017	< 0.001	0.007	< 0.05	< 0.001	2.13	< 0.001	276	< 0.005	< 0.005	0.4	0.81	< 0.001	**0.3**	**0.496**	< 1e-04	**0.326**	7.6	4.1	0.018	1,640	< 0.0005	2,240
153SP-CCR	CTLN-1706-357	6/28/2017	< 0.001	0.003	< 0.05	< 0.001	2.12	< 0.001	287	< 0.005	< 0.005	0.3	0.62	< 0.001	**0.4**	**0.453**	< 1e-04	**0.323**	7.6	3.1	< 0.001	1,630	< 0.0005	2,190
153SP-CCR	CTLN-1708-330	8/1/2017	< 0.001	0.002	< 0.05	< 0.001	1.74	< 0.001	312	< 0.005	< 0.005	0.4	0.61	< 0.001	**0.3**	**0.532**	< 1e-04	**0.307**	7.6	1.7	< 0.001	1,640	< 0.0005	2,240
153SP-CCR	CTLN-1709-495	9/8/2017	< 0.001	0.003	< 0.05	< 0.001	1.78	< 0.001	311	< 0.005	< 0.005	0.3	0.79	< 0.001	**0.4**	**0.541**	< 1e-04	**0.301**	7.6	3.4	< 0.001	1,600	< 0.0005	2,330
Units 1&2 Bottom Ash Pond																								
13M	TLN-1602-904-CCR1	2/19/2016	< 0.001	< 0.001	< 0.05	< 0.001	0.58	< 0.001	565	< 0.005	< 0.005	0.2	0.52	< 0.001	< 0.1	0.347	< 0.0001	< 0.001	7.1	0.9	< 0.001	2,860	< 0.0005	4,560
13M (Dup)	TLN-1602-905-CCR2	2/19/2016	< 0.001	< 0.001	< 0.05	< 0.001	0.68	< 0.001	476	< 0.005	< 0.005	0.2	0.52	< 0.001	< 0.1	0.34	< 0.0001	< 0.001	7.2	1.8	< 0.001	2,680	< 0.0005	4,260
13M	CTLN-1604-145	4/26/2016	< 0.001	< 0.001	< 0.05	< 0.001	0.64	< 0.001	433	< 0.005	< 0.005	0.2	0.91	0.001	**0.1**	0.336	< 0.0001	0.006	7.2	1.8	< 0.004	2,670	0.0008	4,240
13M	CTLN-1606-340	6/28/2016	< 0.001	< 0.001	< 0.05	< 0.001	0.61	< 0.001	434	< 0.005	< 0.005	0.2	0.03	< 0.001	< 0.1	0.188	< 0.0001	< 0.001	7.2	0.4	< 0.002	2,720	< 0.0005	4,220
13M	CTLN-1608-342	8/3/2016	< 0.001	< 0.001	< 0.05	< 0.001	0.68	< 0.001	477	< 0.005	< 0.005	0.2	0.05	< 0.001	< 0.1	0.244	< 0.0001	< 0.001	7.2	1.5	< 0.001	2,640	< 0.0005	4,180
13M	CTLN-1609-346	9/8/2016	< 0.001	< 0.001	< 0.05	< 0.001	0.59	< 0.001	437	< 0.005	< 0.005	0.2	0.07	< 0.001	< 0.1	0.265	< 0.0001	< 0.001	7.3	2.8	< 0.001	2,690	< 0.0005	3,990
13M	CTLN-1611-342	11/30/2016	< 0.001	< 0.001	< 0.05	< 0.001	0.62	< 0.001	440	< 0.005	< 0.005	0.2	0.23	< 0.001	**0.2**	0.303	< 0.0001	< 0.001	7.3	4	< 0.002	2,740	< 0.0005	4,050
13M	CTLN-1702-332A	2/6/2017	0.001	< 0.001	< 0.05	< 0.001	0.6	< 0.001	452	< 0.005	< 0.005	0.2	0.16	0.001	< 0.1	0.168	< 0.0001	0.001	7.2	2.2	< 0.002	2,670	0.0009	4,300
13M	CTLN-1703-335	3/2/2017	< 0.001	< 0.001	< 0.05	< 0.001	0.58	< 0.001	470	< 0.005	< 0.005	0.2	0.03	< 0.001	< 0.1	0.088	< 0.0001	< 0.001	7.2	0.9	< 0.002	2,640	< 0.0005	4,290
13M	CTLN-1705-949	5/1/2017	< 0.001	< 0.001	< 0.05	< 0.001	0.61	< 0.001	443	< 0.005	< 0.005	0.2	0.04	< 0.001	< 0.1	0.017	< 0.0001	< 0.001	7.3	2	< 0.002	2,820	< 0.0005	3,920
13M	CTLN-1708-447	8/16/2017	< 0.001	< 0.001	< 0.05	< 0.001	0.75	< 0.001	421	< 0.005	< 0.005	0.2	0.07	< 0.001	< 0.1	0.221	< 0.0001	< 0.001	7.2	0.6	< 0.001	2,860	< 0.0005	3,980
13S	TLN-1602-902-CCR	2/19/2016	< 0.001	< 0.001	< 0.05	< 0.001	3.31	< 0.001	462	< 0.005	**0.013**	0.3	< 0.02	< 0.001	< 0.1	< 0.001	< 0.0001	< 0.001	7.1	2.4	< 0.002	3,050	< 0.0005	5,190
13S	CTLN-1604-141	4/22/2016	< 0.001	< 0.001	< 0.05	< 0.001	3.54	< 0.001	484	< 0.005	**0.012**	0.3	0.03	< 0.001	< 0.1	< 0.001	< 0.0001	0.002	7.2	0.5	0.003	3,100	< 0.0005	5,060
13S	CTLN-1606-339	6/28/2016	< 0.001	< 0.001	< 0.05	< 0.001	3.4	< 0.001	424	< 0.005	**0.016**	0.3	< 0.03	< 0.001	< 0.1	0.002	< 0.0001	0.002	7.1	4.3	< 0.002	3,000	< 0.0005	5,120
13S	CTLN-1608-340	8/2/2016	< 0.001	< 0.001	< 0.05	< 0.001	3.29	< 0.001	450	< 0.005	**0.015**	0.3	< 0.05	< 0.001	< 0.1	< 0.001	< 0.0001	0.003	7.1	**12.1**	< 0.002	3,030	< 0.0005	5,020
13S	CTLN-1609-345	9/8/2016	< 0.001	< 0.001	< 0.05	< 0.001	3.41	< 0.001	494	< 0.005	**0.014**	0.3	< 0.02	< 0.001	< 0.1	0.001	< 0.0001	0.002	7.1	2.7	< 0.001	3,030	< 0.0005	5,110
13S	CTLN-1611-341	11/30/2016	< 0.001	< 0.001	< 0.05	< 0.001	3.57	< 0.001	436	< 0.005	**0.013**	0.3	0.03	< 0.001	**0.1**	0.003	< 0.0001	0.002	7.0	**6.2**	< 0.002	3,020	< 0.0005	5,060
13S	CTLN-1702-331A	2/6/2017	< 0.001	< 0.001	< 0.05	< 0.001	3.34	< 0.001	461	< 0.005	**0.014**	0.3	0.03	0.002	< 0.1	< 0.001	< 0.0001	0.002	7.1	0.7	< 0.002	3,100	< 0.0005	5,030
13S	CTLN-1703-334	3/2/2017	< 0.001	< 0.001	< 0.05	< 0.001	3.49	< 0.001	427	< 0.005	**0.014**	0.3	< 0.02	< 0.001	< 0.1	< 0.001	< 0.0001	0.003	7.1	2.5	< 0.002	3,150	< 0.0005	5,140
13S	CTLN-1705-304	5/2/2017	< 0.001	0.002	< 0.05	< 0.001	3.97	< 0.001	467	< 0.005	**0.021**	0.3	< 0.02	< 0.001	< 0.1	0.002	< 0.0001	0.002	7.1	2.7	< 0.002	3,150	< 0.0005	5,080
13S	CTLN-1708-441	8/14/2017	< 0.001	< 0.001	< 0.05	< 0.001	**4.48**	< 0.001	499	< 0.005	**0.017**	0.2	< 0.02	< 0.001	< 0.1	0.005	< 0.0001	0.002	7	4.4	< 0.001	3,320	< 0.0005	5,130
48S	TLN-1602-905-CCR1	2/22/2016	< 0.001	< 0.001	< 0.05	< 0.001	1.28	< 0.001	337	< 0.005	< 0.005	0.4	1.29	< 0.001	< 0.1	**1.28**	< 0.0001	0.002	7.1	2	< 0.001	2,380	< 0.0005	4,230
48S	CTLN-1604-146	4/26/2016	< 0.001	< 0.001	< 0.05	< 0.001	1.15	< 0.001	372	< 0.005	< 0.005	0.4	1.1	< 0.001	**0.1**	**1.59**	< 0.0001	0.006	7.3	3.1	< 0.004	2,520	< 0.0005	4,400
48S	CTLN-1604-147	4/26/2016	< 0.001	< 0.001	< 0.05	< 0.001	1.07	< 0.001	340	< 0.005	< 0.005	0.4	1.41	< 0.001	**0.1**	**1.51**	< 0.0001	0.002	7.2	2.8	< 0.004	2,490	< 0.0005	4,420
48S	CTLN-1606-320	6/15/2016	< 0.001 DIS < 0.001 TRC	< 0.001 DIS < 0.001 TRC	< 0.05 DIS < 0.05 TRC	< 0.001 DIS < 0.001 TRC	1.06 DIS 1.08 TRC	< 0.001 DIS < 0.001 TRC	314 DIS 357 TRC	< 0.005 DIS < 0.005 TRC	< 0.005 DIS < 0.005 TRC	0.4	0.49 DIS 2.77 TRC	< 0.001 DIS 0.001 TRC	< 0.1 DIS < 0.1 TRC	**1.46 DIS** **1.68 TRC**	< 0.0001 DIS < 0.0001 TRC	0.002 DIS 0.002 TRC	7.2	2.3 TRC	< 0.001 DIS < 0.001 TRC	2,470	< 0.0005 DIS < 0.0005 TRC	4,210
48S	CTLN-1607-318	7/14/2016	< 0.001	< 0.001	< 0.05	< 0.001	1.12	< 0.001	344	< 0.005	< 0.005	0.4	0.69	< 0.001	**0.1**	**1.44**	< 0.0001	0.002	7.3	1	< 0.001	2,460	< 0.0005	4,490
48S	CTLN-1609-342	9/7/2016	< 0.001	< 0.001	< 0.05	< 0.001	1.11	< 0.001	329	< 0.005	< 0.005	0.4	1.17	< 0.001	< 0.1	**1.35**	< 0.0001	0.002	7.3	3	< 0.001	2,520	< 0.0005	4,340
48S	CTLN-1612-353	12/7/2016	< 0.001 DIS < 0.001 TRC	< 0.001 DIS 0.004 TRC	< 0.05 DIS 0.12 TRC	< 0.001 DIS < 0.001 TRC	1.09 DIS 1.15 TRC	< 0.001 DIS < 0.001 TRC	303 DIS 352 TRC	< 0.005 DIS < 0.005 TRC	< 0.005 DIS < 0.005 TRC	0.3	0.24 DIS 11.1 TRC	< 0.001 DIS 0.004 TRC	**0.1 DIS** **0.2 TRC**	**1.58 DIS** **1.63 TRC**	< 0.0001 DIS < 0.0001 TRC	0.001 DIS 0.002 TRC	7.2	1.4 TRC	< 0.001 DIS < 0.002 TRC	2,360	< 0.0005 DIS < 0.0005 TRC	4,110
48S	CTLN-1702-339	2/13/2017	< 0.001 DIS < 0.001 TRC	< 0.001 DIS < 0.001 TRC	< 0.05 DIS < 0.05 TRC	< 0.001 DIS < 0.001 TRC	1.04 DIS 1.07 TRC	< 0.001 DIS < 0.001 TRC	316 DIS 327 TRC	< 0.005 DIS < 0.005 TRC	< 0.005 DIS < 0.005 TRC	0.4	0.31 DIS 2.26 TRC	< 0.001 DIS < 0.001 TRC	< 0.1 DIS < 0.1 TRC	**1.37 DIS** **1.55 TRC**	< 0.0001 DIS < 0.0001 TRC	0.001 DIS 0.002 TRC	7.2	2.7 TRC	< 0.002 DIS < 0.002 TRC	2,420	< 0.0005 DIS < 0.0005 TRC	4,040
48S	CTLN-1703-357	3/13/2017	< 0.001	< 0.001	< 0.05	< 0.001	1.01	< 0.001	316	< 0.005	< 0.005	0.4	1.32	< 0.001	< 0.1	**1.58**	< 0.0001	0.002	7.3	0.7	< 0.002	2,470	< 0.0005	4,110
48S	CTLN-1704-333	4/24/2017	< 0.001	< 0.001	< 0.05	< 0.001	0.99	< 0.001	301	< 0.005	< 0.005	0.4	3.02	< 0.001	< 0.1	**1.51**	< 0.0001	0.002	7.3	5	< 0.002	2,400	< 0.0005	3,900
48S	CTLN-1708-354	8/10/2017	< 0.001	< 0.001	< 0.05	< 0.001	0.87	< 0.001	292	< 0.005	< 0.005	0.4	1.42	< 0.001	< 0.1	**1.63**	< 0.0001	0.002	7.3	1.8	< 0.001	2,380	< 0.0005	4,030
148A-CCR	CTLN-1604-124	4/12/2016	< 0.001	0.001	< 0.05	< 0.001	2.84	< 0.001	407	< 0.005	**0.009**	0.3	0.56	< 0.001	**0.3**	**1.11**	< 0.0001	< 0.003	7.4	2.8	< 0.001	2,630	< 0.0005	4,650
148A-CCR	CTLN-1606-319	6/15/2016	< 0.001	< 0.001	< 0.05	< 0.001	2.31	< 0.001	392	< 0.005	< 0.005	0.2	0.16	< 0.001	**0.2**	**1.03**	< 0.0001	0.001	7.2	2.3	< 0.001	2,550	< 0.0005	4,260
148A-CCR	CTLN-1607-317	7/14/2016	< 0.001	< 0.001	< 0.05	< 0.001	2.18	< 0.001	366	< 0.005	< 0.005	0.3	0.21	< 0.001	**0.2**	**0.833**	< 0.0001	0.001	7.3	0.4	< 0.001	2,480	< 0.0005	4,490
148A-CCR	CTLN-1609-343	9/7/2016	< 0.001	< 0.001	< 0.05	< 0.001	1.94	< 0.001	341	< 0.005	< 0.005	0.3	0.64	< 0.001	**0.2**	**0.869**	< 0.0001	0.001	7.3	1.5	< 0.001	2,480	< 0.0005	4,380
148A-CCR	CTLN-1611-338	11/29/2016	< 0.001	< 0.001	< 0.05	< 0.001	1.99	< 0.001	366	< 0.005	< 0.005	0.3	0.3	< 0.001	**0.3**	**0.963**	< 0.0001	0.002	7.2	1.5	< 0.002	2,470	0.0005	4,260
148A-CCR (Dup)	CTLN-1611-339	11/29/2016	< 0.001	< 0.001	< 0.05	< 0.001	2.06	< 0.001	375	< 0.005	< 0.005	0.3	0.29	< 0.001	**0.3**	**0.916**	< 0.0001	0.001	7.2	1.5	< 0.002	2,440	< 0.0005	4,240
148A-CCR	CTLN-1702-337	2/13/2017	< 0.001	< 0.001	< 0.05	< 0.001	2	< 0.001	359	< 0.005	< 0.005	0.3	2.15	< 0.001	**0.2**	**1.08**	< 0.0001	0.002	7.2	1	< 0.002	2,610	< 0.0005	4,370
148A-CCR	CTLN-1702-338	2/13/2017	< 0.001	< 0.001	< 0.05	< 0.001	2	< 0.001	360	< 0.005	< 0.005	0.3	2.34	< 0.001	**0.2**	**1.09**	< 0.0001	0.001	7.2	2.8	< 0.002	2,630	< 0.0005	4,350
148A-CCR	CTLN-1703-358	3/13/2017	< 0.001	< 0.001	< 0.05	< 0.001	1.68	< 0.001	347	< 0.005	< 0.005	0.3	1.57	< 0.001	**0.2**	**1**	< 0.0001	0.001	7.3	2.1	< 0.002	2,420	0.0007	4,200
148A-CCR	CTLN-1704-334	4/24/2017	< 0.001	< 0.001	< 0.05	< 0.001	1.83	< 0.001	339	< 0.005	< 0.005	0.3	0.65	< 0.001	**0.2**	**0.94**	< 0.0001	0.002	7.3	2.3	< 0.002	2,580	< 0.0005	4,040
148A-CCR	CTLN-1708-456	8/21/2017	< 0.001	< 0.001	< 0.05	< 0.001	1.75	< 0.001	315	< 0.005	< 0.005	0.3	0.75	< 0.001	**0.2**	**0.998**	< 0.0001	0.001	7.3	1.6	< 0.001	2,870	< 0.0005	4,250
149M-CCR	CTLN-1604-120	4/11/2016	< 0.001	0.002	< 0.05	< 0.001	**37.6**	< 0.001	451	< 0.005	< 0.005	< 0.1	16.7	< 0.001	**0.7**	0.152	< 0.0001	0.001	6.5	1.3	0.002	7,140	0.0005	10,600
149M-CCR	CTLN-1606-316	6/15/2016	< 0.001	0.002	< 0.05	< 0.001	**35**	< 0.001	410	< 0.005	< 0.005	< 0.1	16.1	< 0.001	**0.5**	0.143	< 0.0001	< 0.001	6.3	3.1	< 0.002	6,180	0.0014	8,650
149M-CCR	CTLN-1607-314	7/14/2016	< 0.001	0.001	< 0.05	< 0.001	**32.5**	< 0.001	369	< 0.005	< 0.005	< 0.1	12.7	< 0.001	**0.5**	0.115	< 0.0001	0.001	6.3	1.3	< 0.002	5,670	< 0.0005	8,580
149M-CCR	CTLN-1607-315	7/14/2016	< 0.001	< 0.001	< 0.05	< 0.001	**31.2**	< 0.001	351	< 0.005	< 0.005	< 0.1	12.5	< 0.001	**0.5**	0.117	< 0.0001	0.001	6.3	1.1	< 0.002	5,740	< 0.0005	8,730
149M-CCR	CTLN-1609-339	9/7/2016	< 0.001	< 0.001	< 0.05	< 0.001	**32**	< 0.001	374	< 0.005	< 0.005	< 0.1	13.2	< 0.001	**0.5**	0.108	< 0.0001	< 0.001	6.3	**5.4**	< 0.002	5,730	< 0.0005	8,620
149M-CCR	CTLN-1612-349	12/7/2016	< 0.001	0.002	< 0.05	< 0.001	**32.3**	< 0.001	406	< 0.005	< 0.005	< 0.1	15.9	0.002	**0.5**	0.15	< 0.0001	0.002	6.4	2.8	< 0.004	6,080	0.0017	9,520

APPENDIX F

Colstrip SES Federal CCR Rule Groundwater Draft Baseline Monitoring Data - 2016 Through November 30, 2017

Comparison For Montana DEQ Human Health GW MCLs (If No MCL Listed Then EPA RSL For Tapwater - Ingestion For Child, RSL Limit Was Used)

***Metals analyzed as Total Recoverable (TRC) unless turbidity >10, then metals ran both as Total Recoverable (TRC) and Dissolved (DIS).**

🟧 ***Highlighted Values Exceed MCL or EPA Tapwater RSL***

⬜ ***Highlighted Values Are Detection Limits Higher than the MCL or EPA Tapwater RSL***

Site Code	Sample Code	Date	ANTIMONY 7440-36-0 mg/L	ARSENIC 7440-38-2 mg/L	BARIUM 7440-39-3 mg/L	BERYLLIUM 7440-41-7 mg/L	BORON 7440-42-8 mg/L	CADMIUM 7440-43-9 mg/L	CALCIUM 7440-70-2 mg/L	CHROMIUM 7440-47-3 mg/L	COBALT 7440-48-4 mg/L	FLUORIDE 16984-48-8 mg/L	IRON 7439-89-6 mg/L	LEAD 7439-92-1 mg/L	LITHIUM 7439-93-2 mg/L	MANGANESE 7439-96-5 mg/L	MERCURY 7439-97-6 mg/L	MOLYBDENUM 7439-98-7 mg/L	pH NA standard units	RADIUM 226/228 7440-14-4 pCi/L	SELENIUM 7782-49-2 mg/L	SULFATE 14808-79-8 mg/L	THALLIUM 7440-28-0 mg/L	TDS NA mg/L
			MCL - 0.006	MCL - 0.01	MCL - 1.0	MCL - 0.004	RSL - 4.0	MCL - 0.005	no MCL/ RSL	MCL - 0.1	RSL - 0.006	MCL - 4.0	No MCL/ RSL	MCL - 0.015	RSL - 0.04	RSL 0.43	MCL - 0.002	RSL - 0.1	no MCL/ RSL	MCL - 5.0	MCL - 0.05	no MCL/ RSL	MCL - 0.002	no MCL/ RSL
Units 1&2 Bottom Ash Pond (continued)																								
149M-CCR	CTLN-1702-336A	2/7/2017	< 0.001	0.003	< 0.05	< 0.001	31.5	< 0.001	393	< 0.005	< 0.005	< 0.1	15.5	0.001	0.5	0.158	< 0.0001	0.001	6.4	1.9	< 0.002	7,000	0.0011	9,580
149M-CCR	CTLN-1703-355	3/13/2017	< 0.001	< 0.002	< 0.05	< 0.001	23.1	< 0.001	396	< 0.005	< 0.005	< 0.1	14	< 0.001	0.3	0.12	< 0.0001	0.001	6.2	5.6	< 0.004	5,750	0.0009	8,540
149M-CCR (Dup)	CTLN-1704-338	4/25/2017	< 0.001	0.002	< 0.05	< 0.001	32.8	< 0.001	400	< 0.005	< 0.005	< 0.1	14.8	< 0.001	0.5	0.142	< 0.0001	0.001	6.4	5.3	< 0.002	6,590	0.0006	8,940
149M-CCR (Dup)	CTLN-1704-339	4/25/2017	< 0.001	0.001	< 0.05	< 0.001	32.5	< 0.001	393	< 0.005	< 0.005	< 0.1	15.4	< 0.001	0.4	0.145	< 0.0001	0.002	6.4	4	< 0.002	6,620	0.0006	9,200
149M-CCR	CTLN-1708-444	8/14/2017	< 0.001	0.001	< 0.05	< 0.001	29.4	< 0.001	388	< 0.005	< 0.005	< 0.1	12.6	< 0.001	0.4	0.129	< 0.0001	0.001	6.3	5.8	0.001	6,470	0.0012	8,900
150M-CCR	CTLN-1604-123	4/12/2016	< 0.001	< 0.001	< 0.05	< 0.001	0.8	0.001	634	< 0.005	< 0.005	0.2	9.2	< 0.001	0.2	0.573	< 0.0001	0.002	6.9	3	< 0.001	4,090	< 0.0005	6,140
150M-CCR	CTLN-1606-315	6/15/2016	< 0.001	< 0.001	< 0.05	< 0.001	3.31	< 0.001	588	< 0.005	< 0.005	0.2	17.2	< 0.001	< 0.1	0.473	< 0.0001	< 0.001	6.3	4.8	< 0.002	4,110	0.0012	5,970
150M-CCR	CTLN-1607-320	7/15/2016	< 0.001	0.002	< 0.05	< 0.001	3.85	< 0.001	578	< 0.005	< 0.005	0.2	18.1	< 0.001	0.1	0.454	< 0.0001	< 0.001	6.2	3.2	< 0.002	4,110	< 0.0005	6,180
150M-CCR	CTLN-1609-337	9/7/2016	< 0.001	< 0.001	< 0.05	< 0.001	0.77	< 0.001	607	< 0.005	< 0.005	0.2	10.6	< 0.001	0.1	0.511	< 0.0001	< 0.001	6.8	5.3	< 0.002	4,000	< 0.0005	6,160
150M-CCR (Dup)	CTLN-1609-338	9/7/2016	< 0.001	< 0.001	< 0.05	< 0.001	0.91	< 0.001	594	< 0.005	< 0.005	0.2	11	< 0.001	< 0.1	0.484	< 0.0001	< 0.001	6.8	5.1	< 0.002	4,010	< 0.0005	6,220
150M-CCR	CTLN-1612-348	12/6/2016	< 0.001	0.002	< 0.05	0.002	2.67	< 0.001	595	< 0.005	< 0.005	0.2	15	0.001	0.2	0.486	< 0.0001	< 0.001	6.5	4.8	< 0.004	4,040	0.0008	6,160
150M-CCR	CTLN-1702-335A	2/7/2017	< 0.001	0.001	< 0.05	< 0.001	3.39	< 0.001	545	< 0.005	< 0.005	0.2	16.6	0.001	< 0.1	0.433	< 0.0001	< 0.001	6.3	3.5	< 0.002	4,330	0.0006	6,140
150M-CCR	CTLN-1703-354	3/13/2017	< 0.001	0.003	< 0.05	< 0.001	7.84	< 0.001	421	< 0.005	< 0.005	< 0.1	33.9	< 0.001	< 0.1	0.184	< 0.0001	< 0.001	5.8	2.5	< 0.004	4,220	0.0009	6,390
150M-CCR	CTLN-1704-342	4/26/2017	< 0.001	0.006	0.05	< 0.001	9.56	< 0.001	320	< 0.005	0.005	< 0.1	34.4	< 0.001	0.2	0.126	< 0.0001	0.002	5.6	2.1	< 0.004	4,430	< 0.0005	6,210
150M-CCR (Dup)	CTLN-1708-442	8/14/2017	< 0.001	0.004	0.06	< 0.001	11.9	< 0.001	342	< 0.005	< 0.005	< 0.1	36.3	< 0.001	< 0.2	0.082	< 0.0001	< 0.001	1.4	6.6	< 0.001	5,190	< 0.0005	6,920
150M-CCR (Dup)	CTLN-1708-443	8/14/2017	< 0.001	0.004	0.06	< 0.001	10.8	< 0.001	353	< 0.005	< 0.005	< 0.1	37.4	< 0.001	< 0.1	0.083	< 0.0001	< 0.001	5.4	10.2	< 0.001	4,640	< 0.0005	6,080
151M-CCR	CTLN-1604-130	4/12/2016	< 0.001	< 0.001	< 0.05	< 0.001	0.61	< 0.001	559	< 0.005	< 0.005	0.2	8.87	< 0.001	0.2	0.53	< 0.0001	0.002	7.0	2.5	< 0.001	3,900	< 0.0005	6,000
151M-CCR	CTLN-1606-314	6/15/2016	< 0.001	< 0.001	< 0.05	< 0.001	0.69	< 0.001	588	< 0.005	< 0.005	0.2	10.2	0.001	0.1	0.534	< 0.0001	0.002	6.0	3.2	< 0.002	3,910	0.0018	5,920
151M-CCR	CTLN-1607-313	7/14/2016	< 0.001	< 0.001	< 0.05	< 0.001	0.72	< 0.001	585	< 0.005	< 0.005	0.2	9.95	< 0.001	0.1	0.51	< 0.0001	< 0.001	6.0	3	< 0.002	3,920	< 0.0005	6,070
151M-CCR	CTLN-1609-336	9/7/2016	< 0.001	< 0.001	< 0.05	< 0.001	0.62	< 0.001	545	< 0.005	< 0.005	0.2	9.18	< 0.001	0.1	0.455	< 0.0001	< 0.001	6.4	3.4	< 0.002	3,860	< 0.0005	6,010
151M-CCR	CTLN-1612-347	12/6/2016	< 0.001	< 0.001	< 0.05	< 0.001	0.73	< 0.001	574	< 0.005	< 0.005	0.2	9.51	< 0.001	0.2	0.546	< 0.0001	< 0.001	6.2	3.4	< 0.004	3,820	< 0.0005	5,890
151M-CCR	CTLN-1702-334A	2/7/2017	< 0.001	< 0.001	< 0.05	< 0.001	0.72	< 0.001	577	< 0.005	< 0.005	0.2	9.48	0.001	0.1	0.557	< 0.0001	< 0.001	6.1	2.8	< 0.002	3,980	0.0006	5,860
151M-CCR	CTLN-1703-353	3/13/2017	< 0.001	< 0.002	< 0.05	< 0.001	0.7	< 0.001	555	< 0.005	< 0.005	0.2	9.6	< 0.001	< 0.1	0.543	< 0.0001	< 0.001	6.2	4.5	< 0.004	3,860	0.0008	6,030
151M-CCR	CTLN-1705-302	5/1/2017	< 0.001	< 0.002	< 0.05	< 0.001	0.7	< 0.001	549	< 0.005	< 0.005	0.2	8.91	< 0.001	< 0.1	0.519	< 0.0001	< 0.001	6.1	2.3	< 0.002	3,720	< 0.0005	5,670
151M-CCR	CTLN-1708-440	8/14/2017	< 0.001	< 0.001	< 0.05	< 0.001	1.11	< 0.001	548	< 0.005	< 0.005	0.2	8.66	< 0.001	< 0.1	0.491	< 0.0001	< 0.001	6.1	2.6	< 0.001	4,100	0.0022	5,910
154A-CCR	CTLN-1605-248	5/4/2016	< 0.001	0.001	0.07	< 0.001	35	< 0.001	508	< 0.005	0.015	0.4	0.23	0.001	0.4	4.43	< 0.0001	0.009	7.4	3.4	< 0.004	6,830	< 0.0005	10,100
154A-CCR	CTLN-1606-317	6/15/2016	< 0.001	< 0.001	0.06	< 0.001	35.5	< 0.001	550	< 0.005	0.013	0.3	1.28	< 0.001	0.4	4.53	< 0.0001	0.007	7.2	3.6	0.002	6,830	0.0009	10,000
154A-CCR	CTLN-1607-319	7/14/2016	< 0.001	0.001	< 0.05	< 0.001	45.1	< 0.001	588	< 0.005	0.02	0.4	2.85	< 0.001	0.5	6.28	< 0.0001	0.003	6.9	0.4	< 0.002	7,920	< 0.0005	12,300
154A-CCR	CTLN-1609-340	9/7/2016	< 0.001	0.001	< 0.05	< 0.001	38.1	< 0.001	516	< 0.005	0.018	0.4	2	< 0.001	0.5	5.06	< 0.0001	0.005	7.0	5.5	< 0.002	7,350	< 0.0005	11,500
154A-CCR	CTLN-1612-350	12/7/2016	< 0.001	< 0.001	< 0.05	< 0.001	46.6	< 0.001	589	< 0.005	0.02	0.3	4.5	0.002	0.7	7.74	< 0.0001	0.001	6.9	3.2	< 0.004	8,050	0.0007	12,500
154A-CCR	CTLN-1702-333A	2/6/2017	< 0.001 DIS < 0.001 TRC	< 0.001 DIS 0.002 TRC	< 0.05 DIS < 0.05 TRC	< 0.001 DIS < 0.001 TRC	42.8 **DIS** 43.9 **TRC**	< 0.001 DIS < 0.001 TRC	510 DIS 525 TRC	< 0.005 DIS < 0.005 TRC	0.015 **DIS** 0.013 **TRC**	0.3	2.21 DIS 3.77 TRC	< 0.001 DIS 0.001 TRC	0.5 **DIS** 0.5 **TRC**	5.64 **DIS** 6.22 **TRC**	< 0.0001 DIS < 0.0001 TRC	0.004 DIS 0.001 TRC	7.0	1.6 TRC	0.003 DIS < 0.002 TRC	8,130	< 0.0005 DIS 0.0007 TRC	11,800
154A-CCR	CTLN-1703-351	3/9/2017	< 0.001	0.002	< 0.05	< 0.001	44.8	< 0.001	549	< 0.005	0.015	0.3	7	< 0.001	0.5	6.17	< 0.0001	< 0.001	7.0	1.6	< 0.004	7,900	< 0.001	11,800
154A-CCR	CTLN-1704-336	4/25/2017	< 0.001	0.002	0.05	< 0.001	46.6	< 0.001	575	< 0.005	0.022	0.3	5.29	< 0.001	0.5	7.43	< 0.0001	0.001	6.9	2.7	< 0.004	8,010	< 0.0005	11,500
154A-CCR	CTLN-1708-455	8/21/2017	< 0.001	< 0.001	< 0.05	< 0.001	39.9	< 0.001	482	< 0.005	0.016	0.3	2.46	< 0.001	0.4	2.63	< 0.0001	0.003	7.3	1.5	< 0.001	7,980	< 0.0005	11,100
155A-CCR	CTLN-1605-249	5/4/2016	< 0.001	< 0.001	< 0.05	< 0.001	1.4	< 0.001	311	< 0.005	< 0.005	0.3	0.11	< 0.001	0.1	1.24	< 0.0001	< 0.001	7.4	3.1	< 0.004	2,420	< 0.0005	4,290
155A-CCR	CTLN-1606-318	6/15/2016	< 0.001	< 0.001	< 0.05	< 0.001	1.36	< 0.001	353	< 0.005	< 0.005	0.3	0.11	< 0.001	< 0.1	1.44	< 0.0001	0.001	7.2	2	< 0.001	2,430	< 0.0005	4,130
155A-CCR	CTLN-1607-316	7/14/2016	< 0.001	< 0.001	< 0.05	< 0.001	1.25	< 0.001	332	< 0.005	< 0.005	0.3	0.04	< 0.001	< 0.1	1.22	< 0.0001	0.002	7.2	2	< 0.001	2,350	< 0.0005	4,400
155A-CCR	CTLN-1609-341	9/7/2016	< 0.001	< 0.001	< 0.05	< 0.001	1.44	< 0.001	308	< 0.005	< 0.005	0.4	0.52	< 0.001	< 0.1	1.14	< 0.0001	0.001	7.2	5	< 0.001	2,490	< 0.0005	4,110
155A-CCR	CTLN-1612-351	12/7/2016	< 0.001	< 0.001	< 0.05	< 0.001	2.27	< 0.001	320	< 0.005	< 0.005	0.3	3.71	< 0.001	0.1	0.826	< 0.0001	0.001	7.1	4	< 0.002	2,390	< 0.0005	4,160
155A-CCR (Dup)	CTLN-1612-352	12/7/2016	< 0.001	0.003	< 0.05	< 0.001	2.28	< 0.001	320	< 0.005	< 0.005	0.3	3.65	< 0.001	0.1	0.838	< 0.0001	< 0.001	7.1	1.3	< 0.002	2,340	< 0.0005	4,100
155A-CCR	CTLN-1702-340	2/13/2017	< 0.001	< 0.001	< 0.05	< 0.001	2.21	< 0.001	310	< 0.005	< 0.005	0.3	5.12	< 0.001	< 0.1	0.61	< 0.0001	< 0.001	7.0	4.1	< 0.002	2,510	< 0.0005	4,100
155A-CCR	CTLN-1703-356	3/13/2017	< 0.001	< 0.001	< 0.05	< 0.001	2.44	< 0.001	316	< 0.005	< 0.005	0.3	5.6	< 0.001	< 0.1	0.65	< 0.0001	0.001	7.1	5.2	< 0.002	2,490	< 0.0005	4,190
155A-CCR	CTLN-1704-335	4/24/2017	< 0.001	< 0.001	< 0.05	< 0.001	1.29	< 0.001	293	< 0.005	< 0.005	0.3	2.49	< 0.001	< 0.1	1.13	< 0.0001	0.002	7.2	2.6	< 0.002	2,450	< 0.0005	3,930
155A-CCR	CTLN-1708-446	8/15/2017	< 0.001	< 0.001	< 0.05	< 0.001	1.26	< 0.001	286	< 0.005	< 0.005	0.3	0.57	< 0.001	< 0.1	1.37	< 0.0001	0.002	7.2	2.9	< 0.001	2,650	< 0.0005	3,960
AB20-S	CTLN-1604-111	4/7/2016	< 0.001	< 0.001	< 0.05	< 0.001	60.6	< 0.001	458	< 0.005	0.01	0.8	1.2	< 0.001	1.3	3.51	< 0.0001	0.02	7.3	3	0.012	12,200	< 0.0005	17,200
AB20-S	CTLN-1606-467	6/24/2016	< 0.001	< 0.001	< 0.05	< 0.001	54.8	< 0.001	397	< 0.005	0.01	0.8	0.8	0.001	1.1	3.22	< 0.0001	0.019	7.3	1.7	< 0.002	11,600	< 0.0005	16,500
AB20-S	CTLN-1608-341	8/3/2016	< 0.001	0.002	< 0.05	< 0.001	57.1	< 0.001	391	< 0.005	0.012	0.8	1	< 0.001	1	3.21	< 0.0001	0.022	7.3	9	< 0.004	12,000	< 0.0005	16,500
AB20-S	CTLN-1609-334	9/6/2016	< 0.001	0.002	< 0.05	< 0.001	59.5	< 0.001	414	< 0.005	0.01	0.8	1.5	< 0.001	1.1	2.7	< 0.0001	0.018	7.4	3.8	< 0.002	11,300	< 0.0005	16,100
AB20-S	CTLN-1612-345	12/5/2016	< 0.002 DIS < 0.001 TRC	< 0.001 DIS 0.002 TRC	< 0.05 DIS < 0.05 TRC	< 0.001 DIS < 0.001 TRC	58.0 **DIS** 58.1 **TRC**	< 0.001 DIS < 0.001 TRC	390 DIS 418 TRC	< 0.005 DIS < 0.005 TRC	0.010 **DIS** 0.012 **TRC**	0.8	0.72 DIS 6.0 TRC	< 0.001 DIS 0.004 TRC	1.2 **DIS** 1.3 **TRC**	2.69 **DIS** 2.84 **TRC**	< 0.0001 DIS < 0.0001 TRC	0.018 DIS 0.021 TRC	7.3	1.4 TRC	< 0.003 DIS < 0.008 TRC	10,500	< 0.001 DIS < 0.0005 TRC	15,400
AB20-S	CTLN-1702-160	2/2/2017	< 0.001 DIS < 0.001 TRC	< 0.002 DIS < 0.003 TRC	< 0.05 DIS < 0.05 TRC	< 0.001 DIS < 0.001 TRC	58.5 **DIS** 57.1 **TRC**	< 0.001 DIS < 0.001 TRC	390 DIS 402 TRC	< 0.005 DIS < 0.005 TRC	0.008 **DIS** 0.009 **TRC**	0.9	0.44 DIS 1.34 TRC	< 0.001 DIS 0.001 TRC	1.1 **DIS** 1.1 **TRC**	2.42 **DIS** 2.61 **TRC**	< 0.0001 DIS < 0.0001 TRC	0.019 DIS 0.020 TRC	7.4	1.6 TRC	< 0.007 DIS < 0.004 TRC	10,600	< 0.0005 DIS 0.0008 TRC	14,700
AB20-S	CTLN-1703-346	3/8/2017	< 0.001 DIS < 0.001 TRC	< 0.002 DIS < 0.003 TRC	< 0.05 DIS < 0.05 TRC	< 0.001 DIS < 0.002 TRC	56.7 **DIS** 51.7 **TRC**	< 0.001 DIS < 0.001 TRC	372 DIS 380 TRC	< 0.005 DIS < 0.005 TRC	0.010 **DIS** 0.010 **TRC**	1	0.5 DIS 2.2 TRC	< 0.001 DIS 0.002 TRC	1.1 **DIS** 1.1 **TRC**	2.45 **DIS** 2.62 **TRC**	< 0.0001 DIS < 0.0001 TRC	0.020 DIS 0.018 TRC	7.4	1.3 TRC	< 0.007 DIS < 0.007 TRC	10,400	< 0.0005 DIS < 0.003 TRC	15,100
AB20-S	CTLN-1704-332	4/24/2017	< 0.001	< 0.002	< 0.05	< 0.001	54.8	< 0.001	388	< 0.005	0.012	0.9	0.21	< 0.001	1.1	2.2	< 0.0001	0.02	7.4	0.2	< 0.004	9,970	< 0.0005	14,000
AB20-S	CTLN-1708-445	8/15/2017	< 0.001	< 0.001	< 0.05	< 0.001	54.6	< 0.001	378	< 0.005	0.009	1.3	0.51	< 0.001	0.9	3.13	< 0.0001	0.018	7.4	2.5	< 0.001	11,200	< 0.0005	15,100
AB25-S	TLN-1602-906-CCR	2/23/2016	< 0.001	< 0.001	< 0.05	< 0.001	23.6	< 0.001	500	< 0.005	0.006	2	0.04	< 0.001	0.6	10.3	< 0.0001	0.018	7.4	1.3	< 0.002	5,460	< 0.0005	8,330
AB25-S	CTLN-1604-150	4/27/2016	< 0.001	0.002	< 0.05	< 0.001	21.5	< 0.001	498	< 0.005	0.005	2	0.06	< 0.001	0.7	9.58	< 0.0001	0.018	7.5	2.3	< 0.008	5,750	< 0.0005	8,550
AB25-S	CTLN-1606-464	6/23/2016	< 0.001	< 0.001	< 0.05	< 0.001	20.6	< 0.001	484	< 0.005	< 0.005	1.9	0.05	< 0.001	0.6	8.76	< 0.0001	0.019	7.5	1	< 0.001	6,200	< 0.0005	8,780
AB25-S	CTLN-1608-355	8/10/2016	< 0.001	< 0.001	< 0.05	< 0.001	20.2	< 0.001	447	< 0.005	< 0.005	2	< 0.09	< 0.001	0.6	8.56	< 0.0001	0.019	7.5	2.9	< 0.002	5,740	< 0.0005	8,450
AB25-S	CTLN-1609-357	9/15/2016	< 0.001	< 0.001	< 0.05	< 0.001	17.1	< 0.001	398	< 0.005	< 0.005	2.1	0.11	< 0.001	0.5	7.38	< 0.0001	0.017	7.5	0.9	< 0.002	4,770	< 0.0005	7,360
AB25-S	CTLN-1612-346	12/5/2016	< 0.001	0.004	< 0.05	< 0.001	19.5	< 0.001	460	< 0.005	< 0.005	2.2	0.25	0.001	0.6	8.88	< 0.0001	0.019	7.5	0.8	< 0.004	5,520	< 0.0005	8,310
AB25-S	CTLN-1702-155	2/1/2017	< 0.001	< 0.001	< 0.05	< 0.001	17.8	< 0.001	415	< 0.005	< 0.005	2.3	0.02	< 0.001	0.5	0.001	< 0.0001	< 0.001	7.5	3.9	< 0.004	5,800	0.001	7,640
AB25-S	CTLN-1703-347	3/8/2017	< 0.001	< 0.002	< 0.05	< 0.001	17.8	< 0.001	418	< 0.005	< 0.005	2.5	0.06	< 0.001	0.5	7.32	< 0.0001	0.016	7.5	1.2	< 0.004	5,070	< 0.001	7,750
AB25-S	CTLN-1704-349	4/28/2017	< 0.001	< 0.002	< 0.05	< 0.001	15.8	< 0.001	376	< 0.005	0.007	2.3	0.11	< 0.001	0.5	7.8	< 0.0001	0.018	7.5	1.1	< 0.004	5,030	< 0.0005	7,120
AB25-S	CTLN-1708-429	8/8/2017	< 0.001	< 0.001	< 0.05	< 0.001	15.3	< 0.001	358	< 0.005	< 0.005	2.1	< 0.02	< 0.001	0.2	5.36	< 0.0001	0.014	7.6	1.3	< 0.001	3,640	< 0.0005	5,940

APPENDIX F

Colstrip SES Federal CCR Rule Groundwater Draft Baseline Monitoring Data - 2016 Through November 30, 2017

Comparison For Montana DEQ Human Health GW MCLs (If No MCL Listed Then EPA RSL For Tapwater - Ingestion For Child, RSL Limit Was Used)

***Metals analyzed as Total Recoverable (TRC) unless turbidity >10, then metals ran both as Total Recoverable (TRC) and Dissolved (DIS).**

🟧 ***Highlighted Values Exceed MCL or EPA Tapwater RSL***

▭ ***Highlighted Values Are Detection Limits Higher than the MCL or EPA Tapwater RSL***

Site Code	Sample Code	Date	ANTIMONY 7440-36-0 mg/L	ARSENIC 7440-38-2 mg/L	BARIUM 7440-39-3 mg/L	BERYLLIUM 7440-41-7 mg/L	BORON 7440-42-8 mg/L	CADMIUM 7440-43-9 mg/L	CALCIUM 7440-70-2 mg/L	CHROMIUM 7440-47-3 mg/L	COBALT 7440-48-4 mg/L	FLUORIDE 16984-48-8 mg/L	IRON 7439-89-6 mg/L	LEAD 7439-92-1 mg/L	LITHIUM 7439-93-2 mg/L	MANGANESE 7439-96-5 mg/L	MERCURY 7439-97-6 mg/L	MOLYBDENUM 7439-98-7 mg/L	pH NA standard units	RADIUM 226/228 7440-14-4 pCi/L	SELENIUM 7782-49-2 mg/L	SULFATE 14808-79-8 mg/L	THALLIUM 7440-28-0 mg/L	TDS NA mg/L
			MCL - 0.006	MCL - 0.01	MCL - 1.0	MCL - 0.004	RSL - 4.0	MCL - 0.005	no MCL/ RSL	MCL - 0.1	RSL - 0.006	MCL - 4.0	No MCL/ RSL	MCL - 0.015	RSL - 0.04	RSL 0.43	MCL - 0.002	RSL - 0.1	no MCL/ RSL	MCL - 5.0	MCL - 0.05	no MCL/ RSL	MCL - 0.002	no MCL/ RSL
Units 1&2 B Fly Ash Pond																								
72M	TLN-1602-900-CCR	2/18/2016	< 0.001	< 0.001	< 0.05	< 0.001	0.86	< 0.001	222	< 0.005	< 0.005	0.2	0.53	< 0.001	< 0.1	0.122	< 0.0001	< 0.001	7.2	3.8	< 0.001	1,220	< 0.0005	2,300
72M	CTLN-1604-140	4/21/2016	< 0.001	< 0.001	< 0.05	< 0.001	1.05	< 0.001	226	< 0.005	< 0.005	0.2	1.14	< 0.001	< 0.1	0.129	< 0.0001	< 0.001	7.2	2.7	< 0.001	1,280	< 0.0005	2,370
72M	CTLN-1606-461	6/23/2016	< 0.001	< 0.001	< 0.05	< 0.001	0.98	< 0.001	203	< 0.005	< 0.005	0.2	0.39	< 0.001	< 0.1	0.106	< 0.0001	< 0.001	7.3	1	< 0.001	1,200	< 0.0005	2,230
72M	CTLN-1608-348	8/8/2016	< 0.001	0.001	< 0.05	< 0.001	1.04	< 0.001	214	< 0.005	< 0.005	0.2	1.25	< 0.001	< 0.1	0.124	< 0.0001	< 0.001	7.2	3.4	< 0.001	1,220	< 0.0005	2,310
72M	CTLN-1609-349	9/13/2016	< 0.001	< 0.001	< 0.05	< 0.001	1.04	< 0.001	209	< 0.005	< 0.005	0.3	2.2	< 0.001	< 0.1	0.127	< 0.0001	< 0.001	7.2	**5.7**	< 0.001	1,220	< 0.0005	2,320
72M	CTLN-1612-251	12/6/2016	< 0.001	0.003	< 0.05	< 0.001	1.05	< 0.001	215	< 0.005	< 0.005	0.2	1.33	< 0.001	**0.1**	0.108	< 0.0001	0.003	7.3	3.3	< 0.002	1,170	< 0.0005	2,200
72M	CTLN-1701-152	1/31/2017	< 0.001	< 0.001	< 0.05	< 0.001	1.03	< 0.001	200	< 0.005	< 0.005	0.3	0.59	< 0.001	< 0.1	0.107	< 0.0001	< 0.001	7.2	2.4	< 0.001	1,210	< 0.0005	2,140
72M	CTLN-1703-339	3/6/2017	< 0.001	< 0.001	< 0.05	< 0.001	0.98	< 0.001	202	< 0.005	< 0.005	0.3	1.03	< 0.001	< 0.1	0.116	< 0.0001	< 0.001	7.3	4.1	< 0.002	1,190	< 0.0007	2,190
72M	CTLN-1705-301	5/1/2017	< 0.001	0.002	< 0.05	< 0.001	1.08	0.001	220	< 0.005	< 0.005	0.2	1.52	0.001	< 0.1	0.142	< 0.0001	0.002	7.2	3.3	< 0.002	1,270	0.0018	2,290
72M	CTLN-1708-432	8/9/2017	< 0.001	< 0.001	< 0.05	< 0.001	1.01	< 0.001	236	< 0.005	< 0.005	0.2	1.69	< 0.001	< 0.1	0.144	< 0.0001	< 0.001	7.2	2.9	< 0.001	1,570	< 0.0005	2,600
72M (Dup)	CTLN-1708-434	8/9/2017	< 0.001	< 0.001	< 0.05	< 0.001	1.04	< 0.001	229	< 0.005	< 0.005	0.2	1.66	< 0.001	< 0.1	0.133	< 0.0001	< 0.001	7.3	2.6	< 0.001	1,610	< 0.0005	2,620
156SP-CCR	CTLN-1604-156	4/28/2016	< 0.001	< 0.001	0.05	0.002	**7.82**	< 0.001	438	< 0.005	**0.079**	0.1	0.34	< 0.001	**0.3**	**5.23**	< 0.0001	< 0.001	5.9	4.2	< 0.008	4,720	< 0.0005	7,260
156SP-CCR	CTLN-1606-456	6/22/2016	< 0.001	< 0.001	0.05	< 0.001	**7.12**	< 0.001	408	< 0.005	**0.064**	0.1	0.24	< 0.001	**0.3**	**4.45**	< 0.0001	< 0.001	6.0	3.9	< 0.001	4,610	< 0.0005	6,600
156SP-CCR	CTLN-1608-351	8/9/2016	< 0.001	< 0.001	< 0.05	< 0.001	**6.89**	< 0.001	387	< 0.005	**0.068**	0.1	0.19	< 0.001	**0.2**	**4.6**	< 0.0001	< 0.001	5.9	**5.5**	< 0.002	4,710	< 0.0005	6,940
156SP-CCR	CTLN-1609-352	9/14/2016	< 0.001	< 0.001	0.05	< 0.001	**7.08**	< 0.001	396	< 0.005	**0.073**	0.1	0.21	< 0.001	**0.3**	**4.73**	< 0.0001	< 0.001	5.9	**5.6**	< 0.002	4,480	< 0.0005	6,840
156SP-CCR	CTLN-1612-256	12/7/2016	< 0.001	< 0.001	0.06	< 0.001	**7.33**	< 0.001	400	< 0.005	**0.072**	0.1	0.45	0.001	**0.3**	**4.94**	< 0.0001	0.001	6.0	3.5	< 0.004	4,820	0.0009	7,060
156SP-CCR	CTLN-1702-164	2/2/2017	< 0.001	< 0.001	0.05	< 0.001	**7.08**	< 0.001	363	< 0.005	**0.069**	0.1	0.23	< 0.001	**0.2**	**4.72**	< 0.0001	< 0.001	6.0	**5.1**	< 0.002	5,110	0.0006	7,020
156SP-CCR	CTLN-1703-342	3/7/2017	< 0.001	0.008	< 0.05	< 0.001	**6.66**	< 0.001	353	< 0.005	**0.067**	0.1	0.25	< 0.001	**0.2**	**4.85**	< 0.0001	0.001	6.1	3.5	< 0.004	4,680	< 0.001	7,050
156SP-CCR	CTLN-1704-343	4/27/2017	< 0.001	< 0.002	0.05	< 0.001	**7.19**	< 0.001	343	< 0.005	**0.078**	0.1	0.23	< 0.001	**0.3**	**5.24**	< 0.0001	0.001	6.1	**5.1**	< 0.004	4,730	< 0.0005	7,040
156SP-CCR	CTLN-1708-431	8/9/2017	< 0.001	< 0.001	< 0.05	< 0.001	**7.63**	< 0.001	380	< 0.005	**0.067**	0.1	0.23	< 0.001	**0.2**	**4.88**	< 0.0001	< 0.001	6	2.8	< 0.001	4,690	< 0.0005	7,070
157S-CCR	CTLN-1604-152	4/27/2016	< 0.001	< 0.001	< 0.05	0.001	**21.5**	< 0.001	465	< 0.005	**0.008**	1.8	< 0.05	< 0.001	**0.6**	**4.87**	< 0.0001	0.045	7.5	3.2	< 0.008	4,460	< 0.0005	6,750
157S-CCR	CTLN-1606-454	6/21/2016	< 0.001	< 0.001	< 0.05	< 0.001	**22.6**	< 0.001	473	< 0.005	**0.008**	1.8	0.07	< 0.001	**0.6**	**5.11**	< 0.0001	0.053	7.6	1.5	< 0.001	4,450	< 0.0005	6,640
157S-CCR	CTLN-1608-352	8/9/2016	< 0.001	0.003	< 0.05	< 0.001	**22.6**	< 0.001	442	< 0.005	**0.012**	1.8	< 0.09	< 0.001	**0.5**	**5.19**	< 0.0001	0.052	7.5	1.4	< 0.002	4,520	< 0.0005	6,730
157S-CCR	CTLN-1609-353	9/14/2016	< 0.001	0.003	< 0.05	< 0.001	**23.7**	< 0.001	439	< 0.005	**0.015**	1.6	0.25	< 0.001	**0.6**	**4.55**	< 0.0001	0.039	7.5	2.7	< 0.002	4,300	< 0.0005	6,590
157S-CCR	CTLN-1612-257	12/7/2016	< 0.001	< 0.001	< 0.05	< 0.001	**23.3**	< 0.001	457	< 0.005	**0.014**	1.8	0.19	< 0.001	**0.7**	**4.94**	< 0.0001	0.045	7.5	-0.5	< 0.004	4,550	< 0.0005	6,630
157S-CCR	CTLN-1702-163	2/2/2017	< 0.001	< 0.001	< 0.05	< 0.001	**23.2**	< 0.001	446	< 0.005	**0.012**	1.7	0.12	< 0.001	**0.6**	**4.33**	< 0.0001	0.038	7.5	1.9	< 0.002	4,830	< 0.0005	6,630
157S-CCR	CTLN-1703-343	3/7/2017	< 0.001	< 0.002	< 0.05	< 0.001	**21.4**	< 0.001	428	< 0.005	**0.013**	1.7	0.11	< 0.001	**0.6**	**4.84**	< 0.0001	0.037	7.5	1.6	< 0.004	4,560	< 0.001	6,710
157S-CCR	CTLN-1705-303	5/1/2017	< 0.001	0.003	< 0.05	< 0.001	**23**	0.002	456	< 0.005	**0.014**	1.6	0.12	< 0.001	**0.6**	**4.97**	< 0.0001	0.037	7.5	4.7	< 0.004	4,550	< 0.0005	6,540
157S-CCR	CTLN-1708-438	8/8/2017	< 0.001	< 0.001	< 0.05	< 0.001	**25.6**	< 0.001	478	< 0.005	**0.016**	1.7	0.11	< 0.001	**0.5**	**5.45**	< 0.0001	0.041	7.5	0.9	< 0.001	5,020	< 0.0005	7,770
158S-CCR	CTLN-1604-153	4/27/2016	< 0.001	< 0.001	< 0.05	0.001	**10.6**	< 0.001	495	< 0.005	**0.009**	1.6	0.06	< 0.001	**0.6**	**7.13**	< 0.0001	0.049	7.4	1.9	< 0.008	3,730	< 0.0005	5,700
158S-CCR	CTLN-1606-457	6/22/2016	< 0.001	< 0.001	< 0.05	< 0.001	**10.6**	< 0.001	495	< 0.005	**0.008**	1.6	0.02	< 0.001	**0.5**	**6.5**	< 0.0001	0.054	7.5	0.5	< 0.001	3,680	< 0.0005	5,630
158S-CCR	CTLN-1608-353	8/9/2016	< 0.001	< 0.001	< 0.05	< 0.001	**10.4**	< 0.001	456	< 0.005	**0.008**	1.5	< 0.09	< 0.001	**0.5**	**6.5**	< 0.0001	0.058	7.5	1.1	< 0.002	3,840	< 0.0005	5,680
158S-CCR (Dup)	CTLN-1608-354	8/9/2016	< 0.001	< 0.001	< 0.05	< 0.001	**10.7**	< 0.001	470	< 0.005	**0.008**	1.6	< 0.09	< 0.001	**0.5**	**6.71**	< 0.0001	0.057	7.5	1.7	< 0.002	3,810	< 0.0005	5,670
158S-CCR	CTLN-1609-354	9/14/2016	< 0.001	< 0.001	< 0.05	< 0.001	**10.7**	< 0.001	476	< 0.005	**0.009**	1.5	0.09	< 0.001	**0.5**	**7.29**	< 0.0001	0.032	7.5	2.1	< 0.002	3,720	< 0.0005	5,730
158S-CCR	CTLN-1609-355	9/14/2016	< 0.001	< 0.001	< 0.05	< 0.001	**11.2**	< 0.001	496	< 0.005	**0.009**	1.6	0.45	< 0.001	**0.6**	**7.58**	< 0.0001	0.033	7.5	4.4	< 0.002	3,720	< 0.0005	5,720
158S-CCR	CTLN-1612-258	12/7/2016	< 0.001	< 0.001	< 0.05	< 0.001	**12.3**	< 0.001	537	< 0.005	**0.015**	1.5	0.19	< 0.001	**0.6**	**8.63**	< 0.0001	0.035	7.4	-4	< 0.004	4,410	< 0.0005	6,310
158S-CCR	CTLN-1702-161	2/2/2017	< 0.001	< 0.001	< 0.05	< 0.001	**14.6**	< 0.001	620	< 0.005	**0.02**	1.5	0.08	< 0.001	**0.6**	**9.62**	< 0.0001	0.03	7.4	1.9	< 0.002	5,090	< 0.0005	7,750
158S-CCR (Dup)	CTLN-1702-162	2/2/2017	< 0.001	< 0.001	< 0.05	< 0.001	**14.5**	< 0.001	616	< 0.005	**0.021**	1.5	0.08	< 0.001	**0.6**	**9.96**	< 0.0001	0.031	7.4	2.3	< 0.002	5,260	< 0.0005	7,540
158S-CCR	CTLN-1703-344	3/7/2017	< 0.001	< 0.002	< 0.05	< 0.001	**15.5**	< 0.001	605	< 0.005	**0.029**	1.6	0.07	< 0.001	**0.7**	**11.4**	< 0.0001	0.031	7.4	2.3	< 0.004	5,910	< 0.001	8,760
158S-CCR (Dup)	CTLN-1703-345	3/7/2017	< 0.001	< 0.002	< 0.05	< 0.001	**15.8**	< 0.001	628	< 0.005	**0.03**	1.6	0.09	< 0.001	**0.7**	**11.7**	< 0.0001	0.03	7.4	2.2	< 0.004	5,910	< 0.001	8,750
158S-CCR	CTLN-1704-346	4/27/2017	< 0.001	< 0.002	< 0.05	< 0.001	**22.1**	< 0.001	535	< 0.005	**0.054**	1.4	0.08	< 0.001	**1.1**	**15.6**	< 0.0001	0.033	7.3	2	< 0.004	7,550	< 0.0005	10,800
158S-CCR	CTLN-1708-449	8/16/2017	< 0.001	< 0.001	< 0.05	< 0.001	**19.4**	< 0.001	516	< 0.005	**0.033**	1.5	0.05	< 0.001	**0.7**	**13.1**	0.0001	0.045	7.3	1.1	< 0.001	6,750	< 0.0005	10,200
159S-CCR	CTLN-1604-154	4/27/2016	< 0.001	0.001	< 0.05	< 0.001	**15.4**	< 0.001	469	< 0.005	**0.017**	2	0.06	< 0.001	**0.6**	**8.7**	< 0.0001	0.034	7.5	3.5	< 0.004	4,160	< 0.0005	6,250
159S-CCR	CTLN-1606-459	6/22/2016	< 0.001	< 0.001	< 0.05	< 0.001	**14.9**	< 0.001	470	< 0.005	**0.016**	1.9	0.04	< 0.001	**0.6**	**8.36**	< 0.0001	0.036	7.5	1.3	< 0.001	4,160	< 0.0005	6,250
159S-CCR	CTLN-1608-358	8/10/2016	< 0.001	< 0.001	< 0.05	< 0.001	**15.5**	< 0.001	468	< 0.005	**0.018**	1.9	< 0.09	< 0.001	**0.6**	**8.71**	< 0.0001	0.037	7.4	2.5	< 0.002	4,360	< 0.0005	6,430
159S-CCR	CTLN-1609-356	9/14/2016	< 0.001	< 0.001	< 0.05	< 0.001	**16.1**	< 0.001	484	< 0.005	**0.018**	1.8	< 0.02	< 0.001	**0.6**	**8.79**	< 0.0001	0.032	7.4	3.4	< 0.002	4,370	< 0.0005	6,700
159S-CCR	CTLN-1612-259	12/7/2016	< 0.001	0.001	< 0.05	< 0.001	**17.1**	< 0.001	527	< 0.005	**0.026**	1.8	0.03	0.001	**0.7**	**9.76**	< 0.0001	0.032	7.4	3.7	< 0.004	5,000	< 0.0005	7,140
159S-CCR	CTLN-1702-159	2/1/2017	< 0.001	< 0.001	< 0.05	< 0.001	**18.2**	< 0.001	560	< 0.005	**0.029**	1.8	< 0.02	< 0.001	**0.6**	**8.8**	< 0.0001	0.026	7.4	2.3	< 0.002	5,260	< 0.0005	7,610
159S-CCR	CTLN-1703-349	3/8/2017	< 0.001	< 0.002	< 0.05	< 0.001	**18.5**	< 0.001	567	< 0.005	**0.039**	1.8	< 0.09	< 0.001	**0.6**	**9.69**	< 0.0001	0.026	7.4	2.8	< 0.004	5,580	< 0.001	8,290
159S-CCR	CTLN-1704-345	4/27/2017	< 0.001	< 0.002	< 0.05	< 0.001	**19.3**	< 0.001	584	< 0.005	**0.057**	1.7	0.03	< 0.001	**0.9**	**10.9**	< 0.0001	0.024	7.3	2.8	< 0.004	6,120	< 0.0005	8,970
159S-CCR	CTLN-1708-448	8/16/2017	< 0.001	< 0.001	< 0.05	< 0.001	**24**	< 0.001	574	< 0.005	**0.072**	1.5	< 0.02	< 0.001	**0.7**	**10.1**	< 0.0001	0.018	7.2	2.9	< 0.001	6,390	< 0.0005	9,970
160M-CCR	CTLN-1604-155	4/28/2016	< 0.001	0.005	< 0.05	0.001	**5.98**	< 0.001	473	< 0.005	**0.008**	0.3	0.49	0.001	**0.7**	**1.66**	< 0.0001	0.012	7.1	3.4	< 0.008	7,640	< 0.0005	11,300
160M-CCR	CTLN-1606-460	6/23/2016	< 0.001	0.002	< 0.05	< 0.001	**7.2**	< 0.001	494	< 0.005	**0.008**	0.3	7.28	< 0.001	**0.6**	**1.7**	< 0.0001	0.01	7.1	1.4	< 0.001	7,330	< 0.0005	10,700
160M-CCR	CTLN-1608-357	8/10/2016	< 0.001	0.002	< 0.05	< 0.001	**5.78**	< 0.001	473	< 0.005	0.005	0.3	7.08	< 0.001	**0.6**	**1.65**	< 0.0001	0.003	7.2	4.7	< 0.002	7,600	< 0.0005	10,900
160M-CCR	CTLN-1609-359	9/15/2016	< 0.001	0.004	< 0.05	< 0.001	**38.3**	< 0.001	499	< 0.005	**0.007**	0.3	3.5	< 0.001	**0.4**	**1.44**	< 0.0001	0.01	7.1	1.5	< 0.004	9,240	< 0.0005	13,100
160M-CCR	CTLN-1612-260	12/7/2016	< 0.001	< 0.001	< 0.05	< 0.001	**24**	< 0.001	545	< 0.005	**0.008**	0.3	4.65	< 0.001	**0.4**	**1.66**	< 0.0001	0.007	7.1	1.5	< 0.004	7,750	< 0.0005	11,300
160M-CCR	CTLN-1702-157	2/1/2017	< 0.001	0.001	< 0.05	< 0.001	**20.7**	< 0.001	497	< 0.005	0.005	0.3	5.36	< 0.001	**0.4**	**1.51**	< 0.0001	0.004	7.0	4.6	< 0.002	8,420	< 0.0005	11,200
160M-CCR	CTLN-1703-350	3/9/2017	< 0.001	< 0.002	< 0.05	< 0.001	**25.8**	< 0.001	548	< 0.005	0.006	0.3	3.5	< 0.001	**0.2**	**1.72**	< 0.0001	0.003	7.1	2.3	< 0.004	7,680	< 0.001	11,400
160M-CCR	CTLN-1704-344	4/27/2017	0.001	< 0.002	< 0.05	< 0.001	**27.2**	< 0.001	521	< 0.005	**0.01**	0.3	2.28	< 0.001	**0.4**	**1.92**	< 0.0001	0.004	7	1.2	< 0.004	7,740	< 0.0005	11,100
160M-CCR	CTLN-1708-451	8/16/2017	< 0.001	< 0.001	< 0.05	< 0.001	**5.95**	< 0.001	418	< 0.005	< 0.005	0.3	8.82	< 0.001	**0.5**	**1.07**	< 0.0001	0.001	7	3.1	< 0.001	7,600	< 0.0005	10,800
162M-CCR	CTLN-1604-157	4/28/2016	< 0.001	0.002	< 0.05	< 0.001	1.41	< 0.001	668	< 0.005	**0.042**	0.2	2.03	< 0.001	**0.2**	**7.47**	< 0.0001	0.003	6.7	**6.6**	< 0.004	3,660	< 0.0005	6,190
162M-CCR	CTLN-1606-453	6/21/2016	< 0.001	0.002	< 0.05	< 0.001	1.27	< 0.001	619	< 0.005	**0.042**	0.2	2.88	< 0.001	**0.2**	**6.64**	< 0.0001	0.001	6.7	0.9	< 0.001	3,590	< 0.0005	6,140
162M-CCR	CTLN-1608-350	8/9/2016	< 0.001	0.001	< 0.05	< 0.001	1.23	< 0.001	595	< 0.005	**0.042**	0.2	3.16	< 0.001	**0.1**	**6.61**	< 0.0001	0.001	6.6	4.7	< 0.002	3,720	< 0.0005	6,140
162M-CCR	CTLN-1609-351	9/14/2016	< 0.001	0.001	< 0.05	< 0.001	1.24	< 0.001	598	< 0.005	**0.043**	0.2	3.28	< 0.001	**0.2**	**6.55**	< 0.0001	0.001	6.7	**6.6**	< 0.002	3,580	< 0.0005	6,120
162M-CCR	CTLN-1612-253	12/6/2016	< 0.001	0.003	< 0.05	< 0.001	1.29	< 0.001	636	0.014	**0.042**	0.2	3.18	< 0.001	**0.2**	**6.27**	< 0.0001	0.001	6.7	2.6	< 0.004	3,800	< 0.0005	6,100
162M-CCR	CTLN-1701-154	1/31/2017	< 0.001	0.003	< 0.05	< 0.001	1.2	< 0.001	584	< 0.005	**0.041**	0.2	3.19	< 0.001	< 0.1	**6.17**	< 0.0001	0.001	6.7	3.8	< 0.004	3,690	0.0006	5,980
162M-CCR	CTLN-1703-337	3/6/2017	< 0.001	0.003	< 0.05	< 0.001	1.2	< 0.001	577	< 0.005	**0.04**	0.2	3.44	< 0.001	< 0.1	**6.47**	< 0.0001	< 0.001	6.7	2.5	< 0.004	3,630	< 0.001	6,070
162M-CCR	CTLN-1704-341	4/26/2017	< 0.001	0.002	< 0.05	< 0.001	1.32	< 0.001	544	< 0.005	**0.043**	0.2	2.3	< 0.001	**0.2**	**6.52**	< 0.0001	0.002	6.7	**6.1**	< 0.002	3,830	< 0.0005	6,070
162M-CCR	CTLN-1708-436	8/10/2017	< 0.001	0.001	< 0.05	< 0.001	1.31	< 0.001	560	< 0.005	**0.031**	0.2	0.88	< 0.001	< 0.1	**6.83**	< 0.0001	0.001	6.7	2.5	< 0.001	3,680	< 0.0005	6,140
163M-CCR	CTLN-1604-158	4/28/2016	< 0.001	< 0.001	0.06	< 0.001	0.97	< 0.001	271	< 0.005	< 0.005	0.2	0.12	< 0.001	**0.1**	0.362	< 0.0001	< 0.001	7.2	2.8	< 0.002	1,200	< 0.0005	2,300
163M-CCR	CTLN-1606-462	6/23/2016	< 0.001	< 0.001	< 0.05	< 0.001	0.77	< 0.001	207	< 0.005	< 0.005	0.2	1.29	< 0.001	< 0.1	0.251	< 0.0001	< 0.001	7.3	-0.05	< 0.001	1,080	< 0.0005	2,070
163M-CCR	CTLN-1608-349	8/9/2016	< 0.001	< 0.001	< 0.05	< 0.001	0.78	< 0.001	203	< 0.005	< 0.005	0.2	1.64	< 0.001	< 0.1	0.203	< 0.0001	< 0.001	7.2	3	< 0.001	1,070	< 0.0005	2,070
163M-CCR	CTLN-1609-350	9/13/2016	< 0.001	< 0.001	< 0.05	< 0.001	0.81	< 0.001	205	< 0.005	< 0.005	0.2	1.65	< 0.001	< 0.1	0.197	< 0.0001	< 0.001	7.2	**6.3**	< 0.001	1,050	< 0.0005	2,100
163M-CCR	CTLN-1612-252	12/6/2016	< 0.001	< 0.001	< 0.05	< 0.001	0.81	< 0.001	209	< 0.005	< 0.005	0.2	1.41	< 0.001	< 0.1	0.173	< 0.0001	< 0.001	7.2	2	< 0.002	1,010	< 0.0005	1,950
163M-CCR	CTLN-1701-153	1/31/2017	< 0.001	< 0.001	< 0.05	< 0.001	0.8	< 0.001	199	< 0.005	< 0.005	0.2	1.17	< 0.001	< 0.1	0.175	< 0.0001	< 0.001	7.3	2.3	< 0.001	1,020	< 0.0005	1,890

APPENDIX F

Colstrip SES Federal CCR Rule Groundwater Draft Baseline Monitoring Data - 2016 Through November 30, 2017

Comparison For Montana DEQ Human Health GW MCLs (If No MCL Listed Then EPA RSL For Tapwater - Ingestion For Child, RSL Limit Was Used)

***Metals analyzed as Total Recoverable (TRC) unless turbidity >10, then metals ran both as Total Recoverable (TRC) and Dissolved (DIS).**

🟧 ***Highlighted Values Exceed MCL or EPA Tapwater RSL***

🟦 ***Highlighted Values Are Detection Limits Higher than the MCL or EPA Tapwater RSL***

Site Code	Sample Code	Date	ANTIMONY 7440-36-0 mg/L	ARSENIC 7440-38-2 mg/L	BARIUM 7440-39-3 mg/L	BERYLLIUM 7440-41-7 mg/L	BORON 7440-42-8 mg/L	CADMIUM 7440-43-9 mg/L	CALCIUM 7440-70-2 mg/L	CHROMIUM 7440-47-3 mg/L	COBALT 7440-48-4 mg/L	FLUORIDE 16984-48-8 mg/L	IRON 7439-89-6 mg/L	LEAD 7439-92-1 mg/L	LITHIUM 7439-93-2 mg/L	MANGANESE 7439-96-5 mg/L	MERCURY 7439-97-6 mg/L	MOLYBDENUM 7439-98-7 mg/L	pH NA standard units	RADIUM 226/228 7440-14-4 pCi/L	SELENIUM 7782-49-2 mg/L	SULFATE 14808-79-8 mg/L	THALLIUM 7440-28-0 mg/L	TDS NA mg/L
			MCL - 0.006	MCL - 0.01	MCL - 1.0	MCL - 0.004	RSL - 4.0	MCL - 0.005	no MCL / RSL	MCL - 0.1	RSL - 0.006	MCL - 4.0	No MCL / RSL	MCL - 0.015	RSL - 0.04	RSL 0.43	MCL - 0.002	RSL - 0.1	no MCL / RSL	MCL - 5.0	MCL - 0.05	no MCL / RSL	MCL - 0.002	no MCL / RSL
Units 1&2 B Fly Ash Pond (continued)																								
163M-CCR	CTLN-1703-338	3/6/2017	< 0.001	< 0.001	< 0.05	< 0.001	0.76	< 0.001	190	< 0.005	< 0.005	0.2	1.38	< 0.001	< 0.1	0.169	< 0.0001	< 0.001	7.3	2.9	< 0.002	1,020	< 0.0007	1,960
163M-CCR	CTLN-1705-951	5/2/2017	< 0.001	< 0.001	< 0.05	< 0.001	0.84	0.002	197	< 0.005	< 0.005	0.2	2.31	< 0.001	< 0.1	0.141	< 0.0001	< 0.001	7.3	3.2	< 0.002	1,010	< 0.0005	1,850
163M-CCR	CTLN-1708-437	8/10/2017	< 0.001	< 0.001	< 0.05	< 0.001	0.81	< 0.001	105	< 0.005	< 0.005	0.2	1.46	< 0.001	< 0.1	0.108	< 0.0001	< 0.001	7.3	2	< 0.001	979	< 0.0005	1,880
164M-CCR	CTLN-1604-151	4/27/2016	< 0.001	< 0.001	< 0.05	0.001	1.01	< 0.001	390	< 0.005	0.012	0.2	3.54	0.001	0.1	0.347	< 0.0001	< 0.001	7.1	3.3	< 0.004	2,680	< 0.0005	4,330
164M-CCR	CTLN-1606-463	6/23/2016	< 0.001	< 0.001	< 0.05	< 0.001	0.71	< 0.001	371	< 0.005	< 0.005	0.2	3.97	< 0.001	0.1	0.247	< 0.0001	< 0.001	7.1	1	< 0.001	2,660	< 0.0005	4,160
164M-CCR	CTLN-1608-347	8/8/2016	< 0.001	< 0.001	< 0.05	< 0.001	0.76	< 0.001	371	< 0.005	< 0.005	0.2	4.34	< 0.001	< 0.1	0.249	< 0.0001	< 0.001	7.1	3.9	< 0.001	2,650	< 0.0005	4,230
164M-CCR	CTLN-1609-348	9/13/2016	< 0.001	< 0.001	< 0.05	< 0.001	0.73	< 0.001	366	< 0.005	< 0.005	0.2	4.26	< 0.001	0.1	0.232	< 0.0001	< 0.001	7.1	3.8	< 0.001	2,630	< 0.0005	4,220
164M-CCR	CTLN-1612-255	12/7/2016	< 0.001	< 0.001	< 0.05	< 0.001	1.5	< 0.001	371	< 0.005	0.017	0.2	4.54	0.001	0.1	0.305	< 0.0001	0.001	7.1	1.6	< 0.002	2,780	< 0.0005	4,160
164M-CCR	CTLN-1701-151	1/31/2017	< 0.001	< 0.001	< 0.05	< 0.001	3.1	< 0.001	466	< 0.005	0.103	0.2	1.85	0.007	< 0.1	0.438	< 0.0001	< 0.001	7.1	2.6	< 0.004	3,660	0.0008	5,340
164M-CCR	CTLN-1703-336	3/6/2017	< 0.001	< 0.002	< 0.05	< 0.001	3.71	< 0.001	479	< 0.005	0.15	0.2	1.36	0.011	< 0.1	0.528	< 0.0001	< 0.001	7.2	3.4	< 0.004	3,650	< 0.001	5,680
164M-CCR	CTLN-1705-950	5/2/2017	< 0.001	< 0.001	< 0.05	< 0.001	4.03	0.002	472	< 0.005	0.176	0.2	1.02	0.013	< 0.1	0.519	< 0.0001	< 0.001	7.1	4.2	< 0.002	3,570	< 0.0005	5,320
164M-CCR	CTLN-1708-433	8/9/2017	< 0.001	< 0.001	< 0.05	< 0.001	4.3	0.001	477	< 0.005	0.149	0.2	0.83	0.014	< 0.1	0.537	< 0.0001	< 0.001	7.1	2.7	< 0.001	3,580	< 0.0005	5,860
AB26-S	TLN-1602-904-CCR2	2/22/2016	< 0.001	0.001	< 0.05	< 0.001	18.9	< 0.001	450	< 0.005	0.009	1.8	0.11	< 0.001	0.5	6.26	< 0.0001	0.035	7.3	1.8	< 0.002	4,770	< 0.0005	7,430
AB26-S	CTLN-1604-149	4/27/2016	< 0.001	0.002	< 0.05	0.002	19.6	< 0.001	481	< 0.005	0.009	1.8	< 0.05	< 0.001	0.6	6.08	< 0.0001	0.036	7.4	2.8	< 0.008	4,930	< 0.0005	7,560
AB26-S	CTLN-1606-465	6/23/2016	< 0.001	< 0.001	< 0.05	< 0.001	19.3	< 0.001	459	< 0.005	0.007	1.8	0.04	< 0.001	0.6	5.95	< 0.0001	0.035	7.5	0.5	< 0.001	4,930	< 0.0005	7,200
AB26-S	CTLN-1608-356	8/10/2016	< 0.001	< 0.001	< 0.05	< 0.001	19.4	< 0.001	451	< 0.005	0.008	1.8	< 0.09	< 0.001	0.6	5.79	< 0.0001	0.036	7.4	0.9	< 0.002	5,070	< 0.0005	7,530
AB26-S	CTLN-1609-358	9/15/2016	< 0.001	< 0.001	< 0.05	< 0.001	18.8	< 0.001	435	< 0.005	0.006	1.7	0.04	< 0.001	0.6	5.43	< 0.0001	0.029	7.4	1.4	< 0.002	4,940	< 0.0005	7,440
AB26-S	CTLN-1612-354	12/7/2016	< 0.001	0.005	< 0.05	< 0.001	20	< 0.001	525	< 0.005	0.013	1.7	2.86	0.004	0.7	8.11	< 0.0001	0.034	7.4	0.6	< 0.004	5,300	0.0006	7,920
AB26-S	CTLN-1702-156	2/1/2017	< 0.001	0.001	< 0.05	< 0.001	20.3	< 0.001	511	< 0.005	0.009	1.8	0.24	< 0.001	0.6	6.85	< 0.0001	0.036	7.4	2.6	< 0.002	6,480	< 0.0005	8,440
AB26-S	CTLN-1703-348	3/8/2017	< 0.001	< 0.002	< 0.05	< 0.001	20.6	< 0.001	494	< 0.005	0.01	1.8	0.3	< 0.001	0.6	6.97	< 0.0001	0.035	7.5	1.9	< 0.004	6,100	< 0.001	9,020
AB26-S	CTLN-1704-348	4/28/2017	< 0.001	< 0.002	< 0.05	< 0.001	20.8	< 0.001	470	< 0.005	0.013	2	0.05	< 0.001	0.8	7.47	< 0.0001	0.036	7.4	2.6	< 0.004	6,500	< 0.0005	8,680
AB26-S	CTLN-1708-435	8/10/2017	< 0.001	< 0.001	< 0.05	< 0.001	20	< 0.001	467	< 0.005	0.008	1.7	0.04	< 0.001	0.5	6.97	< 0.0001	0.033	7.5	1.5	< 0.001	5,600	< 0.0005	8,000
Background Wells for Plant Site CCR Units																								
20SP	TLN-1602-901-CCR	2/18/2016	< 0.001	< 0.001	< 0.05	< 0.001	0.24	< 0.001	248	< 0.005	< 0.005	0.2	< 0.02	< 0.001	< 0.1	0.128	< 0.0001	< 0.001	7.0	2.1	< 0.001	1,520	< 0.0005	3,180
20SP	CTLN-1604-159	4/29/2016	< 0.001	< 0.001	< 0.05	< 0.001	0.29	< 0.001	262	< 0.005	< 0.005	0.2	0.05	< 0.001	< 0.1	0.104	< 0.0001	< 0.001	7.1	0.7	< 0.002	1,550	< 0.0005	3,240
20SP	CTLN-1606-444	6/20/2016	< 0.001	< 0.001	< 0.05	< 0.001	0.25	< 0.001	256	< 0.005	< 0.005	0.2	0.04	< 0.001	< 0.1	0.045	< 0.0001	< 0.001	7.1	2.1	< 0.001	1,530	< 0.0005	3,230
20SP	CTLN-1607-539	7/28/2016	< 0.001	< 0.001	< 0.05	< 0.001	0.29	< 0.001	247	< 0.005	< 0.005	0.2	0.03	< 0.001	< 0.1	0.059	< 0.0001	< 0.001	7.1	0.3	< 0.001	1,490	< 0.0005	3,180
20SP	CTLN-1609-360	9/26/2016	< 0.001	< 0.001	< 0.05	< 0.001	0.29	< 0.001	251	< 0.005	< 0.005	0.2	0.06	< 0.001	< 0.1	0.091	< 0.0001	< 0.001	7.0	0.8	< 0.001	1,510	< 0.0005	3,140
20SP	CTLN-1612-243	12/1/2016	< 0.001	< 0.001	< 0.05	< 0.001	0.26	< 0.001	292	< 0.005	< 0.005	0.2	0.2	< 0.001	< 0.1	0.069	< 0.0001	< 0.001	7.0	0.05	0.001	1,970	< 0.0005	3,700
20SP	CTLN-1701-143	1/27/2017	< 0.001	< 0.002	< 0.05	< 0.001	0.23	< 0.001	302	< 0.005	< 0.005	0.2	0.07	< 0.001	< 0.1	0.056	< 0.0001	< 0.001	7.1	0.7	< 0.004	2,040	0.0025	3,710
20SP	CTLN-1703-744	3/9/2017	< 0.001	< 0.001	< 0.05	< 0.001	0.26	< 0.001	293	< 0.005	< 0.005	0.2	0.06	< 0.001	< 0.1	0.043	< 0.0001	< 0.001	7.1	1.6	< 0.002	1,990	< 0.0005	3,730
20SP	CTLN-1704-944	4/25/2017	< 0.001	< 0.001	< 0.05	< 0.001	0.25	< 0.001	282	< 0.005	< 0.005	0.2	0.05	< 0.001	< 0.1	0.07	< 0.0001	< 0.001	7	2.2	< 0.002	2,060	< 0.0005	3,630
20SP	CTLN-1709-494	9/8/2017	< 0.001	< 0.001	< 0.05	< 0.001	0.26	< 0.001	274	0.005	< 0.005	0.2	0.09	< 0.001	< 0.1	1.12	< 0.0001	0.001	7	1.8	< 0.001	2,240	< 0.0005	3,540
21SP-2	TLN-1603-300-CCR	3/31/2016	< 0.001	< 0.001	< 0.05	< 0.001	1.59	< 0.001	362	< 0.005	0.006	0.1	0.04	< 0.001	0.2	0.199	< 0.0001	< 0.001	7.0	2.8	0.002	2,040	< 0.0005	3,670
21SP-2 (Dup)	TLN-1603-301-CCR	3/31/2016	< 0.001	< 0.001	< 0.05	< 0.001	1.58	< 0.001	357	< 0.005	0.005	0.1	0.04	< 0.001	0.2	0.196	< 0.0001	< 0.001	7.0	2.4	0.002	2,040	< 0.0005	3,640
21SP-2	CTLN-1606-443	6/20/2016	< 0.001	< 0.001	< 0.05	< 0.001	1.52	< 0.001	390	< 0.005	< 0.005	0.1	0.02	< 0.001	0.2	0.326	< 0.0001	< 0.001	7.0	1.6	0.002	1,950	< 0.0005	3,680
21SP-2	CTLN-1607-538	7/28/2016	< 0.001	< 0.001	< 0.05	< 0.001	1.65	< 0.001	374	< 0.005	< 0.005	0.1	< 0.02	< 0.001	0.2	0.176	< 0.0001	< 0.001	7.0	0.5	< 0.001	2,050	< 0.0005	3,680
21SP-2	CTLN-1609-363	9/27/2016	< 0.001	< 0.001	< 0.05	< 0.001	1.65	< 0.001	370	< 0.005	< 0.005	0.2	< 0.02	< 0.001	0.2	0.099	< 0.0001	< 0.001	7.2	0.6	0.002	2,050	< 0.0005	3,520
21SP-2	CTLN-1612-248	12/6/2016	< 0.001	< 0.001	< 0.05	< 0.001	1.49	< 0.001	356	< 0.005	< 0.005	0.2	0.1	< 0.001	0.2	0.311	< 0.0001	< 0.001	7.2	2.8	< 0.002	2,020	< 0.0005	3,450
21SP-2	CTLN-1701-142	1/27/2017	< 0.001	< 0.001	< 0.05	< 0.001	1.5	< 0.001	352	< 0.005	< 0.005	0.1	< 0.02	< 0.001	0.1	0.097	< 0.0001	< 0.001	7.3	0.4	< 0.002	2,040	0.001	3,290
21SP-2	CTLN-1703-743	3/9/2017	< 0.001	< 0.001	< 0.05	< 0.001	1.47	< 0.001	383	< 0.005	< 0.005	0.1	< 0.02	< 0.001	0.1	0.147	< 0.0001	< 0.001	7.2	0.3	< 0.002	2,020	< 0.0005	3,440
21SP-2	CTLN-1704-945	4/25/2017	< 0.001	< 0.001	< 0.05	< 0.001	1.4	< 0.001	429	< 0.005	< 0.005	< 0.1	0.03	< 0.001	0.1	0.409	< 0.0001	< 0.001	7	1.2	0.003	2,210	< 0.0005	3,550
21SP-2	CTLN-1705-423	5/31/2017	< 0.001	0.003	< 0.05	< 0.001	1.28	< 0.001	441	< 0.005	< 0.005	0.1	< 0.04	< 0.001	0.1	0.566	< 0.0001	0.002	7	1	0.014	2,320	< 0.0005	3,750
21SP-2	CTLN-1706-354	6/28/2017	< 0.001	< 0.001	< 0.05	< 0.001	1.16	< 0.001	415	< 0.005	< 0.005	0.1	< 0.02	< 0.001	0.1	0.314	< 0.0001	< 0.001	7	1.7	0.002	2,260	< 0.0005	3,460
21SP-2	CTLN-1707-324	7/31/2017	< 0.001	< 0.001	< 0.05	< 0.001	1.11	< 0.001	409	< 0.005	< 0.005	0.1	< 0.02	< 0.001	< 0.1	0.25	< 0.0001	< 0.001	7	0.4	0.001	2,090	< 0.0005	3,300
21SP-2	CTLN-1708-321	8/31/2017	< 0.001	< 0.001	< 0.05	< 0.001	0.98	< 0.001	349	< 0.005	< 0.005	0.2	< 0.02	< 0.001	< 0.1	0.162	< 0.0001	< 0.001	7.1	0.5	0.001	2,080	< 0.0005	3,270
161SP-CCR	CTLN-1604-203	4/19/2016	< 0.001	0.001	< 0.05	< 0.001	0.16	< 0.001	295	< 0.005	0.008	0.1	0.16	< 0.001	< 0.1	2.45	< 0.0001	0.001	7.3	2.6	0.008	2,110	< 0.0005	3,680
161SP-CCR	CTLN-1606-447	6/20/2016	< 0.001	< 0.001	< 0.05	< 0.001	0.14	< 0.001	313	< 0.005	0.012	0.2	1.59	< 0.001	< 0.1	2.74	< 0.0001	0.001	7.0	1.4	< 0.001	2,120	< 0.0005	3,630
161SP-CCR	CTLN-1608-905	8/18/2016	< 0.001	0.002	< 0.05	< 0.001	0.13	< 0.001	296	< 0.005	< 0.005	0.2	0.57	< 0.001	< 0.1	2.84	< 0.0001	< 0.001	7.0	1.4	< 0.001	2,110	< 0.0005	3,650
161SP-CCR	CTLN-1609-369	9/27/2016	< 0.001	0.003	< 0.05	< 0.001	0.16	< 0.001	318	< 0.005	< 0.005	0.2	0.62	< 0.001	< 0.1	2.67	< 0.0001	0.001	7.1	0.8	< 0.001	2,080	< 0.0005	3,510
161SP-CCR	CTLN-1612-246	12/5/2016	< 0.001	0.004	< 0.05	< 0.001	0.15	< 0.001	308	< 0.005	< 0.005	0.2	0.44	< 0.001	< 0.1	2.37	< 0.0001	< 0.001	7.1	0.9	< 0.002	2,100	< 0.0005	3,640
161SP-CCR	CTLN-1702-158	2/1/2017	< 0.001	0.004	< 0.05	< 0.001	0.13	< 0.001	295	< 0.005	< 0.005	0.2	0.4	< 0.001	< 0.1	2.32	< 0.0001	< 0.001	7.1	0.9	< 0.001	2,180	< 0.0005	3,570
161SP-CCR	CTLN-1705-948	5/1/2017	< 0.001	0.003	< 0.05	< 0.001	0.14	0.002	303	< 0.005	< 0.005	0.1	0.91	< 0.001	< 0.1	2.46	< 0.0001	< 0.001	7	5.1	< 0.002	2,230	< 0.0005	3,500
161SP-CCR	CTLN-1705-416	5/31/2017	< 0.001	0.004	< 0.05	< 0.001	0.14	< 0.001	313	< 0.005	< 0.005	0.1	1.1	< 0.001	< 0.1	2.42	< 0.0001	< 0.001	7.1	2.4	0.002	2,210	< 0.0005	3,700
161SP-CCR	CTLN-1706-355	6/28/2017	< 0.001	0.004	< 0.05	< 0.001	0.11	< 0.001	285	< 0.005	< 0.005	0.1	1.18	< 0.001	< 0.1	2.37	< 0.0001	< 0.001	7.1	1.7	< 0.001	2,320	< 0.0005	3,490
161SP-CCR	CTLN-1708-325	8/1/2017	< 0.001	0.004	< 0.05	< 0.001	0.11	< 0.001	273	< 0.005	< 0.005	0.1	1.28	< 0.001	< 0.1	2.53	< 0.0001	< 0.001	7.1	1.6	< 0.001	2,300	< 0.0005	3,520
161SP-CCR	CTLN-1709-492	9/7/2017	< 0.001	0.003	< 0.05	< 0.001	0.11	< 0.001	263	< 0.005	< 0.005	0.2	2.3	< 0.001	< 0.1	2.2	< 0.0001	< 0.001	7.1	3.8	< 0.001	2,320	0.0006	3,610
63S	TLN-1603-303-CCR	3/31/2016	< 0.001	< 0.001	< 0.05	< 0.001	0.63	< 0.001	356	< 0.005	< 0.005	0.2	0.04	< 0.001	< 0.1	0.239	< 0.0001	0.002	7.2	2.6	< 0.001	2,210	< 0.0005	3,890
63S	CTLN-1606-338	6/27/2016	< 0.001	< 0.001	< 0.05	< 0.001	0.68	< 0.001	354	< 0.005	< 0.005	0.2	0.03	< 0.001	0.1	0.218	< 0.0001	0.002	7.2	1.1	< 0.002	2,220	< 0.0005	4,090
63S	CTLN-1608-343	8/3/2016	< 0.001	< 0.001	< 0.05	0.002	0.64	< 0.001	300	< 0.005	< 0.005	0.2	< 0.05	< 0.001	< 0.1	0.199	< 0.0001	0.002	7.3	1.4	< 0.001	2,300	< 0.0005	4,030
63S	CTLN-1608-317	8/29/2016	< 0.001	< 0.001	< 0.05	< 0.001	0.64	< 0.001	327	< 0.005	< 0.005	0.2	< 0.02	< 0.001	0.1	0.209	< 0.0001	0.002	7.3	1	< 0.001	2,840	< 0.0005	4,010
63S	CTLN-1611-335	11/28/2016	< 0.001	< 0.001	< 0.05	< 0.001	0.77	< 0.001	359	< 0.005	< 0.005	0.2	0.23	< 0.001	0.2	0.234	< 0.0001	0.002	7.2	1	< 0.002	2,250	< 0.0005	4,020
63S	CTLN-1702-346	2/15/2017	< 0.001	< 0.001	< 0.05	< 0.001	0.67	< 0.001	328	< 0.005	< 0.005	0.2	0.1	< 0.001	< 0.1	0.25	< 0.0001	0.002	7.3	1.7	< 0.002	2,340	< 0.0005	3,860
63S	CTLN-1703-361	3/14/2017	< 0.001	< 0.001	< 0.05	< 0.001	0.6	< 0.001	317	< 0.005	< 0.005	0.2	0.16	< 0.001	< 0.1	0.254	< 0.0001	0.002	7.3	0.1	< 0.002	2,350	< 0.0005	4,000
63S	CTLN-1705-305	5/2/2017	< 0.001	< 0.001	< 0.05	< 0.001	0.67	< 0.001	330	< 0.005	< 0.005	0.2	0.04	< 0.001	< 0.1	0.239	< 0.0001	0.002	7.2	0.9	< 0.002	2,360	< 0.0005	3,830
63S	CTLN-1708-454	8/21/2017	< 0.001	< 0.001	< 0.05	< 0.001	0.67	< 0.001	310	< 0.005	< 0.005	0.2	< 0.02	< 0.001	< 0.1	0.28	< 0.0001	0.002	7.3	0.7	< 0.001	2,670	< 0.0005	3,990
104A	TLN-1602-911-CCR	2/24/2016	< 0.001	< 0.001	< 0.05	< 0.001	0.55	< 0.001	297	< 0.005	< 0.005	0.2	0.05	< 0.001	< 0.1	0.567	< 0.0001	0.001	7.2	2.4	< 0.001	2,180	< 0.0005	3,850
104A	CTLN-1604-148	4/26/2016	< 0.001	< 0.001	< 0.05	< 0.001	0.66	< 0.001	336	< 0.005	< 0.005	0.2	0.03	< 0.001	0.1	0.239	< 0.0001	0.002	7.4	2.6	< 0.004	2,190	< 0.0005	3,870
104A	CTLN-1606-342	6/28/2016	< 0.001	< 0.001	< 0.05	< 0.001	0.62	< 0.001	308	< 0.005	< 0.005	0.2	1.42	< 0.001	< 0.1	0.192	< 0.0001	0.002	7.2	3.2	< 0.002	2,150	< 0.0005	3,870
104A	CTLN-1608-344	8/3/2016	< 0.001	< 0.001	< 0.05	< 0.001	0.61	< 0.001	286	< 0.005	< 0.005	0.2	< 0.05	< 0.001	< 0.1	0.179	< 0.0001	0.002	7.3	0.3	< 0.001	2,230	< 0.0005	3,870
104A	CTLN-1609-335	9/6/2016	< 0.001	< 0.001	< 0.05	< 0.001	0.59	< 0.001	295	< 0.005	< 0.005	0.2	< 0.02	< 0.001	< 0.1	0.203	< 0.0001	0.002	7.3	1.7	< 0.001	2,250	< 0.0005	3,780
104A	CTLN-1611-343	11/30/2016	< 0.001	< 0.001	< 0.05	< 0.001	0.65	< 0.001	325	< 0.005	< 0.005	0.2	0.02	< 0.001	0.1	0.247	< 0.0001	0.002	7.3	-0.8	< 0.002	2,260	< 0.0005	3,910
104A	CTLN-1702-341	2/13/2017	< 0.001	< 0.001	< 0.05	< 0.001	0.64	< 0.001	323	< 0.005	< 0.005	0.2	0.03	< 0.001	< 0.1	0.217	< 0.0001	0.002	7.3	2.7	< 0.002	2,340	< 0.0005	3,840
104A	CTLN-1703-341	3/7/2017	< 0.001	< 0.001	< 0.05	< 0.001	0.59	< 0.001	302	< 0.005	< 0.005	0.2	0.03	< 0.001	< 0.1	0.238	< 0.0001	0.002	7.3	0.9	< 0.002	2,360	< 0.0007	3,860

*** * DRAFT * ***

5/9/2018

APPENDIX F

Colstrip SES Federal CCR Rule Groundwater Draft Baseline Monitoring Data - 2016 Through November 30, 2017

Comparison For Montana DEQ Human Health GW MCLs (If No MCL Listed Then EPA RSL For Tapwater - Ingestion For Child, RSL Limit Was Used)

***Metals analyzed as Total Recoverable (TRC) unless turbidity >10, then metals ran both as Total Recoverable (TRC) and Dissolved (DIS).**

🟧	***Highlighted Values Exceed MCL or EPA Tapwater RSL***
⬜	***Highlighted Values Are Detection Limits Higher than the MCL or EPA Tapwater RSL***

Site Code	Sample Code	Date	ANTIMONY 7440-36-0 mg/L	ARSENIC 7440-38-2 mg/L	BARIUM 7440-39-3 mg/L	BERYLLIUM 7440-41-7 mg/L	BORON 7440-42-8 mg/L	CADMIUM 7440-43-9 mg/L	CALCIUM 7440-70-2 mg/L	CHROMIUM 7440-47-3 mg/L	COBALT 7440-48-4 mg/L	FLUORIDE 16984-48-8 mg/L	IRON 7439-89-6 mg/L	LEAD 7439-92-1 mg/L	LITHIUM 7439-93-2 mg/L	MANGANESE 7439-96-5 mg/L	MERCURY 7439-97-6 mg/L	MOLYBDENUM 7439-98-7 mg/L	pH NA standard units	RADIUM 226/228 7440-14-4 pCi/L	SELENIUM 7782-49-2 mg/L	SULFATE 14808-79-8 mg/L	THALLIUM 7440-28-0 mg/L	TDS NA mg/L
			MCL - 0.006	MCL - 0.01	MCL - 1.0	MCL - 0.004	RSL - 4.0	MCL - 0.005	no MCL/ RSL	MCL - 0.1	RSL - 0.006	MCL - 4.0	No MCL/ RSL	MCL - 0.015	RSL - 0.04	RSL 0.43	MCL - 0.002	RSL - 0.1	no MCL/ RSL	MCL - 5.0	MCL - 0.05	no MCL/ RSL	MCL - 0.002	no MCL/ RSL
Background Wells for Plant Site CCR Units (continued)																								
104A	CTLN-1705-300	5/1/2017	< 0.001	< 0.001	< 0.05	< 0.001	0.64	0.002	310	< 0.005	< 0.005	0.2	0.03	< 0.001	< 0.1	0.17	< 0.0001	0.002	7.3	2.1	< 0.002	2,310	< 0.0005	3,790
104A	CTLN-1708-453	8/21/2017	< 0.001	< 0.001	< 0.05	< 0.001	0.66	< 0.001	311	< 0.005	< 0.005	0.2	0.03	< 0.001	< 0.1	0.285	< 0.0001	0.002	7.3	0.5	< 0.001	2,530	< 0.0005	3,900
38M	TLN-1604-304-CCR	4/1/2016	< 0.001	< 0.001	< 0.05	< 0.001	0.49	< 0.001	325	< 0.005	< 0.005	0.1	0.94	< 0.001	< 0.1	0.083	< 0.0001	< 0.001	7.2	4.9	< 0.001	1,150	< 0.0005	2,090
38M	CTLN-1606-455	6/22/2016	< 0.001	< 0.001	< 0.05	< 0.001	0.49	< 0.001	248	< 0.005	< 0.005	0.1	1.34	< 0.001	< 0.1	0.075	< 0.0001	< 0.001	7.3	3.9	< 0.001	1,140	< 0.0005	2,090
38M	CTLN-1608-346	8/8/2016	< 0.001	< 0.001	< 0.05	< 0.001	0.44	< 0.001	231	< 0.005	< 0.005	0.1	2.43	< 0.001	< 0.1	0.077	< 0.0001	< 0.001	7.2	4.4	< 0.001	1,150	< 0.0005	2,120
38M	CTLN-1609-333	9/6/2016	< 0.001	< 0.001	< 0.05	< 0.001	0.48	< 0.001	243	< 0.005	< 0.005	0.1	2.26	< 0.001	< 0.1	0.069	< 0.0001	< 0.001	7.3	5.1	< 0.001	1,170	< 0.0005	2,070
38M	CTLN-1611-337	11/29/2016	< 0.001	< 0.001	< 0.05	< 0.001	0.5	< 0.001	265	< 0.005	< 0.005	0.1	2.4	< 0.001	< 0.1	0.078	< 0.0001	< 0.001	7.2	3.8	< 0.002	1,180	< 0.0005	2,070
38M	CTLN-1701-149	1/31/2017	< 0.001	< 0.001	< 0.05	< 0.001	0.48	< 0.001	248	< 0.005	< 0.005	0.1	2	< 0.001	< 0.1	0.069	< 0.0001	< 0.001	7.2	2.8	< 0.001	1,200	< 0.0005	2,130
38M	CTLN-1703-333	3/2/2017	< 0.001	< 0.001	< 0.05	< 0.001	0.46	< 0.001	248	< 0.005	< 0.005	0.1	1.87	0.001	< 0.1	0.07	< 0.0001	< 0.001	7.2	4.4	< 0.002	1,190	< 0.0005	2,100
38M	CTLN-1704-337	4/25/2017	< 0.001	< 0.001	< 0.05	< 0.001	0.58	< 0.001	256	< 0.005	< 0.005	0.1	1.87	< 0.001	< 0.1	0.081	< 0.0001	< 0.001	7.2	4.6	< 0.001	1,210	< 0.0005	2,050
38M	CTLN-1708-430	8/9/2017	< 0.001	< 0.001	< 0.05	< 0.001	0.45	< 0.001	253	< 0.005	< 0.005	0.1	2.01	< 0.001	< 0.1	0.07	< 0.0001	< 0.001	7.3	3.5	< 0.001	1,180	< 0.0005	2,100
39M	CTLN-1604-102	4/4/2016	< 0.001	< 0.001	< 0.05	< 0.001	0.37	< 0.001	151	< 0.005	< 0.005	0.2	0.02	< 0.001	< 0.1	0.025	< 0.0001	< 0.001	7.5	1.4	< 0.001	835	< 0.0005	1,710
39M	CTLN-1606-452	6/21/2016	< 0.001	< 0.001	< 0.05	< 0.001	0.33	< 0.001	167	< 0.005	< 0.005	0.3	< 0.02	< 0.001	< 0.1	0.059	< 0.0001	< 0.001	7.6	2.3	< 0.001	839	< 0.0005	1,640
39M	CTLN-1608-360	8/11/2016	< 0.001	< 0.001	< 0.05	< 0.001	0.37	< 0.001	166	< 0.005	< 0.005	0.2	< 0.05	< 0.001	< 0.1	0.065	< 0.0001	< 0.001	7.5	1.3	< 0.001	844	< 0.0005	1,690
39M	CTLN-1609-344	9/8/2016	< 0.001	< 0.001	< 0.05	< 0.001	0.35	< 0.001	170	< 0.005	< 0.005	0.2	< 0.02	< 0.001	< 0.1	0.058	< 0.0001	< 0.001	7.6	2.8	< 0.001	855	< 0.0005	1,730
39M	CTLN-1611-340	11/30/2016	< 0.001	< 0.001	< 0.05	< 0.001	0.37	< 0.001	180	< 0.005	< 0.005	0.2	< 0.02	< 0.001	< 0.1	0.004	< 0.0001	< 0.001	7.5	2.3	< 0.001	859	< 0.0005	1,640
39M	CTLN-1701-147	1/30/2017	< 0.001	< 0.001	< 0.05	< 0.001	0.35	< 0.001	170	< 0.005	< 0.005	0.3	< 0.02	< 0.001	< 0.1	0.005	< 0.0001	0.001	7.5	0.7	< 0.001	877	0.0006	1,680
39M	CTLN-1703-340	3/7/2017	< 0.001	< 0.001	< 0.05	< 0.001	0.34	< 0.001	171	< 0.005	< 0.005	0.3	< 0.02	< 0.001	< 0.1	0.021	< 0.0001	< 0.001	7.5	2	< 0.002	910	< 0.0007	1,650
39M	CTLN-1704-340	4/26/2017	< 0.001	< 0.001	< 0.05	< 0.001	0.38	< 0.001	166	< 0.005	< 0.005	0.3	< 0.02	< 0.001	< 0.1	0.055	< 0.0001	< 0.001	7.5	4	< 0.001	834	< 0.0005	1,710
39M	CTLN-1708-428	8/8/2017	< 0.001	< 0.001	< 0.05	< 0.001	0.29	< 0.001	156	< 0.005	< 0.005	0.3	< 0.02	< 0.001	< 0.1	0.136	< 0.0001	< 0.001	7.6	0.6	< 0.001	850	< 0.0005	1,700

Appendix G

Responses to DEQ Comments
Revised October 31, 2018

Responses to DEQ Comments on the Plant Site Cleanup Criteria and Risk Assessment Report
DEQ Comments dated 9/15/2017

Specific Comments

1) Page xi, Executive Summary, 2nd paragraph: Please discuss the exposure (or lack thereof) of livestock to surface water with respect to ecological receptors.

   Accepted. Text has been added to the Executive Summary and Appendix C to discuss potential risk to livestock from use of East Fork Armells Creek surface water as a drinking water source. A table has been added to Appendix C to compare chemical concentrations in surface water to livestock-based surface water screening levels. No unacceptable risk is posed to livestock using East Fork Armells Creek as a drinking water source.

2) Page xi, Executive Summary, Last paragraph: Please discuss the use of MCLs for comparison to groundwater concentrations. MCLs are noted in the AOC as a means of comparison for constituents that do not have a DEQ-7, tapwater RSL or risk-based standard.

   Accepted. Text has been added.

3) Page xiii, Executive Summary, Table: Please change the cleanup criteria for cobalt in coal to the RSL of 0.006 mg/L, instead of the BSL.

   Accepted. Change has been made to the table.

4) Page 10, Section 2.3.2, 3rd paragraph: Please indicate that chloride is used as a secondary indicator parameter due to elevated background concentrations.

   Accepted. Text has been added to indicate that chloride is a secondary indicator parameter due to multiple potential area sources that cause a high degree of concentration variability.

5) Page 15, Section 3.0, 3rd paragraph: Please explain how total recoverable concentrations are compared to groundwater standards, which are based upon dissolved concentrations and add information regarding the conservative bias.

   Accepted. Text has been added discussing the comparison of CCR well data as total recoverable concentrations to groundwater standards based on dissolved concentrations and the resulting conservative bias.

6) Page 23, Section 4.4, 2nd paragraph: The report states that Talen has a robust worker safety program and that worker exposures within the controlled access area of the Plant Site are not evaluated. However, outdoor worker exposure is evaluated for all the areas impacted by pond water releases

to soil, and outdoor worker exposure to surface water and sediment is also evaluated. Groundwater is evaluated based upon all the potential cleanup criteria. DEQ generally requires that current workers potential exposure to contaminant releases be evaluated, and it appears that the CCRA includes this evaluation. Perhaps the statement regarding the worker safety program refers to potential employee exposure to the pond residuals located within the ponds. DEQ agrees that this type of exposure to process residuals is covered under the worker safety program. Please reword this paragraph to reflect this or otherwise explain this paragraph to DEQ.

Accepted. Text has been revised to indicate that the worker safety program (OSHA) applies to potential worker exposures to constituent residuals within the Plant Site ponds.

7) Page 23, Table 4-1: Children 0-6 years old are not allowed to hunt. Please change the recreational receptor description to something like children playing in the creek throughout the document.

Accepted. Changes made to Table 4-1, text throughout the document, and Appendix B (RAGS Tables).

8) Page 26, Section 5.0, Human Health Risk Assessment, 4th bullet: This wording is confusing in that it states that no COPCs were identified in soil, but then indicates that cleanup criteria have been developed in a later section. Please clarify.

Accepted. Second sentence in bullet deleted.

9) Page 28, Section 5.1.2 No. 8: Please delete number 8 as this is the Report.

Accepted. Number 8 deleted.

10) Page 32, Section 6.1.3, 1st paragraph, last sentence: Although AR-12 has been established as the primary background point, this should not be the only point used for comparison to background. Four surface water sites were used in determining the Background Screening Levels (Neptune, 2017); if all four sites will not be used for comparison to background, especially with respect to determining impacts from the mine upgradient of the Plant Site, please justify this in the Report with something other than a meeting with DEQ.

Accepted. Additional text has been added to Section 6.1.3 describing additional surface water reference/background samples in addition to AR-12, which is a primary background point. Additional surface water reference/background data have been added to Table B-2.1, as well.

11) Page 34, Section 6.3, 2nd paragraph: Please explain how qualitative evaluation through comparison to DEQ-7 standards resulted in the deletion of manganese as a surface water COPC, when there is no DEQ-7 standard for manganese, or correct this information.

Accepted. The text has been changed to indicate that if DEQ-7 standards were not available, comparisons were made to the USEPA MCLs and/or the USEPA Tapwater RSLs. Text was also added to discuss background comparisons.

12) Page 35, Section 6.3.2, 1st bullet: Please refer to the previous comment regarding comparison of total concentrations to standards.

    Accepted. Text has been added indicating that comparisons of total recoverable concentrations to screening levels based on dissolved concentrations results in conservative bias.

13) Page 39, Section 7.2.4. Please change the reference to Table B-2.4. Please change this paragraph to indicate that lead was identified as a COPC. The concentration of 504 mg/kg exceeds the leaching to groundwater screening level so lead is a COPC for this pathway, which is further evaluated using deeper soil samples. In addition, discussion and evaluation of travel time must be included in that evaluation to show that if the compounds were going to leach to deeper soil, they would have by now. An example of this analysis is included in Section 5.3.3 of the 2016 Montana Risk-Based Corrective Action for Petroleum Releases Guidance.

    Accepted. Reference has been changed to correct Appendix B table (B-2.4). Text has been changed to reflect that lead was identified as a leaching COPC and further evaluated with comparisons to deeper soil samples, including a vadose zone travel time evaluation. Section 10.2 has been revised to include the vadose zone travel time evaluation that concludes that if leaching were occurring, barium and lead would have been found at-depth. Table B-2.4 has also been revised to reflect this change.

14) Page 40, Section 7.2.5.1, 3rd bullet: DEQ does not typically require evaluation of construction worker exposure to sediment and surface water unless reasonably anticipated future use includes activities like irrigation ditch cleanup or repurposing. DEQ is not aware of a scenario like this involving the East Fork of Armells Creek. Please remove this scenario from the Report or explain why it is necessary.

    Accepted. Construction worker exposure to sediment and surface water has been removed.

15) Page 40, Section 7.2.5.1, 4th bullet: Please refer to the previous comment regarding children hunting.

    Accepted. 4th has been changed.

16) Page 45, Section 8.1, Table 8-1: Please delete “recommends using an RfD” from the footnote.

    Accepted. Text has been removed from the footnote.

17) Page 48, Section 9.1, Table 9-1: Please refer to the previous comment regarding children hunting.

Accepted. Table 9-1 has been revised.

18) Page 49, Table 10-1: Please indicate where the “Upstream Background Rosebud Mine” sample was taken (especially in relation to AR-12).

    Accepted. The extensive Rosebud Mine surface water dataset was obtained from the DEQ Coal Program. Section 10 has been revised to include further evaluation of the Rosebud Mine surface water samples in comparison to the East Fork Armells Creek samples collected at the Plant Site. The sampling locations with the highest manganese concentrations are depicted in a figure (Figure 13).

19) Pages 49-50, Section 10.1, last paragraph: Please refer to previous comment regarding surface water background.

    Accepted. Similar to the previous comment/response, the extensive Rosebud Mine surface water dataset was obtained from the DEQ Coal Program. Section 10 has been revised to include further evaluation of the Rosebud Mine surface water samples in comparison to the East Fork Armells Creek samples collected adjacent to the Plant Site. The sampling locations with the highest arsenic concentrations are depicted in a figure (Figure 14).

20) Page 50, Table 10-2: The average values do not match those provided in Appendix D. Please correct this and ensure that the average includes the 504 mg/kg.

    Accepted. There was a typo in Table 10-2: the average lead concentration was shown incorrectly as 32.6 mg/kg and has been corrected to 32.16 mg/kg. The average concentrations presented in Table 10-2 now match Appendix D (specifically Appendix D-4.5, which was incorrectly labelled as Table D-4.2). The average lead value does include the maximum concentration of 504 mg/kg.

21) Page 50, Section 10.2, bullets: Please add information regarding travel time as described above to demonstrate that if leaching was occurring the compounds would already be found at depth.

    Accepted. Text has been changed to reflect that barium was identified as a leaching COPC and further evaluated with comparisons to deeper soil samples, including a vadose zone travel time evaluation, but not retained as a leaching COC. Section 10.2 has been revised to include the vadose zone travel time evaluation concluding that if leaching were occurring, barium and lead would have been found at-depth. Table B-2.4 has also been revised to reflect this change.

22) Page 51, Section 10.2, bullets: Please add information regarding travel time as described above to demonstrate that if leaching was occurring the compounds would already be found at depth.

    Accepted. Text has been changed to reflect that lead was identified as a leaching COPC and further evaluated with comparisons to deeper soil samples, including a vadose zone travel time evaluation, but not retained as a leaching COC. Section 10.2 has been revised to include the vadose zone travel *time evaluation concluding that if leaching were occurring, barium and lead would have been found at-depth. Table B-2.4 has also been revised to reflect this change.*

23) Page 53, Section 12.2, 4th sentence: This sentence indicates that multiple upstream locations have manganese concentrations higher than observed at the plant site. However, no locations other than AR-12 have been discussed so far in the report. Please indicate which upstream locations this sentence refers to. Also see previous comments regarding surface water background.

    Accepted. The text has been edited to refer the reader to (revised) Section 10.1 that discusses the various surface water background/reference data.

24) Page 53, Section 12.2, 5th sentence: This sentence seems to indicate that the lowest rating for the stream is at the Plant Site, when DEQ believes the study indicated that upstream of the creek the rating was “poor.” Please clarify.

    Accepted. A description of the aquatic habitat assessment and benthic community survey that was conducted in upstream portions of East Fork Armells Creek was added to Section 6.1.3. Upstream portions of the Creek were rated as “fairly poor” to “poor”. Text was added to Section 12.2 to indicate that the Plant Site portion of the Creek is expected to be similar to upstream portions.

25) Page 53, Section 12.3: There were COPCs identified for soil but they were not retained as COCs. Please change this language throughout the Report.

    Accepted. The language has been changed throughout the report.

26) Page 54, Section 12.5.3, 1st sentence: Please delete “Discussions of” and capitalize “the.”

    Accepted. Changes have been made.

27) Page 56, Section 12.5.3, Table 12-3: Please change the cleanup criteria for cobalt in coal to the RSL of 0.006 mg/L, instead of the BSL.

    Accepted. Change has been made.

Tables and Figures

28) Figure 6: The SCEM must include the pathways that are used to evaluate COPCs to determine which are COCs and this figure must match Table B-1.1. Please delete the (1) footnote and indicate that the soil exposure pathways for workers and recreational users are complete. Please change the footnote for residents to (2). The inhalation pathway for sediment should be included but considered incomplete as stated in Table B-1.1. Please see previous comment regarding construction worker exposure to the Creek.

Accepted. Figure 6 has been revised per DEQ's requests and has been checked with Tables B-1.1 thru B-1.4.

Appendix A

29) Appendix A, Section A.1: Please include the section on "Control Actions" (Section IV. B), which lists the "regulated substances". Please also include an explanation of the difference between "regulated substances" and "Constituents of Interest (COIs)".

Accepted. The definition of "Control Actions", as well as an explanation of the difference between "regulated substances" and "COIs", have been added to Appendix A, Section A.1.

Appendix B

30) Table B-1.1: Please ensure that Figure 6 matches this table and see previous comment regarding construction worker exposure to the Creek. In the "Notes" section, the description of "Qualitative" should also include BSLs for constituents where a Tapwater RSL is not available.

Accepted. Table B-1.1 has been checked with Figure 6. The description of "Qualitative" has been changed.

31) Table B-1.2: Please ensure that Figure 6 matches this table and see previous comment regarding construction worker exposure to the Creek. Please delete the "Qual." note.

Accepted. Table B-1.1 has been checked with Figure 6. The "Qual." note has been removed.

32) Tables B-2.1 through B-2.5 (RAGS Table 2): Please indicate why the constituents included in the data summary tables differ between media (i.e., surface water, sediment, soil), and why some COIs (including CCR Appendix III and IV constituents) were not included.

Constituents in the data summary tables differ between media because the sampling protocols were established at different times, but all protocols were approved by DEQ. Surface water and sediment in East Fork Armells Creek were initially sampled during a synoptic run sampling event in 2005 prior to the establishment of the Federal CCR Appendices III and IV constituents, but with the analyte list approved by DEQ. The more recent 2014 and 2015 Synoptic Run Data were used in this CCRA because of the dynamic nature of the Creek. The analyte list for the 2014 and 2015 Synoptic Run sampling was established to follow the required parameter list of the DEQ Coal Program, as well as the sampling conducted upstream by the Western Coal Company, at DEQ's request (Letter from Jake Kandelin, DEQ, to Mike Holzwarth, PPL Montana, March 24, 2014). The soil sampling protocols were established in the Interim Response Action Work Plan Soil Sampling at Historic Release Sites along East Fork Armells Creek prepared by Talen (March 2016) and approved by DEQ. Footnotes have been added to Tables B-2.1 through B-2.5 for clarification.

33) Table B-2.4: Please see previous comments regarding leaching to groundwater COPCs.

    Accepted. Table B-2.4 has been changed to reflect that barium and lead were identified as a leaching COPCs and further evaluated with comparisons to deeper soil samples, including a vadose zone travel time evaluation, but not retained as a leaching COCs. Section 10.2 has also been revised to include the vadose zone travel time evaluation that concludes that if leaching were occurring, barium and lead would have been found at-depth.

34) Table B-4: Please see previous comments regarding construction worker exposure to the Creek and regarding children hunting.

    Accepted. Construction worker exposure parameters to sediments have been removed.

35) Table B-7.3: Please see previous comments on construction worker exposure to the Creek.

    Accepted. Table B-7.3 has been removed.

36) Table B-9.3: Please see previous comments on construction worker exposure to the Creek.

    Accepted. Table B-9.3 has been removed.

Appendix C

37) Appendix C, page 4, Section ES-2, last paragraph: Please see previous comments on surface water background.

    Accepted. Additional text has been added to Section ES-2 describing additional surface water reference/background samples in addition to AR-12, which is a primary background point

38) Appendix C, page 31, Section C-4.2.1: Please see previous comments on surface water background.

    Accepted. Additional text has been added to Section C-4.2.1 describing additional surface water reference/background samples in addition to AR-12, which is a primary background point. Text has also been added to Section C-4.2.1 to include further evaluation of the Rosebud Mine surface water samples in comparison to the East Fork Armells Creek samples collected at the Plant Site, and reference has been added to Figure 13, which shows the sampling locations with the highest manganese concentrations.

39) Appendix D, page 12, Section D-2.5.2, Tables: Please see previous comments on surface water background.

    Accepted. The Tables in Section D-2.5.2 included a column for AR-12, labeled as "AR-12 (background)." The word "background" is removed from the labels and text is added to the caption referring to AR-12 more accurately as the "primary background point." The same change was made to tables in Section D-3.5.1.

40) Page 16, Table C-7, Footnote: Please change the citation from (DEQ, 2016) to (DEQ, 2017).

    Accepted. Citation changed to (DEQ, 2017).

41) Page 25, 4th paragraph, last sentence: Please provide a quantitative definition of "fresh water body".

    Accepted. Text has been added to state that freshwater streams typically have specific conductance values ranging from 100 to 2,000 µmhos/cm, and TDS concentrations less than 500 mg/L. East Fork Armells Creek surface water has specific conductance values ranging from 2,600 to 5,900 µmhos/cm, and TDS concentrations ranging from 2,200 to 5,900 mg/L, which fall within the definition range of "brackish water".

42) Page 31, Section C-4.2.1, 1st paragraph, 5th sentence: The comparison of a downstream 95 UCL to an upstream maximum concentration seems biased. 95 UCLs take multiple data points into consideration, whereas a maximum concentration is a one-time measurement. Therefore, the report should compare 95 UCLs upstream and downstream, or a maximum concentration upstream and downstream (if measured during the same sampling event). For example, the maximum upstream concentration was 5,080 µg/L at AR-12; while a simultaneous measurement at AR-5 was 11,600 µg/L. Comparing the two maximum concentrations yields different conclusions than comparing a 95 UCL to an upstream maximum concentration.

    Accepted. Text has been revised to compare individual Plant Site measurements within a given sampling event to the upstream maximum from that same sampling event.

Appendix D

43) Page 7, Section D-2.2.2, Last paragraph, 1st sentence: Comparing dissolved concentrations of calcium and magnesium to total concentrations of other CCR constituents is problematic, as some of the CCR constituents have hardness-related DEQ-7 standards.

    The sentence referred to was "Calcium (Ca) and magnesium (Mg) concentrations were only available from filtered samples ("dissolved") instead of the desired "total" concentrations used for the other COPCs."

    The concentrations of calcium and magnesium are not directly compared to concentrations of other CCR constituents in Appendix D or elsewhere in the report. This sentence was meant to explain that data are only available for calcium and magnesium in the form of dissolved concentrations and therefore dissolved concentrations are used for all analysis involving these two analytes. While total concentrations are typically used for surface water, the use of dissolved for calcium and magnesium is actually consistent with the criteria used for screening for these two analytes for the ecological risk assessment in Appendix C; changes will be added to the wording in Appendix D and information presented in Appendix C to make this explicit. There are no surface water criteria available for *calcium or magnesium in DEQ-7. Aquatic life criteria for calcium and magnesium were taken from EPA Region 3 BTAG screening values, and the criteria for both of these constituents are based on the dissolved concentration in surface water. Screening values for calcium and magnesium are not hardness adjustable. For the metals that do have hardness adjustable screening levels, the DEQ-7 values are based on a total recoverable digestion procedure which is consistent with the reporting of the results for those constituents in the Plant Site CCRA. All surface water samples had hardness values exceeding the maximum allowable adjustment of 400 mg/L CaCO3, therefore the DEQ-7 values for hardness adjustable metals were adjusted to the maximum allowable hardness value.*

Responses to DEQ Comments on the Revised Plant Site Cleanup Criteria and Risk Assessment Report DEQ Comments dated 1/2/2018

Follow-Up on Talen's Response to DEQ's Comments

Previous comment 2: The Executive Summary mentions the use of MCLs for comparison as outlined in the AOC, but the Table in the Executive Summary does not address the use of MCLs. Please include the MCLs (where available), or provide a footnote stating that MCLs are not available.

Accepted. References to MCLs have been added to the Executive Summary Table. Similarly, references to MCLs have been added to the same table (Table 12-1) presented in Section 12.5.3.

Previous comment 14: On pages 42 and 43, the bullets regarding construction worker exposure to sediments are still included even though this evaluation was not done based upon DEQ's comments. In addition, DEQ 2016a is inappropriately referenced.

Accepted. The bullets regarding construction worker exposure to sediments have been removed. The comment referring to the DEQ, 2016a reference has been noted.

Previous comment 34: In Table B-4, please delete (Hunter) for child recreational exposure via ingestion and dermal contact.

Accepted. The prior version of Table B-4 was inadvertently included in the report. The revised version, in which the Hunter receptor has been removed, is now included in the report.

Surface Water Analysis Comments: Sections 6 and 10

General Comment: DEQ agrees with the inclusion of a broader surface water dataset for evaluation of surface water. However, DEQ does not agree with the methodology employed. Obviously, very high concentration outliers (SP-23 and Rosebud 4), particularly from a disturbed area (SP-23) should not be included in the dataset. Given the size of the datasets for manganese and boron, along with the fact that these sample locations are not directly upgradient in the same water body, a background threshold value (BTV) should be calculated for comparison rather than merely a comparison to the maximum. In addition, it is unclear how the datasets for manganese, boron, and arsenic were chosen. High concentration data were included in the datasets so it is not clear what criteria were used to determine which data would be eliminated. The analysis for boron is particularly odd given that the maximum concentration does not exceed the EPA Regional Screening Level and it may legitimately be screened out on this basis. Also, if arsenic is not a contaminant of potential concern for the groundwater, the analysis is not necessary for arsenic either. DEQ does not accept the surface water analysis as presented. Below are additional comments.

Accepted. The boron and arsenic surface water evaluations have been removed from the text. A BTV for manganese in surface water has been calculated and used for comparison. The BTV has been added to Table B-2.1 in Appendix B and Section 6.1.3. A comparison discussion is presented in Section 10.1. Finally, a description of the approach used to estimate the BTV has been added to Appendix D.

1. Page 33, Section 6.1.3, 1st bullet, 2nd paragraph, last sentence: Table B-2.1 shows surface water data from AR-2 to AR-5. Except for AR-5, these locations are downgradient of the Plant Site and should not be used as background/reference concentrations.

   Accepted. AR-5 is located upgradient of the Plant Site and AR-2 through AR-4 are located downgradient of the Plant Site. The text has been changed in Section 6.1.3 and Table B-2.1 has been revised.

2. Page 51, Section 10-2, Table 10-1: Please indicate whether these concentrations are total or dissolved.

   Accepted. Table 10-1 has been revised to indicate the concentrations are total manganese concentrations.

3. Page 51, Section 10.1, last paragraph, last sentence: Spring sites can be problematic for comparing to a surface water dataset. Springs are often more representative of localized water quality emitting from a specific geological unit, as opposed to a surface water dataset, which is often influenced by dilution or mixing from multiple units. As a result, spring data may be biased high or low, depending on the source unit. There are different units within the Tongue River Member that have variable characteristics, as demonstrated by the development of different BSLs for the various units. This should be acknowledged in the report and very high concentration outliers should not be included in the datasets as they are not likely representative of background concentrations in the East Fork of Armells Creek (EFAC).

   Accepted. Spring sites and high concentration outliers have been removed from the surface water evaluation. Rather, a BTV for manganese in surface was estimated and used for comparison.

4. Page 54, Section 10.1, 1st bullet: Although these samples were taken prior to construction of Units 3&4, Units 1&2 were in operation, and the clay-lined ponds associated with Units 1&2 were known to seep, especially since this was before the implementation of more protective liner systems. Additionally, the Plant itself was in operation, and likely was contributing aerial deposition downwind of the site since the scrubber systems at that time were not as efficient as those in place at the Plant today. These samples may have been influenced by operations and may not be appropriate for this dataset.

Accepted. The concentrations of question have been removed from the surface water evaluation, which has been revised and a BTV for manganese in surface water was prepared for comparison.

5. Page 54-56, Section 10.1: It is unclear why this analysis is presented when the maximum boron concentration does not exceed the RSL.

   Accepted. The boron evaluation has been removed.

6. Page 54, Section 10.1, 4th bullet: Please see the previous comments regarding BSLs and springs.

   Accepted. The text has been removed.

7. Page 56, Section 10.1, 1st bullet: Please remove the word "relevant". The two sites referenced here are not in the EFAC drainage, and therefore are probably less relevant to water quality in EFAC than those sites that are and please refer to the general comment regarding this analysis.

   Accepted. Per previous comments, the boron evaluation has been removed.

8. Page 56, Section 10.1, 1st bullet: Only one of the concentrations is a full order of magnitude higher than the concentration at AR-5 (10.4 vs 2.06 mg/L, respectively). Please edit the text accordingly and refer to the general comment.

   Accepted. Per previous comments, the boron evaluation has been removed.

9. Page 56, Section 10.1, 2nd bullet: Please see the previous comment regarding the timing of plant construction.

   Accepted. Per previous comments, the boron evaluation has been removed.

10. Page 56, Section 10.1, 4th bullet: Please see the previous comment regarding BSLs and springs.

    Accepted. Per previous comments, the boron evaluation has been removed.

11. Page 56, Section 10.1, bullets: If there is some justifiable reason for this analysis, please add a bullet that states that upstream boron concentrations within EFAC are the same or higher than those at the Plant Site.

    Accepted. Per previous comments, the boron evaluation has been removed.

12. Pages 57-58, Section 10-1: It is unclear why this analysis is included since arsenic is not a contaminant of potential concern for the groundwater.

    Accepted. The arsenic evaluation has been removed.

13. Page 57, Section 10.1, 2nd paragraph, last sentence: Please note only the outlier is higher than concentrations at AR-12 and AR-5 and it should not be included in the dataset.

    Accepted. The outlier data, along with the arsenic evaluation, have been removed.

14. Page 57, Section 10.1, last bullet: Although the highest concentration is an order of magnitude higher than the concentrations at the Plant Site, the location is 10 miles away from the Plant Site, and in a different drainage. It is therefore not representative of background for EFAC. Also see the previous comment regarding BSLs.

    Accepted. Per previous comments, the arsenic evaluation has been removed.

15. Page 58, Section 10.1, 1st bullet: Please see the previous comments.

    Accepted. Per previous comments, the arsenic evaluation has been removed.

16. Page 58, Section 10.1, 2nd bullet: Please see the previous comment regarding timing of plant construction.

    Accepted. Per previous comments, the arsenic evaluation has been removed.

17. Page 58, Section 10.1, 3rd bullet: On the previous page in Table 10-8, the locations are described as being in an “adjacent drainage”, which indicates that these locations are not upstream of the plant site. Please clarify. Also, these concentrations are lower than those at the Plant Site.

    Accepted. Per previous comments, the arsenic evaluation has been removed.

18. Page 58, Section 10.1, last bullet: Please see the previous comments regarding BSLs and springs.

    Accepted. Per previous comments, the arsenic evaluation has been removed.

19. Page 58, Section 10.1, 1st paragraph, 1st sentence: Except for the outlier, the concentrations originating from regional geology are about 5 times lower than those at the Plant Site. Using this logic contradicts the assertions made regarding boron, which state that the maximum background boron concentrations are “significantly higher” than those at the Plant Site (these concentrations are about 5 times higher). DEQ does not accept this analysis.

Accepted. It was assumed that DEQ's comment refers to arsenic as Page 58, Section 10.1, 1st paragraph, 1st sentence discusses arsenic, rather than boron. Per previous comments, the arsenic evaluation has been removed.

20. Page 58, Section 10.1, 1st paragraph, last sentence: Please refer to previous comments regarding the conclusions drawn here.

    Accepted. Per previous comments, the arsenic evaluation has been removed.

Responses to DEQ Comments on the Revised Plant Site Cleanup Criteria and Risk Assessment Report DEQ Comments dated 4/12/2018

Specific Comments

1. Page 51, Table 10-1: Please remove AR-5 as minimum value since it is now considered a background data point.

   Accepted. The AR-5 value has been removed.

2. Section 10.1: Please provide a table with the data used in the manganese BTV calculations.

   Accepted. Table 10-2 Summary Statistics and Estimated UTL-95/90 (BTV) for Total Manganese in Surface Water has been added to Section 10.1.

3. Appendix D: Exposure Point Concentration (EPC) calculations still use AR-5 due to its location within the Exposure Unit (EU). The EU should not be defined to include background; since AR-5 is now considered a background point, the EPC and the EU should be re-calculated to reflect this change.

   Accepted. The EPC calculations have been revised with the removal of AR-5 because it is a background point. AR-5 was previously included in the EPC calculation as a conservative measure, as well as its location within the (former) boundary of EU1. The boundary of EU1 has been revised (Figure 8). Risk calculations have also been revised for both the human health and ecological risk assessments associated with the revision of the EPCs.

4. Table 3, Radium data: Radium was screened out on the basis that the pond concentrations were below DEQ-7. However, the fly ash itself may represent a source of radium that could explain the higher radium concentrations in downgradient CCR wells versus concentrations in background CCR wells. The CCR well concentrations were above DEQ-7. These represent total concentrations and an assumption was made that the dissolved concentrations would be below DEQ-7. Dissolved concentrations should be sampled to confirm this before screening out radium on this basis. Additionally, the CCR wells also exceed EPA MCLs, which are total concentrations, indicating that radium should not be screened out.

   An incorrect assumption was made in the CCRA regarding the radium DEQ-7 standard. Radium was screened out based on the assumption that dissolved groundwater concentrations would be below 5 pCi/L (the DEQ-7). However, the DEQ-7 standard for radium is based on the total recoverable concentration. Both the DEQ-7 and the MCL are based on a total recoverable radium concentration of 5 pCi/L. As such, groundwater samples should not be collected and analyzed for dissolved radium concentrations.

Following the groundwater COI/COPC identification process that was discussed and agreed to during the February 2017 meeting with DEQ, the Radium 226/228 concentrations in the process ponds were assumed to be the source as a worst-case scenario. The Radium 226/228 concentrations measured in the process ponds were well below the DEQ-7 standard. In other words, the Radium 226/228 concentrations in the assumed worst-case source (the process ponds) were smaller than the concentrations measured in the CCR wells. However, because Radium 226/228 concentrations in a limited number of groundwater samples collected from the CCR wells exceeded the DEQ-7/MCL as stated in DEQ's comment, it was further evaluated in the CCRA. Section 10.4 Evaluation of Radium Concentrations in Groundwater has been added to the CCRA that details this further evaluation. Based on the further evaluation, Radium 226/228 groundwater concentrations at the Plant Site appear to be representative of background concentrations. Consequently, Radium 226/228 was not retained as a groundwater COI.

5. Table B-2.1 and Table B-2.2: Radium should be evaluated in soil, sediment and surface water, especially since it is present in the CCR wells at concentrations above the MCL. Additionally, the constituents evaluated for the spill areas in these tables for the Units 1&2 CCRA are different than those evaluated in spill areas in the Plant Site CCRA: eight constituents are missing in the Plant Site CCRA tables. DEQ may require changes to the Plant Site CCRA based on the results of this risk assessment.

As stated in the previous comment response, Radium 226/228 groundwater concentrations were further evaluated and concluded to be consistent with background levels. Because Radium 226/228 was not found to be a groundwater COI, Radium 226/228 evaluation in soil, sediment, and surface water is not necessary. In addition, DEQ has not required monitoring of radium at the facility in surface water, groundwater, soil, or sediment under the AOC or the site operational monitoring program. Historically, the radiological content of bottom ash (alpha, beta, and gamma radiological characteristics) was measured and determined to be within the range of naturally occurring soil and geological materials in the Colstrip area. Please note that radium was only one contributor to the total radiological content. Based on the results of the radiological measurements, DEQ previously (2004) determined that no land-use controls over development, population, waste disposal, or special safeguards or monitoring were required for radiation impacts associated with the ash.

Monitoring for radium in groundwater at the Facility began in 2016 under the Federal CCR Rule solely in wells used for this Rule. The CCR Rule includes requirements for monitoring two sets of parameters. One set is used for "detection" monitoring and is referred to as Appendix III parameters. Detection monitoring (Appendix III) does not require analysis of radium. Assessment monitoring is triggered when there is a statistically significant increase detected through statistical analysis of the Appendix III parameters. Radium is included as an analyte of the Appendix IV parameter list that is used for assessment monitoring. To date, radium analysis has been conducted on groundwater samples collected from the CCR wells at the Facility solely for the purpose of developing a baseline dataset for the Appendix IV parameters.

Radium was included in the analyte list for the soil samples collected in the spill areas of the Units 1&2 SOEP/STEP area as a conservative measure to include the analytes listed in the Federal CCR Rule. During a meeting with the DEQ in February 2017, it was decided that the CCR Rule Appendices III/IV constituents should be included in the COI screening process. Although groundwater radium data were available from the dataset collected as part of the Federal CCR Rule, radium data in soil (or surface water or sediment) were not available. Various analytes were added to the soil sampling analyte list for the Units 1&2 SOEP/STEP former spill sites that were not included in the soil sampling analyte list for the Plant Site former spill sites based on the February 2017 meeting. At the time of that meeting, the soil samples collected from the Plant Site former spill sites had already been collected and analyzed (sampling event conducted in April 2016). However, the Units 1&2 SOEP/STEP former spill site soil samples had not yet been collected and the CCR Appendices III/IV Constituents were added to that soil sampling event as a conservative measure. In addition, please note that radium was not selected as a soil COC/COI for the Units 1&2 SOEP/STEP spill sites.

Seven of eight constituents noted in the comment are CCR Rule Appendix III/IV constituents. The remaining constituent, magnesium, was inadvertently left out of the Appendix B tables associated with the spill sites at the Plant Site (Tables B-2.3, B-2.4 and B-2.5) and has been added. Magnesium was not selected as a soil COI/COPC for the Plant Site.

6. Public comment: Please note that DEQ received comments stating that Talen may be breaking federal rule by using RSLs/risk-based concentrations, which are above background conditions as cleanup criteria. The AOC allows for risk-based cleanup levels and this CCRA is required under the AOC. Therefore, DEQ will not require changes to the CCRA based upon these comments but Talen is still required to comply with CCR.

   Comment noted.

Responses to DEQ Comments on the Revised Plant Site Cleanup Criteria and Risk Assessment Report
DEQ Comments dated 6/14/2018

General Comments

Based on the data presented in Section 10, DEQ believes that radium should be included as a COC. The discussion between Talen and DEQ on April 26, 2018 indicated that 95 UCL radium concentrations for individual wells at the Plant Site were below DEQ-7 standards, and DEQ approved of this approach. However, the data presented in Section 10 indicates that three wells have 95 UCL concentrations above DEQ-7 standards. The text indicates that the 95 UCL falls fellow DEQ-7 when the maximum concentrations are not used in the calculation, however DEQ does not approve of this approach unless it can be demonstrated that the maximum concentrations reported are due to a lab or sampling error, which would be justified by a data qualifier. Additionally, the tables that present this data (Table 10-7 and Table 10-8) show different values for the 95 UCL (although the values still exceed DEQ-7).

Due to the exceedances of DEQ-7 standards and EPA MCLs, DEQ requests that the report be revised to include radium as a COC, and to propose cleanup criteria for this constituent.

To address the above radium issue, a meeting was held with DEQ in June 2018. DEQ requested that samples be collected and analyzed for radium from the pond solids and plant paste to evaluate the source of the radium. Based on the sampling results, which are presented in Section 10.4, there is no evidence to substantiate that the source of radium in groundwater is the process pond water, bottom ash, fly ash, or plant paste. Radium concentrations in groundwater at the Plant Site appear to be consistent with background levels and radium was not identified as a groundwater COI. However, because a radium groundwater BSL was not available for comparison, as a conservative measure radium will continue to be monitored and evaluated in groundwater. In addition, radium will be monitored in groundwater as part of the Federal CCR Rule compliance monitoring.

Lastly, we agree that an error was present in Table 10-7/10-8; however, Tables 10-7 and 10-8 have been replaced in the report per revisions to Section 10.4.